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Impact of Tannery Effluent in Simulated Condition on Physico-Chemical Characteristics of River Water and Its Seasonal Variation

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ABSTRACT

Water pollution is prime cause of unavailability of the suitable water for domestic and irrigation purposes. Rapid industrialization leads to high discharge of industrial wastewater which may pollute river ecosystem. Industrial effluents are main source of direct and often continuous input of pollutants in to aquatic ecosystem thereby affecting the ecosystem functioning. In present study, an investigation has been made to assess the impact of tannery effluents (TE) on physico-chemical quality of Ganga river water, collected in different season from Jajmau area at Kanpur city, U.P, India. The investigation was done in simulated condition and observed the impact tannery effluent in three different seasons viz, winter, summer and monsoon. The TE collected from CETP, Kanpur, India, was mixed in collected Ganga River water sample at concentration of 5%, 15%, 25%, 50%, 75% v/v under laboratory condition and analyzed for physico-chemical parameters like pH, EC, TDS, TA, TH, DO, BOD, COD and Cr metal seasonally. The data obtained shows seasonal variation. The results of the present study indicate that discharge of TE make highly adverse effect on physico-chemical quality of Ganga river water. The study revealed that if TE is discharged continuously in current manner in to the Ganga River, water quality deterioration could take place, which will be serious threat to human life & aquatic ecosystem.

Keywords: TE, Physico-chemical parameters, Ganga River water, Simulated Condition, Seasonal Variation.

INTRODUCTION

Diverse uses of the Rivers are seriously impaired due to pollution. Water pollution is prime cause of unavailability of the suitable water for irrigation and domestic purpose. The rapid industrialization is accompanied by both direct and indirect adverse effect on environment. River pollution has several dimensions and effective monitoring and control of River pollution requires the expertise from various disciplines [2]. Therefore river water has been extensively surveyed for its physico-chemical parameters. Physicochemical and microbiological characteristics may describe the quality of water [3], therefore an analysis of physico-chemical parameters of Ganga River water was made by many workers [4-8]. Pollution becomes acute when tanneries are concentrated in cluster in small area along the bank of Ganga

River like Kanpur city of Uttar Pradesh. It is a prominent center for leather processing, especially for the manufacture of saddlery products. It has been observed that a wide majority of industries discharge untreated effluent into river and only 10 % industries surveyed had primary treatment plants ranging from oxidation tanks, sedimentation tanks in developing countries [9]. Tanning industry is one of the major sources of aquatic pollution in India. Tanning industry mushrooming in North India has converted the Ganga River in to dumping ground. Tanning industry discharges different types of waste in to the environment, primarily in the form of liquid effluents which contains toxic pollutants. Nearly 80% of the tanneries use chromium as a tanning agent [10]. Tannery effluents are one of the hazardous pollutants of industries. Major problems are due to waste water containing heavy metals, toxic chemicals, chlorides, lime with high dissolved and suspended salts and other pollutants [11]. The wastewater discharged from these industries contains various pollutants, including high amount of chromium [12]. Cr (VI) is a toxic, powerful, epithelial irritant and an established human carcinogen by International Agency for Research on Cancer and World Health Organization (WHO, 1990). In plants, it interferes with several metabolic processes causing phyto toxicity like reduced growth, chlorosis, ultra structural effects on organelles, chromatin condensation, swelling of mitochondria etc. and finally leading to plant death [13]. In 1996, the Supreme Court of India ordered the closure of all tanneries that had not set up pollution control system. Using government subsidies, the tanneries have built numerous Common Effluent Treatment Plants (CETPs) to treat the toxic waste water discharged from tanneries. The treatment of this type of wastewater is very complex mainly because of the variety of chemical products added in different concentrations [14-16]. The effects of various industrial effluents, sludge materials and metal elements on seed germination, growth and yield of crop plants have captivated the attention of many workers [17-19]. The present study was designed to assess the effect of tannery effluent on physico-chemical parametrs like pH, temperature, Conductivity, TH, TA, TDS, DO, COD, BOD, and Cr metal of Ganga river water by addition of % treated tannery effluent in laboratory condition and its seasonal variation. The water quality of Ganga River can be estimated after addition of % tannery effluents in laboratory condition to predict the future physico-chemical status of river water. The Ganga River in Jajmau area at Kanpur city U.P, India is valuable source of irrigation, fishing and house work, so in order to find current status of pollutants discharged from the various tanneries, the study was conducted to analyze the impact of tannery effluent on Ganga river water quality seasonally. As chemical analysis of water provide significant information about the present status of pollution river water with special reference to environmental health. This will prove the current suitability and future physico-chemical status of Ganga river water if it is discharged effluent by industries in current manner and current rate.

MATERIALS AND METHODS

Water samples for characterization of different physico-chemical parameters were collected from Ganga River near Jajmau Bridge area, the hub of Kanpur's leather trade, at Kanpur city, UP, India in three different seasons (winter, summer and monsoon) during month of January, May and July 2013 respectively. The River water samples were collected in plastic container. BOD bottles filled with samples were brought to laboratory with necessary precautions. The final discharged tannery effluent samples were collected from Common Effluent Treatment Plant (CETPs) Kanpur, U.P, India. The pH and temperature were determined at the sampling site using digital pH meter and digital thermometer respectively. Effluent was first filtered through Whatman filter paper No.1 to remove the suspended particles and then percent of effluents viz; 5%, 15%, 25%, 50%, 75%, v/v were made in the collected Ganga river water sample in different season in laboratory. These modulated samples were analyzed for physico-chemical parameters as per standard methods described in APHA, 1998 [1]. TDS was determined by electrometric method. To analyze DO value, it was fixed on the sampling site with magnus sulphate and alkali–iodide-azide solution. It was determined by azide modification method. Titrimetric method was used for the determination of T.A. EDTA titrimetric method was used for total hardness analysis. 5 days incubation method is used to test BOD value. C.O.D was measured by open reflux method. Trace metal like Cr was analyzed by atomic absorption spectrometer (AAS).

RESULTS AND DISCUSSION

The observed average physico-chemical value of Ganga River water quality parameters of the present study in different seasons are given in tables 1, 2, 3 and 4.

Table 1. The average values of physico-chemical parameters of water samples (winter season)

S.N	Parameters	Units	Experimental values *						
			Ganga water	5%	15%	25%	50%	75%	100% TE
1	Temperature	^{0}C	12.6	NA	NA	NA	NA	NA	NA
2	pH	-	8.06	8.34	8.53	8.54	8.38	8.32	8.28
3	EC	$mScm^{-1}$	0.480	1.963	4.36	5.74	8.49	11.90	21.30
4	T.D.S	mgL^{-1}	370	1290	2860	3950	5810	8140	14100
5	T.A	mgL^{-1}	136	260	520	570	870	1490	1900
6	T.H	mgL^{-1}	188	230	340	430	580	690	940
7	D.O	mgL^{-1}	8.5	NA	NA	NA	NA	NA	1.8
8	COD	mgL^{-1}	35.6	64.08	227.80	427.20	619.44	820.00	1280
9	BOD	mgL^{-1}	12.50	28.0	125.00	235.0	300.00	390.00	650.0
10	Cr (metal)	mgL^{-1}	0.0245	0.0294	0.0436	0.0534	0.0640	0.1047	0.1347

*Average of triplicate assay, NA = Not Analyzed

Table 2. The average values of physico-chemical parameters of water samples (summer season)

S.N	Parameters	Units	Experimental values *						
			Ganga water	5%	15%	25%	50%	75%	100% TE
1	Temperature	^{0}C	30.2	NA	NA	NA	NA	NA	NA
2	pH	-	8.07	8.30	8.50	8.54	8.38	8.32	8.30
3	EC	$mScm^{-1}$	0.541	2.19	4.63	6.27	8.50	12.40	22.23
4	T.D.S	mgL^{-1}	440	1310	2950	4060	5900	8245	14500
5	T.A	mgL^{-1}	376	450	630	710	1020	1460	1940
6	T.H	mgL^{-1}	320	370	480	560	670	780	960
7	D.O	mgL^{-1}	4.7	NA	NA	NA	NA	NA	1.60
8	COD	mgL^{-1}	42.40	70.80	234.50	450.80	690	872	1340
9	BOD	mgL^{-1}	19.50	34.50	128	248	315	425	660
10	Cr (metal)	mgL^{-1}	0.0286	0.0343	0.0508	0.0622	0.0745	0.1217	0.1451

*Average of triplicate assay, NA = Not Analyzed

Table 3. The average values of physico-chemical parameters of water samples (monsoon season)

S.N	Parameters	Units	Experimental values*						
			Ganga water	5%	15%	25%	50%	75%	100% TE
1	Temperature	^{0}C	31.7	NA	NA	NA	NA	NA	NA
2	pH	-	7.86	8.10	8.30	8.35	8.40	8.50	8.25
3	EC	mScm^{-1}	0.325	1.50	3.60	5.00	8.00	11.00	20.00
4	T.D.S	mgL^{-1}	216	1050	2260	3290	5270	7900	14000
5	T.A	mgL^{-1}	130	230	460	520	780	1350	1860
6	T.H	mgL^{-1}	128	210	320	410	490	650	900
7	D.O	mgL^{-1}	7.1	NA	NA	NA	NA	NA	1.68
8	COD	mgL^{-1}	37.40	66.40	230.10	440.00	640.40	850.00	1250
9	BOD	mgL^{-1}	15.20	30.00	126.00	240.00	310	410	640
10	Cr (metal)	mgL^{-1}	0.0228	0.0274	0.0406	0.0497	0.0596	0.0973	0.1260

*Average of triplicate assay, NA = Not Analyzed

Table 4. Comparison and Seasonal Variation in physico-chemical properties of Ganga river water

S.N	Parameters	Units	Experimental values (River water)		
			Winter season	Summer season	Monsoon season
1	Temperature	^{0}C	12.6	30.2	31.7
2	pH	-	8.6	8.07	7.86
3	EC	µScm^{-1}	480	541	325
4	T.D.S	mgL^{-1}	370	440	216
5	T.A	mgL^{-1}	136	376	130
6	T.H	mgL^{-1}	188	320	128
7	D.O	mgL^{-1}	8.5	4.7	7.1
8	COD	mgL^{-1}	35.6	42.4	37.40
9	BOD	mgL^{-1}	12.50	19.50	15.20
10	Cr (metal)	mgL^{-1}	0.1347	0.1451	0.1260

Temperature is the most important factor, which influences chemical, physical and biological characteristics of water bodies. The temperature of water of Ganga River ranges from 12.6^{0}C (winter season) to 31.7^{0}C (monsoon season). The mean value of temperature for Ganga water in three different seasons was recorded as 24.83^{0}C. The maximum temperature of 31.7^{0}C was recorded in monsoon season for Ganga river water.

pH is an important parameter which express the acidic or alkaline nature of solution. The pH values did not show remarkable difference in different season. The highest pH value of 8.6 (winter season) and lowest pH value of 7.86 (monsoon season) was recorded. The maximum pH value 8.54 (winter season), 8.54 (summer season) for 25% and 8.50 (monsoon season) for 75% river water samples were observed. The all water samples remain alkaline in nature for in all seasons.

EC is the ability of water to conduct electric current. It is directly related to the amount of total dissolved salts in water. The EC of Ganga water sample was found 325µScm^{-1} in monsoon season, which was lowest

amongst different season. The maximum mean value of EC, 541μScm^{-1} was found in summer season. High value of EC in summer season may due to the presence of higher concentration of ions. The highest value of EC was found 2.19 mScm^{-1} in summer season for 5% modulated sample. The value of EC ranges from 1.50 mScm^{-1} to 2.19 mScm^{-1} for 5% water sample in three different seasons. The increasing trend was found in increasing the concentration of TE in river water sample like 15, 25, 50 and 75%. The increase in EC value may be due to increase in concentration of dissolved ions.

TDS value of Ganga river water was found highest 440 mgL^{-1} in summer while lowest of 216 mgL^{-1} in monsoon season. The value of TDS increases from 370 mgL^{-1} to 1290 mgL^{-1} if 5% TE is mixed river water sample in winter season. However the value of TDS found 1310 mgL^{-1} in summer and 1050 mgL^{-1} in monsoon season for 5% water sample. The values of TDS in all three seasons for 5% modulated samples were found greater than HDL. Consumption of water with high TDS has reported to cause disorder of alimentary canal, respiratory system, nervous system, coronary system besides causing miscarriage and cancer [20]. The increase in TDS value in 5% water sample may be due to the increase in the concentration of carbonates, bicarbonates, chlorides, sulphates, phosphates, nitrates, calcium, sodium, potassium etc. The high TDS and heavy metal may stress on seed germination process. The salt content outside the seed is known to acts as limiting factor and causes less absorption of water by osmosis and inhibits germination of seeds [25].

Alkalinity of water is a measure of its capacity to neutralize strong acids and is due to the presence of bicarbonates, carbonates, and hydroxide compound of calcium, sodium and potassium ions. TA of Ganga water sample was found highest 376 mgL^{-1} in summer season and lowest130 mgL^{-1} in monsoon season. The value of TA ranges from 230 mgL^{-1} to 450 mgL^{-1} from winter to summer season in 5% water sample. The TA value 230 mgL^{-1} is even beyond the highest desirable limit prescribed by W.H.O standard for drinking water [21]. The increase in the value of TA, on increasing the %age of TE may be due to increase of soluble ions.

TH is determined by the concentration of multivalent cations like Mg^{+2} and Ca^{+2} in water. It is measured as equivalent of $CaCO_3$ concentration. The concentration of total hardness was recorded minimum of 128 mgL^{-1} (monsoon season) while maximum of 320 mgL^{-1} (summer season) for Ganga water samples. The high value of TH in summer may due to low flow current and increase in concentration of ions. The value of TH was found 210 mgL^{-1} (monsoon season), 230 mgL^{-1} (winter season) and 370 mgL^{-1} (summer season) for 5% tannery mixed water samples. The rational increasing trend was found while increasing the %age of treated tannery effluent in Ganga river water sample. The presence of calcium, magnesium and bicarbonate in excess makes water unfit for irrigation since its application increase problems of salinity and its permeability detrimental to crop plants [22].

Dissolved oxygen refers to the amount of oxygen dissolved in water bodies. Insufficient oxygen often caused by the decomposition of organic matter tends to suppress the growth of aerobic organism. DO is one of the important parameters in irrigated water system and for survival of aquatic life. The root and shoot length increases if irrigated with aerated nutrient solution [23]. DO value was quite low in treated tannery effluent sample as reported by other workers [24]. The high DO value of 7.10 mgL^{-1} was found in rainy season while low value of 4.7 mgL^{-1} in summer season for Ganga water sample. The DO content in river water was observed high in rainy season as compared to summer season. The high DO content during rainy season was largely attributed due to increase in aeration level with increase flow current of river water. Similar observation was also found by other researchers [26]. The low DO value in summer for river water sample may be due to high pollution load, organic matter and less photosynthetic activity.
High BOD levels are indications of the organic waste pollution strength of the water system. The value of BOD was 12.50 mgL^{-1} (winter season), 19.50 mgL^{-1} (summer season) and 15.20 mgL^{-1} (monsoon season) of Ganga river water samples. The BOD value increases from 12.50 to 28.0 mgL^{-1} (winter season), 19.50 to 34.50 mgL^{-1} (summer season) and 15.20 to 30.0 mgL^{-1} (monsoon season), if 5% treated tannery effluent

was added in river water. An increasing trend in BOD value was observed on increasing the %age of treated TE in river water sample (table 1, 2, 3).

The COD value of was found 35.6 mgL^{-1} (winter season), 42.40 mgL^{-1} (summer season) and 37.40 mgL^{-1} (monsoon season) of Ganga water. The COD value increases from 35.6 to 64.08 mgL^{-1} (winter season), 42.40 to 70.80 mgL^{-1} (summer season) and 37.40 to 66.40 mgL^{-1} (monsoon season), if 5% treated T.E is added river water samples in three different season under laboratory condition. As the %age of treated T.E increases, an increasing trend in COD value was found in three different seasons.

APPLICATIONS

The Ganges is the most sacred with extraordinary religious importance river of Hindus and is also life line to the millions of Indians who live on its course and depend on it for their daily needs. In Kanpur, there are numerous tanneries discharging their effluents thus polluting Ganga river water. This study will provide information about future physico-chemical quality status of Ganga river water. Thus the present study would be helpful to suggest the corrective measures to be taken for maintaining the quality status of Ganga water at its desired level.

CONCLUSIONS

The seasonal distribution pattern of different parameters was found to be influenced by different environmental factors for the Ganga river water in Kanpur city, U.P, India. From the present study it may be concluded that the physico chemical parameters of Ganga river water sample were high in summer season comparatively other season. The diminishing quality of water seriously delimits its use for human consumption and irrigation. Tanneries pollution generally accelerates to cause greater deterioration. The result obtained revealed that, if treated effluent discharged from tannery industry increases from 5% to 15% in current manner, the present physico-chemical quality of Ganga water will be seriously affected. So few years from now, serious water quality deterioration could take place, which will be serious threat to environmental health. Therefore, this study suggest for continuous and periodical monitoring of water quality so that appropriate preventive and remedial measures can be undertaken.

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