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RESEARCH ARTICLE

THE IMPACT OF COAL FLY ASH POWER STATION ON DISTRIBUTION AND BIODIVERSITY OF FRESHWATER FISHES IN RUPNARAYAN RIVER, WEST BENGAL, INDIA

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ABSTRACT

Kolaghat Thermal Power Station is situated on right pool of the river Rupnarayan in Purba Medinipur district. Presently its total power generating capacity is 1260MW, with six units, 210 MW each. The plant generates around 7500-8000 metric tons fly ash which disposed mixed hot waste water on the river and consequently it has an adverse impact on the said river. The fish diversity of the river in relation to physico-chemical parameters was studied by monthly samples taken from May, 2013 to February, 2014. Traditional cast net and craft (Poukia) was used for fish sampling collection. The results of present investigation reflected the occurrence of 27 fish species belonging to 9 order, 18 family and 20 genera. Among the collect species, order Siluriformes (32%) was a good number abundant in all sites besides this order Cypriniformes (20%), Perciformes (17%), Clupeiformes (12%), Mugiliformes and Polynemiformes both (7%), Pleuronectiformes and Symbranchiformes each (2%) respectively. The Simson's index of diversity (1-D) was highest at Site-1(S1) is 0.951 followed by Site-2(S2) is 0.947 and Site-3(S3) is 0.932. This indicated the greater fish biodiversity in site-1 when compared to other two centres. Further, another index such as Shannon Weiner index (H) was also used to assess the richness of fish diversity of all three sites. In this study an effort has been made to evaluate the fish species diversity in the region and suggests mitigating measures.

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INTRODUCTION

Biodiversity is the quantity, variety and distribution across biological scales ranging through genetics and life forms of populations, species, communities and ecosystems (Mace *et al*., 2005). Biodiversity is frequently used as a measure of the health of biological system. But habitat loss and environmental degradation causes rapid beg off in biological diversity which is a critical face up to for the modern era (Vyas *et al*., 2012). About 21,723 living species of fish have been recorded in the world of these 8,411 are freshwater species and 11,650 are marine forms. India is one of the mega biodiversity countries in the world and occupies the ninth position in terms of freshwater mega biodiversity (Mittermeier and Mitemeir, 1997). In India there are 2,500 species of fishes of which 930 live in freshwater and 1,570 are marine (Kar *et al*., 2003).

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The distribution and composition of the fish species in each habitat were closely associated with various factors such as the availability of food, breeding sites, water current, depth, topography and physico-chemical properties of water (Harris, 1995). So, biodiversity is essential for stabilization of ecosystem protection overall environmental quality for understanding intrinsic worth of all species on the earth (Ehrlich and Wilson, 1991). Positive correlations between biomass production and species abundance have been recorded by various earlier workers (Nikolosky, 1978). Freshwater biodiversity has declined faster than either terrestrial or marine biodiversity over the past 30 years. Inland waters and freshwater biodiversity constitute a valuable natural resource, in economic, cultural, aesthetic, scientific and educational terms. Their conservation and management are critical to the interests of all human, nations and governments. The streams and rivers are facing number of environmental problems throughout the world largely associated with anthropogenic activities in their catchment areas.

The Kolaghat Thermal Power Station (K.T.P.S) is situated (22025' latitude & 87052'30 longitude') on the right pool of the river Rupnarayan in Purba Medinipur district, West Bengal. It is a leading thermal power station in West Bengal. It is well connected with south-eastern Railway, NH- 6 and NH-41. This power plant was established during the sixth Five Years Plan period (1980-85). WBPDCL (West Bengal Power Development Corporation Limited) took the charge of this power plant since 1985. Presently its total power generating capacity is 1260MW, with six units, 210 MW each. KTPS generates around 7500-8000 metric tons of fly ash every day following the consumption of 18000 tons of coal (Source: KTPP office, 2009).

Most of the thermal power plants use bituminous coal as a fuel, which contains high amount of ash (up to 40%), sulphur(0.2-06%) and heavy metals (Hg, Mn, Cu, Pb, Ni, Fe, Cr and Cd) in varying proportion. But fly ash generally consists of nearly 50% silica which together with oxides of Al, Fe, and Ca makes up 95-99 % of its contents. Mg, Na, K, Ti, S and C account for 0.5-3.5%. Trace elements make up the rest of the ash (Davison *et al*., 1974). The power plant disposed ash mixed hot waste water on the river Rupnarayan and accordingly it has an adverse impact on the said river. So the physico- chemical characteristics of the river have been changed. A number of studies have showed that a large amount of heavy metal, like lead, copper, nickel, silicon etc and sometimes radionuclide (uranium & thorium) enrichment have been found in the disposal water. Moreover, due to continuous deposition of fly ash on the river depth have been abridged. This change has prohibited Hilsa fish (*Tenualosa ilisha*) migration and laying eggs (Hilsa fish of river Rupnarayan is famous for its taste and smell). Finally, the amount of *Hilsa* fish wedged in the Rupnarayan river has reduced an alarming way.

Numerous studies have reported an embarrassment of effects of coal ash pond discharges on the getting stream or river biota. These include a lessening in number and diversity of heterotrophic bacteria (Gutherie *et al*., 1978; Gutherie and Cherry, 1978; Larrick *et al*., 1981), an alteration of zooplankton community (Spencer *et al*.,1983), a reduction in diversity and density of benthic macro-invertebrates (Cherry and Gutherie, 1977; Cherry *et al*., 1979a,b; Magnuson *et al*., 1980; Gutherie *et al*., 1982; Bamber, 1984; Webster *et al*., 1985); a reduction in fish community (McKim *et al*., 1976; Olmstead *et al*., 1986), reduced fish spermatogenesis(Cochran, 1987), and a reduction in number of water birds (Heinz, 1974; White *et al*., 1978, 1986; Cain and Pafford, 1981).

In India impact of thermal power fly ash effluents in the fisheries diversity in rivers was also done by several workers (Naik *et al*., 2013; Sukla and Sing, 2013; Pitchaikani *et al*., 2010; Wallia and Mehra, 1997 and 1998). Rupnarayan river is one of the significant rivers in west Bengal that need serious concentration in its management and conservation of fishery resources. Detailed studies on this river are still lacking except Dinda (2014).Here we focused the fish diversity of Rrupnarayan river of Purba Medinipur district at Kolaghat are decreases due to spontaneously discharges of coal fly ash in this river. It is clear from this study the river water parameters like temperature, pH, BOD, DO, alkalinity and suspended solid are directly affect the fish diversity. The study area also includes 04 kms upstream and 04 kms downstream from the point where K.T.P.S disposed waste water in the form of – ash mixed (from ash ponds) and oil, etc. mixed hot water in the river Rupnarayan (as a tidal river).

MATERIALS AND METHODS

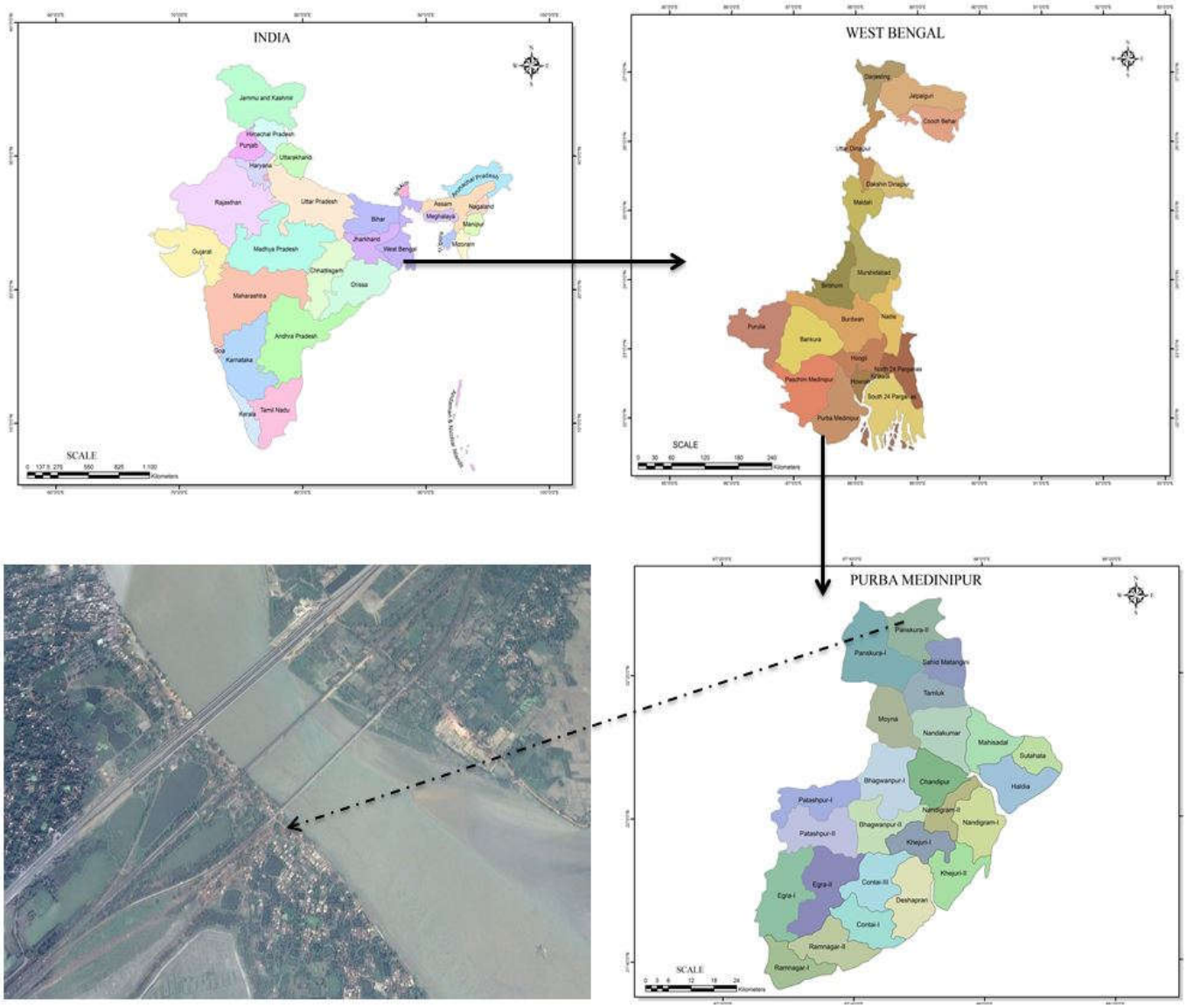
Study area

This study was performed in the catchment area of the Rupnarayan river. The Rupnarayan River is a river in India place at west Bengal state. It begins as the Dhaleswari (Dhalkisor) in the Chhota Nagpur plateau foothills northeast of the town of Purulia. It then follows a tortuous southeasterly course past the town of Bankura, where it is known as the Dwarakeswar river. Near the town of Ghatal it is joined by the Silai, where it takes the name Rupnarayan. Finally, it joins the Hoogli River. It is famous for the Hilsa fish that live in it and are used in Bengali cuisine. It is also remarkable for the West Bengal Power Development Corporation Limited (WBPDCL) thermal power plant at Kolaghat. The study was conducted mainly at the Kolaghat region in the upper 4 kms upstream and 4 kms downstream from the point where Kolaghat Thermal Power Station (K.T.P.S) is disposed waste water in the form of ash mixed (from ash ponds) and oil etc mixed hot water in the river Rupnarayan (as a tidal river).

Fish were sampled monthly at three sampling sites set up in the study area of the river. Three sampling sites were taken for my study, which at a distance preferably of 4 km from each sampling sites. Site-1(S_1) selected in the Rupnarayan river and other two sites were selected within the drainage flow of the disposal sluice system of the ash ponds of KTPS, they also mixed to the canal and finally they fall into the river sites at two sampling sites set up in the site-2 (S_2) is Denan canal and site-3 (S_3) is Banpur canal of Kolaghat region. The total lengths of my study area are 12 km. Fish samples were collected for ten months from May, 2013 to February, 2014. Fish sampling was conducted using gill nets, known as monofilament gill net (mesh size measuring 30, 45, 50 and 60 mm) and cast net at all the three sites.

Fishes were collected from from three sampling station during the study period with the help of local fishermen using different types of nets mainly bhasa and doba behundi nets, gill nets (monofilament gill nets for used *Hilsa* catching) and cast nets. Immediately photographs were taken prior to preservation since formalin decolorizes the fish color on long preservation. Formalin solutions are also taken for future identification. All fish trapped were identified to species level by means of standard taxonomic viz. Fishes of India, FAO identification sheets, Fish Base (http://fishbase.org) and other reference books (Talwar and Jhingran, 1991). Water sample were collected between 9 to 2 PM and further transported to the laboratory immediately for further analysis. Water temperature was measured at the time of sampling using mercury thermometer; pH was measured with standard pH meter, while other parameters were analyzed in the laboratory according to the methods suggested by American Public Health Association (APHA).

Study area map



Diversity indices

Fish species diversity was subjected to diversity analysis using different indices like Shannon-Weiner index (H), Shannon& Wiener(1963) ; Simpson Dominance index (D); Simpson index of diversity (1-D),Simpson(1949).

Shannon-Weiner Index

$H = \sum (Pi)\ I\ In\ Pi\ I$

Where, H = Shannon – Weiner index
Pi is the proportion of the total number of individuals in the population that are in species 'i'
Pi= ni /N

Species diversity was calculated by the following Shannon-Weiner index (H) which depends on both the number of species present and the abundance of each species.
ni = Number of individuals of each species in the sample.
N = Total number of individuals of all species in the sample.

Abundance of fish population was calculated by the sum of all available species in different sites. Species richness was simply estimated by the variety of fish species in three different sites. Data regarding threats faced by the fish species were obtained from both primary (direct observations and interaction with local aratdars and fisher folk population) and secondary sources.

Simpson's Diversity Indices

Simpson's diversity index is a measure of diversity. In ecology, it is regularly used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the abundance of each species.

Simpson's Index of Dominance

$D = \sum ni\ (ni-1)/N\ (N-1)$
ni = The total number of individuals of a Particular species
N = The total number of individuals of all Species.

Simpson's index of diversity 1 – D

However, all the diversity indices were done by using the PRIMER V.6 analytical package developed by Plymouth Marine Laboratory, U.K.

RESULTS

Fish diversity is mainly depends on leading the biotic and abiotic factors and type of the flora and fauna, age of the water body, mean depth, water level fluctuations and bottom have enormous implications. The hydro-biological features of the collection sites also play an effective role in fisheries output to a greater extent. During the entire study period, the result revealed of the occurrence of 27 fish species belonging to 9 order, 18 family and 20 genera were recorded.

Among 27 fish species , the family Cyprinidae was the most dominant in the gathering composition with 20% followed Siluridae and Bagridae with 15%, Clupeidae with 9%, Polynemidae and Mugilidae both with 7%, Anabantidae and Osphronemidae with 5%, Engralidae andAmassidae each with 3%, Schilbeidae, Sciaenidae, Synbranchidae, Centropomidae, Cynoglossidae each with 2% and remaining each with 1% respectively (Fig. 1). The species richness, abundance and biodiversity indices in all the three sites are shown in Table – 1. The Rupnarayan river shows Shannon-Weiner index (H) in site-1 (S_1) 3.251 is followed by site-2(S_2) 2.864 and lowest in site-3(S_3) 2.4532. The Simpson's dominance index (D) value shows high at site-3 0.068 and site-2 0.053 and low at site-1 0.049. With this index, 0 represents infinite diversity and 1, no diversity. That is, the larger the value of D, the poorer the diversity. The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity.

Table 1 Fish species richness, abundance and biodiversity indices of the Rupnarayan River

	Site-1(S_1)	Site-2(S_2)	Site-3(S_3)
Species Richness	25	22	15
Abundance (N)	128	87	44
Shannon- Weiner index (H)	3.251	2.864	2.453
Simpson's index of dominance (D)	0.049	0.053	0.068
Simpson's index of diversity (1-D)	0.951	0.947	0.932

Table 2 Fish species density, abundance, richness and distribution in Rupnarayan River

No	Family	Order	Fish Species	Sampling Sites			Richness	Abundance
				S1	S2	S3		
1	Engraulidae	Clupeiformes	Setipinna phasa	5	3	-	2	8
2	Cyprinidae	Cypriniformes	Puntius sarana	10	6	5	3	21
3			Puntius ticto	6	5	4	3	15
4			Puntius vittatus	2	-	3	2	5
5			Chela cachius	4	6	2	3	12
6	Cichlidae	Perciformes	Oreochromis mossambicus	-	1	-	1	1
7	Bagridae	Siluriformes	Mystus tengara	15	8	7	3	30
8			Mystus seenghala	2	3	1	3	6
9			Mystus cavasius	2	-	-	1	2
10	Siluridae		Ompok pabda	10	7	3	3	20
11			Ompok bimaculatus	2	-	3	2	5
12			Arius maculates	5	9	-	2	14
13	Schilbeidae		Silonia silondia	3	2	-	2	5
14	Sciaenidae	Perciformes	Johnius coitor	3	1	-	2	4
15	Synbranchidae	Synbranchiformes	Monopterus cuchia	4	1	-	2	5
16	Clupeidae	Clupeiformes	Ptenualosa ilisha	6	7	-	2	13
17			Gudusia chapra	7	3	-	2	10
18	Polynemidae	Polynemiformes	Polynemus paradiseus	12	6	-	2	18
19	Pangasidae	Siluriformes	Pangasius pangasius	1	-	1	2	2
20	Centropomidae	Perciformes	Latis calcarifer	4	-	1	2	5
21	Palaemonidae	Decapoda	Macrobrachium rosenbergii	-	1	2	2	3
22	Cynoglossidae	Pleuronectiformes	Cynoglossus cynoglossus	3	1	1	3	5
23	Mugilidae	Mugiliformes	Mugil parsia	5	2	3	3	10
24			Mugil cephalus	4	3	-	2	7
25	Anabantidae	Perciformes	Colisa fasciata	3	4	5	3	12
26	Osphronemidae		Colisa chuna	4	6	3	3	13
27	Amassidae		Chanda nama	6	2	-	2	8
Total				128	87	44		

Among the collected species, order Siluriformes was most abundant in all sites besides this order Perciformes, Cypriniformes, Clupeiforemes, Synbranchiformes, Polynemiformes, Pleuronectiformes, Mugiliformes and another important invertebrate Phylum Arthopoda including order Decapoda also present but these numbers are very much less in all sites (Fig. 2). In this case fish species distribution is quite variable because of environmental conditions. The list of fish species recorded from three sampling sites is given in Table- 2.

In our study the Simpson's index of Diversity (1-D) for site- 1 is 0.951, Site -2 is 0.947 and site- 3 is 0.932 (Table- 1). During the period of investigation the richness is high in site-1 and site-2 in comparison to site-3. Among the collected species, family Cyprinidae was most profuse in all sites after this Siluridae was dominant besides this family Bagridae, Clupidae, Mugilidae, Polynemidae, Osphronemidae, Engraulidae, Cichlidae, Schilbeidae, Sciaenidae,

Synbranchidae and so on is also present but its number is very much less (Fig. 1). The abundance is high in site-1 in comparison to site-2 and site-3 (Table- 1).

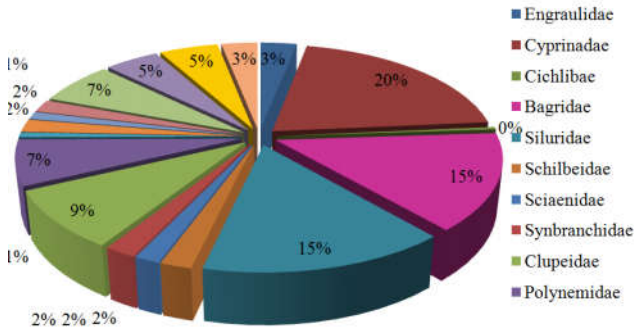


Fig. 1. Percentage occurrence of fish families of the Rupnarayan River, India

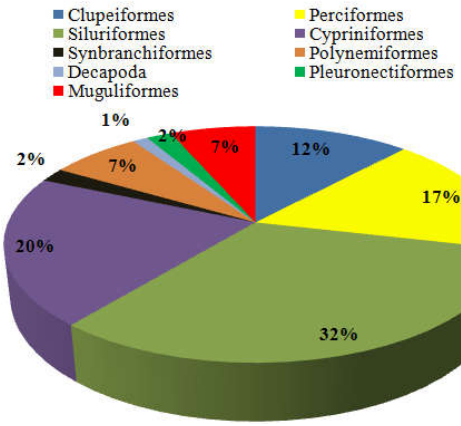


Fig. 2. Percentage occurrence of fish orders of the Rupnarayan River, India

Seasonal Variations in Physicochemical Parameters of Rupnarayan River: Among habitat attributes, pH, temperature, total dissolved solid, BOD, DO and total solid were varying considerably from season to season. Water temperature ranged from 26°C to 32 °C throughout the study period. Highest water temperature was recorded during summer season (32°C) whereas least was observed in winter season (26 °C) (Table 3). (S1=Site 1, S2=Site 2, S3=Site 3).

is very high in Site-3 and low in Site-2 in all seasons which directly affect the fish diversity (Fig. 4).

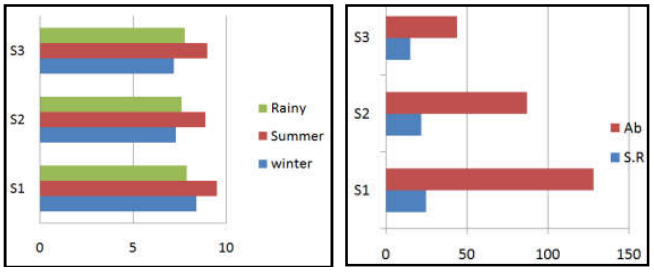


Fig. 3. Effect of (A) pH of Rupnarayan River compared with (B) species richness and abundance

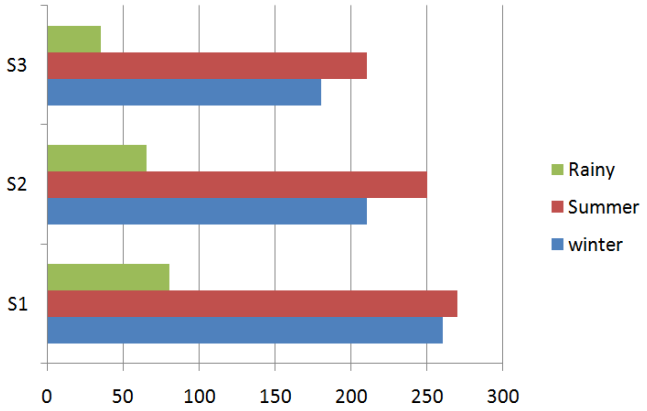


Fig. 4. Effect of (A) BOD of Rupnarayan River compared with (B) species richness and abundance

In site-3 the fish diversity, abundance and richness is minimum because here the BOD level is very high and in the site-1 or 2 BOD level is low. It means high level of fly ash pollution decline the fish diversity. Dissolved oxygen (DO) is the most important parameter which can be used as an index of water quality, primary production and pollution. DO values ranged from 3.3 to 6.0. Minimum values of DO were recorded in Site-3 and maximum in Site-1. Maximum DO may be due to low atmospheric temperature. Similar trends were made by Senthil *et al*. (2012). BOD has been used as a measure of the amount of organic materials in aquatic solution, which support the growth of micro organisms.

Table 3. Seasonal variations of physicochemical parameters of Rupnarayan River

Season	Temperature (^{0}c)			pH			Suspended solid (g/l)			Total dissolved oxygen (mg/l)			BOD (mg/l)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Winter	26.1	26.0	26.7	7.2	7.3	8.4	2.8	3.0	3.5	6.0	5.8	5.0	180	210	260
Summer	32	31.5	30.6	8.9	9.0	9.5	2.8	3.0	4.0	5.2	4.6	4.2	210	250	270
Rainy	28.6	27.4	28.0	7.6	7.8	7.9	3.5	3.4	4.6	4.6	4.0	3.3	35	65	80

The pH was observed in the range of 7.2 (Site-1) to 9.5 (Site-2) which indicates that water was slightly alkaline in nature (Table-3). pH also effect on the number of fish. In S_3 the pH is high and species richness (SR) and abundance (Ab) is low and S_1 pH is Low and richness and abundance is high (Fig. 3). Suspended solid ranged between 2.5g/l to 4.9g/l during study period. And it is highest in Site-3 (4.6g/l) and lowest in Site-2 (2.8g/l). It is clear from following work that fish diversity is depending upon the physicochemical parameter. The BOD

During rainy season, BOD values were low; this is because the temperature retards the rate of reproduction of organisms. Similar observations were also made by Mane and Madlapure (2002).

DISCUSSION

The overall diversity of fish (27 fish species) found in the present study was significantly lower than the number of

species (33) reported from river Bhadra (Thirumala *et al*., 2011). Ahirrao and Mane (2000) recorded 32 fish species belonging to 25 genera, 8 families and 2 orders from fresh waters of Parbhani district of Maharashtra state and Sakhare (2001) recorded 23 fish species belonging to 7 orders in Jawalgaon reservoir in Solapur district. Hiware and Pawar (2006) recorded 43 fish species from Nath Sagar dam, Pathan, in Aurangabad district. In a study from neighboring state of Andhra Pradesh (Savalla Murli Krishna and Piska , 2006) recorded 31 fish species from secret lake Durgamcheruvu, Ranga Reddy district near Hyderabad. It was also recorded (Sukla and Singh , 2013), a total of the occurrence of 18 fish species belonging to 6 order, 11 family and 17 genera of Aami river in Gorakhpur district under Uttarpradesh state. This is very inferior to the other study. According to them, among the collected species, order Cypriniformes was most abundant all sites besides this order Beloniformes, Mastacembelida, Clupeiforemes, Symbranchiformes, Perciformes also present but its number is very less in all sites. The distribution of fish species is quite variable because of environmental conditions.

But from our study analysis, it was observed that the effect of hot water and ash pond slurry from Kolaghat Thermal Power Station (KTPS) disposal on fresh water ecosystem especially change water quality characteristics, fish diversity which have been investigated for a period of one year in three different sites including mixed hot waste water discharge point. Thermal power plants in the temperate zone are discharging the coolant water (heated effluent) into the fresh waters regularly. Such discharged effluent waste water affect the fresh organisms attached to intertidal substrates in the vicinity (Straughan, 1980). The impact of heated effluents on community structure of coastal ecosystem in temperate areas is many (Markowsk, 1960). Mean temperature of site- 1, 2 and station 3 is 28.9 ^{0}C, 28.3 ^{0}C and 28.4 ^{0}C respectively. Minimum (26 ^{0}C) was recorded in the month of November at site- 2 due to rainfall effect. So fly ash effluents directly influence the river water resulting increases temperature. The study finding also showed that temperatures have been decreasing with increasing the distance of the sites.

Dissolved oxygen content of the study area have been increased in site- 1 with increasing distance from discharge point. The temperature is decreased in site-2 and site-3 because of mixing of water. However oxygen level is also increased with distance from the discharge point. It shows that temperature is affecting the dissolved oxygen level in water (Theis, 1975; Guthrie *et al*., 1982; Subramanian *et al*., 1990). Similar observations have been reported (Kailasam and Sivakami, 1996) of the Tuticorin bay. From our observation it was reflected that BOD was more in Site 3 than 2 and 1. Fish biodiversity of River essentially represents the fish faunal diversity and their abundance. River conserves a rich variety of fish species which support to the conservation. This will go a long way towards protecting commercial fisheries (Shinde *et al*., 2009). The present study revealed that physical habitat variables play key role in the fishes in the River Rupnarayan. We observed that among habitat attributes, dissolved oxygen and pH are key habitat features and correlated with the fish diversity and found most important variables in shaping fish distributions. In the discharge area, microbial decomposition of these wastes exerts high BOD and creates anaerobic condition (Francis *et al*., 2006). The study findings showed that fish diversity of the study area is reducing due to the increase of fly ash effluents water pollution.

Fish diversity is low in the discharge points (site- 2 and site- 3) rather than fresh point (site 1). The reduced fish diversity eventually decreases the fish production of native species and creates extinction of several species. These consequences eventually create instability in the socio-economic sector in terms of increased poverty of local fishermen. It reveals that, a rapid decline in fish diversity at discharged zone (polluted) of the Rupnarayan River. This investigation would be used as a tool for controlling the waste water pollution at KTPS adjoining Rupnarayan River and conserving the fish species in this river with the rapid increase in the consciousness human population. Moreover, to increases the Hilsa species fisherman population will have to ensure journey of a long distance of the river for fishing. Uses of small mesh size n*et al*so to be restricted particularly in the breeding season to increase the availability of fish species. The effluents from fly ash disposal ponds thus pose significant problems to aquatic ecosystem by affecting the physico-chemical parameters and the biota of the receiving water. Therefore, for wet-ash disposal, constant monitoring of water quality and stringent laws for disposal of effluents from thermal power stations are most important. Any deviation would lead to further erosion of biodiversity that would be detrimental for fisheries and environment as a whole.

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