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Algal Biodiversity and Quality of Ponds Water within the Coal City Dhanbad

Suman Dhar[1], Kumar Nikhil[2]

[1]M.Tech, Final Year, Student,
Department of Environmental Science & Engineering,
IIT-ISM, Dhanbad, Jharkhand India, +918509578033

[2]Principal Scientist,
Natural Resource & Environment Management (NREM) Group,
CSIR-CIMFR, Dhanbad, Jharkhand, India, +919931135322

Abstract: ***Coal city Dhanbad is famous for coal mining, source for many washeries, power plant, steel industries, fertilizer industries, brick clines, small industries and chimney bhhatta's. The great source of energy coal comes through underground and opencast mining resultant air, water, land pollution affecting vegetation and agriculture of that area. The water pollution and its severity are measured through algae as bio-indicator. The quality of ponds water within Dhanbad city were sampled and tested for few parameters. The availability of algal species and its diversity correlated with water quality of ten ponds studied has shown different results. The sampling and experiment undertaken in June,2017 studied for algal species frequency, dominance, richness, evenness, diversity correlated with quality of ponds water in ten ponds located in coal city of Dhanbad***

Keywords: Algae, species, frequency, richness, diversity. Water quality.

1. Introduction

Dhanbad is famous for coal mining in India, surrounded by major power plants and coal washeries supported power generation and major industrialization in this eastern zone. Due to underground with opencast coal mining the land use changes in original topography and land degradation had taken place in great ways. Cumulative effects of intensive mining and old quarries had resultant air, noise, surface and ground water with land pollution reduced the vegetation and agriculture in this area. The utilization of coal in power plant generation flyash as a waste product resultant air water and land pollution. This can be accessed through environmental impact assessment and environmental management plan. Overall this has resultant in the major changes in socio-economic. But the quality of life has been affected in this area with all other developments (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 45, 66, 78, 87, 100, 102, 105, 106, 107, 122, 123, 124, 129, 131, 132, 140, 142 and 146).

The effect of mining through modeling and simulation were assessed for effective environmental management to achieve sustainable development (47, 49, 69, 70, 71, 72 and 73).

Flora and fauna drastically affected due to many environmental pressure. This leads to changes in the availability of terrestrial and aquatic flora and fauna with avian species. In this connection a study has been undertaken to investigate the availability of different algal biodiversity which is a very good indicator of different type of environment. Algae have different potentiality for the sustainable development of this disturbed area (108, 110, 111, 113, 114, 115, 116, 118, 119, 120, 127, 133, 134 and 141).

Water environment is most concern in the mining areas. For the reclamation of wastewater with land, bio-approach is effective one to restore many things.

Through this approach solve the food and environmental problems in this area (31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 46, 48, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 65, 67, 74, 75, 79, 80, 81, 82, 83, 84, 85, 90, 91, 92, 93, 94, 96, 104, 109 and 135).

The bio-treatment of polluted water vis-a-vis socioeconomic development had found effective in this area. Bio-purification also include using algae (62, 63, 64, 68, 76, 77, 86, 88, 89, 95, 97, 98, 99, 101, 103, 112, 117, 121, 125, 126, 128, 130, 136, 137, 138 and 139).

The task of finding, developing and maintaining suitable water supplies has not been limited to modern times. It has had to be faced wherever large numbers of people have crowded together in small spaces; and therefore the popular indifference towards safe, clean water has prevailed. Other means of pollution abatement in industrial areas may be through roof top garden which are more affective (147 and 148).

Planning for the maximum development of our water resources for long time benefit of all our people when properly conceived, can bind together individual and the community, farmer and urbanate as few other conservation activities can do (143). Ponds are valuable water systems and intensively used for production of drinking water, for fisheries and bathing with washing of clothes. The ecological nature of many ponds, however have desecrated, mainly as a consequence of eutrophication (144). Algal diversity in ponds plays an important role in their conservation (145). More the diversity, more useful is a water body. In the present investigation ten ponds have been selected; of these remains unprotected and free for public use. The algal biodiversity has been studied and diversity indices have been discussed.

2. Material & Methods

2.1 Site Details

The selection of different ponds in coal mining city Dhanbad is selected on the basis of its maximum utilization by the nearby community for their daily uses like washing, bathing except drinking purposes (**Fig.1**). As they get drinking water supply either from Jharia water board from Topchanchi lake or Maithon water supply from Maithon dam. These lakes are live throughout the year. The excess drain water in rainy season comes in these pond of that area.

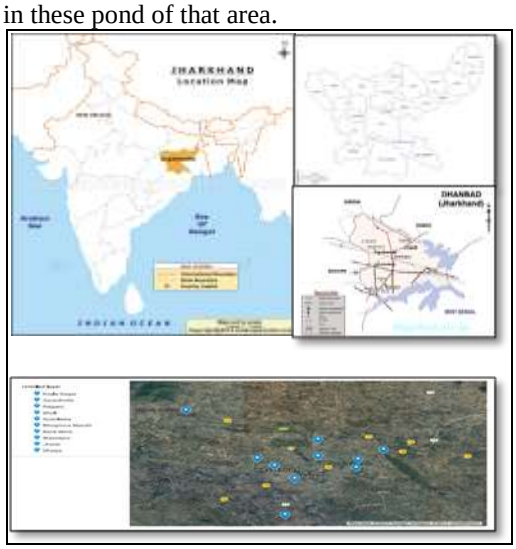

Fig.1: Map showing the sampling location (📍) points of ponds within Coal City Dhanbad, Jharkhand, India

Ten ponds were selected as study areas and water samples were taken to study physic-chemical analysis of water quality parameters and identify the different algae's located within the following study areas which are as follows (**Fig**.2.)

(a) BCCL Koylanagar is located at 23° 48′ 2″ N and 86° 27′ 35″ E.
(b) Saraidhela is located at 23° 48′ 51″ N and 86° 27′ 12″ E.
(c) Rajganj is located at 23° 52′ 36″ N and 86° 20′ 25″ E.
(d) Bhuli is located at 23° 49′ 9″ N and 86° 22′ 32″ E.
(e) Susnilewa is located at 23° 50′ 8″ N and 86° 26′ 9″ E.
(f) Bhuiphore is located at 23° 49′ 3″ N and 86° 28′ 43″ E.
(g) Bank More is located at 23° 47′ 16″ N and 86° 24′ 49″ E.
(h) Wasseypore is located at 23° 47′ 25″ N and 86° 25′ 9″ E.
(i) Jharia is located at 23° 44′ 37″ N and 86° 24′ 55″ E.
(j) Dhaiya is located at 23° 49′ 14″ N and 86° 25′ 59″ E.

Fig.2: Photographs of ten ponds in coal mining city Dhanbad (a-j)

2.2 Chemical parameter for water testing

Water and algal sampleswere collectedfrom different areas pond within coal city Dhanbad in morning of June, 2017 by holding a container collector under water and filling completely. This was transferred into a large, clean container (ex. bucket/pail) that has been pre-rinsed with water in the pond. Continue collecting water around the pond and dump into same big bucket. 2. Thoroughly mix all the collected water in the bucket.100 ml bottle was filled up to the neck with the same water sample, then cap tightly. This sample was collected for Water Quality Test.Same procedure was repeated for sampling for Algal Identification also.

1. Water Temperature (°C)

By Mercury thermometer (149)water temperature were recorded atsampling stations. Water temperature was measured at a depth of about 12 cm, withthe help of hand held mercury thermometer **(°C)**

2. Hydrogen ion concentration (pH)

Electronic Method (IS:3025) (Standard Methods of APHA 1995).pH was determined with the help of universal pH paper and later wasconfirmed in the lab using hand held digital pH meter. This pH system was previouslycalibrated with pH 4.0, 7.0, 9.2 buffers at laboratory temperature.

3. Conductivity (µS cm-1)

Electronic methodConductivity of surface water was measured in the field using digitalconductivity meter.

4. Turbidity

Turbidity is expressed in Nephelometric Turbidity Units (NTU)and wasmeasured in the laboratory using Digital-Nephelo-Turbidity meter. 5ml of hydrazinesulphate and 5 ml of hexamethylenetetramine was taken in 100ml standard flask. Themixture was left a day, and after 24 hours it was made upto 100ml. 10ml of thissolution was taken and diluted to 100ml. Nephelometer was adjusted at 40 NTUusing this standard. Water samples were shaked before taking the readings innephelometer. (150).

5. Total Hardness (mg/l)

Standard methods (APHA-1995) for hardness isgenerally caused by the calcium and magnesium ions present inwater. 50ml of sample was taken in a conical flask and 1ml of buffer solution, 100-200mg of Eriochrome Black T indicator were added, the solution turns wine red. Thecontents were titrated against EDTA solution until the wine red colour changes to blue.

6. Nitrate (mg/l)

Brucine method (APHA-1995)for Nitrate content of the water sample was determined by Brucine method. 10mlof the surface water sample was taken in test tube, to which 2ml of sodium chlorideand 0.5ml of brucinesulphanilic acid solution was added. A blank was also preparedin similar manner using 10ml distilled water. The test tubes were heated on water bath for 20 minutes. The optical density of the sample was measured at 410nm usingspectrophotometer.

7. Sulphate (mg/l)

Turbidimetric method (APHA-1995)Sulphate content of the surface water sample was determined by Turbidimetricmethod. 100ml of the water sample was taken in a conical flask to which 5ml ofconditioning reagent and 10mg of barium chloride crystals were added. A blank wasalso prepared in a similar manner using 100ml distilled water. The optical densities of these samples were measured at 420nm using spectrophotometer.

8. Phosphate (mg/l)

Stannous chloride method (APHA-1995) forInorganic Phosphate content of the surface water sample was determined

usingstannous chloride method. 50ml of the water sample was taken in a conical flask, 2mlof ammonium molybdate and 5 drops of stannous chloride were added. A blank wasalso prepared in a similar manner using 50ml distilled water. The optical density ofthese samples was measured at 690 nm using spectrophotometer.

2.3 Estimation of Algae

Water samples for the estimation of phytoplankton were collectedsimultaneously along with the samples for physico-chemical analysis. 1000mlcomposite sample was sedimented after adding 15 ml 4% formaldehyde and 10 ml oflugol's iodine. Sedimentation was done in glass columns for identification. Thesediment was finally reduced to 20ml and was preserved in a vial. From each vial onedrop was mounted on a slide and a cover slip was carefully placed. Five high powerfield (15x X 45x) observations, one in each corner of the cover slip and one at thecenter were made and the algal populations were estimated. These observations wererandom and were repeated four to five times for each sample. Identification to specieslevel was done using Camera Lucida photographs and by consulting taxonomicguides and monographs. Enumeration was done by Lackey's drop method (151; 152) andmodified (153). Phytoplanktons wereexpressed as organisms/litre (Org/L).

Formula used for the calculation of organism asorg/L is

$$org/L = \frac{n \times v}{V} \times 1000$$

n=No of phytoplankton counted in 0.1ml concentrate.
v = Total volume of concentrate in ml.
V = Total volume of water filtered through net.

2.4 Statistical Analysis

In order to account all the environmental fluctuations ofthe study area, ponds wise analysis andcomparison of different parameters of water like, Temperature, pH, EC, Turbidity, Total hardness, Nitrate, Phosphate and Sulphate. The data reveals the difference in them on different partsof the ponds system. The data were statistically calculated for mean, mode, median, standard deviation, Standard error. Thespecies diversity indices, viz., Shannon-Weiner diversity index (H'), Speciesrichness (S), Margalef's richness (d) and Pielou's evenness index (J') werecomputed for algae (Plymouth Routines inMultivariate Ecological Research, (154).

1. Shannon-Weiner (163), diversity index wasused to emphasize species richness.

H' = −Σ*i*pi loge (*p* i) where *p i*is the proportion of the total count arisingfrom the ith species. The natural logarithm is used for biologicalinterpretation.

2. Margalef's index was used to measure the number of species presentfor a given number of individuals.

d = (S-1) / Log N, where S is the total number of species and N thetotal number of individuals.

3. Evenness of the community was calculated using Pielou's evennessindex (162).

J' = H' / H' max = H'/ log S where H' max is the maximum possiblevalue of Shannon diversity and S is the total number of species

4. Species richness was defined as the number of species (S) caught at asampling station on each sampling date.

1. Shannon's species diversity index (H1)

Shannon and Weaver Index (1949)

The Shannon and Weaver (1949) index was estimated by(163):

$$H' = -\sum_{n=1}^{n} \log pi \,.\, \log 2pi$$

Where
S = total individual number of species
N = Total individual number of all species
pi = S/N

2. Margalef's community diversity index (d')

byMargalef 1957(155)

This is based on Margalet's information theory (1956) Odum (1971)Hutchinson (1967) Bilgram's (1988)

$$d' = \frac{[S-1]}{log\, e\, N}$$

Where d' = Margalef's index
S = The number of species of the particular sample
N = Logarithm oftotal number of individuals of all the species of the sample.

3. *Species Richness index*

Species richness indexes (SRI) were calculated using the following formula given below(161):

$$SRI = \frac{[S-1]}{\log N}$$

Where,
S - Number of species of the particular sample
N - Logerithm of total number (H) of the individuals of all the species of the sample

4. *Spcies Evenness*

Species evenness was calculated using the following formula (163):

$$j = \frac{H'}{\log 2S}$$

Where
H' = Shannon and Weaver Index (1949)
S = Species number

2.5 Correlation Profile

In order to understand most representationvalues, variation spectrum, extent of difference and relationship of some ofthe environment factors, standard statistical methods were applied whichare listed below:

1. Average :

This was calculated with a view to find out a typicalrepresentation of all the observations, with the help of following formula :

Arithmetic mean (x) =

$$X = \frac{\sum_{k=0}^{n} Xi}{N}$$

2. Mean deviation:

It is an arithmetical mean of the deviation of valuesfrom mean of the calculated as follows :

Mean Deviation =

$$x = \frac{\sum|x-\mu|}{N}$$

Variance =

$$\sigma 2 = \frac{\sum|x-\mu|2}{N}$$

3. Standard Deviation ($\sigma 2$)

It is the degree of spread of distribution which was acquired bytaking the square root of variance which is as follows :

$$\sigma 2 = \frac{\sum X2}{N} - \mu 2$$

4. Standard Error ($SE_{\bar{x}}$)

The measure of reliability of data, standard error of mean was obtained byfollowing formula

$$SE_{\bar{x}} \frac{\sigma 2}{\sqrt{N}}$$

SE$\bar{x}$ = Standard Error of the Mean
σ2 = Standard Deviation of the Mean
n = Number of Observations of the Sample

3. Results & Findings

1. Algal species

The distribution of algae in ten ponds is presented in **Table 1**. The overall 36 algae species were found in all ten ponds of coal mining city Dhanbad.

Name of Algae	Number of Algae										Total no. of Algae
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
Actinastrum	2000			2000		2000		2000			8,000
Agmenellum	4000	1000		1000	2000		1000	5000	2000		16,000
Amphora	1000	1000		1000				1000			4,000
Anabaena									3000	2000	5,000
Ankistrodesmus				1000							1,000
Chlamydomonas	6000		5000							5000	16,000
Chlorella		4000					4000			4000	12,000
Chrococcum		5000	4000			4000	5000				18,000
Closterium			1000						1000	2000	4,000
Coelastrum		2000									2,000
Cosmarium	1000				2000						3,000
Cyclotella	1000										1,000
Cymbella	1000		2000				3000	1000	2000	1000	10,000
Desmodesmus		2000	2000				1000				5,000
Diatom	5000	2000	2000			2000	2000	7000	3000	3000	26,000
Dinoflagellates	1000							2000			3,000
Eucapsis								2000			2,000
Euglena		3000	2000			2000	3000		3000	3000	16,000
Gleocapsa	2000		5000		4000	4000	2000	4000			21,000
Gomphonema			1000	2000	1000			1000			5,000
Hantzschia	2000			2000					2000		6,000
Korshikoviella				1000							1,000
Merismopedia				3000	3000						6,000
Navicula	1000	4000				6000	1000				12,000
Oedogonium							3000				3,000
Oscillatoria		1000	2000	3000	6000	1000	4000		7000	6000	30,000
Pediastrum		2000	2000			2000	1000		1000		8,000
Phacus				4000			2000		2000		8,000
Phormidium					4000						4,000
Scenedesmus		2000	11000			9000	8000		4000		34,000
Spirogyra		1000	2000	6000	7000	2000	3000		4000	6000	31,000
Spirulina		1000								9000	10,000
Staurastrum		4000			1000			2000	1000	1000	9,000
Tetradron			1000	1000	2000	1000		1000			6,000
Ulothrix								4000			4,000
Volvox		2000	5000			1000	5000		3000	3000	19,000
Total number of Species	12	16	15	12	10	12	16	12	14	12	36
Total number of Phytoplankton/l	27,000	37,000	47,000	27,000	32,000	36,000	48,000	32,000	38,000	45,000	3,69,000

Table.1: Total algal population in ten different ponds of coal mining city Dhanbad

Table.1 reported that there are 36 different algal species found all over the ten ponds sampled and studied within the coal city Dhanbad.

2. Water Quality of Ponds

	Tem	pH	EC	Turbidity	Total Hardness	Nitrate	Phosphate	Sulphate
(SE)	0.48615	0.137	0.111	6.388	26.317	1.7749	0.0797	2.291
(SD)	1.458	0.413	0.334	19.165	78.953	5.324	0.239	6.873

Table.2: Standard Deviation and Error of water quality parameters of ten ponds

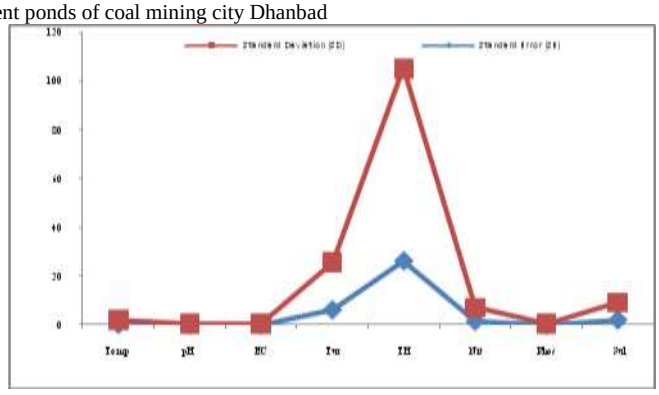

Fig.3: Standard Deviation and Error of water quality parameters of ten ponds

The water quality shown in the **Table.2 and Fig.3** for the ten ponds of coal city Dhanbad is poor in quality compared with the standards (156, 157, 158, 159 and 160).

3. Algal Diversity Studies

Sampling Site	Species Richness	Shannon's Diversity Index	Evenness Index	Margalef's index
BCCL Koylanagar	3.3375	2.28	0.92	1.0781
Saraidhela	4.1236	2.67	0.96	1.4224
Rajganj	3.6362	2.43	0.90	1.3014
Bhuli	3.3375	2.31	0.93	1.0781
Susnilewa	2.5969	2.09	0.91	0.8676
Bhuiphore	3.0696	2.31	0.93	1.0485
Bank More	3.8960	2.59	0.93	1.3943
Wasseypore	3.1739	2.28	0.92	1.0604
Jharia	3.5738	2.09	0.81	1.2328
Dhaiya	2.8897	2.31	0.93	1.0267

Table.3: Shows the different algal indices within the ten ponds of coal city Dhanbad

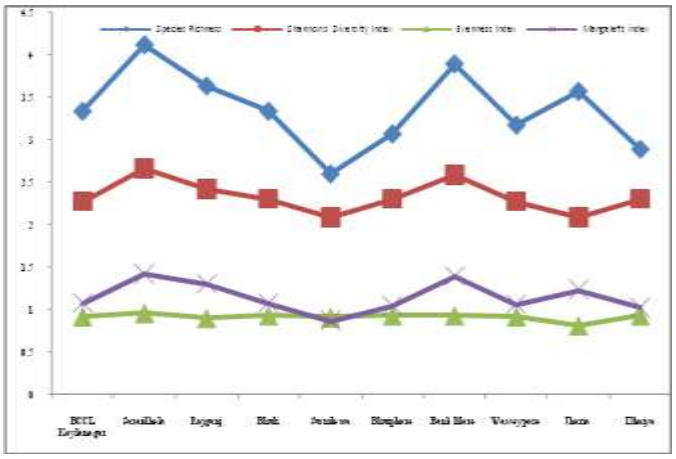

Fig.4: Shows the different indices of algal species found within ten ponds of coal city Dhanbad

Margalef's diversity Index for the algal community within the ten ponds were 1.0781, 1.4224, 1.3014, 1.0781, 0.8676, 1.0485, 1.3943, 1.0604, 1.2328 and 1.0267 respectively.

Species richness or richness index of sampling of ponds in coal mining city Dhanbad were given in **Fig.4**. The species richness of 3.33, 4.12, 3.63, 3.33, 2.59, 3.06, 3.89, 3.17, 3.57 and 2.88 were observed in ponds from BCCL koyalanagar, Saraidhela, Rajganj, Bhuli, Susnilewa, Bhiphore, Bankmore, Wasseypore, Jharia and Dhaiya respectively (**Table.3**). The lowest and heighestvalues resulted were 2.88 and 4.12at stations Dhaiyaand Saraidhela during June, 2017.

Species Evenness of all the ten sampling pondsin June 2017 areprovided in (**Fig.4**). The species evenness ranged from a minimum of 0.81 for Jharia and maximum of 0.96 for Saraidhela pond. Rest of other ponds have 0.92, 0.90, 0.93, 0.91, 0.93, 0.93, 0.92 and 0.93 species evenness indices for BCCL koyalanagar, Rajganj, Bhuli, Susnilewa, Bhiphore, Bankmore, Wasseypore and Dhaiya respectively (**Table.3**).

Shannon and Weiner index (163) represents entropy. It is a diversity index taking intoaccount the number of individuals as well as the number of taxa. It varies from 0 forcommunities with only single taxa to high values for community with many taxa each withfew individuals. This index can also determine the pollution status of a water body. Normalvalues range from 0 to 4. This index is a combination of species present and the evenness ofthe species. Examining the diversity in the range of polluted and unpolluted ecosystems, the values of the index greater than 3 indicate cleanwater; values in the range of 1 to 3 are characterized by moderate pollution and values lessthan 1 are characterized as heavily polluted (166). Moderate pollution can be inferred in this studyfor the all the ten ponds studied. The Shannon's Diversity Index for all the ten ponds studied were found to be from 2.09 to 2.67 which is less than 3 means all ponds are moderately to heavily polluted (143, 144 and 145).

In environmental monitoring it is assumed that the adverse effects of pollution will be reflected in the reduction of diversity or change in the composition of species abundance (143, 144 and 145). Both these factors involve diversity as an index of a good ecosystem (167). The enriched or polluted ecosystems display a reduction in diversity (168 and 169). Shannon and Wiener index is widely adopted in pollution monitoring (170, 171) discussed the role of algal species and assemblage as bio-indicators. Simple species richness and dominance measures are invariably informative. There is considerable evidence that conservation strategies may be improved if information on species abundance patterns is taken into account.

4. Conclusion

The study shows that the algae abundance and diversity was affected by the ten ponds different environmental conditions. The algae abundance and diversity was evaluated as an indicator of pollution.

Calculating the diversity indices during the period may indicate a negative inference. According to the indices of ten ponds has low dominance of species. From the Shannon Wiener diversity index it can be inferred that the water quality of the ten ponds is moderately polluted. The pollution is of autochthonic origin. From the study it is concluded that the ten ponds within coal city Dhanbad needs more care in quality parameters to check pollution for a healthy environment of the area. Constant removal of the pollutant and their debris can check this. Therefore, the lake has to be preserved for its intended use, a sustainable and aesthetic management planning is necessary for the conservation of this water body.

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Author Profile

Mr. Suman Dhar, M.Tech, Student Final Year, Department of Environmental Science & Engineering, IIT-ISM, Dhanbad, Jharkhand India. He has done his in-house training project work at NREM, CSIR-CIMFR, Dhanbad, Jharkhand, India in the year 2017 and publishing his experimental findings

Dr. Kumar Nikhil, Principal Scientist, Natural Resource & Environment Management (NREM) Group, Council of Scientific and Industrial Research (CSIR)-Central Institute of Mining & Fuel Research (CIMFR), Barwa Road, Dhanbad, Jharkhand, India gained more than 30 years of research experiences, involved in more than 60 projects in different capacity. More than 150 scientific publications on his name. Guided more than 60 students of B.Sc, M.Sc, B.Tech.,M.Tech. &Ph.D students in their research work