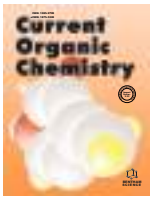
Current Organic Chemistry, 2023, *27*, 206-222

REVIEW ARTICLE

Nitrogen-containing Fused Heterocycles: Organic Synthesis and Applications as Potential Anticancer Agents



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ARTICLE HISTORY

Received: August 29, 2022
Revised: November 26, 2022
Accepted: November 28, 2022

DOI:
10.2174/1385272827666221227120648

Abstract: The fused Nitrogen heterocyclic compounds and their derivatives have grown in prominence over the past several decades as a result of their significant medical value. The adaptable and easily synthesized N-Heterocyclic scaffolds are particularly exciting in both synthetic organic chemistry and the biological sector due to their powerful pharmacological properties, which are taken into consideration while considering their numerous uses. For the synthesis of N-heterocycles and their derivatives, several attempts were undertaken to create a variety of synthetic protocols. The N-Heterocyclic compounds provide a variety of adaptable structures for specific biological applications and represent novel, broad-spectrum antibacterial and anticancer agents. They typically have minimal toxicity profiles. The majority of these N-Heterocycles have demonstrated more cytotoxicity than the effective anticancer medication cisplatin. The design, synthesis, structural characterisation, and biological uses of N-Heterocycles are reviewed in this work. In this article, the developments made in this specific field are comprehensively examined.

Trimurti L. Lambat

Keywords: Organic synthesis, N-heterocycles, anti-cancer agents, novel synthetic protocols, fused N-heterocycles, biological activities.

1. INTRODUCTION

Heterocyclic compounds [1-8] are a fundamental branch of organic chemistry that has its origins in organic synthesis and medicinal chemistry [9-14]. The physicochemical qualities are greatly influenced by the kind and size of the ring structures, as well as the substituent groups of the core scaffold [15-23]. Heterocyclic compounds play an important role in a variety of medicinal applications, including antibacterial [24-26], antiviral [27], antifungal [28], anti-inflammatory [29], and anti-tumor drugs [30-33].

The ongoing identification of novel heterocyclic scaffolds gives new tools for modulating or modifying a variety of disease states [34-38]. A novel scaffold has the advantage of disrupting a signal pathway or blocking an enzyme's active site [39-43]. Synthesis of novel heterocycles using better and easier methodologies [44-50], therefore, attracts synthetic organic chemists' attention. A medium-sized ring-fused heterocycle has a variety of biologically significant properties [51-53]. Furthermore, attaching a suitable substitute as well as adding another fused five- or six-member ring to the scaffold has greatly increased activity [54].

N-containing heterocycles [55-58] are compounds with a distinct structural motif that is abundant in natural products including hormones, alkaloids, and vitamins [59-62]. Pharmaceuticals, natural goods, pigments, organic materials, and biologically active compounds all contain N-heterocycles [63]. For their various actions, heteroaromatic chemical compounds such as benzimidazole, benzothiazoles, indole, acridine, oxadiazole, imidazole, isoxazole, pyrazole, triazoles, quinolines, and quinazolines have sparked a lot of interest in the development and pharmacology in recent years [64-68]. By suppressing cell growth and inducing cell differentiation and apoptosis, these N-heterocyclic compounds have anticancer effects in a variety of cancers [69-72].

The N-heterocycles are the most commonly used structural skeletons of medications in the market. Indeed, at least one nitrogen atom can be found in 84 percent of all molecules, while at least one nitrogen heterocycle being found in 59 percent [73]. Furthermore, the use of heterocycles in drug discovery was stressed in a recent study published by Martins and collaborators [74] on oncological medications approved by the FDA between 2010 and 2015. During that time, 26 of the 40 newly approved chemotherapeutic medicines have heterocyclic fragments in their molecular structure. Nitrogen-based heterocycles accounted for 73 percent of these heterocycles, vastly outnumbering nitrogen-oxygen (15%), oxygen (8%), and nitrogen-sulfur (4%) heterocycles.

Despite their broad spectrum of biological activities, including anticancer activity, there is still a need for creative, practical, and effective methods for nitrogen-containing heterocyclic synthesis,

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1875-5348/23 $65.00+.00

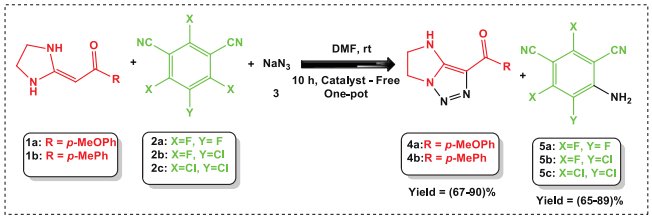
which has become a major aim in modern organic synthesis. Furthermore, the development of drug resistance to cancer chemotherapeutic drugs by chance poses serious medical issues [75]. Drug resistance, either inherent before treatment (intrinsic) or acquired after treatment (acquired), is responsible for the majority of cancer relapses and is one of the leading causes of cancer death [76]. As a result, the discovery of innovative medications with fewer side effects and broad spectrum capabilities is unavoidable if cancer treatment is to improve [77].

2. 1,2,3-TRIAZOLE DERIVATIVES

2.1. Heterocycle-fused 1,2,3-triazole Derivatives

2.1.1. Synthetic Strategy

Yan *et al.* [78] synthesised a series of heterocycle-fused 1,2,3-triazoles by 1,3-dipolar cycloaddition of heterocyclic ketene aminals or N, O-acetal with sodium azide and polyhalo isophthalonitriles in a one-pot reaction at room temperature without a catalyst (Scheme **1**).



Scheme 1. Synthesis of heterocycle-fused 1,2,3-triazole derivatives.

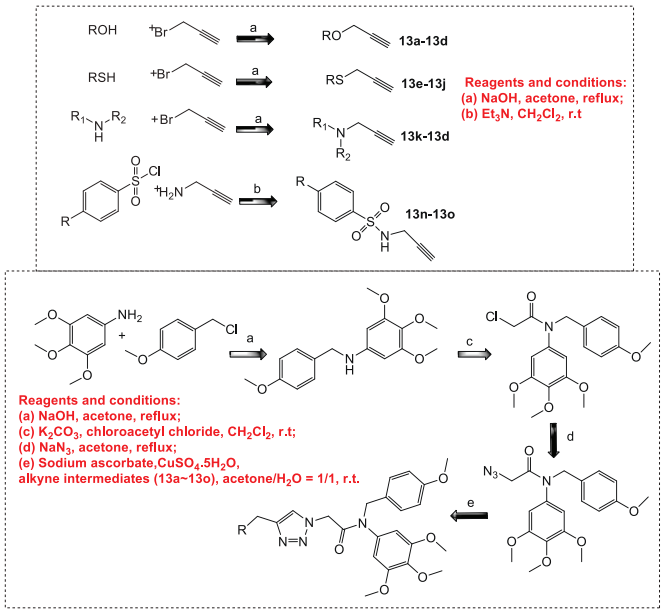
2.1.2. Biological Activity

A series of heterocycle-fused 1,2,3-triazoles were tested *in vitro* against a panel of human tumour cell lines. The most effective derivative was discovered to be 4-methoxyphenyl substituted 1,3-oxazoheterocycle fused 1,2,3-triazole, with IC_{50} values of less than 1.9 g/mL against A431 and K562 human tumour cell lines.

2.2. 1,2,3-triazole Hybrid Moieties

2.2.1. Synthetic Strategy

Fu *et al.* [79] developed and synthesised structurally different trimethoxyphenyl-1,2,3-triazole hybrids (Scheme **2**).



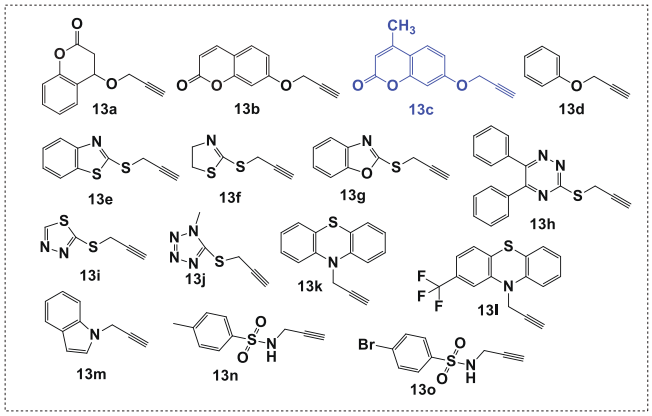
Scheme 2. Synthesis of trimethoxyphenyl-1,2,3-triazole hybrids.

2.2.2. Biological Activity

The synthesized products were tested for antiproliferative efficacy against three cancer cell lines (PC3, MGC803 and HepG2) (Table **1**). Trimethoxyphenyl-1,2,3-triazole containing the coumarin fragment

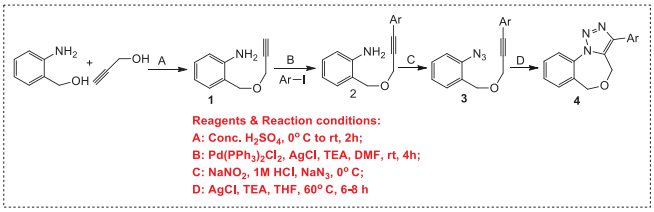
13c showed higher antiproliferative action than the anticancer medication colchicine, with IC_{50} values ranging from 0.13 μM to 1.74 μM. The lead Compound (**13c**) inhibits MGC803 cell growth and colony formation, induces G2/M phase arrest by inhibiting CDK1 expression, and promotes apoptosis *via* regulating the DR5 and Bcl-2 families. Furthermore, tubulin polymerization was substantially suppressed by (**13c**), which interacted with the colchicine site.

Table 1. Chemical structure of synthesized lead moieties of trimethoxyphenyl-1,2,3-triazole hybrids.



2.3. Triazolo-benzoxazepine Derivatives

Banerji *et al.* [80] synthesised small triazolo-benzoxazepine scaffolds employing one-pot four-step synthetic approach incorporating the click reaction (Scheme **3**) and tested them against several cancer cell lines. The MTT assay revealed that these compounds have low micromolar anticancer activity, and phase contrast, fluorescent, and confocal pictures were used to confirm cell death.



Scheme 3. Synthesis of Triazolo-benzoxazepine scaffolds using a one-pot four-step synthetic methodology involving click reaction.

2.4. N-substituted-3-mercapto-1,2,4-triazoles, triazolo [1,3,4]thiadiazines and triazolo [1,3,4]thiadiazoles

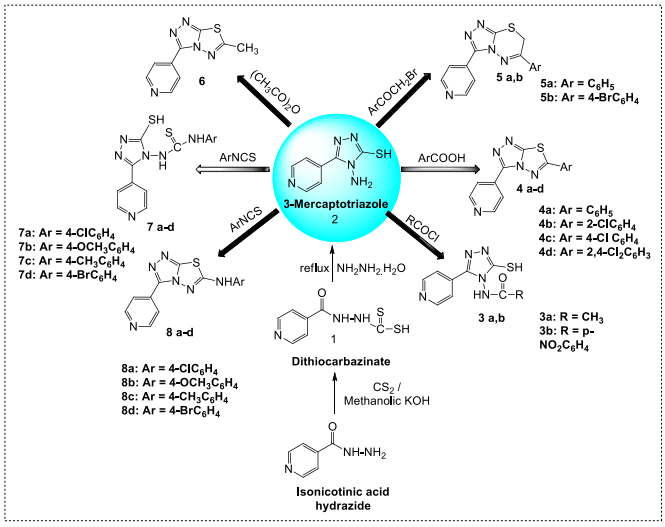
2.4.1. Synthetic Strategy

Kamel and co-workers [81] synthesized a series of novel N-substituted-3-mercapto-1,2,4-triazoles (**3a-3b**, and **7a**, **7e**, **7d**), triazolo [1,3,4]thiadiazines (**5a, 5b**), and triazolo [1,3,4]thiadiazoles (**4a**, **4e**, **4d**, **6** and **8a**, **8e**, **8d**) starting with isonicotinic acid hydrazide (Scheme **4**). On the basis of spectrum data and elemental studies, the structure of the newly synthesised chemicals was validated.

2.4.2. Biological Activity

All compounds were tested for anticancer activity *in vitro* against six human cancer cell lines as well as normal fibroblasts. Most cell lines showed considerable cytotoxicity to seven of the

examined scaffolds (**3a**, **3b, 4c**, **5a**, and **8b**, **8e**, **8d**). Compound (**4c**), among these derivatives, had a cytotoxic impact on a gastric cancer cell line that was comparable to the standard CHS 828 (IC_{50} 14.25 µM). Normal fibroblast cells (WI38) were only slightly affected (IC_{50} > 10.00 µM).

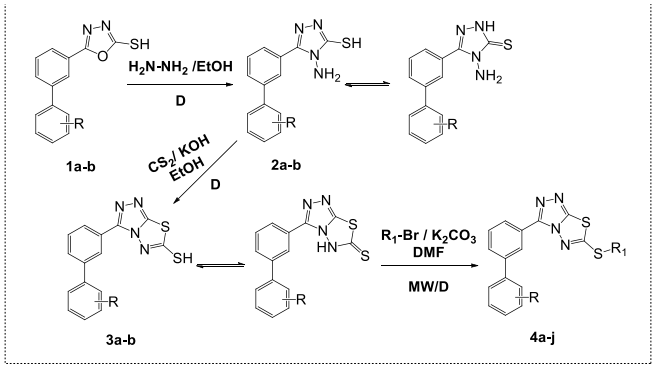


Scheme 4. Synthesis of N-substituted-3-mercapto-1,2,4-triazoles (3a,b, and 7a-d), triazolo[1,3,4]thiadiazines (5a,b) and triazolo[1,3,4]thiadiazoles (**4a-d, 6** and **8a-d**).

2.5. Alkyl Derivatives of 3-(substituted-(1,10-biphenyl)-3-yl) [1,2,4]triazolo [3,4-b] [1,3,4]thiadiazole-6-thiol

2.5.1. Synthetic Strategy

Ramprasad and coworkers [82] used conventional and microwave irradiation methods to synthesize a series of S-alkyl derivatives of 3-(substituted-(1,10-biphenyl)-3-yl) [1,2,4]triazolo [3,4-b] [1,3,4]thiadiazole-6-thiol (**4a–j**) (Scheme **5**). In comparison with the conventional method, the microwave method produced a faster and higher yield.



Scheme 5. Synthesis of alkyl derivatives of 3-(substituted-(1,10-biphenyl)-3-yl)[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole-6-thiol.

2.5.2. Biological Activity

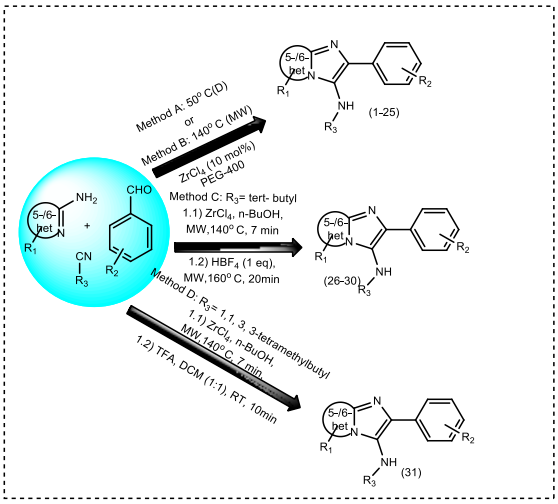
The MTT assay was used to test these substances for anticancer activity *in vitro*. The moiety (**4c**) was the most promising anticancer agent in the HT29 cell line, with an IC_{50} value of 12 µM.

3. BENZIMIDAZOLE DERIVATIVES

3.1. N-Fused Aminoimidazoles

3.1.1. Synthetic Strategy

Baviskar *et al.* [83-85] employed multicomponent protocol to make N-Fused aminoimidazoles using different approaches (Scheme **6**).



Scheme 6. Methods of preparation of investigational compounds as potential htopoiiα inhibitors.

3.1.2. Biological Activity

N-Fused aminoimidazoles were tested *in vitro* against human topoisomerase IIα (hTopoIIα) in decatenation, relaxation, cleavage complex, and DNA intercalation assays. These scaffolds showed substantial anticancer activity in kidney and breast cancer cell lines, as well as low toxicity to normal cells, higher potency in kidney cancer cell lines than etoposide and 5-fluorouracil, and potent suppression of cell migration. In the G1/S phase, several chemicals were discovered to have an apoptotic impact.

3.2. Benzimidazole Associated with Triazolo-thiadiazoles and Triazolothiadiazines

3.2.1. Synthetic Strategy

Two series of Benzimidazoles were synthesised by Husain *et al.* [86] in combination with triazolo-thiadiazoles (**5a-q**, **5r**, **5s**, and **5x-a**) and triazolothiadiazines (**5t-5w**) to produce promising anticancer agents (Scheme **7**).

3.2.2. Biological Activity

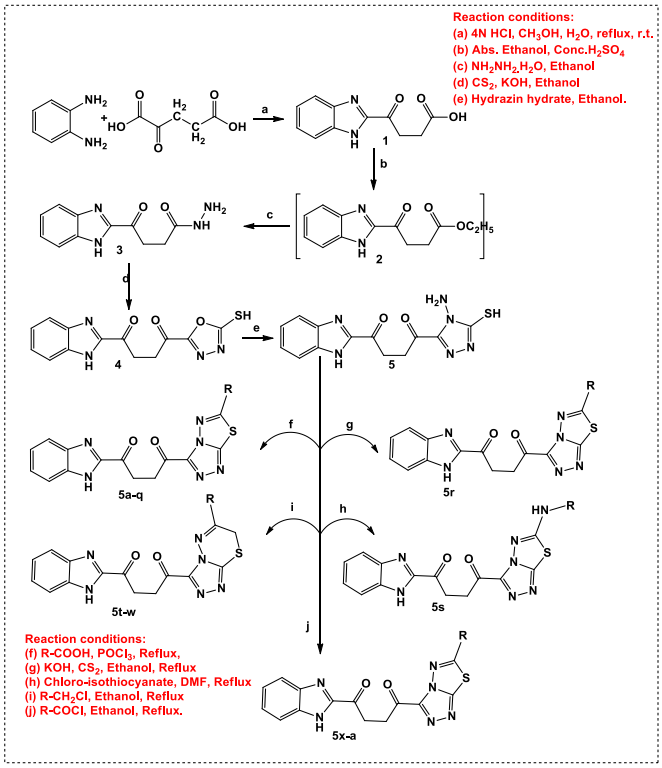
The National Cancer Institute (NCI) tested the *in vitro* anticancer activities of synthesised compounds against the NCI60 cell line panel, and the results showed good to remarkable broad-spectrum anticancer activity. Compound (**5h**) (NCS: 760452, 1) is one of them. 3-(6-(2,4- dichlorophenyl)- [1,2,4]triazolo [3,4-b]-3-(6-(2,4-dichlorophenyl)- [1,2,4]triazolo [3,4-b]-3-(6-([1,3,4]thiadiazol-3-yl) propan-1-one) inhibited growth significantly, with IC_{50} values ranging from 0.20 to 2.58 µM, and was found to have superior selectivity for leukaemia cell lines. It was then screened at 10-fold dilutions of five different concentrations (0.01, 0.1, 1, 10, and 100 µM). **5h** could be used as a lead compound in the development of new anticancer agents.

3.3. Benzimidazole Associated with Oxadiazole and Triazolo-thiadiazoles

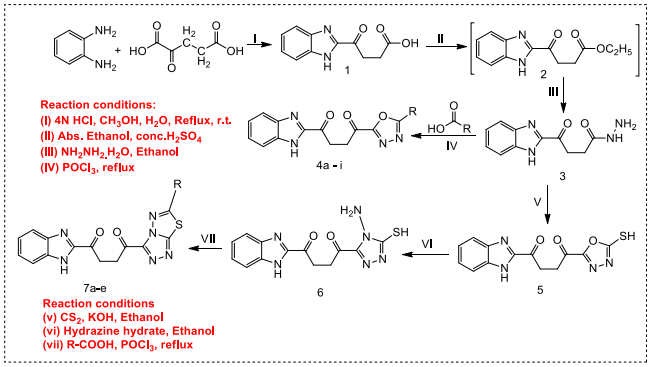
3.3.1. Synthetic Strategy

Husain *et al.* [87] effectively synthesised two new series of benzimidazole-bearing oxadiazole [1-(1H-benzo [d]imidazol-2-yl)-3-(5-substituted1,3,4-oxadiazol-2-yl)propan-1-ones (**4a-l**)]. and triazolo-thiadiazoles [1-(1H-benzo [d]imidazol-2-yl)-3- (6-hydroxybenzo [d]imidazol-2-yl)-6-hydroxybenzo [d]imidazol-2-yl)-6-hydroxybenzo [d]imida (substituted) - [1,2,4] triazolo [3,4-b] [1,3,4]thiadiazol-3-yl)propan-1-one (**7a-e**)] triazolo [3,4-b] [1,3,4]thiadiazol-3-yl)propan-1-one (**7a-e**)] triazolo [3,4]thiadiazol-

3-y with the goal of developing effective anticancer medicines from 4-(1H-benzo [d]imidazol-2-yl)-4-oxobutanehydrazide (**3**) (Scheme **8**).



Scheme 7. Synthesis of Benzimidazole associated with triazolo-thiadiazoles (**5a-q**, **5r**, **5s** and **5x-a**) and triazolothiadiazines (**5t-w**).



Scheme 8. Synthesis of benzimidazole bearing oxadiazole[1-(1H-benzo[d]imidazol-2-yl)-3-(5-substituted-1,3,4-oxadiazol-2-yl)propan-1-ones (**4a–l**)] and triazolo-thiadiazoles[1-(1H benzo[d]imidazol-2-yl)-3- (6-(substituted)-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazol-3-yl)propan-1-one (**7a–e**)]

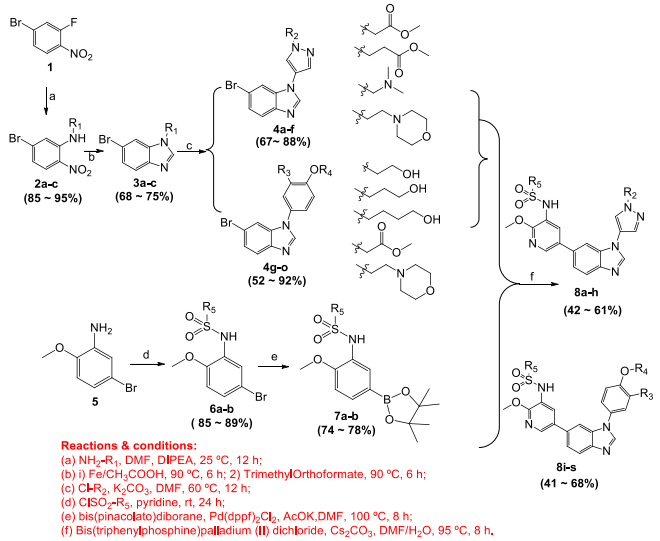
3.3.2. Biological Activity

The anticancer activity of produced compounds was tested *in vitro* against the whole NCI60 human cell line panel at the National Cancer Institute (NCI) in the United States, according to their methodology; the results revealed good to outstanding anticancer activity. Compound (**4j**, NCS: 761980) showed significant growth inhibition and was screened at 10-fold dilutions of five different concentrations (0.01, 0.1, 1, 10, and 100 μM) with IC_{50} values ranging from 0.49 to 48.0 μM. It was found superior for non-small cell lung cancer cell lines like HOP-92 (IC_{50} 0.49, TGI 19.9, IC_{50} >100 and Log10 IC_{50}- 6.30, Log10 TGI- 4.70, Log10 IC_{50}>-4.00).

3.4. 1H-benzo [d]imidazole Derivatives

3.4.1. Synthetic Strategy

Ding *et al.* [88] developed a library of 1,6-disubstituted-1H-benzo [d]imidazole derivatives using multistep synthesis (Scheme **9**).



Scheme 9. Synthesis 1,6-disubstituted-1H-benzo[d]imidazoles derivatives.

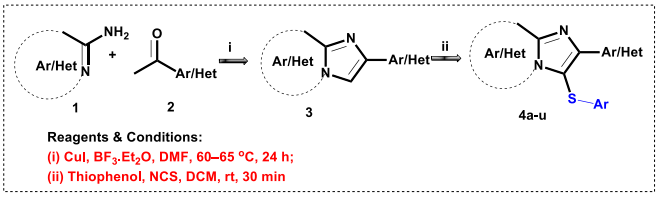
3.4.2. Biological Activity

The synthesized compounds were investigated *in vitro* for their antiproliferative efficacy against the T47D, HCT116, and MCF-7 cancer cell lines. The scaffold (**8i**), which has a 2,4-difluoro substitution pattern on the sulfonyl phenyl ring, demonstrated substantial action against the T47D, HCT116, and MCF-7 cancer cell lines, with IC_{50} values of 0.36 μM, 0.14 μM, and 0.31 μM, respectively. Furthermore, in HCT116 cells, the active scaffold (**8i**) significantly suppressed cell growth by suppressing PI3K kinase and blocking the PI3K/Akt pathway.

3.5. Sulfinylated Imidazo [1,2-a]pyridines

3.5.1. Synthetic Strategy

Chitrakar *et al.* [89] described the design, synthesis, and investigation of the anticancer properties of sulfenylated 2-phenylimidazo [1,2-a] pyridines and their analogues (Scheme **10**).

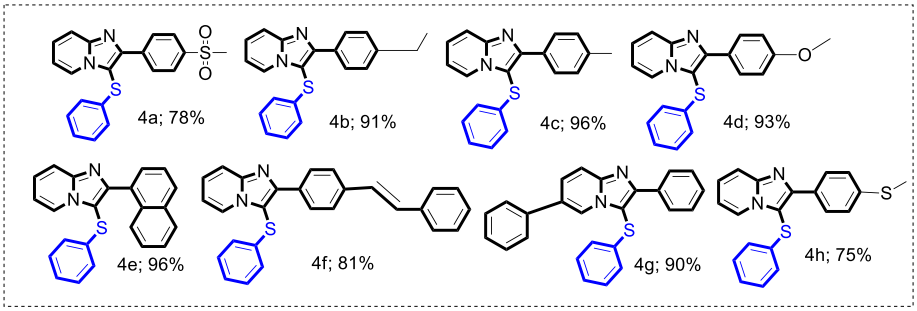


Scheme 10. Synthesis of sulfinylated imidazo[1,2-a]pyridines.

3.5.2. Biological Activity

The MTT assay was used to test the anticancer activity of twenty sulfenylated imidazo [1, 2-a] pyridine derivatives (Table **2**) in seven different human cancer cell lines, MDA MB 231 (breast), HepG2 (liver), Hela (cervical), A549 (lung), U87MG (glioblastoma), SKMEL-28 (skin melanoma), and DU-145 (prostate). Compounds (**4e**) (naphthalene), (**4f**) (styrene), and (**4h**) (thiomethyl) in the series demonstrated potent activity against human liver cancer cells HepG2. Cell cycle analysis revealed that these compounds arrested the cell cycle at the G2/M phase and induced apoptosis in HepG2 human liver cancer cells.

Table 2. Chemical structure of synthesized sulfinylated imidazo[1,2-a]pyridine analogues.

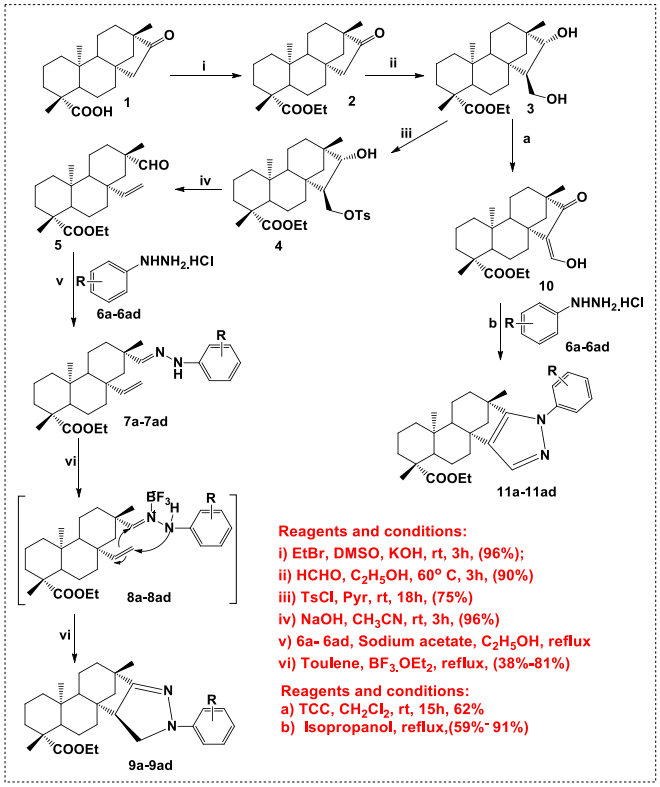


4. FUSED PYRAZOLINE AND PYRAZOLE DERIVATIVES

4.1. Isosteviol-fused Pyrazoline and Pyrazole Moieties

4.1.1. Synthetic Strategy

Zhu *et al.* [90] developed two series of new isosteviol-fused pyrazoline and pyrazole derivatives *via* intramolecular 1,3-dipolar cycloaddition and condensation reactions, respectively (Scheme **11**).



Scheme 11. Stereoselective synthesis of novel isosteviol-fused pyrazoline and pyrazole Scaffolds *via* intramolecular 1,3-dipolar cycloaddition and condensation reaction.

4.1.2. Biological Activity

The four human cancer cell lines (SGC7901, A549, Raji, and HeLa) were investigated *in vitro* for their antiproliferative activity of structurally similar pyrazoline and pyrazole derivatives. The findings demonstrated that isosteviol-fused pyrazole derivatives had significant cytotoxic properties. When compared to cisplatin (IC_{50} values 7.56, 17.78, 17.32, and 14.31 μM, respectively), 2,4-di-Cl-phenylpyrazole derivative (**7**) had improved cytotoxicities with IC_{50} values of 2.71, 3.18, 1.09, and 13.52 μM against SGC7901, A549, Raji, and HeLa.

4.2. Pyrazolylthiazole Derivatives

4.2.1. Synthetic Strategy

Abbas *et al.* [91] developed a novel series of pyrazolylthiazole derivatives by reacting 5-(4-fluorophenyl)-3-aryl-4,5-dihydropyrazole-1-carbothioic acid amide derivatives with various reagents (Scheme **12**).

4.2.2. Biological Activity

The anticancer activity of all synthesized compounds was tested against a breast cancer cell line. Eight of the investigated drugs' derivatives demonstrated effective action against MCF7. In comparison to tamoxifen, some of the investigated compounds demonstrated substantial activity against the breast cancer cell line (MCF7). Compounds (**14g**, **7c**, **7d**, **14f**, **7e**, **5a**, **6b**, and **14d**) have IC_{50} values of 8.10, 8.11, 8.33, 8.65, 8.77, 9.30, 9.60, and 9.90 μg/mL, respectively, and are equivalent to tamoxifen (IC_{50}=8.00 μg/mL). The structure-activity relationship revealed that the antitumor efficacy of these compounds is strongly linked to the type of substituent at positions 4 and 5 of the thiazole ring, as well as position 3 of the pyrazole ring.

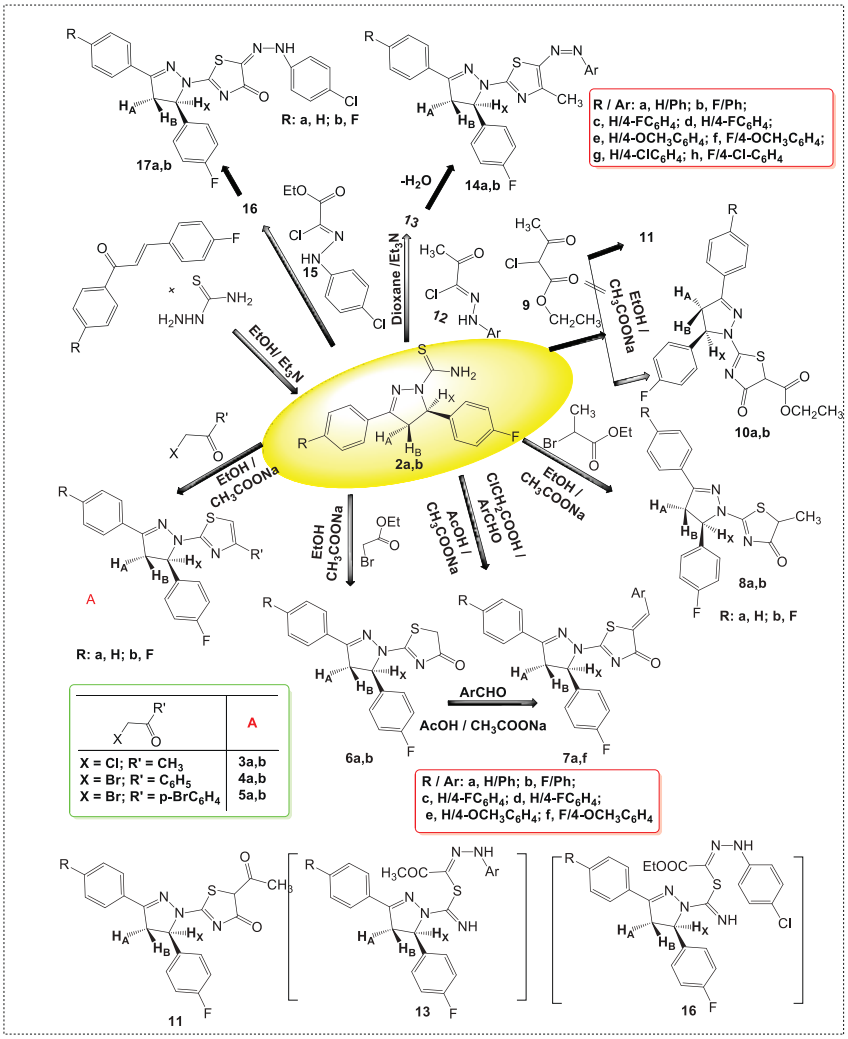
5. NITROGEN-PHOSPHORUS HETEROCYCLES AND PHOSPHONATES

5.1. Synthetic Strategy

Abdou *et al.* [92] synthesised substituted N, P-heterocycles and derived phosphonates efficiently in a tandem process without intermediate isolation (Scheme **13**). The reaction of dialkyl phosphites with Schiff base, Kabachnik–Field intermediates, which are produced in situ from 2-amino-4,6-di-tert-butylphenol and substituted benzaldehydes in a dry THF/FeCl3 (10%) solution, yielded fused oxazole-2-phosphonates in moderate yield (≈55%). By directly applying the same P(III) reagent to the parent Schiff bases, the latter products could be produced in an excellent yield (≥76%). When the Schiff bases were allowed to react with hexaalkyltriamidophosphites at room temperature, oxazaphosphinine2-amines were extracted in high yields (≈77%). When the same reagents were applied to another imino derivative, more P-heterocycles and phosphonates were produced.

5.2. Biological Activity

The anticancer properties of the produced scaffolds were tested biologically and found to be potent. Bioassay data shows that N, P-heterocycles generated have exceptional anticancer efficacy against seventeen human carcinoma cell lines, including breast, prostate, and melanoma (compounds **11a** and **11b**). Several phosphonates (compounds **6a** and **6b**) have been discovered to have anti-breast cancer action particularly in MDA-MB-435 cell lines, while other



Scheme 12. Synthesis of pyrazolylthiazole derivatives by reacting 5-(4-fluorophenyl)-3-aryl-4,5-dihydropyrazole-1-carbothioic acid amide derivatives with various reagents.

compounds (**6d** and **6e**) have anti-melanoma activity in MI4 and SK-MEL-2 cancer cell lines.

6. THIOPHENE BIOISOSTERES

6.1. Synthetic Strategy

Sztanke *et al.* [93] manufactured thiophene bioisosteres (**10-18**) by condensing compound 1-aryl-2-hydrazonoimidazolidine hydroiodides with ethyl 2-thiophen-2-yl-2-oxoacetate in a methanolic medium and triethylamine (TEA) *via* reflux in DMF/MeOH combination (Scheme **14**).

6.2 Biological Activity

All synthesized compounds were found to be significantly more effective than pemetrexed against human tumour cells: A549, HeLa, T47D, and TOV112D, and to be more cytotoxic than pemetrexed against A549, HeLa, and T47D cells. The revealed three thiophene bioisosteres (**11**, **17**, and **18**) are proposed as the most promising anticancer lead structures for the rational design of more selective antitumor medicines because they were found to be significantly less cytotoxic to normal cells than tumour cells. The results of the bioassay based on double fluorochrome staining are noteworthy because they reveal the mode of action of one of the series' most promising anticancer lead structures (**18**).

7. N-SUBSTITUTED INDOLINE AND MORPHOLINE DERIVATIVES

7.1 Synthetic Strategy

Doan *et al.* [94] synthesised indoline and morpholine moieties using sec-amine, boric acid and hetero-substituted aromatic aldehyde in the presence of glycerol at 50-80^{o}C for 24 to 48 hr. (Scheme **15**).

7.2. Biological Activity

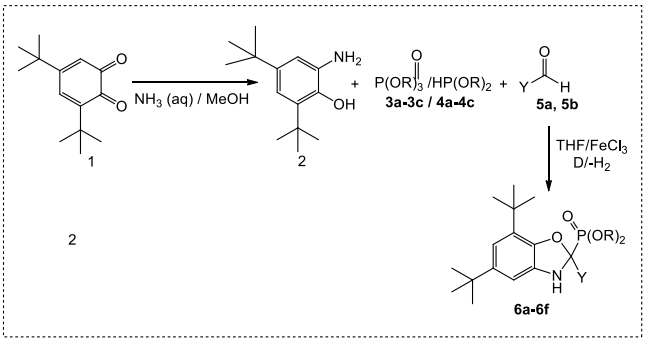
The novel indoline and morpholine derivatives were tested for their cytotoxic effects on osteosarcoma and human embryonic kidney cells. Cytotoxicity, migration, apoptosis markers, and mitochondrial calcium assays were used to characterize cytotoxicity and the mechanism of cell death. Among the compounds tested, indoline derivatives produced a greater cytotoxic effect in osteosarcoma cells than morpholine derivatives. With an IC_{50} of ~74 µM, the new indoline derivative N-(2-hydroxy-5-nitrophenyl(4'-methyl-phenyl) methyl)indoline demonstrated effective cytotoxic activity. The same molecule caused cell death *via* apoptosis and inhibited cell migration. In addition, an examination of mitochondrial calcium levels revealed the presence of calcium-dependent cell death mechanisms in various cell types.

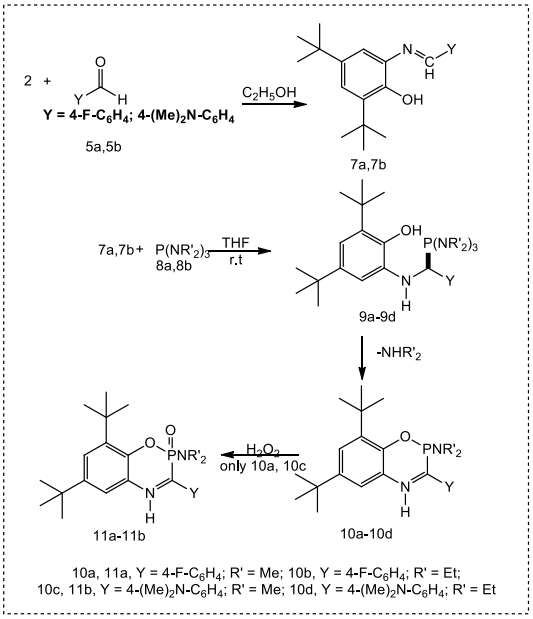
8. QUINOLINE AND THEIR HYBRID DERIVATIVES

8.1. Quinoline Scaffolds

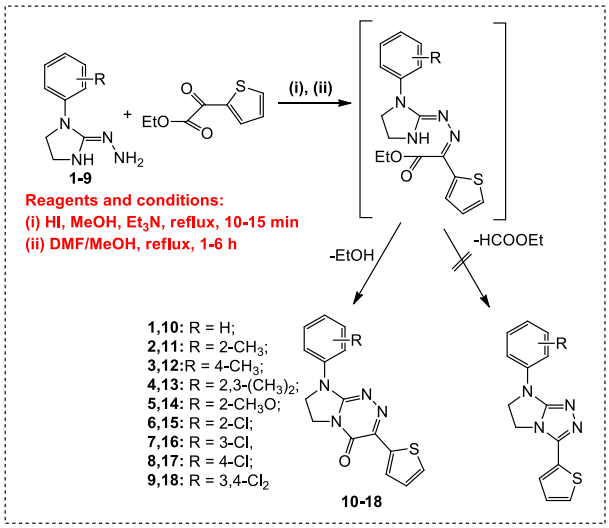
8.1.1. Synthetic Strategy

Su *et al.* [95] developed and synthesised a variety of novel quinoline compounds, which were tested for antiproliferative properties (Scheme **16**).

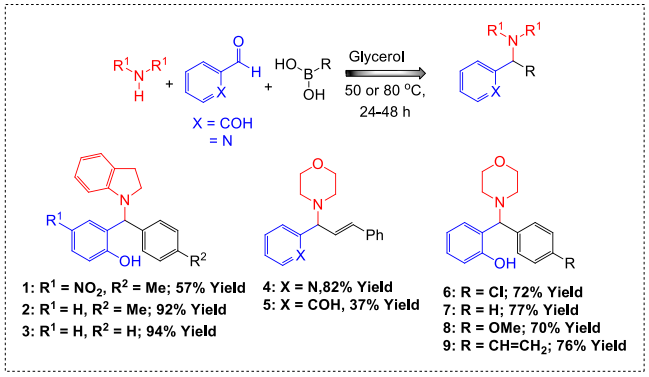




Scheme 13. Synthesis of fused nitrogen-phosphorus heterocycles and derived phosphonates.



Scheme 14. Synthesis of a novel class of 8-aryl-3-(2-thienyl)-7,8-dihydroimidazo[2,1-c][1,2,4]triazin-4(6H)-ones (**10**–**18**).



Scheme 15. Synthesis of N-substituted indolines and morpholines.

8.1.2. Biological Activity

The results showed that compounds (**4p**, **4s**, **4v**, **4x**, and **4y**) had potent antiproliferative activity against seven human tumour cell lines with IC_{50} values of less than 10 μM, with N-(3-methoxyphenyl)-7- (3-phenylpropoxy)quinolin-4-amine (**4x**) being the most potent antiproliferative agent against HCT-116, RKO, A2780, and HeLa cell lines having IC_{50} values of 2.56, 3.67, 3.46 and 2.71 μM, respectively. The anticancer efficacy of the representative compound (**4x**) was further examined in mice, with the results revealing that compound (**4x**) efficiently controlled tumour development (82.1%) and reduced tumour weight in animal models. Further research into the mechanism of action revealed that compound (**4x**) could inhibit colorectal cancer from growing by inhibiting the ATG5-dependent autophagy pathway. As a result, these quinoline derivatives represent a novel class of compounds that could be used to generate new anticancer medicines.

8.2. Benzo and Tetrahydro Benzo- [h]quinolines

8.2.1. Synthetic Strategy

Jafari *et al.* [96] developed and synthesised a new class of benzo- and tetrahydro benzo- [h]quinolines with a flexible (dimethylamino) ethylcarboxamide side chain as DNA intercalating anticancer drugs (Scheme **17**).

8.2.2. Biological Activity

The synthesized compounds were tested for cytotoxicity against four human cancer cell lines: MCF7, A2780, C26, and A549. The cytotoxic activity of compounds with a slight electron donating substitution in the para-position of the phenyl ring was higher than that of the other quinolines. In general, saturated quinolines (tetrahydrobenzo [h]quinolines) were shown to be more cytotoxic than their unsaturated counterparts (benzo [h]quinolines).

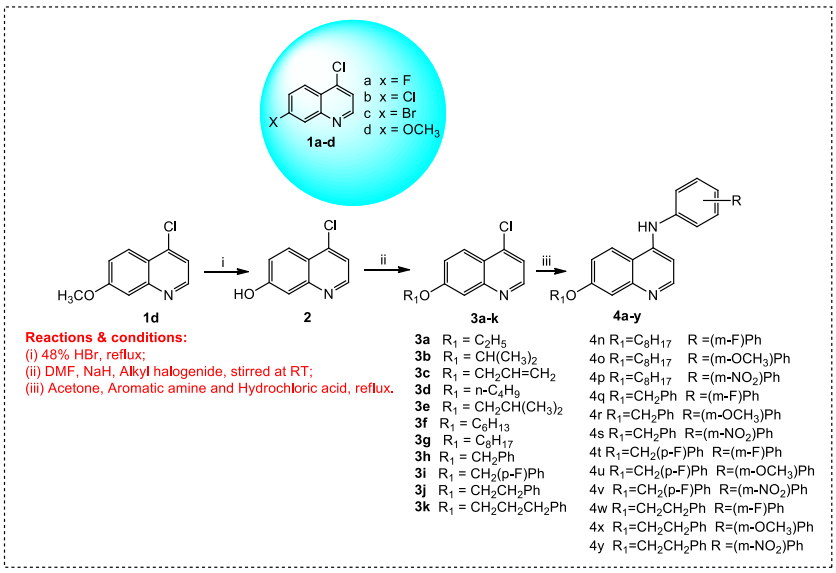
8.3. Pyrano [3,2-c]quinoline Derivatives

8.3.1. Synthetic Strategy

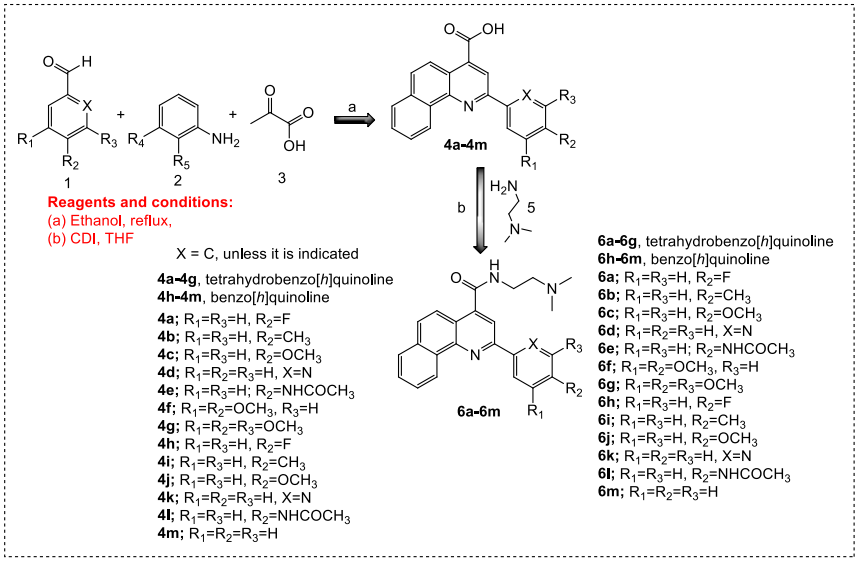
Using a one-pot multicomponent condensation between 2,4-dihydroxy-1-methylquinoline, malononitrile, and various un(substituted) aromatic aldehydes, Upadhyay and group [97] developed a variety of pyrano [3,2-c]quinoline-based structural analogues (Scheme **18**).

8.3.2. Biological Activity

The anti-inflammatory and cytotoxic activity of the produced compounds was tested. All substances were first tested for percent inhibition of cytokine release, as well as cytotoxicity activity and 50% inhibitory dose (IC_{50}). The capacity of the compounds to decrease TNFα production in human peripheral blood mononuclear cells (HPBMC) was investigated further based on the preliminary



Scheme 16. Synthesis of novel quinoline derivatives.



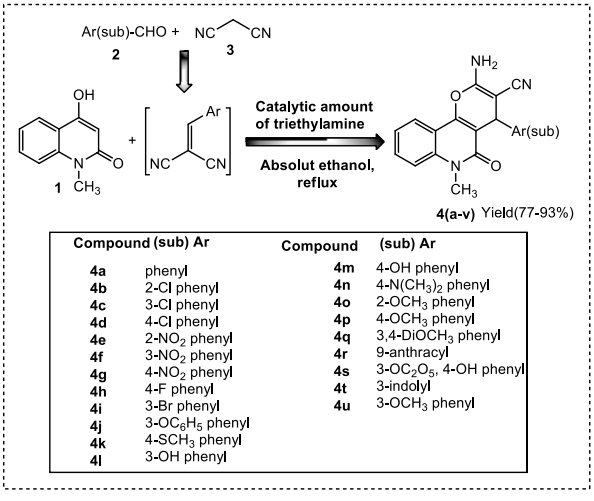
Scheme 17. Synthesis and biological evaluation of novel benzo- and tetrahydrobenzo-[h]quinoline derivatives.

findings. Compounds (**4c**, **4f**, **4i**, and **4j**) were identified to be the most active compounds of the series in terms of anti-inflammatory and anticancer activities, according to the screening results. The structure-activity correlation is explored, and it appears that 3-substitution on the aryl ring at C4 of the pyrano [3,2-c]quinolone structural motif is significant for both TNFα and IL-6 suppression, as well as anticancer action. Structural diversity with electron withdrawing, electron donating, sterically hindered, and heteroaryl substitution, on the other hand, had a significant impact on both inflammation and anticancer activity.

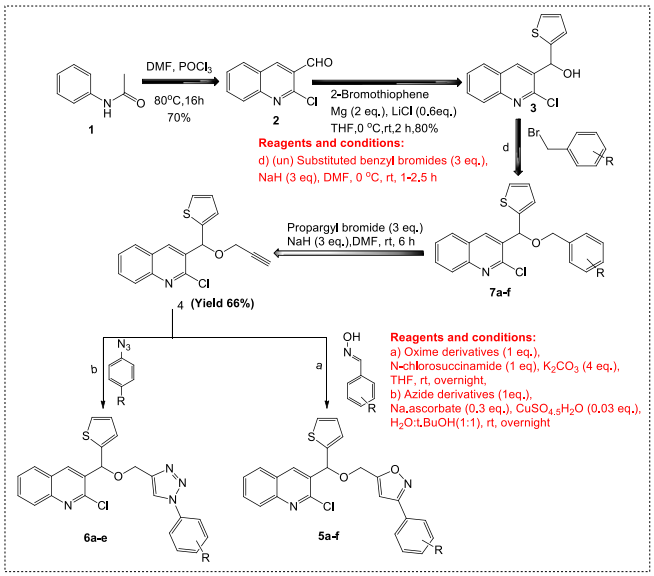
8.4. Thiophen-2-yl-quinoline Scaffolds

8.4.1. Synthetic Strategy

A series of novel 3-thiophen-2-yl-quinoline compounds based on isoxazolyl, triazolyl, and phenyl have been produced (Scheme **19**). In addition, Othman *et al.* [98] announced the discovery of a new valuable synthon, (2-chloroquinolin-3-yl)-(thiophen-2-yl) methanol.



Scheme 18. Synthesis of 2-Amino-6-methyl-5-oxo-4-sub(aryl)-5,6-dihydro-4H-pyrano[3,2-c]quinoline- 3-carbonitrile (**4a-v**).



Scheme 19. Synthesis of (2-chloroquinolin-3-yl))thiophen-2-yl)methanol (**3**), 2-Chloro-3-[(prop-2-yn-1-yloxy)(thiophen-2-yl)methyl]quinoline(**4**), isoxazole derivatives (**5a-f**), triazole derivatives (**6a-e**).

8.4.2. Biological Activity

The antitumor activity of the synthesized products was examined. All derivatives were investigated *in vitro* against a panel of four human cancer cell lines: liver (HepG-2), colon (HCT-116), human cervical cancer (HeLa), and breast cancer (HeLa) (MCF-7). Two compounds, (**7d** and **7e**), were found as potent and selective cytotoxic agents against HeLa and MCF-7 cell lines from the synthesised library.

8.5. Quinoline-thiosemicarbazone Scaffolds

8.5.1. Synthetic Strategy

Lafayette *et al.* [99] synthesized and studied the biological characteristics of twelve 2-(quinolin-4-ylmethylene) hydrazinecarbothioamide compounds (Scheme **20**).

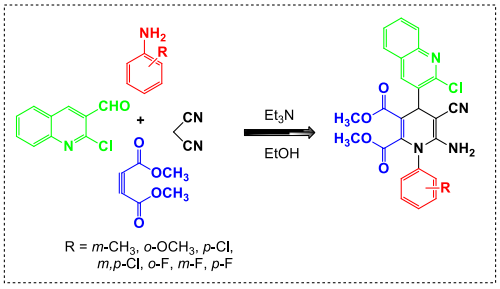
8.5.2. Biological Activity

The tumor cell lines MCF7 and T-47D, all of JF's compounds showed DNA and BSA binding capabilities as well as cytotoxic action. The derivative JF-92 was singled out because it had higher Kb and Ksv values for DNA and BSA binding, indicating a possible mechanism of DNA intercalation, which was confirmed by absorption tests, CD, and molecular docking. This derivative also had a lower IC_{50} value for MCF-7 line (0.82 μM) and partially inhibited topoisomerase IIα, making it an interfacial antitumor inhibitor.

8.6. Quinoline Associated with Dihydropyridine

8.6.1. Synthetic Strategy

Nkosi *et al.* [100] used a four-component reaction of 2-chloro-3-fomyl quinoline malononitrile, arylamines, and dimethyl acetylenedicarboxylate in the presence of a catalytic amount of triethylamine to synthesize a new series of eight quinoline bearing dihydropyridine derivatives in high yield and short reaction times (Scheme **21**).



Scheme 21. Synthesis of novel quinoline associated with dihydropyridine.

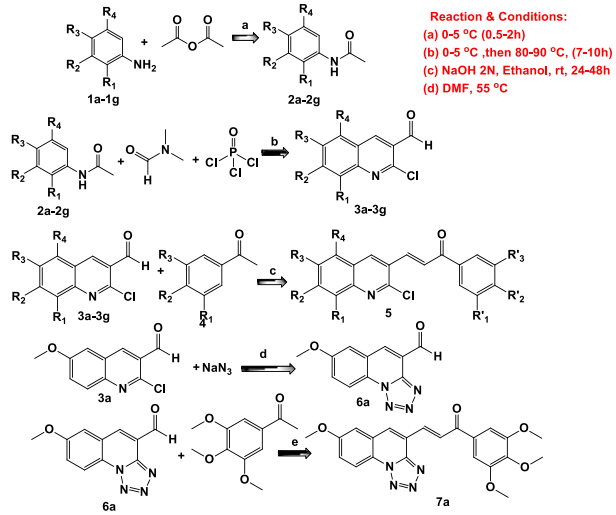
8.6.2. Biological Activity

These synthesized scaffolds were tested for their biological activity in A549 lung cancer cell line and for antibacterial activity. **A2**, **A3**, **A4,** and **A8** all have shown antiproliferative activity, with (**A4**) having maximum toxicity at 250 μg/mL and (**A8**) having high toxicity at 125, 250, and 500 μg/mL, respectively.

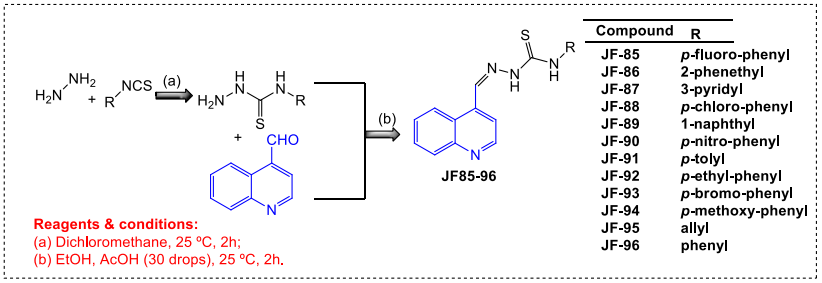
8.7. Quinoline-chalcone Hybrid Derivatives

8.7.1. Synthetic Strategy

Mirzaei and colleagues [101] have developed a new class of quinoline-chalcone hybrids (Scheme **22**).



Scheme 22. Synthesis of quinoline-chalcone hybrids.



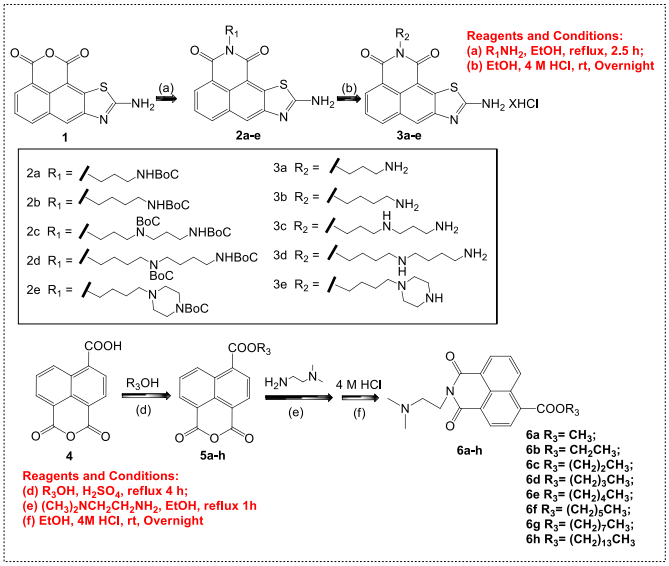
Scheme 20. Synthetic route of the derivatives 4-quinoline-thiosemicarbazones (**JF's**).

8.7.2. Biological Activity

All the compounds were tested for cytotoxicity against four human cancer cell lines: A2780 (human ovarian carcinoma) and A2780/RCIS (Cisplatin resistant human ovarian carcinoma), MCF-7 (human breast cancer cells), MCF-7/MX (Mitoxantrone resistant human breast cancer cells), and normal Huvec cells. The link between the structure and action of produced chemicals was examined. The benzoyl group of quinolines (**5e**, **5g**, and **5j**) demonstrated considerable cytotoxic effects on both resistant cancer cells and their parents. The antiproliferative activity of compounds (**5g** and **5j**) was the highest, with IC_{50} values ranging from 2.32 to 22.4 µM. They were also discovered to be tubulin inhibitors, causing cell cycle arrest in the G2/M phase as well as apoptosis. In four cancer cell lines, compound (**5j**) caused higher G2/M phase arrest than compound (**5g**). Finally, molecular dynamics simulations and molecular docking investigations of compound (**5j**) into tubulin's colchicine-binding site revealed that this compound may interact with tubulin's active site.

9. SYNTHESIS AND BIOLOGICAL ACTIVITY OF NAPHTHALIMIDE DERIVATIVES

Ge *et al.* [102] developed two types of naphthalimide compounds and tested their anti-hepatocellular carcinoma properties *in vitro* (Scheme **23**). Compound (**3a**) suppressed cell migration in SMMC-7721 and HepG2, and additional *in vivo* testing with two animal models indicated that compound (**3a**) substantially inhibited primary H22 tumour development (52.6%) and potently disrupted lung metastasis (75.7%) without noticeable systemic toxicity at the therapeutic dose. Compound (**3a**) suppressed malignant liver cell development primarily by triggering G2/M phase arrest, according to mechanistic studies. (**3a**) might have unregulated the cell cycle-related protein production of cyclin B1, CDK1, and p21, and restricted cell migration by elevating E-cadherin and attenuating integrin α6 expression, according to Western blotting investigations.

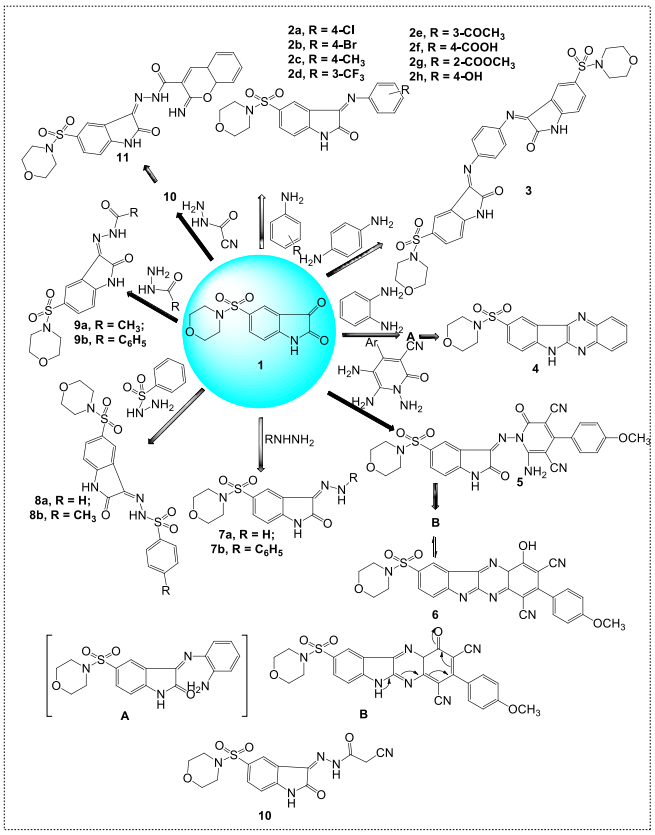


Scheme 23. Synthesis of Naphthalimide Derivatives (**3a**-**e**) & (**6a**-**h**).

10. 5-(MORPHOLINOSULFONYL) ISATIN DERIVATIVES

10.1. Synthetic Strategy

Ammar *et al.* [103] developed and synthesised a new class of 5-(morpholinosulfonyl) isatin derivatives (Scheme **24**). Analyses of spectral and elemental data were used to characterise the novel compounds.



Scheme 24. Synthesis of Schiff's bases of 5-(morpholinosulfonyl)isatin and indolo[2,3-b]quinoxaline derivatives (**2a-h** and **3-6**) & hydrazones and hydrazides (**7a-11**) of 5-(morpholinosulfonyl)isatin.

10.2. Biological Activity

The synthesized compounds were tested using the SRB assay on four cancer cell lines, including HepG2, HCT116, CACO, and MCF7, as well as a non-cancerous human cell line, to see if they were cytotoxic. The normal generated cell line was not cytotoxic (IC_{50} > 130 µ M). In three of the cell lines evaluated, HepG2, HCT116, and CACO compounds (**3**, **6**, **10**, and **11**) had IC_{50} values less than 10 µM. On HepG2, CACO, and HCT116, compounds (**2h**, **5**, and **7b**) had IC_{50} values that were less than or almost equivalent to 10 µM, respectively. On MCF7, compounds (**3** and **6**) had IC_{50} values of less than 12 µM. These IC_{50} values are comparable to those of doxrubicin, which has an IC_{50} range of 4.5 to 8.28 µM in the cell lines studied. With IC_{50} values less than 2 µM, all of these intriguing compounds displayed inhibitory efficacy against EGFR. The most powerful EGFR inhibitors, (**7b**) IC_{50} = 46 µ M and (**10**) IC_{50} = 23 µM, were found to produce G2/M phase cell cycle arrest and apoptosis.

11. SPIRO DERIVATIVES

11.1. Hybrid Spiro Compounds

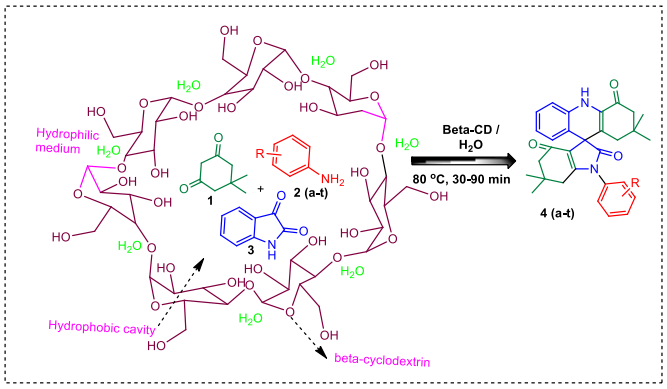
11.1.1. Synthetic Strategy

Chate *et al.* [104] developed a series of novel hybrid compounds called spiro [pyrimido [5,4-b]quinoline-10,5'-pyrrolo [2,3-d]pyrimidine] (Scheme **25**) using beta-cyclodextrin (Beta-CD) as a novel catalyst under greener conditions.

11.1.2. Biological Activity

The synthesized scaffolds were tested *in vitro* against four human cancer cell lines: A431, PC3, MCF7, and MCF-10A. The fused heterocycles (**4m**, **4q**, and **4t**) having a chloro or trifluorome-

thyl group on the benzene ring were shown to be the most effective compounds against a human breast cancer cell line, with IC_{50} values ranging from 7.82 to 9.88 µM. (MCF-7). Compound (**4q**) was shown to be the most effective derivative against the human breast cancer cell line studied, being more active than standard and having cytotoxic activity specific for MCF7.

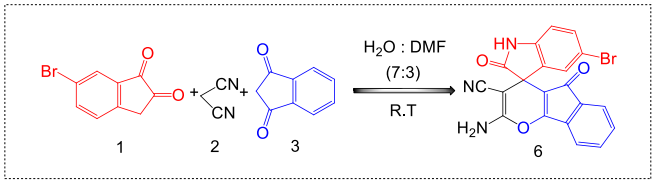


Scheme 25. Synthesis of 3,3,6,6-tetramethyl-10-phenyl-3,4,6,7-tetrahydro-1*H*-spiro [acridine-9,30-indoline]-1,20,8(2*H*,5*H*,10*H*)-trione.

11.2. Indeno-spiro Compounds

11.2.1. Synthetic Strategy

Patravale *et al.* [105] described a sustainable, catalyst-free, bio-oriented multicomponent synthesis of 2- amino-3-cynospiro (5H-indeno [1,2- b]pyran-4,3' indoline)-2'5,-dione using isatin, malono-nitrile, and 1,3- indandione. This study describes a simple method for synthesising indeno-spiro compounds (Scheme **26**).



Scheme 26. Synthesis of 2-amino-3-cyno-5-bromospiro(5H-indeno[1,2-b]pyran-4,3'-indoline)-2'5,-dione.

11.2.2. Biological Activity

The synthesized compounds were tested against breast carcinoma cell lines (MCF7 and MDA-MB-435) as well as normal Vero monkey cell lines. The bromo- and chloro-substituted indeno-fused spirooxindole derivatives were found to have selective potency against the MDA-MB-435 cancer cell lines, with IC_{50} values of 1.8 and 2.1 µM, respectively. The compounds were also tested against the normal Vero monkey cell line, which demonstrated good to excellent selectivity against cancer cell inhibition. Furthermore, *in vitro* confocal microscopy cell imaging of selected compounds revealed cellular shrinkage and apoptosis in cancer cells, implying that indeno-fused spirooxindoles can be investigated as selective oestrogen negative receptors with a favourable safety profile.

12. QUINAZOLINE DERIVATIVES

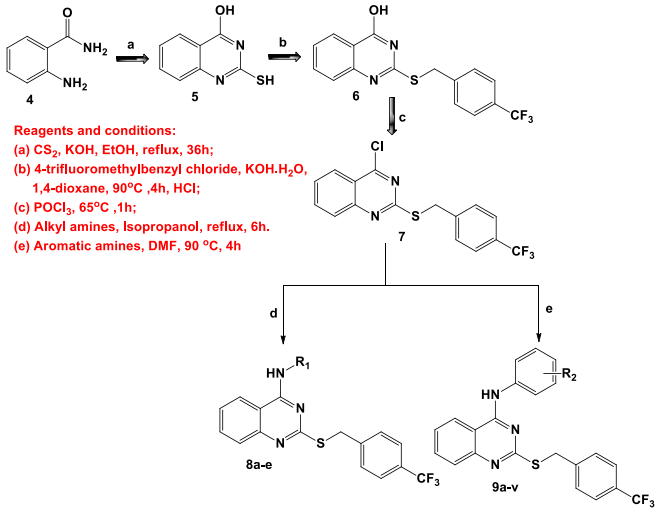
12.1. Substituted Quinazoline Analogues

12.1.1. Synthetic Strategy

Li *et al.* [106] (Scheme **27**) developed a library of 2,4-disubstituted quinazoline conjugates.

12.1.2. Biological Activity

The MTT assay was used to screen the derivatives for anti-cancer activity against five human cancer cell lines, including breast (MCF-7 and MDA-MB-231), gastric carcinoma (HGC-27 and MGC-803), and prostate (PC-3) cancer cells. When compared to regular gefitinib (IC_{50} = 7.34 µM), the trifluoromethyl derivative (**9n**) showed the most promising anticancer activity (IC_{50} = 5.10 µM) with the MCF-7 breast cancer cell line.



Scheme 27. Synthesis of 2,4-disubstituted-quinazoline derivatives.

12.2. Benzimidazole-quinazolinone Hybrid Scaffolds

12.2.1. Synthetic Strategy

Fan *et al.* [107] (Scheme **28**) produced benzimidazole-quinazolinone hybrids.

12.2.2. Biological Activity

The MTT assay was used to assess the synthesized compounds for cytotoxicity and Aurora-A kinase inhibitory activity. All three cancer cell lines tested demonstrated good cytotoxicity activity, with IC_{50} values ranging from 0.38 to 18.13 µM for breast cancer (MDA-MB-231), prostate cancer (PC3), and neuroblastoma (SH-SY5Y). The morpholinoethyl compound (**7h**), for example, showed outstanding activity with IC_{50} values of 0.38 µM (MDA-MB-231), 1.09 µM (PC3), and 0.77 µM, respectively (SH-SY5Y). Compound (**7h**) had a promising inhibitory effect on Aurora-A kinase (IC_{50} = 21.94 µM). Furthermore, by inhibiting Aurora-A kinase, compound (**7h**) triggered G2/M phase cell cycle arrest and cell death.

12.3. Indenoquinoxaline and pyrazine derivatives

12.3.1. Synthetic Strategy

Tantawy *et al.* [108] synthesised some indenoquinoxaline and pyrazine compounds (Scheme **29**).

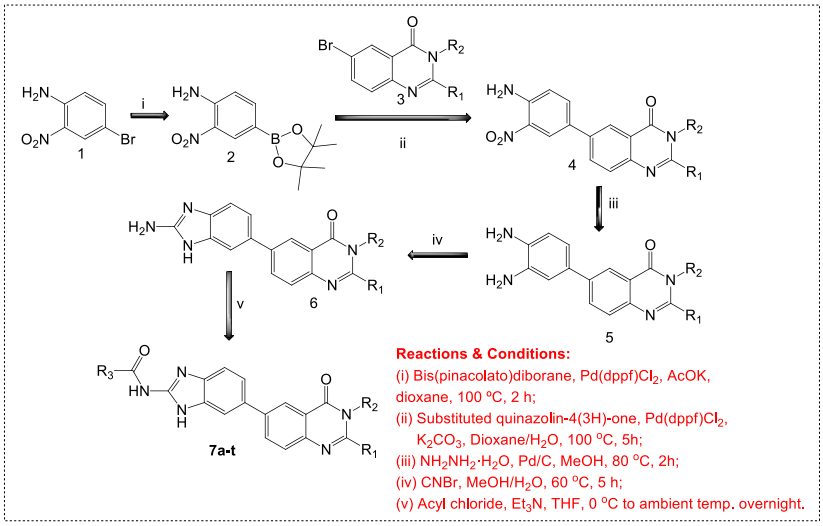
12.3.2 Biological Activity

The newly synthesised compounds were screened for cytotoxicity against MCF7 and A549 cell lines using the MTT assay. Compounds (**6**, **8a**, **9**, **10**, and **11**) have a strong cytotoxic effect. Especially compound (**11**), which has IC_{50} values of 5.4 and 4.3 µM, respectively, against MCF7 and A549 cells.

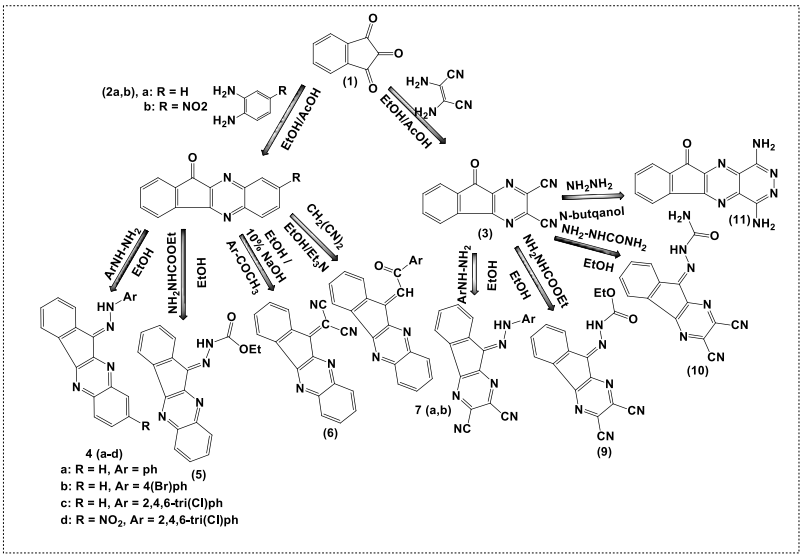
13. TETRACYCLIC ACRIDONES WITH AMIDE FRAMEWORKS

13.1. Synthetic Strategy

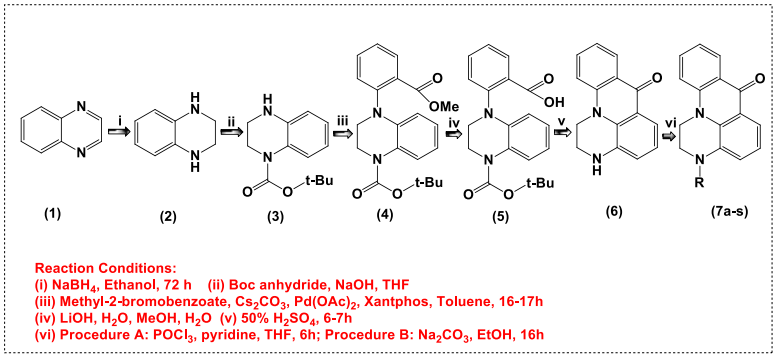
Valigeti and group [109] developed and synthesised a set of tetracyclic acridones with amide frameworks (Scheme **30**), including 3-(alkyloyl/ aryloyl/ heteroaryloyl/ heteroaryl)-2,3-dihydropyrazino [3,2,1-de]acridin-7(1H)-ones.



Scheme 28. Synthesis of 6-(2-amino-1H-benzo[d]imidazol6-yl)quinazolin-4(3H)-one derivatives.



Scheme 29. Synthesis of indenoquinoxaline and pyrazine derivatives.



Scheme 30. Synthesis of 3-aryl/aroyl-2,3-dihydro-1H,7H-pyrazino[3,2,1-de]acridin-7-one derivatives.

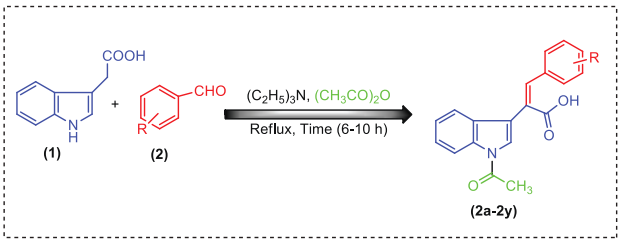
13.2. Biological Activity

The synthesized compounds containing cyclopropyl-acetyl, benzoyl, p-hydroxybenzoyl, p-(trifluoromethyl)benzoyl, p-fluorobenzoyl, m-fluorobenzoyl, picolinoyl, 6-methylpicolinoyl, and 3-nicotinoyl groups were found to be potent against the HT29, MDAMB231 and HEK293T cancer cell lines.

14. 2-(1-ACETYL-1H-INDOLE-3-YL)-3-(PHENYL) PROPIONOIC ANALOGUES

14.1. Synthetic Strategy

Kumar *et al.* [110] synthesized twenty-five new combretastatin 2-(1-acetyl-1H-indole-3-yl)-3-(phenyl) propenoic acid analogues (Scheme **31**) using triethyl amine with acetic anhydride at reflux condition (**2a** to **2y**).

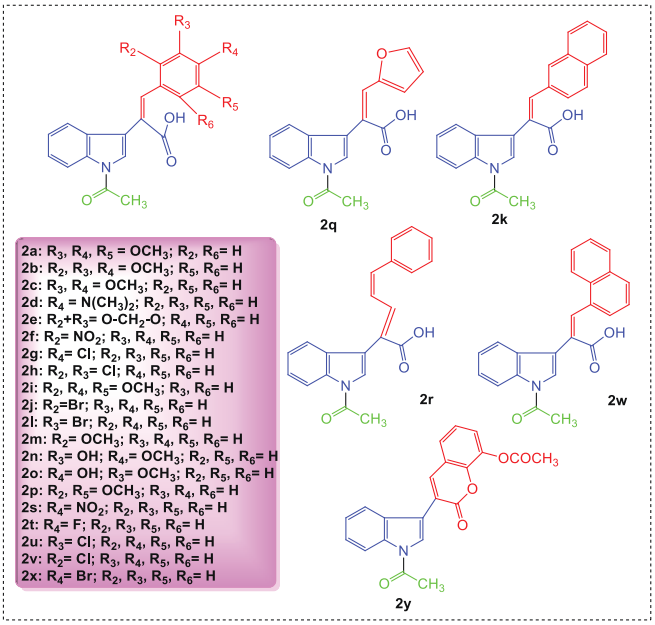


Scheme 31. Synthesis of 2-(1-acetyl-1H-indole-3-yl)-3-(phenyl) propenoic analogues.

14.2. Biological Activity

The Combretastatin 2-(1-acetyl-1H-indole-3-yl)-3-(phenyl)-propenoic acid analogues (**2a** to **2y**) (Table **3**), bearing an indole moiety in place of ring (A) of combretastatin (CA-4), were tested for anticancer activity against cancer cell lines such as THP1(leukaemia), A549 (lung), IGROV1 (ovary), HEP2 (liver), MCF7 (breast), and DU145 (prostate). Compounds (**2d** and **2y**) both demonstrated anticancer action against THP1 and MCF7, with IC_{50} values of 0.80 and 0.37 μM, respectively, and (**2y**) had an IC_{50} of 3.60 μM, which was comparable to paclitaxel.

Table 3. Chemical structure of synthesized 2-(1-acetyl-1H-indole-3-yl)-3-(phenyl) propenoic analogues.



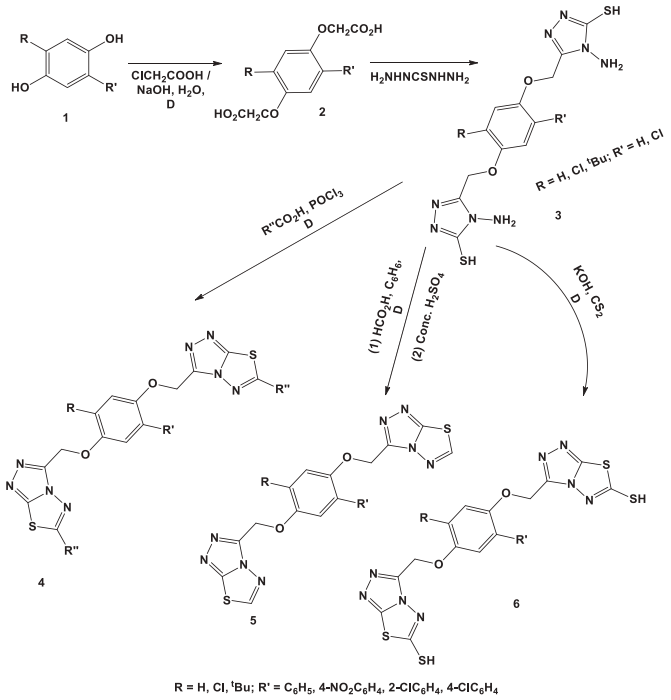
15. BIS-PHENOXYACETIC ACIDS

15.1. Synthetic Strategy

Shivarma *et al.* [111] synthesised a series of bis-phenoxyacetic acids (**2**) from matching unsubstituted/substituted 1,4-quinols (**1**). In a one-pot procedure, bis-phenoxyacetic acids (**2**) were fused with thiocarbohydrazide to get bis- [4-amino-5-mercapto-1,2,4-triazol-3-yl-methyleneoxy]phenylenes (**3**) (Scheme **32**). N-bridged heterocycles (**4** to **6**) were obtained in good yields by reacting bis-triazoles (**3**) with different reagents.

15.2. Biological Activity

The anticancer activity of the newly synthesised compounds was tested against a panel of 60 cell lines drawn from seven cancer types: lung, colon, melanoma, renal, ovarian, CNS, and leukaemia. Some of the substances studied have anticancer characteristics that were promising.



Scheme 32. Synthesis of bis-[4-amino-5-mercapto-1,2,4-triazol-3-ylmethyleneoxy]phenylenes (**3**);1,4-bis-(6-aryl-1,2,4-triazolo[3,4-b]-1,3,4-thiadiazol-3-ylmethoxy)phenylenes Scaffold (**4**,**5**,**6**).

CONCLUSION

The structural variety provided by the fused N-heterocyclic frameworks has proven advantageous in the discovery of novel therapeutics by enhancing pharmacology and other physical and chemical properties. Numerous medications are now being used to treat numerous types of cancer with significant therapeutic efficacy. N-heterocyclic framework in medicinal chemistry has received a lot of attention. The vast majority of benefits of pharmaceuticals containing nitrogen in the medical area, such as simple production, low toxicity, fewer side effects, high bioavailability, reduced drug resistance, strong biocompatibility, *etc.*, motivate efforts for more research and development. The synthetic approach in the present drug development and design system, therefore, depends heavily on the characteristics of these scaffolds. We extensively discussed the recent status of the families of nitrogen-based heterocyclic molecules in this review, including 1,2,4-triazole, fused aminoimidazole, Bis-phenoxyacetic acids, benzimidazole with oxadiazole and triazolo-thiadiazoles, pyrazole, pyrimidine, quinoline, and quinazoline derivatives, among many others, with highly promising biological properties like anticancer and other therapeutic properties. We have also investigated several synthetic routes, including green chemical protocols for their production. The biological investigations of the molecules under discussion provided a deeper comprehension of both the arrangement of various substituents on their N-heterocyclic skeleton and the various substituents present responsible for their efficiency. These key details support the great potential of different fused N-heterocycles and indicate a wide range of possible uses for these intriguing moieties due to their variety of molecular targets. We think that this review paper will be helpful in promoting the synthesis and anticancer development of nitrogen-based medicines that are sustainable, effective, and have few adverse effects against a variety of malignancies.

LIST OF ABBREVIATIONS

hTopoIIα = Human Topoisomerase IIα

NCI = National Cancer Institute

HPBMC = Human Peripheral Blood Mononuclear Cells

Beta-CD = beta-Cyclodextrin

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] Rostamnia, S. *In situ* generation and protonation of the isocyanide/acetylene adduct: a powerful catalyst-free strategy for multicomponent synthesis of ketenimines, aza-dienes, and heterocycles. *RSC Advances,* **2015**, *5*(117), 97044-97065.
http://dx.doi.org/10.1039/C5RA20455K

[2] Rostamnia, S.; Xin, H. Basic isoreticular metal-organic framework (IRMOF-3) porous nanomaterial as a suitable and green catalyst for selective unsymmetrical Hantzsch coupling reaction. *Appl. Organomet. Chem.,* **2014**, *28*(5), 359-363.
http://dx.doi.org/10.1002/aoc.3136

[3] Jalili, F.; Zarei, M.; Zolfigol, M.A.; Rostamnia, S.; Moosavi-Zare, A.R. SBA-15/PrN$(CH_2PO_3H_2)_2$ as a novel and efficient mesoporous solid acid catalyst with phosphorous acid tags and its application on the synthesis of new pyrimido[4,5-b]quinolones and pyrido[2,3-d]pyrimidines *via* anomeric based oxidation. *Microporous Mesoporous Mater.,* **2020**, *294*, 109865.
http://dx.doi.org/10.1016/j.micromeso.2019.109865

[4] Rostamnia, S.; Doustkhah, E. Synthesis of water-dispersed magnetic nanoparticles (H_2O-DMNPs) of β-cyclodextrin modified Fe_3O_4 and its catalytic application in Kabachnik–Fields multicomponent reaction. *J. Magn. Magn. Mater.,* **2015**, *386*, 111-116.
http://dx.doi.org/10.1016/j.jmmm.2015.03.064

[5] Rostamnia, S.; Pourhassan, F. The SBA-15/SO_3H nanoreactor as a highly efficient and reusable catalyst for diketene-based, four-component synthesis of polyhydroquinolines and dihydropyridines under neat conditions. *Chin. Chem. Lett.,* **2013**, *24*(5), 401-403.
http://dx.doi.org/10.1016/j.cclet.2013.03.020

[6] Rostamnia, S.; Doustkhah, E. A mesoporous silica/fluorinated alcohol adduct: an efficient metal-free, three-component synthesis of indazolophthalazinetrione heterocycles using a reusable nanoporous/trifluoroethanol adduct (SBA-15/TFE). *Tetrahedron Lett.,* **2014**, *55*(15), 2508-2512.
http://dx.doi.org/10.1016/j.tetlet.2014.03.019

[7] Alizadeh, A.; Zohreh, N.; Rostamnia, S. One-pot synthesis of functionalized furamide derivatives *via* a three-component reaction between an amine, diketene and dibenzoylacetylene in the presence of triphenylphosphine. *Tetrahedron,* **2007**, *63*(34), 8083-8087.
http://dx.doi.org/10.1016/j.tet.2007.06.021

[8] Alizadeh, A.; Rostamnia, S.; Zhu, L.G. A novel pseudo-seven-component diastereoselective synthesis of λ5-phosphanylidene bis(2,5-dioxotetrahydro-1H-pyrrole-3-carboxylates) *via* binucleophilic systems. *Tetrahedron Lett.,* **2010**, *51*(36), 4750-4754.
http://dx.doi.org/10.1016/j.tetlet.2010.07.027

[9] Lambat, T.L.; Abdala, A.A.; Mahmood, S.; Ledade, P.V.; Chaudhary, R.G.; Banerjee, S. Sulfamic acid promoted one-pot multicomponent reaction: a facile synthesis of 4-oxo-tetrahydroindoles under ball milling conditions. *RSC Advances,* **2019**, *9*(68), 39735-39742.
http://dx.doi.org/10.1039/C9RA08478A PMID: 35541403

[10] [10] Patel, G.; Dewangan, D.K.; Bhakat, N.; Banerjee, S. Green approaches for the synthesis of poly-functionalized imidazole derivatives: A comprehensive review. *Curr. Opin. Green Sustain. Chem*., **2021**, *4*, 100175. https://doi.org/10.1016/j.crgsc.2021.100175

[11] Il'in, M.V.; Sysoeva, A.A.; Novikov, A.S.; Bolotin, D.S. Diaryliodoniums as Hybrid Hydrogen- and Halogen-Bond-Donating Organocatalysts for the Groebke–Blackburn–Bienaymé Reaction. *J. Org. Chem.,* **2022**, *87*(7), 4569-4579.
http://dx.doi.org/10.1021/acs.joc.1c02885 PMID: 35176856

[12] Dadiboyena, S.; Nefzi, A. Synthesis of functionalized tetrasubstituted pyrazolyl heterocycles – A review. *Eur. J. Med. Chem.,* **2011**, *46*(11), 5258-5275.
http://dx.doi.org/10.1016/j.ejmech.2011.09.016 PMID: 21978837

[13] Omar, A. Review article; anticancer activities of some fused heterocyclic moieties containing nitrogen and/or sulfur heteroatoms. *Al-Azhar J. Pharm. Sci.,* **2020**, *62*(2), 39-54.
http://dx.doi.org/10.21608/ajps.2020.118375

[14] Lamberth, C.; Dinges, J., Eds.; *Bioactive heterocyclic compound classes: pharmaceuticals*; John Wiley & Sons, **2012**.
http://dx.doi.org/10.1002/9783527664412

[15] [15] Al-Jumaili, M.H.; Hamad, A.A.; Hashem, H.E.; Hussein, A.D.; Muhaidi, M.J.; Ahmed, M.A.; Albanaa, A. H. A.; Siddiqui, F.; Bakr, E.A. Comprehensive review on the Bis–heterocyclic compounds and their anticancer efficacy. *J Mol. Struct.*, **2022**, *1271*, 133970.
https://doi.org/10.1016/j.molstruc.2022.133970

[16] Liu, J.; Xiao, X.; Lai, Y.; Zhang, Z. Recent advances in transition metal-catalyzed heteroannulative difunctionalization of alkenes *via* C–H activation for the synthesis of heterocycles. *Org. Chem. Front.,* **2022**, *9*(8), 2256-2279.
http://dx.doi.org/10.1039/D2QO00081D

[17] Boas, U.; Heegaard, P.M.H. Dendrimers in drug research. *Chem. Soc. Rev.,* **2004**, *33*(1), 43-63.
http://dx.doi.org/10.1039/b309043b PMID: 14737508

[18] Aldeghi, M.; Malhotra, S.; Selwood, D.L.; Chan, A.W.E. Two- and three-dimensional rings in drugs. *Chem. Biol. Drug Des.,* **2014**, *83*(4), 450-461.
http://dx.doi.org/10.1111/cbdd.12260 PMID: 24472495

[19] Hiesinger, K.; Dar'in, D.; Proschak, E.; Krasavin, M. Spirocyclic scaffolds in medicinal chemistry. *J. Med. Chem.,* **2021**, *64*(1), 150-183.
http://dx.doi.org/10.1021/acs.jmedchem.0c01473 PMID: 33381970

[20] Shelat, A.A.; Guy, R.K. Scaffold composition and biological relevance of screening libraries. *Nat. Chem. Biol.,* **2007**, *3*(8), 442-446.
http://dx.doi.org/10.1038/nchembio0807-442 PMID: 17637770

[21] Craik, D.J.; Fairlie, D.P.; Liras, S.; Price, D. The future of peptide-based drugs. *Chem. Biol. Drug Des.,* **2013**, *81*(1), 136-147.
http://dx.doi.org/10.1111/cbdd.12055 PMID: 23253135

[22] Macielag, M.J. Chemical properties of antimicrobials and their uniqueness.*Antibiotic discovery and development*; Springer: Boston, MA, **2012**, pp. 793-820.
http://dx.doi.org/10.1007/978-1-4614-1400-1_24

[23] Cheng, W.; Zeng, X.; Chen, H.; Li, Z.; Zeng, W.; Mei, L.; Zhao, Y. Versatile polydopamine platforms: synthesis and promising applications for surface modification and advanced nanomedicine. *ACS Nano,* **2019**, *13*(8), 8537-8565.
http://dx.doi.org/10.1021/acsnano.9b04436 PMID: 31369230

[24] Lambat, T.L.; Mahmood, S.H.; Ledade, P.V.; Banerjee, S. Microwave Assisted One-Pot Multicomponent Synthesis Using ZnO-β Zeolite Nanoparticle: An Easy Access to 7-Benzodioxolo[4,5-b]xanthene-dione and 4-Oxo-tetrahydroindole Scaffolds. *ChemistrySelect,* **2020**, *5*(28), 8864-8874.
http://dx.doi.org/10.1002/slct.202002160

[25] Lambat, T.L. Scolecite as novel heterogeneous catalyst for an efficient microwave assisted synthesis of 7-aryl-6H-benzo [H][1, 3] dioxolo [4, 5-b] xanthene-5, 6 (7H)-dione analogues *via* multi-component reaction. *Int. J. Appl. Biol. Pharm. Technol.,* **2017**, *8*, 11-18.
http://dx.doi.org/10.21276/ijabpt

[26] Keri, R.S.; Patil, M.R.; Patil, S.A.; Budagumpi, S. A comprehensive review in current developments of benzothiazole-based molecules in medicinal chemistry. *Eur. J. Med. Chem.,* **2015**, *89*, 207-251.
http://dx.doi.org/10.1016/j.ejmech.2014.10.059 PMID: 25462241

[27] Kaur, R.; Kumar, K. Synthetic and medicinal perspective of quinolines as antiviral agents. *Eur. J. Med. Chem.,* **2021**, *215*, 113220.
http://dx.doi.org/10.1016/j.ejmech.2021.113220 PMID: 33609889

[28] Gong, H.H.; Addla, D.; Lv, J.S.; Zhou, C.H. Heterocyclic naphthalimides as new skeleton structure of compounds with increasingly expanding relational medicinal applications. *Curr. Top. Med. Chem.,* **2016**, *16*(28), 3303-3364.
http://dx.doi.org/10.2174/1568026616666160506145943 PMID: 27150364

[29] Hossain, M.; Nanda, A. K. A review on heterocyclic: synthesis and their application in medicinal chemistry of imidazole moiety. *Science*, **2018**, *6*(5), 83-94.
https://doi.org/10.11648/j.sjc.20180605.12

[30] Liang, X.; Wu, Q.; Luan, S.; Yin, Z.; He, C.; Yin, L.; Zou, Y.; Yuan, Z.; Li, L.; Song, X.; He, M.; Lv, C.; Zhang, W. A comprehensive review of topoisomerase inhibitors as anticancer agents in the past decade. *Eur. J. Med. Chem.,* **2019**, *171*, 129-168.
http://dx.doi.org/10.1016/j.ejmech.2019.03.034 PMID: 30917303

[31] Altaf, A.A.; Shahzad, A.; Gul, Z.; Rasool, N.; Badshah, A.; Lal, B.; Khan, E. A review on the medicinal importance of pyridine derivatives. *J. Drug Des. Med. Chem,* **2015**, *1*(1), 1-11.
http://dx.doi.org/10.11648/j.jddmc.20150101.11

[32] Singh, M.; Singh, S.K. Benzothiazoles: how relevant in cancer drug design strategy? *Anti-Cancer Agents in Medicinal Chemistry,* **2014**, *14*(1), 127-146.

[33] Hosseinzadeh, Z.; Ramazani, A.; Razzaghi-Asl, N. Anti-cancer nitrogen-containing heterocyclic compounds. *Curr. Org. Chem.,* **2018**, *22*(23), 2256-2279.
http://dx.doi.org/10.2174/1385272822666181008142138

[34] Galloway, W.R.J.D.; Isidro-Llobet, A.; Spring, D.R. Diversity-oriented synthesis as a tool for the discovery of novel biologically active small molecules. *Nat. Commun.,* **2010**, *1*(1), 80.
http://dx.doi.org/10.1038/ncomms1081 PMID: 20865796

[35] Schenone, S.; Radi, M.; Musumeci, F.; Brullo, C.; Botta, M. Biologically driven synthesis of pyrazolo[3,4-d]pyrimidines as protein kinase inhibitors: an old scaffold as a new tool for medicinal chemistry and chemical biology studies. *Chem. Rev.,* **2014**, *114*(14), 7189-7238.
http://dx.doi.org/10.1021/cr400270z PMID: 24873489

[36] Carreira, E.M.; Fessard, T.C. Four-membered ring-containing spirocycles: synthetic strategies and opportunities. *Chem. Rev.,* **2014**, *114*(16), 8257-8322.
http://dx.doi.org/10.1021/cr500127b PMID: 25003801

[37] Norwood, V.M., IV; Huigens, R.W., III Harnessing the chemistry of the indole heterocycle to drive discoveries in biology and medicine. *ChemBioChem,* **2019**, *20*(18), 2273-2297.
http://dx.doi.org/10.1002/cbic.201800768 PMID: 30609199

[38] Leoni, A.; Locatelli, A.; Morigi, R.; Rambaldi, M. Novel thiazole derivatives: a patent review (2008 – 2012. Part 2). *Expert Opin. Ther. Pat.,* **2014**, *24*(7), 759-777.
http://dx.doi.org/10.1517/13543776.2014.910196 PMID: 24745553

[39] Toscano, M.D.; Woycechowsky, K.J.; Hilvert, D. Minimalist active-site redesign: teaching old enzymes new tricks. *Angew. Chem. Int. Ed.,* **2007**, *46*(18), 3212-3236.
http://dx.doi.org/10.1002/anie.200604205 PMID: 17450624

[40] Langeberg, L.K.; Scott, J.D. Signalling scaffolds and local organization of cellular behaviour. *Nat. Rev. Mol. Cell Biol.,* **2015**, *16*(4), 232-244.
http://dx.doi.org/10.1038/nrm3966 PMID: 25785716

[41] Murray, J.K.; Gellman, S.H. Targeting protein–protein interactions: Lessons from p53/MDM2. *Biopolymers,* **2007**, *88*(5), 657-686.
http://dx.doi.org/10.1002/bip.20741 PMID: 17427181

[42] Hunter, J.C.; Gurbani, D.; Ficarro, S.B.; Carrasco, M.A.; Lim, S.M.; Choi, H.G.; Xie, T.; Marto, J.A.; Chen, Z.; Gray, N.S.; Westover, K.D. *in situ* selectivity profiling and crystal structure of SML-8-73-1, an active site inhibitor of oncogenic K-Ras G12C. *Proc. Natl. Acad. Sci. USA,* **2014**, *111*(24), 8895-8900.
http://dx.doi.org/10.1073/pnas.1404639111 PMID: 24889603

[43] Kaur, M.; Singh, M.; Chadha, N.; Silakari, O. Oxindole: A chemical prism carrying plethora of therapeutic benefits. *Eur. J. Med. Chem.,* **2016**, *123*, 858-894.
http://dx.doi.org/10.1016/j.ejmech.2016.08.011 PMID: 27543880

[44] Lambat, T.; Deo, S.; Deshmukh, T. Sulphamic acid assisted synthesis of polyhydroquinolines *via* Hantzsch multicomponent reaction: a green approach. *J. Chem. Pharm. Res.,* **2014**, *6*(4), 888-892.

[45] Asatkar, A.; Lambat, T.L.; Mahmood, S.; Mondal, A.; Singh, M.; Banerjee, S. Facile protocol for the synthesis of benzothiazole, benzoxazole and N-benzimidazole derivatives using rice husk derived chemically activated carbon. *Mater. Today Proc.,* **2020**, *29*, 738-742.
http://dx.doi.org/10.1016/j.matpr.2020.04.510

[46] He, Y.; Li, W.; Zhou, H.; Zeng, G.; Chen, Z.; Ge, J-Y.; Lv, N.; Chen, J. Redox-neutral synthesis of polycyclic azaheterocycles *via* cobalt-catalyzed hydroarylation/annulation of maleimides. *Adv. Synth. Catal.,* **2022**, *364*(21), 3730-3735.
http://dx.doi.org/10.1002/adsc.202200809

[47] Reutskaya, E.; Sapegin, A.; Peintner, S.; Erdélyi, M.; Krasavin, M. Sulfur Oxidation Increases the Rate of HIRE-Type [1.4]Thiazepinone Ring Expansion and Influences the Conformation of a Medium-Sized Heterocyclic Scaffold. *J. Org. Chem.,* **2021**, *86*(8), 5778-5791.
http://dx.doi.org/10.1021/acs.joc.1c00236 PMID: 33826339

[48] Wu, J.; Liu, Y.; Qian, B.; Yang, H.; Lu, L.; Zhang, J.; Shang, Y. Catalytic ring expansion of indole toward dibenzoazepine analogues enabled by cationic palladium(ii) complexes. *ACS Catal.,* **2022**, *12*, 6216-6226.
http://dx.doi.org/10.1021/acscatal.1c06021

[49] Il'in, M.V.; Novikov, A.S.; Bolotin, D.S. Sulfonium and selenonium salts as noncovalent organocatalysts for the multicomponent groebke–blackburn–bienaymé reaction. *J. Org. Chem.,* **2022**, *87*(15), 10199-10207.
http://dx.doi.org/10.1021/acs.joc.2c01141 PMID: 35858372

[50] Lambat, T.L.; Chopra, P.K.P.G.; Mahmood, S.H. Microwave: a green contrivance for the synthesis of N-heterocyclic compounds. *Curr. Org. Chem.,* **2020**, *24*(22), 2527-2554.
http://dx.doi.org/10.2174/1385272824999200622114919

[51] Chen, J.R.; Hu, X.Q.; Lu, L.Q.; Xiao, W.J. Formal [4+1] annulation reactions in the synthesis of carbocyclic and heterocyclic systems. *Chem. Rev.,* **2015**, *115*(11), 5301-5365.
http://dx.doi.org/10.1021/cr5006974 PMID: 25992465

[52] Dadmal, T.L.; Appalanaidu, K.; Kumbhare, R.M.; Mondal, T.; Ramaiah, M.J.; Bhadra, M.P. Synthesis and biological evaluation of triazole and isoxazole-tagged benzothiazole/benzoxazole derivatives as potent cytotoxic agents. *New J. Chem.,* **2018**, *42*(19), 15546-15551.
http://dx.doi.org/10.1039/C8NJ01249K

[53] Chattopadhyay, S.K.; Karmakar, S.; Biswas, T.; Majumdar, K.C.; Rahaman, H.; Roy, B. Formation of medium-ring heterocycles by diene and enyne metathesis. *Tetrahedron,* **2007**, *63*(19), 3919-3952.
http://dx.doi.org/10.1016/j.tet.2007.01.063

[54] Reddy, M. S.; Thirukovela, N.S.; Narsimha, S.; Ravinder, M.; Nukala, S.K. Synthesis of fused 1, 2, 3-triazoles of Clioquinol *via* sequential CuAAC and CH arylation; *in vitro* anticancer activity, *in silico* DNA topoisomerase II inhibitory activity and ADMET. *J Mol Struct*, **2022**, *1250*, 131747. https://doi.org/10.1016/j.molstruc.2021.131747

[55] Maleki, A.; Ghassemi, M.; Firouzi-Haji, R. Green multicomponent synthesis of four different classes of six-membered *N* -containing and *O* -containing heterocycles catalyzed by an efficient chitosan-based magnetic bionanocomposite. *Pure Appl. Chem.,* **2018**, *90*(2), 387-394.
http://dx.doi.org/10.1515/pac-2017-0702

[56] Jangir, N.; Bagaria, S.K.; Jangid, D.K. Nanocatalysts: applications for the synthesis of N-containing five-membered heterocycles. *RSC Advances,* **2022**, *12*(30), 19640-19666.
http://dx.doi.org/10.1039/D2RA03122A PMID: 35865567

[57] Schumacher, C.; Molitor, C.; Smid, S.; Truong, K.N.; Rissanen, K.; Bolm, C. Mechanochemical syntheses of *n* -containing heterocycles with tosmic. *J. Org. Chem.,* **2021**, *86*(20), 14213-14222.
http://dx.doi.org/10.1021/acs.joc.1c01529 PMID: 34405999

[58] Zeng, D.; Wang, M.W.; Xiang, M.; Liu, L.W.; Wang, P.Y.; Li, Z.; Yang, S. Design, synthesis, and antimicrobial behavior of novel oxadiazoles containing various *N* -containing heterocyclic pendants. *Pest Manag. Sci.,* **2020**, *76*(8), 2681-2692.
http://dx.doi.org/10.1002/ps.5814 PMID: 32149457

[59] Snoussi, Y.; Besbes, N. Use of aluminosilicates such as acid-activated clays as solid catalysts for the reactivity of the various carbonyl compounds in heterocyclic synthesis. *Moroccan J. Heterocycl. Chem.,* **2020**, *19*(3), 19-3.
http://dx.doi.org/10.48369/IMIST.PRSM/jmch-v19i3.24243

[60] Philip, R.M.; Treesa, G.S.S.; Saranya, S.; Anilkumar, G. Applications of aryl-sulfinamides in the synthesis of N-heterocycles. *RSC Advances,* **2021**, *11*(33), 20591-20600.
http://dx.doi.org/10.1039/D1RA04099E PMID: 35479913

[61] Alamgir, A.N.M. Phytoconstituents—active and inert constituents, metabolic pathways, chemistry and application of phytoconstituents, primary metabolic products, and bioactive compounds of primary metabolic origin.*Therapeutic use of medicinal plants and their extracts*; Springer: Cham, **2018**, Vol. 2, pp. 25-164.
http://dx.doi.org/10.1007/978-3-319-92387-1_2

[62] Majumder, A.; Gupta, R.; Jain, A. Microwave-assisted synthesis of nitrogen-containing heterocycles. *Green Chem. Lett. Rev.,* **2013**, *6*(2), 151-182.
http://dx.doi.org/10.1080/17518253.2012.733032

[63] Prandi, C.; Occhiato, E.G. From synthetic control to natural products: a focus on *N* -heterocycles. *Pest Manag. Sci.,* **2019**, *75*(9), 2385-2402.
http://dx.doi.org/10.1002/ps.5322 PMID: 30624033

[64] Balci, M. Recent advances in the synthesis of fused heterocycles with new skeletons *via* alkyne cyclization. *Tetrahedron Lett.,* **2020**, *61*(24), 151994.
http://dx.doi.org/10.1016/j.tetlet.2020.151994

[65] Kasatkina, S.O.; Geyl, K.K.; Baykov, S.V.; Novikov, M.S.; Boyarskiy, V.P. "Urea to Urea" Approach: Access to Unsymmetrical Ureas Bearing Pyridyl Substituents. *Adv. Synth. Catal.,* **2022**, *364*(7), 1295-1304.
http://dx.doi.org/10.1002/adsc.202101490

[66] Kasatkina, S.O.; Geyl, K.K.; Baykov, S.V.; Boyarskaya, I.A.; Boyarskiy, V.P. Catalyst-free synthesis of substituted pyridin-2-yl, quinolin-2-yl, and isoquinolin-1-yl carbamates from the corresponding hetaryl ureas and alcohols. *Org. Biomol. Chem.,* **2021**, *19*(27), 6059-6065.
http://dx.doi.org/10.1039/D1OB00783A PMID: 34137410

[67] Grintsevich, S.; Sapegin, A.; Krasavin, M. Significant broadening of the substrate scope for the hydrated imidazoline ring expansion (hire) *via* the use of lithium hexamethyldisilazide. *Synthesis*, **2022**, *54*(10), 2494-2510. https://doi.org/10.1055/s-0040-1719882

[68] Ye, D.; Lu, H.; He, Y.; Zheng, Z.; Wu, J.; Wei, H. Rapid syntheses of N-fused heterocycles *via* acyl-transfer in heteroaryl ketones. *Nat. Commun.,* **2022**, *13*(1), 3337.
http://dx.doi.org/10.1038/s41467-022-31063-3 PMID: 35680930

[69] Li, Y.; Liu, G.F.; Tan, C.P.; Ji, L.N.; Mao, Z.W. Antitumor properties and mechanisms of mitochondria-targeted Ag(I) and Au(I) complexes containing N-heterocyclic carbenes derived from cyclophanes. *Metallomics,* **2014**, *6*(8), 1460-1468.
http://dx.doi.org/10.1039/C4MT00046C PMID: 24788133

[70] Liu, W.; Gust, R. Update on metal N-heterocyclic carbene complexes as potential anti-tumor metallodrugs. *Coord. Chem. Rev.,* **2016**, *329*, 191-213.

http://dx.doi.org/10.1016/j.ccr.2016.09.004

[71] Akhtar, J.; Khan, A.A.; Ali, Z.; Haider, R.; Shahar Yar, M. Structure-activity relationship (SAR) study and design strategies of nitrogen-containing heterocyclic moieties for their anticancer activities. *Eur. J. Med. Chem.,* **2017**, *125*, 143-189.
http://dx.doi.org/10.1016/j.ejmech.2016.09.023 PMID: 27662031

[72] Gou, Y.; Wang, J.; Chen, S.; Zhang, Z.; Zhang, Y.; Zhang, W.; Yang, F. α−N−heterocyclic thiosemicarbazone Fe(III) complex: Characterization of its antitumor activity and identification of anticancer mechanism. *Eur. J. Med. Chem.,* **2016**, *123*, 354-364.
http://dx.doi.org/10.1016/j.ejmech.2016.07.041 PMID: 27487566

[73] Pennington, L.D.; Moustakas, D.T. The necessary nitrogen atom: a versatile high-impact design element for multiparameter optimization. *J. Med. Chem.,* **2017**, *60*(9), 3552-3579.
http://dx.doi.org/10.1021/acs.jmedchem.6b01807 PMID: 28177632

[74] Martins, P.; Jesus, J.; Santos, S.; Raposo, L. R.; Roma-Rodrigues, C.; Baptista, P. V.; Fernandes, A. R. Heterocyclic anticancer compounds: recent advances and the paradigm shift towards the use of nanomedicine's tool box. *Molecules*, **2015**, *20*(9), 16852-16891.
https://doi.org/10.3390/molecules200916852

[75] Khan, I.; Ibrar, A.; Ahmed, W.; Saeed, A. Synthetic approaches, functionalization and therapeutic potential of quinazoline and quinazolinone skeletons: The advances continue. *Eur. J. Med. Chem.,* **2015**, *90*, 124-169.
http://dx.doi.org/10.1016/j.ejmech.2014.10.084 PMID: 25461317

[76] Wang, X.; Zhang, H.; Chen, X. Drug resistance and combating drug resistance in cancer. *Cancer Drug Resist.,* **2019**, *2*(2), 141-160.
http://dx.doi.org/10.20517/cdr.2019.10 PMID: 34322663

[77] Garrett, M.D.; Workman, P. Discovering novel chemotherapeutic drugs for the third millennium. *Eur. J. Cancer,* **1999**, *35*(14), 2010-2030.
http://dx.doi.org/10.1016/S0959-8049(99)00280-4 PMID: 10711243

[78] Yan, S.J.; Liu, Y.J.; Chen, Y.L.; Liu, L.; Lin, J. An efficient one-pot synthesis of heterocycle-fused 1,2,3-triazole derivatives as anti-cancer agents. *Bioorg. Med. Chem. Lett.,* **2010**, *20*(17), 5225-5228.
http://dx.doi.org/10.1016/j.bmcl.2010.06.141 PMID: 20655212

[79] Fu, D.J.; Li, P.; Wu, B.W.; Cui, X.X.; Zhao, C.B.; Zhang, S.Y. Molecular diversity of trimethoxyphenyl-1,2,3-triazole hybrids as novel colchicine site tubulin polymerization inhibitors. *Eur. J. Med. Chem.,* **2019**, *165*, 309-322.

[80] Banerji, B.; Pramanik, S. K.; Sanphui, P.; Nikhar, S.; Biswas, S. C. Synthesis and cytotoxicity studies of novel triazolo-benzoxazepine as new anticancer agents. *Chem. Biol. Drug. Des*., **2013**, *82*(4), 401-409.
https://doi.org/10.1111/cbdd.12164
http://dx.doi.org/10.1016/j.ejmech.2019.01.033 PMID: 30690300

[81] Kamel, M.M.; Megally Abdo, N.Y. Synthesis of novel 1,2,4-triazoles, triazolothiadiazines and triazolothiadiazoles as potential anticancer agents. *Eur. J. Med. Chem.,* **2014**, *86*, 75-80.
http://dx.doi.org/10.1016/j.ejmech.2014.08.047 PMID: 25147148

[82] Ramaprasad, G.C.; Kalluraya, B.; Sunil Kumar, B. Microwave-assisted synthesis of triazolothiadiazole analogs as anticancer agents. *Med. Chem. Res.,* **2014**, *23*(8), 3644-3651.
http://dx.doi.org/10.1007/s00044-014-0944-x

[83] Baviskar, A.T.; Madaan, C.; Preet, R.; Mohapatra, P.; Jain, V.; Agarwal, A.; Guchhait, S.K.; Kundu, C.N.; Banerjee, U.C.; Bharatam, P.V. N-fused imidazoles as novel anticancer agents that inhibit catalytic activity of topoisomerase IIα and induce apoptosis in G1/S phase. *J. Med. Chem.,* **2011**, *54*(14), 5013-5030.
http://dx.doi.org/10.1021/jm200235u PMID: 21644529

[84] Rostamnia, S.; Hassankhani, A. $RuCl_3$-catalyzed solvent-free Ugi-type Groebke–Blackburn synthesis of aminoimidazole heterocycles. *RSC Advances,* **2013**, *3*(40), 18626-18629.
http://dx.doi.org/10.1039/c3ra42752h

[85] Rostamnia, S.; Xin, H.; Nouruzi, N. Metal–organic frameworks as a very suitable reaction inductor for selective solvent-free multicomponent reaction: IRMOF-3 as a heterogeneous nanocatalyst for Kabachnik–Fields three-component reaction. *Microporous Mesoporous Mater.,* **2013**, *179*, 99-103.
http://dx.doi.org/10.1016/j.micromeso.2013.05.009

[86] Husain, A.; Rashid, M.; Shaharyar, M.; Siddiqui, A.A.; Mishra, R. Benzimidazole clubbed with triazolo-thiadiazoles and triazolo-thiadiazines: New anticancer agents. *Eur. J. Med. Chem.,* **2013**, *62*, 785-798.
http://dx.doi.org/10.1016/j.ejmech.2012.07.011 PMID: 23333063

[87] Husain, A.; Rashid, M.; Mishra, R.; Parveen, S.; Shin, D.S.; Kumar, D. Benzimidazole bearing oxadiazole and triazolo-thiadiazoles nucleus: Design and synthesis as anticancer agents. *Bioorg. Med. Chem. Lett.,* **2012**, *22*(17), 5438-5444.
http://dx.doi.org/10.1016/j.bmcl.2012.07.038 PMID: 22840417

[88] Ding, H.W.; Yu, L.; Bai, M.; Qin, X.C.; Song, M.; Zhao, Q.C. Design, synthesis and evaluation of some 1,6-disubstituted-1H-benzo[d]imidazoles derivatives targeted PI3K as anticancer agents. *Bioorg. Chem.,* **2019**, *93*, 103283.
http://dx.doi.org/10.1016/j.bioorg.2019.103283 PMID: 31585260

[89] Chitrakar, R.; Rawat, D.; Sistla, R.; Vadithe, L.N.; Subbarayappa, A. Design, synthesis and anticancer activity of sulfenylated imidazo-fused heterocycles. *Bioorg. Med. Chem. Lett.,* **2021**, *49*, 128307.
http://dx.doi.org/10.1016/j.bmcl.2021.128307 PMID: 34363936

[90] Zhu, S.L.; Wu, Y.; Liu, C.J.; Wei, C.Y.; Tao, J.C.; Liu, H.M. Design and stereoselective synthesis of novel isosteviol-fused pyrazolines and pyrazoles as potential anticancer agents. *Eur. J. Med. Chem.,* **2013**, *65*, 70-82.
http://dx.doi.org/10.1016/j.ejmech.2013.04.044 PMID: 23693151

[91] Abbas, E.M.H.; Dawood, D.H.; Farghaly, T.A.; El-hag, F.A.; Ali, M.M. Synthesis and structure–activity relationship study of novel pyrazolylthiazoles as potential anti-breast cancer agents. *J. Heterocycl. Chem.,* **2017**, *54*(3), 1974-1982.
http://dx.doi.org/10.1002/jhet.2794

[92] Abdou, W.M.; Barghash, R.F.; Khidre, R.E. Antineoplastic activity of fused nitrogen-phosphorus heterocycles and derived phosphonates. *Monatsh. Chem.,* **2013**, *144*(8), 1233-1242.
http://dx.doi.org/10.1007/s00706-013-0950-6

[93] Sztanke, M.; Rzymowska, J.; Sztanke, K. Synthesis, structure elucidation and identification of antiproliferative activities of a novel class of thiophene bioisosteres bearing the privileged 7,8-dihydroimidazo[2,1-c][1,2,4]triazin-4(6H)-one scaffold. *Bioorg. Med. Chem.,* **2015**, *23*(13), 3448-3456.
http://dx.doi.org/10.1016/j.bmc.2015.04.037 PMID: 25975637

[94] Doan, P.; Karjalainen, A.; Chandraseelan, J.G.; Sandberg, O.; Yli-Harja, O.; Rosholm, T.; Franzen, R.; Candeias, N.R.; Kandhavelu, M. Synthesis and biological screening for cytotoxic activity of N-substituted indolines and morpholines. *Eur. J. Med. Chem.,* **2016**, *120*, 296-303.
http://dx.doi.org/10.1016/j.ejmech.2016.05.024 PMID: 27214140

[95] Su, T.; Zhu, J.; Sun, R.; Zhang, H.; Huang, Q.; Zhang, X.; Du, R.; Qiu, L.; Cao, R. Design, synthesis and biological evaluation of new quinoline derivatives as potential antitumor agents. *Eur. J. Med. Chem.,* **2019**, *178*, 154-167.
http://dx.doi.org/10.1016/j.ejmech.2019.05.088 PMID: 31181480

[96] Jafari, F.; Baghayi, H.; Lavaee, P.; Hadizadeh, F.; Soltani, F.; Moallemzadeh, H.; Mirzaei, S.; Aboutorabzadeh, S.M.; Ghodsi, R. Design, synthesis and biological evaluation of novel benzo- and tetrahydrobenzo-[h]quinoline derivatives as potential DNA-intercalating antitumor agents. *Eur. J. Med. Chem.,* **2019**, *164*, 292-303.
http://dx.doi.org/10.1016/j.ejmech.2018.12.060 PMID: 30599418

[97] Upadhyay, K.D.; Dodia, N.M.; Khunt, R.C.; Chaniara, R.S.; Shah, A.K. Synthesis and biological screening of pyrano [3, 2-c] quinoline analogues as anti-inflammatory and anticancer agents. *ACS Med. Chem. Lett.,* **2018**, *9*(3), 283-288.
http://dx.doi.org/10.1021/acsmedchemlett.7b00545 PMID: 29541375

[98] Othman, D.I.A.; Selim, K.B.; El-Sayed, M.A.A.; Tantawy, A.S.; Amen, Y.; Shimizu, K.; Okauchi, T.; Kitamura, M. Kitamura, M. Design, synthesis and anticancer evaluation of new substituted thiophene-quinoline derivatives. *Bioorg. Med. Chem.,* **2019**, *27*(19), 115026.
http://dx.doi.org/10.1016/j.bmc.2019.07.042 PMID: 31416740

[99] Lafayette, E.; Almeida, V.S.; da Rocha, P, M.; Carneiro B.E.; Gonçalves da S. T.; de Moura, O.R.; da Rocha P. I.; de Carvalho, L., Jr; do Carmo A.L.M. Synthesis, DNA binding and topoisomerase I inhibition activity of thiazacridine and imidazacridine derivatives. *Molecules,* **2013**, *18*(12), 15035-15050.
http://dx.doi.org/10.3390/molecules181215035 PMID: 24322489

[100] Nkosi, S.M.; Anand, K.; Anandakumar, S.; Singh, S.; Chuturgoon, A. A.; Gengan, R. M. Design, synthesis, anticancer, antimicrobial activities and molecular docking studies of novel quinoline bearing dihydropyridines. *J. Photochem. Photobiol*., **2016**, *165*, 266-276.
https://doi.org/10.1016/j.jphotobiol.2016.10.009

[101] Mirzaei, S.; Hadizadeh, F.; Eisvand, F.; Mosaffa, F.; Ghodsi, R. Synthesis, structure-activity relationship and molecular docking studies of novel quinoline-chalcone hybrids as potential anticancer agents and tubulin inhibitors. *J. Mol. Struct.,* **2020**, *1202*, 127310.
http://dx.doi.org/10.1016/j.molstruc.2019.127310

[102] Ge, C.; Chang, L.; Zhao, Y.; Chang, C.; Xu, X.; He, H.; Wang, Y.; Dai, F.; Xie, S.; Wang, C. Wang, C. Design, synthesis and evaluation of naphthalimide derivatives as potential anticancer agents for hepatocellular carcinoma. *Molecules,* **2017**, *22*(2), 342.
http://dx.doi.org/10.3390/molecules22020342 PMID: 28241441

[103] Ammar, Y.A.; Sh El-Sharief, A.M.; Belal, A.; Abbas, S.Y.; Mohamed, Y.A.; Mehany, A.B.M.; Ragab, A. Design, synthesis, antiproliferative activity, molecular docking and cell cycle analysis of some novel (morpholinosulfonyl) isatins with potential EGFR inhibitory activity. *Eur. J. Med. Chem.,* **2018**, *156*, 918-932.
http://dx.doi.org/10.1016/j.ejmech.2018.06.061 PMID: 30096580

[104] Chate, A.V.; Kamdi, S.P.; Bhagat, A.N.; Jadhav, C.K.; Nipte, A.; Sarkate, A.P.; Tiwari, S.V.; Gill, C.H. Design, synthesis and SAR study of novel spiro [pyrimido[5,4-b]quinoline-10,5′-pyrrolo[2,3-d]pyrimidine] derivatives as promising anticancer agents. *J. Heterocycl. Chem.,* **2018**, *55*(10), 2297-2302.
http://dx.doi.org/10.1002/jhet.3286

[105] Patravale, A.A.; Gore, A.H.; Kolekar, G.B.; Deshmukh, M.B.; Choudhari, P.B.; Bhatia, M.S.; Prabhu, S.; Jamdhade, M.D.; Patole, M.S.; Anbhule, P.V.

Synthesis, biological evaluation and molecular docking studies of some novel indenospiro derivatives as anticancer agents. *J. Taiwan Inst. Chem. Eng.,* **2016**, *68*, 105-118.
http://dx.doi.org/10.1016/j.jtice.2016.09.034

[106] Li, E.; Lin, Q.; Meng, Y.; Zhang, L.; Song, P.; Li, N.; Xin, J.; Yang, P.; Bao, C.; Zhang, D.; Zhang, Y.; Wang, J.; Zhang, Q.; Liu, H. 2,4-Disubstituted quinazolines targeting breast cancer cells *via* EGFR-PI3K. *Eur. J. Med. Chem.,* **2019**, *172*, 36-47.
http://dx.doi.org/10.1016/j.ejmech.2019.03.030 PMID: 30939352

[107] Fan, C.; Zhong, T.; Yang, H.; Yang, Y.; Wang, D.; Yang, X.; Xu, Y.; Fan, Y. Design, synthesis, biological evaluation of 6-(2-amino-1H-benzo[d]imidazole-6-yl)quinazolin-4(3H)-one derivatives as novel anticancer agents with Aurora kinase inhibition. *Eur. J. Med. Chem.,* **2020**, *190*, 112108.
http://dx.doi.org/10.1016/j.ejmech.2020.112108 PMID: 32058239

[108] Tantawy, E.S.; Amer, A.M.; Mohamed, E.K.; Abd Alla, M.M.; Nafie, M.S. Synthesis, characterization of some pyrazine derivatives as anti-cancer agents: *in vitro* and *in silico* approaches. *J. Mol. Struct.,* **2020**, *1210*, 128013.
http://dx.doi.org/10.1016/j.molstruc.2020.128013

[109] Veligeti, R.; Madhu, R.B.; Anireddy, J.; Pasupuleti, V.R.; Avula, V.K.R.; Ethiraj, K.S.; Uppalanchi, S.; Kasturi, S.; Perumal, Y.; Anantaraju, H.S.; Polkam, N.; Guda, M.R.; Vallela, S.; Zyryanov, G.V. Synthesis of novel cytotoxic tetracyclic acridone derivatives and study of their molecular docking, ADMET, QSAR, bioactivity and protein binding properties. *Sci. Rep.,* **2020**, *10*(1), 20720.
http://dx.doi.org/10.1038/s41598-020-77590-1 PMID: 33244007

[110] Kumar, S.; Mehndiratta, S.; Nepali, K.; Gupta, M.K.; Koul, S.; Sharma, P.R.; Saxena, A.K.; Dhar, K.L. Novel indole-bearing combretastatin analogues as tubulin polymerization inhibitors. *Org. Med. Chem. Lett.,* **2013**, *3*(1), 3.
http://dx.doi.org/10.1186/2191-2858-3-3 PMID: 23414667

[111] Shivarama, H, B.; Narayana Poojary, K.; Sooryanarayana Rao, B.; Shivananda, M.K. New bis-aminomercaptotriazoles and bis-triazolothiadiazoles as possible anticancer agents. *Eur. J. Med. Chem.,* **2002**, *37*(6), 511-517.
http://dx.doi.org/10.1016/S0223-5234(02)01358-2 PMID: 12204477

IJBPAS, November, 2022, 11(11): 5368-5375

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

PHYTOCHEMICAL SCREENING, ANTIOXIDANT AND ANTIBACTERIAL ACTIVITIES OF *PHYSALIS MINIMA* AND *LANTANA CAMERA* WILD MEDICINAL PLANTS

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Received 28th Dec. 2021; Revised 26th March 2022; Accepted 16th May 2022; Available online 1st Nov. 2022

https://doi.org/10.31032/IJBPAS/2022/11.11.6586

ABSTRACT

Medicinal plants have great value for the treatment and cure various diseases. Now scientific research has expanded our knowledge to discovered chemical composition and active constituents present in medicinal plants. Present research work was undertaken to the phytochemical, antioxidant and antibacterial activity of *Physalis minima* and *Lantana camera*. Phytochemical screening of all medicinal plants has been done with the use of solvent methanol, ethanol and water. Extracts of leaves were obtained by soxhlet extraction to find out the active constitution of plants. Phytochemical analysis of leaves extract has discovered the presence of medicinally important phytochemicals such as Saponin, Steroid, Tannin, Anthocyanin, Coumarin, Flavonoid, Diterpine, Phenol, Phlobatannin and Chalcone. The antioxidant of leaves extracts was assessed based on the radical scavenging effect of the stable 1,1-diphenyl-2-picryhydrazyl (DPPH). Antibacterial activity of aqueous and ethanolic extracts of *P. minima* and *L. camera* was studies for standard bacteria one Gram-positive (*Bacillus Subtilis*) and Gram-negative (*Escherichia coli*). The optimum inhibition zone size value for both the bacteria *Bacillus Subtilis* and *Escherichia coli* are 02 mm in *P.minima* and *L.camera*. The methanol and ethanol extracts of both plant show significant antioxidant and antibacterial activity. The

diversity of phytochemicals founds in *P. minima* and *L. camera* leaves could serve as a source of useful drugs.

Keywords: *P. minima, L. camera*, Phytochemical, Antioxidant, Antibacterial Activity

INTRODUCTION

Medicinal plants are plants that have all their parts leaves, stems, roots and flowers used for therapeutic purposes. Then desperately need to conservation of medicinal plants and cultivation of wild medicinal plants. Herbal wild medicinal plants are easily available, less expensive, no side effect and more efficient make them more attractive as therapeutic agents when compared to modern medicine **[1, 2]**. India has top ranked herbal medicinal producer because Indian plant biodiversity is the largest source of herbal plant medicine **[3]**. In the word there are 60 to 80 % of people in word use medicinal plants and their products for therapeutic purposes **[4]**. The medicinal value of these plants lies in the bioactive phytochemical constituents present in plants and that are beneficial to humans. Many active phytochemical like flavonoids, terpenoids, vitamins, alkaloids etc. were found to be responsible for these activities **[5]**. Present research work was undertaken on the phytochemical, antioxidant and antibacterial activity of Physalias minima and Lanthena camera. The methanol and ethanol extracts of both plants show significant antioxidant and antibacterial activity. The diversity of phytochemicals found in *P. minima* and *L. camera* leaves could serve as a source of useful drugs.

MATERIALS AND METHODS

Collection of plant materials *P. minima* and *L. camera* were collected from roadside area of near Lakhandur Tahsil of Bhandara district. The plant materials were identified by D. N. Lanjewar, Department of Botany, Yashwantrao Chawhan arts, commerce and science college Lakhandur. The *P. minima* and *L. camera* leaves was washed with tap water and used for the present study. Leaves were cut into small pieces, shade dried and ground to make fine powder. Process for Extraction 500 gm of each powder of the leaves were taken along with the 1000 ml of distilled water in a container. The mixture was shaken continuously with used of rotary shakers and place in a dark for 72 hour with occasional shaking. After 72 hour the mixture was filter and filtrate was concentrated to one third of the original amount. The resultant was used for phytochemical, antibacterial and antioxidant analysis **[6]**.

Phytochemical analysis

The ethanol extract of leaves of *P. minima* and *L. camera* was used for qualitative phytochemical analyses. Phytochemicals such as flavonoids, tannins, steroids, glycosides, saponins, phenolic compounds, terpenoids and alkaloids are analyzed **[5]**.

Antioxidant Activity By 1, 1-diphenyl-2-picrylhydrazyl (DPPH)

The antioxidant activity of the ethanol extracts of *P. minima* and *L. camera* leaves were assessed based on the radical scavenging effect of the stable DPPH **[7, 8]**. 0.005% of DPPH was prepared in ethyl alcohol and 4 ml of this DPPH solution was mixed with 4 ml of ethanolic plant extract solutions. These solution mixtures were kept in dark for 30 min and optical density was measured at 517 nm using UV Visible spectrophotometer. 4ml ethanol with 0.005 DPPH solutions was used as blank. The optical density was recorded in spectrophotometer and % inhibition was calculated using the following formula.

Percentage (%) Inhibition of DPPH (% AA) = A – B × 100 /A

Where A=Optical density of the blank and B=Optical density of the sample.

Extraction concentration providing 50% inhibition IC_{50} values was calculated maximum and minimum values of %AA

Antibacterial activity (disk diffusion method)

Antibacterial activity was carried out to examine the sensitivity of some bacterial species against plant extracts of *P. minima* and *L. camera* leaves with a comparing the antibiotics for it by Disk Diffusion Method **[9]**. These bacteria included Gram-positive (*Bacillus Subtilis*) and Gram-negative (*Escherichia coli*).

RESULTS AND DISCUSSION

Phytochemical analysis

Preliminary screening of phytochemicals of ethanol extract of leaves of *P. minima* and *L. camera* are carried out as follows **[10-12]**.

Saponin:- 5 ml plants extract was mixed with 20 ml of double-distilled water then agitated in graduated cylinder For 15 min formation of foam indicates Saponin.

Steroid:- 1ml extract was dissolved in 10 ml of $CHCl_3$ and 1ml of concentrated H_2SO_4 acid was added from the side of a test tube. The upper layer turns red and the H_2SO_4 layer showed yellow with green fluorescence. This indicates the presence of steroids.

Tannin:- 4ml extract was treated with 4 ml Ferrous chloride formation of green color indicates that presence of condensed tannin.

Anthocyanin:- 2 ml of aqueous extract is added to 2 ml of 2N HCl & NH_3, the

appearance of pink-red turns blue-violet indicates the presence of anthocyanin.

Coumarin:- 3 ml of 2N NaOH was added to 2ml of aqueous extract formation of yellow color indicates coumarins.

Proteins:- Extract was treated with a few drops of concentrated nitric acid formation of yellow indicates the presence of proteins.

Flavonoid:- Extract was treated with 2N NaOH solution, formation of intense yellow color indicates presence of Flavonoid.

Diterpine:- Extract were dissolved in water and treated with 10 drops of $Cu(OAc)_2$ solution, formation of emerald green color indicates the presence of Diterpine.

Phenol:- Test extract were treated with 4 drops of Alcoholic ferrous chloride solution. Formation of bluish black color indicates the presence of Phenol

Phlobatannin:- when extract plant sample is boiled with dilute 0.1N HCl was taken red ppt was obtained as evidence for presence of Phlobatannin.

Chalcone:- 2ml of Ammonium Hydroxide was added to 0.5 ml ethanolic extract, the appearance of the red color showed the presence of Chalcone.

Carbohydrate:- Extract were dissolved individually in 5ml of distilled water and filtered. The filtrate was used for the following test. Filtrate was treated with 2 drops of alcoholic a-naphthol solution, the formation of violet ring at the junction indicates the presence of carbohydrates **(Table 1)**.

Table 1: Test of Phytochemical

Test of Phytochemical	*P. minima* Leaves	*L. camera* leaves
Saponin	+	-
Steroid	+	+
Tannin	+	+
Anthocyanin	+	+
Coumarin	+	+
Protein	-	+
Flavonoid	+	+
Diterpine	+	+
Phenol	+	+
Phlobatannin	+	-
Chalcone	-	+
Carbohydrate	+	+

Note: + = Present and - = Absent

Antioxidant Activity

The stock solution 1 mg/ml of ethanol extracts and DPPH solution was prepared. The required dilutions from 0.01 mg/ml to 0.1 mg/ml were prepared by appropriate dilutions **[7, 8]**. The optical densities of bank DPPH solution and sample solution can be calculate and found. With use of optical density of both solution percent antioxidant activities were calculated in **Table 2**.

Table 2: Optical Density and % Antioxidant Activity for Ethanolic Extract of P. minima leaves: (O.D. of Black DPPH = 0.585)

Conc.mg/ml	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
O.D. of P. minima	0.432	0.353	0.274	0.216	0.201	0.187	0.131	0.112	0.104	0.075
%AA P.minima	26.15	39.65	53.16	63.07	65.64	68.03	77.6	80.85	82.22	87.17

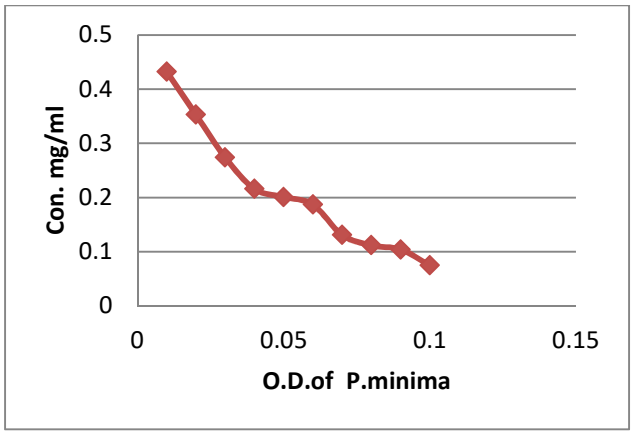

Figure 1: Decrease in Optical Density of Sample with Increase in Concentration of Ethanolic Extracts of P. minima leaves

Table 3: Optical Density and % Antioxidant Activity for Ethanolic Extract of *L. camera*: (O.D. of Black DPPH = 0.585)

Conc.mg/ml	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
O.D. of L. camera	0.412	0.345	0.261	0.214	0.198	0.179	0.127	0.107	0.095	0.042
%AA L. camera	29.57	41.02	55.38	63.41	60.15	69.4	78.29	81.7	83.76	92.82

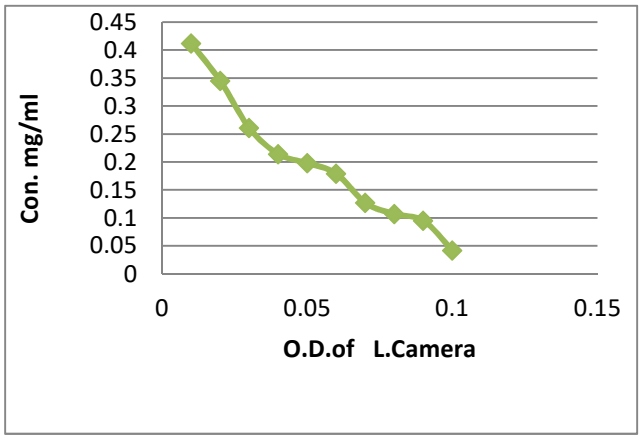

Figure 2: Decrease in Optical Density of Sample with Increase in Concentration of Ethanolic Extracts of *L. camera* leaves

Increase in Percent Antioxidant Activity with Increase in Concentration for ethanolic extract of *P. minima* leaves. Calculation of IC_{50} Value for *P. minima* leaves : = max – ½ (max-min)

= 87.17– ½ (87.17 – 26.15)

=56.66

IC_{50} value from graph corresponding ethanolic extract of P. minima leaves is 0.036 mg/ml.

Increase in Percent Antioxidant Activity with Increase in Concentration for ethanolic extract of *L. camera* leaves. Calculation of IC_{50} Value for *L. camera* leaves : = max – ½ (max-min)

= 92.82– ½ (92.82 – 29.57) =61.20

IC_{50} value from graph corresponding ethanolic extract of *L. camera* leaves is 0.052 mg/ml.

Antibacterial Activity:-

The examined bacterial species included Gram-positive (*Bacillus Subtilis*) and Gram-negative (*Escherichia coli*). Sterile discs 6 mm prepared from Whatman filter paper No. 1 were made to absorb 50 µg of the test samples **[13]**. Standard reference antibiotic discs (Nitrofurantoin 30 µg, and Nalidixic acid 30 µg) for bacterial species were used as positive control and solvent discs (Distilled water and Ethyl Alcohol) were used as negative control **[14]**. The bacterial isolates were first grown in a nutrient broth for 18 h before use and standardized to 0.5 McFarland standards (1.5 x 108 cfu / mL)(15). Mueller-Hinton agar was prepared on the plates as the medium for the test organism **[16]**. The bacterial inoculums were spread evenly onto the surface of the agar plate using the sterile cotton bud and then the extracts discs, 20% DMSO impregnated discs and standard antimicrobial discs were situated on the inoculums agar superficial. The antimicrobial activity was interpreted from the size of the diameter of the zone of inhibition measured to the adjacent mm as experiential from a clear zone surrounding the disc.

Methanol and ethanol extract for *P. minima* and *L. camera* leaves are effective to antibacterial activity while aqua extracts are less effective. The optimum inhibition zone size value for both the bacteria *Bacillus Subtilis* and *Escherichia coli* are 02 mm in both plants. In case optimum inhibition zone size value of antibiotic Nitrofurantoin is 06 mm and Nalidixic acid is 5mm were the details results for antibacterial activity are shown as shown in **Table 4**.

Table 4: The effectiveness of three elements (Plant extracts, Antibiotics and bacteria)

Medicinal Plants		Bacterial Species	Antibiotic	Bacterial Species	Antibiotic
		Bacillus Subtilis (mm)	Nitrofurantoin (mm)	*Escherichia coli* (mm)	Nalidixic Acid (mm)
P. minima	Aqus Extr.	01	02	0.5	02
	Methanol Extr.	02	04	02	03
	Ethanol Extr.	02	05	01	04
L. camera	Aqus Extr.	0.5	01	0.25	01
	Methanol Extr.	01	04	01	05
	Ethanol Extr.	02	06	02	05

Legend: (mm) = Millimeter

CONCLUSION

- Phytochemical screening of selected wild medicinal plants clearly reveals that the maximum classes of photochemical are present in P.minima and L.camera
- The P.minima and L.camera Leave extracts demonstrate good DHHP radical activity with IC_{50} value for P.minima is 0.036 mg/ml and L. camera is 0.052 mg/ml which show good antioxidant activity.
- Leaves extract of P.minima and L.camera are exhibited significant antibacterial activity for bacterial species including Gram-positive (*Bacillus Subtilis*) and Gram-negative (*Escherichia coli*). The optimum inhibition zone size value for both the bacteria *Bacillus Subtilis* and *Escherichia coli* are 02 mm in P.minima and L.camera.
- Phytochemicals in plant extract serve as a source of drugs that are useful in the medicine of some diseases caused by bacteria and also as antioxidant agents.

REFERENCE

[1] Chopra RN, Nayer SL, Chopra IC. Glossary of Indian Medicinal plants, National Institute of science and Communication. C.S.I.R Publication, New Delhi, India, 1956, 330-332.

[2] Kokate C.K, Purohit A. P. and Ghokhale S.B. Pharmacognosy, Nirali Prakashan, Pune, India (1997).

[3] The Indian Pharmacopoeia., Govt. of India, Ministry of Health and Family Welfare, The controller of Publication, 1996, 53, 54, 89.

[4] Kirtikar KR, Basu BD. Indian Medicinal Plants. 2nd Edn.Bishen Singh Mahendra Pal Singh, Dehradun, 1980,312.

[5] Bhandary SK, Kumari NS, Bhat VS, Sharmila KP, Bekal MP. Prelimnary phytochemical screening of various extract of punica granatum peel, whole fruit and seeds, Nitte University Journal of Health Science. 2012; 2(4):34-38.

[6] Trease G.E., and Evan W.C., Pharmacognosy, Ed 12, English language Book society, BalliereTindall, 309-315 and 706-708(1983).

[7] Vertuani S, Angusti A and Manfredini S, The antioxidants and pro-antioxidants network: an overview, *Curr Pharma Design*, 2004, **10**, 1677-1694.

[8] Khairul FK, Nurul Haniza M and Zhari I, Antioxidative properties of various extract of *Labisia pumila* (Kacip Fatimah), *Curr Trends Persp*, 2005, **4**, 306-312.

[9] Centers for Disease Control and Prevention. 2002. National Antimicrobial

Resistance Monitoring System. Enteric bacteria. Centers for Disease Control and Prevention, Atlanta.

[10] Md. Sarfaraj Hussain, SheebaFareed, Mohd. Ali. Hygrophila auriculata (K. Schum) Heine: Ethnobotany, phytochemistry and pharmacology / Asian Journal of Traditional Medicines, 2010, 5(4): 122-131.

[11] Debiyi O. O. and Sofowora F. A., "Pytochemical screening of medical plants," *Iloyidia*, vol. 3, pp. 234–246, 1978.

[12] Ranjani S.S. , Phytochemical study on medicinal plant – Sidacordifolia Linn IJMRD 2015; 2(1): 200-204.

[13] Hossain MJ, Khaleda L, Chowdhury MJ, Arifuzzaman M, Al-Forkan M. Anti-bacterial and anti-oxidant activity of Achyranthus Aspera. Journal of medicinal plant science. 2013; 1(3):105-117

[14] Londonkar R, Reddy VC, Kumar KA. Potential antibacterial and antimicrobial activity of Achyranthus Aspera L., Recent Research in Science and Technology. 2011; 3(4):53-57

[15] Adriana Zapata, Sandra Ramirez-Arcos. A Comparative Study of McFarland Turbidity Standards and the Densimat Photometer to Determine Bacterial Cell Density. Curr Microbiol (2015) 70:907–909.

[16] Bauer A. W., Kirby W. M., Sherris J. L. and Turck M., 1966, Am. J. Clin. Pathol., 45:493.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 11, Dec 2022

REVIEW OF DISCOVER ADULTERATION IN SOME COMMON FOODS ITEM BY BIOCHEMICAL QUALITATIVE ANALYSIS

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Abstract: Food is one most important basic need for all leaving organism, which useful for growth and maintnus. Now day's foods are contain by different adulterants. Adulteration is a substance which reduces the vital importance of foodstuff. Some of the common adulterants are sugar or jiggery in honey, Starch and melamine in milk, Red lead salts and brick powder in chilli powder, Metanil yellow colours in turmeric powder, Malachite green in vegetable, Mineral oil and castor oils in edible oils, Vanaspati ghee in butter, Lead chromate in pulse, Chalk powder in wheat flour, Prussian blue coloring substances in tea powder, Chicory in coffee powder, Papaya seed in black pepper etc. which is causes various diseases such as epidemic dropsy, glaucoma, cardiac arrest, paralysis, brain damage, anemia, abortion, cancer etc. The aim is to evaluate the presence of adulterant from daily uses food materials like honey, milk , sugar, chilli powder, turmeric powder, green vegetable, edible oil, butter, pulses, wheat flour, tea powder, coffee powder and black pepper which we collected from different local grocery stores and discover food adulterants by biochemical qualitative analysis. The colour change of the sample indicate the according to the reagents is indicates the presence of different adulterants. This information can help to grow the food safety and also people can be aware about the food brands for a healthy life which are very beneficial to our society and our future.

Keywords:-Foods, Adulterants, Diseases, Biochemical analysis, Food Safety, Healthy life

I. Introduction

Food, sleter and cloth are basic needs for every living being. Food is the very necessity needs of life because which are use for growth and various life processes. Food contains important nutritional constituent carbohydrates, vitamins and proteins [1]. Almost all foods are of plant or animal origin. Many plants or plant parts such as roots, leaf, flower and fruit are eaten as food. There are around more than 2,000 plant species which are cultivated for food, and many have several distinct cultivars. Maize, wheat, and rice together account for 87% of all grain production worldwide. Animals are also used as food which included such as meat, milk cheese, butter and honey [2].

Nowadays, Food can be contaminated by different adulterants. Food adulteration is the process in which the quality of food is lowered either by the addition of inferior quality material or by extraction of valuable ingredient [3]. There are four different types of food adulteration included intentional adulteration, incidental adulteration, metallic adulteration and packaging

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 11, Dec 2022

hazard [4]. In intentional adulteration substances that look similar to the constituents of the food are added to it, to increase its weight and gain more profit. Example- mixing of pebbles, stones, marbles, sand, mud, filth, chalk powder, contaminated water etc. Incidental adulteration occurs due to negligence while handling food. Example- residues of pesticides in grains, larvae growth, presence of droppings of rodents, etc [5,6]. In metallic adulteration addition of metallic materials into food like lead or mercury is metallic adulteration. It may happen accidentally or even intentionally. The packing materials in which the food is packed may also interfere and mix with the constituents of the food, leading to packaging hazards [7]. Various food adulteration methods included mixing, substituting, using decomposed food, additions of toxic substances, misbranding, and artificial ripening. Also important reason for food adulteration are overgrowing population, urbanization, industrialization, decrease the land of agriculture, environmental hazards, and depleting natural resources then decrease food production [8].

In India normally the adulteration in food is done either for financial gain or due to carelessness and lack in proper hygienic condition of processing, storing, transportation and marketing. Such types of adulteration are quite common in developing countries. Food adulteration has a great impact on our health. Be it any kind of adulteration, prolonged consumption of this type of food is very harmful to the body [9]. Consuming such food increases the toxicity in the body. As the nutritional value of the adulterated food goes down, such food is no longer nutritive for the body. The addition of chemical adulterants and colours many times proves to be fatal [10]. Adulterated food may also affect our internal organs directly leading to heart, kidney, liver, and many more organ disorders and failure. Which is causes various diseases such as epidemic dropsy, glaucoma, cardiac arrest, paralysis, brain damage, anemia, abortion, cancer etc. The Present research work to evaluate the presence of adulterant from daily uses food materials like honey, milk , chilli powder, turmeric powder, green vegetable, Edible oil, Butter, Pulses, wheat flour, tea powder, coffee powder and black pepper which we collected from different local grocery stores and discover food adulterants by biochemical qualitative analysis [11]. The colour change of the sample indicate the according to the reagents is indicates the presence of different types of adulterants. This information can help to grow the food safety and also people can be aware about the food brands for a healthy life which are very beneficial to our society and our future [12].

II. Materials & Methods

Food materials like honey, milk, sugar, chilli powder, turmeric powder, green vegetable, edible oil, butter, pulses, wheat flour, tea powder, coffee powder and black Pepper which we collected from different departmental and local grocery stores. Some reagents like Iodine reagent, Con. HCl, Sucrose, 0.5N ethanolic KOH, Con. HNO_3, Solvent ether, Resorcinol, Carbon tetra-chloride (CCl_4), Con. H_2SO_4, Chloroform, Aniline, some apparatus such as Test tube, Beaker, Conical flask, Watch glass, Glass rod, Funnel, Burette, Pipette, Wash bottle and some paper such Filter paper, Litmus Paper, Cotton plug, blotting paper, were collected which were used for chemical tests. Biochemical qualitative analyses are done for detecting presence of

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adulterants [13].

III. Result & Discussion

Biochemical qualitative analyses of some food are as follows.

1. Food:- Honey

Common adulterant: - Sugar

Biochemical qualitative analysis: - Take 5 ml of honey in a porcelain dish. Add aniline chloride solution (3 ml of aniline dissolved in 7 ml of HCL) and stir well. Orange red colour indicates presence of sugar[14].

2. Food:- Milk

a) Common adulterant:- Starch

Biochemical qualitative analysis: - Take a little amount 3ml of the sample in a test tube. Add a drop of 1% aqueous solution of iodine. Blue or deep blue colorations indicate starch in milk .

b) Common adulterant:- Melamine

Biochemical qualitative analysis: - Take a little amount 5 gm of the sample in a test tube. Add a little amount of soybean powder. After 5 minute, dip a red litmus paper that are change in colour from red to blue indicate the use of Melamine in milk [15].

3. Food:- Sugar

a) Common adulterant:- stone powder or white sand

Biochemical qualitative analysis :- A small amount of sugar was taken in a test tube and shaken with little water. Pure sugar dissolved in water but insoluble stone powder or white sand didn't dissolve.

b) Common adulterant:- washing soda

Biochemical qualitative analysis :-To a small amount of sugar in a test tube , few drops of diluted HCl were added. A brisk effervescence of carbon dioxide confirmed the presence of washing soda in the given sample of sugar[16].

4. Food:- Chili powder

a) Common adulterant:- red lead salts

Biochemical qualitative analysis:- To a sample of chili powder, dil. Nitric Acid was added. The solution was filtered and two drops of potassium iodide were added into it. Yellow ppt. obtained indicated the Presence lead salts in a chili powder.

b) Common adulterant:- brick powder

Biochemical qualitative analysis :- A small amount of given red chili powder was added in a beaker containing water. Settling of some powder at the bottom & floating pure chili powder over water indicates the presence of brick powder in a given sample[17].

5. Food:- Turmeric powder

Common adulterant:- Metanil Yellow colours

Biochemical qualitative analysis Add a few drops of HCl to turmeric in water. Instantly the solution will turn to violet colour [18].

6. Food:- Green vegetables.

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Common adulterant:- Malachite green

Biochemical qualitative analysis:- Take a vegetable and rubbing moistened white cotton plug. Green colour impressions on cotton plug indicates the presence of Malachite green[19].

7. Food:- Ice cream

Common adulterant:- Beaking Soda

Biochemical qualitative analysis Take small Sample of ice cream in beaker add drop of Hydrochloric acid or some lemon juice on this, bubbles are observed if Beaking Soda is present[20].

8. Food:- Edible oil

Common adulterant: - argemone oil

Biochemical qualitative analysis: - take 1 ml of the oil in test tube after add mixture of 1 ml of 2% salicylic acid in methanol and 2 ml of conc. HNO_3, followed by 0.5 ml of conc. H_2SO_4 this mix shake indicate crimson red or deep orange-red colour develops within 20-30 sec- which indicate argemone oil adulteration is present [21].

9. Food:- Butter

Common adulterant:- Starch and hydrogenated vegetable oils

Biochemical qualitative analysis: - Take 2 gm butter in test tube after add 2-3 drops of iodine solution appeared blue colours indicate presence adulterated in butter [22].

10. Food:- Pulses

Common adulterant:- Metanil Yellow and Lead Chromate

Biochemical qualitative analysis:- Take 5 gm of the pulses sample with 5 ml of water in a test tube and add a few drops of concentrated Hydrochloric Acid. A pink colour shows presence of adulterations metanil yellow and lead chromate [23].

11. Food:- Wheat Powder

Common adulterant:- chalk powder.

Biochemical qualitative analysis:- You can check for the presence of adulterant chalk powder by adding 2 to 3 ml dil. HCl to the wheat powder sample in a test tube. Chalk powder creats effervescence in test tube [24].

12. Food:- Tea powder

a) Common adulterant:- Cashew husk

Biochemical qualitative analysis:- Spread a few tea leaves sample on a blotting paper, sprinkle some water on them. Once done, remove the tea leaves and wash the blotting paper under tap water. Observe the colour stains on blotting paper indicate presence of Cashew husk adulterant in tea.

b) Common adulterant:- iron fillings

Biochemical qualitative analysis:- For this you will need a magnet. Spread out a small quantity of tea leaves on a glass plate and gently move the magnet above the tea leaves. If the tea leaves are pure then the magnet will be clean. However, adulteration will manifest when iron fillings get stuck to the magnet.

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c) Common adulterant:- some colorant

Biochemical qualitative analysis:- a glass of water. Ensure that the water is either cold or at room temperature but not hot. If the tea is pure then there will be no change in the water's colour. If the tea leaves have some colorant added to it, the colour will immediately change to red, so beware [25].

13. Food:- Coffee Powder

Common adulterant:- Chicory

Biochemical qualitative analysis:- Drop a pinch of coffee powder on it gently. If the powder floats for some time before sinking, it is coffee. If the powder sinks quickly, it is chicory or some other seed. If it readily diffuses brownish or yellowish colour, it contains Caramel or Chicory [26].

14. Food:- Black Pepper

Common adulterant:- papaya seeds

Biochemical qualitative analysis:- Add some amount of black pepper to a glass of water. Pure black pepper settles at the bottom. In the adulterated black pepper, papaya seeds float on the surface of water [27].

IV. Conclusion

From the above review and discussions adulteration present in some common foods such as honey, milk , sugar, chilli powder, turmeric powder, green vegetable, edible oil, butter, pulses, wheat flour, tea powder, coffee powder and black pepper which we collected from different local grocery stores. Also explain some biochemical method which discovered food adulteration in the food items. Food adulteration can cause tremendous affect on health without our knowledge. Adulteration can be prevented by few alerting steps of our society. Hike of price of food items should be checked by government. While purchasing food items, selection of wholesome and non-adulterated food is necessary to make sure that such food do not cause and health problems. Though presence of adulterants cannot be ensured by visual examination as toxic contaminants are present in very low level but visual examination before purchase can ensure absence of insects, fungus and other foreign materials. The consumer should avoid buying food from places which do not maintain proper hygiene conditions. Both local and branded food stores should be inspected by government bodies. The above general consciousness is simple and easy to initiate for our healthy life. If we tend to actively participate in these changes then we can bring about a healthy and non venturous future for the upcoming generations.

V. References

[1] Frazier, W.C. and Westthroff, W.C. (2006). Food microbiology 3rd Edition, McGraw Hill Publishing Company Limited New York. 163-165, 223-236, 419- 543.

[2] Ades G, Henry CW, Feldstein F. (2012). The Food Safety Challenge of the Global Food Supply Chain. WEBINARS, Food safety magazine.

[3] Abhirami, S. and Radha (2015). Detection of food adulteration in selected food items procured by homemaker. International Journal of Recent Scientific Research. 6 (8): pp 5938-

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 11, Dec 2022

5843.

[4]Awasthi S, Jain K, Das A, Alam R, Surti G, Kishan N. Analysis of Food quality and Food Adulterants from Different Departmental & Local Grocery Stores by Qualitative Analysis for Food Safety. IOSRJESTFT. 2014; 8(2):22-26.

[5] Alauddin S. Food adulteration and society. Global research analysis International. 2012; 1(7):3-5.

[6] Anita G, Neetu S. Hazards of new technologies in promoting food adulterateon. J EnvSci, Tox. F Sci. 2013; 5(1):08-10.

[7] Ankleshwaria, N. and Shah, S.R. (1999). A study on the awareness pertaining to the use of safe edible food colours amongst Indian Housewives. Applied Nutrition. 24 (2): 21-27.

[8] Beniwal, A. and Khetarpaul, N. (1999) Knowledge of consumers during regarding the nature and extent of adulteration of Indian foods. Nutr Health. 13(3) :153-160

[9] Dipak, K. and Dash (2011). National worldwide survey to check food adulteration; Department of food adulteration.

[10] Barro N, Bellow AR, Itsteimbou Y, Savadogo A, Ouattara CAT, Nikiema AP et al. Street-vended foods improvement- contamination mechanisms and application of food safety objective strategy: Critical review. Pakistan Journal of Nutrition. 2007; 6:1-10.

[11] Krishna B.S. (1997). An outbreak of food poisoning in Tamil Nadu associated with Yersenia enterocolytic. 106 : 465-468

[12] Nageswara Rao, R., Sudhakar, P. Ramesh V.Bhat and Gupta C.P. (1989). A study of recorded cases of Foodborne diseases at Hyderabad during 1984-1985. J.Trop Med Hyg.1989; 92:320- 324.

[13] Patel, J.D., Krishnaswamy, M.A. and Nair, K.K.S. (1976). Biochemical characteristics of some coliforms isolated from spices. Jounal of Food Science Technology, India 13; 37-40.

[14] . Pilizota V, Nedic NT. Advances in Honey Adulteration Detection. Food safety Magazine, The online marketplace for food safety solutions, 2009. ttp://www.foodsafetymagazine.com/ magazinearchive1 /a ugustseptember-2009/advances-in-honey-adulterationdetection/.

[15] Afzal A, Mahmood MS, Hussain L, Akhtar, Masood. Adulteration and Microbiological Quality of Milk (A Review). Pak J Nutrit. 2011; 10(12):1195.

[16] Sonika Sharma, Nikita Goel, Pratibha Paliwal (Bhatele); Evaluation of Adulterants in Food by Different Physico-Chemical Method; International Journal for Scientific Research and Development| Vol. 4, Issue 11, 2017:0613-2321

[17] Abhirami S. and R. Radha; Detection of food adulteration in selected food items procured by homemaker; International Journal of Recent Scientific Research. 6, , 8,.5; 2015:5938-5943.

[18] Sasikumar B, Syamkumar S, Remya R, John Zachariah T. PCR based detection of adulteration in the market samples of turmeric powder. Food Biotechnology. 2005; 18:299-306.

[19]. Acharya, M.R. and Shah, R.K. (1999). Some microbiological and chemical attributes of mango pulp samples. Journal of Food Science Technology. 36(4): pp 339-341.

[20]. The fight against food adulteration, Noel G Coley, RSC, Education in chemistry, Issues, Mar 2005

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 11, Dec 2022

[21]. Shelar MK, Bafna AR, Wahile AM, Suresh VT. Evaluation of edible oils for Argemone mexicana seed oil adulteration. Res. J Pharmaceutical, Biological and Chemical Sciences. 2011; 2(3):927-936.

[22] Babu, S. and Shenolikar, I.S. (1995). Health and nutritional implications of food colours. Indian J. of Medical Research. 102 : 245-249.

[23] Weise, Elizabeth (April 24, 2007). "Food tests promise tough task for FDA". USA Today. Retrieved 2007-04-29

[24] . Koppel E, Stadler M, Luthy J, Hubner P. Detection of wheat contamination in oats by polymerase chain reaction (PCR) and enzyme-linked immunosorbent assay ~ 2573 ~ International Journal of Chemical Studies http://www.chemijournal.com (ELISA). European Food Res. and Tech. 1998; 206:399- 403.

[25] Dhiman B, Singh M. Molecular detection of cashew husk (Anacardium occidentale) adulteration in market samples of dry tea (Camellia sinensis). Planta Medica. 2003; 69(9): 882-884.

[26] Patrizia T, Furlan M, Pallavicini A, Giorgio GN, Vignes Lebbe R. Coffee species and varietal identification. InTools for Identifying Biodiversity: Progress and Problems, 2010, 307-313.

[27] Dhanya K, Syamkumar S, Sasikumar B. Development and application of SCAR marker for the detection of papaya seed adulteration in traded black pepper powder. Food Biotechnology. 2009; 23:97-106.

Current Organic Chemistry, 2023, *27*, 223-241

REVIEW ARTICLE

Synthesis of Oxygen and Nitrogen Containing Heterocycles using Zirconium Dioxide/Mixed Oxide Nanoparticles as Reusable Green Catalysts: A Comprehensive Update

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ARTICLE HISTORY

Received: August 29, 2022
Revised: November 16, 2022
Accepted: December 19, 2022

DOI:
10.2174/1385272827666230106112146

Abstract: The remarkable improvements in organic synthesis facilitated by zirconium dioxide-based nanoparticles are updated and summarized in this review. The ZrO_2 acts as a versatile heterogeneous nanocatalyst and is used in various elementary organic reactions and many multicomponent reactions. The employment of these catalysts in organic synthesis leading to bio-active scaffolds provides the opportunity to carry out the reactions using facile synthetic protocol under mild environments that furnish the equivalent products in high yields and shorter reaction times. According to reports in the literature, ZrO_2-based catalysts were removed from the reaction mixture and recycled many times.

Trimurti L. Lambat

Keywords: Green chemistry, ZrO_2 nanoparticles, heterogeneous nanocatalyst, O & N-heterocycles, bio-active scaffolds, reusable green catalyst.

1. INTRODUCTION

Green synthesis routes have recently attracted significant attention leading to important developments in the fields of click reactions [1] and green chemistry [2-9], with the advances of environmentally and proficient benign protocols [10-15] being in focus. As catalysts, nanoparticles (NPs) demonstrated superiority to conventional catalysts in several aspects relevant to sustainable development [16-18]. Additionally, NPs were extensively investigated for potential use in nanomedicine, particularly for drug delivery [19] and early detection of cancer cells. Mesoporous nanomaterials were also employed for a variety of organic reactions [20]. The high specific area and active surface sites in nanomaterials render these materials more important than their bulk counterparts for a wide range of science and technology applications [21].

Metal oxides are frequently employed as solid catalysts that can either function as the active phase or the supports [22], exhibiting favorable catalytic activity and providing perhaps the largest class of heterogeneous catalysts [23-30]. In addition to metal oxides, metals are also widely employed in chemical synthesis [31-40]. The catalytic activity of transition and noble metals is attributed to the electronic configuration of the outer valence electrons [41]. Further, mixed metal oxides account for many solid catalysts frequently used in the pharmaceutical industry [42, 43].

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Zirconium dioxide (zirconia, ZrO_2) demonstrated efficacy and potential for a number of significant applications, including catalysis, fuel cell electrolytes, buffer layers for superconductor development, oxygen sensors, gate dielectrics, and ceramics wear-resistant optical coatings [44–55]. This oxide can exist in three structural phases, monoclinic, tetragonal, and cubic [56], which exhibit different catalytic activities.

The surface of ZrO_2 NPs [57] can support active hydroxyl groups and oxyanions and contains Zr^{4+} ions, enabling zirconia to function as a dual acid-base catalyst [58]. Even though the employment of ZrO_2 NPs for the preparation of biologically active blocks *via* solvent-free multicomponent reactions was rarely addressed [59, 60], The development of green synthesis methods and research on the synthesis of isatin-based heterocycles were reported. [61-75]. The interesting properties of sulfated zirconia, including its cost-effectiveness, thermal stability, and super acidity, render these materials industrially important for a number of reactions [76]. In addition, zirconia NPs were reported to improve the mechanical properties of ceramics [77] and modify their electrical, thermal, magnetic performance and optical properties [78]. Further, nanoscale zirconia exhibited catalytic activity for the dehydration of alcohols, the selective synthesis of dimethyl carbonate, the selective oxidation of methanol, and redox activity [79-85]. For creating zirconia NPs, several synthesis methods have been used, including but not limited to hydrothermal, sol-gel, chemical vapour deposition (CVD), and sputtering approaches [86-90].

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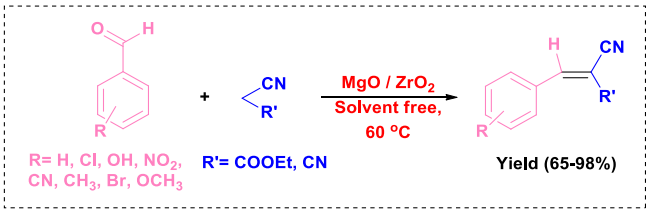
One of the most extensively researched reactions in organic synthesis, organic transformations employing zirconium dioxide/mixed oxides are well displayed on the surface of zirconium dioxide/mixed oxides under various reaction circumstances. Zirconium dioxide/mixed oxides serve an equally significant role in the overall catalyst system used as other heterogeneous catalysts do. We will briefly discuss the use of zirconium dioxide and mixed oxides in this review's synthesis of fine chemicals, organic synthesis, and industrial, and green chemistry.

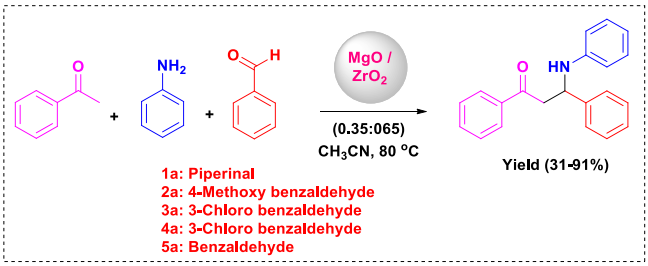
2. SYNTHESIS *VIA* MgO/ZrO_2 AS A CATALYST

Gawande & coworkers [91] in 2006 introduced MgO/ZrO_2 as a novel green catalyst for the Knoevenagel condensation of ethyl cyanoacetate with aromatic aldehydes and malonitrile (Scheme **1**). The structural characterization of the catalyst indicated that the crystallization of the catalyst oxide components is highly dependent on the sintering temperature. X-ray diffraction pattern (XRD) of the catalyst sintered at 600°C revealed the existence of a cubic MgO and a monoclinic ZrO_2 phases, as well as evidence of the presence of a secondary tetragonal ZrO_2 phase. Before utilizing the catalyst in the 60°C, solvent-free processes, the catalyst was ground to a particle size of 0.5 to 0.7 m. The catalyst gave relatively high yields of the products. It exhibited a high degree of recyclability, whereas, in the case of 4-fluoro benzaldehyde, the yield (95%) decreased slightly to 91% after the fifth cycle of reusing the catalyst.



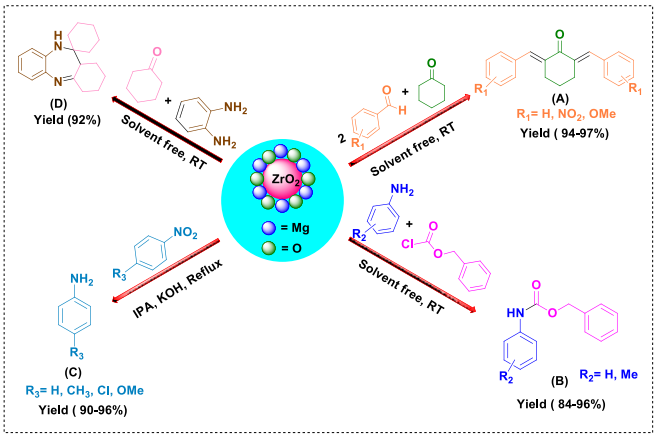
Scheme 1. Knoevenagel condensation of an aromatic aldehyde with ethylcyanoacetate and malononitrile.

In 2010, Nagrik *et al.* [92] described an efficient three-component one-pot condensation of ketones, aldehydes, and amines using MgO/ZrO_2 catalyst for Mannich reaction for the synthesis of *β*-amino carbonyl compounds (Scheme **2**). The yield depended on the ratio of the two oxides in the catalyst, and the highest yield of 91% was achieved at the MgO/ZrO_2 molar ratio of 0.35/0.65. It was demonstrated that the catalyst could be used repeatedly for five runs without significantly losing its catalytic activity.



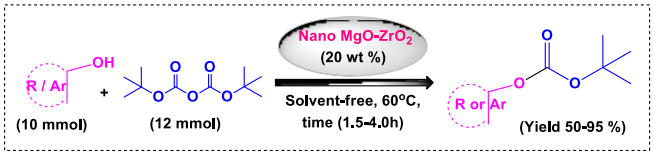
Scheme 2. Synthesis of β-amino carbonyl compound by Mannich reaction *via* MgO/ZrO_2 catalyst.

Later in 2011, Gawande *et al.* [93] have prepared MgO–ZrO_2 (MZ) catalyst by an ultra-dilution method, and tested its versatility for a number of organic reactions (Scheme **3**). The XRD pattern indicated the presence of Monoclinic ZrO_2 and cubic MgO phases in the catalyst. The catalyst provided superior to outstanding yields of the products. For example, it gave 94-97% yield in the cross-aldol condensation of aromatic aldehydes with cyclohexanone, and 84-96% yield in the *N*-benzyloxycarbonylation of amines by using 10 wt.% of the catalyst. According to reports, catalyst weight percentages up to 10% led to an increase in catalytic activity, after which no significant improvement was observed. Also, the catalyst was found to be effective up to six successive cycles of the synthesis of the target products.



Scheme 3. Organic reactions catalyzed by MgO-ZrO_2 **(A)** Cross-Aldol condensation under solvent-free condition, **(B)** N-Benzyloxycarbonylation of amine under solvent-free condition, **(C)** Reduction of aromatic nitro compounds, **(D)** 1,5-benzodiazepine synthesis by using cyclohexanone and orthophenylene diamine**.**

MgO-ZrO_2 NPs were used by Gawande *et al.* [94] in 2012 to establish a straightforward solvent-free chemoselective O-tert-Boc protection of phenols & alcohols. (Scheme **4**). This method's advantages include using a heterogeneous, reusable catalyst, superior chemoselectivity, enhanced substrate compatibility, high reaction rates, operational simplicity, and moderate reaction conditions. The size of the catalyst is in the nano range (20–35 nm), according to the TEM investigation of MgO–ZrO_2 mixed metal oxides. Under solvent-free conditions at 60°C, the reusability of the catalyst was tested for the reaction of phenol with Boc anhydride. The catalyst was filtered out and rinsed twice or three times after the reaction was finished. with ethyl acetate, dried at 120°C in an oven for 3 hours, and then used again for the reaction. Even after six cycles, the catalytic activity reduced marginally.



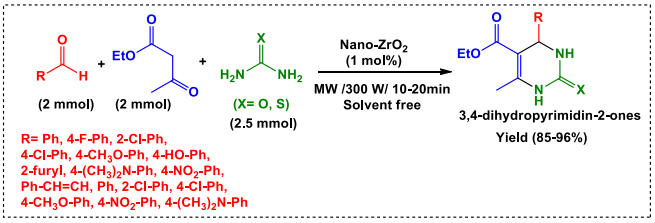
Scheme 4. O-tert-Butoxycarbonylation of phenol by using nano MgO-ZrO_2 catalyst.

3. SYNTHESIS USING ZrO_2 NANOPARTICLE AS A CATALYST

Bhojegowd *et al.* [95] (Zirconium nitrate with alanine were combined in stoichiometric proportions in aqueous solutions to synthesize nano crystalline-ZrO_2.) developed nanocrystalline zirconium (IV) oxide (nc-ZrO_2) with a bulky surface area in 2011 (Scheme **5**). For characterization of nc-ZrO_2, SEM, powder XRD and surface area measurements were used. The powder XRD results show that the nc-ZrO_2 possesses a pure tetragonal phase. The crystallite size and BET surface area computed using Scherrer's formula were determined to be around (53-57 nm) and 275 m^2/g, respectively. SEM image revealed the microporous character of the powder. The synthesis of 3,4-dihydropyrimidin-2-ones was accomplished without solvents in the microwave (MW)-aided multi-component,

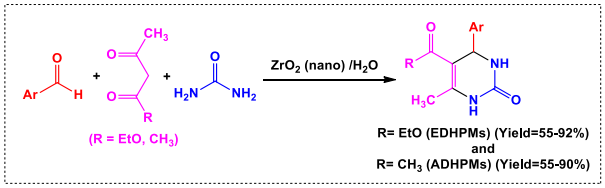
one-pot Biginelli condensation reaction of ethylacetoacetate, aryl aldehydes and urea or thiourea (DHPMs). In this reaction scenario, DHPMs are produced quickly (10–20 minutes) and in good to exceptional yields (85%-96%).

By using repeated filtering, the catalyst may be readily removed from the mixture, repeated washings with distilled water and ethanol, and dried under vacuum for 2-3 hours before re-use. The recycled catalyst was employed five times to get 5-ethoxycarbonyl-4-(phenyl)-6-methyl-3,4-dihydropyrimidin-2(1H)-one with no discernible yield loss. For 1-5 cycles, the yields were 96%, 93%, 93%, 90%, and 89%, respectively; the drop in yield could be attributed to substrate adsorption on active sites. The catalyst was filtered out of the reaction mixture and replenished after each reaction.



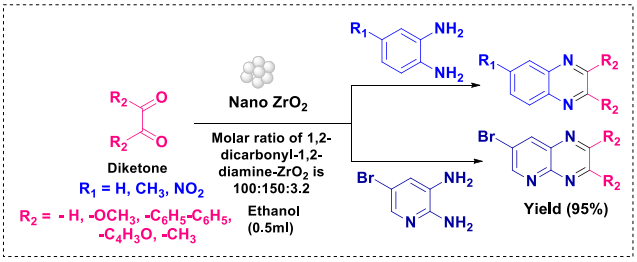
Scheme 5. Synthesis of 3,4-dihydropyrimidin-2-ones by Biginelli condensation of aldehyde, ethylacetoacetate and urea or thiourea using ZrO_2 as a nanocatalyst.

Farhadi *et al.* [96] discovered a simple and efficient one-pot three-component reaction of various aromatic aldehydes, b-keto compounds, and urea in the presence of a catalytic quantity of nano-ZrO_2 catalyst in the presence of water in 2013 (Scheme **6**). The results show that by employing nano-ZrO_2 as a catalyst, several aldehydes may be converted to their corresponding 3,4-dihydropyrimidin-2(1H)-ones in good to exceptional yields, comparable to the $SO4^{2-}/ZrO_2$ catalyst.



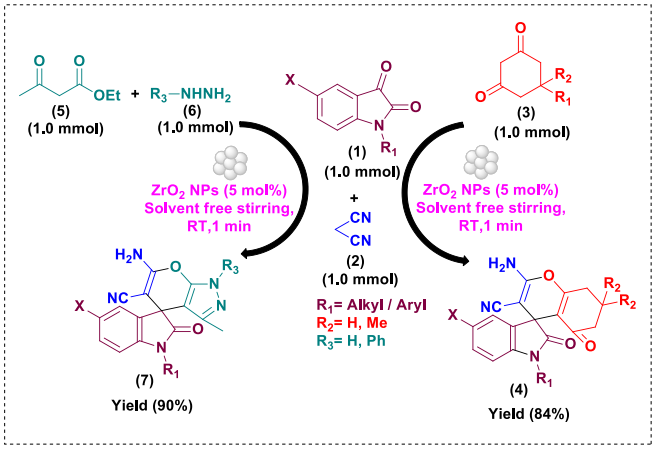
Scheme 6. Nano-ZrO2-catalyzed synthesis of monosubstituted derivatives of 3,4-dihydropyrimidin-2(1*H*)-ones.

In 2014 Jafarpour *et al.* [97] described the synthesis and characterization of monoclinic ZrO_2 nano catalyst using the sol-gel technique. The catalyst was used for the condensation of 1,2-diamines with Quinoxaline and pyridopyrazine heterocyclic compounds may be made using 1,2-dicarbonyl chemicals (Scheme **7**). The catalyst displayed high activity, which also produced products with acceptable to exceptional yields (up to 96%). Without noticeably losing much of its catalytic activity, the catalyst was recycled and utilized for up to five further cycles.



Scheme 7. Synthesis of quinoxaline derivatives and pyrido pyrazines in the presence of m-ZrO_2 nanoparticles in ethanol.

In 2015, Bodhak *et al.* [98] examined the effectiveness of the catalysis using ZrO_2 NPs for the synthesis of multi-functionalized spirooxindole derivatives using two different condensation protocols. They compared the results with reactions performed by using different catalysts and solvents in one-pot multi-component reactions. The study revealed the superiority of zirconia nano catalyst, which provided 84% and 90% yields of spiro[4*H*-pyran-3,3′-oxindoles] and spiro[indoline-3,4′(1*H*′)-pyrano-[2,3-*c*]pyrazol-2-ones in an amazingly short time of 1 min. by using 5 mol.% of the catalyst (Scheme **8**). Only a small increase in the yields (86% and 91%) was seen when using a greater catalyst loading of up to 20 mol%. The study also showed that the catalyst may be used again for up to five runs without substantially reducing activity. The suggested mechanisms of the spirooxindole compounds' formation are demonstratedin Figs. (**1** & **2**) below.



Scheme 8. Synthesis of spiro[4H-pyran-3,3'-oxindoles] (**4**) and spiro[indoline-3,4'(1H')-pyrano-[2,3-c]pyrazol-2-one derivatives (**7**).

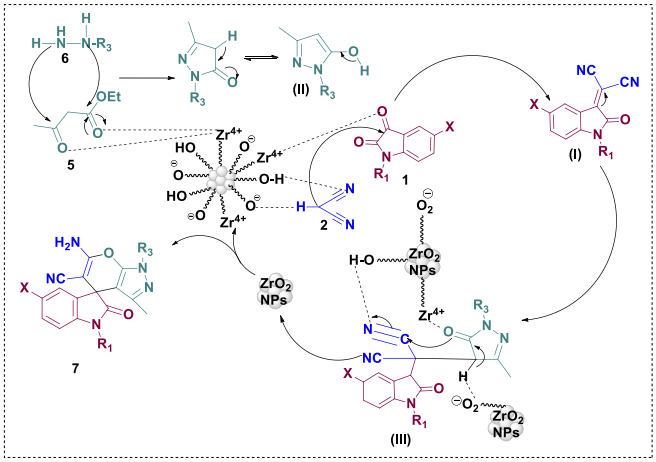


Fig. (1). possible mechanism for the preparation of spirooxindoles (**7**).

At the surface of the ZrO_2 NPs, the hydroxyl, oxide and Zr^{4+} ions enable the NPs to function as a dual acid-base catalyst for the reactions. The reactants are adsorbed at the active sites of the NPs surfaces, leading to a significant increase of the local concentration of the reactants, and resulting in a significant acceleration of the rate of reaction. The catalyst's acid-base properties facilitate the first Knoevenagel condensation of malononitrile (**2**) with isatins (**1**), which leads to the production of the common intermediate (I). Next, intermediate (I) undergoes Michael-type condensation with intermediate (II) to generate the intermediate, and pyrazole intermediate (II) originates in situ from the reaction of ethylacetoacetate (**5**) and hydrazine (**6**). (III). Finally, Intermediate

(III), assisted by the acidic and basic nature of the of the surface sites of the ZrO_2 NPs, undergoes intra-molecular electrophilic cyclization followed by tautomerization, resulting in the formation spirooxindoles (**7**). In a similar fashion, the intermediate (I) undergoes Michael-type addition with the enol form of cyclohexane-1,3-diones (IV), leading to the formation of intermediate (V), which subsequently transforms into spirooxindoles (**4**) assisted by the catalytic activity of the zirconia NPs.

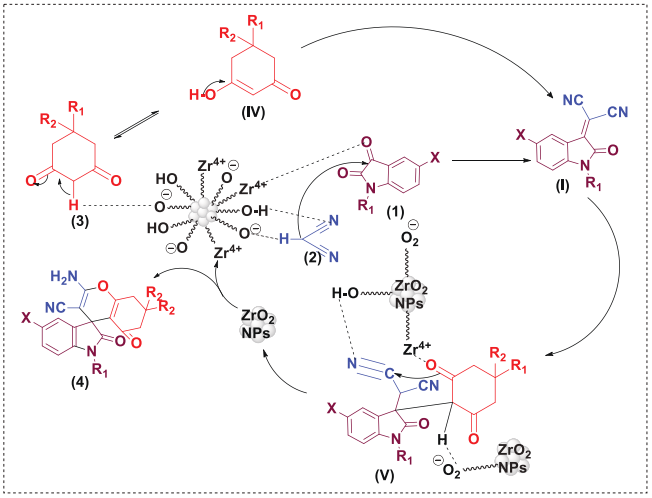
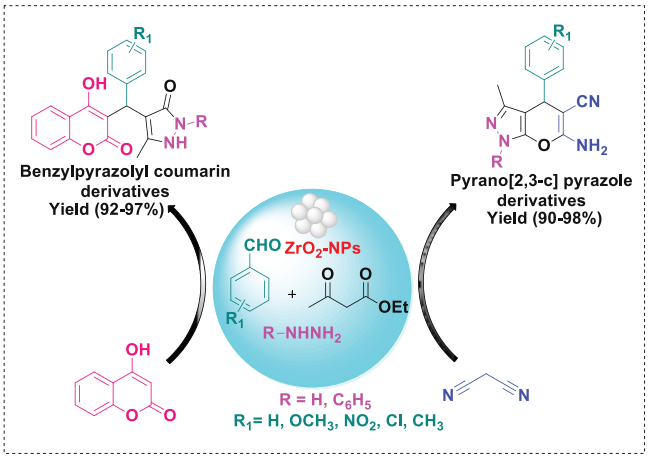


Fig. (2). Probable mechanism for the preparation of spirooxindoles (**4**).

Subhash Banerjee *et al.* [99] and collaborator reported the synthesis of ZrO_2 NPs catalyst with tetragonal symmetry to be used in a synthesis of bioactive pyrano[2,3-c]pyrazole and benzylpyrazolyl coumarin derivatives *via* a one-pot multicomponent reaction at room temp. (Scheme **9**). The authors investigated the effects of experimental conditions, including the catalyst loading, reaction time and solvent, and obtained high yields (92-98%) of the products in 2-10 min. Further, the authors demonstrated the high catalytic of the catalyst even after recycling for up to 10 successive runs. The authors concluded that the catalytic activity of the tetragonal phase of ZrO_2 NPs is higher than that of the monoclinic phase.



Scheme 9. Synthesis of benzylpyrazolyl coumarin and pyrano[2,3-c] pyrazole scaffolds *via* ZrO_2 NPs as a catalyst.

The active hydroxyl, oxide, and Zr^{+4} ions bound to the surface of the ZrO_2 NPs enable their dual activity as Lewis acids or bases, which is how the ZrO_2 NPs play a part in the MCR for the synthesis of pyrano[2,3-c]pyrazoles. In (Fig. **3**), a potential pathway for the production of pyranopyrazole derivatives aided by ZrO_2 NPs is shown. First, pyrazolone (I) and 2-phenylidenemalononitrile (II) intermediates are simultaneously formed by cyclo-condensation and Knoevenagel reaction, respectively, promoted by the ZrO_2 NPs (Fig. **3**). The activation of (I) by the Lewis basic (O) sites of the NPs leads to the formation of these two intermediates, which subsequently undergo Michael type addition to yield the enolate intermediate (III). Lastly, the NPs' Lewis acidic and basic sites help promote intramolecular electrophilic cyclization and tautomerization, which results in the required pyrano[2,3-c]pyrazole derivative. The manufacture of pyrano[2,3-c]pyrazole utilizing a step-by-step process, where the precursors (I) and (II) were synthesized individually from the corresponding starting materials *via* ZrO_2 NPs as a catalyst, allowed the authors to demonstrate the viability of the proposed mechanism. The resulting reaction of these two precursors in the presence of ZrO_2 NPs produced the required pyrano[2,3-c]pyrazole derivative, supporting the viability of the proposed process.

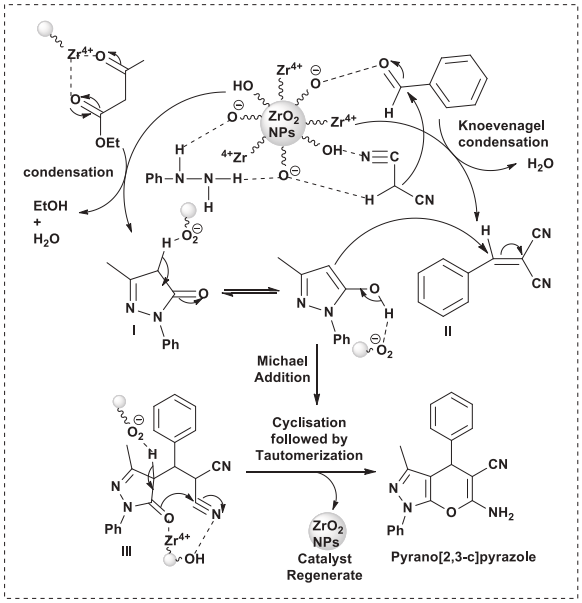
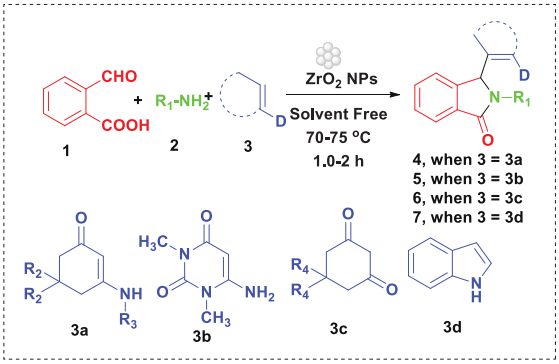


Fig. (3). probable mechanism for ZrO_2 NPs-catalyzed synthesis of 6-amino-3-methyl-1,4-diphenyl-1,4-dihydro-pyrano[2,3-c]pyrazole-5-carbonitrile.

A straightforward one-pot three-component reaction catalyzed by ZrO_2 NPs in solvent-free conditions was introduced by Debnath *et al.* [100] for the synthesis of multi-functionalized 2,3-disubstituted isoindoline-1-ones. The active surface sites of the ZrO_2 nanoparticles facilitating the dual acid-base functionality of the catalyst were reported to be efficient in the condensation of 2-carboxybenzaldehyde, aliphatic amines and nucleophile (enamines/6-amino 1,3-dimethyluracil/1,3- cyclohexadiones/ indole) to produce 2,3-disubstituted isoindoline-1-ones with high yields (Scheme **10**). The reported additional advantages of the adopted methodology include simplicity, short reaction time and low temperature, avoiding the use of hazardous solvents, wider substrate scope, and the recyclability of the catalyst for successive cycles of the reaction.

In the presence of ZrO_2 NPs in solvent-free conditions, the authors postulated a likely mechanism for the synthesis of the isoindoline-1-one derivatives 4-7 (Fig. **4**). The active sites on the surface of the ZrO_2 NPs, which function as a dual acid-base catalyst, have been suggested by other researchers in the discussion above as an aid to condensation processes. The 2-carboxybenzaldehyde (1) and aliphatic amines (2) are condensed to produce intermediates in a

first step in which the Zr^{4+} ion at the surfaces of the NPs functions as a potent Lewis acid acceptor and triggers the carbonyl group (**8**). The intermediate is then created *via* a Michael-type addition involving (**8**) and the nucleophile (**3**) that is catalysed by ZrO_2 NPs (**9**). To produce the end products, the intermediate (**9**) is then made easier to cyclize and tautomerize intramolecularly by the acidic and basic sites of ZrO_2 NPs (isoindoline-1-ones).



Scheme 10. Synthesis of multi–functionalized isoindoline-1-one derivatives (**4-7**).

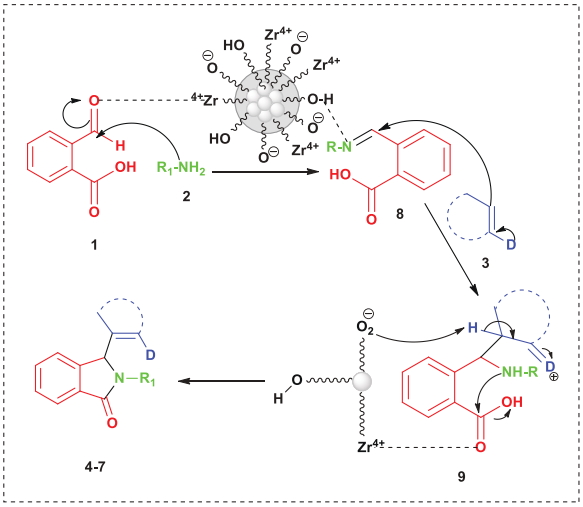
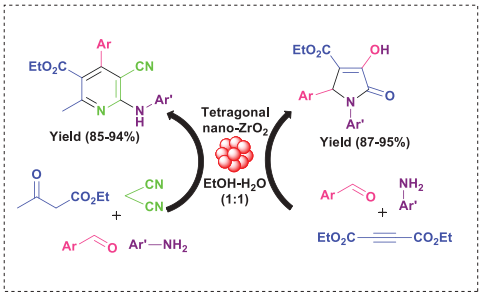


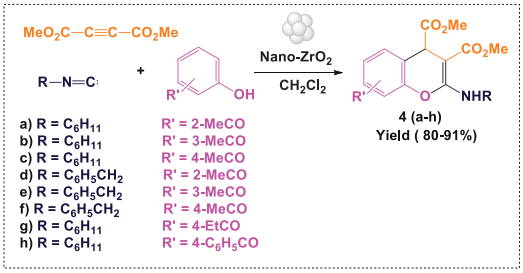
Fig. (4). A probable mechanism for the formation of isoindoline-1-one derivatives.

Saha *et al.* [101] in 2016 further explored the catalytic activity of tetragonal *t*-ZrO_2 NPs for the synthesis of poly-substituted 6-arylamino pyridines and 2-pyrrolidone derivatives (Scheme **11**). The authors reported a high yield of the products, and the recyclability of the catalyst revealed a small reduction of the yield (92% to 83%) after eight successive runs using the recycled catalyst.



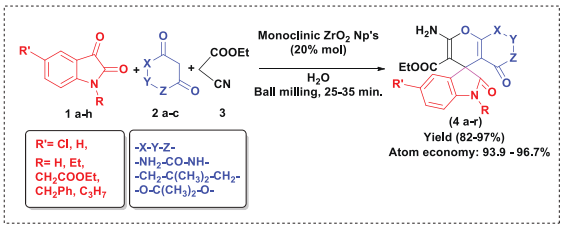
Scheme 11. Tetragonal nano-ZrO_2 catalyzed synthesis of functionalized pyridine and 2-pyrrolidinone derivatives.

In order to synthesise novel functionalized chromenes, Zonouzi *et al.* [102] developed a fresh, succinct, and effective procedure (Scheme **12**). ZrO_2 nanoparticles with a specific surface area of 25 m^2/g (100 nm particle size (TEM), d = 5.89 g/Lit) substantially altered and regulated the reaction's pathway. The anticipated findings, indenes, were not generated; rather, chromene derivatives were.



Scheme 12. Preparation of some new 2-amino-4H-chromenes using nano-sized zirconium oxide.

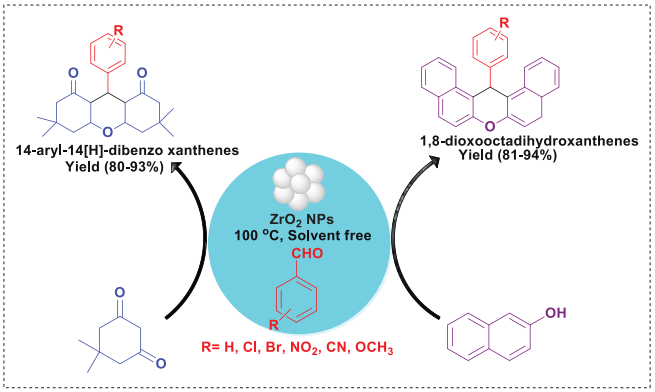
On the other hand, Bajpal *et al.* [103] reported an efficient green protocol for employing a monoclinic m-ZrO_2 NPs catalyst in a multicomponent reaction of isatin derivatives with ethyl cyanoacetate and 1,3-dicarbonyl compounds in a ball mill to create substituted spirooxindoles (Scheme **13**). The approach was put out as a workable synthesis strategy for industrial-scale manufacturing in medicinal chemistry. Under ideal reaction circumstances, the reusability of the m-ZrO_2 NPs was investigated. The catalyst showed good catalytic activity in subsequent reactions up to 10 runs, at which point the yield marginally dropped from 97% to 90%. It was also reported that calcination of the recycled catalyst at 750°C after washing and drying resulted in an improvement of the yield (from 90% in the 9th cycle to 95% in the 10th cycle).



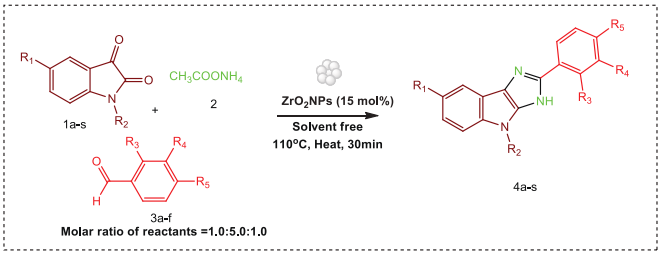
Scheme 13. Synthesis of Spirooxindole using m-ZrO_2 NPs catalyst by Ball milling method.

Recently, Bansal *et al.* [104] also used ZrO_2 NPs catalyst for effective solvent-free one-pot synthesis of biologically active xanthene derivatives (Scheme **14**). For this purpose, the co-precipitation technique prepared tetragonal t-ZrO_2 NPs with sizes in the range of 8-11 nm and average pore size of ~ 3 nm. Xanthene derivatives were achieved with high yields (80-94%) within 16-33 min. by the use of a *t*-ZrO_2 nanocatalyst. The catalyst was demonstrated high yielding up to four additional runs.

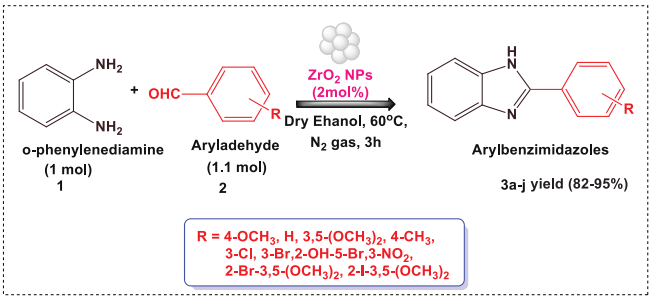
Singh and his coworker [105] in (2019) developed an ecologically friendly and highly effective approach for the synthesis of modified imidazoles employing a multicomponent reaction of isatin derivative products with ammonium acetate and aromatic aldehydes under solvent-free conditions. (Scheme **15**). Because of the cheap and widely available starting materials, easy methodology, and bioactive nature of imidazoles, this strategy is beneficial to medicinal chemistry. Due to the presence of various m- and t-phases in the sample, some aggregation of the NPs can be seen in the TEM micrograph of the sample. After each reaction, the catalyst was filtered, washed, air-dried, and reused for the next reaction up to run number ten. The study revealed that there is no discernible loss in product yield during subsequent reuse, demonstrating ZrO_2 NPs' reusability and recyclability.



Scheme 14. Synthesis of 14-aryl-dibenzo xanthenes and 1,8-dioxooctadihydroxanthenes by using ZrO_2 NPs.



Scheme 15. Nano ZrO_2 catalyzed synthesis of imidazole derivatives.



Scheme 16. Nano ZrO_2 catalyzed synthesis of 2-aryl benzimidazoles.

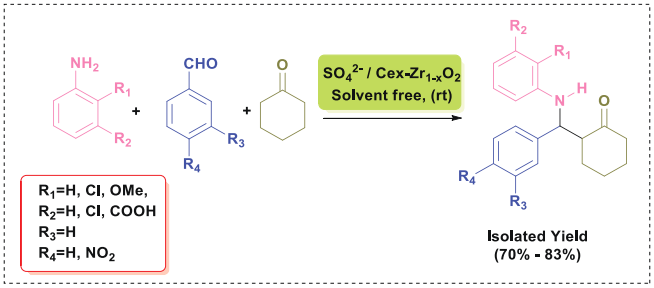
Recently, a zirconia-based nano-catalyst (Nano-ZrO_2), with intermolecular C-N bond formation for the synthesis of various benzimidazole-fused heterocycles in a concise method is reported by Rao *et al.* [106] (Scheme **16**). The robustness of this reaction is demonstrated by the synthesis of a series of benzimidazole drugs in a one-pot method. More importantly, the nano-ZrO_2 catalyst showed excellent recyclability of up to five cycles in dry ethanol.

To check the reusability of nano-ZrO_2, when the reaction of o-PDA (ortho-Phenylenediamine) with various substituted aromatic aldehydes was over, the product formed was extracted with ethyl acetate and the catalyst was purified. It was washed with ethyl acetate repeatedly, dried, and reused for the reaction of o-PDA with various aryl aldehydes.

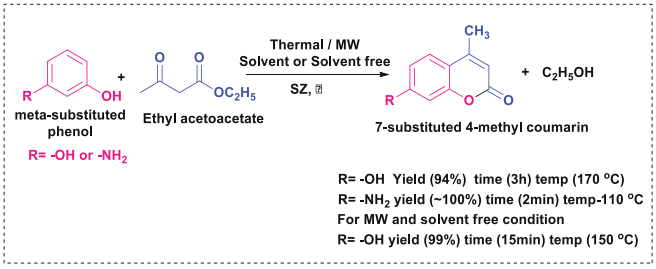
4. SYNTHESIS USING CRYSTALLINE NANO-SULFATED-ZIRCONIA (SZ) AS A CATALYST

Reddy *et al.* [107] invented the synthesis of an interesting solid super-acidic $SO_4^{2-}/Ce_xZr_{1-x}O_2$ catalyst by co-precipitation of cerium ammonium nitrate and zirconium nitrate to produce cerium and zirconium hydroxide gel, which was subsequently added with H_2SO_4 to impregnation the sulfate ions on the Ce-Zr hydroxide surface. In the three-component Mannich-type reactions at room temperature without using solvents, the sulfated $Ce_xZr_{1x}O_2$ catalyst demonstrated significant catalytic activity and produced product yields ranging from 72% to 83%. (Scheme **17**).

Tyagi *et al.* [108] described employing a nano-crystalline sulfated-zirconia catalyst made using the sol-gel method and calcining it at 600°C to produce coumarin derivatives. The sulfated zirconia catalyst's XRD pattern showed a purely tetragonal crystalline phase with nano-crystallite sizes between 9 and 16 nm. The catalyst has high catalytic activity for the solvent-free Pechmann reaction's production of 7-substituted 4-methyl coumarins (Scheme **18**). The authors reported higher reactivity of *m*-aminophenol compared to *m*-hydroxy phenol, where 100% conversion of *m*-aminophenol with ~100% selectivity of 7-amino 4-methyl coumarin was obtained at 110°C within 2 min. On the other hand, 94% yield of 7-hydroxy 4-methyl coumarin was obtained after 3 h at 170°C using a phenol-to-catalyst weight ratio of 80. Compared to thermal heating, where the slow diffusion rate of the reactant molecules in polar nitrobenzene and non-polar toluene solvents resulted in slow kinetics of the reaction, the authors concluded that the solvent-free microwave-assisted synthesis of the hydroxy derivative is an advantageous alternative which provides an excellent yield of 99% in a much shorter time of 15 min at a lower temperature (150°C). The reported synthesis of coumarins is economically feasible, since small amounts of sulfated-zirconia catalyst were required, and the activated catalyst was reusable for several successive runs (up to six cycles).



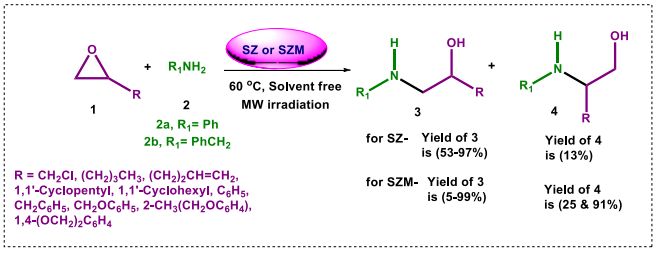
Scheme 17. $SO_4^{2-}/Ce\text{-}Zr_{1-x}O_2$ catalyzed three-component Mannich-type reactions.



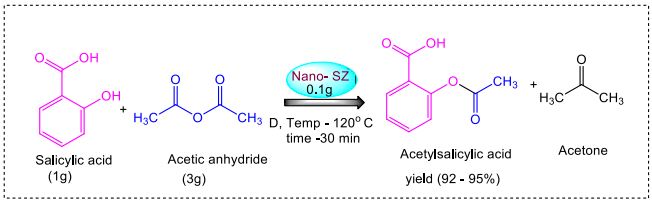
Scheme 18. Synthesis of 7-substituted 4-methyl Coumarin by Pechmann reaction using nano crystalline sulfated- Zirconia (SZ) as a catalyst.

Negron-Silva *et al.* [109] described a solvent-free approach for the regioselective synthesis of *β*-amino alcohols using sulfated zirconia (SZ) and sulfated zirconia over MCM-41 (SZM) as catalysts (Scheme **19**). The employment of microwaves in the synthesis reduced the time significantly and improved the yield compared to conventional heating. The catalysts were recovered and reactivation at 550°C for 1 h, and subsequently reused for at least three successive cycles without a significant decrease in the yield and regioselectivity. The results of the study revealed that reactivating of the SZ catalyst resulted in the development of a secondary monoclinic phase along with the original tetragonal phase. However, the authors reported evidence that the reactivation of SZM destroyed the MCM-41 phase, and concluded that the sulfated zirconia drove the catalytic activity, be it tetragonal or monoclinic.

Tyagi *et al.* [110] in 2010 used solid acid catalysts such as nano-crystalline sulfated zirconia, sulfated titania, zeolite H-beta, H-Y, H-ZSM-5, and acid-treated K-10 clay to synthesize acetylsalicylic acid, often known as aspirin or Ecotrin, in an environmentally friendly way (Scheme **20**). The tetragonal phase of sulfated zirconia was discovered to have a crystallite size of 11 nm. Nano-crystalline sulfated zirconia had the highest catalytic activity of all the solid acid catalysts examined and was shown to be efficient in a small amount to produce an excellent yield (95 wt percent) of acetylsalicylic acid crystals. The yield of the thermally regenerated catalyst was comparable to that of the fresh catalyst. After washing with acetone, drying at 110°C for 2 hours, and activation at 450°C for 2 hours, the spent sulfated zirconia catalyst was recovered from the reaction mixture and reused under comparable reaction conditions. Until the fifth reaction cycle, a thermally regenerated catalyst gave the same yield of acetylsalicylic acid as the fresh catalyst.

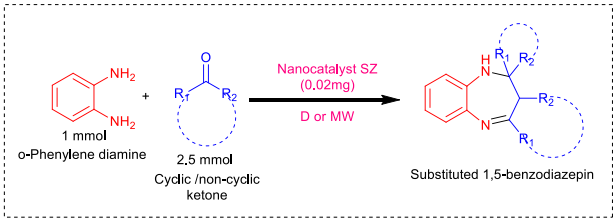


Scheme 19. Ammonolysis of Oxirane using sulfated Zirconia (SZ) and Sulfated Zirconia over MCM-41 catalyst (SZM).



Scheme 20. Synthesis of acetyl salicylic acid by O-acetylation of salicylic acid with acetic anhydride over solid acid catalyst.

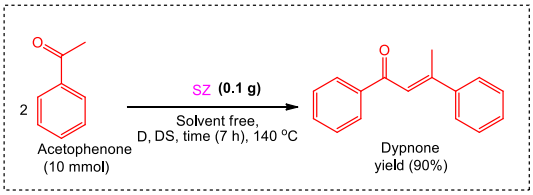
Gondaliya *et al.* [111] also employed sulfated ZrO_2 NPs catalyst for the synthesis of 1,5-benzodiazepine derivatives by conventional and microwave-assisted protocols (Scheme **21**). The catalyst was prepared by the sol-gel method and heat treatment at 600°C, and the structural analysis indicated a structural transformation from the monoclinic phase of the un-sulfated zirconia to the triclinic phase. The conventional heating method provided high yields of the products in 40-50 min, whereas the microwave-assisted method provided the yields in a much shorter time of 2-4 min. Also, the catalyst was reusable for 3-4 successive reactions.



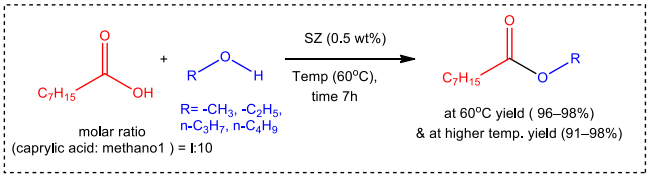
Scheme 21. Synthesis of 1,5-benzopdiazepine derivatives using Sulfated-Zirconia as a nanocatalyst in solvent-free conditions by conventional and microwave methods.

Saravanan *et al.* [112] investigated the solvent-free self-condensation of acetophenone to dypnone using a Nano-crystalline sulfated zirconia catalyst produced by a two-step sol-gel technique (Scheme **22**). The catalyst had a maximum dypnone selectivity of 92 percent and 68.2 percent acetophenone conversion at 170°C after 7 hours of calcination at 650°C. The used SZ-650 catalyst was recovered from the reaction mixture, properly washed with acetone, and dried at 120°C overnight before being re-used for another reaction cycle under comparable reaction conditions to investigate its reusability.

Saravanan *et al.* [113] examined the catalytic activity of a nano-crystalline sulfated zirconia catalyst produced by the sol-gel process. They described using various analytical techniques for the esterification of caprylic acid with various short-chain alcohols (Scheme **23**). At 60°C, the lower catalyst concentration (0.5wt%) resulted in 96–98% caprylic acid conversion with methanol and 100% selectivity for methyl caprylate. At 60°C, conversion decreased with increasing carbon chain lengths of alcohols, such as ethanol, n-propanol, and n-butanol, but increased dramatically (91-98 percent) at higher temperatures. Due to the water generated during the reaction, the catalyst's activity dropped marginally with each of the next five reaction cycles. To test the catalyst's reusability, it was extracted from the reaction mixture, washed with methanol, dried, and activated at 45°C for 2 hours before being employed in another reaction cycle.



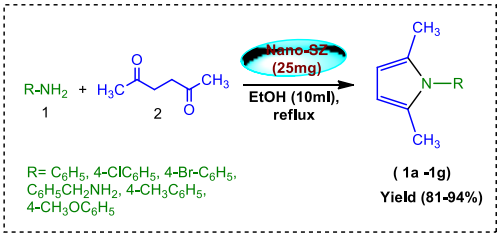
Scheme 22. Synthesis of dypnone by self-condensation of ACP over sulfated zirconia catalyst using Dean-Stark (DS) apparatus



Scheme 23. Esterification of caprylic acid with various alcohols using nano-sulfated zirconia as a catalyst.

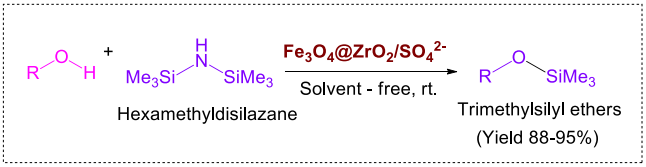
Abbas *et al.* [114] devised a novel and effective one-pot green synthesis method for producing Pyrrole by using Sulfated Zirconia as a solid acid nano crystalline catalyst in ethanol as a solvent at moderate temperature Scaffold from the Paal-Knorr condensation reaction (Scheme **24**). The advantages of this unique procedure are easy availability, stability, reusability, catalyst eco-friendliness, high to exceptional yield, and simple experiment setup.

After the reaction was completed, the catalyst was separated by filtering, washed three times with 5 mL acetone, then rinsed numerous times with doubly distilled water before being dried at 110°C. The recovered catalyst was then utilized in the following run. Three successive runs revealed that the catalyst may be reused multiple times without losing significant activity.



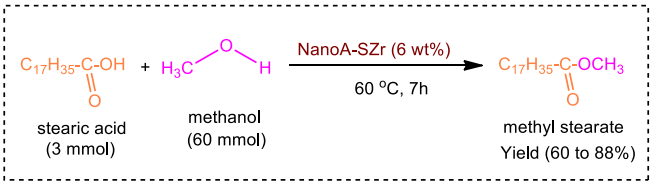
Scheme 24. Synthesis of N-substituted pyrrole derivatives by the condensation reaction of 2,5-hexandione with aromatic amine using sulfated zirconia as a nanocatalyst.

Ghafuri *et al.* [115] discovered that nanomagnetic sulfated zirconia (Fe_3O_4@ZrO_2/SO_4^{2-}) can be employed as a magnetic solid acid catalyst for the conversion of alcohols to their corresponding trimethylsilyl ethers using hexamethyldisilazane (HMDS) at ambient temperature and in a solvent-free environment (Scheme **25**). This process has a number of advantages, including a simple set-up method, quick reaction times, high product yields, and facile catalyst recovery and reusability.



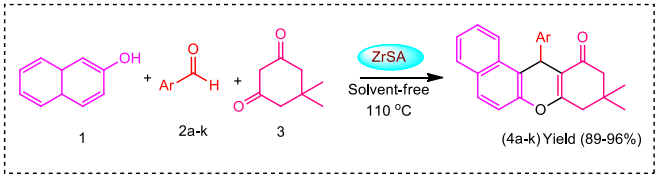
Scheme 25. Fe_3O_4@ZrO_2/SO_4^{2-} catalyzed silylation of alcohols using HMDS.

Saravanan *et al.* [116] used the sol-gel method to make a sulfated aerogel zirconia (A-SZr) solid acid catalyst, which was then supercritically dried in the n-propanol solvent (Scheme **26**). Under the same reaction conditions, the A-SZr catalyst showed higher activity than other heterogeneous acid catalysts such as ion-exchange resins, Nafion, and acid clay; it also showed similar activity with conventional Brönsted (H_2SO_4) and Lewis ($ZrOCl_2$) acids, emphasizing its potential to replace homogeneous acid catalysts.



Scheme 26. Esterification of stearic acid with methanol using Aerogel sulfated zirconia as a nanocatalyst.

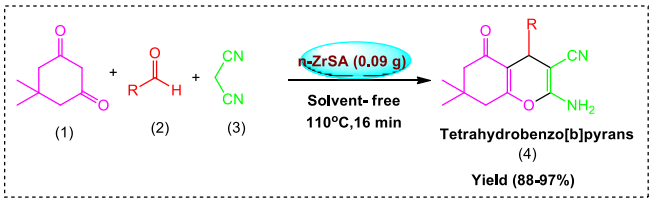
The catalytic effect of Zirconia Sulfuric Acid (ZrSA) nanoparticles, which are formed *via* the combination of ZrO_2 with chlorosulfonic acid, was examined in the production of tetrahydrobenzo[a]xanthene-11-ones by a one-pot three-component reaction of -naphthol, aromatic aldehydes, and dimedone by Nakhaei *et al.* [117] (Scheme **27**). Several reaction conditions were examined in the presence of ZrSA nanoparticles as catalysts. The findings revealed that ZrSA has a strong catalytic activity for the synthesis of tetrahydrobenzo[a]xanthene-11-ones, with high yields of the desired products. The catalyst was also recyclable, implying it could be reused at least three times without losing its catalytic activity. Overall, this innovative catalytic technique for the synthesis of tetrahydrobenzo[a]xanthene-11-ones avoids the use of hazardous organic solvents and offers rapid access to the required compounds under solvent-free conditions at 110°C following a simple workup procedure.



Scheme 27. ZrSA catalyzed synthesis of tetrahydrobenzo[*a*]xanthene-11-ones.

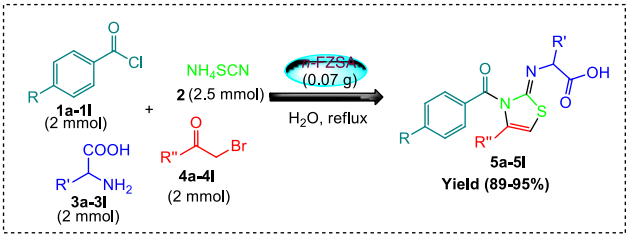
Nakhaei *et al.* [118] investigated the use of n-ZrSA to catalyze the synthesis of tetrahydrobenzo[b]pyrans from dimedone, aldehydes, and malononitrile in a one-pot, three-component reaction at 110°C under solvent-free conditions (Scheme **28**). The procedure was quick and high yielded, and the set-up was simple. After easy handling, the catalyst can be recycled and reused at least four times without losing its catalytic activity. The technique is also favorable in that it is a quick reaction in a solvent-free environment making it ecologically benign.

After the transformation was completed, the catalyst was filtered through a sintered glass Büchner funnel under heated temperatures. A small amount of hot ethanol was used to wash the catalyst. The combined filtrate was allowed to cool to room temperature before being used. Filtration was used to recover the precipitated solid, which was then recrystallized from ethanol to produce high quantities of tetrahydrobenzo[b]pyrans.



Scheme 28. ZrSA nanoparticles catalyzed synthesis of tetrahydrobenzo[*b*]pyrans.

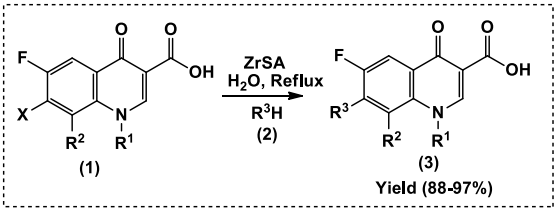
Nakhaei *et al.* [119] synthesized a Fe_3O_4 magnetic core with a zirconia shell containing sulfonic acid groups (Fe_3O_4@ZrO_2–SO_3H) that were employed as an efficient acidic catalyst in the synthesis of thiazole derivatives from acyl chloride, ammonium thiocyanate, amino acids, and alkyl bromides. In the production of thiazole derivatives, Fe_3O_4@ZrO_2–SO_3H showed strong catalytic activity (Scheme **29**)**.** After refluxing and a simple workup procedure, this innovative catalytic approach for thiazole derivatives allowed rapid access to the target chemicals in high yields in aqueous media. The new process for synthesizing thiazole derivatives is a major advance above what is already available. The catalyst could be utilized at least four times without losing its effectiveness (96, 95, 94, 94%). An external magnet was used to extract the catalyst, which was then washed in hot ethanol (10 mL). The mixture was kept at room temperature after half of the solvent was evaporated. The precipitated solid was filtered out and recrystallized from ethanol to obtain the corresponding product.



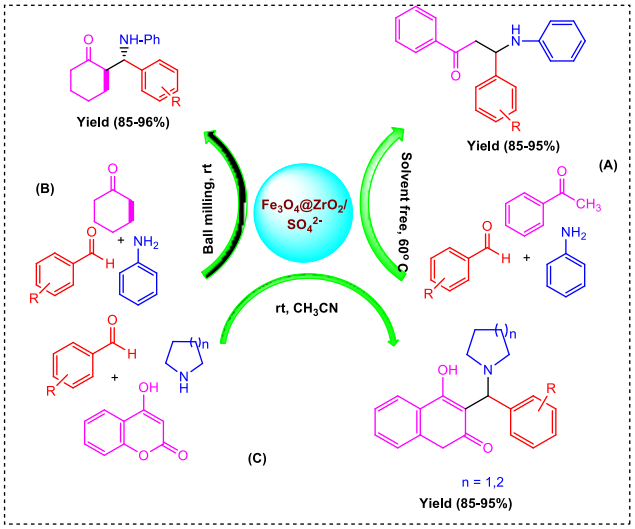
Scheme 29. Synthesis of thiazole derivatives in the presence of n-FZSA.

Nakhaei *et al.* [120] synthesized a variety of antibacterial fluoroquinolone compounds by amination of 7-halo-6-fluoroquinolone-3-carboxylic acids with a variety of piperazine derivatives and (4aR,7aR)-octahydro-1H-pyrrolo[3,4-b] pyridine in the presence of ordinary or magnetized water (Water treated with a magnetic field, often known as (magnetised water acting as green solvent) under reflux conditions (Scheme **30**). ZrSA has high catalytic activity in the formation of fluoroquinolone derivatives in two different types of water, according to the findings. On the other hand, the magnetized water functioned better. The catalyst was also recyclable, implying it could be reused at least three times without losing any catalytic activity. Overall, this innovative catalytic technique for synthesizing fluoroquinolone derivatives allows for rapid access to the necessary compounds in refluxing water after a simple workup procedure while avoiding hazardous organic solvents.

Ghafuri *et al.* [121] devised an efficient Mannich-type reaction technique for the production of β-amino carbonyl compounds and benzylamino coumarin derivatives in high yields (Scheme **31**). The research is divided into two parts. β - Amino carbonyl derivatives were produced in a solvent-free environment in the first section. At room temperature, benzylamino coumarin compounds were produced in the other part. Short reaction periods, low cost, easy workup, mild reaction conditions, excellent yields, ease of recovery and reusability of the catalyst with five runs without considerable loss of activity are all advantages of the current technique.

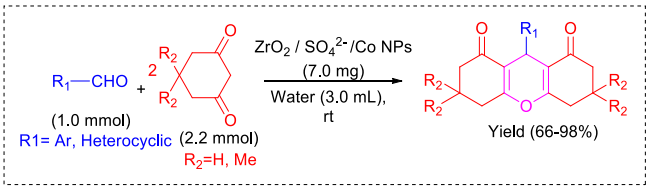


Scheme 30. Synthesis of fluoroquinolone derivatives in the presence of ZrSA under refluxing ordinary or magnetized water.



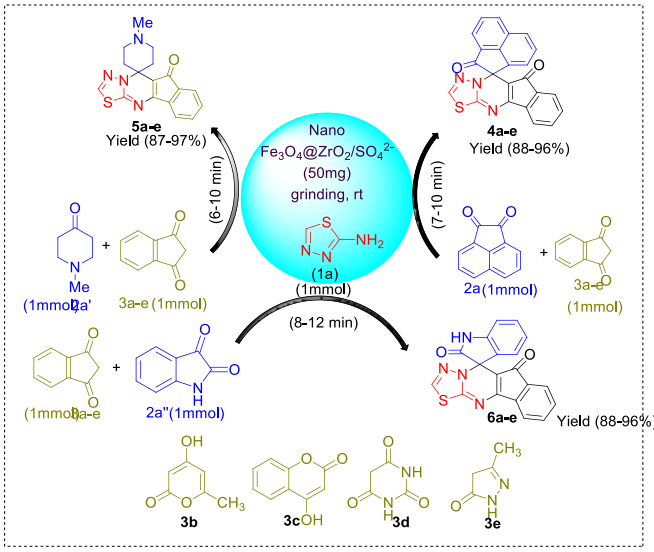
Scheme 31. Synthesis of β - amino carbonyl derivatives through Mannich reaction of various (**A**) aldehydes with aniline and acetophenone catalyzed, (**B**) aldehydes, anilines and cyclic ketones (**C**) aldehydes, amines and 4 hydroxycumarin catalyzed by $Fe_3O_4@ZrO_2/SO_4^{2-}$.

Nasseri and co-authors [122] prepared sulfated zirconia incorporated with cobalt (ZrO_2/SO_4^{2-}/Co) as a catalyst for the synthesis of 1,8-dioxo-octa-hydro xanthene derivatives using a one-pot multicomponent reaction under mild conditions (Scheme **32**). The catalyst consisted of both monoclinic and tetragonal phases with a mean size of 13 nm. The adopted methodology revealed a wide scope for the condensation of aldehydes bearing different functional groups with dimedone and/or 1,3-cyclohexadione in water at room temperature and gave good-to-high yields in short reaction times. The catalyst was recovered and efficiently reused several times (at least eight consecutive runs) without appreciable loss of its activity.



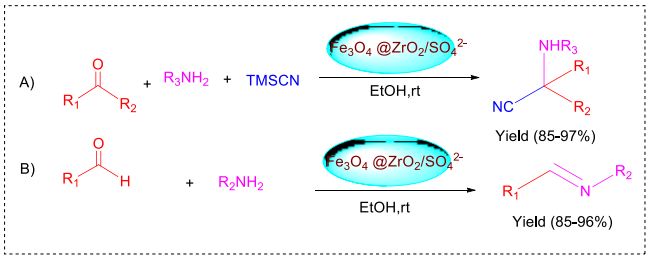
Scheme 32. Synthesis of 1,8-dioxo-octahydroxanthene catalyzed by ZrO_2/SO_4^{2-}/Co NPs.

Tailor *et al.* [123] described a multicomponent reaction of 2-amino-1,3,4-thiadiazole, isatin/N-methyl-4-piperidone/ 1,2-acenaphthylenedione and carbonyl compounds for the synthesis of spiroheterocycles spiroannulated with 1,3,4-thiadiazolo[3,2-a]pyrimidine (Scheme **33**). The reaction was carried out by solvent-free grinding at room temperature, and catalysed by magnetite-supported nanocrystalline sulfated zirconia ($Fe_3O_4@ZrO_2/SO_4^{2-}$), which is magnetically recoverable for further use. The cubic (magnetite) and tetragonal (SZ) phases were confirmed by XRD. The synthesis route was environmentally benign and gave excellent yields of products. The yields did not decrease appreciably when the recovered catalyst was used for five successive cycles (only 4% decrease was reported after the 5th cycle).



Scheme 33. Synthesis of spiroheterocycles spiroannulated with 1, 3, 4-thiadiazolo[3, 2-a]pyrimidine.

In 2015, Ghafuri *et al.* [124] prepared sulfated zirconia supported on magnetic nanoparticles and its catalytic activity was investigated in one-pot three-component green synthesis of α -aminonitriles using various aldehydes and ketones at room temperature in ethanol (Scheme **34**). This protocol has various advantages: simple work-up, short reaction time, high product yields and easy recovery and reusability of the catalyst up to five times without any considerable loss of catalytic activity. The TEM and SEM micrographs showed a homogeneous structure of $Fe_3O_4@ZrO_2/SO_4^{2-}$ with Fe_3O_4 core and average particle size of about 30 and 25 nm, respectively. The authors suggested a mechanism for the formation of α -aminonitriles (Fig. **5**). According to this mechanism, $Fe_3O_4@ZrO_2/SO_4^{2-}$ catalyzes the *in situ* formation of the imine intermediate by activating the oxygen atom of the carbonyl group. In the presence of the catalyst, the imine carbon is attacked by cyanide to give the product.



Scheme 34. The Strecker reaction of carbonyl compounds and amines with TMSCN catalyzed by Fe_3O_4 $@ZrO_2/SO_4^{2-}$(**A**), synthesis of imines by Fe_3O_4 $@ZrO_2/SO_4^{2-}$ (**B**).

In addition, Ghafuri *et al.* [125] also synthesized the magnetite-supported SZ (Fe_3O_4@ZrO_2/SO_4^{2-}) catalyst, which was used for the synthesis of α-aminonitriles derivatives in Kabachnik-Fields reaction (Scheme **35**). The catalyst gave good to excellent yields of the products and was successfully recovered and reused for 5 subsequent reactions without appreciable loss of its catalytic activity. The authors provided a proposed mechanism for the synthesis of α-aminophosphonate using the Fe_3O_4@ZrO_2/SO_4^{2-} catalyst (Fig. **6**). They suggested that the catalyst facilitates the formation of imine intermediate by activating the carbonyl group. Subsequently, the carbon of imine is attacked by phosphite leading to the formation of the desired product.

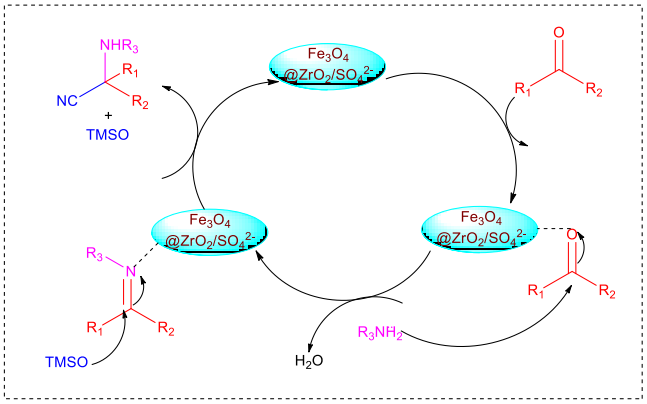
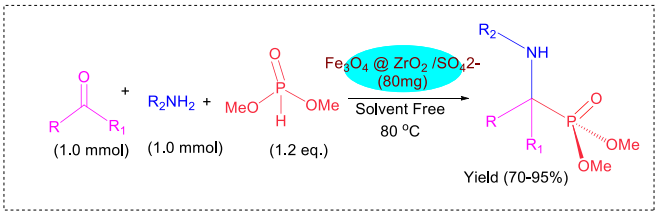


Fig 5. A plausible mechanism for the synthesis of α-aminonitriles catalyzed by Fe_3O_4@ZrO_2/SO_4^{2-}.



Scheme 35. Kabachnik-Fields reaction catalyzed by magnetite-supported sulfated zirconia (Fe_3O_4 @ZrO_2/SO_4^{2-}).

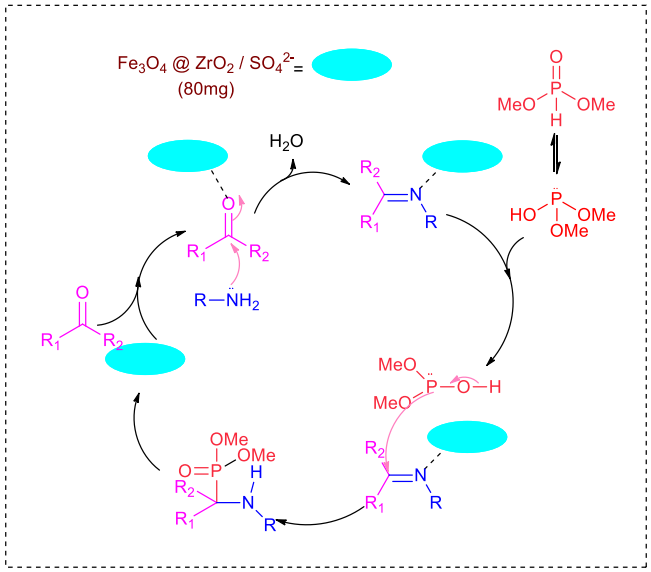
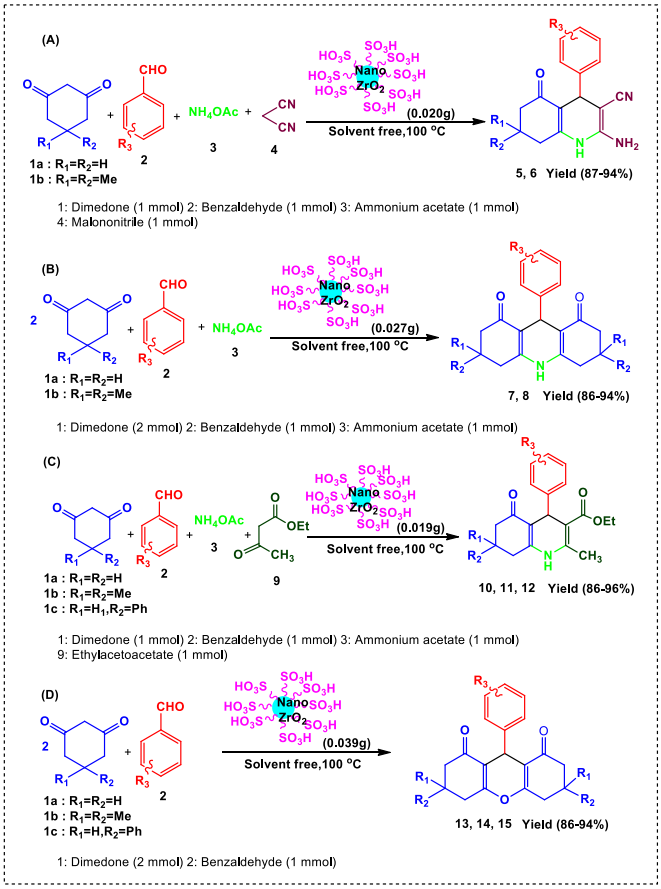


Fig (6). The proposed mechanism of the Kabachnik-Fields reaction in the presence of a Fe_3O_4@ZrO_2/SO_4^{2-} catalyst.

In 2016, Amoozadeh *et al.* [126] synthesized the heterogeneous acidic ZrO_2-SO_3H nanocatalyst (35-40 nm) for organic synthesis. The catalyst efficiently provided high yields of hexahydroquinoline, 1,8-dioxo-octahydroacridine, polyhydroquinoline, and 1,8-dioxo-octahydroxanthene derivatives (Scheme **36**). The reactions were carried out under solvent-free conditions at 100°C using the one-pot multicomponent protocol. The catalyst (ZrO_2-SO_3H) was recovered and reused for 5 successive reactions and showed only a slight decrease in the yield from 94% to 90% in a typical reaction.



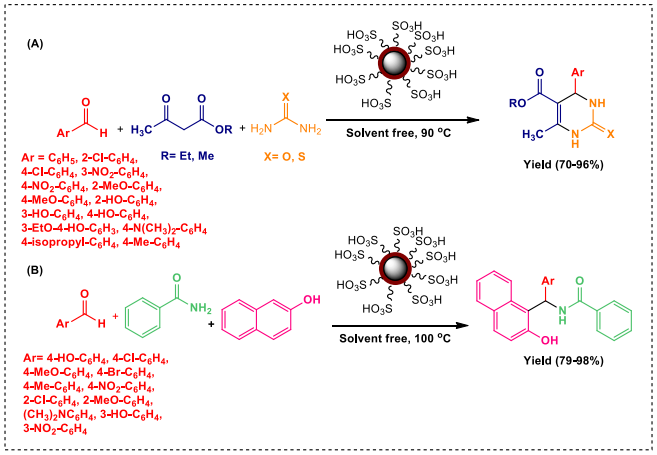
Scheme 36. Synthesis of (**A**) hexahydroquinolines, (B) 1,8-dioxo-decahydroacridines, (**C**) polyhydroquinolines, and (**D**) 1,8-dioxo-octahydroxanthenes using nano-ZrO_2-SO_3H catalyst.

More recently, the magnetically separablecore–shell Fe_3O_4@ZrO_2-SO_3H nanoparticle catalyst (n-FZSA) was introduced by Hosseini and Kolvari [127] as a novel heterogeneous solid acid catalyst. The catalytic activity of the prepared n-FZSA was evaluated in a one-pot multicomponent reaction for the synthesis of 3,4-dihydopyrimidin-2(1*H*)-ones (Scheme **37**). The reaction was carried out at 90°C under solvent-free conditions. The n-FZSA catalyst exhibited a high catalytic activity with a negligible decrease of the yield (from 96% to 95%) up to the 3rd successive reaction using the recovered catalyst and a higher decrease (from 96% to 86%) upon reusing the catalyst for 6 successive cycles.

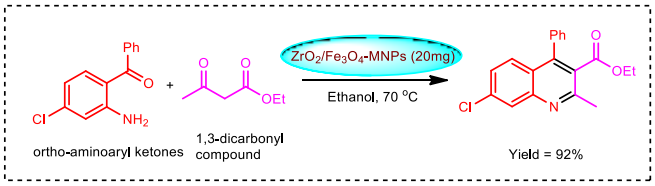
Hejazi *et al.* [128] employed ZrO_2/$Fe3O_4$-MNPs as a reusable heterogeneous catalyst to establish a convenient, suitable, and environmentally acceptable technique for synthesizing quinoline derivatives *via* a Friedländer reaction (Scheme **38**). Green reactions, simple and straightforward setup, excellent product yields, and short reaction times are all advantages of this technique. Furthermore, the catalyst could be retrieved and reused three times without losing its catalytic activity utilizing an external magnetic field.

5. SYNTHESIS USING NiO-ZrO2 NANOCATALYST

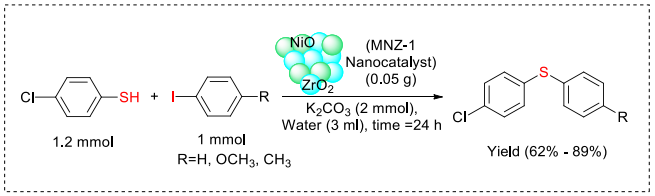
Pal and Bhaumik [129] reported the synthesis of mesoscopic self-assembled NiO–ZrO_2 nano-catalyst (MNZ-1) using a non-ionic surfactant *via* evaporation self-assembly and calcination at 773 K for 5-6 h. The MNZ-1 exhibited good catalytic activity for the C-S cross-coupling and synthesis of diaryl sulfides with moderately high yields from reactions of different iodoaryl compounds with 4-chlorothiophenol in an eco-friendly water medium (Scheme **39**). The product yield was improved significantly from 39% at room temperature to (62-89%) at 353 K. The authors reported significantly lower yields of products when the reactions were catalyzed by pure NiO or a physical mixture of pure NiO and ZrO_2, and concluded that the surface area and mesoporosity of the self-assembled MNZ-1 nanocatalyst is an important factor in obtaining the higher yields.



Scheme 37. n-FZSA-catalyzed one-pot synthesis of (**A**) 3,4-dihydropyrimidinones, and (**B**) 1-amidoalkyl-2-naphthols.



Scheme 38. ZrO_2/Fe_3O_4-MNPs catalyzed synthesis of ethyl 2-methyl-4-phenylquinoline-3-carboxylate.



Scheme 39. C-S cross-coupling reaction using NiO–ZrO_2 nanocrystals.

The authors suggested the plausible reaction mechanism illustrated in Fig. (**7**) for the C–S coupling. First, the 4-chlorothiophenol forms a red colour complex with the Ni atom of the catalyst (intermediate (I)); this was confirmed by the FT-IR spectrum of the thio-Ni complex which revealed the disappearance of the characteristic S-H stretching bond of the 4-chlorothiophenol near 2550–2600 cm^{-1}. The authors' suggestion that the thiol complexation is with the Ni rather than with the Zr ions was supported by the low activity of pure ZrO_2 in this reaction. Then K_2CO_3 (B) promotes the reaction of intermediate(I) with iodobenzene leading to the formation of a six-membered ring (II) *via* the oxidative addition of the iodo compound to intermediate (I). The electron-donating substituent facilitates the coordination of the metal to the π-bond of the aromatic ring providing higher conversion. Finally, intermediate (II) on reductive elimination *via* intermediate (III) gives the desired product.

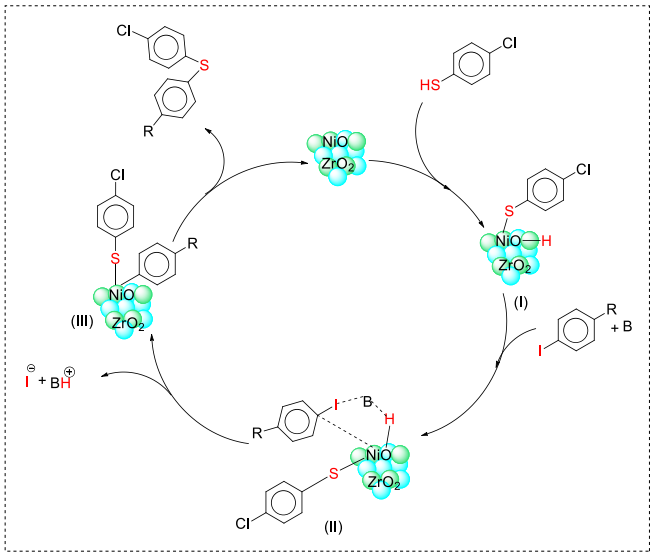
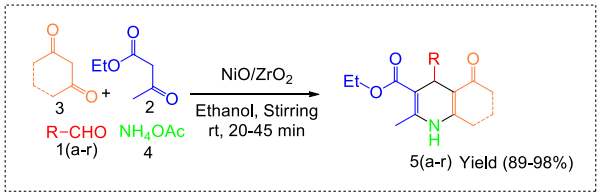


Fig. (7). Mechanism for the C–S coupling reaction.

Bhaskaruni *et al.* [130] used nickel oxide loaded on zirconia (NiO/ZrO_2) as an efficient catalyst to synthesize 18 unsymmetrical 1,4-dihydropyridine derivatives (Scheme **40**). With outstanding yields of 89-98% and a completion time of 20-45 minutes, the Lewis acidic character of the catalyst proved to be a good choice for the one-pot, four-component fusion reaction. According to mechanistic studies, enamine and imine functionality are two probable mechanisms for the production of 1,4-dihydropyridines with good selectivity. Two new compounds (**5a, 5c**) have their crystal structures described.

Up to six cycles of reusability were demonstrated with the catalyst. After each run, the catalyst was extracted from the reaction mixture, washed with ethanol, and dried at 120°C for 2 hours. This procedure is green and cost-effective due to the room-temperature reaction and use of ethanol as a solvent.

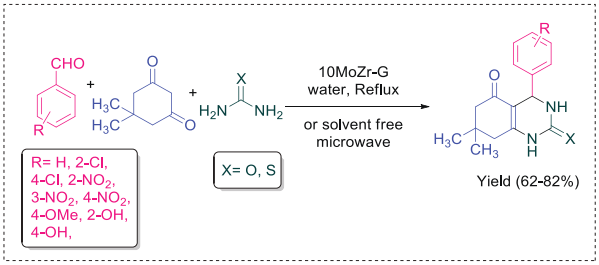


Scheme 40. synthesis of novel unsymmetrical 1,4-dihydropyridine derivatives.

6. SYNTHESIS USING OTHER METAL OXIDES/ZrO_2 NANOCOMPOSITES AND ZrO_2-SO_3H NANOCATALYST

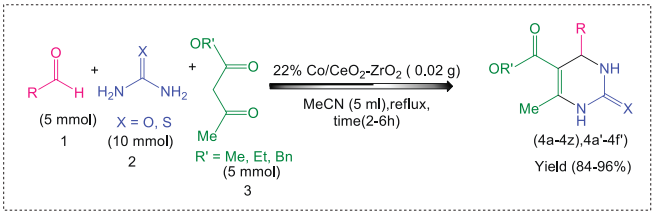
Samantaray and Mishra [131] prepared pure ZrO_2 and MoO_3-ZrO_2 nanocomposite (10MoZr-G) from MoO_3 (10 mol.%) and ZrO_2 oxides by solution combustion method using different glycine fuel contents. The 10MoZr-G nanocomposite was used to catalyze the synthesis of octahydroquinazolinones by multicomponent condensation of dimedone, urea and arylaldehydes in aqueous media under solvent-free conditions using microwave irradiation (Scheme **41**). The 10MoZr-G catalyst was reported to be more active than other composites prepared by using other fuel types such as urea and hexamethylene, giving a relatively high yield in a short time (180

s). The catalyst was recovered, washed with ethanol, and heat treated at 400°C for 1 h, and its catalytic activity was evaluated. The regenerated catalyst was reported to produce the target product without a significant decrease in the yield in three successive cycles.



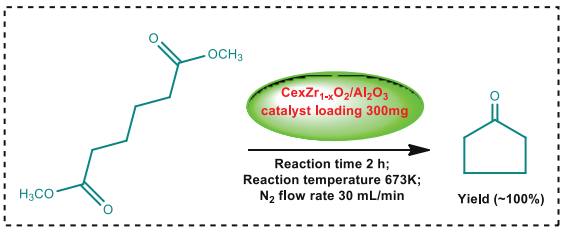
Scheme 41. One pot synthesis of octahydroquinazolinones using 10MoZr-G catalyst.

Biklarian *et al.* [132] created four unprecedented DHPMs 22% Co/CeO_2-ZrO_2 catalysed as a unique catalyst in refluxing acetonitrile using a simple modification of Biginelli's dihydropyrimidinone and thiones synthesis (Scheme **42**). This approach is complementary to existing methods because of its high product yields, gentle reaction conditions, and straightforward procedure. After calcination at 800-850°C, XRD patterns of nano spherical catalysts $Ce_{0.75}Zr_{0.25}O_2$ cubic structure with 32 nm crystallite size implies a 22% Co content. Furthermore, the catalyst may be easily recovered and reused (up to four times) without a significant decrease in activity, which is advantageous from a green chemical standpoint. The catalyst was filtered and rinsed with diethyl ether at the end of the process. A second or even third reaction could be performed on the recycled catalyst.



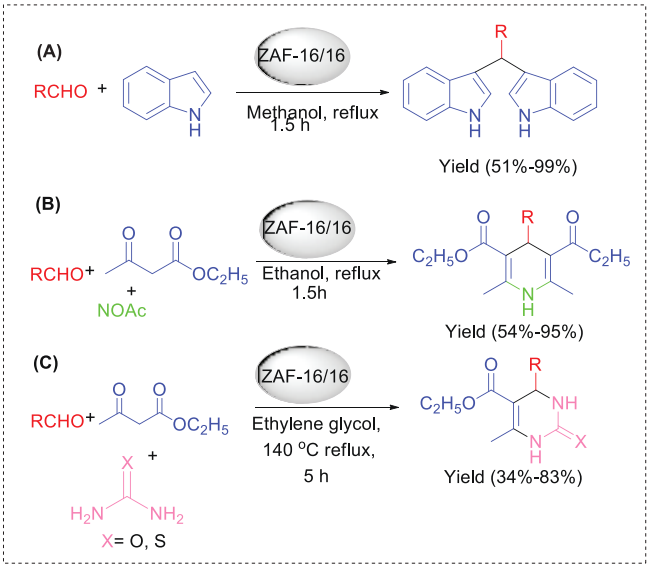
Scheme 42. Synthesis of 1,2,3,4-tetrahydro-2-pyrimidinones and thiones by using 22% Co/CeO_2-ZrO_2 nanocatalyst.

Sudarsanam *et al.* [133] create an innovative and simple method for synthesising cyclopentanone, a useful industrial component (Scheme **43**). As a result, $Ce_xZr_{1-x}O_2$ and $Ce_xZr_{1-x}O_2/M$ (M = SiO_2 and Al_2O_3) ceria–zirconia-based nano-oxide catalysts were developed and tested for the title reaction. C, CZ, CZ/A, and CZ/S samples had average crystallite sizes of 8.9, 4.7, 3.7, and 3.4 nm, respectively. The catalytic results showed that nano-oxides based on $Ce_xZr_{1-x}O_2$ are promising heterogeneous catalysts for cyclopentanone production. Because of its advantageous physicochemical features, the $Ce_xZr_{1-x}O_2/Al_2O_3$ catalyst achieved 100% conversion with 75% targeted cyclopentanone product selectivity.



Scheme 43. Synthesis of cyclopentanone from dimethyl adipate by using nanostructured ceria–zirconia solid solution catalysts.

Wang *et al.* [134] reported the synthesis of a number of ZrO_2–Al_2O_3–Fe_3O_4 (ZAF) nanocomposites with different zirconia and alumina molar ratios relative to magnetite (the molar ratio of which is taken as 1). The catalysts were structurally and chemically characterized in details using different techniques, and the esterification of acetic acid and n-butyl alcohol for the synthesis of n-butyl acetate as a model reaction examined their catalytic activity. The maximum conversion of 90% was obtained by using the catalyst ZAF-16/16 (ZrO_2:Al_2O_3:Fe_3O_4 molar ratios of 16:16:1). Subsequently, the optimal catalyst ZAF-16/16 was used for the synthesis of bis-indolylmethanes and other organic reactions shown in (Scheme **44**). The results of the study highlighted the importance of the proposed methodology for the synthesis of a variety of biologically active pharmacological heterocyclic compounds. The reactions gave moderate to good yields of the target compounds. On the other hand, the magnetic nanoparticles in the catalyst facilitate a simple magnetic recovery of the catalyst for subsequent reactions, which proceeded without obvious loss of the catalytic activity.



Scheme 44. ZAF-catalyzed reactions for (**A**) the synthesis of bis-indolylmethanes, (**B**) Hantzsch reaction, and (**C**) Biginelli reaction.

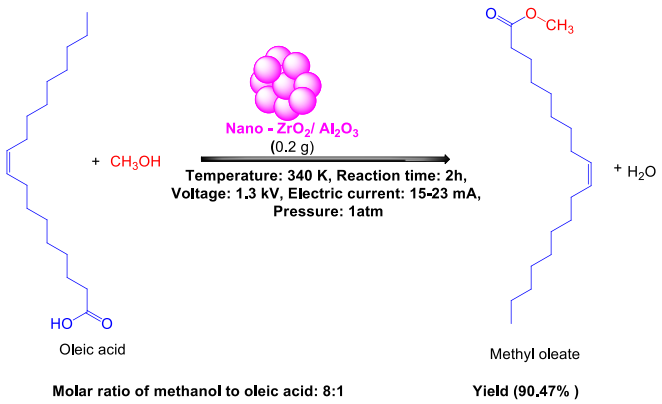
Mahdavi *et al.* [135] present the synthesis and catalytic activity of a ZrO_2/Al_2O_3 nano-catalyst that transforms oleic acid and methanol into fatty acid esters under high voltage circumstances in a low temperature and atmospheric pressure process (Scheme **45**). This protocol's key benefits are the use of a low-cost and reusable catalyst, high yields in a short period of time, and environmental friendliness.

In four runs, the reusability and recycling of nano-catalyst were also examined. The findings revealed that the nano-catalyst can be reused multiple times (up to 4 runs) without losing catalytic activity. The nano-catalyst was separated, washed, and dried at 80°C for the next reaction after each reaction.

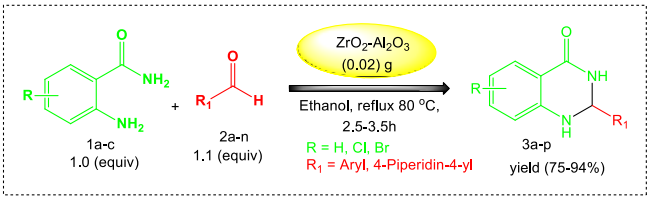
Narasimhamurthy *et al.* [136] describe the production of a nano acid catalyst ZrO_2-Al_2O_3 using urea as a fuel and the evaluation of its catalytic efficacy in the synthesis of a variety of novel substituted dihydroquinazolinones (Scheme **46**).

Under mild circumstances, the catalyst was shown to be a highly effective solid acid catalyst, with substantial catalytic activity in converting substituted 2-aminobenzamides to analogous 2, 3-dihydroquinazolin-4-(1H) –ones. The improved synthesis process is simple, quick, and efficient, and it has the potential to become one

of the most effective methods for obtaining pharmaceutically valuable dihydroquinazolines. Solid acid catalytic material was filtered from the reaction mixture, washed with ethanol, dried for 1 hour at 120°C, and calcined for 0.5 hours at 550°C. A reactivated solid acid catalyst was employed in the next reaction cycle to synthesize 2, 3-dihydroquinazolin-4(1H)-ones under comparable reaction conditions. The utilized solid acid catalyst was reactivated and reusability was tested four to five times.

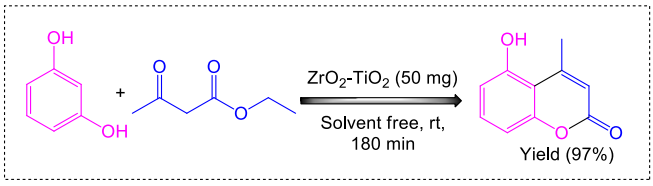


Scheme 45. Synthesis of fatty acid esters by using oleic acid and methanol by using Nano catalyst ZrO_2/Al_2O_3 under high voltage conditions.



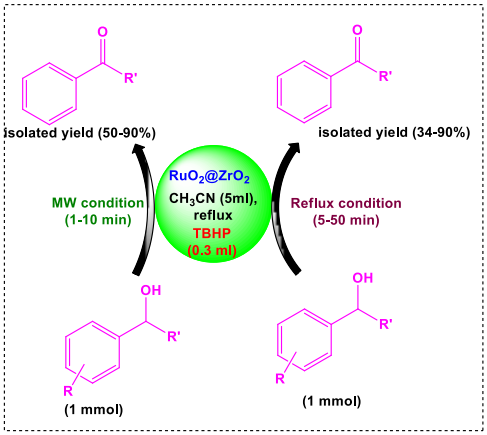
Scheme 46. Synthesis of 2,3-dihydroquinazolin-4 (1H) using ZrO_2-Al_2O_3 nano catalyst.

Khan *et al.* [137] describe the synthesis of coumarin in a solvent-free environment at room temperature utilising zirconia-based heterogeneous catalysts (ZrO_2-Al_2O_3, ZrO_2-ZnO, and ZrO_2/cellulose) (Scheme **47**). In comparison to ZrO_2-ZnO, ZrO_2-TiO_2 showed the best catalytic performance for this process. The rate of reaction in a solvent-free environment is 1.7 103 g mol1 min1 at ambient temperature. At 60°C, however, the rate of reaction in ethanol is 1.7 102, and in toluene is 5.6 103 g mol^{-1} min^{-1}. FESEM was used to analyse the morphology of ZrO_2-TiO_2, ZrO_2-ZnO, and ZrO_2/cellulose. The ZrO_2-TiO_2 was grown as particles, while the ZrO_2-ZnO was produced in the shape of a flower. ZrO_2-ZnO was mostly formed as nanoparticles with an average size of 25–30 nm clumped together to form a flower-shaped structure. ZrO_2 was developed as particles on the surface of cellulose in the case of ZrO_2/cellulose.



Scheme 47. Zirconia-based catalyst for the one-pot synthesis of coumarin through Pechmann reaction.

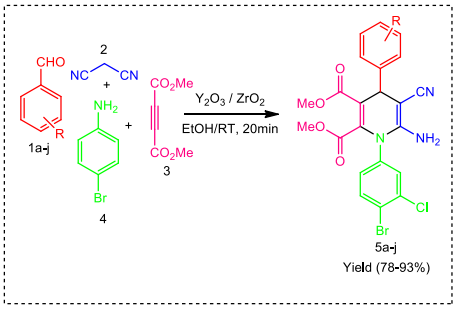
Shojaei *et al.* [138] used synthesized nanostructured RuO_2@ZrO_2 as a heterogeneous catalyst and microwave irradiation in acetonitrile to establish a simple and highly efficient process for the oxidation of benzylic alcohols to the corresponding aldehydes or ketones (Scheme **48**). Under mild circumstances, the catalyst has excellent activity and high conversion. After the reaction was completed, the catalyst was centrifuged and cleaned with deionized water and chloroform before being dried and reused in consecutive cycles. RuO_2@ZrO_2 4 wt% can be reused three times without considerable activity loss, according to the conversion results.



Scheme 48. Oxidation of Benzyl alcohol by using RuO_2@ZrO_2 core–shell nano particles under different conditions.

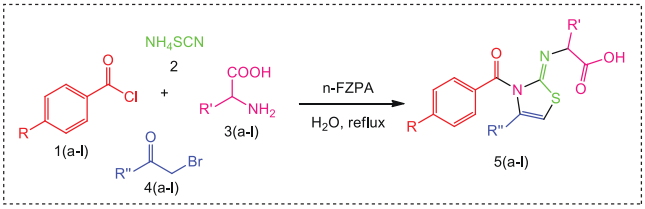
Shabalala *et al.* [139] present a very efficient approach for synthesizing 1,4-dihydropyridine compounds utilizing a 2.5% Y_2O_3/ZrO_2 heterogeneous catalyst in their study. In the green solvent ethanol, substituted aldehyde, malononitrile, 4-bromoaniline, and dimethylacetylenedicarboxylate are combined in a one-pot four-component synthesis (Scheme **49**). Easy set-up, green solvent, low reaction durations (less 20 minutes), energy efficient reaction conditions, no chromatographic separation procedures, and outstanding yields are all advantages of this unique methodology (88-95%).

The reaction mixture was simply filtered under vacuum, washed with ethyl acetate, and dried in a vacuum oven at 110°C for 3 hours after the reaction was completed. In the subsequent reactions, the flexibility of the recovered catalyst for reuse was examined, and no yttria leaching was observed. It can be reused for at least six runs in consecutive reactions without losing substantial yield.



Scheme 49. Synthesis of novel 1,4-dihydropyridine derivatives.

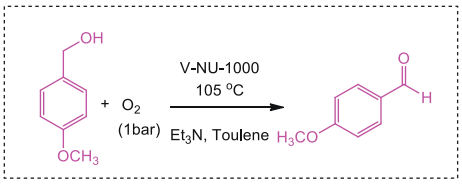
Nakhaei A. [140] developed a new method for synthesising thiazole compounds from acyl chloride, ammonium thiocyanate, amino acids, and alkyl bromides catalysed by nano-Fe_3O_4@ZrO_2-H_3PO_4 (n-FZPA) in high yields in a fast reaction time using conventional or magnetised water and a simple work-up procedure (Scheme **50**). Overall, the magnetised water performed better as a reaction solvent. The catalyst can be easily recycled by magnetic separation, and it can be reused up to four times without losing any catalytic activity. The catalyst is low-cost and easy to obtain, as well as stable and storable.



Scheme 50. Synthesis of thiazole derivatives in the presence of *n*-FZPA.

NU-1000 is a porous Zr-based metal-organic framework (Zr-MOF) that is an effacious catalyst support due to its distinct crystal structure, protonic grafting sites on its nodes, and thermal stability, which together help with catalytic reactive site studies. Cui *et al.* [141] created V-NU-1000, a vanadium oxide catalyst based on NU-1000 synthesised by solvothermal deposition in MOFs (SIM). The catalytic activity of V-NU-1000 is investigated using 4-methoxybenzyl alcohol oxidation in an O_2 atmosphere, and it is discovered that it has higher conversion and selectivity than vanadium oxide supported on high surface area zirconia (V-ZrO2) (Scheme **51**).

Recyclability and leaching studies show that the recollected V-NU-1000 retains equal catalytic ability to the fresh catalyst with no loss of metal loading. With a turn-over frequency (TOF) of 2.6 h-1 measured at a conversion level of 3.2 percent, V-NU-1000 exhibited a conversion of about 56 percent after 8 hours. As shown by GC-MS, this catalyst is highly selective (>99 percent) for the synthesis of 4-methoxy benzaldehyde without generating the over-oxidized product 4-methoxy benzoic acid.

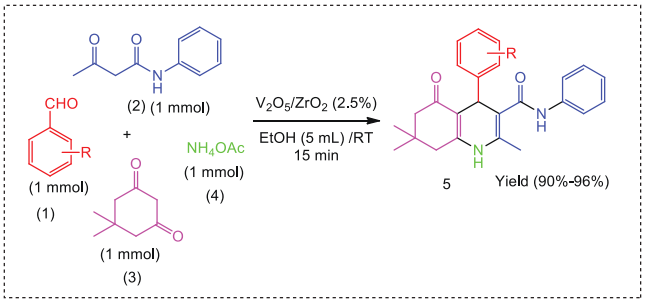


Scheme 51. Synthesis of 4-methoxybenzaldehyde by oxidation 4-methoxybenzylalcohol using V-NU-1000 as nanocatalyst.

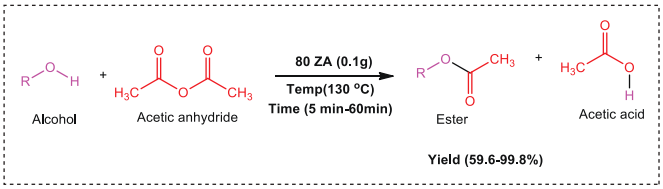
By cyclo-condensation of aromatic aldehydes, 5,5-dimethyl-1,3-cyclohexanedione, acetoacetanilide, and ammonium acetate, Bhaskaruni *et al.* [142] establish a viable technique for the one-pot, multicomponent synthesis of 1,4-dihydropyridine derivatives employing aromatic aldehydes, 5,5-dimethyl-1,3-cyclo Using ethanol as a solvent and V_2O_5/ZrO_2 as a heterogeneous catalyst, ten novel 1,4-dihydropyridines were synthesised at room temperature (reaction time: 20 min) (Scheme **52**). XRD, TEM, SEM, and BET were used to characterise the catalyst materials. Simple set-up, green solvent, short reaction times, mild reaction conditions, and good yields (90-96%) are the advantages of this unique approach. Without the use of chromatography, the reaction product can be easily isolated in pure form.

Heterogeneous catalysts have the advantage of being easily recyclable, making them a great choice, especially in terms of cost and environmental benefits. As a result, examination of the stability of catalyst recycling has been conducted. The catalyst was vacuum-separated from the reaction mixture after each run, washed with ethanol solvent, and dried for 4 hours at 120-130°C. The recycled catalyst showed no significant loss of catalytic activity even after five cycles, showing that there is no leaching or loss of vanadia throughout the process and that it is intact in the zirconia lattice.

Thimmaraju *et al.* [143] used the solution combustion method (SCM) to prepare solid acids such as Al_2O_3, ZrO_2, and ZrO_2–Al_2O_3 containing different ZrO_2 loadings (10–100 mol percent) and characterised them for total surface acidity and crystallinity using the NH_3-TPD/n-butylamine back titration method and powder X-ray diffraction (PXRD) technique respectively. With acetic anhydride (AA) as an acetylating agent, these solid acids were tested for their catalytic activity in the synthesis of new O-acetylated compounds from substituted phenols, pyridine alcohols, and aryl alcohols (Scheme **53**). The catalyst, molar ratio of the reactants, reaction temperature, and catalyst amount were all changed to improve the reaction conditions. In this investigation, all of the solid acids utilized had good catalytic activity in the process. ZrO_2–Al_2O_3 with 80 mol% ZrO_2 was shown to be very active in the acetylation reaction, yielding a high yield of acetylated products. Surface acidity, crystallinity, and catalytic activity of solid acids were found to have a triangular relationship. It was discovered that these solid acids may be reactivated and reused.



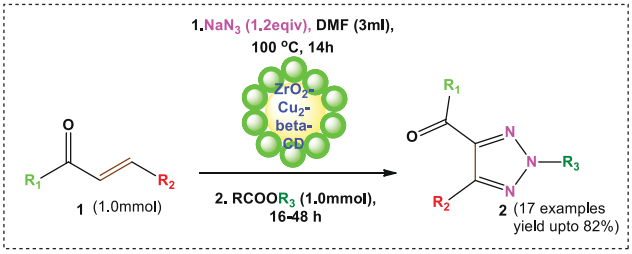
Scheme 52. Synthesis of 1,4-dihydropyridine moieties *via* V_2O_5/ZrO_2 as a heterogeneous catalyst.



Scheme 53. O-acetylation of different hydroxyl compounds with AA over ZrO_2–Al_2O_3 solid acid.

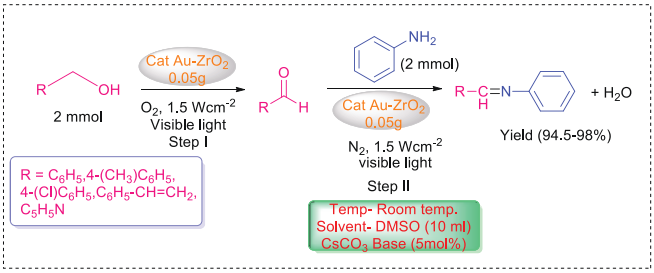
7. SYNTHESIS USING ZrO_2-SUPPORTED Cu(II)–β-CYCLODEXTRIN AND AU/ZrO_2 AS A CATALYST

Girish *et al.* [144] prepared ZrO_2 nanoparticle-supported Cu (II)-β-cyclodextrin complex to catalyze the synthesis of N-2-substituted-1,2,3-triazoles *via* azide-chalcone oxidative cycloaddition and post-triazole alkylation using a one-pot multi-component stepwise approach (Scheme **54**). The authors have introduced the N-2 alkylation of triazoles using different aryl-alkyl esters without any additives as a novel approach. The reported simple and atom-economical synthetic route exhibited regioselectivity and good yields (~81%). The recovered catalyst maintained its high catalytic activity for four consecutive reactions. The small decrease in the catalytic activity (81% to 77%) could be partially attributed to a small loss of the catalyst during the recovery process.



Scheme 54. N-2-substituted-1,2,3-triazole in the presence of ZrO_2-Cu_2-β-CD.

Motivated by the potential of Au/ZrO_2 NPs as an efficient photocatalyst for organic synthesis due to their limited to a small area surface Plasmon resonance (LSPR) effect, Zheng *et al.* [145] prepared Au/ZrO_2 nano-powders (average particle size of 5 nm) by a solution method for employment as a heterogeneous catalyst used in organic transformations. In this study reveals that the photosynthesis of imines from alcohols & aniline raised by aerobic oxidation of the alcohols by the nucleophilic addition of aniline (Scheme **55**). The reaction was carried out by using dimethyl sulphoxide (DMSO) as a solvent. The imines in reactions performed with 3 wt% Au/ZrO_2 and irradiation by visible light at room temperature were high (over 90%) compared to reactions performed without irradiation. The reaction outcome depended strongly on the intensity and wavelength of the light, and the catalyst was recovered and reused for at least five successive reactions. The results of the study indicated that the reaction of alcohols with aniline in the presence of Au/ZrO_2 as the photocatalyst can proceed under environmentally friendly conditions.



Scheme 55. Synthesis of Imine from alcohols and aniline by using Au/ZrO_2 as a photocatalyst.

The alcohol was initially oxidised to an aldehyde in the presence of Au/ZrO_2 under an O_2 environment and exposure to visible light, according to the authors' probable reaction mechanism (Fig. **8**). Alcohol is oxidised by the Au-NPs by the process of electron capture because of the strong electro negativity of gold. By promoting interband electronic transitions in Au NPs through the LSPR effect, visible light can catalyse the oxidation of organic molecules while also releasing energy.

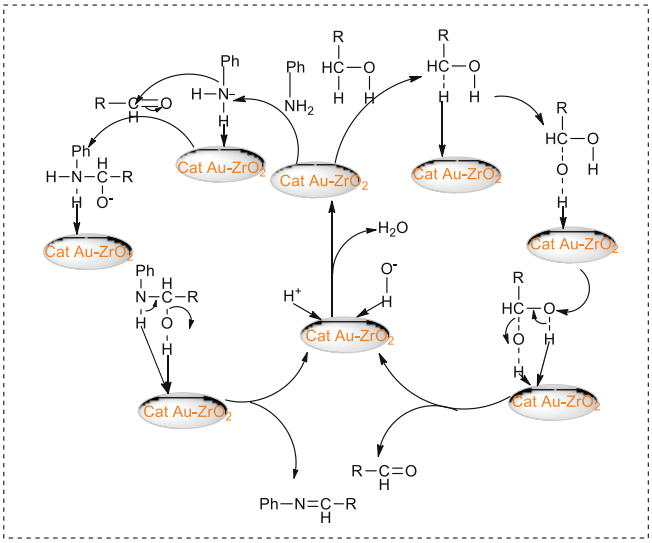


Fig. (8). Possible mechanism for the synthesis of imines from aniline and alcohols over Au/ZrO_2.

An oxygen atom can be inserted between the carbon-hydrogen bonds as a result of the Au nanoparticle pulling on the hydrogen atom bound to the carbon. As a result, a water molecule is taken out, and aldehyde is created. An atom of hydrogen is drawn off of the amine by the catalyst, which is a nucleophilic reagent with a single pair of electrons. The amine then attacks the carbonyl group, resulting in a nucleophilic addition process (the CQ-O bond was broken, and the hemiacetal amine intermediates were obtained). The imine was eventually created after removing a water molecule from the intermediates.

CONCLUSION

This article discusses current advancements in the synthesis of organic materials using zirconium compounds as green catalysts. The importance and benefits of zirconium compounds as catalysts or reagents in organic reactions were amply illustrated by the examples in this review appreciation of their high reactivity, distinctive selectivity and methods of recyclability. Even though these results are encouraging, much more work must yet be done in this field to investigate the potential uses of zirconium compounds fully.

LIST OF ABBREVIATIONS

ZrO_2	=	Zirconium Dioxide
SZ	=	Sulfated Zirconia
SZM	=	Sulfated Zirconia Over MCM-41
HMDS	=	Hexamethyldisilazane

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

The author T. L. Lambat would like to acknowledge the financial support through INSPIRE Fellowship [Grant no. IF120418] research grant awarded from DST, New Delhi.

CONFLICT OF INTEREST

Dr. Subhash Banerjee is the Executive Guest Editor of the journal COC.

ACKNOWLEDGEMENTS

The author T.L. Lambat would like to acknowledge the financial support through INSPIRE Fellowship research grant awarded from DST, New Delhi.

REFERENCES

[1] Kimber, R.L.; Parmeggiani, F.; Joshi, N.; Rakowski, A.M.; Haigh, S.J.; Turner, N.J.; Lloyd, J.R. Synthesis of copper catalysts for click chemistry from distillery wastewater using magnetically recoverable bionanoparticles. *Green Chem.,* **2019**, *21*(15), 4020-4024. http://dx.doi.org/10.1039/C9GC00270G

[2] (a) Lambat, T.L.; Mahmood, S.H.; Taher, D.; Banerjee, S. Sulfamic acid catalyzed oxonium-ene reactions under ball milling conditions: Straightforward access to highly functionalized Oxabicyclo[3.2.1]octenes. *Curr. Res. Green Sustain. Chem.,* **2021**, *4*, 100118. http://dx.doi.org/10.1016/j.crgsc.2021.100118
(b) Chopra, P.K.P.G.; Lambat, T.L.; Mahmood, S.H.; Chaudhary, R.G.; Banerjee, S. Sulfamic acid as versatile green catalyst used for synthetic organic chemistry: A comprehensive update. *ChemistrySelect,* **2021**, *6*(27), 6867-6889. http://dx.doi.org/10.1002/slct.202101635
(c) Lambat, T.L. Microwave assisted scolecite as heterogeneous catalyst for multicomponent one-pot synthesis of novel chromene scaffolds with quantitative yields. *J. Chinese Adv. Mater. Soc.,* **2018**, *6*(2), 134-144. http://dx.doi.org/10.1080/22243682.2018.1426040
(d) Lambat, T.L. Scolecite as novel heterogeneous catalyst for an efficient microwave assisted synthesis of 7-aryl-6H-benzo [H][1, 3] dioxolo [4, 5-b] xanthene-5, 6 (7H)-dione analogues via multi-component reaction. *Int. J. Appl. Biol. Pharm. Technol.,* **2017**, *8*, 11-18.

[3] Mondal, A.; Aziz, S.T.; Potbhare, A.K.; Mondal, S.; Lambat, T.L.; Chaudhary, R.G.; Abdala, A.A. Applications of metal/metal oxides nanoparticles in organic transformations. *Mater. Res.,* **2020**, *83*, 134-156.

[4] Duan, H.; Wang, D.; Li, Y. Green chemistry for nanoparticle synthesis. *Chem. Soc. Rev.,* **2015**, *44*(16), 5778-5792. http://dx.doi.org/10.1039/C4CS00363B PMID: 25615873

[5] Kumar, S.; Jain, S.; Nehra, M.; Dilbaghi, N.; Marrazza, G.; Kim, K.H. Green synthesis of metal–organic frameworks: A state-of-the-art review of potential environmental and medical applications. *Coord. Chem. Rev.,* **2020**, *420*, 213407. http://dx.doi.org/10.1016/j.ccr.2020.213407

[6] Bouafia, A.; Laouini, S.E.; Ouahrani, M.R. A review on green synthesis of CuO nanoparticles using plant extract and evaluation of antimicrobial activity. *Asian J. Res. Chem,* **2020**, *13*(1), 65-70. http://dx.doi.org/10.5958/0974-4150.2020.00014.0

[7] Hemra Hamrayev, ; Kamyar Shameli, ; Mostafa Yusefi, ; Serdar Korpayev, Green route for the fabrication of ZnO nanoparticles and potential functionalization with chitosan using cross-linkers: A review. *J. Res. Nanosci. Nanotechnol.,* **2021**, *3*(1), 1-25. http://dx.doi.org/10.37934/jrnn.3.1.125

[8] Kumar, B. Green synthesis of gold, silver, and iron nanoparticles for the degradation of organic pollutants in wastewater. *J. Composit. Sci.,* **2021**, *5*(8), 219. http://dx.doi.org/10.3390/jcs5080219

[9] Ghamari kargar, P.; Bagherzade, G. The anchoring of a Cu(II)–salophen complex on magnetic mesoporous cellulose nanofibers: Green synthesis and an investigation of its catalytic role in tetrazole reactions through a facile one-pot route. *RSC Advances,* **2021**, *11*(31), 19203-19220. http://dx.doi.org/10.1039/D1RA01913A PMID: 35478649

[10] Gautam, P.K.; Shivalkar, S.; Samanta, S.K. Environmentally benign synthesis of nanocatalysts: Recent advancements and applications. In: *Handbook of nanomaterials and nanocomposites for energy and environmental applications*; Springer: Amsterdam, **2021**, pp. 1163-1181.

[11] Deb, A.K.; Biswas, B.; Goswami, N.; Hilder, E.F.; Naidu, R.; Rahman, M.M. Synthesis of environmentally benign ultra-small copper nanoclusters-halloysite composites and their catalytic performance on contrasting azo dyes. *Appl. Surf. Sci.,* **2021**, *546*, 149122. http://dx.doi.org/10.1016/j.apsusc.2021.149122

[12] Ahluwalia, V.K. *Green chemistry: Environmentally benign reactions*; Springer Nature, **2021**. http://dx.doi.org/10.1007/978-3-030-58513-6

[13] Aligol, D.A.; Sepahvand, H. Environmentally benign oxidation of primary and secondary alcohols catalyzed by stabilized gold nanoparticles on A-hydroxy amide-functionalized graphene oxide. *SSRN,* **2021**, 3859149. http://dx.doi.org/10.2139/ssrn.3859149

[14] Chaturvedi, S.; Dave, P.N. Nanocatalyst: As green catalyst. In: *Handbook of Greener Synthesis of Nanomaterials and Compounds*; Elsevier, **2021**; pp. 445-458. http://dx.doi.org/10.1016/B978-0-12-821938-6.00013-X

[15] Balali, M.; Bagherzadeh, M.; Nejat, R.; Keypour, H. Palladium supported on schiff base functionalized magnetite nanoparticles as an efficient catalyst for coupling reactions. *Inorg. Chem. Res.,* **2021**, 82-93.

[16] Song, X.; Li, N.; Guo, Y.; Bai, Y.; Wu, T.; Yu, T. Comprehensive identification and characterization of simple sequence repeats based on the whole-genome sequences of 14 forest and fruit trees. *For. Res.,* **2021**, *1*(1), 1-10.

[17] Almeida, L.D.; Wang, H.; Junge, K.; Cui, X.; Beller, M. Recent advances in catalytic hydrosilylations: Developments beyond traditional platinum catalysts. *Angew. Chem. Int. Ed.,* **2021**, *60*(2), 550-565. http://dx.doi.org/10.1002/anie.202008729 PMID: 32668079

[18] Mondelli, C.; Gözaydın, G.; Yan, N.; Pérez-Ramírez, J. Biomass valorisation over metal-based solid catalysts from nanoparticles to single atoms. *Chem. Soc. Rev.,* **2020**, *49*(12), 3764-3782. http://dx.doi.org/10.1039/D0CS00130A PMID: 32459227

[19] Li, M.; Sun, J.; Zhang, W.; Zhao, Y.; Zhang, S.; Zhang, S. Drug delivery systems based on CD44-targeted glycosaminoglycans for cancer therapy. *Carbohydr. Polym.,* **2021**, *251*, 117103. http://dx.doi.org/10.1016/j.carbpol.2020.117103 PMID: 33142641

[20] Morawski, F.M.; Xavier, B.B.; Virgili, A.H.; Caetano, K.S.; de Menezes, E.W.; Benvenutti, E.V.; Costa, T.M.H.; Arenas, L.T. A novel electrochemical platform based on mesoporous silica/titania and gold nanoparticles for simultaneous determination of norepinephrine and dopamine. *Mater. Sci. Eng. C,* **2021**, *120*, 111646. http://dx.doi.org/10.1016/j.msec.2020.111646

[21] Jia, Y.; Yang, C.; Chen, X.; Xue, W.; Hutchins-Crawford, H.J.; Yu, Q.; Topham, P.D.; Wang, L. A review on electrospun magnetic nanomaterials: Methods, properties and applications. *J. Mater. Chem. C Mater. Opt. Electron. Devices,* **2021**, *9*(29), 9042-9082. http://dx.doi.org/10.1039/D1TC01477C

[22] (a) Regalado Vera, C.Y.; Manavi, N.; Zhou, Z.; Wang, L.C.; Diao, W.; Karakalos, S.; Liu, B.; Stowers, K.J.; Zhou, M.; Luo, H.; Ding, D. Mechanistic understanding of support effect on the activity and selectivity of indium oxide catalysts for CO_2 hydrogenation. *Chem. Eng. J.,* **2021**, *426*, 131767. http://dx.doi.org/10.1016/j.cej.2021.131767
(b) Ghiaci, M.; Kalbasi, R.J.; Mollahasani, M.; Aghaei, H. Vapor phase acylation of phenol with ethyl acetate over H_3PO_4/TiO_2-ZrO_2. *Appl. Catal. A Gen.,* **2007**, *320*, 35-42. http://dx.doi.org/10.1016/j.apcata.2006.12.013
(c) Ghiaci, M.; Kalbasi, R.J.; Aghaei, H. Highly selective vapor phase Fries rearrangement of phenyl acetate to 2-hydroxyacetophenone using H_3PO_4/ZrO_2–TiO_2. *Catal. Commun.,* **2007**, *8*(11), 1843-1850. http://dx.doi.org/10.1016/j.catcom.2007.02.026
(d) Ghiaci, M.; Aghaei, H.; Abbaspur, A. Size-controlled synthesis of ZrO_2–TiO_2 nanoparticles prepared via reverse micelle method. *Mater. Res. Bull.,* **2008**, *43*(5), 1255-1262. http://dx.doi.org/10.1016/j.materresbull.2007.05.022
(e) Ghiaci, M.; Esfahani, R.N.; Aghaei, H. Efficient dehydration of cinnamaldoxime to cinnamonitrile over H_3PO_4/Al-MCM-41. *Catal. Commun.,* **2009**, *10*(6), 777-780. http://dx.doi.org/10.1016/j.catcom.2008.11.036
(f) Ghiaci, M.; Aghaei, H.; Oroojeni, M.; Aghabarari, B.; Rives, V.; Vicente, M.A.; Sobrados, I.; Sanz, J. Synthesis of paracetamol by liquid phase Beckmann rearrangement of 4-hydroxyacetophenone oxime over H_3PO_4/Al-MCM-41. *Catal. Commun.,* **2009**, *10*(11), 1486-1492. http://dx.doi.org/10.1016/j.catcom.2009.03.025

[23] Banerjee, S. Functionalized hybrid nanomaterials for biomedical and analytical applications. *Curr. Nanosci.*, **2022**, *18*(4), 409-409. https://doi.org/10.2174/1573413718042204291237 25

[24] Li, X.; Zhang, L.; Wang, S.; Wu, Y. Recent advances in aqueous-phase catalytic conversions of biomass platform chemicals over heterogeneous catalysts. *Front Chem.,* **2020**, *7*, 948. http://dx.doi.org/10.3389/fchem.2019.00948 PMID: 32117861

[25] Chen, Z.; Liu, Y.; Liu, C.; Zhang, J.; Chen, Y.; Hu, W.; Deng, Y. Engineering the metal/oxide interface of Pd nanowire@ CuOx electrocatalysts for efficient alcohol oxidation reaction. *Small,* **2020**, *16*(4), 1904964. http://dx.doi.org/10.1002/smll.201904964 PMID: 31867858

[26] Leonel, A.G.; Mansur, A.A.P.; Mansur, H.S. Advanced functional nanostructures based on magnetic iron oxide nanomaterials for water remediation: A review. *Water Res.,* **2021**, *190*, 116693. http://dx.doi.org/10.1016/j.watres.2020.116693 PMID: 33302040

[27] Yang, M.; Shen, G.; Liu, M.; Chen, Y.; Wang, Z.; Wang, Q. Preparation of Ce–Mn composite oxides with enhanced catalytic activity for removal of benzene through oxalate method. *Nanomaterials (Basel),* **2019**, *9*(2), 197. http://dx.doi.org/10.3390/nano9020197 PMID: 30717455

[28] Hamed Bateni, ; Chad Able, Development of heterogeneous catalysts for dehydration of methanol to dimethyl ether: A review. *Catal. Ind.,* **2019**, *11*(1), 7-33. http://dx.doi.org/10.1134/S2070050419010045

[29] Liu, C.; Zhang, J.; Liu, H.; Qiu, J.; Zhang, X. Heterogeneous ligand-free rhodium oxide catalyst embedded within zeolitic microchannel to enhance regioselectivity in hydroformylation. *Ind. Eng. Chem. Res.,* **2019**, *58*(47), 21285-21295. http://dx.doi.org/10.1021/acs.iecr.9b03598

[30] Maduraiveeran, G.; Sasidharan, M.; Jin, W. Earth-abundant transition metal and metal oxide nanomaterials: Synthesis and electrochemical applications. *Prog. Mater. Sci.,* **2019**, *106*, 100574. http://dx.doi.org/10.1016/j.pmatsci.2019.100574

[31] Gautam, S.; Agrawal, H.; Thakur, M.; Akbari, A.; Sharda, H.; Kaur, R.; Amini, M. Metal oxides and metal organic frameworks for the photocatalytic degradation: A review. *J. Environ. Chem. Eng.,* **2020**, *8*(3), 103726. http://dx.doi.org/10.1016/j.jece.2020.103726

[32] Lv, Y.; Han, C.; Zhu, Y.; Zhang, T.; Yao, S.; He, Z.; Dai, L.; Wang, L. Recent advances in metals and metal oxides as catalysts for vanadium redox flow battery: Properties, structures, and perspectives. *J. Mater. Sci. Technol.,* **2021**, *75*, 96-109. http://dx.doi.org/10.1016/j.jmst.2020.09.042

[33] Ndolomingo, M.J.; Bingwa, N.; Meijboom, R. Review of supported metal nanoparticles: Synthesis methodologies, advantages and application as catalysts. *J. Mater. Sci.,* **2020**, *55*(15), 6195-6241. http://dx.doi.org/10.1007/s10853-020-04415-x

[34] Rahmati, M.; Safdari, M.S.; Fletcher, T.H.; Argyle, M.D.; Bartholomew, C.H. Chemical and thermal sintering of supported metals with emphasis on cobalt catalysts during Fischer–Tropsch synthesis. *Chem. Rev.,* **2020**, *120*(10), 4455-4533. http://dx.doi.org/10.1021/acs.chemrev.9b00417 PMID: 32363864

[35] wassel, A.R.; El-Naggar, M.E.; Shoueir, K. Recent advances in polymer/metal/metal oxide hybrid nanostructures for catalytic applications: A review. *J. Environ. Chem. Eng.,* **2020**, *8*(5), 104175. http://dx.doi.org/10.1016/j.jece.2020.104175

[36] Bhattacharya, C.; Saji, S.E.; Mohan, A.; Madav, V.; Jia, G.; Yin, Z. Sustainable nanoplasmon-enhanced photoredox reactions: Synthesis, characterization, and applications. *Adv. Energy Mater.,* **2020**, *10*(40), 2002402. http://dx.doi.org/10.1002/aenm.202002402

[37] Wu, Z.P.; Lu, X.F.; Zang, S.Q.; Lou, X.W.D. Non-noble-metal-based electrocatalysts toward the oxygen evolution reaction. *Adv. Funct. Mater.,* **2020**, *30*(15), 1910274. http://dx.doi.org/10.1002/adfm.201910274

[38] Hong, F.L.; Ye, L.W. Transition metal-catalyzed tandem reactions of ynamides for divergent N-heterocycle synthesis. *Acc. Chem. Res.,* **2020**, *53*(9), 2003-2019. http://dx.doi.org/10.1021/acs.accounts.0c00417 PMID: 32869969

[39] Mondal, S.; Nagmote, M. S.; Kombe, S. V.; Dutta, B. K.; Lambat, T. L.; Chouke, P. B.; & Mondal, A. Ecofriendly microorganism assisted fabrication of metal nanoparticles and their applications. In: *Biogenic Sustainable Nanotechnology*; Elsevier: Amsterdam, **2022**, 77-105. https://doi.org/10.1016/B978-0-323-88535-5.00002-0

[40] (a) Shi, Q.; Zhu, C.; Du, D.; Lin, Y. Robust noble metal-based electrocatalysts for oxygen evolution reaction. *Chem. Soc. Rev.,* **2019**, *48*(12), 3181-3192. http://dx.doi.org/10.1039/C8CS00671G PMID: 31112142
(b) Aghaei, H.; Ghiaci, M. Use of H_3PO_4/ZrO_2–TiO_2–surfactant mixed oxide for catalytic vapor-phase dehydration of 1-octanol. *React. Kinet. Mech. Catal.,* **2020**, *131*(1), 233-246. http://dx.doi.org/10.1007/s11144-020-01854-0
(c) Ghiaci, M.; Sedaghat, M.E.; Aghaei, H.; Gil, A. Synthesis of CdS- and ZnS-modified bentonite nanoparticles and their applications to the degradation of eosin B. *J. Chem. Technol. Biotechnol.,* **2009**, *84*(12), 1908-1915. http://dx.doi.org/10.1002/jctb.2264
(d) Zarei, A.; Khazdooz, L.; Hajipour, A.R.; Aghaei, H. Fast, efficient and convenient method for the preparation of arylazo sulfides using aryl diazonium silica sulfates under mild and solvent-free conditions. *Dyes Pigments,* **2011**, *91*(1), 44-48. http://dx.doi.org/10.1016/j.dyepig.2011.02.010
(e) Mehrali-Afjani, M.; Nezamzadeh-Ejhieh, A.; Aghaei, H. A brief study on the kinetic aspect of the photodegradation and mineralization of BiOI-Ag3PO4 towards sodium diclofenac. *Chem. Phys. Lett.,* **2020**, *759*, 137873. http://dx.doi.org/10.1016/j.cplett.2020.137873
(f) Zarei, A.; Hajipour, A.; Khazdooz, L.; Aghaei, H. Fast, efficient, and convenient method for the preparation of arylazo aryl sulfones using stable aryldiazonium silica sulfates under mild conditions. *Synlett,* **2010**, *2010*(8), 1201-1204. http://dx.doi.org/10.1055/s-0029-1219811

[41] Mustieles Marin, I.; Asensio, J.M.; Chaudret, B. Bimetallic nanoparticles associating noble metals and first-row transition metals in catalysis. *ACS Nano,* **2021**, *15*(3), 3550-3556. http://dx.doi.org/10.1021/acsnano.0c09744 PMID: 33660508

[42] Neal, C.J.; Fox, C.R.; Sakthivel, T.S.; Kumar, U.; Fu, Y.; Drake, C.; Parks, G.D.; Seal, S. Metal-mediated nanoscale cerium oxide inactivates human coronavirus and rhinovirus by surface disruption. *ACS Nano,* **2021**, *15*(9), 14544-14556. http://dx.doi.org/10.1021/acsnano.1c04142 PMID: 34436866

[43] Surra, E.; Correia, M.; Figueiredo, S.; Silva, J.G.; Vieira, J.; Jorge, S.; Pazos, M.; Sanromán, M.Á.; Lapa, N.; Delerue-Matos, C. Life cycle and economic analyses of the removal of pesticides and pharmaceuticals from municipal wastewater by anodic oxidation. *Sustainability (Basel),* **2021**, *13*(7), 3669. http://dx.doi.org/10.3390/su13073669

[44] Guillon, O.; Dash, A.; Lenser, C.; Uhlenbruck, S.; Mauer, G. Tuning the microstructure and thickness of ceramic layers with advanced coating technologies using zirconia as an example. *Adv. Eng. Mater.,* **2020**, *22*(11), 2000529. http://dx.doi.org/10.1002/adem.202000529

[45] Karthikayan, S.; Ganesan, S.; Vasanthakumar, P.; Sankaranarayanan, G.; Dinakar, M. Innovative research trends in the application of thermal barrier metal coating in internal combustion engines. *Mater. Today Proc.,* **2017**, *4*(8), 9004-9012. http://dx.doi.org/10.1016/j.matpr.2017.07.253

[46] Wang, Z.; Lu, Q.; Zhu, X.F.; Zhang, Y. Catalytic fast pyrolysis of cellulose to prepare levoglucosenone using sulfated zirconia. *ChemSusChem,* **2011**, *4*(1), 79-84. http://dx.doi.org/10.1002/cssc.201000210 PMID: 21226215

[47] Sable, S.S.; Panchangam, S.C.; Lo, S.L. Abatement of clofibric acid by Fenton-like process using iron oxide supported sulfonated-ZrO_2: Efficient heterogeneous catalysts. *J. Water Process Eng.,* **2018**, *26*, 92-99. http://dx.doi.org/10.1016/j.jwpe.2018.10.001

[48] Sable, S.S.; Shah, K.J.; Chiang, P.C.; Lo, S.L. Catalytic oxidative degradation of phenol using iron oxide promoted sulfonated-ZrO_2 by Advanced Oxidation Processes (AOPs). *J. Taiwan Inst. Chem. Eng.,* **2018**, *91*, 434-440. http://dx.doi.org/10.1016/j.jtice.2018.06.030

[49] David, M.; Lyth, S.M.; Lindner, R.; Harrington, G.F. *Future-proofing fuel cells: Critical raw material governance in sustainable energy*; Springer Nature, **2021**. http://dx.doi.org/10.1007/978-3-030-76806-5

[50] Del Tedesco, A.; Piotto, V.; Sponchia, G.; Hossain, K.; Litti, L.; Peddis, D.; Scarso, A.; Meneghetti, M.; Benedetti, A.; Riello, P. Zirconia-based magnetoplasmonic nanocomposites: A new nanotool for magnetic-guided separations with sers identification. *ACS Appl. Nano Mater.,* **2020**, *3*(2), 1232-1241. http://dx.doi.org/10.1021/acsanm.9b01982

[51] Susner, M.A.; Haugan, T.J. A review of the state-of-the-art superconductor technology for high power applications. *2018 AIAA/IEEE Electric Aircraft Technologies Symposium (EATS),* **2018**, pp. 1-17. http://dx.doi.org/10.2514/6.2018-5030

[52] Geng, C.; Zong, H.; Li, M.; Liu, H.; Wu, J.; Yang, J.; Cao, G.; Kang, C. Influence of the thickness of ZrO2 buffer layer on the electrical and optical properties of VO_2 films. *Infrared Phys. Technol.,* **2019**, *102*, 103016. http://dx.doi.org/10.1016/j.infrared.2019.103016

[53] Tsuji, Y. Study on thin film fabrication process and electrode reaction analysis for high efficiency solid oxide fuel cell. Doctoral dissertation, Kyoto University, **2020**.

[54] G, M.S.; Adarakatti, P.S.; Udayakumar, V. Engineering of CuO/ZrO_2 nanocomposite-based electrochemical sensor for the selective detection of hydrogen peroxide. *Ionics,* **2021**, *27*(12), 5309-5322. http://dx.doi.org/10.1007/s11581-021-04243-2

[55] Kandpal, K.; Gupta, N.; Singh, J.; Shekhar, C. On the threshold voltage and performance of ZnO-based thin-film transistors with a ZrO2 gate dielectric. *J. Electron. Mater.,* **2020**, *49*(5), 3156-3164. http://dx.doi.org/10.1007/s11664-020-08055-4

[56] Bocanegra-Bernal, M.H.; de la Torre, S.D. Phase transitions in zirconium dioxide and related materials for high performance engineering ceramics. *J. Mater. Sci.,* **2002**, *37*(23), 4947-4971. http://dx.doi.org/10.1023/A:1021099308957

[57] Lazić, V.; Pirković, A.; Sredojević, D.; Marković, J.; Papan, J.; Ahrenkiel, S.P.; Janković-Častvan, I.; Dekanski, D.; Jovanović-Krivokuća, M.; Nedeljković, J.M. Surface-modified ZrO2 nanoparticles with caffeic acid: Characterization and *in vitro* evaluation of biosafety for placental cells. *Chem. Biol. Interact.,* **2021**, *347*, 109618. http://dx.doi.org/10.1016/j.cbi.2021.109618 PMID: 34364836

[58] Patel, G.; Dewangan, D. K.; Bhakat, N.; & Banerjee, S. Green approaches for the synthesis of poly-functionalized imidazole derivatives: A comprehensive review. *Curr. Res. Green Sustain. Chem.*, **2021**, *4*, 100175. https://doi.org/10.1016/j.crgsc.2021.100175

[59] (a) Patel, A. R.; Patel, G.; Maity, G.; Patel, S. P.; Bhattacharya, S.; Putta, A.; & Banerjee, S. Direct oxidative azo coupling of anilines using a self-assembled flower-like $CuCo_2O_4$ material as a catalyst under aerobic conditions. *ACS omega*, **2020**, *5*(47), 30416-30424. https://doi.org/10.1021/acsomega.0c03562
(b) Lambat, T. L.; Deo, S. S. Synthesis of novel benzofluorenone derivatives and their HIV reverse transcriptase inhibitory activity. *J Chin. Adv. Mater. Soc.,* **2017**, *5*(1), 20-32. https://doi.org/10.1080/22243682.2016.1251334

[60] Bajpai, S.; Singh, S.; Srivastava, V. Nano zirconia catalysed one-pot synthesis of some novel substituted imidazoles under solvent-free conditions. *RSC Advances*, **2015**, *5*(36), 28163-28170. https://doi.org/10.1039/C4RA16211K

[61] Ambati, S. R; Patel, J. L.; Gudala, S.; Chandrakar, K.; Penta, S.; Mahapatra, S. P.; & Banerjee, S. Synthesis of novel coumarinyl-pyrido [2, 3-d] pyrimidine-2, 4-diones using task-specific magnetic ionic liquid,[AcMIm] $FeCl_4$ as catalyst. *Synth. Commun.,* **2020**, *50*(1), 104-111. https://doi.org/10.1080/00397911.2019.1686526

[62] Deepthi, A.; Thomas, V.; Sathi, V. Green Protocols for the Synthesis of 3, 3′-spirooxindoles–2016-mid 2019. *Curr. Green Chem.,* **2019**, *6*(3), 210-225. http://dx.doi.org/10.2174/2213346106666191019144116

[63] Brandão, P.; Marques, C.S.; Carreiro, E.P.; Pineiro, M.; Burke, A.J. Engaging isatins in multicomponent reactions (MCRs)–easy access to structural diversity. *Chem. Rec.,* **2021**, *21*(4), 924-1037. http://dx.doi.org/10.1002/tcr.202000167 PMID: 33599390

[64] Wang, L.C.; Du, S.; Chen, Z.; Wu, X.F. $FeCl_3$-Mediated Synthesis of 2-(Trifluoromethyl)quinazolin-4(3*H*)-ones from Isatins and Trifluoroacetimidoyl Chlorides. *Org. Lett.,* **2020**, *22*(14), 5567-5571. http://dx.doi.org/10.1021/acs.orglett.0c01927 PMID: 32610908

[65] Youseftabar-Miri, L.; Hosseinjani-Pirdehi, H.; Akrami, A.; Hallajian, S. Recent investigations in the synthesis of spirooxindole derivatives by Iranian researchers. *J. Indian Chem. Soc.,* **2020**, *17*(9), 2179-2231. http://dx.doi.org/10.1007/s13738-020-01921-2

[66] Brandão, P.; Marques, C.; Burke, A.J.; Pineiro, M. The application of isatin-based multicomponent-reactions in the quest for new bioactive and druglike molecules. *Eur. J. Med. Chem.,* **2021**, *211*, 113102. http://dx.doi.org/10.1016/j.ejmech.2020.113102 PMID: 33421712

[67] Nath, R.; Pathania, S.; Grover, G.; Akhtar, M.J. Isatin containing heterocycles for different biological activities: Analysis of structure activity relationship. *J. Mol. Struct.,* **2020**, *1222*, 128900. http://dx.doi.org/10.1016/j.molstruc.2020.128900

[68] Haribabu, J.; Alajrawy, O.I.; Jeyalakshmi, K.; Balachandran, C.; Krishnan, D.A.; Bhuvanesh, N.; Aoki, S.; Natarajan, K.; Karvembu, R. N-substitution in isatin thiosemicarbazones decides nuclearity of Cu(II) complexes – Spectroscopic, molecular docking and cytotoxic studies. *Spectrochim. Acta A Mol. Biomol. Spectrosc.,* **2021**, *246*, 118963. http://dx.doi.org/10.1016/j.saa.2020.118963 PMID: 33017789

[69] Rajesh Kumar, M.; Violet Dhayabaran, V.; Sudhapriya, N.; Manikandan, A.; Gideon, D.A.; Annapoorani, S. p-TSA.H_2O mediated one-pot, multi-component synthesis of isatin derived imidazoles as dual-purpose drugs against inflammation and cancer. *Bioorg. Chem.,* **2020**, *102*, 104046. http://dx.doi.org/10.1016/j.bioorg.2020.104046 PMID: 32688115

[70] Abdizadeh, R.; Ghatreh-Samani, K.; Hadizadeh, F.; Abdizadeh, T. Structural investigation of isatin-based benzenesulfonamides as carbonic anhydrase isoform IX inhibitors endowed with anticancer activity using molecular modeling approaches. *J. Mol. Struct.,* **2021**, *1229*, 129735. http://dx.doi.org/10.1016/j.molstruc.2020.129735

[71] Mudithanapelli, C.; Vasam, C.S.; Vadde, R.; Kim, M. Highly efficient and practical N-heterocyclic carbene organocatalyzed chemoselective N1/C3-

functionalization of isatins with green chemistry principles. *ACS Omega,* **2018**, *3*(12), 17646-17655. http://dx.doi.org/10.1021/acsomega.8b02361 PMID: 31458364

[72] Thakur, R.K.; Joshi, P.; Upadhyaya, K.; Singh, K.; Sharma, G.; Shukla, S.K.; Tripathi, R.; Tripathi, R.P. Synthesis of isatin based N^1-alkylated 3-β-C-glycoconjugated-oxopropylidene oxindoles as potent antiplasmodial agents. *Eur. J. Med. Chem.,* **2019**, *162*, 448-454. http://dx.doi.org/10.1016/j.ejmech.2018.11.008 PMID: 30469040

[73] Varun, V.; Sonam, S.; Kakkar, R. Isatin and its derivatives: A survey of recent syntheses, reactions, and applications. *MedChemComm,* **2019**, *10*(3), 351-368. http://dx.doi.org/10.1039/C8MD00585K PMID: 30996856

[74] Wang, R.; Yin, X.; Zhang, Y.; Zhang, T.; Shi, W. Design, synthesis, and *in vitro* anti-tumor activities of 1,2,3-triazole-tetraethylene glycol tethered heteronuclear bis-schiff base derivatives of isatin. *J. Heterocycl. Chem.,* **2018**, *55*(12), 3001-3005. http://dx.doi.org/10.1002/jhet.3341

[75] Tiwari, S.; Sharif, N.; Gajare, R.; Vazquez, J.; Sangshetti, J.; Damale, M.; Nikalje, A. New 2-oxoindolin phosphonates as novel agents to treat cancer: A green synthesis and molecular modeling. *Molecules,* **2018**, *23*(8), 1981. http://dx.doi.org/10.3390/molecules23081981 PMID: 30096835

[76] Reddy, B.M.; Patil, M.K. Organic syntheses and transformations catalyzed by sulfated zirconia. *Chem. Rev.,* **2009**, *109*(6), 2185-2208. http://dx.doi.org/10.1021/cr900008m PMID: 19408954

[77] El-Kemary, B.M.; El-Borady, O.M.; Abdel Gaber, S.A.; Beltagy, T.M. Role of NANO-ZIRCONIA in the mechanical properties improvement of resin cement used for tooth fragment reattachment. *Polym. Compos.,* **2021**, *42*(7), 3307-3319. http://dx.doi.org/10.1002/pc.26060

[78] Ahmed, W.; Iqbal, J.; Aisida, S.O.; Badshah, A.; Ahmad, I.; Alamgir, K.; Gul, I.H. Structural, magnetic and dielectric characteristics of optically tuned Fe doped ZrO2 nanoparticles with visible light driven photocatalytic activity. *Mater. Chem. Phys.,* **2020**, *251*, 122999. http://dx.doi.org/10.1016/j.matchemphys.2020.122999

[79] Olaniyan, B.; Saha, B. Comparison of catalytic activity of ZIF-8 and Zr/ZIF-8 for greener synthesis of chloromethyl ethylene carbonate by CO_2 utilization. *Energies,* **2020**, *13*(3), 521. http://dx.doi.org/10.3390/en13030521

[80] Nasseri, M.A.; Kazemnejadi, M.; Mahmoudi, B.; Assadzadeh, F.; Alavi, S.A.; Allahresani, A. Efficient preparation of 1,8-dioxo-octahydroxanthene derivatives by recyclable cobalt-incorporated sulfated zirconia (ZrO_2/SO_{42-}/Co) nanoparticles. *J. Nanopart. Res.,* **2019**, *21*(10), 214. http://dx.doi.org/10.1007/s11051-019-4643-x

[81] Patel, A. R.,; Asatkar, A.; Patel, G.; & Banerjee, S. Synthesis of rice husk derived activated mesoporous carbon immobilized palladium hybrid nano-catalyst for ligand-free mizoroki-heck/suzuki/sonogashira cross-coupling reactions. *ChemistrySelect*, **2019**, *4*(19), 5577-5584.ss https://doi.org/10.1002/slct.201900384

[82] Dabbagh, H.A.; Zamani, M. Catalytic conversion of alcohols over alumina–zirconia mixed oxides: Reactivity and selectivity. *Appl. Catal. A Gen.,* **2011**, *404*(1-2), 141-148. http://dx.doi.org/10.1016/j.apcata.2011.07.024

[83] Reta, J.L.; García, R.; Sandoval, G.; Rivera, J.L.; Hernández, J.M.; de Oca, A.M. Preparation of zirconium oxides modified with borate ions tested in catalytic dehydration of ethanol. *Rev. Mex. Fis.,* **2009**, *55*(1), 98-101.

[84] Akune, T.; Morita, Y.; Shirakawa, S.; Katagiri, K.; Inumaru, K. ZrO_2 nanocrystals as catalyst for synthesis of dimethylcarbonate from methanol and carbon dioxide: Catalytic activity and elucidation of active sites. *Langmuir,* **2018**, *34*(1), 23-29. http://dx.doi.org/10.1021/acs.langmuir.7b01294 PMID: 28974090

[85] Cannilla, C. Editorial special issue "Heterogeneous catalytic materials: Synthesis, characterization and applications for energetic purposes". *Catalysts,* **2020**, *10*(10), 1174. http://dx.doi.org/10.3390/catal10101174

[86] Teymourian, H.; Salimi, A.; Firoozi, S.; Korani, A.; Soltanian, S. One-pot hydrothermal synthesis of zirconium dioxide nanoparticles decorated reduced graphene oxide composite as high performance electrochemical sensing and biosensing platform. *Electrochim. Acta,* **2014**, *143*, 196-206. http://dx.doi.org/10.1016/j.electacta.2014.08.007

[87] Reddy Yadav, L.S.; Ramakrishnappa, T.; Pereira, J.R.; Venkatesh, R.; Nagaraju, G. Electrical property of zirconium oxide nanoparticle synthesized by hydrothermal method. *Mater. Today Proc.,* **2022**, *49*, 686-689. http://dx.doi.org/10.1016/j.matpr.2021.05.172

[88] Batool, T.; Bukhari, B.S.; Riaz, S.; Batoo, K.M.; Raslan, E.H.; Hadi, M.; Naseem, S. Microwave assisted sol-gel synthesis of bioactive zirconia nanoparticles – Correlation of strength and structure. *J. Mech. Behav. Biomed. Mater.,* **2020**, *112*, 104012. http://dx.doi.org/10.1016/j.jmbbm.2020.104012 PMID: 32949867

[89] Torres-Huerta, A.M.; Domínguez-Crespo, M.A.; Ramírez-Meneses, E.; Vargas-García, J.R. MOCVD of zirconium oxide thin films: Synthesis and characterization. *Appl. Surf. Sci.,* **2009**, *255*(9), 4792-4795. http://dx.doi.org/10.1016/j.apsusc.2008.11.059

[90] Patel, U.S.; Patel, K.H.; Chauhan, K.V.; Chawla, A.K.; Rawal, S.K. Investigation of various properties for zirconium oxide films synthesized by sputtering. *Proc. Technol.,* **2016**, *23*, 336-343. http://dx.doi.org/10.1016/j.protcy.2016.03.035

[91] Gawande, M.B.; Jayaram, R.V. A novel catalyst for the Knoevenagel condensation of aldehydes with malononitrile and ethyl cyanoacetate under solvent free conditions. *Catal. Commun.,* **2006**, *7*(12), 931-935. http://dx.doi.org/10.1016/j.catcom.2006.03.008

[92] Nagrik, D.M.; Ambhore, D.M.; Gawande, M.B. One-pot preparation of β–amino carbonyl compounds by Mannich reaction using MgO/ZrO_2 as effective and reusable catalyst. *Int. J. Chem.,* **2010**, *2*(2), 98-101.

[93] Gawande, M.B.; Branco, P.S.; Parghi, K.; Shrikhande, J.J.; Pandey, R.K.; Ghumman, C.A.A.; Bundaleski, N.; Teodoro, O.M.N.D.; Jayaram, R.V. Synthesis and characterization of versatile MgO–ZrO_2 mixed metal oxide nanoparticles and their applications. *Catal. Sci. Technol.,* **2011**, *1*(9), 1653-1664. http://dx.doi.org/10.1039/c1cy00259g

[94] Gawande, M.B.; Shelke, S.N.; Branco, P.S.; Rathi, A.; Pandey, R.K. Mixed metal MgO-ZrO_2 nanoparticle-catalyzed O-tert-Boc protection of alcohols and phenols under solvent-free conditions. *Appl. Organomet. Chem.,* **2012**, *26*(8), 395-400. http://dx.doi.org/10.1002/aoc.2846

[95] Bhojegowd, M.R.M.; Siddaramanna, A.; Siddappa, A.B.; Thimmanna, C.G.; Pasha, M.A. Combustion derived nanocrystalline-ZrO_2 and its catalytic activity for biginelli condensation under microwave irradiation. *Chin. J. Chem.,* **2011**, *29*(9), 1863-1868. http://dx.doi.org/10.1002/cjoc.201180325

[96] Farhadi, A.; Takassi, M.A.; Hejazi, L. Study of the synthesis of some biginelli-type products catalyzed by Nano-ZrO_2. *Z. Naturforsch. B. J. Chem. Sci.,* **2013**, *68*(1), 51-56. http://dx.doi.org/10.5560/znb.2013-2192

[97] Jafarpour, M.; Rezapour, E.; Ghahramaninezhad, M.; Rezaeifard, A. A novel protocol for selective synthesis of monoclinic zirconia nanoparticles as a heterogeneous catalyst for condensation of 1,2-diamines with 1,2-dicarbonyl compounds. *New J. Chem.,* **2014**, *38*(2), 676-682. http://dx.doi.org/10.1039/C3NJ00655G

[98] Bodhak, C.; Kundu, A.; Pramanik, A. ZrO_2 nanoparticles as a reusable solid dual acid–base catalyst for facile one-pot synthesis of multi-functionalized spirooxindole derivatives under solvent free condition. *RSC advances*, **2015**, *5*(104), 85202-85213. https://doi.org/10.1039/C5RA16259A

[99] Saha, A.; Payra, S.; Banerjee, S. One-pot multicomponent synthesis of highly functionalized bio-active pyrano[2,3-c]pyrazole and benzylpyrazolyl coumarin derivatives using ZrO_2 nanoparticles as a reusable catalyst. *Green Chem.,* **2015**, *17*(5), 2859-2866. http://dx.doi.org/10.1039/C4GC02420F

[100] Debnath, K.; Mukherjee, S.; Bodhak, C.; Pramanik, A. Facile one-pot three-component synthesis of diverse 2, 3-disubstituted isoindolin-1-ones using ZrO_2 nanoparticles as a reusable dual acid–base solid support under solvent-free conditions. *RSC advances*, **2016**, *6*(25), 21127-21138. https://doi.org/10.1039/C6RA00870D

[101] Saha, A.; Payra, S.; Banerjee, S. In-water facile synthesis of poly-substituted 6-arylamino pyridines and 2-pyrrolidone derivatives using tetragonal nano-ZrO_2 as reusable catalyst. *RSC Advances,* **2016**, *6*(104), 101953-101959. http://dx.doi.org/10.1039/C6RA24367C

[102] Zonouzi, A.; Afjei, S.J.; Rahmani, A.; Ng, S.W. Novel synthesis of some 2-aminochromene derivatives using nano-sized zirconium oxide as catalyst. *Org. Prep. Proced. Int.,* **2016**, *48*(1), 45-54. http://dx.doi.org/10.1080/00304948.2016.1127099

[103] Bajpai, S.; Singh, S.; Srivastava, V. Monoclinic zirconia nanoparticle-catalyzed regioselective synthesis of some novel substituted spirooxindoles through one-pot multicomponent reaction in a ball mill: A step toward green and sustainable chemistry. *Synth. Commun.,* **2017**, *47*(16), 1514-1525. http://dx.doi.org/10.1080/00397911.2017.1336244

[104] Bansal, P.; Kaur, N.; Prakash, C.; Chaudhary, G.R. ZrO_2 nanoparticles: An industrially viable, efficient and recyclable catalyst for synthesis of pharmaceutically significant xanthene derivatives. *Vacuum,* **2018**, *157*, 9-16. http://dx.doi.org/10.1016/j.vacuum.2018.08.018

[105] Singh, S.; Bajpai, S. Eco-friendly and facile synthesis of substituted imidazoles *via* nano zirconia catalyzed one-pot multicomponent reaction of isatin derivatives with ammonium acetate and substituted aromatic aldehydes under solvent free conditions. In: *Nanocatalysts*; IntechOpen, **2019**. http://dx.doi.org/10.5772/intechopen.82720

[106] Rao, T.N.; AlOmar, S.Y.; Ahmed, F.; Albalawi, F.; Ahmad, N.; Rao, N.K.; Rao, M.V.B.; Cheedarala, R.K.; Reddy, G.R.; Naidu, T.M. Reusable nano-zirconia-catalyzed synthesis of benzimidazoles and their antibacterial and antifungal activities. *Molecules,* **2021**, *26*(14), 4219. http://dx.doi.org/10.3390/molecules26144219 PMID: 34299494

[107] Reddy, B.M.; Sreekanth, P.M.; Lakshmanan, P.; Khan, A. Synthesis, characterization and activity study of SO_{42-}/CexZr1−xO_2 solid superacid catalyst. *J. Mol. Catal. Chem.,* **2006**, *244*(1-2), 1-7. http://dx.doi.org/10.1016/j.molcata.2005.08.054

[108] Tyagi, B.; Mishra, M.K.; Jasra, R.V. Synthesis of 7-substituted 4-methyl coumarins by Pechmann reaction using nano-crystalline sulfated-zirconia. *J. Mol. Catal. Chem.,* **2007**, *276*(1-2), 47-56. http://dx.doi.org/10.1016/j.molcata.2007.06.003

[109] Negrón-Silva, G.; Hernández-Reyes, C.; Angeles-Beltrán, D.; Lomas-Romero, L.; González-Zamora, E. Microwave-enhanced sulphated zirconia and SZ/MCM-41 catalyzed regioselective synthesis of β-amino alcohols under solvent-free conditions. *Molecules,* **2008**, *13*(4), 977-985. http://dx.doi.org/10.3390/molecules13040977 PMID: 18463599

[110] Tyagi, B.; Mishra, M.K.; Jasra, R.V. Solvent free synthesis of acetyl salicylic acid over nano-crystalline sulfated zirconia solid acid catalyst. *J. Mol. Catal. Chem.,* **2010**, *317*(1-2), 41-45. http://dx.doi.org/10.1016/j.molcata.2009.10.019

[111] Gondaliya, M.B.; Maheta, T.; Mamtora, M.J.; Shah, M.K. Reusable nanocatalyst: Zirconia and sulfated zirconia. *Int. Lett. Chem. Phys. Astronomy,* **2014**, *17*, 73716711.

[112] Saravanan, K.; Tyagi, B.; Bajaj, H.C. Synthesis of dypnone by solvent free self condensation of acetophenone over nano-crystalline sulfated zirconia catalyst. *J. Sol-Gel Sci. Technol.,* **2012**, *61*(1), 275-280. http://dx.doi.org/10.1007/s10971-011-2624-3

[113] Saravanan, K.; Tyagi, B.; Bajaj, H.C. Esterification of caprylic acid with alcohol over nano-crystalline sulfated zirconia. *J. Sol-Gel Sci. Technol.,* **2012**, *62*(1), 13-17. http://dx.doi.org/10.1007/s10971-011-2671-9

[114] Teimouri, A.; Chermahini, A.N. One-pot green synthesis of pyrrole derivatives catalyzed by nano sulfated zirconia as a solid acid catalyst. *Chin. J. Chem.,* **2012**, *30*(2), 372-376. http://dx.doi.org/10.1002/cjoc.201100143

[115] Ghafuri, H.; Rashidizadeh, A.; Ghorbani, B.; Paravand, F. Nano magnetic sulfated zirconia (Fe_3O_4@ZrO_2/$SO_4$2-) as a solid acid and reusable catalyst for the protection of hydroxyl groups under solvent-free condition. **2014**.

[116] Saravanan, K.; Tyagi, B.; Bajaj, H.C. Nano-crystalline, mesoporous aerogel sulfated zirconia as an efficient catalyst for esterification of stearic acid with methanol. *Appl. Catal. B,* **2016**, *192*, 161-170. http://dx.doi.org/10.1016/j.apcatb.2016.03.037

[117] Nakhaei, A. Synthesis of tetrahydrobenzo[A]xanthene-11-one derivatives using zro2–So3H as highly efficient recyclable nano-catalyst. *J. Appl. Chem. Res.,* **2017**, *11*(3), 72-83.

[118] Nakhaei, A.; Nakhaei, Z. Catalytic activity of ZrO_2–SO_3H as highly efficient recyclable nano-catalyst for the synthesis of tetrahydrobenzo [b] pyrans. *Iranian J. Org. Chem.,* **2017**, *9*, 2135-2144.

[119] Nakhaei, A. Synthesis of thiazole derivatives using magnetic nano zirconia–sulfuric acid as an efficient and recyclable catalyst in water. *Russ. J. Gen. Chem.,* **2017**, *87*(8), 1850-1856. http://dx.doi.org/10.1134/S1070363217080333

[120] Nakhaei, A.; Davoodnia, A.; Yadegarian, S. **2018**, An efficient green approach for the synthesis of fluoroquinolones using nano zirconia sulfuric acid as highly efficient recyclable catalyst in two forms of water. *Iran. J. Chem. Chem. Eng.,* **2018**, *37*(3), 33-42.

[121] Ghafuri, H.; Ghorbani, B.; Rashidizadeh, A.; Talebi, M.; Roshani, M. Fe_3O_4@ZrO_2 /SO_4^{2-}: A recyclable magnetic heterogeneous nanocatalyst for synthesis of β-amino carbonyl derivatives and synthesis of benzylamino coumarin derivatives through Mannich reaction. *Appl. Organomet. Chem.,* **2018**, *32*(3), e4147. http://dx.doi.org/10.1002/aoc.4147

[122] Nasseri, M. A.; Kazemnejadi, M.; Mahmoudi, B.; Assadzadeh, F.; Alavi, S. A.; Allahresani, A. Efficient preparation of 1, 8-dioxo-octahydroxanthene derivatives by recyclable cobalt-incorporated sulfated zirconia (ZrO_2/SO_4^{2-}/Co) nanoparticles. *J. Nanopart. Res.*, **2019**, *21*(10), 1-14. https://doi.org/10.1007/s11051-019-4643-x

[123] Tailor, Y.K.; Khandelwal, S.; Gopal, R.; Rushell, E.; Prajapati, A.; Kumar, M. Use of nanomagnetic sulfated zirconia (Fe_3O_4@ZrO_2/SO_4^{2-}) as sustainable heterogeneous acid catalyst for synthesis of spiroheterocycles under solvent-free conditions. *ChemistrySelect,* **2017**, *2*(34), 11055-11061. http://dx.doi.org/10.1002/slct.201702422

[124] Ghafuri, H.; Rashidizadeh, A.; Ghorbani, B.; Talebi, M. Nano magnetic sulfated zirconia (Fe_3O_4@ZrO_2 /SO_4^{2-}): An efficient solid acid catalyst for the green synthesis of α-aminonitriles and imines. *New J. Chem.,* **2015**, *39*(6), 4821-4829. http://dx.doi.org/10.1039/C5NJ00314H

[125] Ghafuri, H.; Rashidizadeh, A.; Esmaili Zand, H.R. Highly efficient solvent free synthesis of α-aminophosphonates catalyzed by recyclable nano-magnetic sulfated zirconia (Fe_3O_4@ZrO_2/SO_4^{2-}). *RSC Advances,* **2016**, *6*(19), 16046-16054. http://dx.doi.org/10.1039/C5RA13173A

[126] Amoozadeh, A.; Rahmani, S.; Bitaraf, M.; Abadi, F.B.; Tabrizian, E. Nano-zirconia as an excellent nano support for immobilization of sulfonic acid: A new, efficient and highly recyclable heterogeneous solid acid nanocatalyst for multicomponent reactions. *New J. Chem.,* **2016**, *40*(1), 770-780. http://dx.doi.org/10.1039/C5NJ02430G

[127] Hosseini, M.M.; Kolvari, E. Nano-magnetic zirconia sulfuric acid (Fe_3O_4@ ZrO_2-SO_3H): Magnetically separable and reusable heterogeneous catalyst for multicomponent reactions. *Chem. Lett.,* **2017**, *46*(1), 53-55. http://dx.doi.org/10.1246/cl.160793

[128] Hejazi, S.; Shojaei, A.; Tabatabaeian, K.; Shirini, F. Preparation and characterization of ZrO_2 supported Fe_3O_4 MNPs as an effective and reusable superparamagnetic catalyst for the riedländer synthesis of quinoline derivatives. *J. Serb. Chem. Soc.,* **2015**, *80*(8), 971-982. http://dx.doi.org/10.2298/JSC141023031H

[129] Pal, N.; Bhaumik, A. Self-assembled NiO–ZrO_2 nanocrystals with mesoscopic void space: An efficient and green catalyst for C–S cross-coupling reaction in water. *Dalton Trans.,* **2012**, *41*(30), 9161-9169. http://dx.doi.org/10.1039/c2dt30343d PMID: 22576811

[130] Bhaskaruni, S.V.H.S.; Maddila, S.; van Zyl, W.E.; Jonnalagadda, S.B. Four-component fusion protocol with NiO/ZrO_2 as a robust recyclable catalyst for novel 1, 4-dihydropyridines. *ACS Omega,* **2019**, *4*(25), 21187-21196. http://dx.doi.org/10.1021/acsomega.9b02608 PMID: 31867512

[131] Samantaray, S.; Mishra, B.G. Combustion synthesis, characterization and catalytic application of MoO_3–ZrO_2 nanocomposite oxide towards one pot synthesis of octahydroquinazolinones. *J. Mol. Catal. Chem.,* **2011**, *339*(1-2), 92-98. http://dx.doi.org/10.1016/j.molcata.2011.02.017

[132] Biklarian, H.; Behbahani, K.F.; Fakhroueian, Z. 22% Co/CeO_2-ZrO_2-catalyzed synthesis of 1, 2, 3, 4-tetrahydro-2-pyrimidinones and-thiones. *Lett. Org. Chem.,* **2012**, *9*(8), 580-584. http://dx.doi.org/10.2174/157017812802850159

[133] Sudarsanam, P.; Katta, L.; Thrimurthulu, G.; Reddy, B.M. Vapor phase synthesis of cyclopentanone over nanostructured ceria–zirconia solid solution catalysts. *J. Ind. Eng. Chem.,* **2013**, *19*(5), 1517-1524. http://dx.doi.org/10.1016/j.jiec.2013.01.018

[134] Wang, A.; Liu, X.; Su, Z.; Jing, H. New magnetic nanocomposites of ZrO_2 – Al_2O_3 –Fe_3O_4 as green solid acid catalysts in organic reactions. *Catal. Sci. Technol.,* **2014**, *4*(1), 71-80. http://dx.doi.org/10.1039/C3CY00572K

[135] Mahdavi, M.; Abedini, E.; Darabi, A. Biodiesel synthesis from oleic acid by nano-catalyst (ZrO_2 /Al_2O_3) under high voltage conditions. *RSC Advances,* **2015**, *5*(68), 55027-55032. http://dx.doi.org/10.1039/C5RA07081C

[136] Narasimhamurthy, K.H.; Girish, Y.R.; Thimmaraju, N.; Rangappa, K.S. Utility of ZrO_2–Al_2O_3 in the synthesis of 2,3-dihydroquinazolin-4(1H)-ones. *Chem. Data Collect.,* **2019**, *21*, 100230. http://dx.doi.org/10.1016/j.cdc.2019.100230

[137] Khan, S.A.; Khan, S.B.; Asiri, A.M.; Ahmad, I. Zirconia-based catalyst for the one-pot synthesis of coumarin through Pechmann reaction. *Nanoscale Res. Lett.,* **2016**, *11*(1), 345. http://dx.doi.org/10.1186/s11671-016-1525-3 PMID: 27460593

[138] Shojaei, A.F.; Tabatabaeian, K.; Hamidiyan, M.; Hejazi, S.Z. Synthesis and characterization of RuO2@ZrO2 core–shell nano particles as heterogeneous catalyst for oxidation of benzylic alcohols in different conditions. *J. Indian Chem. Soc.,* **2016**, *13*(5), 803-808. http://dx.doi.org/10.1007/s13738-015-0794-6

[139] Shabalala, S.; Maddila, S.; van Zyl, W.E.; Jonnalagadda, S.B. Innovative efficient method for the synthesis of 1,4-dihydropyridines using Y_2O_3 loaded on ZrO_2 as catalyst. *Ind. Eng. Chem. Res.,* **2017**, *56*(40), 11372-11379. http://dx.doi.org/10.1021/acs.iecr.7b02579

[140] Nakhaei, A. Nano-Fe_3O_4@ZrO_2-H_3PO_4 as an efficient recyclable catalyst for the neat preparation of thiazole derivatives in ordinary or magnetized water. *Curr. Catal.,* **2018**, *7*(1), 72-78. http://dx.doi.org/10.2174/2211544706666171010155918

[141] Cui, Y.; Rimoldi, M.; Platero-Prats, A.E.; Chapman, K.W.; Hupp, J.T.; Farha, O.K. Stabilizing a vanadium oxide catalyst by supporting on a metal–organic framework. *ChemCatChem,* **2018**, *10*(8), 1772-1777. http://dx.doi.org/10.1002/cctc.201701658

[142] Bhaskaruni, S.V.H.S.; Maddila, S.; van Zyl, W.E.; Jonnalagadda, S.B. V 2 O 5 /ZrO 2 as an efficient reusable catalyst for the facile, green, one-pot synthesis of novel functionalized 1,4-dihydropyridine derivatives. *Catal. Today,* **2018**, *309*, 276-281. http://dx.doi.org/10.1016/j.cattod.2017.05.038

[143] Thimmaraju, N.; Mohamed Shamshuddin, S.Z.; Pratap, S.R.; Shyam Prasad, K. Effective synthesis of novel O-acetylated compounds over ZrO_2-Al_2O_3 solid acid. *Arab. J. Chem.,* **2019**, *12*(8), 1860-1869. http://dx.doi.org/10.1016/j.arabjc.2014.12.011

[144] Girish, Y.R.; Sharath Kumar, K.S.; Muddegowda, U.; Lokanath, N.K.; Rangappa, K.S.; Shashikanth, S. ZrO_2 -supported Cu(II)–β-cyclodextrin complex: Construction of 2,4,5-trisubstituted-1,2,3-triazoles via azide–chalcone oxidative cycloaddition and post-triazole alkylation. *RSC Advances,* **2014**, *4*(99), 55800-55806. http://dx.doi.org/10.1039/C4RA09970B

[145] Zheng, J.; Li, J.; Wei, H.; Yu, J.; Su, H.; Wang, X. The investigation of gold/zirconia as a photocatalyst for the direct synthesis of imines from alcohols and aniline. *Mater. Sci. Semicond. Process.,* **2015**, *32*, 131-136. http://dx.doi.org/10.1016/j.mssp.2015.01.010

An International Registered Peer Reviewed Bilingual Research Journal

SATRAACHEE

ISSN 2348-8425

सत्राची

A UGC-CARE Enlisted
Peer Reviewed Research Journal

Year 11, Issue 26,
Vol 38, No. 3.
Jan.-March, 2023

"Contemporary Issues of Social Science, Commerce, and Business Management"

ISSN : 2348-8425

SATRAACHEE

UGC Care Enlisted, Peer Reviewed research Journal

Issue 26, Vol. 38, No. 3, Jan-March, 2023

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C/A No. 40034072172. IFSC : SBIN0006551,
State Bank of India, Boring Canal Rd.-Rajapool,
East Boring Canal Road, Patna, Bihar, Pin: 800001

Editing/Publishing: Unpaid/ Unprofessional
Publisher: *Satraachee Foundation, Patna*

Editorial Contact:

Anand Bihari
Kala Kunj, Besdide Canara Bank
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Patna-800016

Website : http://satraachee.org.in
E-mail : satraachee@gmail.com
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CONTEMPORARY ISSUES OF INDIAN AGRICULTURE SECTOR

❍ **Dr. Vinod Madhao Barde***

Abstract:

Agriculture is the Foundation of the Indian economy. There was a great importance to agriculture in 18th century. Even today also farming occupation is an important because 52% population of India are in agriculture sector as a profession. Out of total national income in India, ¼ income is from agriculture and allied sector. Agriculture was traditional and non-developed with low labour source and productivity. Farmers used to adopt old traditional method for cultivation of land. Use of chemical fertilizers was so limited. Agriculture was only cultivated for survival but not for income. During green revolution productivity has been raised in India. Due to new technology involvement in agriculture water and irrigation is most essential, which affects the uncertainty reflects concerning to the agriculture productivity. Its truth that in future also agriculture sector will play an important role in India. Currently many farmers migrated to urban areas for the searching job in industrial sector. Several farmers committed suicide the reason of crop production failure, increasing loan, water unviability. Farmers faced Emerging challenges like Rain-water uncertainty, climate changes, overburden of population, demand and supply of product, economic problem, lack of marketing knowledge, insufficient finance etc.In this research paper discuss the importance of emerging issues of Indian agriculture sector, and which scheme implemented for the farmers.

Keywords: Agriculture, farmers, challenges, scheme, income.

Introduction :

India is apredominantly agricultural nation. Agriculture is important to the Indian economy. Agriculture is a tool of economic production and medium of cultural development. Agriculture is a backbone of Indian economy. There was a great importance to agriculture in 18th century. Even today also farming occupation is an important because 52% people

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of India are in agriculture sector as a profession. Out of total national income in India, ¼ income is from agriculture. Its truth that in future also agriculture will play an important role in India.

During Indian independence, agriculture was traditional and non-developed with low labour source and productivity. Farmers used to adopt old traditional method for cultivation of land. Use of chemical fertilizers was so limited. Agriculture was only cultivated for survival but not for income. Commercialization of farming had been not propagated with limited utilization of money. Indian agriculture was totally dependent on nature. Around 54.21% agriculture was dependent on monsoon in the year 2015-16. Even today also nature plays an important role in farming sector.

Due to hybridization of seeds (except wheat) the dependency on nature has been increased drastically. During green revolution productivity has been raised in India. Due to new technology involvement in agriculture water and irrigation is most essential, which affects the uncertainty reflects concerning to the agriculture productivity. Agriculture development is high and steady in irrigation facility prone area. There is total uncertainty to non-irrigated and monsoon dependent agriculture land.

Objectives of the Study :

1. To understandthe Significance of the Agriculture sector.
2. To Research the issues facing the Agriculture sector.
3. To study the scheme for the farmers.

Research Methodology

The current study is based on secondary data that is primarilydescriptive. The information gathered from the ministry of Agriculture & Farmers Welfare's, Annual Report, the Reserve Bank of India Bulletin, the Indian Economic Association, Report, the NABARD Reports,articles, books, journals, websites and government publications.

Importance of Agriculture in Indian Economy :

An important part of the Indian economy is Agriculture. In 2021-22, 45.6% of the total work force in India will be employed in activities related to agriculture and associated sector, According to the government of India's "Annual Report of the Department of Agriculture & Farmers Welfare Ministry of Agriculture & Farmers Welfare",at current prices, agriculture's contribution tonational income (Gross Value Added) that year was 18.8%. In India, agriculture is expected to contribute 14.2% of exports and 18.8% of GDP in the years 2020-21. According the the government's 2018-19 report, out of the total geographical area, 139.3 million hectares were recorded as net deeded and 197.3 million hectares as gross cropped, with a cropping intensity of 141.6%. The net area sown is 42.4% of the total area.

Scheme for the farmers :

PM KISAN Program : It is program of the federal government to help land holding farmers with their financial needs. With this program, land holding farmers receive a direct benefit transfer of Rs. 6000 per year in financial benefit. In Accordance with the economic surveyfor 2022-23, the program covered approximately 11.3 crore farmers. This program

has aided farmers in making profitable investment in agriculture endeavors. In 2023 (Varsney& Joshi).

PMFBY : Pradhan MantriFasalBimaYojana, is the world's largest crop insurance programme. Every year, over 5.5 crore farmers engage in this programme. The programme guarantees that farmers will have less financial risk because they only have to pay 1.5% of the entire premium during the Rabi season and 2% during the Kharif season. Farmers paid a premium of Rs. 25,186 crore during the last six years of its implementation and received claims of rupees 1.2 lakh crore (as of 31 October 2022).

KISAN Credit (KCC) : In order to encourage farmers to buy agricultural inputs and services such as seeds, fertiliser, pesticides, etc. on credit, the Kisan credit card programme was created in 1998. According to the Indian Economic Survey, banks provided Kisan Credit Cards (KCC) to 3.89 crore eligible farmers as of December 30, 2022, with a KCC limit of $4,51,672 billion (Varsney & Joshi, 2023).

Mission for Integrated Development of Horticulture (MIDH) : The objectives of the Mission for integrated development of horticulture is to promote increasing the horticulture production area and farmers income. In This programme, which includes fruits, vegetables, plantation crops, spices, flowers, and root and tuber crops, was introduced in 2014-15. Economic survey statistics show that on a surface area of 28.0 million hectares, a record production of 342.3 million tonnes was attained. Twelve of the fifty-five horticultural clusters designated by the Indian central government have been chosen for the Cluster Development Program trial phase.

Challenges of Agriculture Sector : Since the green revaluation, there has been a significant change in the country's food situation. India experienced a severe food scarcity and widespread starvation, and millions of people's lives were saved by food imports. High Yielding Varieties of wheat and paddy were made available after the green devaluation, and irrigation was increased.Improved and High Yielding Varieties were also developed in many other crops. These changes effect on land quality, ecosystem, and environment. Therefore it is imperative to discuss challenges facing Indian agriculture.

Dependability of Rainfall : In the more than fifty percentage parts (over 56%) of the country, agriculture is mostly dependent on rainfall, specially the summer monsoon. Inappropriately, the behaviour of summer monsoon is highly unpredictable. Therefore, the variability of rainfall is high which affects the agricultural return unfavourably. Just 54.21 percent of the total planted area is irrigated, which gives farmers greater assurance about their agricultural revenues even when the monsoon fails, as it did in 2015-16, according to the Government of India Report.

Climate Changes : Currently the climate change is significant factor, those effecting on agriculture productivity. Increasing temperature along with increased occurrences of unsafe weather circumstances have made climate change a major hazard to Indian agriculture sector and productivity defeat.

Over burden of population :

Indian agriculture is characterised by a significant population burden. A total of 46% of the nation's population is either directly or indirectly reliant on agriculture.At present,

due to the CORONA pandemic heavy burden on agriculture. Per head availability of agriculture land has decreasing, but the rate of population increasing, hence dependability on agriculture of population is increased.

Economic Problems:Indian farmers are basically poor, it is not possible to buy agricultural machinery, use of new technology, improved seeds. Therefore, it is not possible to do new experiments in agriculture and to practice modern agriculture. Due to the high indebtedness of the farmers, after deducting the expenses from the income, the remaining amount does not meet even his primary needs, so the poor farmer is getting poorer.

Demand and Supply: If the farmers hark work is supported by nature, the farm yields huge income, at a time when supply is high, demand is low, and thus prices are low. Adequate godowns have not yet been created by the government in Indian to store the goods without selling them at falling prices when the cost of the increased production falls. In fact, it seems to be ignored at the government level. While promising to double the production of the country's farmers, there has been no substantial achievements in the last decade in terms of building basic facilities for it. As a result, due to the neglect of the storage of agriculture produce, crores of goods are seen to be worthless. In the five years from 2017 to 2022, more than 13 thousand tons of grain was wasted due to lack of necessary facilities in the government grain godown. This is evident from the figures of the Ministry of Food and Civil Supplies of the Central Government.

Traditional Method: A most of the Indian farmers are still farming with old traditional tools, are overall production is growing slowly. Lack of capital required to use modern technology and tools, lack of technical knowledge and lack of support from the administration level, while implementing the plans at the government level is causing Indian farmers to fail to use new technology. It affects the total production of the farmer and it is seen that the economic condition is getting weaker.

Lack of Marketing: Due to the large number of middlemen in the Indian market, the farmer does not sell the crop directly to the consumer. Whereas the middlemen buy the goods from the farmers and get the brokerage money. Bargaining power is low as farmers are unorganized and their organizational power is low. Due to the lack of market prices and related information, it is seen that Indian farmers are losing profit by selling their goods in market.

Conclusion :

The government's actions to increase crop and livestock productivity, guarantee certainty of return to farmers through price support, encourage crop diversification, improve market infrastructure by providing encouragement for the formation of farmer-producer societies, and promote investment in infrastructure facilities have all contributed to the sector's resilient performance over the past few years. Inadequate infrastructure, inadequate irrigation, and a lack of market expertise, particularly in rural regions, are the major issues that currently plague Indian agriculture.

References :

1. Department of Agriculture & Farmers Welfare (2022) : Annual Report- 2021-22, Ministry of Agriculture & Farmer Welfare, Government of India, New Delhi.

2. Dr. G.N Zamare (2016) : "Indian Economy", Pimpalpure and Publishers, 2016.
3. GirishKuber (2023) : "KadhavekiKujave", Daily Newspaper, Editorial Loksatta, 1 March, 2023.
4. Meenakshi Rajeev (2018) : "Contemporary Issues in Indian Agriculture", Social and Economic Change Monograph Series, Number 60, July 2018.
5. Ramesh Chand (2022) : "Agricultural Challenges and Policies for the 21st Century", Department of Economic Analysis and Research, NABARD Research and Policy Series No.6/2022
6. Ramesh Chand (2019) : "Transforming Agriculture for Challenges of 21st Century", 102 Annual Conference, Indian Economic Association, 27-29 December 2019.
7. Reserve bank of India : "Bulletin", January 2022.
8. Department of Economic Affairs (2023) "Economic Survey 2022-23", New Delhi, January 2023.
9. S.K.Goyal, Prabha, Jai P. Rai and Shree Ram Singh (2016) : "Indian Agriculture and Farmers-Problems and Reforms", Indian Agriculture and Farmers, Jan. 2016, pp.79-87.

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सत्राची फाउंडेशन, पटना

शोध, शिक्षा एवं प्रकाशन की समाजसेवी संस्था

यह संस्था -

- साहित्यिक सम्मान देती है।
- शोध पत्रिकाएँ प्रकाशित करती है।
- पुस्तकें प्रकाशित करती है।
- सेमिनार आयोजित करती है।
- राजभाषा/राष्ट्रभाषा सेवियों को प्रोत्साहित करती है।
- शोधकर्ताओं को स्तरीय शोध के लिए प्रोत्साहित करती है।
- नेट/जे.आर.एफ. के अभ्यर्थियों को निःशुल्क मार्गदर्शन देती है।
- हिन्दी साहित्य के शिक्षार्थियों को प्रतियोगी परीक्षाओं के लिए तैयार करती है।

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ISSN 2348-8425

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Year 11, Issue 26,
Vol 38, No. 4,
Jan.-March, 2023

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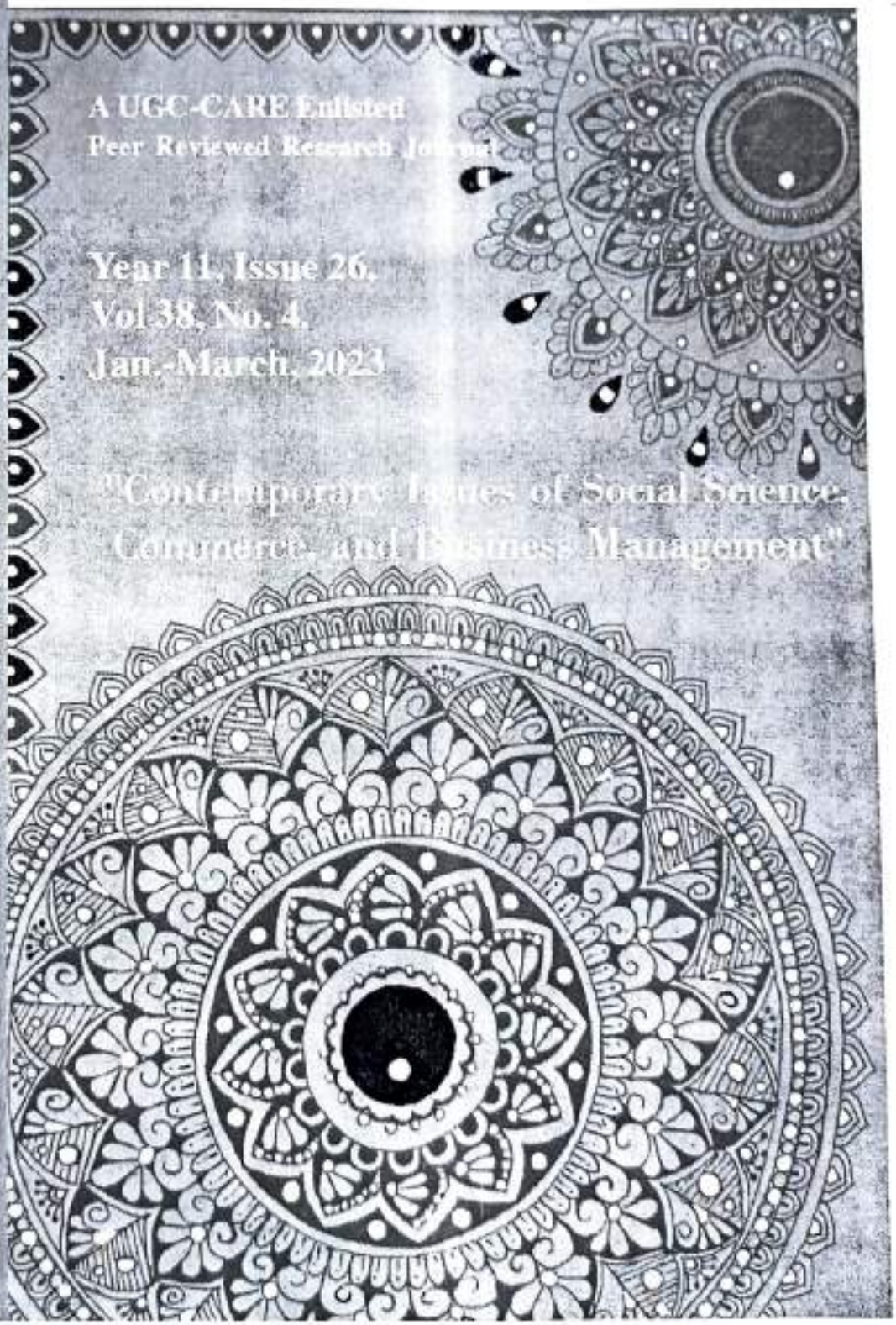

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Population Charactstics and it's Impact on Socio-Economic Development of Gadchiroli District : A Geographical Analysis

- Prof. (Dr.) Ganesh L. Dhote *
- Prof. (Dr.) Kishor Y. Thakare **

Abstract

Gadchiroli is the large district in the maharashtra state having 4.69% of the area of the state. Gadchiroli district is located in the some what eastern part of maharashtra. The west side in district wainganga river basin.its impact over the distribution of population as well as density of the population of the Gadchiroli district and East side of district cover on forest .therfour population on the region is low .Gadchiroli districts holds 1.87% of population to the state over 4.69% of its area among the 12 tehsil. Chamorchi teshil is the most population while korchi is the least population. Population live in rural area of 88.00% .The populationof sc and st in district shows trend the study 2011. The % of S.C. population 11.25%. while S.T. population 38.70%.In this census 2011 the percent of Scheduled cast population was 11.25% and Scheduled tribles population was 38.70%. Out of Scheduled cast population of the districts 41.76% lived in rural areas and 14.44% lived in urban area.Qualitative population accelerates the socio-economic condition of the reason. Topographical accessibility helps to the people for better development while inaccessibility stands as a obstacle.

Key Word: population distribution, Growth, Density, Economic structure, Socio-Econimic Development.

Introduction

The proposed study aims to highlight the major characteristics of population and the impact of its on socio-economic development with special reference to the geographical region of the Gadchiroli districts.The study of population never be viewed in isolation.Population and other physical environmental and geographical etc. factors are

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interrelated. population its self is an important aspect. Characteristics of population involves distribution of population, growth of population, standard of living, density and economic structure.

These Characteristics are useful to understand population personality of the region.The study is related to the distribution of population.

Physical factor involves the topographical features such as mountain, plateaus and plains. The distribution of population is concerned, mountains play favorable as well as unfavorable roles. Normaley pleteaus are suitable for human settlement while plain aceclerates the population growth. The Gadchiroli districts on which the study includes mountain ous and forest areas of east region.

Objectives of the study

The majour objectives of the present study is to make a comprehensive and impact of socio- economic development of Gadchiroli district.

Hypothesis

Population characteristics has impact on social and economic aspects of the region.

Data Base & Methodology

The data collected and used for the period various census book ,districts statical abstract,socio-economical review of Gadchiroli district etc.

Study Area

Gadchiroli is the large district in the maharashtra state having 4.69% of the area of the state .Gadchiroli district is located in the some what eastern part of maharashtra lying between 18°46' north to 20°50' north latitudes and 79°46' east to 80°55'east longitude. Geographical area of the district is 15433.10 sq.km. Which is 4.69 ? of the total area of the maharashtra. The population as per 2011 census is 10,72,942 out of which 9,54,909 is rural and 1,18033 is urban population. The area of the district is distributed among 12 sub divisions [Tahsil] .For the administrative purpose.

Physiography is one of the dominant paeameter of physical environmental, The district includes the gondwana land its three division,easted of shoots as Tipagadh & surjagadh range ,the middle land is slope and western part of wainganga river basin. Forest cover in the districts is 77% above.

The climate of the districts is mainly monsoon type. It,s is characterized with hot summers and dry winters.The winter season which last February. The average annual rainfall in the districts is 1150.00m.m. the average temperature of the district is 41° cg during summer season and winter season lowest temprature in December 11°cg. The drainage of Gadchiroli districts deals with three major river, the wainganga in the west,Indrawati river in east- south, and Godavari rivers in west-south. Minerals, especially of economic importance are avalible in the district.The forest covered in distrist 76% and surjegadh range in Iron minerals on Etapalli tahisil.

Impact of physiography on population characteristics of the District

Physiography or physical set of the Gadchiroli District is unique in nature. The district is a elevated tableland. It,s location to the wainganga river in west border.The physiography of the district.Indrawati river in the south border and east border surjagadh.The west side

in district wainganga river basin.its impact over the distribution of population as well as density of the population of the Gadchiroli district and East side of district cover on forest .therfour population on the region is low

Tahsil wise population [%] in Gadchiroli District -2011

TABAL-1

Sr. no	Name of the Tahsil	Population in [%]
1	Desaiganj	7.79
2	Armori	9.06
3	Kurkheda	8.02
4	Korchi	3.99
5	Dhanora	7.70
6	Gadchiroli	13.60
7	Chamorchi	16.69
8	Mulchera	4.27
9	Etapalli	7.63
10	Bhamragadh	3.38
11	Aheri	10.90
12	Sironcha	6.97
	District	100.00 %

Source:Gadchiroli district,census,report-2011

Korchi taluka bears 3.99%, Muiehera 4.22% ,Bhamragadh 3.38%, Dhanora 7.70%, Sironeha 6.97% Ettapallil 7.63%, These distributions are due to somewhat impact of the physiography of the region the region with river of waingang,pranhita,godavari,chimorchi, aheri shows 7.79% ,905%,13.60%,10.90% (2011) population growth .

The 2011 census record shows following distribution of density in the district. The region with low density below 100 consist korchi, Dhanora, Etapalli,bhamgradh are dominance in physiography, which shows,its impact over population density of the region. The region with high density are Desaiganj, Armori,Gadchiroli,Chimorchi are in the wainganga basins.

Cast wise Population

[Schedule Caste and Scheduled Tribles]

Districts census handbook [2011] contains data about schedule cast and scheduled tribes. This data is usefully for plan out their socio-ecoromic enlistment and both the planners

and administrator

S.C. and S.T. population in Gadchiroli district- 2011.

TABAL-1

Cast	Total	Rural	Urban
S.C.	11.25	10.67	15.98
S.T.	38.70	41.71	14.44

The population of s.c. and s.t. in district shows trend the study 2011. The % of S.C. population 11.25%. while S.T. population 38.70%.

Taluka	Total Population	S.C. Population	S.C. Populatin %	S.T. Population	S.T. Populatin %
Desaiganj	83,607	14138	16.91	7119	8.61
Armori	97,097	11368	11.71	23,120	23.81
Kurkheda	86,073	8963	10.41	46,826	54.40
Korchi	42,811	3442	8.04	31,333	73.19
Dhanora	82,698	3934	4.76	58,745	71.19
Gadchiroli	1,45,963	21,023	14.40	28,421	19.47
Chimorchi	1,79,120	16,135	9.01	32,623	18.21
Mulchera	45,787	2726	5.95	14,834	32.40
Etapalli	81,713	2893	3.54	66,597	81.50
Bhamragadh	36,325	1128	3.11	29,459	81.10
Aheri	1,16,992	16683	14.26	58,233	49.78
Sironcha	74,756	18,312	24.50	17,916	23.97
District	10,72,942	1,20,745	11.25	4,15,306	38.70

In Gadchiroli district S.C. Population was 1,20,745 [11.25%] in 2011. Sironcha taluka most S.C. population 24.50% and bhamragadh taluka lowest population 3.11%.

The Gadchiroli district S.T. Population was 4,15,306 [38.70 %] and S.T. population Etapalli taluka most S.T. population 81.50% and Desaiganj taluka lowest population 8.61%. The urban area most ratio in s.c. poipulation and rural area most ratio in s.t.population.

Scheduled Cast and Scheduled Tribe Occupational Characteristics:

People are engaged in different works as a economic activities.These activities are

closed in three categories as primary activities (Cultivators, Agricultural laboures, livetock, Forestry, Fishing, Hunting, Plantations, and mining etc.) Secondary activities (Manufacturing, processing, reprising in household etc.), and Other activities (Trade, Transport,Communication etc. The Gadchiroli district has population of these categories accelerate their socio-economic life.

Table-3

Tahsil	Population		hTotal workers		Main workers		Primary activities		Secondary activities		Other activities	
	S.C.	S.T.	S.C.	S.T.	S.C.	S.T.	S.C.	S.T.	S.C.	S.T.	S.C.	S.T.
Desaiganj	14138	7119	7127	3647	4310	2203	2675 71.98	685 52.65	161 3.73	47 2.13	1474 (31.19)	474 (21.48)
Armori	11368	23120	6389	12885	3867	8088	2914 75.28	7656 88.11	85 2.19	110 1.26	868 (22.44)	922 (10.61)
Kurkheda	8963	46826	5129	26894	2967	15472	2311 77.88	14053 91.02	42 1041	157 1.01	614 (20.69)	1262 (8.15)
Korchi	3442	31333	1985	18089	1140	10592	794 69.64	9842 92.92	39 3.42	86 0.81	307 (26.92)	664 (6.21)
Dhanora	3934	58745	2220	34326	1626	23104	1212 74.53	21581 84.99	47 2.89	226 0.98	367 (22.57)	1297 (5.61)
Gadchiroli	21023	28421	5226	14793	7101	9984	3557 50.08	6414 64.13	158 2.22	181 1.81	3386 (47.68)	3325 (33.30)
Chimorchi	16135	32623	8675	18708	5824	12305	4436 76.16	10405 88.66	58 0.99	82 0.66	1330 (22.83)	1218 (9.89)
Mulchera	2726	14834	1516	7870	719	4194	540 75.09	3754 89.50	08 1.11	35 0.83	171 (23.78)	405 (9.66)
Etapalli	2893	66597	1443	36995	1005	26930	602 59.89	24679 91.63	24 2.38	317 1.18	379 (37.71)	1934 (7.18)
Bhamragadh	1128	29459	658	17218	457	14279	278 60.83	13043 91.33	08 1.75	167 1.16	171 (37.41)	1069 (7.48)
Aheri	16683	58233	8065	29182	5695	19865	4026 70.66	16466 82.88	119 2.08	155 0.78	1550 (27.21)	3244 (16.33)
Sironcha	18312	17916	11818	10737	8568	7062	7867 91.81	6294 89.12	184 2.14	36 0.50	517 (6.03)	613 (8.68)
Total	120745	415306	64854	232344	43279	154681	31212 72.71	136655 88.35	933 2.15	1599 1.03	11134 (25.72)	16427 (10.62)

The Tables gives distribution of workers by three categories of economic activities in the district of 2011.The proportion of all these categories difference from tahsil to tahsil.The

closed in three categories as primary activities (Cultivators, Agricultural laboures, livetock, Forestry, Fishing, Hunting, Plantations, and mining etc.) Secondary activities (Manufacturing, processing, reprising in household etc.), and Other activities (Trade, Transport,Communication etc. The Gadchiroli district has population of these categories accelerate their socio-economic life.

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The Tables gives distribution of workers by three categories of economic activities in the district of 2011.The proportion of all these categories difference from tahsil to tahsil.The

schedule cast and scheduletribes of Primary activities is between 91.63% to 52.65% .The schedule cast Primary activities in highest is in Sironcha tahsil 91.81% and lowest Etapalli tahsil 59.89% . Secondary activities in district 2.15%.The height % is in Desaiganj 3.73% and lowest 0.99% is in Chamorchi tehsil. Other activities in district 25.72%. The highest in Etapalli 37.71% and lowest 6.03% is in Sironcha.

The scheduletribe of Primary activities is between 91.92% to 52.65% .The scheduletribePrimary activities in highest is in korchi tehsil 91.92% and lowest Desaiganj tahsil 52.65% . Secondary activities in district 1.03%.The height % is in Desaiganj 2.13% and lowest 0.50% is in Sironcha tahsil. Other activities in schedule tribe in district 10.62%. The highest inGadchiroli 33.30% and lowest 5.61 % is in Dhanora tahsil.

Conclusions

Gadchiroli districts holds 1.87% of population to the state over 4.69% of its area among the 12 tahsil.Chamorshi tahsil is the most population while korchi is the least population. Population live in rural area of 88.00% the district.The districts density 74 persons per km2 from 2011 the most density in desaiganj teshil 335persons per km2, and lowest density is in bhamradh tashil 28 persons per km 2.

The schedule cast &scheduletribesworkers in three different categories of economics activities in the district.The Primary activities in 91.81% and schedule tribe Primary in activities in 91.92%

Scheduled cast & Scheduledtribes are made available by the census.These statistics are use full for the planning of socio-economic development in the districts by the government .In this census 2011 the percent of Scheduled cast population was 11.25% and Scheduled tribes population was 38.70%. Out of Scheduled cast population of the districts 41.76% lived in rural areas and 14.44%lived in urban area.Qualitative population accelerates the socio-economic condition of the reasion.Topographical accessibility helps to the people for better development while inaccessibility stands as a obstacle.

References

1. Abusar M.,'Socio-economic aspects of population Geography',Rawat pub.Jaipur.
2. Bhende Asha,(1985),'Principal of population studies", Himalaya pub.House ,Mumbai
3. Hand Book, Gadchiroli District 2001
4. Gadchiroli district Census handbook- 2011 (C.D.)
5. Karlekar Shrikant, 'Remote sensing book, Dimand pub. Pune.
6. Samajik va Arthik Samalochan in Gadchiroli District- 2011,2021

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ISSN 2348-8425

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An International Registered Peer Reviewed Bilingual Research Journal

सत्राची

A UGC-CARE Enlisted
Peer Reviewed Research Journal

Year 11, Issue 26,
Vol 38, No. 3,
Jan.-March, 2023

"Contemporary Issues of Social Science, Commerce, and Business Management"

ISSN : 2348-8425

SATRAACHEE

UGC Care Enlisted, Peer Reviewed Research Journal

Issue 26, Vol. 38, No. 3, Jan-March, 2023

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SERVICE SECTOR : A MEDICINE FOR STRONGEST INDIAN ECONOMY

Dr. Rita R. Raut*

Abstract :

The service sector has taken the lead in many places in India.Agriculture and industry sectors are developing at a large rate while services are being developed.Generally service work is transferred from one person to another in an invisible form.Services are also in intangible, invisible and visible form. The development of industry sector, agriculture sector, education sector, trade sector and various sectors mainly depends on service sector. The progress of other service organizations depends on the availability and readiness of the service.So, in the current situation the service areas are expanding day by day and continuously. It mainly pushed and boosted capital development, employment Generation, proper utilization of human resources, increase in technology, customer satisfaction, economic and industrial development etc. It also helps in day-to-day life cycle. In 2021-22 total expenditure on medical fare is only 2.1% of GDP as compare to Japan or other countries. The highly contribution of Travel and Tourism industry in India by 178 billion dollars to Indian GDP. The total contribution of service sector in Indian GDP is 60%.In India, the expansion of the service sector has given a major boost to job creation.It has helped a lot in solving the problem of unemployment in the country. Services are also expanding due to current globalization.

Keywords : Service, Indian Economy, Start Up, Digital Platforms, Employment

Introduction

Services are not visible like goods. Service is the main part of any humanity and with the help of service factor, we maintain connectivity in society. In the modern era, the importance of marketing has increased and the role of the service sector is important in it.Along with goods, the demand for services has increased.But services cannot be measured like goods. Some services are not visible like medical services, entertainment services, travelling services etc. Service Sector is played an important role in developing economy

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of India. Service sector is wide area. It includes various contents like trade, hotel, transport, storage, communication, financing, business services, personal services etc. There is need of service of schools, hospitals, administrative and accountings for development of Indian Economy. Increase in service sector of India is a unique example of traditional model of development of Indian Economy. But it providing less employment.

Agriculture and production department still contain high employment. Start-up concept provide many new employments with grateful services. It proposes digital platforms to societies which give new inspiration to young generation. Service sector increases its importance after Corona Period. It is third source of earning in Indian Economy. Service sector includes all contents which are taken by people using time and knowledge for improvement in productivity, uses, capacity, possibility, durable etc. The object of this study is to provide awareness about employment providing sector i.e., service sector which is giving positive approach in young generation.

Objectives of Study :

India has tremendous structures nearby creativity in ability development content. India Government has started the "Digital India" notion overall India. Within this concept, many peoples were coming under service factor and the purpose of India Government providing the digital platform is self - employment.

On this basis, in this study the purpose is taken according to the need of employment at present date. Some Objectives are here-

1. To provide awareness within society about service sector in India.
2. To maintain Sustainable Development through service area.
3. To provide knowledge about role of service sector in employment.
4. To study the startup features about service sector

Research Methodology :

In this study, some data is taken from secondary sources like books, newspapers, periodicals, articles, websites etc. some data is primary type was usual by online survey. As well as it primarily be contingent upon exploratory in countryside. The study is based on quantitative and qualitative methods.

Review of Literature :

The aspect of FDI i.e., foreign direct investment in India service sector(a study of post liberalization) are analyzed by most of the scholars and researchers that are Dr. Arjun Singh Sirari and Mr. Narendra Singh Bohra.2011 examined the role of FDI in service sector.

Indian Economy and service sector: When the importance of online increased during the Corona period, online services were increased according to the needs of households.When the importance of online increased during the Corona period, online services were increased according to the needs of households.And the benefit of this is the increase in the number of unicorns that offer large-scale online services.Out of which a large number of employments were generated.It shows that the demand for service sector is more.More than 6 lakh jobs created by unicorns in India. It includes Ola, Big Basket, Paytm and so on.

The economy is depending upon three criteria which are agriculture, industrial and

service.Out of these the third sector is very helpful for creating employment and to boo
Indian economy by giving contribution in many fields like medical, tourism, leisure's a
In 2020-21, the gross value added at current price is 53.89% of total India's G
Industry Sector contribute% as well as agriculture sector contributes 20.19% in GA
gets highest range in country's Net National Product.As usual the agriculture sector
mostly contributed sector in Indian Economy.

The following table shows the sector wise GAV in India and their shares.

Table No.1.1 GAV in Indian Economy (2020-21)

Sr.No.	Sectors	GAV Rupees in Crore.	Shares in %
1	Public Administration, Defense and other services	2,761,996	15.42
2	Financial Real Estate and prof. services	3,950,786	22.05
3	Trades, hotels, transport, communication and services related to broadcasting	2,941,477	16.42
Total GAV at basic prices		**9,654,259**	**53.89%**

Source : Ministry of Statistics and Programme Implementation 2020-21

From above table, there is 53.89% in shares of Indian Economy.Financial Real Est
and prof. services contribute 22.05% in it. Agriculture sector contributes 20.19% in GA
same as Industry Sector contributes 25.92% in GAV.

The contribution of service sector in Indian GDP is increased for continuously accordi
to many peoples. Foreigners are taking interest in Indian Service Facilities because
India has a big group of skilled worker, low charges and high education. Practically, it h
quality which is liked by people in other country. So, on this basis, many other countr
are started out sourcing in business services and in ITsector services.Due to this,servi
facilities have been providing a boosting power to Indian Economy and the result is show
in GDP growth.

FDI and Service Sector :

FDI increases job opportunities in country and help to create skill-based thing. It al
boosts Indian export system and encourage to international organization for entering
domestic market. In March 2021, FDI in insurance sector is increases from 49% to 7
FDI helps in reforming economy of many countries and it is very essential factor for growi
economic globalization. FDI means investing in a company in another country.RBI contro
FDI under FEMA.FDI inflow of foreign currency into India leads to creation of la
infrastructure in India, increase in productivity and in turn increase in employment.
service sector accounts for the largest share of foreign investment inflows to India.In
first half of 2021-22, foreign direct investment of USD 16.73 billion has flowed into
services sector."The Economic Survey report shows a significant increase in foreign dir
investment in financial, business, outsourcing, research and development, coun
technology testing and analysis and education sub-sectors.Currently ENCUBE
announced a new R&D Center of Excellence at Palava.

Trade in Service Sector :

Services are the backbone of the global economy, accounting for more than two-thirds of global GDP and attracting three-quarters of FDI. Globally, new job creation takes place on a large scale.Service trade has become very important.First sea trade was seen only then insurance trade increased.Service is mainly seen in it. Now the importance of IT sector is increases day by day. Specially in communication technology, services are popular by peoples. It brings new service pattern in society. That's why some companies are economically developed. It includes legal, engineering, professional services, computer services, telecommunication etc. GATTS provides special rules for service market which help to determine the status of transaction whether it is residents or non-residents. Basically the "the mode of supply" is known for the service provide on the basis of transactions between supplier and customer at territorial place which contracts about the trade services. India has a lion's share in exporting services globally. In 2020, India has taken place in First Ten's list in service exporter. In 2020, services are covered at 4.1% contribution in commercial services as compared to 2019 which was 3.4%. The Net export growth rate in 2021-22 is 22.8%.

In the year 2021-22, the IT sector will provide 5 million jobs in India and account for 51% of services exports. IT sector provide more than 290 M&As by focusing digital platforms. Industry and digital revenue contribute five times more than service sector in Indian economy by various new skills in employees.

Start-Up and Digital platforms :

Currently, start-ups have taken over the services marketing.The start-up helped the youth to find employment.Many service professionals have gained a foothold in the market.Many service professionals have gained a foothold in the market.Among the various ecosystems in India, startups are becoming important.Among the various ecosystems in India, startups are becoming important.The services sector has captured the market share in the Indian economy.The services sector has captured the market share in the Indian economy. Service base business growing fastest in India because it contributes in GDP growth, employment, trade, and in investment also. There is also major contribution of E-Commerce in pie. By Morgan Stanley study says in 2020 that the business of E-Commerce market has been increases from $ 102 billion to $ 119 billion. Many start-ups in India having advantages because of service based businesses.There are some reasons for successful a start-up project like low capital cost, faster to launch, lower business risk, flexibility and adaptability etc. There is some successful service-based startups in India are Zomato, Practo, Rentomojo etc.Zomata is working for search a particular restaurant by online and provide choices for taking decision within 1 million options in 23 countries. This service is launched in 2008 by providing service to 3,31,200 restaurants in 19 countries.Practo is known for health tech company with more than 1 lakhs doctors and more than 20 million patients across the worlds. Rentomojo is providing online rental facility for furniture.

Service Sector and Sustainable Development :

Sustainable development is achieved by managing the natural processes of things. Business of services in it is certainly a pollution-free matter. Big factories have to be set up

for the production of goods and this leads to destruction of the structure of nature. Serv businesses can avoid these side effects. Service marketing plays its role after the goods manufactured.Services include travel, hoteling, medical as well as religious and soc culture. It receives a large amount of foreign investment. Service sector is based on onli mode also. Hence it similar to digital economy. Service can reach everywhere by fro online to offline way.so, each and every person can get the benefits of any products at a place. ITU's contributed in 17 SDGs goals. It also taking place in service area. Servi Area provide a huge number of services which are paperless also. So, day by day t importance of service sector is increases though various platforms which are helpful growth in digital economy.

Conclusion

The service sector plays an important role in developing Indian Economy as well digital economy. It helpful in creating digital jobs, pollution free environment, increas FDI. It also helpful in maintaining sustainability. IT sector and Banking Sector are provid best services to peoples by many securing applications. Due to service sector, from urb to rural area all type of peoples can involve and make themselves economically stron One thing is it difficult in requirement of skill which are not properly gathered. Vision people need to be change for implementation of the sector.

References :

1. https://statisticstimes.com/economy/country/india-gdp-sectorwise.php
2. https://www.ijeronline.com/documents/volumes/Vol2issue2/ijer20110202(2).pdf
3. https://mospi.gov.in/download-reports
4. https://www.oecd.org/trade/topics/services-trade/
5. Udojak Magazine Diwali 2022 Seva Kshetra pg.no.35, 47.
6. Mohanty R.P., Lakhe R.R., "TQM in service sector - Understanding The Service Syste Jaico Publishing House, Mumbai 2011, pg.no.879 &1054.
7. Nayyar Gaurav, "The Service Sector in India's Development", Cambridge University Pre 2012, pg.no.302.
8. Thakur Gurudev Singh, "Service Marketing-Service Sector Global Dominance", pg.no.
9. https://www.investindia.gov.in/sector/it-bpm
10. Bodhankar Sudhir and Parakhi Megha, "Sevakshetravyavsthapan", Sainath Publica Nagpur, pg. no.1-54.
11. https://startuptalky.com/service-based-start ups-successful-india/
12. https://www.forbes.com/sites/bobeccles/2019/11/03/the-importance-of-the-services-sect to-the-sustainable-development-goals/?sh=66421b3878ff
13. https://www.unesco.org/en/education-sustainable-development
14. https://www.mospi.gov.in/national-sample-survey-nss

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Dr. Rita R. Raut*

Abstract :

The service sector has taken the lead in many places in India.Agriculture and industry sectors are developing at a large rate while services are being developed.Generally service work is transferred from one person to another in an invisible form.Services are also in intangible, invisible and visible form. The development of industry sector, agriculture sector, education sector, trade sector and various sectors mainly depends on service sector. The progress of other service organizations depends on the availability and readiness of the service.So, in the current situation the service areas are expanding day by day and continuously. It mainly pushed and boosted capital development, employment Generation, proper utilization of human resources, increase in technology, customer satisfaction, economic and industrial development etc. It also helps in day-to-day life cycle. In 2021-22, total expenditure on medical fare is only 2.1% of GDP as compare to Japan or other countries. The highly contribution of Travel and Tourism industry in India by 178 billion dollars to Indian GDP. The total contribution of service sector in Indian GDP is 60%.In India, the expansion of the service sector has given a major boost to job creation.It has helped a lot in solving the problem of unemployment in the country. Services are also expanding due to current globalization.

Keywords : Service, Indian Economy, Start Up, Digital Platforms, Employment

Introduction

Services are not visible like goods. Service is the main part of any humanity and with the help of service factor, we maintain connectivity in society. In the modern era, the importance of marketing has increased and the role of the service sector is important in it.Along with goods, the demand for services has increased.But services cannot be measured like goods. Some services are not visible like medical services, entertainment service, travelling services etc. Service Sector is played an important role in developing economy

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ISSN 2348-8425

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SAMAJIK

An International Refereed Peer Reviewed Bilingual Research Journal

AUGC-CARE Enlisted
Peer Reviewed Research Journal

Year 11, Issue 26,
Vol 38, No. 4.
Jan.-March, 2023

"Contemporary Issues of Social Science, Commerce, and Business Management"

ISSN : 2348-8425

SATRAACHEE

UGC Care Enlisted, Peer Reviewed research Journal

Issue 26, Vol. 38, No. 4, Jan-March, 2023

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Self-Help Groups in India an Effective Tool for Women Economic Empowerment and Poverty Eradication

Dr. Mahendra B. Wasker *

Abstract

People experiencing challenging conditions are found to be stronger when organized as a group and more empowered when given the chance to engage in an environment that is free, open, and non-threatening. Due to unequal access to governmental, social, and economic resources in India, which has led to high infant mortality rates, low nutritional standards, and low rates of female literacy, women are regarded as the "unsung heroines" of the country. In order to overcome these challenges, rural women needed to be grouped in order to develop their skills and increase their capacity for interaction, thought, inspiration, and action with a self-sufficient mindset. Government and non-governmental organizations (NGOs) have established self-help groups (SHGs) to inform women about their constitutional rights, dietary requirements, and political participation.

Keyword:- SHG members, women groups, women, self.

Introduction

People facing challenging circumstances are found to be stronger when organized collectively and more empowered when certain the chance to participate in unrestricted, open, and non-threatening environment, according to community groups. It is predicated on the idea that it is malleable.

Empowering women

In India, the term "women's empowerment" is popular. India as a nation is dedicated to promoting women. Even ignorant and undeserving men felt superior to women who did not earn them, despite the fact that women are viewed as "unsung heroines who work from dawn to dusk." Since then, the government has worked diligently to eradicate different biases.

In India, women play a variety of responsibilities both within the family and in society at large. Innovations that cater to women's practical requirements as well as their strategic

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interest are essential in response to these roles and responsibilities. To guarantee their success, enabling mechanisms must go along with innovations. This is the path to a change in society that will strengthen women.

Coming together

It was urgently necessary to group these rural women in order to showcase their skills. This group initially lacked initiative because of low self-confidence, a dearth of capital to launch new businesses, and poor credit worthiness. Due to their unequal access to political, social, and economic means, women had suffered. Low female reading rates, high infant mortality rates, and sinister nutritional standards were the direct results of this. It was discovered that working with specific women did not result in any beneficial changes to their standard of living. In order to improve the women's capacity to communicate, think critically, motivate others, and act in a self-sufficient way, we thought it was essential to encourage the women to establish self-help groups.

Ways with self-help

The key to empowering women is educating them about their legal rights, health and nutrition, gender equity, and the legislative process. There was a real need for the groups to lead training classes so that they could acquire skills and boost their confidence. By organizing different skill-based, income-oriented training programmers in agricultural operations, significant efforts were made to instill entrepreneurial essence and information among the rural farm women. Members were encouraged to cut back on unnecessary expenses and save between 100 and 200 rupees each month, depositing the funds in a joint account run by the elected group leaders.

In all these mechanism about the empowerment of women, Government and NGOs are unanimously established Self Help Group (SHG) to strengthen the women. If the women becomes independent in financial aspect, she will independently start her business and build up her career. Keeping this in views, it is essential to understand what Self Help Group is and its functioning.

Self-Help Groups

Self-Help Groups are a small, volunteer group of underprivileged individuals, ideally from the same socioeconomic bracket. They become entrepreneurial thanks to the microcredit provided. It may consist of only males, only women, or even a mix of both. However, it has been observed that C.B.'s groups perform better in all of the crucial SHGS. Concept of Self Help Group India

The concept of SHG was established by Mohd Yunus in Bangladesh. Later on, this concept brought out change in the social and financial fields. In India, during 1970-80, in the states like Karnataka and Andra Pradesh, there were small saving groups of women and they conducted the meetings of groups in them. Thus, they created the group norms and guidelines. In such way such groups started out in this way. From dependency towards independency, and from interdependency towards interdependency, is the definition of Self Help Group. SHG is not any kind of scheme nor any project. But it is a group which

imparts progressive education to women. To bring sea change in the psychological, argumentative and financial condition of the members is the motive behind the establishment of these groups. To make its members financially independent is the thought behind the SHG To bring about improvement in financial condition of the family through the saving, to think about the crisis in the society, to maintain amount for the business-all these can be possible with the help of SHG

Self Help Groups is a collection of pastoral poor people who offered to form clubs in an effort to end poverty among their members. They make a commitment to save consistently and combine their funds into the Group Corpus, a collective fund. Members of the organization consent to using these common funds as well as any additional funds they might obtain through collective management. When forming groups, the following basic principles are taken into account:

A self-help club typically has between 10 and 20 members. However, this number may range from 5 to 20 in challenging parts like deserts, mounts, and areas with dispersed and sparse populations, as well as in cases of minimal irrigation and people with disabilities.

However, if necessary, up to 20% and, in exceptional circumstances, up to 30% of the individuals in a group may be drawn from families just above the poverty line who live continuously with BPL families and if they are acceptable to the BPL. Participants in the gathering. Multiple people from the same household cannot be included in the same group An individual shouldn't belong to more than one group at a time. The managing and decision-making, which normally shouldn't be left entirely in the hands of APL families, must involve the BPL families actively. Additionally, members of the Self-Help Group who earn more than the federal poverty level are not allowed to serve as office holders (Group Leader, Assistant Group Leader).

In order to adhere to it, groups should create a code of conduct (a code of group leadership). Regular meetings that function democratically and allow for the open exchange of ideas and members' participation in the decision-making process should be held on a regular basis (either weekly or biweekly). Every meeting should be able to have an agenda that the group can use to make choices.

Members should consistently save money to develop their bodies. At routine group meetings, the group should be able to receive any required minimum savings amount from each participant. The Group's company funds are the savings that are thus gathered

Loans to the member should be advanced using the group corpus that was identified The organization should create financial management guidelines that cover the process for approving loans as well as the interest rates and repayment schedule

All lending decisions should be made by the participants in the group meetings using a participatory decision-making method.

The group ought to be able to prioritize loan applications, establish repayment plans, determine the appropriate rate of interest for loans given, and carefully watch over the loanee's repayment of loan installments.

It is preferable for the Group to have a Group Account at a bank branch in the area region where Members can deposit any outstanding amounts after a payment has been made.

Simple basic records like a minute's book, attendance register, loan ledger, general ledger, cash book, bank passbook, and individual passbook should be kept by the organization. What do women's self-help groups do?

Facilitate members to participate in government schemes.

Encourage children, especially girls, to go to school.

Celebrate important days.

Attend Gram Sabha (village group) meetings

Assist in the health campaigns and veterinary camps

Develop unity and self-confidence among the group members

Form a platform where groups can interact to accumulate and share new concepts andtechnics

Inculcate the habit of savings and initiate income-generating activities

Create a space for women's participation in socio-economic development

Social awareness

As the capacities and capabilities of the self-help group members grow, they communities feel for the first time able to address social issues to the pertinent government agencies. These issues include:

iThe need for safe drinking water, street lights, public sanitation and roads

iThe scrubbing of public spaces

iReceiving land patta (deeds) for houses

iFinding inexpensive lodgings or restrooms

Gaining strength

Rural women's lifestyles, attitudes, and approaches have undergone radical change as a result of the establishment of women's self-help organizations.

- They are management their own insurances. They take part in making decisions for the home.
- They have the ability to participate in societal issue decisions.
- They are able to assist other members of their community and are more responsible to their needs and those of their society.
- They can communicate with representatives of government agencies, NGOs, and banks to get their wants and rights met.
- In accumulation to generating income for themselves as a group, their strength of unity have opened up new opportunities for improvements in society.

- They have learned novel techniques in farming and other fields.
- The importance of a child's schooling is recognized especially girls. By giving their children more nutritional food and the appropriate vaccinations, women are protecting both their own and their children's health.
- The women are ambassadors for the development message, raising awareness throughout their complete family and community.

Suggestions & Recommendations:

1. It is necessary to try to encourage illiterate women to involve in SHG.
2. Government, social organizations, NGO's should try to encourage the participation more and more women from all strata of society in SHG's.
3. It is necessary to conduct a special drive for women to encourage them to save at least 10% of their earnings every month.
4. Innovative methods should be implemented while conducting the meetings of SHG during the peak period of agricultural work.
5. Member should be trained and informed about book keeping and accounting, time to time transactions and audit.
6. Government should issue considerable grants each year for SHG.
7. Government should provide special grants to SHG's for Emergency Conditions.
8. SHG should conduct regular literacy drive for the illiterate women in the village. As such, Adult Literacy Classes should be conducted for illiterate members in the village.
9. There should be strict supervision on whether the members are utilizing the amount of loan for their genuine need. As such, there should be watch on the timely repayment of loan. In case of any fault the repayment of the loan should be done in one stroke.
10. Special awards should be given to members and office bearers of SHG for their exemplary work in the field.
11. Women members should produce marketable goods. The product should be sold on the center established by District Rural development mechanism.

References

Devisiddaiah, B. S. (2005), Impact of a Participation in Local Governance in Rural India, Institute of Social Scientist, New Delhi.

Devisiddaiah, B. S., & Ramamurthy, S.V. (1998), Rural Co-operatives in India: A Comparative Analysis of their Economic Survival and Social Impact, Institute of Co-operation in Indian Economy, (New Series).

Devisiddaiah, S. (2007), Women's Participation in Self Help Groups and a Proposal for Institutional Networking, Synergistic Linkages, Centre for Women's

Development Studies, New Delhi.

Harper, M. (2002), Promotion of Self Help Groups under the Swarnajayanti Gram Swarozgar Yojana: Can Microfinance Reach the Poor?, Paper presented at the Workshop on Self Help Groups and Microfinance in India: Women Empowerment and Social Security, ANGRAU, Hyderabad, 28 Feb - 2 March.

Kabeer, N. (2005), Is Microfinance a Magic Bullet for Women's Empowerment? Analysis of Findings from South Asia, Economic and Political Weekly, October 29, pp. 4709-4718.

Kumar, A. (2005), Self-Help Group, Gender and Microfinance in India: Women Empowerment and Social Security, University Press, Hyderabad.

Mayoux, L. (2000), Participatory Learning for Women's Empowerment in Micro-finance Programmes: Technique, Process and Impact, Journal of International Development, Vol. 12, pp. 1-14.

Mayoux, L. (2001), Tackling the Down Side: Social Capital, Women's Empowerment and Micro-finance in Cameroon, Development and Change, Vol. 32, pp. 435-464.

Mayoux, L. (2002), Women's Empowerment and Micro-finance: Towards Best Practice, Available at http://www.enterprise-impact.org.uk/pdf/BestPractice.pdf.

Mayoux, L. (2005), Women's Empowerment through Sustainable Micro-finance: Rethinking 'Best Practice', Discussion Paper, Available at http://www.genfinance.info.

Mishra, S. N. (2002), Micro-finance in India: Through Self-Help Groups, A.P.H. Publishing Corporation, New Delhi.

Mosley, P. (1996), Metamorphosis from NGO to Commercial Bank: Lessons from Bolivia, Development in Practice, Vol. 6, No. 4, pp. 291-301.

Mosley, P. and Rock, J. (2004), Microfinance, Labour Markets and Poverty in Developing Countries, Routledge, London.

Nair, T. S. (2005), The Grameen Bank: Service Disguised as Business, Economic and Political Weekly, October 29, pp. 4741-4744.

Nair, T. S. and Tankha, R. (2005), The Ambiguous Nature of Self-Help Groups, Economic and Political Weekly, October 29, pp. 4729-4740.

Nanda, P. (2002), Gender Dimensions of User Fees: Implications for Women's Utilization of Health Care, Reproductive Health Matters, Vol. 10, No. 20, pp. 127-134.

Nanda, P. (2003), Women's Participation in Rural Credit Programmes in Bangladesh and Their Demand Effects, Economic Development and Cultural Change, Vol. 52, No. 1, pp. 93-118.

Nanda, P. (2004), Gender Dimensions of Health Insurance in Developing Countries, Journal of Development Economics, Vol. 75, No. 1, pp. 237-263.

Nanda, P. (2005), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2006), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2007), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2008), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2009), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2010), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2011), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2012), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2013), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2014), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2015), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2016), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2017), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2018), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2019), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2020), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2021), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2022), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2023), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2024), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

Nanda, P. (2025), Gender Dimensions of Health Insurance in Developing Countries, Edward Elgar, Cheltenham, UK.

ISSN 2348-8425

SAHITYA AACHEE

Multilingual Research Journal

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A UGC-CARE Enlisted
Peer Reviewed Research Journal

Year 11, Issue 26,
Vol 38, No. 4.
Jan.-March, 2023

"Contemporary Issues of Social Science, Commerce, and Business Management"

ISSN : 2348-8433

SATRAACHEE

UGC Care Enlisted, Peer Reviewed research Journal

Issue 26, Vol. 38, No. 4, Jan-March, 2023

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C/A No. 40034072172. IFSC : SBIN0006551,
State Bank of India, Boring Canal Rd.-Rajapool,
East Boring Canal Road, Patna, Bihar, Pin: 800001

Editing/Publishing: Unpaid/ Unprofessional
Publisher: *Satraachee Foundation, Patna*

Editorial Contact:
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V.S. Naipaul's Perspective on Contemporary India through 'India: A Million Mutinies Now'

Dr. Rakesh Vishwanath Talmale*

Abstract

The research paper is an attempt to explore V.S. Naipaul's perspective on contemporary India which he had experienced in the decade 1980-1990. His travelogue 'India: A Million Mutinies Now' is the third book of his visit to India. It is a mirror of contemporary India having truthful picture of Indian social, religious and political scenario. He frankly but truthfully depicts the 'mutinies' of India like religious, regional, commercial and caste-based. In his travel he meets with number of people and places showing positive aspects in them. Despite Naxalite, Dalit, Dravidian, Khalisthaniterrorist movements, India is aspiring progress in various fields. V.S. Naipaul's is satisfied with the present Indian scenario than his experience in previous visit explored in two books.

Keywords: Contemporary, Colonial, Indian, Travelogue, Third world

VidiadharSurajprasad Naipaul is an elegant writer of West Indies. His father was migrated from India to West Indies. He was born and bought up at Trinidad. He is famous for his comic and autobiographical writings. In his 50 years of writing career, he wrote thirty books both fiction and non-fiction genre. He was born in 17th August 1932 in a Brahmin family. His father was an English language journalist who wrote short stories in the 'Trinidad Guardian'. His father encourage him for the writing career but before he could achieve success, his father passed away in 1953. He started writing with novel at the age of 18 but could not get a willing publisher. His debut work 'The Mystic Masseur' (1957) is about a bright youth's pursuit to become writer.

V.S. Naipaul's post-colonial writing created controversy in literary world. He was keen to explore the legacy of colonialism of the British Empire. The novels he wrote were based on the colonial as well as ex-colonial societies. The novels were

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marked with the problems of the colonized people and the impact of colonisation on them. His travelogues containing series of three books 'An Area of Darkness' (1964), 'India: A Wounded Civilization' (1977) and 'India: A Million Mutinies Now' (1990). Naipaul's attraction to homeland India urged him to write about contemporary scenario of India through these travelogues. These books contained impact of colonisation on India and recently emerged as third world. He skillfully transformed the travelogue into text, mainly post-colonial text. These text revealed passionate picture of contemporary India. The last travelogue 'India: A Million Mutinies Now' is fine picture of realistic India 1980 to 1990.

V.S. Naipaul's started literary career in 50's in Britain. He established himself as a novel writer, so he got a fellowship of Trinidad and Tobaco government. He returned to Caribbean exploring the novel and travelogue writing. It was the time when anti-colonial movements were reaching at its height. 'India: A Million Mutinies Now' conveys the post-colonial and home coming ideas of Naipaul. It is a recommendation of his love-hate relationship for India. He expresses his detachment with India mostly sensitive than negative. He expresses view on India as a leading Third World which differs from his last visits. He observes modernity and traditional aspects in homogeneous ways. These are the harmonious principals prevailed oneness rather than showing different aspects.

> India as a hybridized cultural formation where Hinduism and Parliamentary democracy, mantras and transistor, radios, bullock carts and nuclear power can co-exist perfectly. (Cronin, 1989, 113)

This travelogue explains various changes and developments found in India. Though, India's journey is in right direction, it is far away to reach level of developed country. Naipaul explores 'million mutinies' of India will help to flourish it like western countries. Naipaul conveys

> 'What the mutinies were also helping to define was the strength of the general intellectual life and wholeness and humanism of the values to which all Indians now feel they could appeal and – strange irony – the mutinies were not to be wished away. They were part of the beginning of a new way for many millions, and part of its restoration. (Naipaul, 150, 518)

Naipaul explores number of mutinies of India containing regional, religious, commercial, caste based etc. The movements like Naxalite, Dalits, Dravidian, Khalistani terrorists, South Indian are explosive one but not stumble block in the uniformity of India. Unlike this, Naipaul wondered to experience agricultural,

BabasahebAmbedkar the huge crowd emerged on road sides. He met with Shivsena leaders who were staunch follower of Hinduism and aggressively putting forward their ideology. Naipaul saw wretched condition of Muslim community. He visited to Mohammad Ali road highly populated with Muslim community. He met with Anwar, an educated young man. Anwar had great belief in Islam who thought that illiteracy in Muslims caused greatly in their progress. He says,

> It is inevitably that they will fight for Islam. It is contradictory roll. They will continue their criminal activities, but at the same time they will read the Koran, and do the namaaz, five times a day. The community does not admire these people, but the people are enchanted by the way the dons behave with the common muslims.
> (Naipaul, 1990, 43)

In this ways, Naipaul put focus on the dark side, chaos and the mutinies in India. The societies are separated on the basis of religion, caste, region and languages. On account of this, Indian people have the strong belief in powerful patriotic ideas which bind them in single thread of uniformity.

But, in the present scenario of 2023, India seems fanatical changeson social, political, religious and cultural fields. Due to lack of ruling visionary people, it seems that India is getting backward on number of fronts. Unlike V.S. Naipaul's views of powerful 'Third World', it emerges great anxiety in the scholarly world that India is making somewhat pessimistic regression in every walk of life.

To conclude it can be said that V.S. Naipaul observesin 'India: A Million Mutinies Now' the colonization and its positive picture on the multiple horizon of contemporary India. Despite mutinies, India seems strong unified, homogenous and bounded nation. He meets and observes people thinking about modernization and globalization. At last, we can say that Naipaul strongly feels that India is flourishing as a powerful and progressive third world.

References

- Cronin, Richard (1989) Imagining India. New York: St. Martin's Press.
- Edward Said, Culture and Imperialism, London: Vintage, 1994.
- Naipaul, V.S. (1964) An Area of Darkness, New York: Vintage Books.
- Naipaul, V.S. (1977) India: A Wounded Civilization, New York: Alfred A. Knopf.
- Naipaul, V.S. (1990) India: A Million Mutinies Now, New York: Viking.

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गोंदिया जिले की ग्रामीण अधिवासों का भौगोलिक अध्ययन-2011

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संक्षिप्ति :

प्रस्तुत अध्ययन का मुख्य उद्देश्य ग्रामीण वस्तियों के प्रकार और अध्ययन क्षेत्र को प्रभावित करने वाले कारक की पहचान करना है। ग्रामीण वस्ती के विस्तृत विश्लेषण के लिए, बर्नार्ड (1931) की संकेन्द्रण सुचकांक (Degree of Concentration) पद्धति का उपयोग करके गणना की गई है। वर्तमान अध्ययन मुख्य रूप से द्वितीयक डेटा पर आधारित है और इसे गोंदिया जिले की जनगणना पुस्तिका 2011 से एकत्रित किया गया है। इन गणना किए गए सूचकांक से पता चलता है की गोंदिया तहसिल में संकेन्द्रण सूचकांक मध्यम है। इसका मुख्य कारण यह है कि गोंदिया तहसिल के पश्चिम में पहाड़ी और पूरब एवं दक्षिण में जंगल व्याप्त भाग है। कृषकों ने अपने कृषि कार्यस्थल पर ही घर (निवास स्थान) बना लिए है। जहाँ कृषि कार्य हेतु सिंचाई की सुविधा है। अध्ययन क्षेत्र के पूरब, दक्षिण और पश्चिम दिशा में संकेन्द्रण सुचकांक मुख्य रूप से कम है। इसका मुख्य कारण यह है कि इस दिशा भाग में भी पहाड़ी, बीहड़ स्थलाकृति, जंगल व्याप्त क्षेत्र अधिक है। जहाँ सिंचाई की सुविधा है वहाँ कृषक कार्यस्थल में ही घर (निवास स्थान) बनाकर रहते है। इसी वजह से छोटी-छोटी बस्तियों का निर्माण हुआ है। यह बस्तिया मुख्यरूप से तिरोडा, गोरेगांव, आमगांव, सड़क/अर्जुनी, अर्जुनी/मोर. सालेकसा तथा देवरी तहसिल में पाई जाती है। इन तहसिलों में कम गुणवत्ता वाली भूमि और अन्य कारणों से भी यहाँ एकाकी/ प्रकीर्ण प्रकार की बस्तियाँ है।

बीज शब्द : ग्रामीण अधिवास, संकेन्द्रण सूचकांक, एकाकी अधिवास, अपखंडित या पुरवा युक्त अधिवास।

प्रस्तावना :

अधिवास मानव द्वारा निर्मित सांस्कृतिक भूदृश्यों में सर्वाधिक महत्वपूर्ण और स्पष्ट रचना होती है, जिसे वह अपने निवास के किए, काम के लिए, विभिन्न सामग्रियों के संग्रह के लिए या सामाजिक सांस्कृतिक एवं राजनीतिक क्रियाओं को सम्पन्न करने के लिए निर्मित करता है। भूगोल में, अधिवास अध्ययन का एक

❁ शोधकर्त्ता, यशवंतराव चव्हाण महाविद्यालय लाखांदूर (संशोधन केन्द्र)भूगोल विभाग प्रमुख रा.तु.म.नागपूर विश्वविद्यालय, नागपूरयशवंतराव चव्हाण महाविद्यालय लाखांदूर।

❁❁ मार्गदर्शक, यशवंतराव चव्हाण महाविद्यालय लाखांदूर (संशोधन केन्द्र) भूगोल विभाग प्रमुख रा.तु.म.नागपूर विश्वविद्यालय, नागपूरयशवंतराव चव्हाण महाविद्यालय लाखांदूर

महत्वपूर्ण स्थान है क्योंकि अधिवासों को मनुष्य और पर्यावरण के बीच संबधों की एक मौलीक अभिव्यक्ति के रूप में देखा जाता हे। (शर्मा 2015)। बस्तियों को जनसंख्या सघनता का बिंदू माना जाता है। निवास स्थान या अधिवास वह स्थान है जहाँ, लोगों ने अपना स्थायी निवास स्थापित किया। सामाजिक-आर्थिक विशेषताओं, व्यावसायिक संरचना, जीवन के तौर तरीके, जनसंख्या आकार के आधार पर मानव बस्तियों को दो प्रकारों में वर्गीकृत किया गया है। वे प्रकार ग्रामीण और शहरी इस प्रकार है। ग्रामीण बस्तियाँ वे बस्तियाँ है, जहाँ के लोग अधिकतर कृषि और कृषि संबधी गतिविधियों में लगे रहते हैं। जबकी शहरी बस्तियाँ वे बस्तियाँ है, जिनके निवासी गैर-कृषिगत गतिविधियों में लगे रहते हैं (आर.एल.सिंह 2002)। ग्रामीण और शहरी बस्तियों को उनके उप-प्रकारों में वर्गीकृत किया गया है। उसके लिए अनेक भूगोलवेत्ताओं और विद्वानों द्वारा विभिन्न विधियों का परिचय दिया जाता है। जो उनके प्रकारों को वर्गीकृत करती हैं। ओरोसेल (1920), बर्नार्ड (1931), पावलोव्स्की (1938), डेवोबेरी (1943), ट्रेवार्था (1946) मंडल (1972), हडसन (1976), गिलग (1996), और अन्य कई भूगोलवेत्ताओं ने ग्रामीण बस्तियों के प्रकारों की विभिन्न मानदंड और सांख्यिकीय तरीके के आधार पर व्याख्या की है। बस्तियों की सघनता बस्तियाँ निर्मित क्षेत्र के तहत कुछ क्षेत्र को इंगित करती है। (नंदी और मिस्त्री 2018), आर.एल.सिंह (1955), ने बस्तियों के मुख्य चार प्रकार बताये है जैसे-सधन बस्तियाँ (Compact Settlement) अर्ध-सधन बस्तियाँ (Semi compact) पुरवा युक्त बस्तियाँ (Semi Sprinkled) और प्रकीर्ण या एकाकी बस्तियाँ (Dispersed) सभी मानव बस्तियाँ एक दूसरे से भिन्न हैं और यह आसपास के वातावरण पर निर्भर करता है। इसलिए ग्रामीण बस्तियाँ मानव अधिवास सुविधाओं और पर्यावरण का पारंपारीक संबध दर्शाती है (सिंह 1961) भारत में बस्तियों का ढांचा केन्द्रीकृत से परिक्षिप्त या बड़े गावों के लिए टोला आकार में विविधतापूर्ण है (Dey & Bhaduri 2016)। सधन अधिवास अधिकतर अत्यधिक उत्पादक जलोढ़ मैदान में पाए जाते है, जबकि बिखरी हुई बस्तियाँ आम तौर पर अत्यधिक (चरम) जलवायु क्षेत्र, पहाड़ी इलाके, घने जंगल, घास के मैदान, खराब कृषि भूमि, व्यापक खेती के क्षेत्र और ऐसे क्षेत्र जहाँ यह आवश्यक है कि, किसान को गाँव के बजाय अपनी कृषि भूमि पर रहना चाहिए में पाई जाती है (मजीद हुसैन 2018)। ग्रामीण अधिवासों का प्रकार एवं प्रतिरूप पूर्णत: क्षेत्र की भौतिक और सामाजिक-आर्थिक स्थिती पर निर्भरकरता है। इसलिए पृथ्वी की सतह पर हर जगह बस्तियों को समान नही देखा जाता है।

साहित्य समीक्षा :

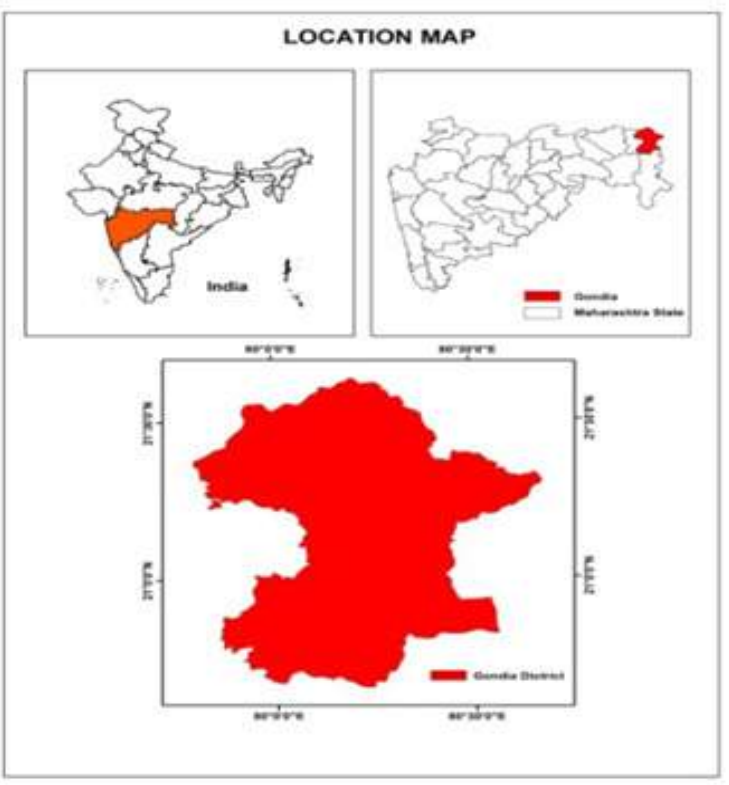
अधिवास भूगोल यह मानव भूगोल की एक मूलभुत ज्ञानशाखा है। आधुनिक अधिवास भूगोल का अध्ययन कई भूगोलवेत्ताओंने किया है। उसमें रिचथोफेन, विदाल-द-ब्लाश, डिमांजीयन, ब्रून्ज, फिंच, ट्रिवार्था, डॉक्सियाडिस, डिकिनसन, डॉ. आर.एल.सिंह, आर.वाय.सिह, जयराम यादव, ऐसे भूगोलवेत्ताओं का समावेश है। ब्लाश ने सघन एवं एकाकी अधिवासों की जानकारी दी है। 1909 मे ब्योपेट ने युक्रेन, 1910 में चोर्ले ने फ्रान्स, 1993 में रॉबर्ट ग्रैण्डमेन ने जर्मनी के ग्रामीण अधिवासोका विस्तृत अध्ययन किया है।

भारत में भौगोलिक अध्ययन की शुरुआत बहुत देरी से हुई। सर्वप्रथम स्पेट ने अपनी किताब 'भारतीय गांव' सी.डी.देशपांडे के सहयोग से लिखी। 1967 में आर.सिंह, एस.बोस, 1970 में एस.पी.सिंह, 1971 में टी.पी.पाटील इन्होंने अनेक ग्रामीण अधिवासों का अध्ययन किया। श्रीनिवास इनकी "India"s Village" यह किताब बहुत ही महत्वपूर्ण है। अयोध्याप्रसाद ने छोटा नागपुर, एस.आर. चौधरी ने खानदेश के ग्रामीण अधिवासों का विस्तृत अध्ययन किया है। इस प्रकार कई विद्वानों ने ग्रामीण अधिवासों का अध्ययन किया है।

अध्ययन क्षेत्र :

गोंदिया जिला महाराष्ट्र राज्य के विदर्भ प्रांत के पुरब में बसा है। 1 मई 1999 को भंडारा जिले का विभाजन हुआ और नवनिर्मित गोंदिया जिले की स्थापना हुई। गोंदिया जिले का अक्षांरीय विस्तार 20035'

उत्तर से 21045' उत्तर और देशांतरीय विस्तार 79045' पुरब से 80045' पूरब है। गोंदिया जिले में आठ तहसिल है। वे गोंदिया, गोरेगांव, तिरोडा आमगाव, सालेकसा, देवरी, सडक/अर्जुनी एवं अर्जुनी/मोरगांव इस प्रकार है। क्षेत्रफल की दृष्टि से देखा जाए तो देवरी सबसे बड़ा एवं आमगांव सबसे छोटा तहसिल है। गोंदिया जिले के पूरब दिशा में राजनांदगांव जिला (छ.ग), पश्चिम दिशा में भंडारा जिला, उत्तर दिशा में बालाघाट जिला (म.प्र.) एवं दक्षिण दिशा में गडचिरोली जिला (म.रा.) इनकी सिमांए स्पर्श करती है।



Map No. 1

जिले का कुल भौगोलिक क्षेत्रफल 5234 चौ. कि.मी (2021 चौ.मैल) है। यह राज्य के क्षेत्रफल का 1.70 प्रतिशत है महाराष्ट्र राज्य के 36 जिलो में क्षेत्रफल की दृष्टि से गोंदिया जिले का 29 वा स्थान है। 2011 की जनगणना के आकड़ों के अनुसार जिले की जनसंख्या 1322507 है। यह राज्य के कुल जन संख्या का 1.18 प्रतिशत है। जनसंख्या के बारे में सोचा जाए तो विश्व की 47.87 प्रतिशत (2011), भारत की 68.84 प्रतिशत (2011), महाराष्ट्र की 54.78 प्रतिशत (2011) और गोंदिया जिले की 88.05 प्रतिशत जनसंख्या ग्रामीण भाग में रहती है। जिले में जनसंख्या घनता एक चौ.कि.मी. में 253 (2011) है। जबकि महाराष्ट्र राज्य के 36 जिलों की जनसंख्या के दृष्टि से जिले का स्थान 29 वा है और घनता की दृष्टि से 24 वा स्थान है। जिले में सबसे अधिक घनता गोंदिया तहसिल में 422 प्रति चौ.कि.मी. है। जबकि सबसे कम घनता 97 प्रति चौ.कि.मी. देवरी तहसिल में है। जिले में लिंग अनुपात 999 है। यह अनुपात ग्रामीण भाग में 1001 और शहरी भाग में 988 है। जिले में देवरी एवं गोरेगांव तहसिल में सबसे अधिक 1014 लिंग

अनुपात है। जिले में 13.31 प्रतिशत अनुसूचित जाती और 16.20 अनुसूचित जनजाति (2011) जनसंख्या है। जिले में जंगल क्षेत्र, 2715.48 चौ.कि.मी. है। यह जिले के कुछ भौगोलिक क्षेत्रफल का 51.88 प्रतिशत है। अध्ययन क्षेत्र में 942 (2011) ग्रामीण बस्तियाँ है।

उद्देश्य :

वर्तमान अध्ययन का मुख्य उद्देश्य अध्ययन क्षेत्र को प्रभावित करणे वाले भौगोलिक एवं सांस्कृतिक इकाई के अनुसार ग्रामीण अधिवासों के प्रकार और उनकी पहचान करना है।

परिकल्पना :

गोंदिया जिले के ग्रामीण अधिवासों पर भौगोलिक एवं सांस्कृतीक इकाईयों का प्रभाव पड़ा है।

डेटाबेस एवं कार्यप्रणाली (Database and Methology):

वर्तमान अध्ययन मुख्य रूप से आंकडों के द्वितीयक स्त्रोत पर आधारीत है। द्वितीयक डेडा गोंदिया जिले का सामाजिक आर्थिक समालोचन (सार) 2011, गोंदिया जिले की जनगणना पुस्तिका 2011, और Website से लिया गया है। गोंदिया जिले के तहसिलों को ग्रामीण बस्ती के स्थानिक विश्लेषण के लिए एक इकाई के रूप में लिया गया है। संदर्भ प्रयोजन के लिए कुछ किताबों, शोध पत्रों, Website के लेखों का भी उपयोग किया गया है। विश्लेषित डेटा को कोरोप्लेथ मानचित्र के साथ विश्लेषित किया गया है। ग्रामीण अधिवास प्रकारों के मापन की मात्रात्मक विधि का उपयोग किया गया है। जिसमें ग्रामीण अधिवासों के संकेन्द्रण सूचकांक मापन हेतु बर्नार्ड (1931) द्वारा प्रस्तावित सूत्र का उपयोग किया गया है।

$$K = \frac{S \times M}{N^2}$$

Where,

K=Degree of Concentration

S= Area of the Tahsil

M= Total Number of House in the Tahsil

N = Number of Settlement Groups in the Tahsil

गोंदिया जिले मे ग्रामीण अधिवासों के प्रकार (Types of Rural Settlement in Gondia District):

ग्रामीण अधिवासों को उनकी स्थिति, आकारिकी (Morphology) समूहन तथा गृह-अन्तरण आदि के आधार पर विभिन्न वर्गों में विभक्त किया जाता है, अर्थात ये किसी बस्ती के भवनों के बीच रिक्त स्थानों के द्योतक होते हैं। अत: गृहों की दूरी व उनकी सघनता अधिवासों के प्रकारो में भेद का प्रमुख आधार माना जा सकता है। इस आधार से ग्रामीण बस्तीयों के चार प्रकार/भेद होते है।

1. एकाकी या प्रकीर्ण (Dispersed Settlement)

ऐसे अधिवासों में मकानो का बसाव बिखरा हुआ मिलता है। इस प्रकार की बस्तियां सामान्यत: खेतों के द्वारा एक-दूसरे से अलग होती है। इन मकानों के मध्य की भूमि पर कृषि कार्य भी होता है। बिखरी हुई बस्तियों को पृथक बस्तियों के रूप में भी जाना जाता है। छोटा आकार, जिसमें एक घर से लेकर घरों का एक छोटा समूह इस बस्ती की एक विशेषता है। गोंदिया जिले में इस प्रकार की बस्तियां ज्यादा तर तिरोडा, गोरेगांव, आमगांव, सालेकसा, सडक/अर्जुनी, अर्जुनी/मोर., देवरी तहसिलों में देखी जाती हैं। इस समूह की श्रेणी का संकेन्द्रण सुचकांक 1500 से नीचे है। इस प्रकार की बस्तियों के निर्माण एवं विकास के कारक निम्न हैं। जिसमें बिहड़ स्थलाकृति, खड़ी ढलान, कम भुजल स्तर और कम गुणवत्ता वाली मिट्टी आदि है।

ये बस्तियां आकार में छोटी तथा जंगल तथा पहाड़ी क्षेत्रों में बिखरी हुई है। बीहड़ स्थलाकृति (Rugged topography), पहाड़ी और जंगल क्षेत्र की वजह से कनेक्टीविटी कम है। खासकर जिले की पूरब दिशा और दक्षिण दिशा। पूरब दिशा में सालेकसा तहसिल है। जो पूर्णत: पहाड़ी जंगल से व्याप्त है। देवरी तहसिल जिले के दक्षिण दिशा में है। इस तहसिल में भी पहाड़ और जंगल हैं। इसी वजह से कनेक्टीविटी कम है। संपूर्ण गोंदिया जिले का विचार किया जाए तो यह जिला पिछड़ा आदिवासी जिला है, यहाँ की भूमि गुणवत्ता भी कम, भू-जल स्तर नीचे है, जिले में ऊपरी तहसिलों में से कुछ जैसे-आमगांव, सडक/अर्जुनी, अर्जुनी/मोर। सालेकसा इन तहसिलों में तालाबों द्वारा जल सिंचाई होने की वजह से खेती सिंचित है। इस क्षेत्र में घर एक दूसरे से बहुत दूर है। बस्तीयाँ छोटी एवं दूर है। अधिकांश हिस्सा आदिवासी है। इन बस्तियों में प्राथमिक व्यवसाय; जैसे, कृषि, पशुपालन, खोदकाम, वनउपज इकठ्ठा करना; जैसे- मोहफूल, आवला, हिरडा, बेहड़ा, शहद, चार ऐसे अन्य कई प्रकार की वनऔषधी और फलफूल इकठ्ठा करके गांव-गांव में जाकर बेचना जैसी आर्थिक गतिविधियोंका बोलबाला है। कृषक कृषि कार्यस्थल में घर बनाकर रहते है। इसलिए यहाँ एकाकी बस्तिया पाई जाती है।

TableNo-1 Gondia District : Types of Settlement 2011
(Based on Bernards Method of degree of concentration)

Sr. No.	Tahsil	Area (Sq.Km.)	No.of Village	Number of House hold	N	Index (K)	Type
1.	Tirora	607.24	123	33865	15129	1359	D
2	Goregaon	484.42	99	28046	9801	1386	D
3	Gondia	612.19	147	55373	21609	1569	SP
4	Amgaon	333.32	81	28404	6561	1443	D
5	Salekasa	450.88	91	20026	8281	1090	D
6	Sadak Arjuni	651.42	108	26543	11664	1482	D
7	Arjuni/Morgaon	988.21	159	34856	25281	1362	D
8	Deori	1040.23	134	24944	17956	1445	D

(Source –Computed by Researcher with help of census data 2011)

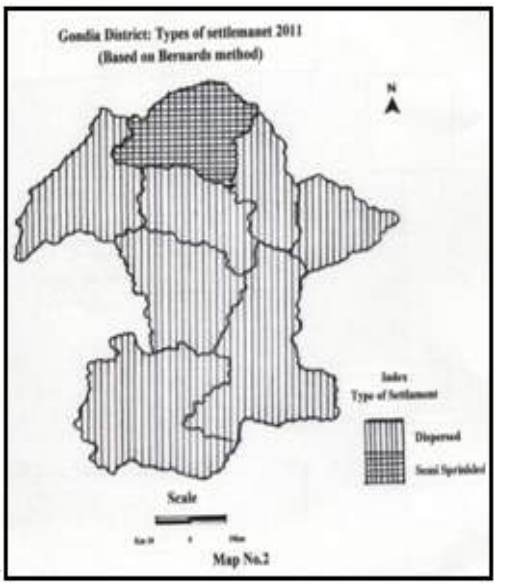
(Note–C-Compact, SC-Semi Compact, SP-Semi Sprinkled & D- Dispersed)

Table No. 2 Gondia District: Types of Settlement 2011
(Based on Bernards method of degree of concerntation)

Sr. No.	Types of Settlement	Range (Index)	Tahsil	Total No. of Settlement	Total Area (%)
1.	Compact (C)	Above 4500	—	—	—
2.	Semi Compact (SC)	3000-4500	—	—	—
3.	Semi Sprinkled (SP)	1500-3000	Gondia	147	11.85
4.	Dispersed (D)	Bellow 1500	Goregaon, Amgaon,Tirora,SalekasaDeori,Sadak/Arjuni,Arjuni/Mogaon	795	88.15

अपखंडित अधिवास :

जिस ग्रामीण अधिवास में गांव की सीमा के भीतर ही बसाव बिखरा हुआ मिलता है अर्थात गांव के घर एक-दूसरे से थोड़ी दूरी पर बने होते हैं अथवा छोटे-छोटे पुरवे या नगले थोड़ी-थोड़ी दूरी पर बसे होते हैं तथा कोई भी केन्द्रीय ग्राम नहीं होता उसे अपखंडित बसाव कहा जाता है। इस प्रकार के अधिवास को एकाकी अधिवास नहीं कहाँ जा सकता। क्योंकि अमेरीकन या यूरोपीय 'फार्मगृह' के समान विपरीत इन छोटी-छोटी बस्तियों मे एक ही परिवार का होना आवश्यक नहीं है। दूसरे इनमें सामाजिक संघठन, श्रम विभाजन एवं सामुदायिक भावना पाई जाती है। प्रो. सिंह ने ऐसी बस्तियों को पुरवो का अधिवास या अपखंडित (Fragmented) अधिवास कहा है। यह बस्तियां आकार में छोटी होती हैं एवं कृषि योग्य भूमि के निकट होती है। इन बस्तियों का संकेद्रण सूचकांक 1500 से 3000 होता है। मुख्य रूप से इस प्रकार की बस्ती का वितरण अध्ययन क्षेत्र के गोंदिया तहसिल में पाया जाता है। इस प्रकार की बस्तीयाँ गोंदिया शहर जो कि जिला मुख्यालय है के आसपास के क्षेत्र में पाई जाती है। बस्ती का यह प्रकार मुख्य रूप से गोंदिया तहसिल के कृषि योग्य भूमि के पास पाया जाता है। गोंदिया तहसिल में मुख्य रूप से राईस मिल ज्यादा होने की वजह से भी इस प्रकार की बस्तीया यहाँ पाई जाती है। संपूर्ण गोंदिया जिला कृषि प्रदान है। और यहाँ धान/चावल का उत्पादन अधिक मात्रा में होने की वजह से राईस मिल उद्योग को बढावा मिलने की वजह से भी यह बस्तिया यहाँ पाई जाती हैं। कृषक कृषी कार्यस्थल में ही घर (निवास स्थान) बनाकर रहते है। और इनकी छोटी-छोटी बस्तिया होती है। गोंदिया तहसिल में जिला मुख्यालय होने की वजह से अन्य व्यवसाय भी यहाँ थोड़ी-थोड़ी मात्रा में पनम (फलफुल) रहे है। इन बस्तियों की प्रमुख विशेषत: यह है कि इनमें गरीबों के घर अधिक मात्रा में पाये जाते हैं और पूरे क्षेत्र में फैले है। तथा सड़को की गुणवत्ता कम है एवं कनेक्टीविटी भी कम है।



अर्ध-सघन अधिवास :

अर्ध-सघन अधिवास में प्रकीर्ण एवं सघन अधिवासों के बीच की अवस्था से सम्बन्धित विशेषताओं का विकास होता है। जो समाजोन्मुखी तथा समाज विमुखी शक्तीयों की अन्योन्य क्रिया का प्रतिफल माना जाता है। ऐसी बस्तियों में आवास बहुत सघन रूप से जुड़े नहीं होते और एक साथ गुंथे हुए होते हैं। यह एक सामान्य बात है (Mandal & Roy 2020) । ऐसी बस्तियों की विशेषता यह है कि छोटी लेकीन सघन होती है। इस अधिवास के मूल केन्द्र (Nucles) पर बसे प्रमुख अधिवास के अतिरिक्त गांव की सीमा के भीतर कुछ-कुछ दूरी पर एक या अनेक पूरवे (Hemlets) बसे होते हैं। इन अधिवासों का संकेन्द्रण सुचकांक/एकाग्रता मान 3000 से 4500 तक होता है। गोंदिया जिले में किसी भी तहसिल में यह प्रकार देखने को नहीं मिलता। क्योंकि यहाँ बड़े कृषक नहीं और बड़ी मात्रा में व्यापारी कृषि नहीं की जाती।

सघन या पुंजीत अधिवास : ऐसी बस्तीयों में मकान एक दुसरे के पास बनाये जाते है। इनका विकास नदी

घाटियों तथा उपजाऊ मैदोनों में होता है। यहाँ रहने वाले लोगों का व्यवसाय समान होता है। तथा यह समुदाय समूह बनाकर रहते हैं। इस गुच्छित (Clustered) प्रकार की बस्तियों में ग्रामीण घरों के संहत (Dense) खण्ड पाये जाते हैं। इन बस्तियों में सामान्य क्षेत्र स्पष्ट रूप से निकटवर्ती खेतों, घरों (बाड़ो) तथा चरागाहों से अलग होता है। इस प्रकार की बस्तियां अत्यंत उपजाऊ जलोढ मैदानी (Alluvial Plain) क्षेत्रों में पाई जाती है। सघन अधिवास स्थायी कृषि उत्पाद भूमि और अनुकुल जलवायु परिस्थितियों का उत्पाद है (Patil, 2019)। अध्ययन क्षेत्र में इस प्रकार की भौगोलिक परिस्थिति उपलब्ध नहीं होने की वजह से ग्रामीण अधिवास का यह प्रकार देखने नही मिलता।

परिणाम

बर्नार्ड (1931) विधि द्वारा सरल सुत्र का उपयोग करके संकेन्द्रण सूचकांक की गणना की गई है। आर. एल.सिंह ने ग्रामीण अधिवासों के 1) एकाकी 2) अपखंडीत 3) अर्ध-सघन 4) सघन या पूंजीत यह चार प्रकार बताये हैं। उनमें से बर्नार्ड के संकेन्द्रण सूचकांक के अनुसार गोंदिया जिले में 1) एकांकी 2) अपखंडीत ये दो ही प्रकार दिखाई देते है। अध्ययन क्षेत्र का संकेन्द्रण सुचकांक तालीका संख्या 2 और अधिवासों के प्रकार मानचित्र संख्या 2 में दर्शाये गए हैं। यही मुख्य परिणाम अध्ययन क्षेत्र में दिखाई देते है।

सुझाव (Suggestion):

अध्ययन क्षेत्र ग्रामीण और कृषि प्रधान होने के बावजूद भी कुछ सुविधाओं के अभाव में विकास दिखाई नहीं देता। अध्ययन क्षेत्र की ग्रामीण क्षेत्र और कृषि क्षेत्र का विकास होना जरूरी है। तभी यहाँ की कृषकों की आर्थिक समस्या दूर होगी। पक्की सड़कें हर ग्रामीण बस्ती एवं कृषि कार्यस्थल तक बनना जरूरी है। कृषि आधारित व्यवसाय को शुरू करना जरूरी है; जैसे, अध्ययन क्षेत्र की मुख्य फसल चावल है। यहाँ राईस मिल इन्डस्ट्रीज है, चावल से व्यावसायिक दृष्टि से अन्य उत्पाद बनाने का उद्योग निर्माण होना जरूरी है। पहाड़ी क्षेत्रों का विकास होना जरूरी है। जंगलों में आवश्यक फल एवं औषधि वृक्ष लगाना चाहिये। जिन ग्रामीण बस्तियों में जल सिंचाई की सुविधा नहीं है वहाँ के कृषकों को आर्थिक सहायता देना चाहिए ताकि वह अपने कृषि कार्यस्थल में कुआँ एवं बोरवेल का खोदकाम कर, जल स्रोत निर्माण कर सके। सरकार की जो कई अलग-अलग सुविधाएँ है उनकी जानकारी आज भी ग्रामीण अधिवासों तक नही पहुची है। जब कि वह जानकारी पहुँचना जरूरी है। इसकी जवाबदारी सरकार ने बस्तियों के प्रतिष्ठित, सामाजिक व्यक्तियों को देनी चाहिए और उन व्यक्तियों ने वह पूरी जानकारी ग्रामीण जनता तक पहुँचाना चाहिए। ऐसी सुविधाओं का उपयोग करने पर, गोंदिया जिले में अर्द्धसघन और सघन अधिवासों के यह दो प्रकार दिखाई नही देते वे अधिवासों के प्रकार ऊपर दिये गये सुझाव से शायद भविष्य में दिखाई दे सकते है।

निष्कर्ष :

शोध कार्य का समग्र विश्लेषण इंगित करता है कि अध्ययन क्षेत्र की बस्तियों के विकास में भौगोलिक एवं सास्कृतिक इकाई का प्रभाव दिखता है। भौगोलिक एवं सांस्कृतिक इकाईयों के प्रभाव से अध्ययन क्षेत्र में अधिवासों के एकाकी और अपखंडित यह केवल दो ही प्रकार है। अध्ययन क्षेत्र के गोंदिया तहसिल में अपखंडित अधिवास और तिरोडा, आमगाव, गोरेगाव, अर्जुनी/मोर., सड़क अर्जुनी, देवरी एवं सालेकसा इन तहसिलों में एकाकी अधिवास है।

References:

1. Ahmat Inayat : "Rural House Types in Uttar Pradesh", Geographical Outlook, 11(1971)

2. Falguni Dey & Sukla Bhaduri (2016), "Changing pattern of settlement structure in rural West Bengal", Journal of Humanities and Social Science Volume 21, Issue 9, Ver.11, Sep. 2016, Pp.22-32.
3. Government of India : Census of India 2011 Godnaia District, Part A & B
4. Majid Husain (2018), "Human Geography", Rawat Publication, Jaipur, Pp.265-281.
5. Pagar S.D.: "Geographohical Analysis of Types of Rural Settlement in Nashik District Maharashtra", Peer Reviewed International Research Journal of Geography, Maharashtra Bhugolshastra Sanshodhan Patrika, Vol.38, No.2, July – Dec. 2021 pp 76-81.
6. Patil Husain (2019),: "Dispersal Index of Rural Settlement in Panhala Tahsil: A Statistical Approach", Think India Journal', Vol-22, Issue-38, December-2019, pp 176-181.
7. Singh L.R.(2002) : "Fundamentals of Human Geography", Sharda Pustak Bhavan Allahabad, Pp11-43.
8. Singh, R.y. (1994) : 'Geography of settlement' Rawat Publication, New Delhi.
9. Souvik Mondal & Taniya Roy (2020), "A case Study on Rural Settlement with Aspects of Socio Economic Movement & GIS in Bhagwanpur – I CD Block", Studies in Indian Place Names, Vol -40-Issue-50-March-2020, and Pp.1650-1689.
10. Sumana Nandi and Tapas Mistri (2018), " Nature and Characteristice of Riral Settlements in Salanpur, Paschim Bardhaman, West Bengal, India", International Journal of Innovative Knowledge Concepts, 6(5) May-2018, Pp.202-210.
11. Website – www.mahades.maharashtra.gov.in
12. खुल्लर डी.आर : भूगोल : राज्य सिविल सेवा और अन्य प्रतियोगिता परीक्षाओ हेतु. टाटा मॅक्ग्रा-हिल, नई दिल्ली 2011
13. गोंदिया जिल्हा (महाराष्ट्र) : जिल्हा सामाजिक व आर्थिक समालोचन 2011
14. सवदी एस.बी., कोळेकर पी.एस.: भूगोलाची मूलतत्वे(खंड दूसरा) 2021 सवदी ग्राफिज-द-मेगा सिरीज, निराली प्रकाशन, पूणे।
15. हुसैन मजिद 2001 : मानव भूगोल, रावत पब्लिकेशन्स जयपुर।

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2022-2023

UGC - CARE LISTED

ISSN: 0974 - 8946

अनुसन्धान-प्रकाशन-विभागीया त्रैमासिकी शोध-पत्रिका

शोध-प्रभा

(A Refereed & Peer-Reviewed Quarterly Research Journal)

48.2 वर्षे तृतीयोऽङ्कः (जनवरी - मार्च) 2023 ई.

श्रीलालबहादुरशास्त्रीराष्ट्रियसंस्कृतविश्वविद्यालयः
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ISSN: 0974-8946
Vol. 48, Issue. 01, No.3: 2023

SPORTS AND EMPLOYMENT: OPPORTUNITIESAND GROWTH IN CAREER

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Abstract

Employment is the continuous employment of the country's current workforce in economic activity. Employment, working and employment indicate employment. Employment is an important concept for both the labor market and the economy in general. Sports the executives is an interdisciplinary field, drawing on parts of advertising, law, money and management. A particular graduate degree assists understudies with creating fundamental abilities in business organization, financial matters, account, law, brain research and showcasing – all with a particular spotlight on the games area. It is vital satisfactory (preparing) of representatives in sport (sports organization) to stay up with the improvement of data advances and how to take full advantage of the advancement that we permit new advances. With the coming and improvement of data innovation in our nation at home and abroad are progressively the inquiry is skill sports organization (sports the executives) to satisfactorily and appropriately do their positions and how to save time and assets of their association. The vast majority of the games association tolerating the advancement of new innovation learning, create and receive new techniques (data and correspondence innovation) that will assist them with improving their items and benefits and carry them nearer to their clients.

Introduction

An overview of sports associations in the early 21st century involves the use of methods and methodologies that are evident in most business, government and philanthropic organizations today. Game executives participate in necessary arrangements, oversee large numbers of paid and voluntary employees, manage billions of dollars in broadcast contracts

deal with state aid from major competitors that in some cases require multiple normal compensations, and work deep inside. coordinates global organizations of global gambling federations, public gaming associations, government agencies, media companies, sponsors and local associations. Students seeking a career as a gaming administrator must gain an understanding of the unique highlights of the game and its joint ventures, the operating environment of sports federations and the various gaming associations that operate in the public, philanthropic and professional spheres. of the gaming industry. The rest of the episode is given to discussing those priorities and covers the exceptional parts of the board. The game is used by a large number of people all over the planet, played or watched by the majority of the entire population, and has grown from a novice to a huge industry at the world or expert level. The development and professionalism of the game has led to changes in the use, creation and management of games and associations at all levels of the game.

Sports and Employment

Employment is the continuous employment of the country's current workforce in economic activity. Employment, working and employment indicate employment (Kamacı, 2016). Employment is an important concept for both the labor market and the economy in general. Employment has two main purposes: an economic purpose and a social purpose. The financial goal is to organize and increase production. To achieve financial goals, it is necessary to succeed in social goals. In this regard, the social goals of employment are to find work for all who want work, increase productivity, ensure labor peace and harmonize the demand and supply of work (Murat, 2007). Youth employment is very important for sustainable economic and social structure and social well-being. In this sense, countries mainly design regulations that enable young people to participate in the labor market, take steps to create a relationship between education and employment, and often develop active employment policies to ensure youth employment (Kılıç and Bülbül, 2012). There is no linear relationship between youth unemployment and the level of economic development. The fact that unemployment affects the young population of continental European countries most clearly shows that such a relationship does not exist between youth unemployment and the level of development of the country. However, there are differences in the causes of youth unemployment. Although the cause of youth unemployment in developed countries is mainly related to population distribution and development, in developing countries the main reasons are insufficient educational level and

corresponding, as they work in cooperative energy, not avoided. No craftsmanship by science, or science with creation, the portion of workmanship. Human asset the executives in sport is another hypothetical, logical and realistic methodology, which from one perspective, alludes to the administration of competitors by mentors, group of specialists and sports researchers, then again, the productive and viable administration of the whole game association by control in sport, sports supervisors, promoting administrators and sports volunteers. The executives of sports includes the investigation of confused and demonstrated information on how a games association accomplishes its objectives, obtaining, dispersing and the utilization of restricted human, material, data and monetary wellsprings of its prosperity. Sports Management as the workmanship and art observational, unstructured experience of skilled administrators of individual competitors, groups and clubs arose with the presence of the principal pro athletics association. The presence of a methodical, logical organized information on sports the board is associated with the development of professionalization of game and its standards assurance - administration market economy, and the rise of the executives science, first in the benefit area, corporate business, and afterward, and it's spreading to the area of non-benefit public and private area. Understudies keen on both business and sports can track down their optimal program with Sports Management. This degree can open up a wide range of open positions inside the games business. It can situate understudies to become specialists, group promoting chiefs, athletic division directors, mentors, wellness focus administrators, group supervisors and the sky is the limit from there.

Understudies can likewise work at various levels, from nearby games and lower levels to territorial and public game affiliations, giving a lot of development freedoms to those intrigued. A Sports Management degree can likewise help graduates discover positions at amusement focuses, recreational areas, and other related associations. It's moreover customary for understudies to be enthusiastic about the benefits and weaknesses of Sports Management at whatever point they have graduated and are looking for a wonderful calling. Advantages to this degree.

Occupation Flexibility

As we referred to above, there are various occupation choices for Sports Management. On the off chance that you are keen on local area authority and public diversion the executives for neighborhood parks, Sports Management can help you. On the off chance that you need to fill in

as a specialist for players or a PR administrator for a group or game in emergency, this degree is phenomenal arrangement. In the event that you have your eyes set in turning into a group executive or chief, a Sports Management degree is a vital advance in arriving. The program upholds so various profession ways that it's a solid match for a wide range of interests.

Travel and Experience

Sports Management can be entertaining. In the event that you like travel, investigating new areas, and visiting new urban communities, a Sports Management profession could be an incredible decision for you. Numerous vocations in the games business include going all throughout the planet for different occasions and occupation duties. It very well may be a little glimpse of heaven for understudies who need a functioning way of life that remunerates their hunger for new experiences. Goodness, and in the event that you're not actually the voyaging sort, there are still a lot of chances for overseeing sports settings and different places that include altogether less travel.

You Can Give Back to Your Community

Rewarding your local area is simple with a Sports Management degree. This program gives the abilities you need to a wide range of volunteer exercises or philanthropic endeavors to energize actual wellness, make beginner groups, and substantially more. There are a couple of things, nonetheless, you should remember while seeking after this kind of degree. To begin with, in contrast to certain ventures, it can require critical exertion to arrive at center and more elevated level administration positions. Understudies ought not anticipate getting an administration position in the games business just after graduation (even those with MBAs). Second, pay can shift significantly for Sports Management occupations relying upon the position, so it tends to be hard to rely on a specific compensation. A few positions may have unpredictable hours or are occasional dependent on the kind of game. It isn't for everybody, except it very well may be exactly the thing you're searching for.

Career opportunities In Sports Management

A Sports Management certificate shows understudies abilities and ideas identified with Management, Finance, Marketing, and Law identified with the games business. Sports Management classes will assist you with figuring out how to outline the business side of a games association with the utilization of the most recent patterns and advancements. You'll build up an expansive arrangement of abilities, yet the absolute most significant are basic

reasoning, critical thinking, correspondence, and thoughtfulness regarding subtleties. These will prove to be useful in any circumstance. Regardless of whether you're arranging a sponsorship contract for a nearby occasion or a multimillion-dollar bargain for a player or group you address, the capacities you create during a Sports Management degree are fundamental.

Conclusion

It is vital satisfactory (preparing) of representatives in sport (sports organization) to stay up with the improvement of data advances and how to take full advantage of the advancement that we permit new advances. With the coming and improvement of data innovation in our nation at home and abroad are progressively the inquiry is skill sports organization (sports the executives) to satisfactorily and appropriately do their positions and how to save time and assets of their association. The vast majority of the games association tolerating the advancement of new innovation learning, create and receive new techniques (data and correspondence innovation) that will assist them with improving their items and benefits and carry them nearer to their clients. To accomplish the greatest in the game, it is important to make, adjust, arrange, and consistently to execute anongoing and last readiness of world class competitors, and alongside that, work on finding themost reasonable authoritative structures, techniques and substance of work in getting ready eliteathletes for the most elevated level agent donning accomplishments. Contemporary expressions association in the present powerful climate described by continuous changes andnumerous contenders can not make due without the executives.

References

1. Fort, R. (2011). Game Economics. third Edition. Upper Saddle River, NJ: Prentice Hall/Pearson.
2. Hoye, R., Nicholson, M. and Houlihan, B. (2010). Game and Policy: Issues and Analysis. Oxford, UK: Elsevier/Butterworth Heinemann.
3. Hoye, R., Nicholson, M. and Smith, A. (2008). Special parts of overseeing sport associations. In C.
4. Jarvie, G. (2013). Game Culture and Society: An Introduction. second edn. Routledg London.
5. Game Management Academic Programs - Johan Cruyff Institute Johan Cruyff Institut

6. " North American Society for Sport Management. Recovered 28 April 2016.

7. Sports and Management Research Institute.

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He/ She has presented a research paper entitled Sports And Employment: Opportunities And Growth In Career
We appreciate your valuable participation.

Dr. C. S. Kombhare	Dr. Ravi S. Dharpawar	Asst. Prof. Ganesh P. Surjuse
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VOLUME 9 ISSUE 1 2023

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 9, No. 1, 566-571 (2023)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Studies on Zooplankton Composition and α-Diversity Indices at Thanegaon Reservoir, Maharashtra, India

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Received: 21st January, 2023; **Accepted:** 11th March, 2023; **Published online:** 1st April, 2023

https://doi.org/10.33745/ijzi.2023.v09i01.062

Abstract: Present study was undertaken to investigate the zooplankton diversity of Thanegaon reservoir located in Arvi tehsil of Wardha district in the Indian state of Maharashtra. Samples were collected on the monthly basis for six months during January 2020 to June 2020. In this reservoir we have studied the four major groups of zooplankton: Rotifera, Copepoda, Cladocera and Ostracoda. Rotifera was found to be the dominant group during the entire study period. The study revealed a total 34 species of zooplanktons during the entire study period, of which 19 species belong to Rotifera, 8 belong to Cladocera, 5 belong to Copepoda and 2 belong to Ostracoda. Statistical analysis of data was done by using α- diversity indices. Shanon-Wiener index 4.50 to 4.72, Simpson index 0.034 to 0.043 indicated the diverse nature of the zooplankton community. Margalef richness index 5.86 to 6.23 and Menhinick index 2.40 to 2.92 indicated the good species richness. Equitability index was in the range from 0.92 to 0.95 showing much evenness of species during the study. Relative biovolume % of zooplankton and composition in terms of density was also calculated. It showed the maximum number of species during the months of January, March and June.

Keywords: Thanegaon reservoir, Zooplankton, Rotifera, α-Diversity indices, Shannon-Wiener index, Simpson index

Citation: Dorlikar A.V. and Thengare M.R.: Studies on zooplankton composition and α-diversity indices at Thanegaon Reservoir, Maharashtra, India. Intern. J. Zool. Invest. 9(1): 566-571, 2023.

https://doi.org/10.33745/ijzi.2023.v09i01.062

Introduction

Thanegaon reservoir (Wardha district, Maharashtra, India) is a freshwater natural lake which is filled to its maximum capacity throughout the year. Thus, this reservoir serves as a source of domestic and agricultural water for nearby areas. Thus, it becomes necessary to keep the quality of water good for these purposes. Study of zooplankton composition is very important due to their role in the food web by linking the producers with consumers in the Lake Ecosystem and prediction of primary productivity and aquatic pollution (Nimbalkar *et al*., 2013; Ghosh and Biswas, 2015). Many species of the zooplanktons are sensitive to pollution and thus act as a

Fig.1: Google map image of Thanegaon Reservoir.

bioindicator to monitor the quality of water (Ferdous and Muktadir, 2009; Sivalingam *et al*., 2013). Zooplankton community constitutes the faunal composition of water bodies which are sensitive to water quality parameters and aquatic pollution (Schindler,1987; Jose and Senthil Kumar, 2015). Thus the aim of the present investigation was to study the zooplankton composition and structure, density, dominance and abundance along with α- diversity indices in the Thanegaon reservoir.

Materials and Methods

Thanegaon reservoir (Fig. 1) is a freshwater natural lake situated at 21° 08' 48" N Latitude and 78° 28' 41" E Longitude at the elevation of 484 Mts. near Sirsi and Kharas Khanda, approximately 10 kilometers away from Karanja (Ghadge) in Wardha district, Maharashtra, India. Collection of sample was done on monthly basis for 6 months from January 2020 to June, 2020 around 7.00 to 7.30 a.m. from selected site by filtering 50 liters of the lake water by using a standard 55 µm pore size bolting nylon plankton net. All specimens collected were preserved in 4% formalin soon after collection. Identification of the specimens was performed according to Kolisko (1974); Koste (1978); Ward and Whipple (1959); Mizuno (1964); Mizuno and Takahashi (1991), Battish (1992) and Dhanapathi (2003). Six indices were used to estimate biodiversity and species richness. Species diversity index was calculated based on Simpson (1949) and Shannon-Weiner (1949); richness index was adopted by Margalef (1951) and Menhinick (1964) and equitability Index by Magurran (1988). Dominance index or Simpson's index of diversity was calculated using formula 1-Simpson index. The percentage relative abundance and density of the specimens was estimated by direct count.

Statistical Analysis:

Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS 10.0). Graphs were drawn using Microsoft Excel Software.

Results and Discussion

Zooplankton diversity and α-diversity indices play key roles in evaluating the trophic status of lakes and suitability of water for domestic purposes and irrigation. In the present study, zooplankton diversity belonging to Rotifera, Cladocera, Copepoda and Osracoda have been undertaken. In the present study 19 species of Rotifera including 6 families and 9 genera, 8 species of Cladocera including 5 families and 8 genera, 5 species of Copepoda including 3 families and 5 genera and 2 species belonging to Ostracoda were noted. Overall 34 species of zooplankton were recorded (Table 1). The most abundant taxonomic group recorded during the study was the rotifer. Pereira *et al*. (2002) noted the rotifers as a most abundant group. Main abundant species of rotifer observed by them were *Keratella quadrata, K. cochlearis,*

Table 1: Zooplankton species identified in Thanegaon reservoir

Phylum: Rotifera			
S. No.	Class and Order	Family	Genus and Species
1.	Class: Monogonata Order : Ploima	Brachionidae	*Brachionus quadridentatus Var. Entzi*
2.			*Brachionus falcatus*
3.			*Brachionus forficula*
4.			*Brachionus diversicornis*
5.			*Brachionus calyciflorus Var.Hymani*
6.			*Brachionus platulus*
7.			*Brachionus bidentata*
8.			*Brachionus rubens*
9.			*Brachionus ureceolaris*
10.			*Keratella vulga*
11.			*Keratella tropica* (Apstein)
12.			*Platyias species*
13.		Colurellidae	*Colurella adriatica*
14.		Lecanidae	*Lecane arculata*
15.			*Monostyla bulla*
16.		Asplanchnidae	*Asplanchna intermedia*
17.		Gastropodidae	*Ascomorpha species*
18.	Class: Monogonata Order: Floscullariaceae	Filinidae	*Filinia longiseta*
19.			*Filinia apoloensis*
Phylum: Arthopoda			
20.	Subphylum: Crustacea Class:Branchiopoda Order:Cladocera	Sididae	*Diaphanasoma*
21.		Moinidae	*Moinodaphnia* (Herrik, 1887)
22.			*Moina macrura*
23.		Daphnidae	*Daphnia longispina*
24.			*Cereodaphnia reticulata*
25.		Bosminidae	*Bosmina longirostris*
26.		Chydoridae	*Chydorus sphaericus*
27.			*Alona rectangula*
28.	Class: Hexanauplia Subclass: Copepoda Order:Cyclopoida	Cyclopidae	*Mesocyclops species*
29.			*Cyclops viridis*
30.	Subclass: Copepoda Order:Calanoida	Diaptomidae	*Skistodiaptomus*
31.			*Diaptomus*
32.	Class: Hexanauplia Subclass: Copepoda	Canthocamptidae	*Nauplius*
33.	Subclass: Ostracoda Order: Podocopida	Cypridae	*Cypretta frontanalis*
34.			*Cypridopsis helvetica*

Polyarthra vulgaris, Filinia terminalis and Hexarthra mira. Picapedra *et al*. (2020) have identified a total of 115 taxa of zooplanktons. Rotifers were the richest group. However, the copepods were the most abundant. They have reported the inter-annual changes in zooplankton species composition from large daphinids and calanoid copepods to small cladocerans (e.g. bosminids) and generalist rotifers. Zooplankton were present in the following order of dominance; Cladocera > Rotifera > Copepoda > Ostracoda. The zooplankton community structure showed a mixed composition of mesotrophic to eutrophic species. Among the zooplanktons, the population of cladocera was rich in density and poor in species diversity. Rotifers are the dominant in the eutrophic lakes which are indicators of eutrophication and *Brachionus* species are indicators of eutrophic conditions (Aboul-Ezz *et al*., 1996; Baloch and Soomro, 2004; Ceirans,

2007). *Moina macrura*, *Bosmina longirostris*, *Chydorus sphaericus*, *Alona rectangula* were the dominant cladocerans in the Thanegaon reservoir. Abundance of the rotifer species like *Brachionus*, *Lecane*, *Filinia* and *Keratella* indicates the mesotrophic and semi polluted water and enrichment of nutrients in the reservoir.

Khan *et al*. (2016) have noted a total of 22 species of zooplanktons where rotifers were dominant and were represented by 15 species whereas cladocera and copepoda were represented by three species each and Ostracoda was represented by one species. 15 species of rotifers noted by them were *Asplanchna priodonta*, *Brachionus bidentata*, *Brachionus calyciflorus*, *Brachionus falcatus*, *Brachionus urceolaris*, *Cephalodella gibba*, *Habrotrocha bidens*, *Keratella tropica*, *Lecane luna*, *Monostyla bulla*, *Mytilina ventralis*, *Mytilini acanthophora*, *Platyias quadricornis*, *Rotifer tardus*, and *Filinia longiseta*. Cladocera was represented by *Ceriodaphnia cornuta, Chydorus sphaericus, Moina brachiata* and among Copepoda, *Heliodiaptomus viduus, Mesocyclops leuckarti, Tropocyclops prasinus* were noted by them and Ostrocoda was represented by *Hemicypris fossiculata*. They noted the seasonal variation in zooplanktons and found maximum number of species during summer and the minimum number of species in rainy season. Density was also recorded high during the summer as compared to rainy season. Zooplankton density and relative biovolume is represented in the Figure 2 and 3, respectively. Relative biovolume, density and composition of the zooplankton community is strongly dependent on the season. Relative biovolume of cladocerans was maximum during winter season in the month of January (46.38%) while it was minimum at the end of the summer season in the month of June (40%). Maximum number of zooplankton (Org/lit) was recorded during the winter in the month of January was 166 whereas minimum number of zooplankton 105 was noted in the month of June.

Shukla *et al*. (2012) noted the zooplankton population (Org/L) during different seasons and found maximum number of zooplankton as 285±18.68/lit during pre-mansoon whereas minimum number recorded was 215±27.33/lit during mansoon season. The observed Cladocerans species by them were *Bosmina longirostris, Cerioaphnia, Cypris, Daphnia, Moina* and *Macrothris*. Among the copepods they noted *Diaptomus, Helidiaptomus, Macrocyclops, Nauplius* and *Vidumus*. Rotifers noted by them were *Slanchna, Brachionus, Distimus, Filinia, Keratella, Nothoica and Flurcularia*. Among protozons they reported *Amoeba, Acrella, Centroysis* and *Paramecium*. Dagne *et al*. (2008) have noted the extremely high variation in abundance of zooplanktons which was ranging from 2 to 1000+ individuals per litre and correlated abundance of crustaceans with the increased phytoplankton production at the onset of rainy season. Rotifer biovolume was observed maximum in the month of January (28.91%) and it was found to be minimum in the month of May (22.42%) in summer season. Copepods showed their maximum biovolume in the month of February (23.56%). However, rapid decline in their biovolume was observed in the month of March (15.97%). Ostracods showed their maximum biovolume at the end of the summer in the month of June (9.52%) and minimum at the end of winter season in the month of March (5.55%) (Fig. 3). Annalakshmi and Amsath (2012) have recorded 45 species of zooplanktons in the Cauvery. They observed rotifera species as dominant (34.97%); followed by Cladocera (29.92%), Copepoda (18.27%), Protozoa (12.2%) and Ostracoda (8.72%), however, Dorak *et al*. (2014) have noted the Copepoda as a most abundant taxa (53%), followed by Cladocera (33%), and Rotifera (14%).

Values for α-biodiversity indices that are Simpson index, Dominance index, Shannon-wiener index, Menhinick index, Margalef richness index and Equitability index are represented in the Table 2. Simpson index was found as low as 0.034 during June and was maximum during 0.043 in summer in the month of April while Dominance index was high as 0.96 revealed the rich diversity of species in this reservoir. Shannon-Wiener index

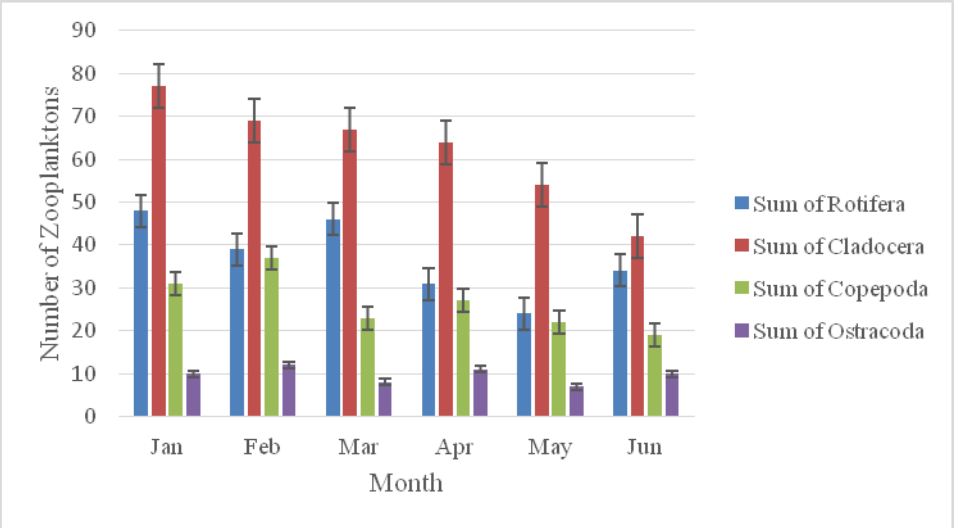

Fig. 2: Composition of zooplanktons in terms of density (Organisms lit^{-1}).

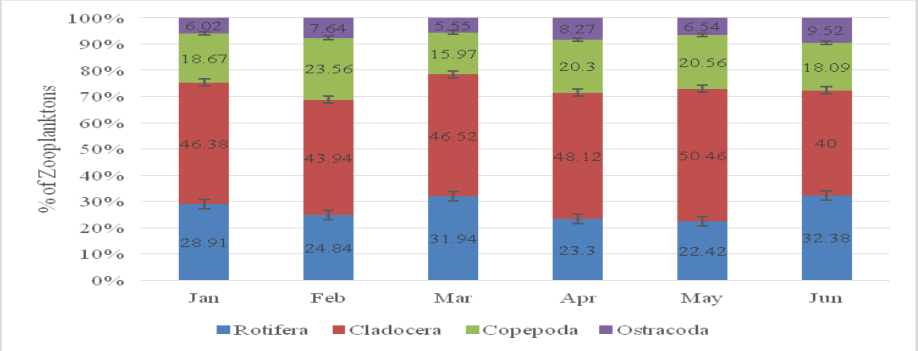

Fig. 3: Relative Biovolume (%) of Zooplanktons.

Table 2: Zooplankton community structure and α- biodiversity indices of Thanegaon reservoir

Month	Simpson Index	Dominance Index	Shanon-Wiener Index	Menhinick index	Margalef Richness Index	Equitability Index
Jan	0.037	0.96	4.71	2.4	5.86	0.95
Feb	0.039	0.96	4.66	2.74	5.93	0.94
Mar	0.036	0.96	4.72	2.58	6.03	0.95
Apr	0.04	0.95	4.6	2.68	6.13	0.92
May	0.043	0.95	4.5	2.8	5.99	0.92
Jun	0.034	0.96	4.69	2.92	6.23	0.95

values were in the range of 4.50 to 4.72, Menhinick indexes were in the range of 2.40 to 2.92 and Margalef richness index values were in the range of 5.86 to 6.23 confirms the mesotrophic status of this reservoir. The equitability index was in the range of 0.92 to 0.95 and the distribution of zooplankton species during the study was even and follows the Lorenz graph. No major fluctuation was found in the equitability index during the entire study period.

References

Aboul-Ezz SM, Salem SA, Samaan AA, Latif AFA and Soliman AA. (1996) Distribution of rotifers in the Rosetta Nile branch (Egypt). J Egyptian German Social Zool. 20(D): 85-123.

Annalakshmi G and Amsath A. (2012) Studies on the hydrobiology of river Cauvery and its tributaries Arasalar from Kumbakonam region (Tamilnadu, India) with reference to zooplankton. Int J Appl Biol Pharmaceut Technol. 3(1): 325-336.

Baloch WA and Soomro AN. (2004) Rotifers of the adjacent areas of Hyderabad, Sindh. Pak J Zool. 36 (4): 319-322.

Battish SK. (1992) Freshwater zooplankton of India. Oxford and IBH Publising Co., Pvt., Ltd., New Delhi.

Ceirans A. (2007) Zooplankton indicators of trophy in Latvian lakes. Acta Universitat Latviensis 723: 61-69.

Dagne A, Herzig A, Jersabek CD and Tadesse Z. (2008) Abundance, species composition and spatial distribution of planktonic rotifers and crustaceans in Lake Ziway (Rift Valley, Ethiopia). Int Rev Hydrobiol 93(2): 210-226.

Dhanapathi MVSSS. **(**2003) Rotifers from Andhra Pradesh, India– III. Hydrobiologia 48(1): 9-16.

Dorak Z, Gaygusuz Ö, Köker L, Tarkan AS and Aydın H. (2014) Effects of physicochemical factors and Chlorophyll a on diel changes in vertical distribution of zooplankton in a eutrophic reservoir (Tahtalı Reservoir, NW Turkey). Ege J Fish Aqua Sci, 31(4): 167-179.

Ferdous Z and Muktadir AKM. (2009) Potentiality of zooplankton as bioindicator. American J Appl Sci. 6(10): 1815-1819.

Ghosh D and Biswas J. (2015) Zooplankton diversity indices: Assessment of an Ox-Bow Lake ecosystem for sustainable management in West Bengal. Int J Adv Biotechnol Res. 6 (1): 37-43.

Jose D and Senthilkumaar P. (2015) Physicochemical parameters and zooplankton diversity in Anicadu Chira, Kerala, India. Int Res J Biol Sci. 4(11): 55-60.

Khan YDI, Nautiyal S, Tikhile P, Sastry V and Bhaskar K. (2016) Diversity of zooplankton and their seasonal variations of Gogi Lake, Shahapur taluk, Yadgir district, Karnataka, India. Int Res J Environ Sci. 5(1): 32-38.

Kolisko RA. (1974) Plankton rotifers biology and taxonomy. Die Binnengewasser. XXVI/I. Supplement, Stuttagart, pp. 146.

Koste RA. (1978) Die Radertiere Mitteleuropas I. Textband. Berlin, Stuttgart, pp. 670.

Magurran AE. (1988) Ecological diversity and its measurement. Princeton University Press, Princeton, New Jersey.

Margalef DR. (1951) Diversidad de especies en les communideades natural. Public Institutte of Biologic, Barcelonia 9: 5- 27.

Menhinick EP. (1964) A comparison of some species-individuals diversity indices applied to samples of field insects. Ecology 45: 859-861.

Mizuno T. (1964) Illustrations of freshwater plankton of Japan. Hoikusha, pp. 351.

Mizuno T and Takahashi E. (1991) An illustrated guide to Freshwater Zooplankton in Japan. Tokai University Press.

Nimbalkar RK, Kamtikar VN, Shinde SS and Wadikar MS. (2013) Studies on zooplankton diversity in relation to water quality of Ambe Ghosale lake of Thane city, (MS) India. Biosci Discovery 4(1): 124-127.

Pereira R, Soares AMVM, Ribeiro R and Goncalves F. (2002) Assessing the trophic state of Linhos lake: a first step towards ecological rehabilitation. J Environ Managem. 64: 285-297.

Picapedra PHS, Fernandes C, Taborda J, Baumgartner G and Sanches PV. (2020) A long-term study on zooplankton in two contrasting cascade reservoirs (Iguacu, River, Brazil): effects of inter-annual, seasonal, and environmental factors. PeerJ. 8: e8979.

Schindler DW. (1987) Detecting ecosystem responses to anthropogenic stress. Canadian J Fisheries Aquat Sci. 44(Suppl. 1): 6-25.

Shannon CE and Wiener W. (1949) The mathematical theory of communication. University of Illinois Press Urbana, pp. 125.

Shukla A, Shukla JP and Mishra M. (2012) Biotic spectrum of Chando Lake in context of ecological status and zooplankton diversity. Curr Res J Biol Sci. 4(6): 690-695.

Simpson EH. (1949) Measurement of diversity. Nature 163: 688.

Sivalingam P, Swamy M and Ravinder Reddy T. (2013) Zooplankton diversity with reference to the physico-chemical parameters of Kajjarla Lake, Adilabad District, AP, India. Int Res J Biol Sci. 2(11): 24-28.

Ward HB and Whipple GC. (1959) Freshwater Biology. 2nd Ed., John Wiley and Sons Inc., New York, pp. 124.

ISSN 2348-8425

SATRAVAACHEE

An International Registered Peer Reviewed Bilingual Research Journal

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A UGC-CARE Enlisted
Peer Reviewed Research Journal

Year 11, Issue 26,
Vol 38, No. 4.
Jan.-March, 2023

"Contemporary Issues of Social Science, Commerce, and Business Management"

ISSN : 2348-8425

SATRAACHEE

UGC Care Enlisted, Peer Reviewed research Journal

Issue 26, Vol. 38, No. 4, Jan-March, 2023

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Historical Significance of Shankarpat in Bhandara District

- Prof. (Dr.) Bharat VithobaNakhate *
- Prof. (Dr.) Ganesh Laxman Dhote **

Abstract

Through Shankarpata, rural life, their livestock, farm labour, agriculture-based supplementary businesses in the village are sustained. In the 21st century, the means of entertainment have changed, rural life has been destroyed and cities have blossomed, problems of urbanization have arisen. RashtrasantTukdojiMaharaj says, "No business in the world can stop unemployment, unemployment. Agriculture is the only occupation in which maximum number of people are given employment. The power to convince the unemployed and give them work is only in agriculture/agribusiness." While doing agriculture business in Bhandara district, Shankarpat is played as entertainment and entertainment. Farmers and rural people are brought together and agricultural culture is cultivated. Communal harmony, social unity, cultural heritage are preserved. Thus, rural culture gets a revival.

Key Words: Agribusiness, Sankarpat, entertainment, folk festivals, customs, culture, social unity.

Introduction:

"Man's life begins with celebration and ends with celebration."

India, which is full of diversity, has different rivers, mountains, land surrounded by sea on three sides, there is no other country in the world that has such diversity. From Kashmir to Kanyakumari and Andaman and from Gujarat to Bengal, each region has a different language, religion, dress, food, festivals and culture. All the provinces have preserved their culture. All these have created a profoundly rich Indian culture.

Agriculture and animal husbandry are two major occupations in India. Starting from the Harappan civilization. Excavations have yielded physical means of entertainment in the Harappan culture. Humans have sung, played music and danced on occasions of joy as entertainment. It is from this that the need and necessity of various means of entertainment

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has arisen.

Folk culture, ethos, sports, various arts and entertainment in India changed over time. Marathi people are celebratory. Padwa, GaneshaChaturthi, Dussehra, Diwali, Eid, Natal Asha along with various festivals also get to see various sports. In the Vidarbha region of Maharashtra, in fact, during the harvest season, one can see dandar, mandai, wrestling riots, animal fights, bullock cart rides i.e. Shankarapat, drama, tamasha, chaos and other means of entertainment and folk festival.

The tradition of Shankarapats is ancient in Bhandara district. E.g. Rural farmers pay attention to animal husbandry along with farming and use animals for entertainment through these Sankarpats such as Masal Cha Pat, PachgaonPalependhari Pat, Pimpalgaon (Road) Pat etc. Chariot races in Aryan period, animal fights in Harappan culture, cock fights, bull races were popular in rural areas and even today in the 21st century in the age of internet in Bhandara district, second day Shankarpat is held to celebrate Sanam during the harvest season.

Objective

The main objective of this study is to study Shankarpata in Bhandara district and explain its historical importance.

Apart from this there are other objectives

- Entertainment is an important human need.
- Many devices are used for entertainment.
- Entertainment gives rise to various addictions.

Importance of study :

These Shankarpats have social, cultural, economic, political and historical importance. Shankarapatas are also used as a means of preserving folk culture. Traditional history, folk songs, folk culture are preserved through dramas, dandars, gondhall, tamasha, qawwali, kustidangal. Therefore, it is necessary to study the real picture of rural life by understanding their historical significance. Agricultural labourers, rural professionals, artists, women etc. participate. Also, their participation in maintaining rural and agricultural culture is very valuable.

Importance of Shankarpatas

"Another one got the idea. He made the pair cool all around.
A second pair of bulls was planted. to run
Attracted public attention. It was fun.
Later Shankar pata started. Village by village.
It would have been better to have some purpose in it. Bullocks are fed by Devoni.
The competition increased the strength of the bulls. For agriculture. ..
But it also has side effects. Keep up the good work.
Bull driving season. It comes next. .
Agricultural work remained. Shankarpat's venture.
People do Kasab Karma. Nanapari.. (Gram Gita)

Social Significance

Human is a social animal. Along with food, clothing, shelter, entertainment is also a

human need. Social unity in rural life, burning of social customs and socialization process etc. were maintained through Shankarapata. For hundreds of years, the culture is being preserved by filling the Shankarpat every year. Shankarapata has a lot to contribute in family life and marriage institution. Shankarapat is an important means of marriage, marriage and marriage in rural areas through watching and hospitality. On this occasion, important tasks such as seeing girls, choosing boys and coming together of two families become successful due to Shankarpatra.

Economic Importance

Entertainment and entertainment are not as important as Shankar pata, but entertainment is done through night plays, tamasha, chaos, qawwali etc. The expenditure on this is in lakhs. Also in Shankarpata money is poured on gambling, sattapatti, zendi-mundi, hod etc. Race is important in Shankarapat. Apart from that, there is a turnover of lakhs of rupees, many kinds of rewards and prizes. Shankarapat is not complete without racing.

Markets, toys, observing the sky, getting innovative products. Business is done as a means of rural employment. Many rich farmers have become deshodhadi due to the hobby of Shankarpata, due to this financial turnover, politics, social causes and family system in the rural areas have also had bad effects.

Historical Significance

In the 21st century (the age of LPG and internet) where agricultural systems are being destroyed by sez; Bullocks, cows, goats, horses, buffaloes are decreasing. Humans have started eating these animals. Mechanized agriculture has come. But even in this case Shankarapat is filled on the occasion of a special festival. The contribution of rural culture is important in maintaining this tradition. The agrarian culture that changed during the British era and lost its form in the 21st century. Protecting agriculture, preserving agricultural culture means protecting the country. Rural culture is disappearing in the process of urbanization. Villages dried up, cities swelled and no one was ready to do farm work.

Increasing Addiction

Addictions like drugs, alcohol, gambling, smoking, etc. for entertainment are initially done as entertainment, then after getting used to it, it becomes a physical and mental need. The last person becomes addicted to addictions and becomes a home for various diseases. The remedies of doctors, physicians, hakims do not work. Getting used to any good or bad habit is addiction, now the whole world is concentrated in mobile due to internet, today mobile addiction has become a global problem. Many problems are arising affecting childhood, family life, social sphere, rural life, sports, etc.

Communal Significance

Shankarpats are held for celebration and entertainment, in which people of different castes, religions, sects and parties in the rural areas forget all differences and enjoy it together, thus creating an atmosphere of unity in rural life through art, entertainment, sports. Shankarpat, animal fights, folk art, drama. , Tamasha, Gondhals, Dandaretc occasions create communal harmony.

Conclusion

Due to the global pendamic corona, the people of India started to understand the

importance of their villages, agriculture, the passivity of urban life was proved.

RashtrasantTukdojiMaharaj while preaching through bhajans says that,-

"Let's go to the small village, don't stay in the city,
Not food, but MarsheelUpashi.
All the land is like gold, but no one has Rahena.
He got up and became a servant, greedy for money.
Who will do the work of agriculture? Speak up brother Majsi..."
Oh, the empty wheel spins
Isn't the shrine of your village?
A poor person living in a village, fasting,
Food-SatraLavitosiKashi.....
..... who serves the poor village
He is honored with fame. (RashtrasantTukdojiMaharaj)

Tukdoji Maharaj has emphasized the importance of rural life through the above hymns. The Maharashtra government had banned Shankarpats by law in the interim, but in 2021-22 the ban on Shankarpats was lifted once again and approved. From this, the government has realized the necessity of Shankarpata.

Thus, the social, cultural, religious, economic and political importance of Shankarpata as animal husbandry, agriculture, rural life and entertainment needs to be preserved even today.

Reference

- Tukaramdada Gitacharya (Critic), "Sarth Gram Gita" (R.T.M.) Ed.-Savarkar, Sudam Prakashak, Shri. Gurudev Prakashan, Atmanusandhana Bhu-vaikuntha, Adyaal (Hill), 15th edition.
- Rashtrasant, Shri Tukdoji Maharaj, "Abhang Gatha" Shri. Gurudev Publications, Gurukunj, Ashram Mozri, Third Edition, 2010
- Rashtrasant Shri.Tukdoji Maharaj, "Antrang", Publisher, Shri. Gurudev Publications, Atmanusandhan, Bhu-Vaikunth Adyal (Hill).
- Dhavalikar, Madhukar, Keshav, 'Maharashtra's Clan Story', Rajahans Prakashan, Pvt. Ltd. Pune.
- Editor, Mohod, Baba, "Sermons of National Saints", Sri. Gurudev Publications, Gurukunj, Ashram, Mozri, Panchmavrthi, 2011
- Aakashvani, Nagpur, (News from Pachgaon Pendhari)
- Newspaper, - DainikTarun Bharat, Dainik Lokmat, Dainik Sakal, Nagpur Patrika.

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Acquisition of natural remanence in the basaltic later ites of Deccan volcanic province (India): Implications to palaeomagnetic studies in laterites

Article *in* CATENA · April 2023

DOI: 10.1016/j.catena.2023.107154

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ARTICLE INFO

Keywords:
Laterite
Mineralogy
Rock magnetism
Deccan basalt
Palaeomagnetism

ABSTRACT

Lateritization in the Deccan basalt province (India) represents a large spectrum of chemical weathering with up to 99% of CIA values and the complete ferri- to antiferromagnetic transformations. We combined rock magnetic, palaeomagnetic, XRD, and XRF analyses to investigate the mineralogical transformations and its relationship to the acquisition of natural remanent magnetization (NRM) by sampling a 25 m thick Deccan lateritic profile from the West Coast of India. Significant amount of amorphous hematite (*ha*), crystalline hematite (*hc*), goethite and their Al- substituted forms were detected along with gibbsite and kaolinite. The domain size association of 'SP + SD and 'SP + SD + MD' in the ferri- as well as antiferromagnetic forms; and combination of *ha* and *hc* yield strong NRMs amongst these laterites. Low field demagnetization (< 5mT) allows removal of ha_{NRM}; and the secondary components due to ferrimagnetic oxides can be removed at < 25 mT. Thereafter, the hc_{NRM} continued to decay up to > 150 mT. Palaeomagnetic tests (Koenigsberger ratio, MDF, intensity decay and Zijderveld diagrams) indicate stable Characteristic remanent magnetizations (ChRM) due to *hc*; and the Al-substitutions does not affect the ChRM stability, depicting these laterites as excellent palaeomagnetic recorders. The stable ChRMs due to Chemical/Crystallization RMs due to '*hc*' also benchmarks the degree of maturity within the process of lateritization.

1. Introduction

Laterites are the manifestations of deep, prolonged, and intensive chemical weathering that occurred on differing host lithologies (Widdowson and Cox, 1996; Bourman and Ollier, 2002; Wimpenny et al., 2007, Ollier and Sheth, 2008, Babechuk et al., 2014, Ghosh et al., 2015). Selective diminution of alkali, alkaline earth elements, and silica from parent rock through the process of lateritization results in gradual enrichment of the iron and aluminium oxides and hydroxides along with some residual clays (Widdowson and Gunnell, 1999; Borger and Widdowson, 2001; Widdowson, 2007).

Widespread occurrence of laterites is observed in tropical regions particularly during the Cenozoic period (Bardossy, 1981; Gunnell, 2003). Laterites from the Indian subcontinent particularly preserve a variety of processes from different ages and host rocks (Meshram and Randive, 2011; Caner et al., 2011). Some of the pioneering and fundamental information on laterites is also derived from the Indian west coast occurrences (Buchanan, 1807) and were studied using physical, geochemical (Widdowson and Cox, 1996; Kısakürek et al., 2004; Babechuk et al., 2014, 2015; Suhr et al., 2018) and mineral magnetic perspective (Liu et al., 2019; Singh et al., 2020).

The prolonged process of lateritization permits sufficient time for NRM acquisition depicting them as good magnetostratigraphic recorders. However, there is ambiguity in understanding the acquisition in terms of the lateritization process. A single lateritic profile can be perceived through different superimposing processes dominated by solution and precipitation activities (Widdowson, 2007; Babechuk et al., 2014, Suhr et al., 2018). Palaeomagnetic studies in lateritic profiles therefore demand detailed mineralogical assessment in context to NRM acquisition. The renewed interest in basaltic laterites as possible analogues of Martian weathering processes (Hynek et al., 2002; Thomas et al., 2005; Greenberger et al., 2012), CO_2 sequestration during basaltic

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https://doi.org/10.1016/j.catena.2023.107154
Received 14 May 2021; Received in revised form 12 March 2023; Accepted 6 April 2023
0341-8162/

weathering (Seifritz, 1990; Schuiling and Krijgsman, 2006; Gislason and Oelkers, 2014) further demand detailed studies from ideal basaltic laterites, such as the Deccan traps. Iron oxides being the chief constituent of laterites, magnetic mineralogy and spectroscopy makes some of the most suitable approaches for such investigations.

The basalts are enriched with ferrimagnets and hence provide a complete spectrum of transformation to antiferromagnetic oxides during through the process of lateritization. The complex nature of lateritization allows many repeated and superimposed reaction series of partial to complete oxidation, hydroxylation, dissolution, and precipitation leading to the processes such as maghematization, ferry-hydroxylation, Al-substitution, crystallization, and recrystallization. Several residual, crystalline, and amorphous minerals are produced during lateritization compelling the use of multiple spectroscopic and magnetic approaches to analyse the laterites. On the other hand, it enriches our understanding on NRM acquisition by chemical/crystallization remanent magnetizations (CRMs). This study is aimed at finding the efficacy of NRM in terms of palaeomagnetic signatures from the laterites.

The mineral/rock magnetism is a well-established approach for identification of different phases of iron oxides enabling their semi-quantitative estimates (Thompson and Oldfield, 1986, pp. 21–38; Evans and Heller, 2003, pp. 50-78; Liu et al., 2012). Intensive work has been made to delineate and differentiate dominant phases of ferrimagnetic mineralogy (i.e. magnetite, maghemite, and greigite) from the antiferromagnetic minerals. Further the studies are available to provide distinction within the antiferromagnetic phases (e.g., Dekkers and Rochette, 1992; France and Oldfield, 2000; Sangode and Bloemendal 2004; Roberts et al., 2020; Jiang et al., 2022). The antiferromagnetic minerals can carry stable remanence over a longer period makes them suitable for palaeomagnetic studies (Dunlop and Özdemir, 1997, pp. 16–42; Roberts et al., 2020). Previously, Schmidt et al. (1983) made palaeomagnetic attempts on Indian laterites and found considerable scatter in data which he then inferred mixing of normal and reverse magnetization demanding detailed mineralogical studies. Substitution of cations (e.g., Al) and amorphous to crystalline transformations within antiferromagnetic complexes (Cornell and Schwertmann, 2003, pp. 39-57; Liu et al., 2007; Hu et al., 2016) is a crucial factor in the determination of magnetic properties akin to the standard and theoretical values. Laterites being highly enriched with antiferromagnetic oxides/hydroxides such as hematite, goethite, ferrihydrites and lepidocrocite (Kısakürek et al., 2004; Meshram and Randive, 2011; Babechuk et al., 2014, 2015; Suhr et al., 2018; Singh et al., 2020) provide an opportunity to study the complex processes and their implications on NRM. Here we characterized the lateritic magnetic minerals, their concentration and domain sizes to understand its implications on NRM acquisition.

2. Study area

The Indian subcontinental drift from the southern to northern hemisphere continued until its collision with Asia to form the Himalayas (Klootwijk and Pierce, 1979; Courtillot et al., 1988). During this transect voluminous lavas were erupted at ~ 65 Ma ago around the Cretaceous-Tertiary (K-T or K-Pg) boundary, occupying an area of 500,000 km^2, thus creating the Deccan traps (Klootwijk and Pierce, 1979) as large igneous province. This formed the substrate for the lateritization typically under the tropical humid conditions over suitable geomorphological surfaces. The studied laterites are formed over the Poladpur Formation of Deccan traps. The thickness of lava flows belonging to the Poladpur Formation varies from 3 to several 10′s of meters spread over wide distances (Duraiswami et al., 2014). The studied laterites occur on the Konkan plain are known as low-level laterites (Widdowson and Cox, 1996) and are depicted in the Fig. 1a. Schimdt et al. (1983) divided Indian laterites into late Cretaceous-early Tertiary laterites and mid-to-late Tertiary laterites.

3. Materials and methods

Large oriented block samples (greater than30 cm^3) of laterites were collected at 5 m intervals from the freshly excavated laterites near the Chiplun area covering an entire profile of 25 m. Sample 1 and sample 7 are from the top and bottom of the profile, respectively. Samples of the fresh host basalt were obtained at the base of the profile for mineralogic and palaeomagnetic reference. All the samples were cored into standard specimen sizes keeping the orientations in-tact and the sets of palaeomagnetic and rock magnetic studies were prepared. For instance, specimens of sample number 1 are labelled 1.1, 1.2, 1.3, etc. for palaeomagnetic measurements, and 1A, 1B, 1C for rock magnetic measurements.

3.1. Rock magnetic measurements

Magnetic susceptibility was measured using Bartington MS2B susceptibility meter operated dual frequency (χ_{lf} at 0.465 and χ_{hf} at 4.65 kHz). The χ_{fd} and χ_{fd} % were calculated using ($\chi_{lf} - \chi_{hf}$) and [($\chi_{lf} - \chi_{hf}$)/χ_{lf}] × 100, respectively. Anhysteretic remanent magnetization (ARM) was induced by a peak AC field of 200 mT superimposed over 0.1 mT DC bias field using Magnon alternating field demagnetizer (Germany). The values for susceptibility of ARM (χ_{ARM}) were calculated by normalization of ARM with DC bias field. Isothermal remanent magnetization (IRM) was imparted using ASC-IM-10–30 (USA) impulse magnetizer. The field was induced at incremental steps from 25 to 2200 mT and backfields from −10 to −1000 mT. The magnetizations were measured using Molspin (Minispin) magnetometer (Sensitivity: 3 × 10^{-5} A/m), whereas the palaeomagnetic remanence was measured using the JR-6A spinner magnetometer (AGICO, Czech) (Sensitivity: 2.4 × 10^{-6} A/m). The maximum field available in the laboratory (i.e., 2200 mT) was considered as saturation field to calculate the SIRM (Evans and Heller, 2003, pp. 50-78). The values of susceptibilities and remanent magnetizations throughout the calculations were mass normalized. Table 1 (Supplementary file) summarizes the parameters used for estimation of different parameters and Table 2 (Supplementary file) accounts the mean values of the studied parameters. Backfield data were used to calculate the coercivity of remanence (B_{CR}). Rock magnetic and palaeomagnetic analyses were carried out at the Palaeomagnetic laboratories of Department of Geology, Savitribai Phule Pune University (SPPU) and the CSIR- National Geophysical Research Institute (NGRI), Hyderabad.

3.2. Hysteresis loops and thermomagnetic measurements

Set of samples were analysed for thermomagnetic, XRF and XRD studies using standard methods. Hysteresis loops and thermomagnetic curves were generated on advanced variable field translation balance (AVFTB) (Sensitivity- 5 × 10^{-5} Am^2/kg, Temperature window- 0 to 800 °C) at CSIR- NGRI. The hysteresis loop parameters were analyzed using software 'rockmaganalyzer' (https://earthref.org/RockMagAnalyzer/).

3.3. X-ray fluorescence (XRF)

A set of powdered samples (six samples of laterite and two samples of basalt) were used for XRF analyses to calculate the weathering indices. The analyses were made on ED-XRF SPECTRO XEPOS III unit at SPPU following the sample preparation procedure described in Kisakurek et al (2004). USGS standards AGV-1, BHVO-1, VL-1 and VL-2 were used as standards for calibration (LaBrecque and Schorin, 1987). The geochemical indices were calculated using spreadsheet provided by Babechuk et al (2014). Chemical index of alteration (CIA) and Mafic index of alteration (MIA)(oxidation) were measured using moles of oxides

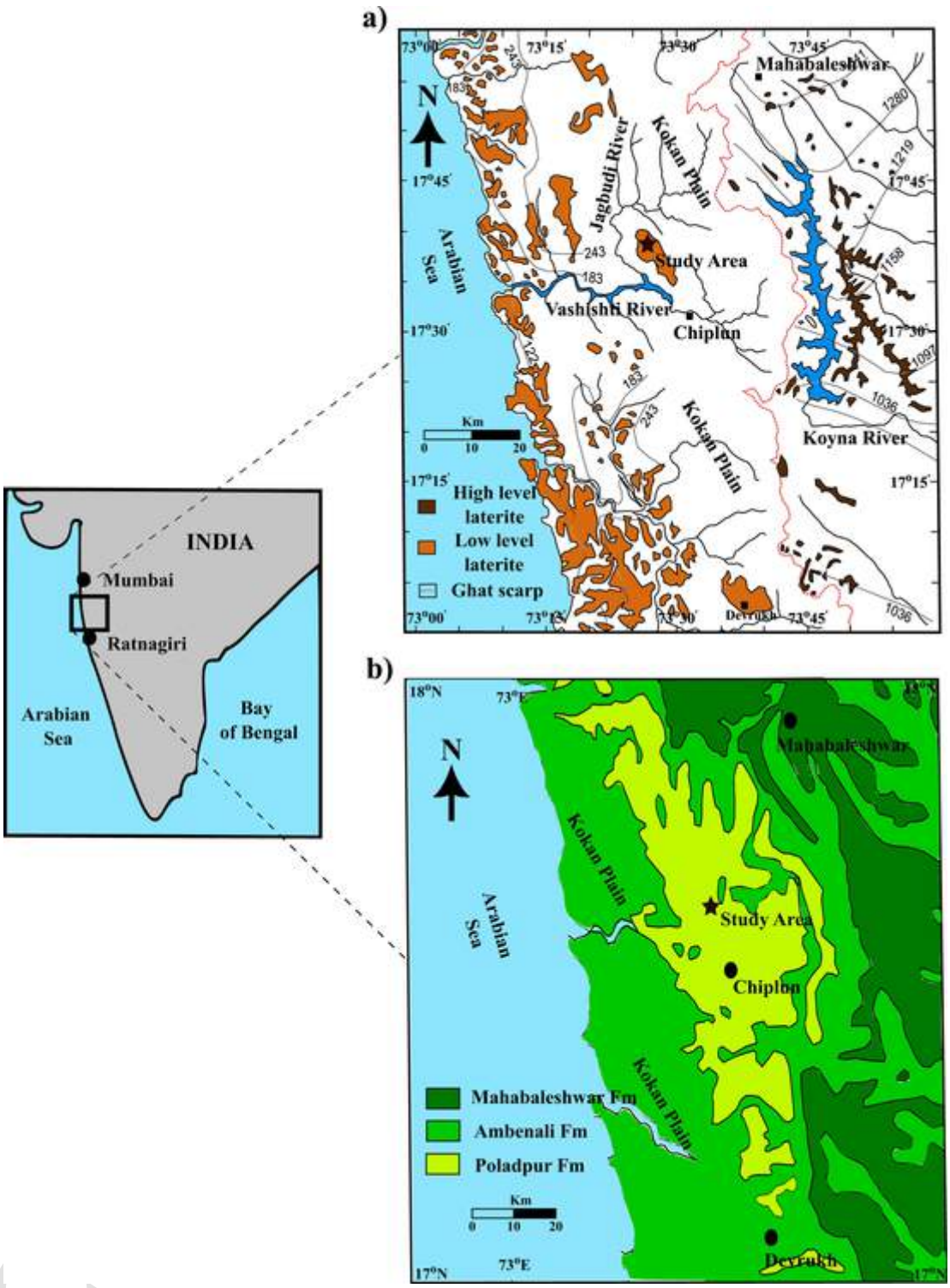

Fig. 1. Location map of the study area. a) High level (dark brown) and low level (orange) laterites separated by the Western Ghats escarpment (dashed red line). Black dot lines represent the elevation contours in meters. Inland water bodies are marked in blue colour. The study area (near Chiplun) is indicated by a black star. b) Geological map of the study area after Widdowson and Cox (1996). The Deccan trap stratigraphy is shown by shades of green colour. The studied laterites are developed on basalts belonging to Poladpur Formation of Deccan volcanic province (modified after Widdowson and Cox (1996)).

in their formulae, while oxide wt % were used in the case of the index of lateritization (IOL) with formulae given below.

$$CIA = [Al_2O_3/(Al_2O_3 + CaO + Na_2O + K_2O)] \times 100.$$

$$MIA = [(Al_2O_3 + Fe_2O_{3(T)})/(Al_2O_3 + Fe_2O_{3(T)} + MgO + CaO + Na_2O + K_2O)] \times 100.$$

$$IOL = [(Al_2O_3 + Fe_2O_{3(T)})/(SiO_2 + Al_2O_3 + Fe_2O_{3(T)})] \times 100.$$

3.4. X-ray diffraction (XRD)

RIGAKU XRD Model ULTIMA IV was used to generate the XRD spectra for bulk powder samples from each unit at SPPU. The 2θ scan range

was set at 10 to 80° with a step interval of 0.02θ and speed of 4 per second. Samples were measured in Cu-Kα mode applying a voltage of 45 keV and the intensity of 40 mA. Phase identification and refinement were accomplished using Match software (https://www.crystalimpact.com/match/) having options for library data search to enable the mineral identifications in the bulk samples.

4. Results and discussion

4.1. Rock magnetism

The magnetic susceptibility (χ_{lf}) variation within the profile (Fig. 2a and Table 2) shows values from 31 to 105 × 10^{-8} m^3/kg in *Zone I*, 2 to 40 x10^{-8} m^3/kg in *Zone II,* and 77 to 84 x10^{-8} m^3/kg in *Zone III* from top to bottom. The overall range of values for *Zone I* and *III* are substantially higher than that for *Zone II* depicting possible ferrimagnetic influence for the former compared to antiferromagnetic nature of mineralogy in *Zone II*. The χ_{fd}% (approximate concentration of SP grains) is higher in *Zone II* relative to *Zone I and III* (Fig. 2b). The *Zone II* values range from 0.4 to 5.5%, whereas the average values for χ_{fd}% in *Zone I and III* are 0.5 and 0.8%. Lateritization process favours a large-scale transformation within magnetic mineralogy by dissolution and precipitation in an oxidative regime of Eh-pH conditions. The χ_{fd} % represents the effect of viscosity at room temperature for the superparamagnetic (SP) domain fraction with diameters less than 3–50 nm. The behaviour of SP grains is largely dependent on temperature and the time span of observation (O'Reilly, 1984, pp. 58-97). The χ_{fd}% enrichment amongst *Zone II* samples suggests its formation possibly by intense dissolution-solution-precipitation activity during lateritization. The ferrimagnetic SP may arise by the dissolution of larger ferrimagnetic grains or simply by maghemitization. Whereas, *Zone II* is marked by the highest coercivities (B_{CR}) and hard isothermal remanent magnetizations (HIRM) (described below) suggest the possible antiferromagnetic nature of the SP fraction. The intense antiferromagnetic transformations in laterites lead to the formation and precipitation of ferrihydrite and limonitic complexes in their amorphous states and nanoforms to produce the SP.

The χ_{ARM} is generally related to the concentration of stable single domain (SSD) ferrimagnetic grains (Maher, 1988; Egli and Lowrie, 2002). As seen in Fig. 2c, the χ_{ARM} is strikingly lower in *Zone II* compared to *Zone I and III,* with Zone *III* representing higher concentration of SSD grains of ferrimagnetic nature. The Saturation Isothermal Remanent Magnetization (SIRM) collectively depends upon the coercivity of magnetic mineral phases (Thompson and Oldfield, 1986, pp. 21-38). Magnetically hard minerals (high coercivity and low remanence) resist the applied field while soft minerals (low coercivity and high remanence) align easily along external fields. The SIRM in *Zone I* (max: 0.84 Am^2/kg) and *III* (max: 0.46 Am^2/kg) show exceptionally higher values than *Zone II* (Fig. 2d). SIRM values for *Zone I* and *Zone III* thus indicate a dominant contribution from ferrimagnetic minerals e.g. magnetite/titanomagnetite and maghemite; while *Zone II* indicates majority of antiferromagnetic complexes (hematite, goethite, and their substitutes). The SIRM values for *Zone I* are much higher than *Zone III* depicting significant ferrimagnetic contribution from magnetite-maghemite phases.

The S-ratio depict relative abundance of soft versus hard magnetic minerals (King and Channell, 1991). Theoretically, the values close to '1' correlate well with soft ferrimagnetic minerals like magnetite and prevailing lower values correspond to magnetically hard minerals such as hematite and goethite. In the present scenario, *Zone I* and *III* show the S ratios close to 0.9 implying dominant ferrimagnetic mineralogy (Fig. 2e). The maximum and minimum values are observed in *Zone II* and are within the range from 0.67 to 0.02 suggesting minor contribution of ferrimagnetic minerals in overall antiferromagnetic assemblage

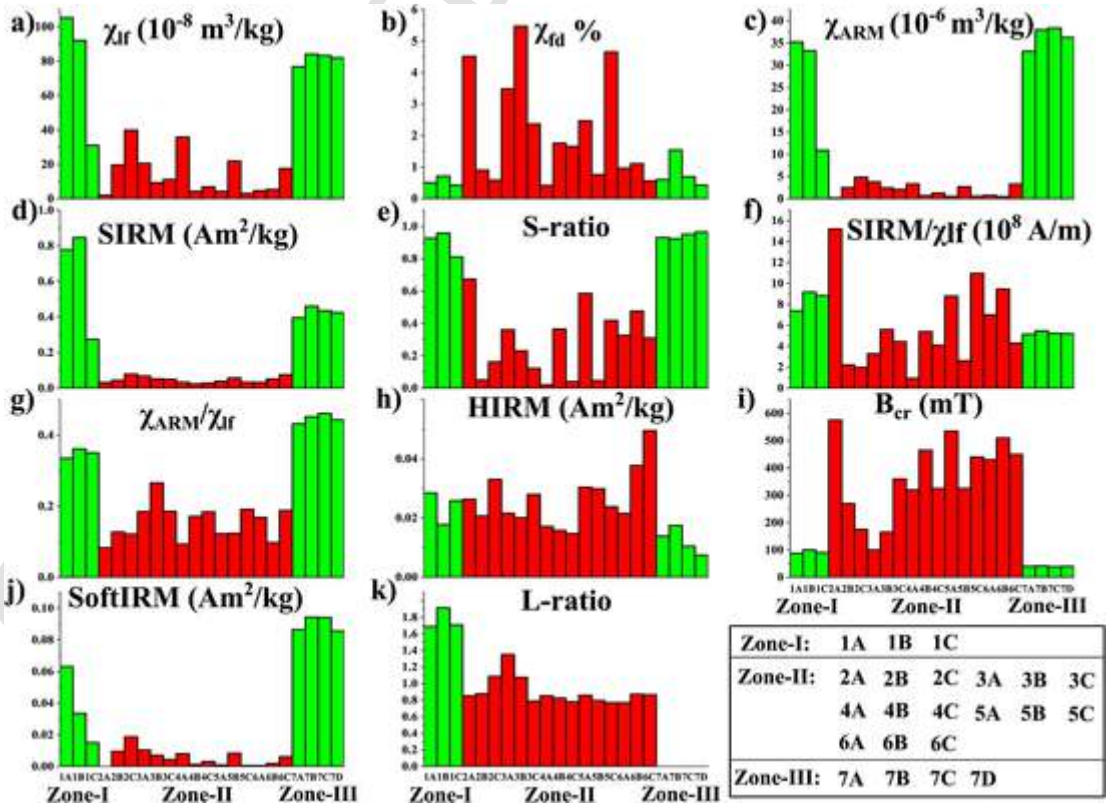

Fig. 2. Bar plots of different environmental magnetic parameters against the specimens of their respective samples. Green-coloured bars represent Sample 1 (specimens 1A, 1B, 1C) of laterite and Sample 7 (specimens 7A, 7B, 7C, 7D) of basalt, while Sample 2–6 of the typical laterites are shown in red bars. Index on the lower right side of the diagram represents zones and their corresponding specimens. The parameters employed in this study are a) χlf (10^{-8} m^3/kg), b) χfd %, c) χARM (10^{-6} m^3/kg), d) SIRM (Am^2/kg), e) S-ratio, f) SIRM/χ (10^8 A/m), g) χARM/χlf, h) HIRM (Am^2/kg), i) B_{cr} (mT), j) Soft IRM (Am^2/kg), k) L-ratio.

(Fig. 2e). However, the use of S-ratio for relative contribution is statistically non-linear and the interpretation is based on their non-unique nature (Heslop, 2009).

The SIRM/χ_{lf} ratio broadly delineates the changes in domain-size; and in the present case, it is sensitive to changes in the magnetic mineral phases along with a possible contribution from paramagnetic minerals (predominantly the clay minerals). In *Zone II*, the combination of SIRM/χ_{lf} and χ_{ARM}/χ_{lf} depict bimodal distribution due to smaller and larger SD grains (Fig. 2f, 2g). The higher values of χ_{ARM}/χ_{lf}, a grain size indicator depict relative enrichment of SD particles and its lower values show a bias towards SP or Multidomain (MD) particles (Liu et al., 2012).

The HIRM and Soft IRM ratios are primarily inferred for discrimination of bulk concentration of ferrimagnetic and antiferromagnetic mineralogy (Robinson, 1986; Thompson and Oldfield, 1986, pp. 21-38). Overall, the high HIRM in *Zone II* indicated the predominance of antiferromagnetic minerals relative to *Zone III* (Fig. 2h). The Soft IRM values in *Zone II* are 17 times lower than *Zone III* suggesting the relative abundance of hematite and/or goethite like mineral phases (Fig. 2j). The coercivity of remanence (B_{cr}) is a complex parameter that depends upon mineralogy, domain states, and crystal structures (Dunlop and Özdemir, 1997, pp. 133–140). The substitution of Al or Ti in the structures of magnetic minerals however causes drastic changes in the magnetic properties (Liu et al., 2007; Liu et al., 2012). This may result in an increase or decrease in the values of saturation magnetization, coercivity, and Neel/Curie temperatures (Liu et al., 2007). The B_{cr} values are higher in *Zone II* (max- 575) than *Zone I* and *Zone III* (Fig. 2i). Nonetheless, B_{cr} in *Zone I* is twice as higher as *Zone III*. Low S-ratio, high χlf, and SIRM along with high B_{cr} values thus indicate the existence of both antiferromagnetic and ferrimagnetic minerals in *Zone I*. Liu et al. (2007) suggested constancy of L-ratio to reflect the absolute changes in the concentration of hematite or goethite,. For conventional use of S-ratio and HIRM, therefore we estimated the L-ratio. The values were uniform in *Zone I* and *II*, attesting the fair usage of S-ratio and HIRM (Fig. 2k).

Finally, the inferences from routine mineral magnetic analysis are summarized below.

1) The topmost *Zone I* is dominated by an equitable proportion of soft and hard magnetic minerals with a significant concentration of SD grains. The surficial ferrimagnetic inputs can be attributed to secondary/detrital processes as described in Singh et al (2020).

2) The intermediate *Zone II* represents a predominant antiferromagnetic zone with minor ferrimagnetic contribution and the predominance of SP fraction. This zone mainly represents the intense lateritization with almost complete transformation of ferrimagnetic oxides along with possible addition of antiferromagnetic complexes along with other minerals by dissolution and precipitation during intense chemical weathering enriching the antiferromagnetic oxides.

3) The lowermost *Zone III* represents a dominant ferrimagnetic mixture of SD and MD grains along with low antiferromagnetic contributions.

4.2. Modelling of the isothermal remanent magnetization (IRM) spectra

When the samples are dominated by mixed magnetic mineralogy, detailed analysis of IRM curves can provide differentiation of admixtures (France and Oldfield, 2000; Liu et al., 2012). The values of acquired magnetization are plotted on the y-axis and corresponding field values on the x-axis. Fig. 3 thus depict that *Zone II* specimens are typical of antiferromagnetic nature (Dekkers and Linssen, 1989). The antiferromagnetic mineral hematite usually saturates in the fields up to 2–5 T,

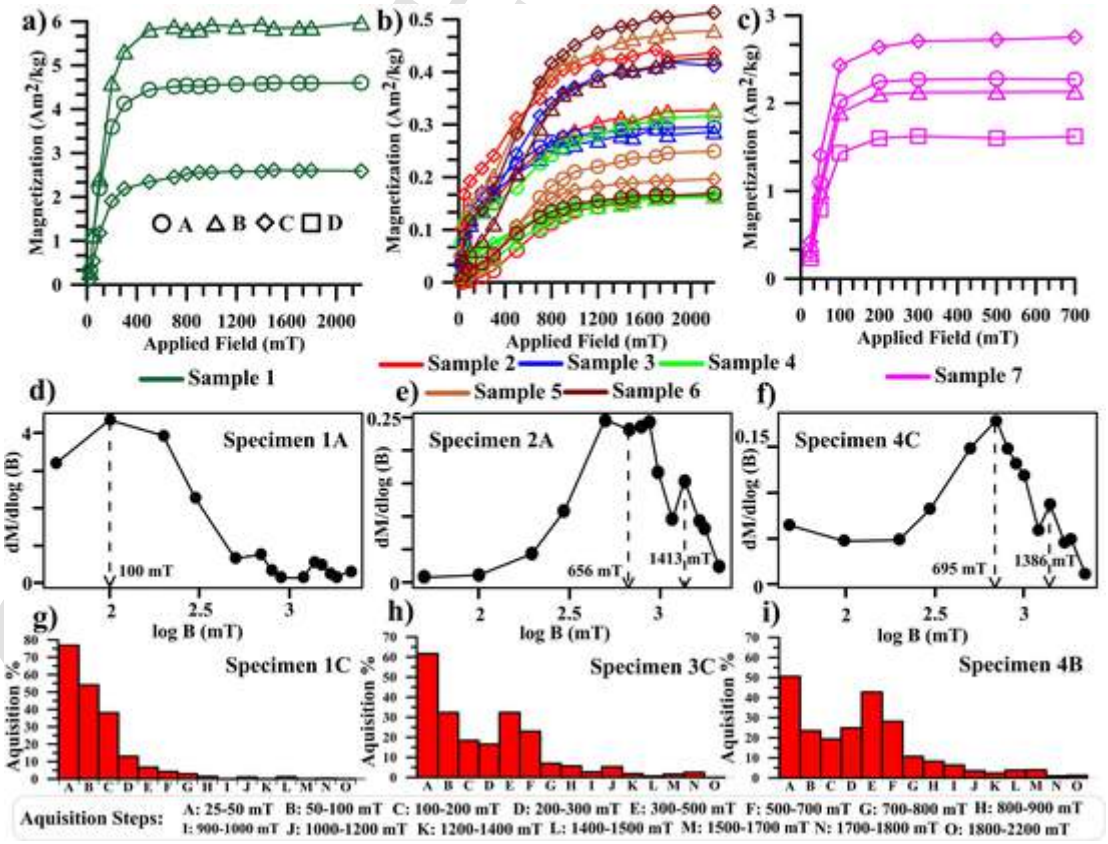

Fig. 3. The first row shows IRM acquisition (magnetization against applied field) for a sample from *Zone I*, *Zone II*, and *Zone III* in sequence. The second-row plots the coercivity spectra [d(M)/d(log B)] vs log B mT for specimens from *Zone I* (d), and *Zone II* (e, f). The dashed lines represent the mean coercivity values of the components. In the third row, we have plotted the RPM (relative percentage of magnetization acquisition) for specimens belonging to *Zone I* (g) and *Zone II* (h, i). Letters A to O on the x-axis represents the intervals of applied field in mT. Acquisition steps are shown at the bottom of the figure.

but the presence of goethite can increase the field of saturation up to ~ 6–9 T or even higher (Dekkers, 1988; Rochette et al., 2005; Liu et al., 2012). The saturation magnetization, coercivity, and Curie/Neel temperatures also depend upon the amount of substitution and degree of crystallinity (Cornell and Schwertmann, 2003, pp. 111-136; Liu et al., 2007). Thus the IRM curves for *Zone II* specimens can be subdivided into three parts depending upon the maximum magnetization induced (Fig. 3b). This proposes the variations in the mineralogy and domain size perhaps as a result of crystalline to amorphous varieties and their substitutions within the hematite dominant mineralogy along with some proportion of goethite. *Zone I* specimens show the highest enhancement compared to *Zone III*. However, *Zone III* specimens exhibit higher values of magnetization as it is dominated by ferrimagnetic minerals. This indicates a significant ferricretization in *Zone I*, while *Zone II* is dominated by lateritization.

The discrete IRM spectra are further useful for modelling the components of acquisition based upon the coercivity characters (e.g. Kruiver et al., 2001; Heslop et al., 2002; Maxbauer et al., 2016). These methods are generally applied when magnetic minerals are originated from different sources. The requirements for these methods are monotony in the data which will be achieved by increasing the IRM acquisition steps along with less magnetic interaction. As the applied field increments were less in this study, and also the magnetic minerals are grown from only one source (i.e. unimodal chemical origin), we used a plot of [d(M)/d(log B)] against log B (Fig. 3d, 3e, 3f) to identify mean coercivity components prior to applying further statistical procedures (e.g. smoothing, component fitting) (Tauxe et al., 1996; Maxbauer et al., 2016). The minerals that were not identified/detected by the values of coercivity from back-field application (possibly because of their lower concentration) can be separated using this plot. The plot for specimens 2A and 4C represents two coercivity components (Fig. 3e and 3f). For specimen 2A, the mean coercivity for components 1 and 2 are 656 mT and 1413 mT, respectively (Fig. 3e). Assigning the components for specific minerals depends on the source variation (eventually which will affect the magnetic signal) (Kruiver et al., 2001; Heslop et al., 2002; Maxbauer et al., 2016).

The lateritic mineralogy being antiferromagnetic (AFM) dominant, the coercivity analysis and the rate of change of IRM acquisition (RPM) appears to have been governed by the variation within the AFM phases. IRM being an indirect method, in this lateritic composition, we anticipate these different phases as a result of substitution (e.g. Aluminium-) and the grain size variations within the range of crystalline to amorphous oxides. We further examined this mineralogy using more advanced approaches in rock magnetism and the spectroscopy (i.e., XRD). In the present case, we assign the lower values of coercivity to hematite and higher values to goethite. The significant presence of goethite apart from hematite has been confirmed using x-ray diffraction analysis (presented later). The assigned value (656 mT) of coercivity is still higher than that expected for hematite (Peters and Dekkers, 2003). As stated above, the Al-substitution increases the values of coercivity for hematite and it decreases for goethite (Roberts et al., 2006; Liu et al., 2007). Similar two components were identified for specimen 4C. However, as shown in Fig. 3f, the curve initiates with elevation (x-axis) as opposed to specimen 2A. This initial enhancement implies the influence of a small/soft ferrimagnetic (FM) component which can be attested from the rate of acquisition (RPM) plots (Fig. 3i). Furthermore, specimen 1A is dominated by only one component (i.e., FM) having a mean coercivity of 100 mT, that is in agreement with the values obtained from backfield data (Fig. 3d).

The RPM for specimen 1C shows substantial acquisition up to 500 mT, depicting magnetite-maghemite-like ferrimagnetic phases (Fig. 3g). For specimen 3C, the percentage acquisition shows two trends, one up to 300 mT and the other from 300 mT upwards (Fig. 3h). Similar results were obtained for specimen 4B. This anticipates the presence of maghemite-like phases within *Zone II*. Furthermore, it also justifies the initial peak exhibited by specimen 2A as mentioned above. We considered the possibility of maghemite (/titanomaghemites) within FM mineralogy due to the commonly occurring process of maghemitisation during weathering of magnetite/titanomagnetites sourced from the parent Deccan basalts. In a nutshell, these results indicate that *Zone II* is dominantly hematitic (Al substituted?) along with variable contributions from goethite and maghemite; and maghemite (or magnetite) is the major phase in *Zone I*.

4.3. Hysteresis and thermomagnetic analysis

The hysteresis curve data are plotted for representative specimens of laterite and parent rock basalt (Fig. 4). The changes in magnetization with applied fields are measured using hysteresis loops (Thompson and Oldfield, 1986, pp. 21-38). The height, width, squareness, and steepness of the hysteresis loops are the consequence of magnetic concentration, stability, ease of magnetization, and grain interactions respectively (Maher and Thompson, 1999, pp. 29-31). Also, there is a significant impact of magnetic domain size on hysteresis curves (Dunlop and Özdemir, 1997). The laterites (Sample 2–6) typically showed wasp-waisted loops, except for Sample 1 (Fig. 4). Tauxe et al. (1996) demon-

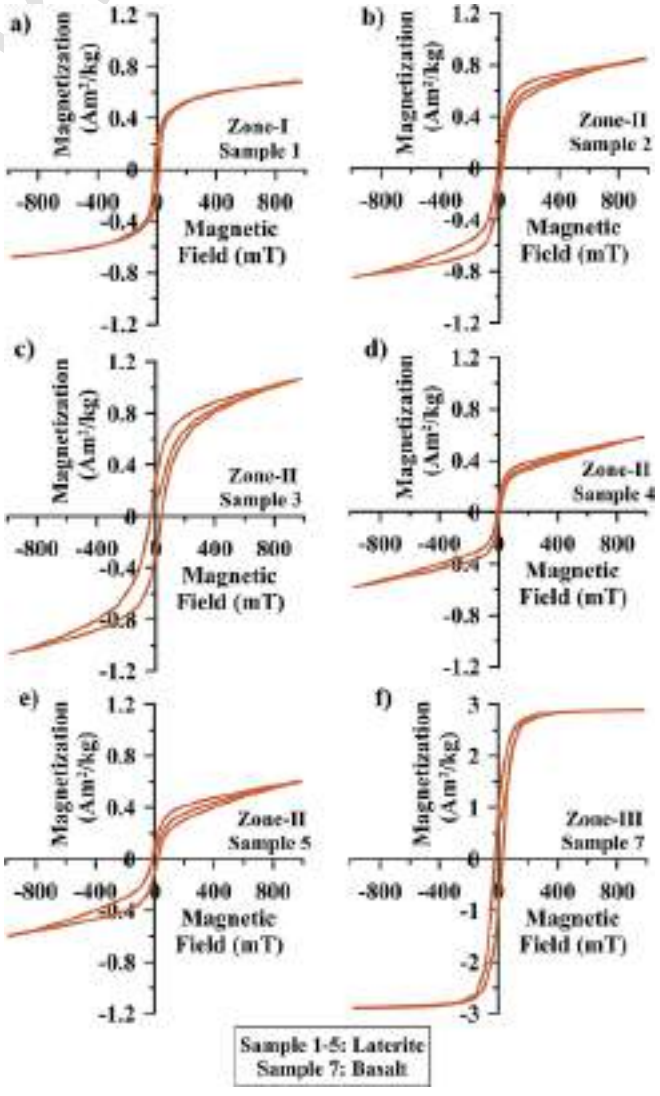

Fig. 4. Hysteresis curves for samples representing all three zones (*Zone-I, II and III*) from the studied profile. The figure shows wasp-waisted curves for laterite samples (b-e). The hysteresis curve of Sample 1 (laterite) showed similarity with the Sample 7 (basalt) (a, f).

strated that the mixtures of SP and SD grains with a size range of greater than 8 nm of SP can produce wasp-waisted curves. Also, a threshold size of 15–20 nm of SP grains along with some SD grains would create an exact shape, which is exhibited in the present scenario. There is a remarkable difference between the loops from *Zone I* (Sample 1), *Zone II* (Sample 2–6) and *Zone III* (Sample 7) as expected (Fig. 4). The hysteresis loop for Sample 1 closes at lower coercivity indicating dominant ferrimagnetic mineralogy (Fig. 4a). Lower values of coercivity can be observed in Sample 7 (basalt) compared to lateritic samples indicating SD to MD magnetite grain size population in basalt (Fig. 4f; Tauxe, 2002, pp. 35-75; Liu et al., 2012).

The graph of reduced saturation remanence (M_{rs}/M_s) against reduced coercivity (B_{cr}/B_c) so called 'Day Plot' has been pervasively used in many studies to discriminate the grain size variations (Day et al., 1977). Here, we used the Day-Dunlop plot as modification of the Day plot (Dunlop, 2002) shown in Fig. 5. Dunlop (2002) calculated theoretical as well as actual mixing lines for magnetite domains, with modified limits of reduced ratios in the Day plot. As seen in Fig. 5, majority of the samples of laterites fall within the range of 15 and 20 nm SP-SD mixing lines with one sample falling in 10–15 nm SP-SD mixing line. This suggests varying proportion of SP and SD grains in the lateritic samples. Furthermore, it supports the illustration given for hysteresis curves. The crystallinity of hematite determines the SD threshold size (Dekkers and Linssen, 1989).

The thermomagnetic curves (Fig. 6, discussed below) indicated that the hematites are Al- substituted. The exact delineation of critical SD size of hematite is limited by substitution (Dekkers and Linssen, 1989). However, the critical SD size for hematite could possibly be elevated to 100 μm (Kletetschka, 2002). Basalt sample is exactly falling on the mixing line of SD-MD having 15 % of MD mixtures in SD grains of magnetite (Ti). The explanation of hysteresis loops and Day-Dunlop plot suggests that the lateritic mineralogy is dominated by SP (10–20 nm) and SD AFMs. The SP fraction appears to be abundantly the amorphous hematite apart from other poorly crystalline antiferromagnetic fractions.

The identification of magnetic minerals using their respective Curie/Neel temperature has been widely used, although magnetic enhancement and diminution effects during heating/cooling often mask

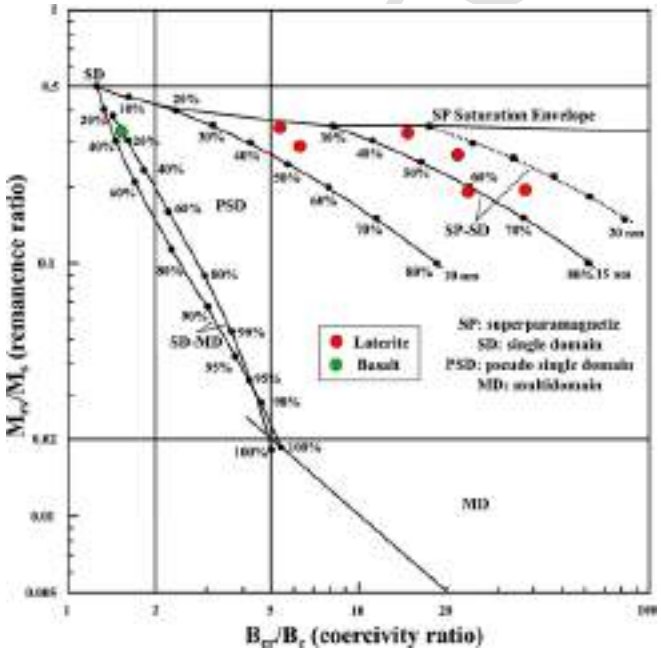

Fig. 5. Day-Dunlop plot (Day et al., 1977; Dunlop, 2002). Domain state mixing lines are adopted from Dunlop (2002). Red circles indicate laterite samples (Sample 1–6) while green circle indicate basalt sample (Sample 7).

the recognition (Liu et al., 2004; Torrent et al., 2006; Zhang et al., 2010). Fig. 6 illustrates the heating and cooling cycles (marked by red and blue arrows) for laterite and basalt analysed using AVFTB. Sample 1 showed dramatic change in magnetization during heating (300–500 °C) and a large rise during cooling, in contrast to the other laterites (Fig. 6a). The final decline in magnetization around 580 °C indicates the existence of magnetite (Fig. 6a). All the remaining laterite samples show a similar pattern by sudden decrease in magnetization at 300–500 °C during heating (Fig. 6b, 6c, 6d, 6e). Removal or conversion of mineral phase with higher magnetization to that with lower one possibly explains this behaviour. During the cooling cycle, we observed a significant loss of magnetization (50–80 %) concerning initial magnetization. Liu et al. (2005) observed similar changes in thermomagnetic curves for loess samples attributing such changes to conversion (inversion) of maghemite to hematite during heating in the same temperature range as observed here. They further suggested that this behaviour could also be used as an index for the presence of SP particles. The inversion temperature have been reported from 250 °C to ≥ 750 °C depending upon grain size, degree of oxidation, and incorporation of impurity to the crystal structure (Dunlop and Özdemir, 1997) and the Neel temperature of hematite is 657 °C (Dunlop and Özdemir, 1997, p. 51). However as seen in Fig. 6, the heating curve drops around 640 °C depicting the lowering of Neel temperatures due to substitution. The Al-substitution could be the most common reason for lowering of the Neel temperature of hematite (Dunlop and Özdemir, 1997, pp. 69–74; Liu et al., 2007). The diamagnetic bias of Al substitution decreases the crystallinity of hematite eventually affecting its Neel temperature and coercivity (Cornell and Schwertmann, 2003, pp. 39-57; Liu et al., 2007).

Identification of goethite in the present case is demanding as Al-substitution, excess water and crystallinity could reduce its Neel temperature to room temperature (Dekkers, 1990; Liu et al., 2012). Also, dehydration of natural and synthetic goethite occurs at considerably lower temperatures, at less than 270 °C (Lewis and Schwertmann, 1979). Dekkers (1990) reported dehydration of goethite at the temperature range from 260 to 360 °C. The basalt sample has shown a gentle decrease in magnetization up to 300 °C, thereafter a small drop was observed in a temperature range of 300–400 °C (Fig. 6f). Jiang et al. (2015) suggested magnetic enhancement in synthetic samples due to iron content from clay minerals and subsequent production of magnetite. There is a possibility of titanomagnetite to be exsolved into Ti-rich and Ti-poor magnetite phases at elevated temperatures (Dunlop and Özdemir, 1997, pp. 61–66), fairly enhancing the magnetization while cooling.

4.4. X-ray fluorescence analysis

The intensity and magnitude of alterations in the magnetic mineralogy of basalt could be traced using various alteration indices (Nesbitt and Young, 1984; Nesbitt and Wilson, 1992; Fedo et al., 1995; Babechuk et al., 2014). The CIA values primarily track dissolution of feldspar and higher values promote the removal of labile elements (Ca, Na and K) (Babechuk et al., 2014). CIA greater than 99% indicates complete removal of mobile elements and retention of Aluminium (Fig. 7a) (Table 3, Supplementary file). CIA values for basalt are less than 33% which are well within the basaltic weathering range (Fig. 7a). In SAF triangular diagram, all laterite samples fall in moderately to strongly lateritised fields, suggesting the deep nature of weathering in a complete profile (Fig. 7b). In the laterites from Gujarat, Meshram & Randive (2011) reported similar strong lateritization from the SAF diagrams. The IOL is a prime index of lateritization whose values in these laterites are significantly higher (greater than 70%) (Fig. 7b). Basaltic sample at the base fall in kaolinitised field in SAF diagram (this could represent the initiation of lateritization process in *Zone III*) (Fig. 7b). The basalt IOL values are consistent with values obtained by Babechuk et al. (2014). Lastly, the MIA (oxidation) represents the retention of Fe^{3+} and

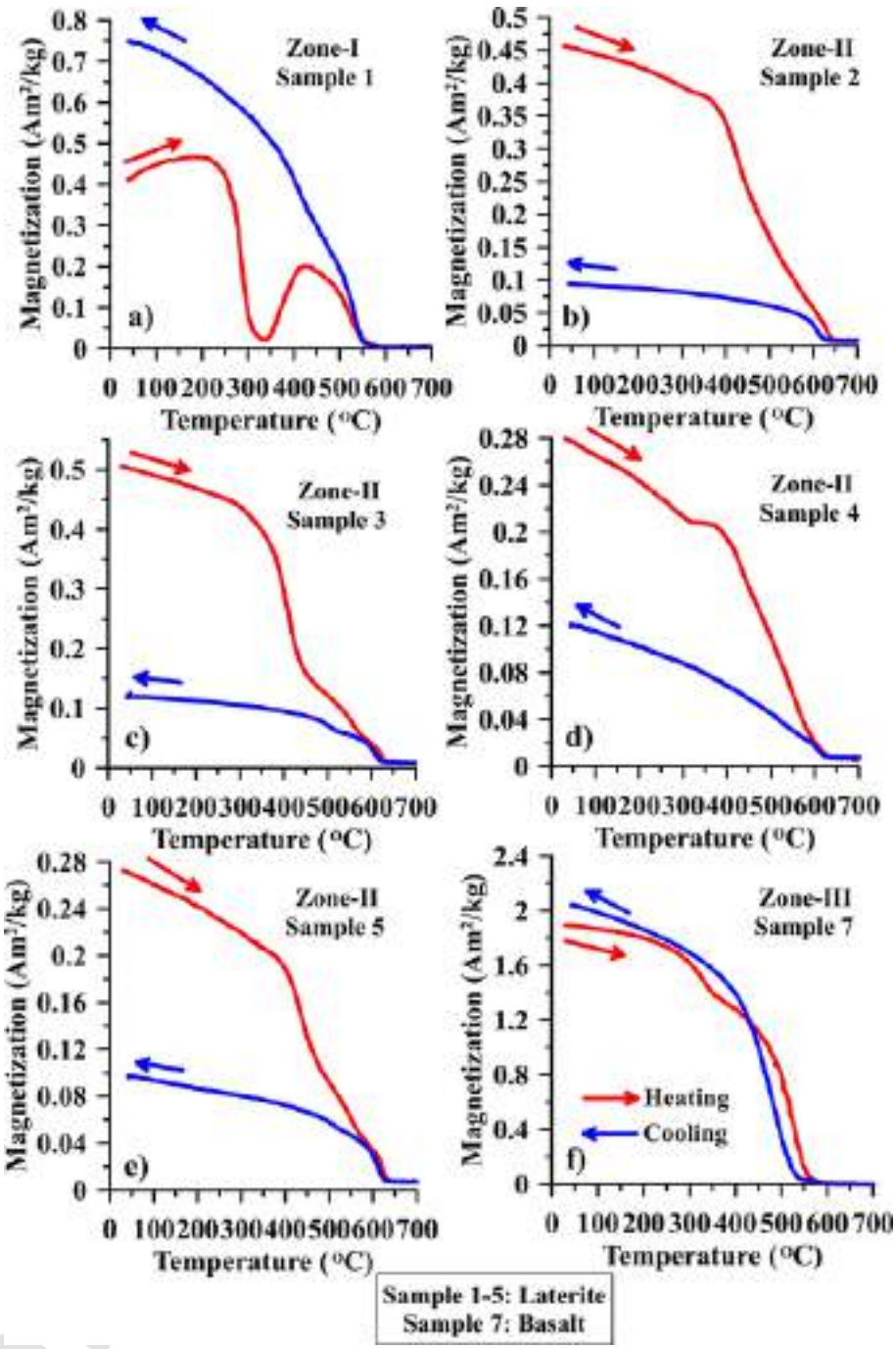

Fig. 6. Thermomagnetic curves for laterites (Sample 1–5) and basalt (Sample 7). Distinct patterns of heating are observed for samples from *Zone I* (a), *Zone II* (b-e) and *Zone III* (f). Laterite samples showed large differences in the magnetization after heating and cooling cycles (irreversible behaviour). Reversible curves were produced for basaltic sample (Sample 7). Red and blue arrows indicate heating and cooling curves.

aluminium over other oxides eventually noting the vital characteristics of laterite formation. As seen in Fig. 7c, all the laterite samples fall on the Fe_2O_3-Al_2O_3 line indicating their enrichment and maturity.

Above mentioned alteration diagrams clearly indicate absolute maturation of the laterite profile and completion of the lateritization process. The conversion of magnetic minerals from basaltic lithology has experienced laterite weathering to the fullest possible extent. This strengthens our inference of detrital ferrimagnetic input in the highest horizons of laterites contributing to ferrimagnetism in an AFM dominant process of lateritization.

4.5. X-ray diffraction analysis

The XRD analyses have been extensively practiced both quantitatively and qualitatively to study geological formations. We used *Match*-3 software to analyse and refine the XRD data (https://www.crystalimpact.com/match/). This software utilizes extensive data library search to identify the mineral phases in the sample. We found background noise in the data similar to Suhr et al. (2018) which was later assigned to the widespread occurrence of ferrihydrite and amorphous phases of hematite. Iron and aluminium oxides and hydroxides along with clay minerals were observed throughout the laterite profile. Majority of the iron oxide and hydroxide peaks occur at 30^0 (2θ) on-

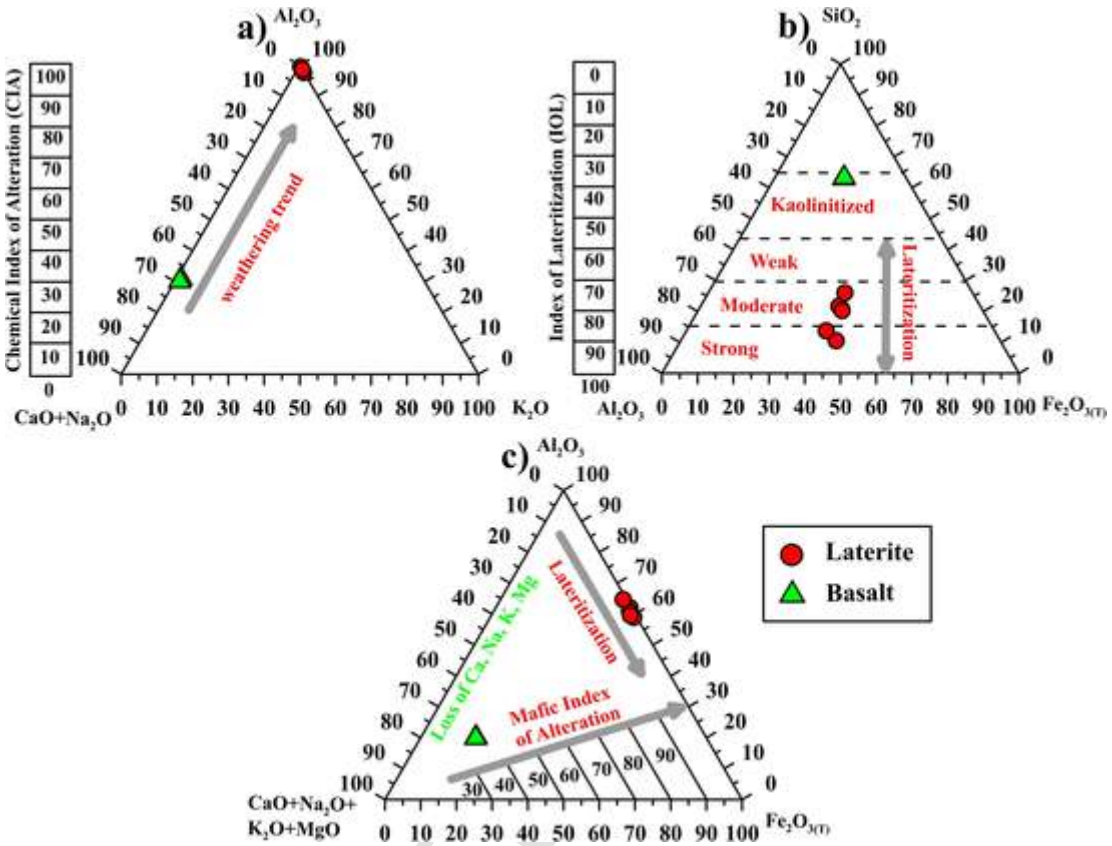

Fig. 7. Ternary diagrams indicating changes in various oxides along with weathering indices. Laterites are marked by red circles while basalt samples are shown by green triangles. The first diagram (a) is A-CN-K ternary plot along with the chemical index of alteration (CIA) (Nesbitt and Young, 1984; Nesbitt and Wilson, 1992; Fedo et al., 1995). The second diagram (b) is S-A-F ternary plot after Schellmann (1986) indicating the degree of lateritization. A-L-F ternary plot (c) indicating losses of mafic against alkali oxides (Babechuk et al., 2014).

wards. Identification of maghemite and magnetite is challenging as their maximum peaks coincide. However, magnetite does not exhibit a peak at lower values of 2θ (2 5 ^{0}). Stoichiometric hematite produced characteristic peaks in the XRD spectra (Fig. 8). Furthermore, the Al-hematite peaks (d-values: 2.2076, 1.4552) are identified using software's library and the XRD spectra of Al-hematite in Roberts et al. (2006). The higher Al-substitution in hematite moves 2 thetas to higher values (Roberts et al., 2006). Furthermore, hematite and goethite peaks were checked and confirmed using XRD data of France and Oldfield (2000). XRD spectra of samples representing all the three zones are shown in Fig. 8. The minerals identified are gibbsite, Al-hematite, maghemite, goethite, hematite, ferrihydrite, and kaolinite (Fig. 8). Similar minerals were observed by Singh et al. (2020) while studying the laterites from the nearby Patan (Satara, Maharashtra) area of Deccan province. The XRD for basalt samples detected characteristic minerals of the rock (plagioclase, pyroxene, olivine, and minor quartz) (Fig. 8c). Initiation of the process of lateritization due to weathering of parent rock (formation of saprolite) could affect the primary mineral assemblage resulting in the formation of secondary clay minerals. Minor magnetic enhancement during thermomagnetic (high temperature) treatments is probably due to the conversion of these minerals into new magnetic mineral phases (e.g., magnetite; Jiang et al., 2015) (Fig. 6f).

The exact quantification of minerals by XRD spectra depends on crystal structure of the mineral phase present, their substitution, defects, polytypes, and also peak collisions (Zhou et al., 2018). Substitution and varying crystallinity are possible in laterites evident from their behaviour during thermomagnetic analysis. In this regard, laterite from *Zone I* and *Zone II* show similar mineralogy in XRD spectra but for their relative quantification, we rely on characteristic rock magnetic parameters because of earlier discussed factors.

The laterite mineralogy being complex, the results produce several uncertainties in XRD spectra. A dedicated study focussing on the mineralogical aspects of laterites using advanced microscopy (scanning electron microscopy) is required for the identification of the full spectrum of minerals (magnetic and non-magnetic). Therefore, maintaining the focus upon the main objectives of rock magnetism and palaeomagnetism, further spectroscopic analysis on mineral separates were restricted and the overall information based on XRD and rock magnetism endorsed the presence of at least two varieties of hematite (crystalline and amorphous), the goethite (with substitutions); maghemite, and possible products of partial maghemitization of magnetites. Rock magnetism also suggested a mixture of SD + SP + MD and SD + SP under dominant antiferromagnetic mineralogy. Thermomagnetic data confirmed the existence of goethite, maghemite, and magnetite. XRD showed kaolinite as a dominant clay mineral along with goethite, hematite, and gibbsite and their substitutional varieties.

4.6. NRM acquisition

Above mineralogical studies infer that these laterites are enriched with both amorphous and crystalline antiferromagnetic oxides as the possible agents of NRM in the form of chemical/crystallization remanent magnetization (CRM). Amongst the two, crystalline hematites are the best possible candidates for stable and characteristic remanent magnetization (ChRM). On these premises, we conducted the palaeomagnetic analysis using alternating field demagnetization on the set of representative sister samples and are described below.

We relied upon the alternating field demagnetization, as thermal demagnetization was highly susceptible to laboratory heating-induced changes due to the abundance of amorphous and poorly crystalline iron

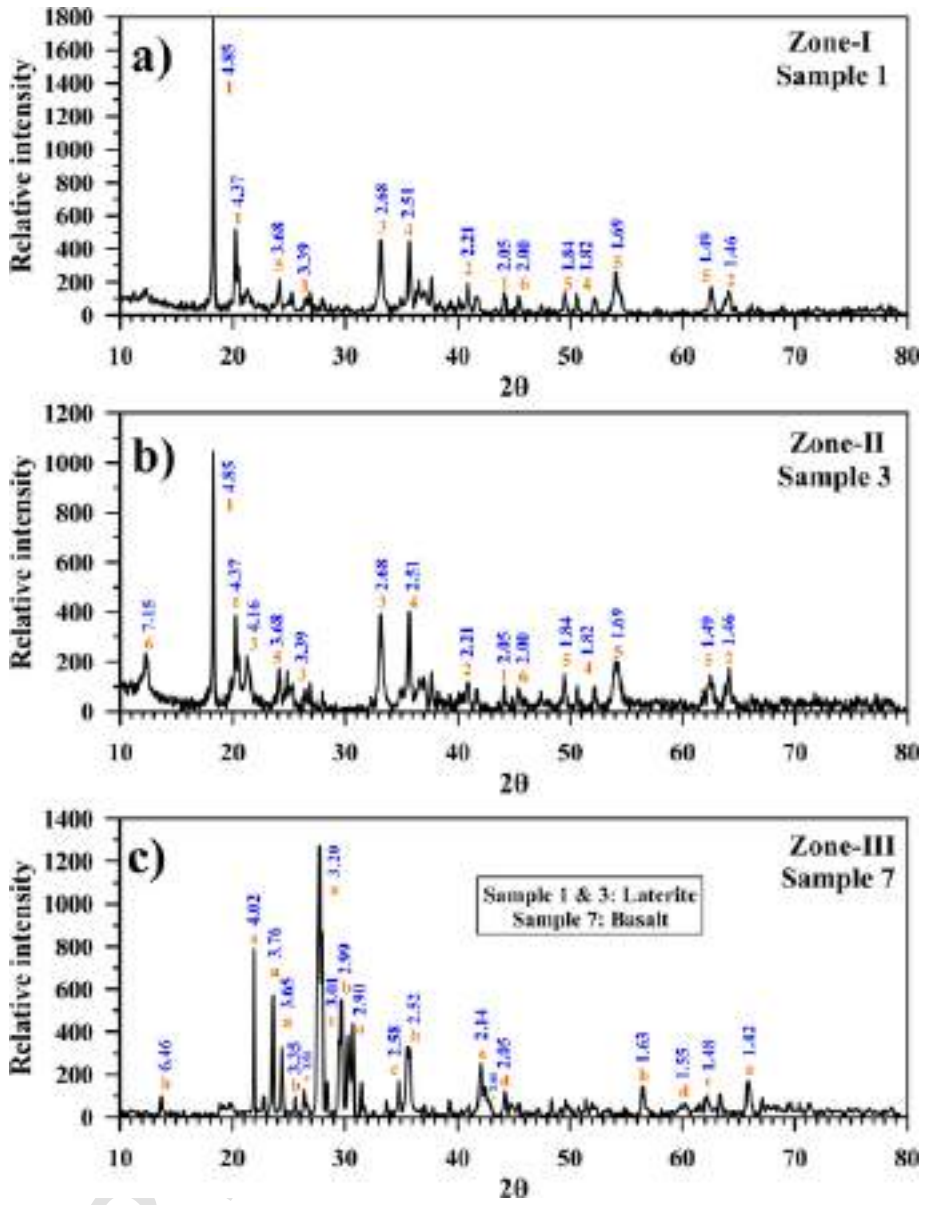

Fig. 8. XRD diffraction patterns of samples representing all three zones. a) Sample 1 (Zone-I) b) Sample 3 (Zone-II) c) Sample 7 (Zone-III). The characteristic minerals identified are marked by numbers for laterite (sample 3) and small letters for basalt (sample 7). The d-values for the identified peaks are shown in blue coloured text. 1-Gibbsite, 2-Al-hematite, 3-Goethite, 4-Maghemite, 5-Hematite, 6-Kaolinite, a-Plagioclase, b-Pyroxene, c-Olivine, d-Quartz, e-Magnetite.

oxide/hydroxide complexes (limonitic – ferrihydrites) and the presence of goethites resulting in strong secondary magnetization. The AF (alternating field) demagnetization on the other hand yielded convincing intensity decay as well as vector migration paths. The progressive demagnetization was carried up to the fields of 150 mT and showed stable components of remanence (Fig. 9).

We found sudden increase in magnetization at 5 mT (Fig. 9e) due to the removal of antiparallel or high angle viscous component, increasing the intensity for the resultant component. This followed a steady decay even at higher fields depicting single stable component in the NE direction. Alternating fields up to 150 mT removed large, low stability components parallel/subparallel to the NRM directed towards NE with an inclination of ~ 10^0. For majority of the samples, we found a trend in intensity decay partitioned into 0–25 mT and 60–150 mT. All the secondary components were removed by 25 mT depicting the ferrimagnetic components, further, there is a 90% loss of intensity by 150 mT (Fig. 9e).

The equal-area projection for the demagnetization spectra for specimen 2.1 shows a well-clustered nature with stable declination (D) and inclination (I) values. It shows the D/I values of 10^0 and 46^0, respectively (Fig. 9a). Specimen 2.5 showed a sudden increase in intensity at the demagnetizing field of 5 mT, similar to the previous sample (Fig. 9f). Afterwards, there is complete decay or removal of remanent magnetization linearly from 5 to 25 mT. The equal-area projection shows good clustering of data with constant inclination and declination. Similar results were obtained for specimens 2.8 and 2.10. Specimens 3.1 and 3.5 showed a scattering of data in equal-area projection, although there is smooth decay in the fields of 0–25 mT and then 60–150 mT (not shown). These specimens show unimodal ChRM components without any secondary magnetization. Specimen 3.8 show stepwise decay of intensity of magnetization (Fig. 9g). Specimen 4.5 showed overlapping components with scattering in equal-area projection (Fig. 9d, 9 h).

Further, in order to test the stability of NRM, we have calculated the Koenisberger ratio (Q-ratio) (Koenigsberger, 1938) using the equation Q = NRM (A/m) / [χ (SI) × H (A/m)], where χ indicates the magnetic

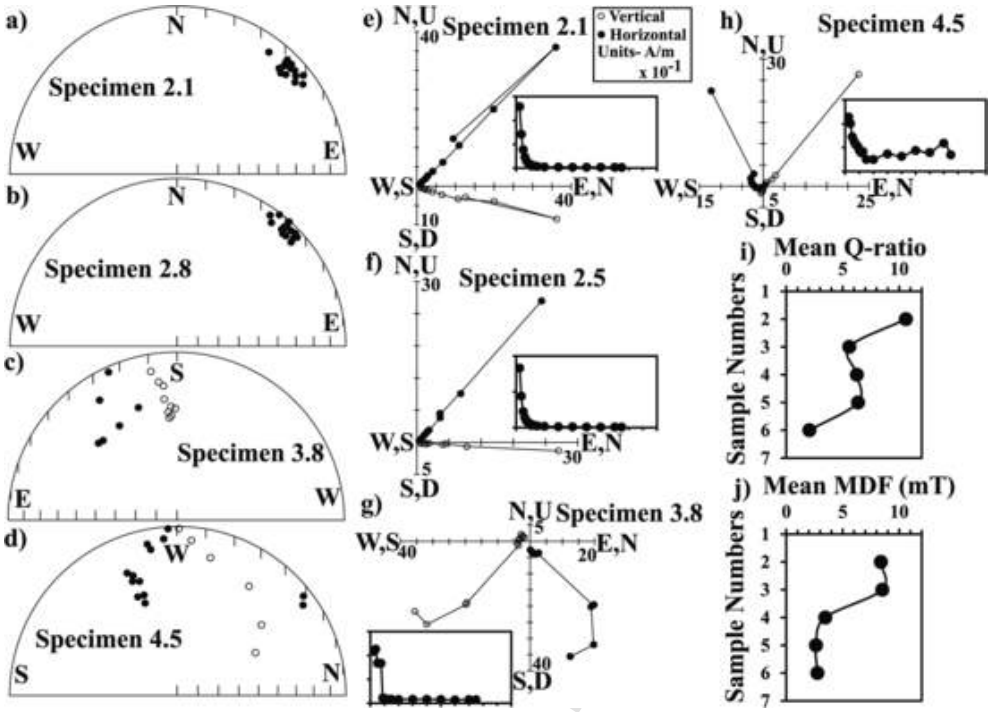

Fig. 9. The equal area projection of vector migration (a, d, c, d) and the Zijderveld diagrams (e, f, g, h; Zijderveld, 1967) for representative laterite specimens. The nature of magnetic intensity decay curve for respective specimens is shown in the inset graphs. Variation in the Koenisberger ratio (Q-ratio) (i) indicating an upward increase along with the profile. The graph between sample numbers and median destructive field of NRM indicates an upward increase in MDF along with the laterite profile (j).

susceptibility and H represents the local geomagnetic field (Table 4, Supplementary file). The Q-ratio for present samples was calculated taking local geomagnetic field value of 34.18 A/m referred from International Geomagnetic Reference Field (12th Generation) values. The values Q greater than 1 indicate remanent magnetization dominates over induced magnetization (Clark, 1997; Dunlop and Özdemir, 1997, pp. 238–239) and the contribution of remanence properties is major to the total magnetization of the rock. Fig. 9i shows an upward rise in the Q-ratio along the laterite profile suggesting that the rock possesses stable carriers that can hold stable remanence.

The median destructive field (MDF) of NRM is the magnetic field required to eliminate half the remanent saturation magnetization (Dankers, 1981; Brachfeld and Banerjee, 2000). This parameter measures remanence stability by targeting the carriers of natural and induced remanences (Brachfeld and Banerjee, 2000). It is calculated by AF demagnetizing the sample through steps until we get the one-half value of the original NRM (Table 5, Supplementary file). MDF of studied samples increases upward in profile suggesting more stable remanence carriers (Fig. 9j). Generally, lower values of MDF of NRM suggest magnetite-titanomagnetite mineral phases while higher values suggest hematite-goethite minerals phases (Dankers, 1981).

The primary remanent magnetization (ChRM) in the studied samples was thus obtained after removal of the viscous components (at less than 5 mT), while the secondary remanence due to ferrimagnetic components are removed by 25 mT (Fig. 9). This indicates that the stable CRM in laterites is attributed to a sufficiently long duration of the process of lateritization surpassing the time of lock-in remanence. The amorphous AFMs appear to have little or no influence in disturbing or overprinting the NRM and can be demagnetized at low field values of 5 mT. The study, therefore, indicated: a) suitability of laterites to acquire stable NRMs and b) Crystalline hematite as benchmark mineral to record the NRM within the complex process of lateritization.

5. Basaltic weathering and natural remanent magnetization

Basalts are some of the most susceptible substrates to chemical weathering under a large spectrum of Eh-pH and temperature conditions. The basaltic weathering is an effective process of CO_2 sequestration (Gislason and Oelkers, 2014), while it is considered a possible analogy to the Martian weathering conditions (Greenberger et al., 2012) due to the existence of both basalt and hematite over the planet. Another very important aspect of the basalts and their weathering products is its enrichment with ferrimagnetic minerals which can have unique pathways of conversions to maghemite and hematite. Lateritization permits sufficient reaction time and porosity for fluid migrations to convert these ferrimagnetic sources into antiferromagnetic, apart from the conversion of several other Fe oxides bearing silicates to such end product. Geologically laterites contribute to significant information on the paleogeographic status of a continent. The longitudinally drifting continent like India further preserve an important record of paleolatitudes to be determined from palaeomagnetic and magnetostratigraphic approaches.

Our studies have broadly inferred the total transformation of the parent basalts into antiferromagnetic during lateritization; and ferrimagnetism if any present is because of the lateral/surficial inputs during the process of lateritization. The abundance of feldspars in these basalts is also a possible reason for the early advancement of lateritization. The feldspar weathering has created labile elements besides their larger grain size providing effective porosity for the migration of solution. Early weathering of feldspar is also the source of ionic Al- to be readily available for substitution with ferrihydrites and hence hematites and goethite. The abundance of solution due to precipitatious and humid conditions near the coast further accelerated the formation of limonites and goethite; which later permitted the formation of amorphous hematites by release of hydroxyl ions. Further maturity formed the crystalline hematites as the stable and advanced stage of lateritization reached. Once formed, the crystalline hematite (hc) remained stable preserving the NRMs. The process of formation of crystalline

hematites (hc) from the amorphous hematites (ha) strengthened the CRM with sufficient time for lock-in, although a possibility of superimposition of CRMs cannot be ruled out. Our palaeomagnetic results could not trace such superimposition and almost a unimodal *hc* component was detected in these samples. However, a strong secondary component is observed due to ferrimagnetism (removed at 25 mT) which was accommodated as surficial input as discussed above.

This type of remanence acquired during the conversion of one mineral phase to another predominantly lead to growth-CRM (Haigh, 1958; Stokking and Tauxe, 1990) and can be strongly represented by primary remanence in palaeomagnetic studies (Walker et al., 1981). Hematites can be crystallized through various pathways, directly from the hydrolysis of ferric iron salts (Schwertmann and Cornell, 2000, pp. 121-134) or indirectly via the ferrihydrite → hematite reaction (Schwertmann and Cornell, 2000, pp. 121-134), later being common during the initial process of lateritization anticipating the strong CRM.

The CRM is acquired below their Curie/Neel points during the conversion of one mineral phase to another (Dekkers and Linssen, 1989; Jiang et al., 2015). CRM can be simple crystal growth (growth-CRM) or the alteration of parent magnetic minerals (alteration-CRM) (Haigh, 1958; Stokking and Tauxe, 1990). In laterites, there are several possibilities for the unstable/transitional nature of the components. Such components can arise from; i) partial transformations of detrital magnetite to maghemite, ii) partial transformation of amorphous to crystalline hematites, iii) re-lateritization of the re-deposited or precipitated laterites, iv) post formation deformation within laterite zones imparting porosity, or v) groundwater-related activity in the porous laterite. The crystalline hematites are developed only during matured stage of lateritization, and they tend to remain stably prevented from the secondary magnetization, although the deformation may cause physical scattering of directions. Alternatively, the CRM in these laterites arises from crystallization remanent magnetization (sensu stricto). Our study depicted the middle zone to be more mature and abundant with SD hematites, whereas the upper zone is influenced by surficial ferruginous/lateritic inputs. The CRMs therefore can be used reliably for the magnetostratigraphic approach in the Deccan laterites, when the surficial inputs, deformation, and other disturbances are restricted. The present approach of palaeomagnetism combined with mineral magnetism can be developed to understand the otherwise complex nature of timing in the lateritic processes. Determination of the timing of degree of lateritization at various stages is therefore helpful in studying various applications including CO_2 sequestration and Martian weathering analogy.

6. Conclusions

The Deccan Laterites represent peak basaltic weathering conditions by complete ferri- to antiferromagnetic transformations and further mobilizations within antiferromagnetic oxides. The combination of rock magnetism, XRD spectroscopy, palaeomagnetism, and XRF analysis provide an ideal approach to characterize the mineralogical influence over natural remanence. This integrated study inferred a set of minerals depicting partial to complete maghemitization, total hematization, goethite formation, ferrihydrite complexes, and their Al-substituted varieties in addition to gibbsite and kaolinite. The abundance of amorphous- (ha) and crystalline hematite (hc) varieties interests the palaeomagnetic studies to investigate the nature of NRMs, while the ferrimagnets are represented as secondary components. A range of domain sizes occurs with mixtures of SP + SD and SP + SD + MD, and SD remains common to most of the profile. The secondary/viscous NRM due to *ha* is removed at 5 mT and the secondary component due to ferrimagnets (magnetite or maghemites) removed at 25 mT. The *hc* component continues to decay linearly up to 150 mT depicting unicomponent behaviour after 25 mT. The palaeomagnetic tests (Koenisberger ratio, MDF, intensity decay, and Zijderveld diagrams) indicated stable directions (ChRMs) due to *hc*; and the Al-substitution does not affect the stability of ChRM. The lock-in CRM from *hc* also benchmarks the maturity of the profile in terms of mineralogical advancement during lateritization. These laterites are thus ideal for palaeomagnetic studies and intricacies and scattered directions may arise from other secondary processes during lateritization such as internal deformation and solution/precipitation activities through secondary porosity. The ferrimagnetic abundance in basaltic laterites permits a large amount of crystalline hematite which once formed remain stable favouring reliable ChRM directions due to CRM.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgments

We greatly acknowledge the anonymous referees and the handling editors for many critical comments and suggestions that improved the previous version of this manuscript. Several limitations and uncertainties in the XRD results were identified by anonymous referee, is acknowledged. We acknowledge Head, Department of Geology, Savitribai Phule Pune University for encouragement and support; Ministry of Earth Science grant MoES/P.O. (Seismo)/1(353)/2018-2019 funding for analysis. Director, CSIR-National Geophysical Research Institute (Hyderabad) and Director, CSIR-National Institute of Oceanography (Goa) are acknowledged for encouragements, support and permissions during analyses.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.catena.2023.107154.

References

Babechuk, M., Widdowson, M., Kamber, B., 2014. Quantifying chemical weathering intensity and trace element release from two contrasting basalt profiles, Deccan Traps, India. Chem. Geol. 363, 56–75. https://doi.org/10.1016/j.chemgeo.2013.10.027.

Babechuk, M., Widdowson, M., Murphy, M., Kamber, B., 2015. A combined Y/Ho, high field strength element (HFSE) and Nd isotope perspective on basalt weathering, Deccan Traps, India. Chem. Geol. 396, 25–41. https://doi.org/10.1016/j.chemgeo.2014.12.017.

Bardossy, G., 1981. Paleoenvironments of laterites and lateritic bauxites – effect of global tectonism on bauxite formation. In: International Seminar on Lateritization Processes (Trivandrum, India). Balkema, Rotterdam, pp. 284–297.

Borger, H., Widdowson, M., 2001. Indian laterites, and lateritous residues of southern Germany: a petrographic, mineralogical, and geochemical comparison. Zeit. Für Geomorph. N.F. 45, 177–200. https://doi.org/10.1127/zfg/45/2001/177.

Bourman, R., Ollier, C., 2002. A critique of the Schellmann definition and classification of 'laterite'. Catena 47 (2), 117–131. https://doi.org/10.1016/S0341-8162(01)00178-3.

Brachfeld, S.A., Banerjee, S.K., 2000. A new high-resolution geomagnetic relative paleointensity record for the North American Holocene: A comparison of sedimentary and absolute intensity data. J. Geophys. Res. Solid Earth 105 (B1), 821–834. https://doi.org/10.1029/1999JB900365.

Buchanan, F., 1807. A Journey from Madras through the Countries of Mysore, Kanara, and Malabar 2 & 3. East India Company, London.

Caner, L., Petit, S., Joussein, E., Fritsch, E., Herbillon, A., 2011. Accumulation of organo-metallic complexes in laterites and the formation of Aluandic Andosols in the Nilgiri Hills (southern India): similarities and differences with Umbric Podzols. Europ. J. Soil. Sci. 62 (5), 754–764. https://doi.org/10.1111/j.1365-2389.2011.01389.x.

Clark, D.A., 1997. Magnetic petrophysics and magnetic petrography: aids to geological interpretation of magnetic surveys. AGSO J. Aust. Geol. Geophys. 17, 83–103.

Cornell, R.M., Schwertmann, U., 2003. The iron oxides: structure, properties, reactions, occurrence and uses. Wiley-VCH Verlag GmbH & Co, KGaA, Weinheim.

Courtillot, V., Feraud, G., Maluski, H., Vandamme, D., Moreau, M.G., Besse, J., 1988.

Deccan flood basalts and the Cretaceous Tertiary boundary. Nature 333, 843–846. https://doi.org/10.1038/333843a0.
Dankers, P., 1981. Relationship between median destructive field and remanent coercive forces for dispersed natural magnetite, titanomagnetite and hematite. Geophys. J. Royal Astron. Soc. 64, 447–461. https://doi.org/10.1111/j.1365-246X.1981.tb02676.x.
Day, R., Fuller, M., Schmidt, V.A., 1977. Hysteresis properties of titanomagnetites: Grain size and composition dependence. Phys. Earth Plan. Int. 13, 260–267. https://doi.org/10.1016/0031-9201(77)90108-X.
Dekkers, M.J., 1988. Magnetic behaviour of natural goethite during thermal demagnetization. Geophys. Res. Lett. 15 (5), 538–541. https://doi.org/10.1029/GL015i005p00538.
Dekkers, M.J., 1990. Magnetic properties of natural goethite-III. Magnetic behaviour and properties of minerals originating from goethite dehydration during thermal demagnetization. Geophys. J. Int. 103, 233–250. https://doi.org/10.1111/j.1365-246X.1990.tb01765.x.
Dekkers, M.J., Linssen, J.H., 1989. Rock magnetic properties of fine- grained natural low temperature haematite with reference to remanence acquisition mechanisms in red beds. Geophys. J. Int. 99, 1–18. https://doi.org/10.1111/j.1365-246X.1989.tb02012.x.
Dekkers, M.J., Rochette, P., 1992. Magnetic properties of chemical magnetisation in synthetic and natural goethite: prospects for a natural remanent magnetisation/thermoremanent magnetisation ratio paleomagnetic stability test? J. Geophys. Res. Solid Earth 97, 17291–17307. https://doi.org/10.1029/92JB01026.
Dunlop, D.J., Özdemir, Ö., 1997. Rock Magnetism, Fundamentals and Frontiers. Cambridge University Press, Cambridge, U. K. https://doi.org/10.1017/CBO9780511612794.
Dunlop, D.J., 2002. Theory and application of the Day plot (Mrs/Ms versus Hcr/Hc), 1. Theoretical curves and tests using titanomagnetite data. J. Geophys. Res. Solid Earth 107 (B3), EPM 4-1-EPM 4-22. https://doi.org/10.1029/2001JB000486.
Duraiswami, R.A., Gadpallu, P., Shaikh, T.N., Cardin, N., 2014. Pahoehoe–a'a transitions in the lava flow fields of the western Deccan Traps, India-implications for emplacement dynamics, flood basalt architecture and volcanic stratigraphy. J. Asian Earth Sci. 84, 146-166. https://doi.org/10.1016/j.jseaes.2013.08.025.
Egli, R., Lowrie, W., 2002. Anhysteretic remanent magnetization of fine magnetic particles. J. Geophys. Res. Solid Earth 107 (B10), 2209. https://doi.org/10.1029/2001JB000671.
Evans, M.E., Heller, F., 2003. Environmental magnetism: principles and applications of enviromagnetics. Academic press, San Diego, California.
Fedo, C., Nesbitt, H., Young, G., 1995. Unraveling the effects of potassium metasomatism in sedimentary rocks and paleosols, with implications for paleoweathering conditions and provenance. Geology 23, 921–924. https://doi.org/10.1130/0091-7613(1995)023<0921:UTEOPM>2.3.CO;2.
France, D.E., Oldfield, F., 2000. Identifying goethite and hematite from rock magnetic measurements of soils and sediments. J. Geophys. Res. Solid Earth 105, 2781–2795. https://doi.org/10.1029/1999JB900304.
Ghosh, S., Guchhait, S.K., Hu, X., 2015. Characterization and evolution of primary and secondary laterites in northwestern Bengal Basin, West Bengal. India. J. Paleogeography 4 (2), 203–230. https://doi.org/10.3724/SP.J.1261.2015.00074.
Gislason, S.R., Oelkers, E.H., 2014. Carbon storage in basalt. Science. 344 (6182), 373–374. https://doi.org/10.1126/science.1250828.
Greenberger, R.N., Mustard, J.F., Kumar, P.S., Dyar, M.D., Breves, E.A., Sklute, E.C., 2012. Low temperature aqueous alteration of basalt: Mineral assemblages of Deccan basalts and implications for Mars. J. Geophys. Res. Planets. 117, E00J12. https://doi.org/10.1029/2012JE004127.
Gunnell, Y., 2003. Radiometric ages of laterites and constraints on long-term denudation rates in West Africa. Geology 31 (2), 131. https://doi.org/10.1130/0091-7613(2003)031<0131:RAOLAC>2.0.CO;2.
Haigh, G., 1958. The process of magnetization by chemical change. Phil. Mag. 3, 267–286. https://doi.org/10.1080/14786435808238219.
Heslop, D., 2009. On the statistical analysis of the rock magnetic S-ratio. Geophys. J. Int. 178 (1), 159–161. https://doi.org/10.1111/j.1365-246X.2009.04175.x.
Heslop, D., Dekkers, M.J., Kruiver, P.P., Van Oorschot, I.H.M., 2002. Analysis of isothermal remanent magnetisation acquisition curves using the expectation-maximisation algorithm. Geophys. J. Int. 148, 58–64. https://doi.org/10.1046/j.0956-540x.2001.01558.x.
Hu, P., Jiang, Z., Liu, Q., Heslop, D., Roberts, A.P., Torrent, J., Barrón, V., 2016. Estimating the concentration of aluminum-substituted hematite and goethite using diffuse reflectance spectrometry and rock magnetism: Feasibility and limitations. J. Geophys. Res. Solid Earth. 121, 4180–4194. https://doi.org/10.1002/2015JB012635.
Hynek, B.M., Arvidson, R.E., Phillips, R.J., 2002. Geologic setting and origin of Terra Meridiani hematite deposit on Mars. J. Geophys. Res. Solid Earth 107 (E10), 5088. https://doi.org/10.1029/2002JE001891.
Jiang, Z., Liu, Q., Roberts, A.P., Dekkers, M.J., Barrón, V., Torrent, J., Li, S., 2022. The magnetic and color reflectance properties of hematite: From Earth to Mars. Reviews of Geophysics 60 (1), e2020RG000698. https://doi.org/10.1029/2020RG000698.
Jiang, Z., Liu, Q., Zhao, X., Jin, C., Liu, C., Li, S., 2015. Thermal magnetic behaviour of Al-substituted haematite mixed with clay minerals and its geological significance. Geophys. J. Int. 200, 130–143. https://doi.org/10.1093/gji/ggu377.
King, J., Channell, J.E., 1991. Sedimentary magnetism, environmental magnetism, and magnetostratigraphy. Rev. Geophy. 29, 358–370. https://doi.org/10.1002/rog.1991.29.s1.358.
Kısakürek, B., Widdowson, M., James, R., 2004. Behaviour of Li isotopes during continental weathering: The Bidar laterite profile. India. Chem. Geol. 212, 27–44. https://doi.org/10.1016/j.chemgeo.2004.08.027.
Kletetschka, G., Wasilewski, P.J., 2002. Grain size limit for SD hematite. Phys. Earth Planet. Int. 129 (1–2), 173–179. https://doi.org/10.1016/S0031-9201(01)00271-0.
Klootwijk, C.T., Pierce, J.W., 1979. India's and Australia's pole path since the late Mesozoic and the India-Asia collision. Nature 282, 605–607. https://doi.org/10.1038/282605a0.
Koenigsberger, J.G., 1938. Natural residual magnetism of eruptive rocks. Terr. Magn. Atmos. Electr. 43 (3), 299–320. https://doi.org/10.1029/TE043i003p00299.
Kruiver, P.P., Dekkers, M.J., Heslop, D., 2001. Quantification of magnetic coercivity components by the analysis of acquisition curves of isothermal remanent magnetization. Earth Planet. Sci. Lett. 189, 269–276. https://doi.org/10.1016/S0012-821X(01)00367-3.
LaBrecque, J.J., Schorin, H., 1987. Some statistical parameters for selected trace elements in VL-1. Z. Geomorphol. N.F. 64, 33–38.
Lewis, D. G., Schwertmann, U., 1979. The influence of aluminum on the formation of iron oxides. IV. The influence of [Al],[OH], and temperature. Clays and Clay Minerals 27, 195–200. https://doi.org/10.1346/CCMN.1979.0270304.
Liu, Q.S., Deng, C.L., Yu, Y.J., Torrent, J., Jackson, M.J., Banerjee, S.K., Zhu, R.X., 2005. Temperature dependence of magnetic susceptibility in an argon environment: Implications for pedogenesis of Chinese loess/palaeosols. Geophys. J. Int. 161, 102–112. https://doi.org/10.1111/j.1365-246X.2005.02564.x.
Liu, Q., Jackson, M.J., Banerjee, S.K., Maher, B.A., Deng, C., Pan, Y., Zhu, R., 2004. Mechanism of the magnetic susceptibility enhancements of the Chinese loess. J. Geophys. Res. Solid Earth 109, B12107. https://doi.org/10.1029/2004JB003249.
Liu, X., Mao, X., Yuan, Y., Ma, M., 2019. Aeolian accumulation: An alternative origin of laterite on the Deccan Plateu, India. Paleogeogr., Paleoclim. Paleoeco. 518, 34–44. https://doi.org/10.1016/j.palaeo.2019.01.003.
Liu, Q., Roberts, A.P., Torrent, J., Horng, C.S., Larrasoana, J.C., 2007. What do the HIRM and S-ratio really measure in environmental magnetism? Geochem. Geophys. Geosyst. 8, Q09011. https://doi.org/10.1029/2007GC001717.
Liu, Q., Roberts, A.P., Larrasoaña, J.C., Banerjee, S.K., Guyodo, Y., Tauxe, L., Oldfield, F., 2012. Environmental magnetism: Principles and applications. Rev. Geophys. 50, RG4002. https://doi.org/10.1029/2012RG000393.
Maher, B.A., 1988. Magnetic properties of some synthetic submicron magnetites. Geophys. J. Int. 94, 83–96. https://doi.org/10.1111/j.1365-246X.1988.tb03429.x.
Maher, B.A., Thompson, R., 1999. Quaternary climates, environments and magnetism. Cambridge University Press, New York.
Maxbauer, D.P., Feinberg, J.M., Fox, D.L., 2016. MAX UnMix: A web application for unmixing magnetic coercivity distributions. Comp. Geosc. 95, 140–145. https://doi.org/10.1016/j.cageo.2016.07.009.
Meshram, R., Randive, K., 2011. Geochemical study of laterites of the Jamnagar district, Gujarat, India: Implications on parent rock, mineralogy and tectonics. J. Asian Earth Sci. 42, 1271–1287. https://doi.org/10.1016/j.jseaes.2011.07.014.
Nesbitt, H.W., Wilson, R.E., 1992. Recent chemical weathering of basalts. Am. J. Sci. 292, 740–777. https://doi.org/10.2475/ajs.292.10.740.
Nesbitt, H.W., Young, G.M., 1984. Prediction of some weathering trends of plutonic and volcanic rocks based on thermodynamic and kinetic considerations. Geoch. Cosmoch. Act. 48 (7), 1523–1534. https://doi.org/10.1016/0016-7037(84)90408-3.
Ollier, C.D., Sheth, H., 2008. The High Deccan duricrusts of India and their significance for the 'laterite' issue. J. Earth Syst. Sci. 117 (5), 537–551. https://doi.org/10.1007/s12040-008-0051-9.
O'Reilly, W., 1984. Rock and Mineral Magnetism. Chapman and Hall, New York.
Peters, C., Dekkers, M.J., 2003. Selected room temperature magnetic parameters as a function of mineralogy, concentration and grain size. Phys. Chem. Earth, Parts A/B/C 28 (16–19), 659–667. https://doi.org/10.1016/S1474-7065(03)00120-7.
Roberts, A.P., Liu, Q., Rowan, C.J., Chang, L., Carvallo, C., Torrent, J., Horng, C.S., 2006. Characterization of hematite (a-Fe2O3), goethite (a-FeOOH), greigite (Fe3S4), and pyrrhotite (Fe7S8) using first-order reversal curve diagrams. J. Geophys. Res. Solid Earth 111, B12S35. https://doi.org/10.1029/2006JB004715.
Roberts, A.P., Zhao, X., Heslop, D., Abrajevitch, A., Chen, Y.H., Hu, P., Jiang, Z., Liu, Q., Pillans, B.J., 2020. Hematite (α-Fe2O3) quantification in sedimentary magnetism: limitations of existing proxies and ways forward. Geosci. Lett. 7 (1), 1–11. https://doi.org/10.1186/s40562-020-00157-5.
Robinson, S.G., 1986. The Late Pleistocene palaeoclimatic record of North Atlantic deep-sea sediments revealed by mineral magnetic measurements. Phys. Earth Planet. Inter. 42, 22–47. https://doi.org/10.1016/S0031-9201(86)80006-1.
Rochette, P., Mathe, P.E., Esteban, L., Rakoto, H., Bouchez, J.L., Liu, Q.S., Torrent, J., 2005. Non-saturation of the defect moment of goethite and fine-grained hematite up to 57 Teslas. Geophys. Res. Lett. 32, L22309. https://doi.org/10.1029/2005GL024196.
Sangode, S.J., Bloemendal, J., 2004. Pedogenic transformation of magnetic minerals in Pliocene-Pleistocene palaeosols of the Siwalik Group, NW Himalaya, India. Palaeogeogr., Palaeoclim., Palaeoeco. 212 (1–2), 95–118. https://doi.org/10.1016/j.palaeo.2004.05.019.
Schellmann, W., 1986. A new definition of laterite. In: Banerji, P.K. (Eds.), Lateritisation processes, Memoir of Geological Survey of India, pp. 1-7.
Schmidt, P.W., Prasad, V., Raman, P.K., 1983. Magnetic ages of some Indian laterites. Paleogeogr., Paleoclim Paleoeco. 44, 185–202. https://doi.org/10.1016/0031-0182(83)90102-5.
Schuiling, R.D., Krijgsman, P., 2006. Enhanced weathering: an effective and cheap tool to sequester CO_2. Clim. Chang. 74, 349–354. https://doi.org/10.1007/s10584-005-3485-y.
Schwertmann, U., Cornell, R.M., 2000. Iron oxides in the laboratory. Wiley-VCH Verlag GmbH, Weinheim. https://doi.org/10.1002/9783527613229.
Seifritz, W., 1990. CO_2 disposal by means of silicates. Nature 345, 486. https://doi.org/10.1038/345486b0.
Singh, J., Sangode, S.J., Bagwan, M.F., Meshram, D.C., Dhobale, A., 2020. Episodic

ferricretization of the Deccan laterites (India): Inferences from ore microscopy, mineral magnetic and XRD spectroscopic studies. J. Earth Syst. Sci. 129, 76. https://doi.org/10.1007/s12040-019-1334-z.
Stokking, L.B., Tauxe, L., 1990. Properties of chemical remanence in synthetic hematite: Testing theoretical predictions. J. Geophys. Res. Solid Earth 95 (B8), 12639–12652. https://doi.org/10.1029/JB095iB08p12639.
Suhr, N., Schoenberg, R., Chew, D., Rosca, C., Widdowson, M., Kamber, B., 2018. Elemental and isotopic behaviour of Zn in Deccan basalt weathering profiles: Chemical weathering from bedrock to laterite and links to Zn deficiency in tropical soils. Sci. Total Environ. 619–620, 1451–1463. https://doi.org/10.1016/j.scitotenv.2017.11.112.
Tauxe, L., 2002. Paleomagnetic principles and practice. Kluwer academic press, London. https://doi.org/10.1007/0-306-48128-6.
Tauxe, L., Mullender, T.A.T., Pick, T., 1996. Potbellies, wasp-waists, and superparamagnetism in magnetic hysteresis. J. Geophys. Res. Solid Earth 101 (B1), 571–583. https://doi.org/10.1029/95JB03041.
Thomas, M., Clarke, J.D.A., Pain, C.F., 2005. Weathering, erosion and landscape processes on Mars identified from recent rover imagery, and possible Earth analogues. Austr. J. Earth Sci. 52 (3), 365–378. https://doi.org/10.1080/08120090500134597.
Thompson, R., Oldfield, F., 1986. Environmental magnetism. Allen and Unwin Press, London. https://doi.org/10.1007/978-94-011-8036-8.
Torrent, J., Barrón, V., Liu, Q., 2006. Magnetic enhancement is linked to and precedes hematite formation in aerobic soil. Geophys. Res. Lett. 33, L02401. https://doi.org/10.1029/2005GL024818.
Walker, T.R., Larson, E.E., Hoblitt, R.P., 1981. Nature and origin of hematite in the Moenkopi Formation (Triassic), Colorado Plateau: A contribution to the origin of magnetism in red beds. J. Geophys. Res. Solid Earth Solid. Earth 86 (B1), 317–333. https://doi.org/10.1029/JB086iB01p00317.
Widdowson, M., 2007. Laterite and ferricrete. In: Nash, D.J., McLaren, S.J. (Eds.), Geochemical Sediments and Landscapes. Wiley-Blackwell, Oxford, UK, pp. 46–94.
Widdowson, M., Gunnell, Y., 1999. Lateritization, geomorphology and geodynamics of a passive continental margin: the Konkan and Kanara coastal lowlands of western Peninsula India. In: Thiry, M., Simon-Coinçon, R. (Eds.), Palaeoweathering, Palaeosurfaces and Related Continental Deposits, International Association of Sedimentologists, Oxford, Blackwell, pp. 245-274.
Widdowson, M., Cox, K.G., 1996. Uplift and erosional history of the Deccan Traps, India: Evidence from laterites and drainage patterns of the Western Ghats and Konkan Coast. Earth Planet. Sci. Lett. 137, 57–69. https://doi.org/10.1016/0012-821X(95)00211-T.
Wimpenny, J.B., Gannoun, A., Burton, K.W., Widdowson, M., James, R.H., Gislason, S., 2007. Rhenium and osmium isotope and elemental behaviour accompanying laterite formation in the Deccan region of India. Earth Planet. Sci. Lett. 261 (1–2), 239–258. https://doi.org/10.1016/j.epsl.2007.06.028.
Zhang, C., Liu, Q., Huang, B., Su, Y., 2010. Magnetic enhancement upon heating of environmentally polluted samples containing haematite and iron. Geophys. J. Int. 181 (3), 1381–1394. https://doi.org/10.1111/j.1365-246X.2010.04590.x.
Zhou, X., Liu, D., Bu, H., Deng, L., Liu, H., Yuan, P., Du, P., Song, H., 2018. XRD-based quantitative analysis of clay minerals using reference intensity ratios, mineral intensity factors, Rietveld, and full pattern summation methods: A critical review. Solid Earth Sci. 3 (1), 16–29. https://doi.org/10.1016/j.sesci.2017.12.002.
Zijderveld, J., 1967. AC Demagnetization of rocks: Analysis of results. In: Collinson, D., Creer, K., Runcorn, S. (Eds.), Methods in Paleomagnetism. Elsevier, New York, pp. 254–286.

International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 14-04-2023, Accepted: 30-04-2023, Published: 15-05-2023
Volume 8, Issue 5, 2023, Page No. 27-30

Studies on cholesterol level in wild caught females of the Embollonurid Bat, *Taphozous kachhensis* (Dobson) in relation with reproductive cycle

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Abstract
Bats play a key role as pollinators and significantly contribute in controlling insects but very scanty information is available on their basic physiology. The aim of the present investigation was to estimate the significant differences in level of cholesterol in female *Taphozous kachhensis* during various stages of the reproductive cycle. Estimation of cholesterol level was done for twelve months representing all stages of the reproductive cycle. During lactation, quiescence, recrudescence and oestrous mean cholesterol level was found to be 149 ± 2.55 mg/dL, 154 ± 2.76 mg/dL, 155 ± 3.21 mg/dL and 158 ± 3.13 mg/dL respectively. During early pregnancy and mid pregnancy mean cholesterol level was found to be 164.91 ± 1.27 mg/dL and 161.08 ± 3.02 mg/dL respectively. Significant decrease in mean cholesterol level was noted during advanced pregnancy when compared with early and mid pregnancy. Mean cholesterol level was observed in the range of 137-173 mg/dL during the entire reproductive cycle in females. Present investigation revealed the significant differences in the level of cholesterol during the reproductive cycle and thus providing the information regarding basal physiological measurement of bats.

Keywords: bat, *Taphozous kachhensis*, chiroptera, cholesterol

Introduction
Order chiroptera is the second most diverse, abundant group of mammals, which is represented by more than 1421 species grouped in 21 families (Simmons and Cirranello, 2020) [12]. Study of the ecological and physiological characteristics of bats as representative of the numerous and thriving order chiroptera is important. The relatively high life expectancy of some species of bats is of great interest. Information of many unknown aspects of the basic biology and physiology of bats is scanty. Bats are of immense importance to human beings for medical research and public health. However baseline values of hematological profiles of many of the species of the bats are not studied. Physiological changes during the reproductive cycle of the bats is related with the changes in the hematological profile of these bats. The present study revealed useful information on basal values of cholesterol level during various stages of the reproductive cycle for research and conservation of this species.

Material and methods
The present study was conducted on females of the Embollonurid bat, *Taphozous kachhensis*. Identification of the animal was done using standard monograph (Bates and Harrison, 1997) [1]. A mist net of the mesh size (10mm) was used to capture the bats. These were collected from from Ambai Nimbi, 45 kilometers from Bramhapuri (M.S.). After capturing the bats, female bats were separated and were brought to the laboratory. These were weighed on the electronic weighing balance and anesthetized with ether. Blood samples were collected from subclavian and pectoral veins without hurting the animal. Blood samples were collected and was centrifuged to separate the serum. After recovery from the anesthesia, all specimens were released in their natural habitat. Auto analyser was used for quantitative estimation of the serum cholesterol.

CHOD/PAP method was used for the estimation of serum cholesterol. Cholesterol esterase hydrolyses esterified cholesterol to free cholesterol. Hydrogen peroxide is formed from free cholesterol due to oxidation which then reacts in the presence of peroxidase enzyme with 4-aminoantipyrine and phenol which result in quinoneimine red dye complex. The intensity of the dye is directly proportional to the concentration of cholesterol present in the serum.

$$\text{Cholesterol esters} + H_2O \xrightarrow{\text{Cholesterol Esterase}} \text{Cholesterol} + \text{Fatty acids}$$

$$\text{Cholesterol} + O_2 \xrightarrow{\text{Cholesterol Oxidase}} \text{Cholestenone} + H_2O_2$$

$$H_2O_2 + 4\ \text{Aminoantipyrine} + \text{Phenol} \xrightarrow{\text{Peroxidase}} \text{Red Quinoneimine dye} + H_2O$$

This kit has
Cholesterol reagent (L1) and Cholesterol standard 200 mg/dL (S)

Protocol for test
Sample: (0.01ml serum + Cholesterol reagent (L1) 1.0 ml

Standard: (0.01ml standard + Cholesterol reagent (L1) 1.0 ml

Blank: (0.01ml Distilled water + Cholesterol reagent (L1) 1.0 ml
Mix well and incubate the solution at 37 °C for 5 min. or at room temperature for 15 minutes. Measure the absorbance of the Standard and test sample against the blank within 60 min at 505 nm.

Calculations
Cholesterol in mg/dL = Absorbance of test / Absorbance of Sample X 200

Statistical analysis

Raw data was analyzed to give mean, standard error and significance using Statistical Package for Social Sciences (SPSS 10.0). All graphs in this study were drawn using Microsoft Excel Software.

Results

Mean cholesterol level observed during different stages of reproductive cycle in female *Taphozous kachhensis* and the P-value corresponding to F-statistic value of one way ANOVA (P = 0.0007) is presented in table 1 and 2 respectively. Histograph showing cholesterol level in female *Taphozous kachhensis* during reproductive cycle is presented in figure 1.

Table 1: One-way ANOVA with post- hoc Tukey HSD showing comparison of cholesterol (mg/dL) in female *Taphozous kachhensis* during reproductive cycle.

Reproductive status	No. of Bats	Cholesterol Range in (mg/dL)	Mean ± S.E	Variance	Standard Deviation
Lactation	18	137 – 170	149.00 ± 2.55[a]	117.52	10.84
Quiescence	12	140 – 170	154.00 ± 2.76[a]	91.63	9.57
Recrudescent	06	145 – 165	155.00 ± 3.21[a]	62.00	7.87
Oestrous	06	148 – 168	158.00 ± 3.13[a]	58.80	7.66
Early Pregnancy	12	158 – 170	164.91 ± 1.27[ab]	19.53	4.42
Mid Pregnancy	12	145 – 173	161.08 ± 3.02[ab]	109.53	10.46
Advanced Pregnancy	06	145 – 165	155.00 ± 3.02[a]	54.80	7.40
Pooled Total	72		156.25 ± 1.21	106.04	10.29

Table 2: One-way ANOVA of seven independent groups showing P-value corresponding to F- statistic.

Source	sum of squares SS	degrees of freedom	mean square MS	F statistic	p-value
Treatment	2,225.6667	6	370.9444	4.5460	0.0007
Error	5,303.8333	65	81.5974		
Total	7,529.5000	71			

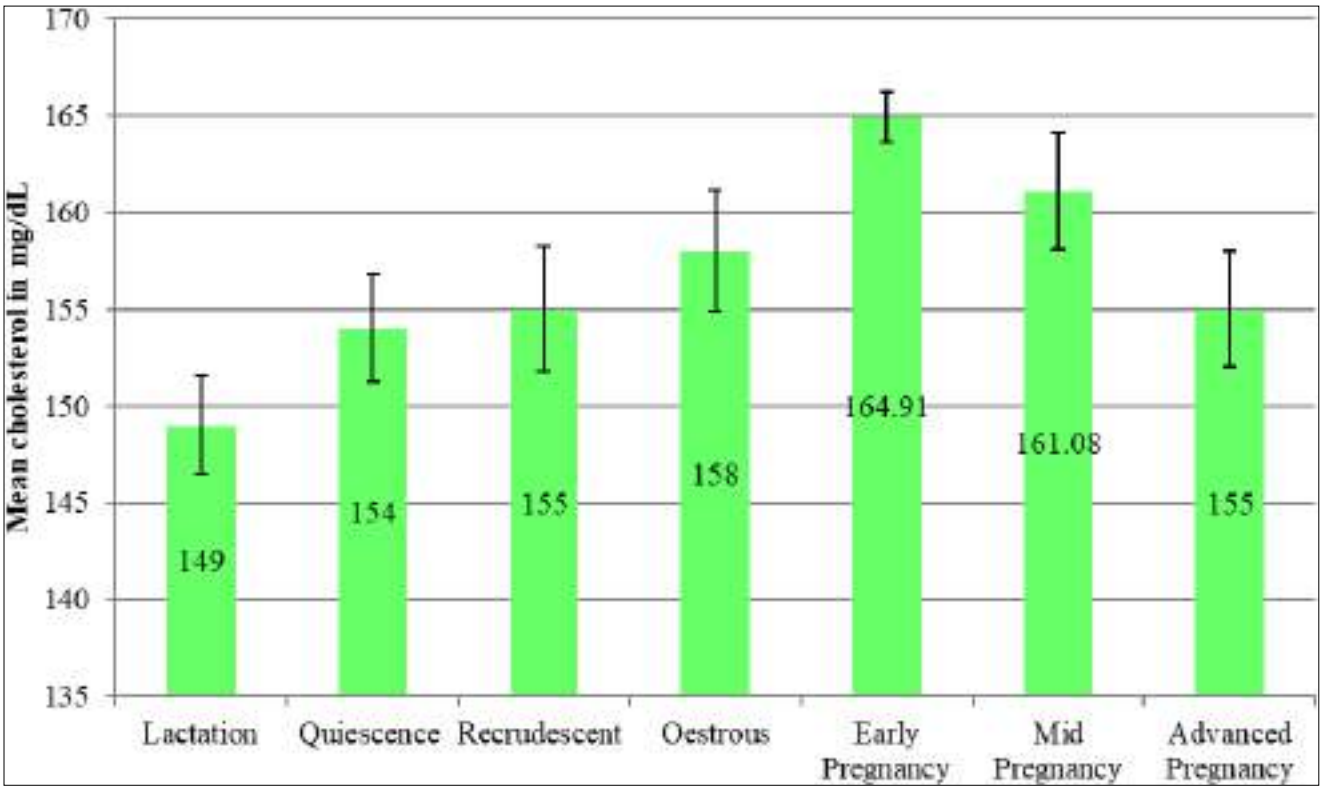

Fig 1: Mean cholesterol in female *Taphozous kachhensis* during reproductive cycle

During lactation, quiescence, recrudescence and oestrous mean cholesterol level was found to be 149 ± 2.55 mg/dL, 154 ± 2.76 mg/dL, 155 ± 3.21 mg/dL and 158 ± 3.13 mg/dL respectively. No significant differences were observed in mean cholesterol level during lactation, quiescence, recrudescence and oestrous stages. Significant increase in mean cholesterol level was noted during early pregnancy and mid pregnancy. During early pregnancy and mid pregnancy mean cholesterol level was found to be 164.91 ± 1.27 mg/dL and 161.08 ± 3.02 mg/dL respectively. Significant decrease in mean cholesterol was observed during advanced pregnancy when compared with early pregnancy and mid pregnancy. Pooled total mean cholesterol level during all stages of reproductive cycle in females was found to be 156.25 ± 1.21 mg/dL. During the entire reproductive cycle in females, mean cholesterol level was observed in the range of 137 – 173 mg/dL.

Discussion

Cholesterol is a lipid which is widely distributed in various types of animal tissues. It is synthesized in the liver and is a normal component of bile and principal constituent of gallstones. Cholesterol acts as a precursor for the synthesis of various steroid hormones like adrenal corticoids and sex steroid in mammals. Total level of cholesterol is related to liver function. Increased level of cholesterol is generally found in pathological conditions like hypothyroidism, nephrosis, coronary artery disease, hyperlipoproteinemias, diabetes mellitus and many liver disorders. Low level of cholesterol occurs during malnutrition, acute infections, haemolytic jaundice, pernicious anemia and hyperthyroidism. In humans normal level of total cholesterol is between 152 to 240 mg/dL. Ageing is associated with an increase in serum total cholesterol. In the present investigation pooled mean total cholesterol in females of *Taphozous kachhensis* found to be 156.25 ± 1.21 mg/dL. In females of *Taphozous kachhensis* no significant variation in total cholesterol were observed during lactation, quiescence, recrudescence, oestrous and advanced pregnancy. Significant elevated level of total cholesterol was noted during early pregnancy and mid pregnancy is associated with higher anabolic activity of the liver for the synthesis of sex steroids like 17-β oestradiol and progesterone. Higher levels of these hormones are required for the maintenance of pregnancy. McMichael et al. (2015) [7] had noted the total cholesterol in wild black flying foxes, *Pteropus alecto* and reported significant differences in the level of cholesterol in females at $P < 0.001$ level. They had noted the plasma total cholesterol females of *Pteropus alecto* was 17.40 mg/dL. Selig et al. (2016) [11] observed mean cholesterol level 23.5 mg/dL in straw colored fruit bats (*Eidolon helvum*). Low level of total cholesterol in pteropodid bats as compared to insectivorous bat are likely due to a low-protein diet, as cholesterol is obtained either by diet or by synthesis within liver (Widmaier et al., 1996; Heard and Whittier, 1997) [13, 4]. Moretti et al. (2021) [8] had observed very low value of triglycerides in healthy captive Egyptian fruit bat *Rousettus agyptiacus*. Esher et al. (1973) [3] had noted 87% decrease in liver cholesterol during torpid condition in *Myotis lucifugus*. Widmaier et al. (1996) [13 had noted the high fasting plasma cholesterol level (215 ± 8 mg/dL) in insectivorous Mexican free tailed bat, *Tadarida brasiliensis mexicana* during late pregnancy and lactation. They had correlated extra ordinary high levels of cholesterol with consumption of double the amount of insect diet which is high in fat.

Normal level of total cholesterol in captive *Pteropus hypomelanus* was 12 ± 4 mg/dL. Such low levels of total cholesterol was related to primary frugivorous habit associated with consumption of fruit (Widmaier et al., 1996; Heard and Whittier, 1997) [13, 4]

Heard and Whittier (1997) [4] had observed the plasma cholesterol level in *Pteropus vampyrus*, *Pteropus rodricensis* and *Pteropus hypomelanus* was 30 ± 14, 33 ± 40 and 17 ± 10 mg/dL respectively. They had observed the cholesterol level in *Pteropus rodricensis* was in the range of 2 to 152 mg/dL. McLaughlin et al. (2007) [6] has found cholesterol level 46.4 ± 0.7 mg/dL in wild caught flying fox, *Pteropus giganteus*. Highest range level cholesterol of *Pteropus rodricensis* shows similarity with our study. Sarmin et al. (2020) noted the cholesterol level in juvenile buckes of *Ettawa* crossbred goats in the range of 68-162 mg/dL. The high cholesterol level in this study was comparable to our finding.

Korine et al. (1999) [5] had observed the seasonal variations in the cholesterol level in fruit eating bat, *Rousettus aegyptiacus*. They have noted the total cholesterol level during winter, spring, summer and autumn were 1.00 ± 0.02, 1.00 ± 0.00, 9.17 ± 2.63 and 2.00 ± 1.41 mg/dL respectively and suggested cholesterol as a function of diet (Carroll and Kurowska, 1995; Widmaier et al., 1996; Heard and Whittier, 1997) [2, 13, 4].

Otis et al. (2011) [9] had studied the cholesterol and lipoprotein dynamics in hibernating squirrels and found similar concentrations of cholesterol during spring and summer. Cholesterol transported by lipoprotein particles in circulation. Excess cholesterol is excreted from the body in the form of bile acid by fecal excretion. They had observed a high level of cholesterol in plasma during hibernation was due to thirteen fold lower expression of cholesterol alpha-hydroxylase enzyme. Low concentration of cholesterol during winter is related to efficient use of lipoprotein in mammals essential for their survival.

References

1. Bates PJJ, Harrison DL. Bats of the Indian Subcontinent. Harrison Zoological Museum Publications, 1997, 258.
2. Carroll KK, Kurowska EA. Soy consumption and cholesterol reduction: review of animal and human studies. J. Nutr.,1995:125:594–597.
3. Esher RJ, Fleischman AI, Lenz PH. Blood and liver lipids in torpid and aroused little brown bats, *Myotis lucifugus.* Comparative Biochemistry and Physiology Part A: Physiology,1973:45(4):933–938.
4. Heard DJ, Whittier DA. Hematologic and plasma biochemical reference values for three flying fox species (*Pteropus* sp.). Journal of Zoo and Wildlife Medicine,1997:28(4):464-470.
5. Korine C, Zinder O, Arad Z. Diurnal and seasonal changes in blood composition of the free living Egyptian fruit bat (*Rousettus aegyptiacus*). Journal of Comparative Physiology B,1999:169:280-286.
6. McLaughlin AB, Epstein JH, Prakash V, Smith C. S., Daszak, P., Field, H. E. and Cunningham, A. A. Plasma biochemistry and hematologic values for wild-caught flying foxes (*Pteropus giganteus*) in India. Journal of Zoo and Wildlife Medicine,2007:38(3):446-452.
7. McMichael L, Edson D, McLaughlin A, Mayer D, Kopp S, Meers J, Field H. Haematology and Plasma Biochemistry of Wild Black Flying-Foxes, (*Pteropus alecto*) in Queensland, Australia. PLoS ONE,2015:10(5):1-13.
8. Moretti P, Ravasio G, Magnone W, Di Cesare F, Paltrinieri S, Pecile A, et al. Haematological, serum biochemical and electrophoretic data on healthy captive Egyptian fruit bats (*Rousettus aegyptiacus*). Laboratory Animals,2021:55(2):158-169.
9. Otis JP, Sahoo D, Drover VA, Yen CLE, Carey HV. Cholesterol and Lipoprotein Dynamics in a Hibernating Mammal. *PLoS ONE.*,2011:6(12):e29111.
10. Sarmin Widiyono I, Anggraeni D. Comparison of Hematological and Biochemical Parameters of Clinically Healthy Buck Kid of Saanen, Sapera, and Ettawa Crossbred in Indonesia International

Symposium on Water, Ecology and Environment. IOP Conf. Series: Earth and Environmental Science,2021:690:012029.
11. Selig M, Lewandowski A, Kent MS. Establishment of reference intervals for hematology and biochemistry analytes in a captive colony of straw-colored fruit bats (*Eidolon helvum*). Journal of Zoo and Wildlife Medicine,2016:47(1):106-112.
12. Simmons NB, Cirranello AL. Bat species of the world: a taxonomic and geographic database. Accessed on, 2020, 7(10).
13. Widmaier EP, Gornstein ER, Hennessey JL, Bloss JM, Greenberg JA, Kunz TH. High plasma cholesterol, but low triglycerides and plaque-free arteries in Mexican free-tailed bats. American Journal of Physiology,1996:271(5-2):R1101-R1106.