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Study on The Physico-Chemical and Microbial Profile of The Pond Water in Context of Pollution at Kolaghat Thermal Power Plant, West Bengal, India

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ABSTRACT

We investigated the fluctuations of physico-chemical and microbial profile of pond water at different stations due to leaching of effluent and flying ash from Kolaghat thermal power plant (KTPP), West Bengal, India. The fluctuations of electrical conductivity, Water pH, water temperature, alkalinity, hardness, Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), heavy metals and coliform load was observed with respect to direction and distance from thermal power plant. We observed that all the studied parameters are higher in the North and South side pond water which are mainly due to directly connected with ash disposal line and fly ash throughout the year. Therefore, proper monitoring is required to minimize the effect of fly ash and bottom ash originated from kolaghat thermal power plant, otherwise pose an adverse effect on socio-economic development in the kolaghat, purba Medinipur, West Bengal, India.

KEYWORDS : Physico-chemical, Microbial profile, Kolaghat thermal power plant, Fly ash

Introduction

Coal is the only natural resource and fossil fuel for electricity generation through out the world with the ever-increasing growth in human civilization, for example, advances in industrial development and human living standards (Mishra, 2004). In India, Power generation has increased manifold in the recent decades to meet the demand of the increasing population(Jamil et al, 2009). Generating capacity has grown many times from 1362MW in 1947 to 147,403MW (as on December 2008). India has about 90,000 MWe installed capacity for electricity generation, of which more than 70% is produced by coal-based thermal power plants. The coal available in India is of poor quality, with very high ash content and low calorific value. High ash content in Indian coal and inefficient combustion technologies contribute to India's emission of air particulate matter and other trace gases, including gases that are responsible for the greenhouse effect. Combustion of coal at thermal power plants emits mainly carbon dioxide (CO2), sulphur oxides (SOx), nitrogen oxides (NOx); CFCs other trace gases and air borne inorganic particulates, such as fly ash and suspended particulate matter (SPM). CO2, NOx and CFCs are greenhouse gases (GHGs). The present coal consumption in thermal power station in India results in adding ash estimated 12.21 million tons fly ash in to the environment a year of which nearly a third goes in to air and the rest is dumped on land or water(Shamshad et al, 2012).

The solid wastes produced from the coal-fired thermal power plants are mainly of two types, i.e. fly ash and bottom ash. Bottom ash is the coarse-grained fraction that is collected from the bottom of the boiler and is disposed of by the wet disposal methods in a slurry from to nearby waste disposal sites (ash ponds). Fly ash consists of finer sized particles, ranging from 0.5-200 um. Owing to its relatively small size and , hence, large surface area, the ashes have a greater tendency to absorb trace elements that are transferred from coal to waste products during combustion (Shamshad et al, 2012). Most of the toxic elements (As, Cd, Cr, Ni, Co, Cu and Sb) become enriched in the soil and ground water through leaching from the bottom ash , causing soil and water pollution. The fly ash emitted from the stacks is dispersed in the air and remains suspended for long periods of time causing air pollution in the neighbouring areas. On this background, we study the Physico-chemical and Microbial profile of the pond water in context of pollution at Kolaghat thermal power plant, West Bengal, India.

Materials and methods

Study area

The present study was conducted around the Kolaghat thermal power plant (KTPP) which is situated in the Midnapur district of West Bengal and near Mecheda railway station on the South-Eastern Railways route. It is located at latitude 22°25'N and longitude 87°53'E.The sampling stations was selected on the basis of buffering around KTPP in different direction (Fig.1) as North (N), South (S) and West (W) but East (E) side was not selected due to presence of Rupnarayan river.

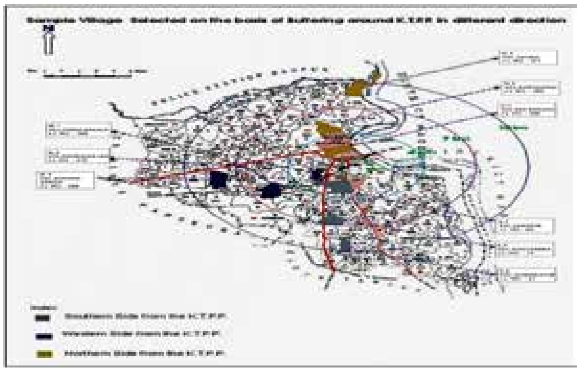


Fig.1 Map of the study region showing the sampling stations namely North (N1,N2,&N3), South (S1,S2, &S3), and West (W1,W2, &W3)

Sampling

The water sample was collected from different pond around the Kolaghat thermal power. The water samples were collected from all the nine selected stations between 8 to 10 a.m of 10 cm below the water surface in the month of May 2013. Samples were collected in plastic bottles for physico-chemical analysis. For Biochemical oxygen demand (BOD) and dissolved oxygen (DO), samples were collected in BOD bottles. Temperature and pH of the water were measured at the sampling sites. The anthropogenic stress of the selected station are tabulated below -

Table-1 Characteristics of anthropogenic sourses in different sampling stations

Sample stations	Distance from KTPP (Km)	Remarks
N1	4	Linked with land and domestic waste water and affected by fly ash and bottom ash
N2	7	Linked with land and domestic waste water and affected by fly ash and bottom ash
N3	10	No such any linked but affected by fly ash and bottom ash
S1	4	Linked with land and domestic waste water and directly connected with ash disposal line throughout the year
S2	7	Linked with land and domestic waste water and affected by fly ash
S3	10	Linked with land and domestic waste water and affected by fly ash
W1	4	Linked with Agricultural land
W2	7	Linked with Agricultural land
W3	10	Linked with Agricultural land

Methods for analysis of physico-chemical and microbial parameters

For chemical variables of water like dissolved oxygen, Biochemical oxygen demand , Chemical oxygen demand , total alkalinity, conductance, and total hardness etc, was analyzed by the standard method of APHA (2005) and Trivedy and Goel (1986).

pH was measured using pH meter and temperature was measured using simple, mercury filled Celsius thermometer.

For heavy metal analysis, water samples were filtered through Nuclepore filters (0.4 µm pore diameter) and aliquots of the filters were acidified with sub-boiling distilled nitric acid to a pH of about 2 and stored in cleaned low-density polyethylene bottles. Dissolved heavy metals were separated and pre-concentrated from the seawater using dithiocarbamate complexation and subsequent extraction into Freon TF, followed by back extraction into HNO3(Lindsay et al , 1978). Extracts were analyzed for Zn, Cu, Mn and Fe by Atomic Absorption Spectrophotometer (Perkin Elmer: Model 3030).

The coliform bacteria present in water was done by using standard procedure mentioned by APHA (1998).

Results and discussion

Water temperature and pH

The surface water temperature at all the sampling stations showed a more or less parallel trend of variation. In the present study, the water temperature was found to be directly influenced by air temperature and hence showed average temperature is 32°C because during May month, air temperature is upward trend. Similarly, the water pH of all the stations showed slightly alkaline and remained almost constant (table 2). Alkaline pH of each water bodies was due to the dissolved the flying ash in the the water because the pH of fly ash is generally highly alkaline due to low sulfur content of coal and presence of hydroxides and carbonates of calcium and magnesium. According to Boyd (1990), the pH can also affect fish health. For most freshwater species, a pH range between 6.5 - 9.0 is ideal, but most marine animals typically cannot tolerate as wide range pH as freshwater animals, thus the optimum pH is usually between pH 7.5 and 8.5. Therefore, the observed pH and temperature of water in different stations indicates good water quality as it falls within the normal range for aquaculture.

Total hardness and alkalinity

Hardness in water is due to the natural accumulation of salts of mainly Calcium and Magnesium. The station wise values of total hardness of the pond water are depicted in Table 3. According to Kannan (1991), water with the hardness having values more than 180 mg/L is very hard. The acceptable limit of total hardness is 500mg/L (WHO, 1983). Based on the total hardness, Sawyer and McCarty (1966) have classified the water into four classes such as soft (less than 75mg/L), moderately hard (75-150mg/L), hard (150- 300mg/L) and very hard (more than 300mg/L). The standard unit for the total hardness specified is 300mg/L and is considered potable; beyond this limit it produces gastrointestinal irritation (ICMR, 1975). In the present study, total hardness ranged from 152±1.2 mg/L to 322±8.2 mg/L (Fig.2, Table 2). Therefore, South and Northern side of water sample is not potable for domestic perpose. This may be due to both domestic waste water, fly ash and bottom ash which is absent in western side.

The alkalinity of the water fluctuated from 48.1±1.01 mg/L to 96.1±0.77 mg/ L (Table 2). The range of alkalinity in Indian waters varies from 40mg/L to over 1000mg/L but the recommended alkaline values for aquaculture production and natural system are –

Recommended alkaline levels for aquaculture production

Total alkaline value (mg/L)	**Species**
> 20	Catfish
> 80-100	Hybrid striped bass

Recommended alkaline levels in natural system

Total alkaline value (mg/L)	**Natural System**
5-500	Freshwater
116 (mean value)	Seawater

Source: Lawson, 1995

Therefore, water from all the stations are not good quality with respect to its alkality but maximum values of bicarbonates alkalinity recorded at station S1 was probably due to the input of domestic sewage and directly connected with ash disposal line throughout the year.

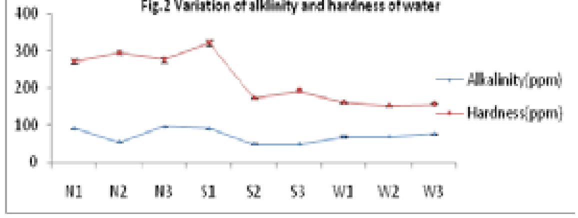


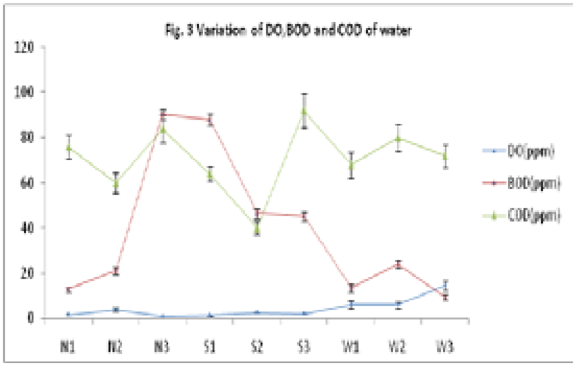
Fig.2 Variation of alklinity and hardness of water

Dissolved oxygen, Biochemical oxygen demand and Chemical oxygen demand (COD)

The dissolved oxygen (DO) is one of the most important parameters of water quality assessment. It plays an important role on the biotic life of a aquatic system and this can be used as an index of water quality for pollution studies (Thirumala et al., 2011). The concentration of dissolved oxygen of the water was fluctuated in different stations (Fig.3 ,table 2). Maximum values of DO observed were 14.6±2.25 mg/lit at station W3 and minimum values observed were 1.0±0.02 mg/ lit at station N1 during the study period. High values of DO at W3 could be due to greater macro vegetation which is absent in north and south side. At station N3, saturation level of dissolved O2 was very low (1.04 ppm). It may be due to high rate of oxygen consumption by oxidizable matter coming in along with sewage.

Low level of DO is again indicative of polluted nature of water body. Such low level of oxygen was also noted by Iqbal et al. (2006) on addition of sewage waste from human settlements to Dal Lake. Dissolved oxygen is considered as one of the most important aspect of aquaculture. It is needed by fish to respire and perform metabolic activities. Thus low levels of dissolved oxygen are often linked to fish kill incidents. On the other hand, optimum levels can result to good growth, thus result to high production yield. In general, a saturation level of at least 5 mg/lit is required (Lioyd, 1992). Values lower than this can put undue stress on the fish, and levels reaching less than 2 mg/L may result to death (but 3 mg/L to some species). Therefore, Western side is considered as suitable site for aquaculture than Northern and southern sampling site.

The BOD and COD of water sample varied from 9.3±1.2 to 90.2±2.1 ppm and 40±3.1 to 92±7.7 ppm throughout the sampling stations (Fig.3 and table 2). Higher values of BOD may be attributed to the maximum biological activity at elevated temperature, whereas the lowest BOD in indicated lower biological activity. Similar observations were made by Rao et al., 1985. Station wise, the BOD values show high fluctuation primarily due to the addition of domestic sewage. Higher BOD and COD values were recorded at station N3, owing to high amount of organic matter in domestic sewage and fly ash from KTPP because of strong south-west wind stress. Kudesia and Verma 1986 and Mahadevan and Krishnaswamy, (1984) also reported that an increase in BOD level as indicative of increasing pollution, which is supported by Sinha, (1988) Chandrashekar et al., 2003.



Heavy metals in water

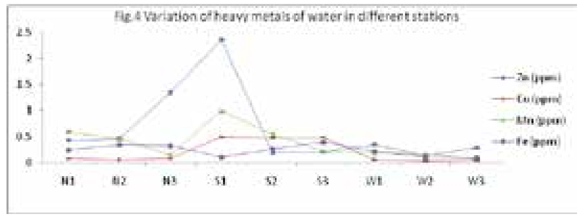
The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both man and animal. Nowadays, the increasing use of the waste chemical and agricultural drainage systems represents the most dangerous chemical pollution. The most important heavy metals from the point of view of water pollution are Zn, Cu, Pb, Cd, Hg, Ni and Cr. Some of these metals (e.g. Cu, Ni, Cr and Zn) are essential trace metals to living organisms, but become toxic at higher concentrations. Others, such as Pb and Cd have no known biological function but are toxic elements. The permissible level of studied metal for animal are-

Permissible level*	Cu	Zn	Fe	Mn
Water(ppm)	1	20	0.01	0.2

*** Permissible level as recommended by Egyptian Organization for Standardization (1993)**

The same is true for certain elements with respect to drinking water. Selenium, for example, is essential for humans but becomes harmful or even toxic when its concentration exceeds a certain level. Metal concentrations in water at different water sample are illustrated in Table -3 and Fig.4. Metals concentrations in water were found in the following order: Zn > Mn > Cu> Fe.

Present study revel that the concentration of heavy metal in water is belongs to permissible lebel except Fe and Mn, therefore hardness increases and create adverse effect on aquatic animal.



Conductance

Electrical conductivity of water at different stations was recorded to be 1060 to 2040 µmhos/cm(table-3). Freshwater, fish ponds, in general, exhibit low EC values which may be expressed as µmoles cm^{-1}. Sharma et al (2011) stated that natural waters usually have EC values of 20 to1500 µmhos/cm. But, present result indicates that four pond water (N1, N2, N3 and S3) have high EC value which is not suitable for aquaculture. Natural water has low conductivity, but pollution increases it. Most of the salts dissolved in water can conduct electricity. Thus, the electrical conductivity of water depends upon the concentration of ions and the status of nutrient in it.

Highest value, 2040 µmhos/cm, was recorded at station N3. This might be due to the addition of sewage into it. An increase in electrical conductivity is regarded as pollution indicator in water bodies (Das et al., 2006).

Coliform in water

Coliform bacteria consist of several genera belonging to Family *Enterobacteriaceae.* Fecal coliform which belongs to this group is found mostly in feces and intestinal tracts of humans and other warm blooded animals. It is not pathogenic per se; however, it is a good indicator of the presence of pathogenic bacteria. High levels of fecal coliform in the water may cause typhoid fever, hepatitis, gastroenteritis, dysentery and eat infection. In recent times increased attention is given to the possibility of cultured fish as vector of human pathogenic bacteria (Islam et al., 2000). Fish living in natural environment are known to harbor pathogenic Enterobacteriaceae (pillay, 1990). Invasion of fish muscles due to the breakage of immunological barrier of fish by pathogen is likely to occur, when the fish are raised in pond with coliform of greater than 10^4per 100 ml, in pond water (Guzman et al., 2004).

The maximum density of total coliform (TC) in the water was recorded in N1 and N2 station and low amount of TC was enumerated in W3 station(Table- 3) but the coliform load in all the stations are exist in the normal range for aquaculture.

CONCLUSION

Results from this work demonstrate the need for future monitoring of the biological effects in the Northern and Southern sector of Kolaghat Thermal power plant. Data from the present study also conclude that water pollution in North and South side of KTPP have been associated with the fly and bottom ash from kolaghat power plant. Therefore, modern technology is required to minimize the pollution from thermal power plant for ensuring health safety.

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Table 2 Determination of Physico-chemical and coliform load in pond water from kolaghat thermal power plant

Pond water	DO (ppm)	BOD (ppm)	COD (ppm)	Water pH	Water Temp. (°C)	Alkalinity (ppm)	Hardness (ppm)	Coliform (MPN/100ml)
N1	1.6±0.08	12.9±1.2	76±5.1	7.4±0.01	32.0±2.2	90.6±0.50	272±4.8	24000±350
N2	4.0±1.09	21.2±1.5	60±4.5	7.7±0.02	32.5±2.1	54.6±1.05	294±5.0	24000±35
N3	1.0±0.02	90.2±2.1	84±6.0	7.8±0.02	32.0±2.0	96.1±0.77	276±6.0	3500±321
S1	1.3±0.01	88.0±2.5	64±3.2	7.8±0.02	33.0±2.2	90.2±0.52	322±8.2	170±55

Pond water	DO (ppm)	BOD (ppm)	COD (ppm)	Water pH	Water Temp. (°C)	Alkalinity (ppm)	Hardness (ppm)	Coliform (MPN/100ml)
S2	2.6±0.01	46.5±2.2	40±3.1	7.3±0.01	32.5±2.1	49.2±1.10	172±1.8	330±192
S3	2.0±0.01	45.1±2.0	92±7.7	7.4±0.01	33.0±2.0	48.1±1.01	192±2.0	9200±200
W1	6.2±1.68	13.4±1.8	68±5.6	7.2±0.01	32.5±2.1	68.6±2.57	160±1.5	16000±390
W2	6.0±1.51	24.1±1.7	80±5.9	7.5±0.02	33.0±2.2	69.2±0.75	152±1.2	120±30
W3	14.6±2.25	9.3±1.1	72±4.9	7.6±0.02	32.0±2.0	76.3±0.68	156±1.6	60±22

Table 3 Heavy metal and conductivity in different pond water from Kolaghat Thermal power Plant

Pond water	Distance from KTPP (Km)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)	EC (mmoh/cm)
N 1	4	0.43±0.015	0.08±0.003	0.59±0.011	0.24±0.009	1.54±0.007
N2	7	0.45±0.013	0.06±0.001	0.47±0.029	0.34±0.012	1.70±0.008
N3	10	1.35±0.236	0.08±0.003	0.16±0.004	0.32±0.015	2.04±0.007
S 1	4	2.36±0.101	0.49±0.006	0.99±0.008	0.11±0.002	1.16±0.002
S 2	7	0.19±0.006	0.47±0.002	0.54±0.046	0.26±0.005	1.14±0.005
S 3	10	0.21±0.007	0.48±0.002	0.22±0.007	0.39±0.009	1.63±0.009
W 1	4	0.35±0.011	0.06±0.004	0.19±0.025	0.22±0.008	1.13±0.001
W 2	7	0.14±0.001	0.03±0.013	0.17±0.002	0.11±0.001	1.12±0.001
W 3	10	0.29±0.005	0.04±0.002	0.073±0.003	0.09±0.001	1.06±0.002

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