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ORIGINAL ARTICLE

Seasonal Variation of Water Quality and Its Impact on Fish Diversity in Harabhanga Abandoned Open Castpit, Raniganj Coalfield, West Bengal, India

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ABSTRACT
The abandoned open cast pit (OCP) lake in Harabhanga, Raniganj coalfield is formed by filling up with surface runoff and groundwater discharge in the post mining phase.The water quality of the pit lake varies with the change of season. The water quality and fish diversity of OCP were analysed in pre-monsoon, monsoon and post-monsoon. The abandoned OCP is occupied by seven fish species, viz., Catla catla,Labeo rohita, Cirrhinus mrigala, Hypophthalmichthys molitri,Labeo calbasu, Puntius sophore, Oreochromis niloticus. Shannon Weiner's Species Diversity Index (SDI) reveals that post monsoon season is rich in fish diversity (H=1.9) due to low surface runoff and low rate of evaporation. On the other hand the fishdiversity is comparatively lower (H=1.39)in monsoon due to admixture of large quantity of surface runoff and water discharge from coal mine area. The major findings of the present work were to explore the nature of fish diversity in Harabhanga OCP in different seasons and find out the impact of physiochemical parameters on the diversity of fish.
KEY WORDS: *Abandoned OCP lake; Fish diversity; Physiochemical parameters; Pre-monsoon; Monsoon; Post-monsoon; Shannon Weiner's Species Diversity Index (SDI).*

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INTRODUCTION
In our country, the coal mining activity generally based on underground and opencast coal extraction procedure. Among these two methods, opencast is one of the cheap and well used one. But it may affect the surrounding environment as well as creating a havoc impact on living beings [2, 6, 8, 16]. After the completion of coal extraction from an open cast mine, pit has been formed and then the pit will filled up by adjoining surface runoff and underground water viz it became a potential and abandoned water body [7, 4]. Pit lake has a unique and different physiochemical characteristics. As the pit water contaminated through surface runoff and ground water table, the water bodies may be used only limited purposes [5]. In India, numbers of pit lakes are reported regarding their uses for utilitarian prospective in both industries and local inhabitants [3, 11, 12]. According to Politano *et al*. [9], the growth and productivity of planktons are determined on the limnological characteristics of a pit lake, which is influenced by the seasonal variation. Simultaneously, physicochemical properties like water temperature, pH, total suspended solid, DO, BOD, COD, hardness, alkalinity, organic pollutants may control the nature of aquatic organisms. The objective of present study is to determine the fish diversity as per Shannon Weiner's Species Diversity in the respect of seasonal variation of water parameters in this abandoned OCP.

STUDY AREA
The present study site, Harabhanga abandoned OCP situated in Harabanga Village under Tirat gram panchayat, Raniganj Block of Paschim Bardhaman in West Bengal. Geographically it is located at

23^{0}39'52'' N latitude and 87^{0}01'44'' E longitude. This pit lake is a part of Eastern Coalfield Ltd (Satgram area) as per the coal mining map of India.

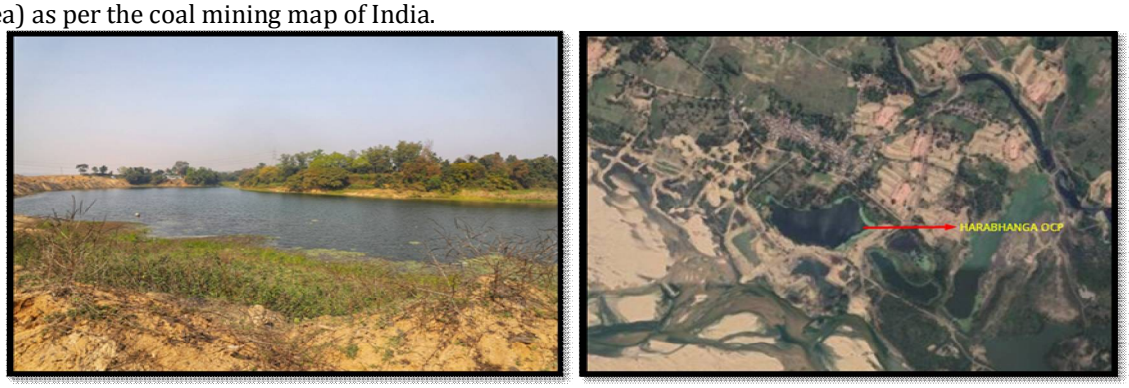

Figure 1. A & B: Harabhanga OCP (Crocodile Shaped)

MATERIAL AND METHODS

During present work, primary water samples were collected from three seasonal phases i.e. pre monsoon, monsoon and post monsoon season. Surface water was collected from five points of Harabanga abandoned OCP and mixed it thoroughly [15]. After that it was brought to the laboratory to analyse the data using APHA 23rd Edition, 1060 technique. Parameters like weather elements, pH, TSS, DO, BOD, COD, Hardness and Alkalinity were considered for observation. Apart from this, various inorganic pollutants have also been measured. For the purpose of seasonal impact analysis, metallurgical data was also taken from local two weather stations, i.e. Asansol and Panagarh, to find out the relative relationship between monsoon wise rainfall and fish diversity. During sampling and analyses of the mine water, standard protocols and methodologies were strictly maintained for getting desired result. Whereas comparative line graph was drawn by using SPSS statistical software version 16.0 for analysing the data set and get better understanding on interrelationship between season wise difference of catches of fish species. ANOVA (two way factor) was also computed to analyse the actual dependency among different physiochemical properties of pit water. South-west monsoon is the most influencing factor for the hydrological regime of the present study area, thus the whole sampling procedure was categorised into pre-monsoon, monsoon and post-monsoon season.

To know the seasonal nature of fish diversity, Shannon Weiner's Species Diversity Index (SDI) has been applied. It is the most useful statistical tools to determine the species diversity in different time scale or in different area or condition.

RESULTS AND DISCUSSION

The fish and water samples were collected from study site during three different seasons. These three seasons are basically categorized on the basis of temperature and rainfall. Data on air and water temperature and rainfall we recollected from Asansol and Panagarh weather station.

Table 1. Season wise physiochemical properties of water

PROPERTISE	Pre-monsoon	Monsoon	Post-monsoon	Limit as per MoEF Schedule-VI Standard
Air Temp (^{0}C)	36	28	29	-
Water Surface Temp (^{0}C)	33	26	27	-
Rainfall (cm)	2.7	4.4	1.6	-
pH (at 25^{0}C)	6.32	5.74	6.96	5.5-9.0
Total Suspended Solid (TSS) i.e. pollutants(mg/l)	1.8	4.5	3	100
Dissolved Oxygen (DO) (mg/l)	5.5	6.22	5.18	-
BOD(mg/l)	10	9	10	30
COD(mg/l)	52.57	49.48	59.52	250
Total Hardness as $CaCO_3$(mg/l)	109.35	117.88	110.43	-
Total Alkalinity as $CaCO_3$(mg/l)	198	182	204	-
Nitrate(mg/l)	2.2	2.9	1.7	50
Ammonia(mg/l)	2	2.8	1.8	5
Phosphate(mg/l)	0.02	0.03	0.01	5
Sulphate(mg/l)	0.2	0.5	0.2	2

SD= Standard Deviation, MoEF= Ministry of Environment and Forest

Two way ANOVA was made to show the exact relation in between different variables and season wise deviation of physiochemical parameters in pit water bodies. In this statistical test, two points are taken into consideration for making optimum result, i.e. **F observed** value and **F critical** value.

Table 2. ANOVA (Two way factor) on season wise physiochemical properties of water

Source of Variation	SS	df	MS	F obs	P-value	F crit
Within the Properties	79101.47	11	7191.04	260.84	1.19	2.82
Within the Season	21.57	1	21.57	0.78	0.39	4.84
Error	303.26	11	27.57			
Total	79426.3	23				

Notes: SS = Sum of Squares, df = Degree of Freedom, MS = Mean Sum of Squares, F_{obs} = Observed F, P-value = Probality, F_{crit} = Critical F.

Figure 2. Netting of fish in Harabhanga OCP

Fishes were collected from the abandoned open cast pit (OCP) lake in Harabhanga, Raniganj coalfield during pre-monsoon, monsoon and post-monsoon to estimate the fish diversity (Figure 3). In the present study Shannon Weiner's Species Diversity index (SDI) was used to find out season wise fish diversity [1].

The formula used for Shannon Weiner's Species Diversity index:

$$H = -\sum_{i=1}^{s} pi \ln pi$$

Where, H = Shannon-Weiner species diversity index (SDI); $P_i = n_i/N$ (n_i = Number of individuals of i^{th} species and N= total number of individuals of all the species in the quadrate).

Table 3. Shannon Weiner's Species Diversity Index (SDI) on catches of fish species

Fish Species	Pre-monsoon					Monsoon					Post-monsoon				
	No of fish catches	Pi	Inpi	Pi*Inpi	H	No of fish catches	Pi	Inpi	Pi*Inpi	H	No of fish catches	Pi	Inpi	Pi*Inpi	**H**
Cirrhinusm rigala	1	0.0769	-2.5649	-0.1973	1.84	1	0.25	-1.3862	-0.3465	1.39	2	0.1176	-2.1400	-0.2517	1.9
Labeo rohita	3	0.2307	-1.4663	-0.3383		1	0.25	-1.3862	-0.3465		4	0.2352	-1.446	-0.3404	
Labeo calbasu	2	0.1538	-1.8718	-0.2879		1	0.25	-1.3862	-0.3465		2	0.1176	-2.1400	-0.2517	
Puntius sophore	1	0.0769	-2.5649	-0.1973		0	0	0	0		2	0.1176	-2.1400	-0.2517	
Oreochromis niloticus	1	0.0769	-2.5649	-0.1973		0	0	0	0		2	0.1176	-2.1400	-0.2517	
Catla catla	3	0.2307	-1.4663	-0.3383		1	0.25	-1.3862	-0.3465		3	0.1764	-1.7346	-0.3061	
Hypophtha lmichthys molitrix	2	0.1538	-1.8718	-0.2879		0	0	0	0		2	0.1176	-2.1400	-0.2517	

H= Shannon Weiner's Species Diversity Index (SDI)

Comparative line graph is drawn to show season and species wise fish catches. It has been pointed out that post monsoon is the dominant season for maximum species accumulation. Beside this, large volume of fish concentration is observed during this season. Monsoon is the less important season for both species and volume concentration of fishes.

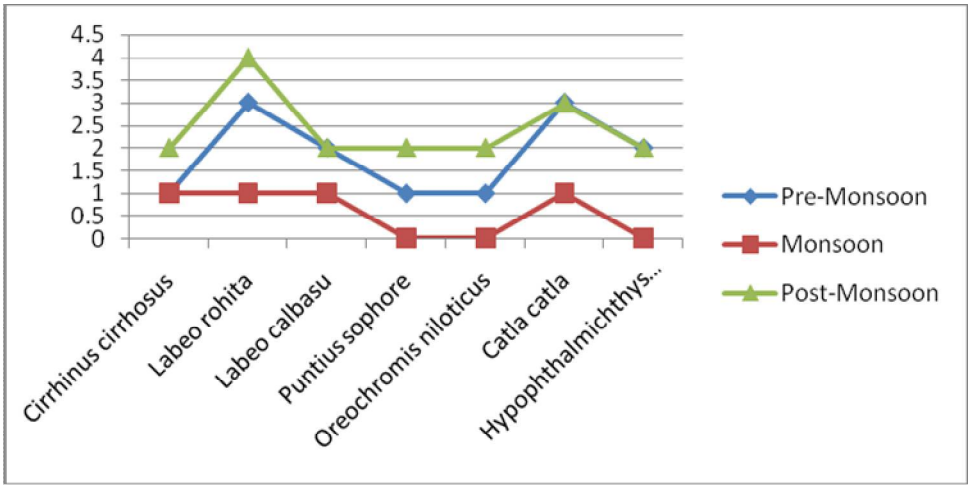

Figure 3. Season wise concentration of fish species

From Table 1, it may be pointed out that temperature becomes the highest in summer with an average at 41^0C and gets maximum value at 47^0C. Rainfall volume is cm in summer time or pre monsoon. Monsoon season is become hot and humid with excessive rainfall (cm). Due to presence of moderate vegetation cover, humidity will increase with an increase of evapotranspiration. Post monsoon season received less amount of rainfall (cm on an average) and therefore, it simply indicates the dry winter season. Western disturbance is also occurs during this season.

As a result of heavy rainfall, excessive amount of waste materials are flow through this runoff and the physical properties of water become affected [13]. Basically, it has been observed that the water quality also season dependent. Due to high evaporation rate in summer season, large proportion of water will going into the air. The volume of water is also decreases. Therefore, water quality may differ in various season with precipitation rate [14]. On the other hand, low precipitation rate in post monsoon season is also creating the same condition. But in monsoon, diversity and richness of water quality parameters, become high. So water quality may largely affect during monsoon season. Various physical parameters are analysed in departmental lab after getting the water sample from study site. The major indicators like as TSS, DO, pH, COD, BOD, TH, TA are taken into consideration for analysing water quality. MoEF Department, Govt. of India, has given permissible standard in respect of each different water parameters or indicators. All the parameters are categorised in respect of this standard limit. In case of pH, COD, TA monsoon wise variation is as

Post Monsoon > Pre Monsoon > Monsoon

Whereas TSS, DO, BOD, TH values may vary in different season as

Monsoon > Post Monsoon > Pre Monsoon

Like graph is also showing a clear view on the season wise deviation of different water parameters. In all monsoon COD, BOD, TH, TA rate are high. But pH level, TSS, DO, Level is slightly near about in all seasons. Specifically, it is argued that, the inner deviation rate is low in these cases.

ANOVA (Two way factor) is also analysed to know the significant level among different physiochemical parameters (variable) of this pit lake. It is found that 1) in case of within the parameter, $\mathbf{F}_{\text{observed}}$ Value (260.84) is greater than $\mathbf{F}_{\text{Critical}}$ value (2.82), which means, there is significant difference in opinion on the dependency or inter relations among different water parameters. Generally it is symbolised that there no such dependency among the variables. On the other hand, 2) in case of within the season, $\mathbf{F}_{\text{observed}}$ Value (0.78) is less than $\mathbf{F}_{\text{Critical}}$ value (4.84). That means there are no significant differences in observation regarding. It may also be pointed that there is no such differences are observed to find out the interrelationship between seasons and water parameters and between different water properties. This study further shows that water parameters are directly influenced by various seasons. Interrelation among water parameters and seasons are found positive.

Figure 5: Fishing activity at Harabhanga OCP

The Shannon-Weiner index was based on measuring uncertainty and developed from information theory [1]. The nature of unevenness of predicting the species of a random sample is related to the diversity of a community. It is observed that if a community has low diversity (dominated by one species), the uncertainty of prediction is low; a randomly sampled species in most of the cases is going to be the dominant species. However, it may argued that if the nature of diversity is high, uncertainty will be also high.

It is commonly observed during fishing activity that 7 types of fishes are found. We have selected three seasons for fishing to test the density, volume and number of fish species. *Labeo rohita* (Rohu Fish) and *Catla catla* (Catla Fish) are the dominant fish species which are found throughout the year. Rich fish diversity has been found in post-monsoon (**H=1.9**) due to low pollutant concentration as well as better water quality. As low rate of surface runoff and low rate of evaporation, pollution level or water quality may not be going higher. Due to this, 7 types of fishes were found during this season with high number. Pre-monsoon season is also playing a significant on fish diversity variation, because low rate of precipitation. So TSS, TH, TDS level may not increases at higher rate in absence of low surface water discharge. But because of high evaporation rate, water volume is decreasing in pit lake. As a result of low material concentration and lowering rate of water level, there is comparatively moderate condition prevailing there. In this season fish diversity is became also moderate (**H=1.84**). In case of monsoon season, water quality is terribly hampered or deteriorated due to high rate of leaching process. Leaching rate is controlled by rainfall occurrence and huge amount of surface runoff. It is experiencing that water volume is increasing rapidly in this season and because of it TSS, TH, TDS, ammonia, nitrate, phosphate and sulphur rate may also increases in this time. Therefore an adverse condition is creating for existence of fish species. It may also hamper the rate of fish production and fish growth. Due to depletion of water quality, fish diversity became low (**H=1.39**). So, the season wise fish diversity may be shown as:

Post-monsoon>Pre-monsoon>Monsoon

CONCLUSION

On the basis of discussion, it might be said that monsoon season is the main concern of that area regarding the quality issue of water bodies. It is found that post-monsoon is the most productive season for fish diversity and fish volume. There is a need of serious intervention from the Government and local NGOs is necessary to restore the degraded condition of pit water bodies in abandoned open cast pit lake, otherwise it may face complete depletion in near future. Chemical treatment processes and biological treatment processes may be used to purify water quality during monsoon season. Managed fishing may be initiated in post-monsoon season as there is large fish diversity has been recorded. There will be a great future scope on fishing activities which may use sustainable tools for the inhabitants of that area.

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