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Effects of Textile Effluents Disposal on water quality of Sub Canal of Upper Ganga Canal at Haridwar (Uttarakhand), India

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ABSTRACT

The present investigation was conducted to assess the characteristics of textile effluent and its effect on water quality of a sub canal originated from Upper Ganga Canal at Haridwar. The samples were collected before the confluence (control) and after discharge of textile effluent from S, S_1, S_2, S_3, S_4 and S_5 located at 0, 100, 200, 300, 400 and 500 m distance from the confluence point. The results revealed that disposal of textile effluent showed high pollution level in terms of physico-chemical and microbiological parameters viz. temperature (29.58 ^oC), turbidity (39.56 NTU), TS (1580 mg L^{-1}), EC (2.45 mg L^{-1}), BOD (864.34 mg L^{-1}), COD (1245.36 mg L^{-1}), Cl^- (832.78 mg L^{-1}), total phosphorus (212.76 mg L^{-1}), nitrate nitrogen (124.86 mg L^{-1}), SO_4^{2-} (135.46 mg L^{-1}), Cd (1.96 mg L^{-1}), Cu (2.88 mg L^{-1}), Cr (1.12 mg L^{-1}), Fe (4.56 mg L^{-1}), Ni (1.76 mg L^{-1}), Mn (0.68 mg L^{-1}), Pb (0.89 mg L^{-1}), Zn (1.34 mg L^{-1}), SPC (4.8×10^6 SPC ml $^{-1}$) and FC (6.7×10^6 FC 100 ml $^{-1}$) at confluence point. Discharge of textile effluent significantly change ($P<0.05$) in temperature, turbidity, TS, EC, BOD, COD, Cl^-, total phosphorus, nitrate nitrogen, SO_4^{2-}, Cd, Cu, Cr, Fe, Ni, Mn, Pb, Zn, SPC and FC of water at all the sampling sites S, S_1, S_2, S_3, S_4 and S_5 in comparison to control. The water quality index (WQI) rating of sub canal water was of medium and after discharge of textile effluent it turned to very bad. Thus, the textile effluents considerably deteriorated the quality of sub canal water.

Keywords: Textile effluent, Sub canal, water quality, WQI, contamination.

INTRODUCTION

Water quality is extremely important because constant access to good quality water is necessary for life as well as the economy [1]. Since rivers constitute the main inland water resources for domestic, industrial, and irrigation purposes, it is imperative to have a monitoring program, providing a representative and reliable estimation of the quality of surface waters [22], necessary to prevent and control water pollution [19]. Contamination of river water by industrial effluents has been given much attention due to their low biodegradability and toxic effects [9]. TS values are considered important in determining the usage of water. Higher TS values are not suitable for both irrigation and drinking purposes. The scarcity of clean water and pollution of fresh water has therefore led to a situation in which one-fifth of the urban dwellers in developing countries and three quarters of their rural dwelling population do not have access to reasonably safe water supplies [14].

Textile industries have been placed in the category of most polluting industries by the Ministry of Environment and Forests, Government of India. India has a large network of textile industries of varying capacity which are spread throughout the country. Their effluents constitute a major part of the total industrial effluents in India [19]. The improper and indiscriminate disposal of textile effluents in natural waters and land is posing serious problems. Furthermore, the improper and indiscriminate disposal of textile effluents in natural waters and land is of great concern [6]. The textile effluent contains organic and inorganic chemical species which have adverse effect on water quality and growth of all plants and animals. The water containing textile effluent used for irrigation contains heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn etc.), which accumulate in various parts of plants that result in various clinical problems in animals as well as in human beings including hepatic and renal system damages, mental retardation and degradation of basal ganglia of brain and liver [6, 8].

At the same time there are adverse effects of textile effluents on water quality and aquatic biota as well. Due to drainage of textile effluent there is significant increase in TDS, turbidity, BOD, COD, chlorides, sulphates, nitrate nitrogen, total phosphorus and heavy metals like Fe, Zn, Cd, Cr, Cu, Ni, Mn and Pb of the receiving water bodies [16]. Thus, these effluents pose an environmental problem mainly in terms of COD, color, toxicity and salinity [16, 23]. Keeping above in view the present investigation was conducted to study the characteristics of textile effluents and their effects on water quality of a sub canal at Haridwar (Uttarakhand) India.

EXPERIMENTAL SECTION

2.1. Samples collection and analysis

The Rishabh Velveleen (Pvt.) Ltd. Haridwar located at Delhi Dehradun National Highway (NH-58) near Haridwar city was selected for present investigation, which drain their effluents in the sub canal originated from Upper Ganga Canal. The samples were collected before the confluence (control) and after confluence from S, S_1, S_2, S_3, S_4 and S_5 located at 0, 100, 200, 300, 400 and 500 m distance from the confluence point. The samples were collected in the plastic containers, brought to the laboratory and were analyzed for various physico-chemical properties viz. temperature, turbidity, total solids (TS), pH, electrical conductivity (EC), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), chlorides (Cl^-), total phosphprus, sulphate (SO_4^{2-}), nitrate nitrogen, heavy metals such as cadmium (Cd), copper (Cu), chromium (Cr), iron (Fe), nickel (Ni), lead (Pb), manganese (Mn), zinc (Zn) and microbiological properties like Standard plate count (SPC) and Fecal coliform (FC) following standard methods [2].

2.2. Heavy metals analysis

For heavy metal analysis, 5-10 ml sample of water/ effluent of sub canal were taken in digestion tube, added 3.0 ml conc. HNO_3 and digested on electrically heated block for 1 h at 145^o C. Then added 4.0 ml of $HClO_4$ and heated to 240^o C for an additional hour. Cooled and filtered through Whatman # 42 filter paper and makeup volume 50.0 ml and used for analysis following standard methods [2].

2.4. Statistical analysis

Data were analyzed for student t-test to determine the difference between sample characteristics before and after confluence in the sub canal. The mean and standard deviation were also calculated with the help of MS Excel. Water Quality Index (WQI) was calculated following standard method [2].

RESULTS AND DISCUSSION

3.1. Characteristics of sub canal water

The mean ± SD values of physico-chemical and microbiological parameters of sub canal water at various sampling stations are presented in Table 1.

The sub canal water showed temperature (15.32 ^{o}C), turbidity (2.23 NTU), TS (120 mg L $^{-1}$), EC (0.15 mg L $^{-1}$), BOD (3.24 mg L $^{-1}$), COD (6.14 mg L $^{-1}$), Cl^- (67.89 mg L $^{-1}$), total phosphorus (0.21 mg L $^{-1}$) nitrate nitrogen (0.78 mg L $^{-1}$), SO_4^{2-} (88.43 mg L $^{-1}$), Cu (0.04 mg L $^{-1}$), Fe (0.06 mg L $^{-1}$), Ni (0.03 mg L $^{-1}$), Mn (0.02 mg L $^{-1}$), Zn (0.51 mg L $^{-1}$), SPC (1.4 × 10^2 SPC ml $^{-1}$) and FC (1.0 ×10^2 FC 100 ml $^{-1}$), while Cd, Cr and Pb were not detected in the sub canal water (Table 1). The water quality index of sub canal water showed that it was of moderate rating (Table 2).

Table 1. Effects of textile effluents disposal on water quality of a sub canal at Haridwar

Parameters	Before confluence	At confluence S (0m)	After confluence					F-calculated	CD	BIS for disposal
			S_1 (100 m)	S_2 (200 m)	S_3 (300 m)	S_4 (400 m)	S_5 (500 m)			
Colour	Light bluish	Dark brownish	Moderate brownish	Moderate brownish	Brownish	Brownish	Light Brownish	-	-	-
Temperature (°C)	15.32 ±1.21	29.58a ±1.23	26.67a ±1.65	24.12a ±1.77	21.45a ±1.44	20.56a ±1.50	20.36a ±1.22	12.54^{*}	3.34	-
Turbidity (NTU)	2.23 ±1.20	39.56a 3.89	32.99a 4.11	28.63a ±3.24	24.41a ±4.40	19.78a ±2.98	16.45a ±3.45	9.63^{*}	4.68	-
TS (mg L^{-1})	120 ±3.56	1580a ±4.88	1432a ±5.55	1265a ±4.47	1043a ±5.22	876a ±4.60	654a ±5.57	74.48^{**}	12.55	1900
pH	7.14 ±0.12	8.50 ±0.22	8.12 ±0.12	7.98 ±0.14	7.82 ±0.10	7.74 ±0.13	7.62 ±0.16	1.20^{NS}	0.14	5.5-9.0
EC (dS m^{-1})	0.15 ±0.02	2.45a ±0.08	1.86a ±0.03	1.46a ±0.03	1.26a ±0.03	1.08a ±0.06	0.89a ±0.07	3.47^{**}	0.8	-
DO (mg L^{-1})	9.87 ±1.01	Nil	3.96a ±1.12	4.87a ±1.12	5.68a ±1.09	6.23a ±1.00	6.49a ±1.07	256.38^{**}	6.85	-
BOD (mg L^{-1})	3.24 ±1.20	864.34a ±3.66	623.51a ±3.25	274.55a ±4.20	244.35a ±4.20	220.12a ±3.78	186.71a ±4.11	8.96^{**}	5.96	100
COD (mg L^{-1})	6.14 ±2.14	1245.36a ±5.36	976.88a ±5.65	578.31a ±4.74	528.19a ±4.11	488.38a ±3.70	423.66a ±4.23	142.32^{**}	5.74	250
Chlorides (mg L^{-1})	67.89 ±2.42	832.78a ±4.52	744.21a ±4.70	646.90a ±3.96	616.90a ±3.96	567.87a ±3.30	534.88a ±4.56	695.86^{**}	6.87	500
Total phosphorus (mg L^{-1})	0.21 ±0.12	212.76a ±4.22	201.11a ±3.45	189.27a ±2.80	174.23a ±2.67	151.66a ±3.55	140.22a ±2.42	12.30^{**}	4.57	-
Sulphate (mg L^{-1})	88.43 ±1.85	435.46a ±2.45	422.52a ±2.87	372.42a ±1.96	352.32a ±2.46	229.65a ±2.20	194.89a ±2.20	26.31^{**}	15.63	1000
Nitrate nitrogen (mg L^{-1})	0.78 ±0.56	124.86a ±3.25	112.67a ±3.20	97.45a ±1.20	82.20a ±2.32	68.98a ±3.15	57.61a ±4.22	26.36^{***}	6.86	100
Cadmium (mg L^{-1})	Nil	1.96a ±0.06	1.42a ±0.08	1.12a ±0.08	0.87a ±0.04	0.75a ±0.03	0.54a ±0.04	24.12^{***}	0.85	0.01
Copper (mg L^{-1})	0.04 ±0.00	2.88a ±0.04	1.74a ±0.03	1.34a ±0.02	1.02a ±0.01	0.91a ±0.01	0.72a ±0.03	145.27^{**}	0.25	3.00
Chromium (mg L^{-1})	Nil	1.12a ±0.03	0.98a ±0.02	0.88a ±0.02	0.62a ±0.03	0.52a ±0.04	0.32a ±0.05	96.39^{**}	0.12	2.00
Iron (mg L^{-1})	0.06 ±0.00	4.56a ±0.14	3.56a ±0.11	2.56a ±0.10	2.31a ±0.12	2.22a ±0.10	2.02a ±0.06	75.48^{**}	0.69	1.0
Nickel (mg L^{-1})	0.03 ±0.00	1.76 ±0.41	1.18a ±0.04	0.78a ±0.06	0.58a ±0.03	0.42a ±0.04	0.25a ±0.07	42.7^{**}	0.26	-
Lead (mg L^{-1})	Nil	0.89a ±0.04	0.76a ±0.01	0.56a ±0.01	0.41a ±0.02	0.36a ±0.03	0.26a ±0.04	187.85^{**}	0.10	1.00
Manganese (mg L^{-1})	0.02 ±0.00	0.68a ±0.04	0.52a ±0.02	0.32a ±0.03	0.20a ±0.02	0.15a ±0.01	0.10a ±0.01	28.54^{**}	0.52	-
Zinc (mg L^{-1})	0.51 ±0.01	1.34a ±0.01	1.22a ±0.02	1.15a ±0.02	0.82a ±0.02	0.70a ±0.02	0.62a ±0.02	24.52^{**}	0.05	15
SPC (SPC ml^{-1})	1.4×10^{2} ±11.00	4.8×10^{9a} ±38.00	2.6×10^{8}a ±22.00	3.4×10^{7}a ±26.00	4.0×10^{5}a ±26.00	5.2×10^{4}a ±34.00	3.1×10^{4}a ±31.00	369.89^{***}	45.96	10000
FC (FC 100 ml^{-1})	1.0×10^{2} ±16.00	6.7×10^{6a} ±45.00	4.2×10^{5}a ±27.00	5.2×10^{5}a ±22.00	6.7×10^{4}a ±19.00	5.9×10^{4}a ±16.00	7.4×10^{3}a ±16.00	288.78^{***}	36.58	5000

*Mean ± SD of six values; *, **, ***significantly different to the values before the confluence at P<0.05, 0.01 and 0.001 ANOVA; a-significantly different to the confluence point; CD-critical difference; NS-not significant.*

3.2. Effect of textile effluent on sub canal water

3.2.1. Temperature, turbidity and TS

In the present study, the temperature, turbidity and TS of sub canal water was increased from 15.32 °C, 2.23 NTU and 120 ±3.56 mgL^{-1} to 29.58 °C, 39.56 NTU and 1580 mgL^{-1} respectively after mixing the textile effluent at confluence point. It was found to be significantly (P<0.05) different in the water of the sub canal after the confluence in comparison to before the confluence. TS was also noted more significantly (P<0.01) different at all the sampling stations after the confluence point in comparison to before the confluence point. The value of temperature, turbidity and TS was observed 20.56 °C, 16.45 NTU and 654 mgL^{-1} respectively at sampling station S_5 (Table 1). Awomeso et al reported the drainage of textile effluent increase the TS 2202 mgL^{-1} of Ibeshe stream in Nigeria. TS is not deemed to be associated with health effects, but it is rather used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of presence of a broad array of chemical contaminants [18]. According to Olayinka [18], effluents from textile industries are capable of increasing TS of water body. Lee and Lin [13] described solids concentration as important characteristic of wastewater.

Table 2. Water quality index before and after disposal of textile effluents in sub canal.

Parameter	Before confluence point			At confluence point			At S_5 sampling station		
	Q-value	Weighting factor	Subtotal	Q-value	Weighting factor	Subtotal	Q-value	Weighting factor	Subtotal
pH	91	0.12	10.87	73	0.12	8.75	91	0.12	10.90
Change in temp	28	0.11	3.11	10	0.11	0.00	19	0.11	2.05
DO	8	0.18	1.38	0	0.18	0.00	6	0.18	1.01
BOD	71	0.12	8.52	2	0.12	0.24	2	0.12	0.24
Turbidity	92	0.09	8.24	46	0.09	4.11	66	0.09	5.98
Total Phosphorus	49	0.11	5.38	5	0.11	0.55	5	0.11	0.55
Nitrate Nitrogen	80	0.10	7.96	1	0.10	0.10	1	0.10	0.10
Total solids	39	0.17	6.70	18	0.17	3.14	23	0.17	3.97
Fecal coliforms	43	0.17	7.39	2	0.17	0.34	12	0.17	1.96
Total		1.17	59.55	-	1.17	17.23	-	1.17	26.75
Water quality index			50.90	-	-	14.73	-	-	22.86
Water quality rating			Medium	-	-	Very bad	-	-	Very bad

3.2.2. EC and pH

Conductivity is the ability of a substance to conduct electricity. The conductivity of water is a more-or-less linear function of the concentration of dissolved ions. It can serve as an indicator of other water quality problems. If the conductivity of a stream suddenly increases, it indicates that there is a source of dissolved ions in the vicinity. Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems. The pH is a measure of acidity or alkalinity of water. A pH of 7 is considered to be neutral. Acidity increases as pH values decrease, and alkalinity increases as pH values increase. The pH of water affects the solubility of toxic as well as nutritive chemicals which affect the availability of these substances to aquatic organisms. As acidity increases, most metals become more water soluble and more toxic.

In the present study, the EC and pH of the sub canal water was increased 2.45 and 8.50 from their initial 0.15 and 7.14 levels. The change in EC and pH after confluence were found to be significantly ($P<0.05$) different from the values noted before the confluence at all the sampling sites. The pH and EC was observed 7.62 and 0.89 at S_5 sampling site (Table 1). This might be connected with the release of chemical salts from the textile industry as well as influx of lagoon water. One of the effects of EC in water is the impacts on the taste of water [17].

3.2.3. Dissolved oxygen, BOD and COD

Dissolved oxygen (DO) is the most important pollution assessment parameter of the receiving water bodies. Stabilization of organic matter, when discharged untreated or partially treated in receiving waters, leads to depletion of DO. Depletion of DO in natural water reduces its ability to sustain aquatic life. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. If effluent with high BOD is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river. Chemical oxygen demand (COD) is a vital test for assessing the quality of effluents and waste waters prior to discharge. The COD test predicts the oxygen requirement to oxidize all organic material into carbon dioxide and water.

In the present study, DO was decreased 3.96 mgL^{-1} from it initial level 9.87 mgL^{-1}. The BOD and COD of the unpolluted sub canal water were recorded 3.24 mgL^{-1} and 6.14 mgL^{-1}. The BOD and COD were increased 864.34 mgL^{-1}, 1245.36 mgL^{-1} in the sub canal water at the confluence point respectively. The dissolved oxygen, BOD and COD were decreased significantly ($P<0.01$) in the sub canal water after drain of textile effluent. The DO, BOD and COD were observed 6.49 mgL^{-1}, 186.71 mgL^{-1} and 423.66 mgL^{-1} respectively at S_5 site (Table 1). High BOD and COD might be due to presence of high oxidizable organic matter and rapid consumption of dissolved inorganic materials. The higher bacterial load (SPC and FC) in textile effluent might be due to presence of more dissolved solids and organic matter in the effluent [23, 24].

The low DO of the stream might be linked directly to high value of nutrients (nitrate and phosphate) observed from the stream with subsequent high coliform populations which might have reduced the DO [5]. This implies that the effluent discharge from the textile industry might have released high oxygen-demanding wastes [4]. Environmental implication of low DO is death of aquatic organisms [4]. High COD in water indicates the presence of biologically resistant organic substances [20]. The elevated values of COD in this study were in line with the study of Olayinka [18] who found a high value of COD in groundwater close to textile effluent discharge.

3.2.4. Chlorides, total phosphorus, nitrate nitrogen and sulphates

The chlorides, total phosphorus, nitrate nitrogen and sulphates in sub canal water were 67.89 mgL^{-1}, 0.21 mgL^{-1}, 0.78 mgL^{-1} and 88.43 mgL^{-1} respectively. At confluence point the values of chlorides, total phosphorus, nitrate nitrogen and sulphates were found 832.78 mgL^{-1}, 212.76 mgL^{-1}, 124.86 mgL^{-1} and 435.46 mgL^{-1} in the sub canal water after mixing the textile effluent. The content of chlorides (534.88 mgL^{-1}), total phosphorus (140.22 mgL^{-1}), nitrate nitrogen (57.61 mgL^{-1}) and sulphates (194.89 mgL^{-1}) at S_5 site were recorded. The values of chlorides, sulphate and nitrate nitrogen were significantly ($P<0.01$) different at all the sampling sites in comparison to the control (Table 1). Effluent discharge generally adds significant quantities of salts such as sulfates, phosphates, bicarbonates, chlorides of sodium, calcium, potassium and magnesium to the aquatic environment [23, 24].

3.2.5. Heavy metals

The heavy metals are at very low concentrations in the natural environment. They are introduced to surface waters as waste by human activities. Some of the metals of concern for human and aquatic health are cadmium, lead, copper, mercury, selenium, and chromium etc. The content of Cu, Fe, Ni, Mn and Zn were recorded 0.04 mgL^{-1}, 0.06 mgL^{-1}, 0.03 mgL^{-1}, and 0.02 mgL^{-1}, 0.5 mgL^{-1} respectively while Cd, Cr and Pb were not detected in sub canal water before the confluence. At confluence point these were increased Cd (1.96 mg L^{-1}), Cu (2.88 mg L^{-1}), Cr (1.12 mg L^{-1}), Fe (4.56 mg L^{-1}), Ni (1.76 mg L^{-1}), Mn (0.68 mg L^{-1}), Pb (0.89 mg L^{-1}) and Zn (1.34 mg L^{-1}) respectively. The metal contents increased significantly ($P<0.01$) in sub canal water at all the sampling sites after discharge of textile effluent (Table 1).Health implications of high concentration of lead include anemia, kidney damage and cerebral edema [6, 8]. Chromium, zinc and potassium values lie within the permissible limits [24, 25, 26] as given by Yusuff and Sonibare [25, 26]. Sekhar et al. and Vinod and Chopra [21, 23, 24] have correlated heavy metal contamination to industrial effluent discharge.

3.2.6. FC and SPC

Bacterial parameters, such as fecal coliform and standard plate count which serve as indicators of fecal pollution were studied. The FC and SPC in unpolluted sub canal water were found 1.8×10^2 FC100 ml^{-1} and 1.4×10^2 SPC ml^{-1}. Their values increased in water to 6.7×10^6 FC100 ml^{-1} and 4.8×10^9 SPC ml^{-1} respectively at confluence point. FC and SPC values were noted 7.4×10^3 FC100 ml^{-1} and 3.1×10^4 SPC ml^{-1} at S_5 site. The FC and SPC were increased significantly ($P<0.001$) in the water after discharge of textile effluent at all sampling sites in comparison to control point (Table 1). The presence of TC in water is an indication of contamination by human sewage or animal droppings which could contain disease-causing organisms.

4. Water quality index (WQI)

Water quality index is a 100 point scale that summarizes results from a total of nine different measurements like temperature, turbidity, total solids, pH, dissolved oxygen, biochemical oxygen demand, nitrate nitrogen, total phosphorus and fecal coliform. The 100 point index can be divided into several ranges viz. excellent (90-100), good (70-90), medium (50-70), bad (25-50) and very bad (0-25). In the present study, the WQI rating of sub canal water was of medium (50.90), it changed to very bad (14.73) at confluence point with marginal change (22.86) at S_5 sampling station after discharge of textile effluent (Table 2).

CONCLUSION

The present study was concluded that the textile effluent has high chemical and biological contaminants in terms of physico-chemical and microbiological parameters. Drainage of effluent considerably increased the physico-chemical, microbiological characteristics and metal contents viz. TS, EC, pH, BOD, COD, Cl^-, total phosphorus, nitrate nitrogen, SO_4^{2-}, Cd, Cu, Cr, Fe, Mn, Ni, Pb, Zn, SPC and FC of sub canal water after confluence. The study suggested that the effluents being discharged into the stream by the textile industry have considerable negative effects on the water quality of the sub canal and the water is not good for human consumption and domestic use. WQI showed that the sub canal water quality changed moderate to very bad after discharge of textile effluent. Thus, textile effluent deteriorates the water quality of sub canal which is an ultimate source of potable and irrigation water as well. It is therefore recommended that the effluents from the textile industry should be treated before being disposed into the water bodies. Further investigation is required on the quality of sub canal water and its impact on human, livestock and agricultural health where it is used.

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