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RESEARCH ARTICLE

Assessment of water quality of Chatta canal affected by textile bleaching, dyeing and printing effluents in Maheshtala Region, South 24-Parganas, West Bengal, India

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Abstract

Chatta Canal and Churial Canal are under severe pollution stress due to the discharges of huge quantity of effluent from more than 800 tiny and small scale (SSI) textile bleaching, dyeing and printing units located at Maheshtala Region (22.29 ^{0} N, 88.11^0 E), South 24-Parganas, West Bengal. In the past, the canal was a source of fishing and feeding water to the adjoining land for irrigation. The canal now carries exclusively industrial effluents and sewage except in rainy season and hence poses severe threat to agri-irrigation. Surface water samples were collected from various locations of Chatta canal during summer, rainy and winter season for two years (2012-13) for assessment of water quality following standard analytical methods. The study revealed that the chemical parameters like COD (552mg/l), suspended solids (540mg/l), total dissolve solids (3398 mg/l), biological oxygen demand (172 mg/l), carbonate (711mg/l), Chromium (0.10mg/l) and Lead (0.027 mg/l) exceeded the maximum permissible discharge limits laid down by Bureau of Indian Standards (BIS) and WHO (2003) standards. Hence, a comprehensive eco-planning is urgently required to reduce contamination of agricultural fields as well as crops, fruits and vegetables grown for human consumption.

INTRODUCTION

Textile industries are considered as one of the most polluting industries. These industries consume high quantum of underground and surface water. The discharges from such textile units into surface water bodies have adverse effects on both the physicochemical and biological profile (Sagodoyin, 1991). Those contaminated and degraded surface waters, in turn become unfit for agricultural, drinking, industrial, recreation and other purposes (Simenonov et al., 2003; Jarvie, 1998). Several unclassified chemicals belonging to the red list of the Pollution Control Board which are considered to be harmful and unhealthy are in regular use in this textile hub (Ravikumar and Dutta, 1996). Dyeing is a combined process of colouring and bleaching which generates large quantities of waste water and is discharged to the adjoining canal and land creating environmental degradation. The textile effluents consists of high concentration of BOD, COD, TDS, TSS, chlorides, $CaCO_3$, heavy metals and carcinogenic dye ingredients (Tchobanoglous and Burton, 1995). Several studies (Khadka and Khanal, 2008; Mtethia et al., 2008; Vega et al. 1998) have assessed the effects of dying effluents on surface waters like river and canal as well as on adverse biological effects (Kannan et al., 2005; Olayinka and Alo, 2004; Navarro et al., 2001). Further, in the bleaching and dyeing units the bleaching chemical and colour dyes are frequently used which impart ecotoxic and genotoxic effects (Sankar, 2000).

So far, there is no comprehensive study of the quality of canal water and its effect on agricultural land and water body in Chatta, Mahishpota, Kalikapur under Maheshtala region. The object of the study is to ascertain the pollution level of the canal water and its impact on agricultural land and crops.

Study Area :

Maheshtala is an urban area having administrative headquarter at Alipore of South 24-Parganas district of West Bengal (Fig. 2 and 3). The area lies between 10.45^{0} N latitude to $75.90\ ^{0}$E longitude with a population of 185,567 as per 2011 census with 700 bleaching and dyeing units. Chatta, Chatta bazaar, Mahishpota, and Kalikapur are the area where the study was conducted. Chatta canal is passing through this area (Fig. 1). The wastewater of Chatta canal is falling on Churial canal at Mahishpota. The Churial canal meets the Hoogly River at Budge Budge. The Chatta canal is 12 Km long and receives the maximum effluent of the bleaching and dyeing units from these area. Apart from that the canal also receives waste water and sewage from different inters connecting drains of the neibourhood. The water caring capacity of Chatta canal is reducing over the years due to improper cleaning and siltation. The slope of the Chatta canal is generally less than 5%. Effluent discharged from bleaching and dying units in the surrounding area and villages in this area has caused severe pollution and contamination of water quality. Untreated effluents from this industries are discharged to the open adjoining land partly seeps into the underground aquifer and partly discharged into surface water increases the concentration of pollutants resulting in damage of agriculture land and its crops and other produces.

Fig. 1. The location of Chatta canal in Maheshtala region.

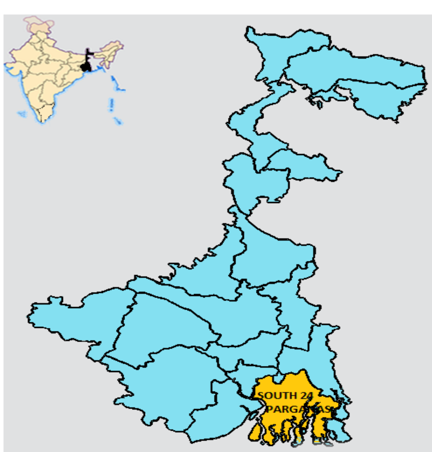

Fig 2: Map of West Bengal

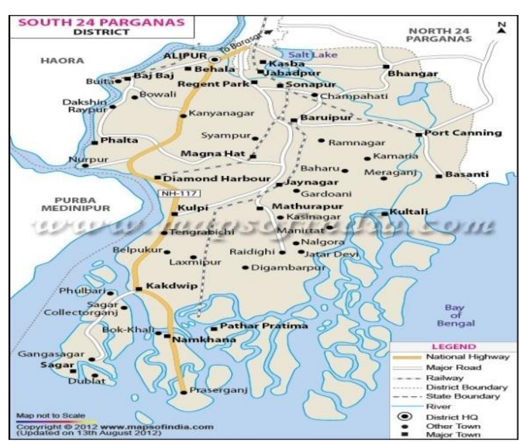

Fig3: Map of South 24 Parganas showing Maheshtala

Materials and Methods

Water samples were collected from seven different points of Chatta canal during three different seasons, viz., summer, rainy and winter for two consecutive years (2012-2013). pH and dissolved oxygen (DO) were measured by portable meters and electrical conductivity was measured by portable EC meter in the field. Alkalinity, calcium, magnesium, chloride were measured by titrimetric methods. Sodium and potassium were measured by Flame photometer (AIMIL),turbidity and sulphate by turbidity meter (SISTRONICS), nitrate by UV spectro photometer (SISTRONICS). For heavy metal samples were filtered by WHATMAN filter–paper no.40 and then acidified with AR HNO_3 (0.1%). Metal concentrations were determined by atomic absorption spectrophotometer. For analysis of COD, samples were stabilized by acidifying with H_2SO_4 below 2 and it was measured by dichromate titration method.. All the above parameters were measured as suggested by American Public Health Association (APHA, 2001).

Results and Discussion:

The canal water has maximum flow of bleaching, dyeing and printing effluents discharged from different industrial units. The pH of canal water in various locations was found to vary between 6.8 -7.9. The effluent flowing in the canal is thus alkaline in nature at all the sites studied. Highest value of pH was observed at Chatta. For various reasons alkaline effluent discharged directly into the canal stretch which exceeds the maximum permissible limits (5.5- 9.0) as prescribed by Bureau of Indian Standard (BIS) for industrial effluent. The nature of effluents flowing in the canal bed is highly saline. Due to excessive use of salt and acids like sodium carbonate, sodium bicarbonate, sodium hydroxide, sodium silicate, sodium peroxide, sodium bisulphate, bleaching powder, sulphuric acid, acetic acid, tannic acid, detergents in various preparatory and dyeing process of grey clothes. The total dissolved solids (3398 mg/l), biological oxygen demand (365 mg/l), carbonate (867mg/l), chromium (0.10mg/l) and lead (0.027 mg/l) forms the major quantity of the dissolved solids . The obtained results are presented in Table 3. The standard tolerance limits for irrigation water are given in Table 2 below.

Table1. Types of pollutants associated with various types of dyes

Class	Fiber	Nature of pollution
Direct dye	Cotton	Salts,unfixed dyes, copper salts, cationic fixing agents
Reactive dye	Cotton	Salts, unfixed dyes, alkali
Vat dye	Cotton	Alkali, oxidizing agent, reducing agent
Sulphur dye	Cotton	Alkali, oxidizing agent, reducing agent, unfixed dyes
Acid dye	Wool	Unfixed dyes, organic dyes
Disperse dyes	Polyester	Carriers, reducing agent, organic acids

Table.2. Tolerance limit and excessive limits of irrigation water quality parameters as prescribed by WHO(2003), FAO(1985), BIS(1991)

Parameter	Tolerance Limit (standard)	Excessive Limit
pH	7.5	4.5 if < 7.5 9.6 if > 7.5
Nitrate (NO_3, mg/l)	25	140
Chloride (Cl, mg/l)	250	1000
Sulphate (SO_4, mg/l)	200	500
TDS (mg/l)	500	2000
TSS (mg/l)	500	1000
Chromium (Cr, mg/l)	1.0	5.0

Lead (Pb, mg/l)	5.0	15.0
Copper (Cu, mg/l)	0.2	1.0
Arsenic (As, mg/l)	0.05	1.0
Zinc (Zn, (mg/l)	5.0	15.0
E. coli (CFU/100ml)	5000	10000
BOD (mg/l)	10	20
COD (mg/l)	250	500

Table 3. Physicochemical parameters of Chatta Canal water at different sites. S1-S7 designate samples collected from different points of Chatta canal during different seasons for two year (2012-13). TSS= Total suspended solids, TDS= Total dissolved solids, summer indicates month of April, May and June, Rainy indicates July, August and September, Winter indicates October, November, December and January.

Sl no.	Parameters	S1 Summer’12	S2 Summer’12	S3 Summer’12	S4 Rainy’12	S5 Rainy’12	S6 Winter’12	S7 Summer’13
1	pH	7.6	7.0	6.9	7.2	7.1	7.9	6.8
2	Turbidity(NTU)	-----	42	40	8.7	16	60	15.70
3	Temp ^{0}C	34	37	35	31	31	29	30
4	TDS (mg/l)	3394	---	---	2240	---	2700	3398
5	BOD (mg/l)	-----	172	365	40	16	91	22
6	COD (mg/l)	----	552	979	125	70	256	80
7	TSS (mg/l)	52	540	110	30	22	51	48
8	$CaCO_3$ (mg/l)	---	---	666		---	867	601
9	DO	---	----	0.00	0.90	4.00	0	5.00
10	Fe (mg/l)	---	-----	0.35	0.21	0.11	1.54	----
11	Cd (mg/l)	0.01	0.013	0.019	0.00	0.00	0.023	0.003
12	Pb (mg/l)	0.013	0.22	0.06	0.02	0.027	0.103	0.014
13	Cu (mg/l)	0.05	----	0.006	0.01	-----	----	----
14	Zn (mg/l)	0.05	0.94	0.284	1.15	0.18	----	----
15	Cr (mg/l)	0.03	0.05	0.007	0.00	0.061	0.061	0.025
16	Ni (mg/l)	----	0.012	0.05	0.05	----		-----
17	As (mg/l)	0.004	0.013	0.011	0.011	0.00	0.037	0.028
18	*E.coli* (CFU/100ml)	----	---	380000	10000	------	12000	12000
19	Na (mg/l)	----	-----	-----	-----	-----	----	861
20	NO_3 (mg/l)	-----	-----	-----	-----	-----	3.98	13.9
21	Floride (mg/l)	----	-----	-----	-----	-----	-----	0.23

Table 4: Mean values of different physicochemical parameters of canal water during Summer, Rainy and Winter season along with tolerance limits (standard) as per WHO (2003).

SL No.	Parameters	Summer (2012)	Rainy (2012)	Winter (2012)	Summer (2013)	Tolerance Limit
1	Temp ^{0} C	35	31	29	30	
2	pH	7.16	7.10	7.9	6.8	7.5
3	TDS (mg/l)	3394	2240	2700	3398	700

4	TSS (mg/l)	234	26	50	51	1000
5	BOD_5 (mg/l)	268	28	91	22	10
6	COD (mg/l)	765	98	256	80	250
7	DO (mg/l)	0.00	2.5	0.00	5.0	6.0
8	$CaCO_3$ (mg/l)	666	461	867	601	500
9	Cd(mg/l)	0.014	0.00	0.023	0.03	0.01
10	Pb (mg/l)	0.097	0.023	0.103	0.014	5.0
11	Cr (mg/l)	0.029	0.03	0.06	0.025	0.10
12	As (mg/l)	0.009	0.02	0.037	0.028	0.05
13	Zn (mg/l)	0.42	0.66	0.00	0.00	5.0
14	*E.coli* (CFU/100ml)	380000	10000	12000	12000	5000

Summer season:

Table 4 shows that almost all the parameters of TDS (3394 mg/l, BOD (268 mg/l), COD (765 mg/L), $CaCO_3$ (734 mg/L) exceeded its standard limits. Similarly metal concentrations (e.g. Cd 0.014 mg/l) were also higher than their standard limits. On the other hand, Zn concentration (0.66 mg/l) is lower than the standard limit. The effect of high TDS, BOD, COD, and $CaCO_3$ indicates that water quality of Chatta canal being very poor adversely affects the agricultural production (Balchandra et al., 2010). Higher concentration of TDS is not suitable for irrigation purpose (Kannan and Thavamani,1993). High level of hardness results in leaching of calcium and magnesium and other di- and polyvalent cations from soil. Hardness in water may causes heart diseases (Alam and Ahmed, 2002). High BOD and COD levels in water indicate the organic pollution in the canal water due to heavy industrialization particularly discharge of oxygen demanding chemicals (Sastry et al., 2003). Dissolved oxygen (DO) was found very low and levels even reduced to zero during summer and winter owing to heavy organic loading in less water flow through the canal. The absence of DO revealed the anaerobic conditions prevailing throughout the canal way.

Rainy season:

Chatta canal has high water volume and good flow during rainy season only. The canal witnessed the maximum discharge during July to August month of the year. Chatta canal at its origin carries fresh water with a pH value of 7.5 and moderate levels of dissolved oxygen (5 mg/l) but with a low level of COD (4.50 mg/l) and BOD (8.00 mg/l). It is obvious that during Rainy season the canal Chatta drains fresh water upstream Chatta area and canal water is suitable for domestic, irrigation and industrial purposes. But as soon as the canal enters the Chatta industrial area its physicochemical qualities deteriorate due to a cocktail of effluents released by textile bleaching, dyeing and printing units. The canal water turns turbid and colour changed into reddish brown to greenish black. The influence of seasonal change on the physicochemical parameters was prominent particularly during monsoon season. Due to dilution effect of rain and mixing of fresh water coming from upstream Chatta the concentration of BOD decreases from 3394 mg/l to 2240 mg/l ,COD lowered from 765 mg/l to 98 mg/l, $CaCO_3$ declined from 666 mg/l to 461 mg/l, metal concentration also decreases i.e Cd and Pb from 0.014 mg/l to 0.00 mg/l and 0.097mg/l to 0.023mg/l respectively, Zn concentration increases from 0.42mg/l to 66 mg/l ,E-coli decreases from 380000 CFU/100ml to 10000CFU /100ml which indicates the quality of canal water varied from very poor to poor quality (Table 2 and 4.

Winter Season:

The characteristics of canal water changed during winter season. The major parameters like TDS, TSS, BOD, COD, $CaCO_3$, Pb, Cd, coliform load all showed an increasing trend from rainy season to winter season. TDS increased from 2240 mg/l to 2700 mg/l, TSS increased from 26 mg/l to 50 mg/l, BOD increased from 28mg/l to 91mg/l, COD rose from 98 mg/l to 256 mg/l, $CaCo_3$ increased from 461 mg/l to 867 mg/l, pH up from 7.16 to 7.9, metal concentration Cd increased from 0.00 mg/l to 0.023 mg/l , Pb increased from 0.023 mg/l to 0.103 mg/l, E-Coli increased from 100000 CFU/100 ml to 120000 CFU/100 ml but Zn alone reduced from 0.66 mg/l to negligible level. The above mentioned parameters exceeded the tolerance limits of WHO, FAO,BIS and ICMR presented in Table 2 and 4. Thus the canal water in winter season is also not considered suitable for even domestic and agri-irrigation purposes.

The result of the physico-chemical parameters of surface water from Chatta canal shows that 66% of the parameters studied (nine parameters out of 14 parameters) failed to meet the standard limit prescribed by WHO required for agriculture as they crossed the tolerance limits of water required for irrigation purpose. The seasonal trends of variation in the values of pH, TDS, TSS, BOD and COD, were identical and the order shown is as follows:

summer>winter>rainy. The water quality pattern being worst in summer, moderate in rainy season to poor in winter and further deterioration in summer as witnessed in the present study conforms to the finding of Balchandra et al. (2010).

Conclusion :

The results obtained from physicochemical analyses indicate that the canal water running through Chatta, Kalikapur, Mahispota of Maheshtala region are very poor in summer and poor in water quality during summer and winter seasons that improved slightly to fairly during rainy season. The canal water is not at all suitable for drinking, domestic and agriculture purposes. This observation is also quite similar to physical verification done during collection of samples that there is almost no agricultural production of crops in the vicinity and the neighborhood villages along the textile bleaching and dyeing cluster except certain tall grass varieties.
Adequate action is required to be taken to control unplanned growth of such textile bleaching, dyeing and printing units. Need of the time is immediate introduction of common effluent treatment plant and proper eco-planning in the area as well as regular monitoring by the respective regulatory authorities to control discharge of raw effluents to the canal and adjoining agricultural land area.

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Conflict of Interest :

The authors do not have any conflict of interest either financial or non financial.

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