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Impact of Dye Industrial Effluent on Physicochemical Characteristics of Kshipra River, Ujjain City, India

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Abstract

The wastewater has greatest potential for polluting the receiving water. River Kshipra is one of the sacred Indian rivers is being polluted by effluents discharged from Bhairavgarh dye industries. The most common textile processing unit consists of desizing, scouring, bleaching, mercerizing and dyeing process. The present study was an attempt for assessment of water quality being polluted by effluents. Selected parameters include pH, temperature, electrical conductivity, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), chemical oxygen demand (COD), total alkalinity, total hardness and chloride content. These were monitored in the untreated effluent and receiving watershed (River Kshipra) following standard protocol. High levels were observed in COD (73-345 mg/l), pH (7.6-9), TS (2100-6050 mg/l), TDS (1990-5820 mg/l), DO (0-8 mg/l), total hardness (321-880 mg/l), which exceeds the standard levels of BIS and world health organization (WHO). The study revealed that there was an adverse impact on physicochemical characteristics of river Kshipra as a result of directly discharge of untreated effluents from Bhairavgarh dye industries. This poses a health risk to several rural communities which rely on the receiving water bodies primarily as their source of domestic water.

Keywords: River Kshipra, Dye industrial effluent, physico-chemical analysis, COD, DO, TDS.

Introduction

Water is an essential compound for the survival and sustenance of life on the planet earth. The waste water or sewage water thrown out from industries is either used for irrigation purposes or it runs off to natural sources of water. If these effluents are not treated before their disposal they can be harmful for human consumption as well as for other uses too[1].

The residual dyes from different sources e,g., textile industries, paper and pulp industries, dye and dye intermediates, tannery, and kraft bleaching industries, etc. are contain wide variety of organic pollutants introduced into natural water resources or wastewater treatment systems.

One of the main sources with severe pollution problems worldwide is the textile industries and its dye-containing wastewaters. 10-25% of textile dyes are lost during the dyeing process, and 2-20% is discharged as aqueous effluents in different environmental components.

In particular, the discharge of dye-containing effluents into the water environment is undesirable because of their colour, released directly and breakdown products are toxic, carcinogenic or mutagenic to life forms mainly because of carcinogenic, such as benzidine, naphthalene and other aromatic compounds [2-3].

The textile industry consumes large amounts of potable and industrial water as processing water (90-94%) and a relatively low percentage as cooling water (6-10%). The recycling of treated wastewater has been recommended due to the high levels of contamination in dyeing and finishing processes (i.e. dyes and their breakdown products, pigments, dye, intermediate, auxiliary chemicals and heavy metals[4-7].

The objective of this study was to assess qualitative analysis of effluents discharged into the river Kshipra by some physico-chemical parameters and to identify common pollutants in river Kshipra.

Material and Methods

The study area selected was River Kshipra also known as “Avanti Nadi” located in the city of Ujjain, Madhya Pradesh, India. Its total length is about 195km out of which 93km flow through Ujjain. Bhairav garh is about 5 km from the Ujjain city which is famous for dye industries (Bhairav garh Prints) not only in M.P but also throughout the India. The wastewater or effluents are directly discharged into the River Kshipra. Industrial effluents were sampled and analyzed in the lab.

River Kshipra was divided into four zones for sampling - the upstream point, Industrial effluent point, Point of confluence (effluents and river) and the downstream point. Samples were collected during the month of February to June 2012 in plastic containers, pre-cleaned by washing with non-ionic detergents, rinsed in tap water, 1:1 hydrochloric acid and finally with doubled distilled water. Bottles were rinsed three times with sample water before being filled with the sample. The actual samplings were done midstream by dipping each sample bottle at approximately 20-30 cm below water surface, projecting the mouth of the container against the flow direction. The samples were than transported in cooler boxes containing ice to the laboratory for further analysis within 2 to 4 hour after sampling.

All field equipments were checked and calibrated according to the manufacturing specification. pH, temperature, alkalinity and dissolved oxygen (DO) of the samples were determined onsite. The parameters such as; electrical conductivity, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), total hardness and chemical oxygen demand (COD) were analysed in the laboratory by the standard protocol[8-9].

Results and Discussion

Water temperature at site-1 (Upper-Stream) ranged between 19 to 23.5°C, site-2 (industrial effluents) 20 to 23°C, at site-3 (confluence point) 20 to 21°C, and at site-4 (downstream) 19 to 22°C, table-1and figure-1. The most important measure of water quality is the dissolved oxygen[10]. Hydrogen sulphide is formed under conditions of deficient oxygen in the presence of organic material and sulphate. The dissolved oxygen throughout the study was zero at site-2, at site-3 ranged between 0 to 2 mg/l., at site-4 (0 to 5 mg/l.) and at site-1 maximum DO recorded were 6.5 to 8 mg/l. table-1 and figure-2. The DO in untreated effluent and DO in the downstream was observed to deplete faster than upper-stream could be attributed to the presence of degradable organic matter which resulted in a tendency to be more oxygen demand. The effluent waste discharge to surface water source is largely determined by oxygen balance of the system and its presence is essential in maintaining life within a system[11]. Dissolved oxygen concentration in unpolluted water normally range between 8 to 10 mg/l and concentration below 5 mg/l adversely affect aquatic life[12].

pH is a measure of the acidity or alkalinity of water. Anything either highly acidic or alkaline would kill aquatic life[13]. The toxicity of heavy metals also gets enhanced at particular pH. Thus, pH is having primary importance in deciding the quality of wastewater effluents. Waters with pH value of about 10 are exceptional and reflect contamination by strong base as NaOH and $Ca(OH)_2$. The range of desirable pH value for drinking purpose prescribed by ISI and WHO is 6 to 5 and 8 to 5. In the present study the values of pH at site-1 (7.6 to 7.9), at the site-2 (8.6 to 9.0), site-3 (7.7 to 8.4), Site-4 (7.9 to 8.2) table-1 and figure-3. At all the sites pH values within the permissible limit, except at site-2 which was above the permissible limit. High pH of effluents affects physico-chemical properties of water which in turn adversely affects aquatic life, plants and humans. This also changes soil permeability which results in polluting underground resources of water.

Results of alkalinity levels for the site-1 ranged between 129 to 168 mg/l, at the site -2 ranged between 375 to 430 mg/l, at site-3 ranged between 316 to 390 mg/l, and at site-4 ranged between 298 to 365 mg/l table-1and Figure-4. High levels of alkalinity at, site-3 and site-4 may be due to direct discharge of untreated effluent into the river. More alkalinity associated with increase in the presence of bicarbonates and carbonates from effluents and leachats. Further increased alkalinity might be due to more CO_2 release in the water Stream[14].

Maximum chemical oxygen demand (COD) observed 310 to 345 mg/l. at site-2 followed by site-3 (280 to 310 mg/l.) and site-4 (250 to 305 mg/l.) and minimum at site-1 i.e. 73 to 105mg/l respectively table-1and figure-5. Standard limits for COD in discharge of effluents into receiving water-body was 250 mg/l. Higher levels of COD were observed at all sites expect site-1. This is undesirable because continuous discharge of effluents has impacted the receiving water-body to some extent and this may have negative effects on the quality of freshwater and subsequently cause harm to aquatic life especially fish[15]. Increase in COD could be attributed to an increase in the addition of both organic and inorganic contaminant entering the systems from the municipal sewage treatments plants [16].

During the present study the maximum electrical conductivity was recorded at site-2 (289 to 337.5 µS/cm) followed by site-3 (275.6 to 310 µS/cm) and site-4 (246 to 277 µS/cm) while minimum at site-1 i.e. 90.5 to 148 µS/cm respectively table-1 and figure-6. Impact of discharge wastewater on physicochemical qualities of a receiving watershed in a typical rural community[17].

The minimum chloride values were recorded at the site-1 i.e. 219.99 to 232 mg/l. and maximum at site-2 i.e. 549.99 to 669.99 mg/l. table-1and figure-7. High chloride concentration are harmful for metallic pipes as well as for agriculture crops. Chloride in excess (> 250 mg/l) imparts a salty taste to water and people who are not accustomed to high chloride may subject to laxative effects. The results indicate maximum chloride content of 669.99 mg/l in the effluent samples and maximum of 300 mg/l in downstream of river which are above the acceptable limits of 200 mg/l set by WHO and 250mg/l set by ISI. The reason of high chloride content in the downstream was the discharge of untreated dye industrial effluents into the river.

Total solids (TS) was minimum at site-1 i.e. 2100 to 2280 mg/l, while maximum at site-2 i.e. 5800 to 6050 m/l followed by site-3 (4750 to 5900 mg/l) and site-4 (5000 to 5400 mg/l) table-1 and figure-8. The high TS may be attributed to use of salts during dyeing process. The TS ranged from 1475.6-13499.2 mg/l., were study on physico-chemical parameters of wastewater from Taloja Industrial area, Mumbai, India[13].

The maximum values of TDS were obtained from site-2, and minimum values were obtained at site-1table-1and figure-9. High content of dissolved solids affects the density of water, influences osmoregulation of freshwater organisms, reduces solubility of gases (like oxygen), and utility of water for drinking, irrigation purpose[13]. The high TSS values were observed at site-3 and minimum values were also observed at site-1 table-1and figure-10. Same results of TSS 200-6000mg/l., were worked out the analysis of industrial effluents and its comparison with other effluents from residential and commercial areas in Solan, H.P.[1].

Total Hardness is the property of water which prevents the lather formation with soap and increases the boiling point of water. Hardness of water mainly depends upon the amount of calcium and magnesium salts or both. The highest values of hardness were observed at site-2 and site-3 and downstream site, and lowest values of hardness 321mg/l were observed from site-1 table-1and figure-11. The values of hardness in the downstream can be attributed to the discharge of untreated effluents into the stream. Calcium hardness ranged between 217 to 420 mg/l and magnesium hardness ranged between 22.81 to 121mg/l. Highest values of calcium and magnesium were obtained at site-2 and lowest values were obtained at site-1 table-1 and figure-12-13. Similar results were obtained in studying the effect of industrial effluents and wastes on physicochemical parameters of river Rapti [18-20].

Conclusion

The results indicate that the effluents affects the water quality which lead to significant environmental and health risk to the rural communities who rely on the receiving water as their source of domestic water purpose without treatment. The study showed a need for a continuous pollution monitoring programme for the river Kshipra. In addition to this provincial government and NGO's of India should evolve measures to check and ensure that discharge effluents comply with laid down rules and regulations. Finally, the study revealed that there was an adverse impact on physicochemical characteristics of the river Kshipra as a result of discharge of untreated effluents of Bhairavgarh Ujjain. Hence, there is an urgent need to treat the effluents before discharge into river Kshipra.

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Table-1
Analysis of Physico-chemical characteristics of water samples and untreated effluent

S. No.	Parameters	Site-1		Site-2		Site-3		Site-4	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
01	Temperature (°C)	23.5	19	23	20	21	20	22	19
02	DO (mg/l)	8	6.5	0	0	2	0	5	0
03	pH	7.9	7.6	9	8.6	8.4	7.7	8.2	7.9
04	Total Alkalinity (mg/l)	168	129	430	375	390	316	365	298
05	COD (mg/l)	105	73	345	310	310	280	305	250
06	Conductivity (µS/cm)	148	90.5	337.5	289	310	275	277	246.5
07	Chloride (mg/)	249.9	219.99	669.99	549.99	379.99	323.99	340.9	300
08	Total Solids (mg/l)	2280	2100	6050	5800	5900	4750	5400	5000
09	TDS (mg/l)	2190	1990	5820	5600	5800	4500	5310	4850
10	TSS (mg/l)	120	90	230	180	250	60	150	75
11	Total Hardness (mg/l)	338	321	880	730	608	520	532	440
12	Ca Hardness (mg/l)	241.7	217	420	369	344.4	294	357	309
13	Mg hardness (mg/l)	25.27	22.81	121	78.73	64.95	54.91	54.18	27.16

Note: Site-1 = Upstream; Site-2 = Industrial effluents; Site-3 = Confluence point of industrial effluents and river Kshipra; Site-4 = Downstream

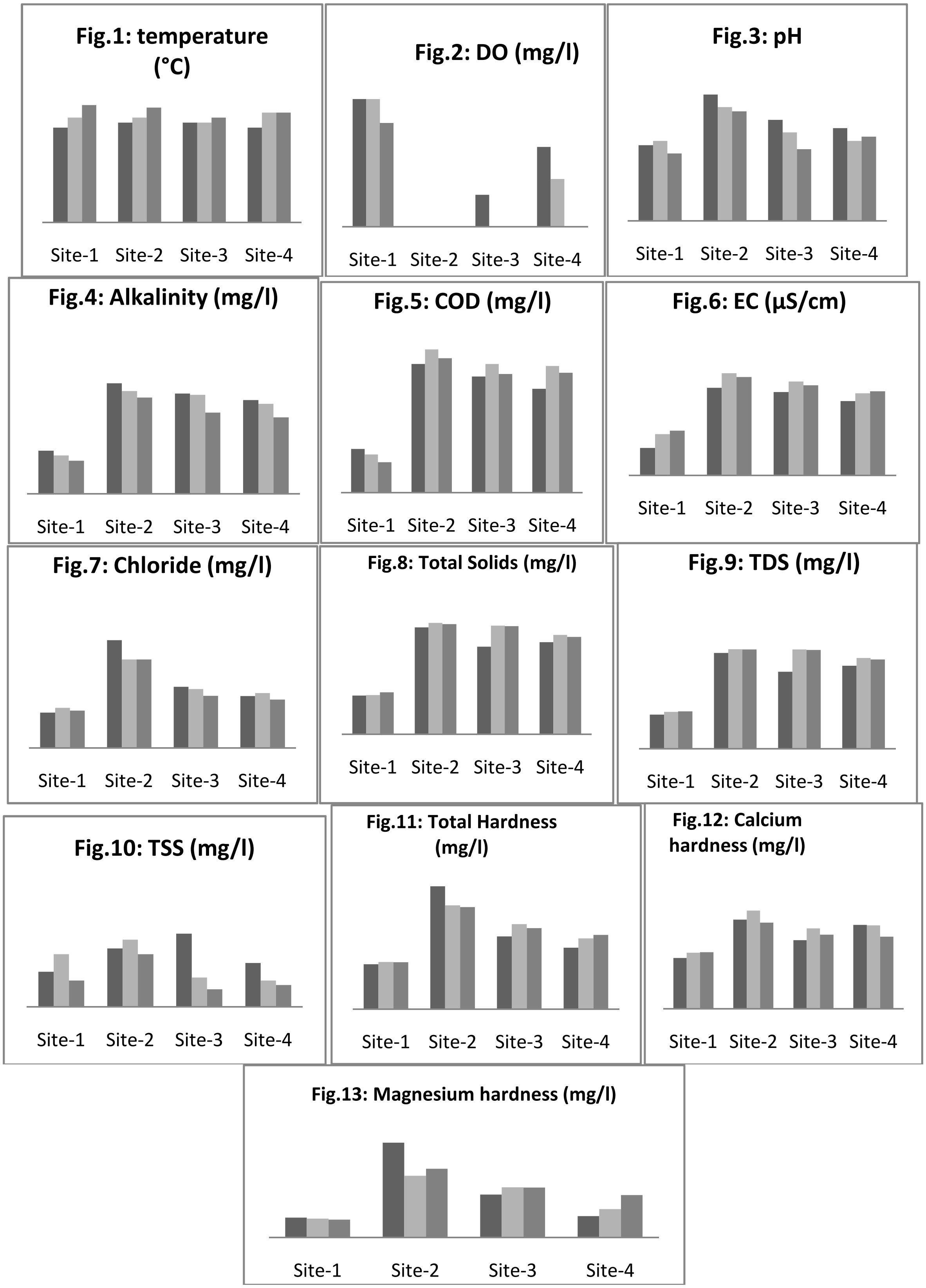

Figure 1-13
Variation in different Physico-chemical parameters