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Assessment of Physico-Chemical Properties of Tannery Waste Water and Its Impact on Fresh Water Quality

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ABSTRACT

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The present investigation was undertaken to evaluate the physico-chemical properties of tannery waste water of Kanpur and Unnao area and its impact on the fresh water quality. The result revealed that 10.05 and 9.15 for pH, 14.89 and 11.43 for EC, 16500 and 9500 for TDS, 1290 and 1160 for total hardness, 1456 and 1434 for alkalinity and 3124 and 1160 for chloride, DO absent, 1248 and 896 for BOD, 3154 and 2857 for COD and 68.01 and 38.60 for total Cr in tannery waste water samples of both sites respectively. Whereas rise in all parameters was observed on an addition of different concentrations of tannery waste water in fresh water, the data shows a significant increase in pH 10.15 ± 1.03 , EC 3.73 ± 0.02 , TDS 5806.33 ± 1.85 , TH 1219.33 ± 2.96 , TA 986.00 ± 4.63 , CI 1232.66 ± 1.78 , BOD 58.64 ± 1.16 , COD 424.33 ± 1.20 of Site 1 with 20% TWW in fresh water. The increase in the physico-chemical properties of fresh water clearly indicates that it may be toxic to the nearby aquatic environment and advance corrective measures to be taken before any damage.

Introduction

Industrial and urban development has become an important factor for the development of a country's economy. The tannery industry is one of the oldest industries, which is unevenly scattered and more than 2,500 tanneries are located in different urban centers of India processing about 500,000 tonnes of hides and 314 kg skins per annum which generate about 100,000 m³ of wastewater per day (Mohan *et al.*, 2006) which alters the physical, chemical and biological properties of the aquatic environment. Tanning and finishing industry in India is concentrated in Madras, Ranipet, Amber Vaniyambadi, Erode, Dindigul,

Perambut, Agra, Calcutta, Maharashtra, West Bengal, Rajasthan, Punjab, Kanpur (Jajmau) and Unnao area of Uttar Pradesh (Vijayan and and Hempriya, 2014).

Tannery industries consume a considerable amount of water in their manufacturing processes and serve as a major source of tanned and untanned solid waste and liquid effluents which contain high organic load, salts and chromium, releasing about 40 – 25,000 mg/L of chromium in their effluent (Obgonna *et al.*, 2008). Most developing countries without any treatment directly

discharge tannery effluent into aqueous system (Farenzena *et al.*, 2005) which is highly polluted in terms of biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), nitrogen, conductivity, sulphate, sulphide and chromium (Wosnie and Wondie, 2014).

Dissolved organic contents consume a large amount of oxygen and increase BOD level which leads to anaerobic fermentation and produces organic acids and hydrolysis of these organic acids causes the decrease in pH values (Ahmed *et al.*, 2011). High TDS, BOD and COD content cause decrease in DO of the water system creating stress condition to the aquatic living organisms (Kambole, 2003). Degradation of dissolved organic contents generates cations and anions and changes in the ionic composition of water which can also exclude some species while promoting population growth of others (Scannell and Duffy, 2007). Das *et al.*, (2010) have also reported a higher amount of TDS, BOD, COD, EC, salinity, alkalinity, hardness and lower amount of DO in tannery effluent.

Cr is one of the most important pollutants released from the tanning industries and the biggest problem is its disposal and recovery. Compared to the recommended permissible limit of 2 mg/L prescribed by BIS, India alone released about 2000-3000 tons of chromium into the environment annually from tanneries with chromium concentrations ranging between 40- 5000mg/L. Chromium is a potential pollutant and well known for its mutagenicity (Cheng and Dixon, 1998) and carcinogenicity (Wang *et al.*, 1999) effects in humans, animals and plants. Soil profile, surface water bodies (ponds and rivers), human health, fishes and other aquatic biodiversities are at risk of serious threat due to the extensive use of chromium in tanning industries and discharge of wastewater (Mohanta *et al.*, 2010). In a study conducted

by Blacksmith Institute about 75% of chromium sites located in South Asia out of them, a third are associated with tannery operations, with mining and metallurgy sites. Due to the abundance of tanneries, South Asia has highly concentrated chromium sites. Many of these tanneries have poor environmental controls and are regarded as a threat to the environment (Azom *et al.*, 2012).

The aim of the present study is to evaluate the dilution effect of tannery waste water on fresh water quality. The Indian industries function under the strict guidelines of the Central Pollution Control Board (CPCB) but the situation of environmental pollution is still far from satisfactory results (Lokhande *et al.*, 2011) industries in India despite working under strict guidelines of central pollution control board are still in continuous criticism. Over all tanneries waste water play a significant role in deteriorating the quality freshwater system. Keeping in view the importance of the study the present investigation was conducted to evaluate the physico-chemical properties of the tannery waste water of Kanpur and Unnao area of Uttar Pradesh and its impact on the fresh water quality

Materials and Methods

The present study was conducted collaboratively in laboratory Department of Environmental Science, College of Forestry, SHUATS and laboratory of Environmental science, I.B.S.B.T., C.S.J.M. University Kanpur.

Study area

Effluent samples for the study work were taken from one of the tannery industry from Jajmau area of Kanpur district and second sample from Banthar, Unnao District of Uttar Pradesh, India. The study area of Kanpur

District (Kanpur Nagar District) is one of the famous districts Uttar Pradesh, India. Currently Kanpur, is very famous for Leather Industry in the world. The district lies between $25^{\circ} 25'$ and $25^{\circ} 54'$ latitudes and $79^{\circ} 34'$ and $80^{\circ} 34'$ longitudes. Kanpur is bounded by Kannauj and Hardoi in north, Unnao in east, Fatehpur and Hamirpur in south and Kanpur Dehat in west. The Holy Ganga River separates it from district Unnao in east and forms the natural boundary. River Pandu separates it from district Kanpur Dehat and Fatehpur in west and south respectively. The total geographical area of district Kanpur Nagar is 3155 sq. Kms as per record. The major cluster of tanneries at Kanpur is located in Jajmau area. Jajmau is located on the right bank of river Ganga on the north eastern border of Kanpur city and there are 400 tanneries in the cluster. The Jajmau area of Kanpur has 04 major drains. The drains mainly carry storm water as well as industrial effluent and join the river, Ganga.

On the other hand the Unnao is another township across the Ganga about 20 km from Jajmau situated between rivers Ganga and Sai, The District lies in between Latitude $26^{\circ}8' N$ and $27^{\circ}2' N$ and Longitude $80^{\circ}3' E$ & $81^{\circ}3' E$. It is bounded by Hardoi on the North, Lucknow on the East, Rae Bareli on the South and Ganga on the West which separates it from Kanpur & Fatehpur. Its Geographical area is 4589 sq. km. The main rivers of the district are Ganga which form the western and southern boundary and the Sai which forms the northern and eastern boundary. Adjoining to Kanpur the town of Unnao also has some tanneries and about 20 are situated in this area. Leather Technology Park in Banthar, Unnao is dedicated to Leather Industry Development and environment protection of Unnao. The treated effluents are discharged (through the UPSIDC drainage) finally into the City Jail drain which ultimately meets the river Ganga (Fig. 1).

Effluent sample collection

The treated tannery effluent was collected in a plastic container (Tarson) from Jajmau, Kanpur nagar and Banthar, Unnao, Districts Uttar Pradesh, India.

Physico-chemical analysis of effluent and water sample

Water analysis was done following the standard methods of (APHA, 1998). The physico-chemical characteristics such as temperature, pH, EC, TDS (total dissolved solids), Total hardness, Total alkalinity, chloride, DO (dissolved oxygen), BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand). The pH and EC were measured by digital portable kit (model pp9040) portable battery operated with glass and calomel electrodes.

Metal estimation

Metal concentration was estimated by the method of Piper, (1942) for this purpose, 1000 ml of effluent and different concentration of tannery wastewater samples were taken in the conical flask and evaporated till dried. The dried samples were digested in 10:1 $HNO_3:HClO_4$ (v/v). The white crystals were found in digested samples and these crystals were dissolved in 10 ml double distilled water. The supernatant was filtered through Whatman Number 1 filter paper and was read directly with Atomic Absorption Spectrophotometer (Thermo scientific iCE3300 FL AA System, designed in UK and made in China.) for estimation of total Cr content. The acetylene gas was used for the estimation of Cr.

Statistical analysis

The data observed in the experiments were statistically analyzed for the calculation of

standard error (S.E.) and one way ANOVA for testing the hypothesis with the help of computer software IBM SPSS Statistics 21.0×86 program. The data shown are the average of three replicates \pm S.E.

Results and Discussion

The physico-chemical characteristics of treated tannery wastewater of both sites are shown in table 1. All the parameters in tannery waste water like pH, EC, TDS, Total hardness, total alkalinity, Chloride, BOD, COD and Cr were found higher than prescribed limit of BIS.

From table 2 it's revealed that the physico-chemical characteristics of the fresh water which is the addition of different concentration of tannery waste water to the fresh water. In experimental water the pH, EC, total hardness (TH), total alkalinity (TA), chloride, BOD, COD and Cr of test medium increased on addition of each concentration of tannery wastewater (5%,10%, 15% and 20% Tannery wastewater) with fresh water respectively while the dissolved oxygen (DO) was observed decreased with increase in concentration of tannery waste water.

The results of the tannery waste water revealed that the color of the effluent was dark brown at both sites (site-1 and site-2) with the unpleasant foul smell. Similar results were reported by Smrithi and Usha, (2012) and Bhatnagar *et al.*, (2013) that the color of the effluent may be due to the presence of biodegradable and non-biodegradable organic compounds and high amounts of inorganic chemicals like sodium and chromium used during processing and the odour may be due to the putrefaction of organic residues from the processed skins and hides (Table 1).

pH- One of the most important characteristic of the water is pH and any slight changes can

affect the pH level of water making it unfit for drinking and other purposes. The higher value of pH shows that the pH of tannery waste water was alkaline in nature which is above the permissible limit of 5.0 to 9.0 given by BIS. Maximum pH was observed in 20% concentration of tannery wastewater 10.15 and 9.13 at both site- 1 and site -2 respectively. The alkaline nature of the tannery effluent is due to the presence of carbonates and bicarbonate. Similar results were reported by Navaraj and Yasmin, (2012).

EC- Conductivity is a measure of its ability to conduct electricity and also an indirect measurement of salt content present in water. The maximum EC was observed 3.73 and 3.14 dSm^{-1} at both sites 1 and 2. Elevated level of conductivity is due to the presence of chloride ions and inorganic salt cations (Na^+ , K^+ , Ca^{2+} and Fe^{3+}) that creates more salinity in water. Murali *et al.*, (2013) reported similar results of higher conductivity in untreated and treated tannery effluent indicating higher discharge of chemicals as cations and anions in waste water.

TDS- Total Dissolved Solids (TDS) is the measure of total inorganic salts and other dissolved substances in water. In the present experiment, the TDS was found much greater than the prescribed limit of BIS (2100 mgL^{-1}). The maximum TDS was observed 5806 and 1874 mgL^{-1} in 20% TWW at site-1 and site-2 respectively. Higher values of TDS are due to the presence of dissolved organic and inorganic impurities. Das *et al.*, (2010) have also reported similar results of the increase in TDS.

Hardness

Hardness is a chemical parameter of water that represents the total concentration of calcium, magnesium, carbonates, bicar-

bonates, sulphates, chlorides, nitrates, toxic metals and organic matter. The maximum hardness was observed 1219.33 and 876.66 mgL⁻¹ in 20% TWW at both sites 1 and 2. Sugasini and Rajgopal, (2015) have also reported the increase in hardness.

Alkalinity

Total alkalinity represents the quantity of base present in water. The presence of bicarbonates, carbonates, phosphates, hydroxides, etc causes an increase in alkalinity level.

In the present study, the maximum alkalinity was observed 986.00 and 686.00 mgL⁻¹ in 20% TWW at both sites-1 and 2. Noorjahan, (2014) have also reported similar findings of alkalinity.

Chloride

Chloride present in water is used as a disinfectant and according to BIS maximum permissible limit for chloride in discharged effluent is 1000 mgL⁻¹. The maximum Cl was observed 1232.66 and 943.66 mgL⁻¹ in 20% TWW at both site-1 and 2. Presence of chloride in tannery effluents is the result of addition of NaCl in the large quantity of common salts for the preservation and pickling processes of skins and hides. The presence of chloride ions increases the salinity of the receiving water body. The high value of chlorides in effluents pollutes the drinking water making it suitable for easy growth of microbes, leading to water borne diseases. Sugasini and Rajgopala (2015) have also reported similar findings.

Table.1 Physico- chemical characteristics of tannery waste water

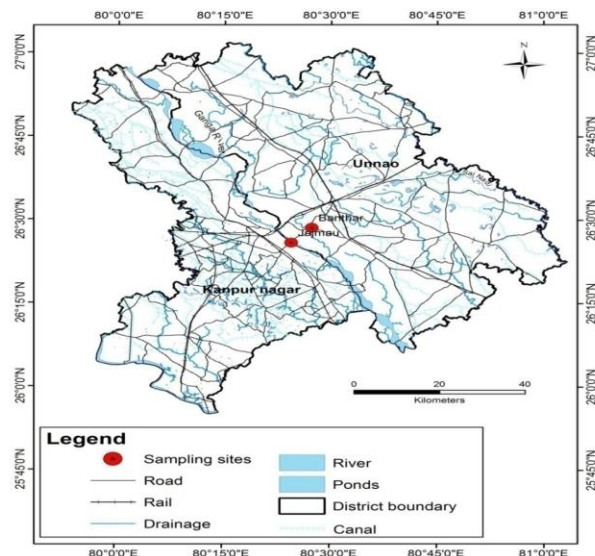
S.N.	Parameters	Site – 1 (Kanpur)	Site –2 (Unnao)	BIS Standard of effluent discharged (IS:2296-1982)
1.	Colour	Dark brown	Dark brown	-
2	Odour	Foul smell	Foul smell	-
3	pH	10.05	9.15	5.5-9.0
4	EC (dSm ⁻¹)	14.89	11.43	8.50
5	TDS (mgL ⁻¹)	16500	9500	2100
6	T. Hardness (mgL ⁻¹)	1290	1160	600
7	T. Alkalinity (mgL ⁻¹)	1456	1434	600
8	Chloride (mgL ⁻¹)	3124	1163	1000
9	D.O. (mgL ⁻¹)	Nil	Nil	Nil
10	B.O.D.(mgL ⁻¹)	1248	896	30
11	C.O.D (mgL ⁻¹)	3154	2857	250
12	Chromium (mgL ⁻¹)	68.01	38.60	2

Table.2 Physico-chemical characteristic of experimental water

Study Area	Treatments	Parameters									
		pH	EC	TDS	TH	TA	Cl	DO	BOD	COD	Cr
Site 1	Control	7.52 ±0.02	0.98 ±0.00	501.66 ±4.40	238.00 ±1.15	263.35 ±0.88	84.77 ±0.61	6.96 ±0.04	1.91 ±0.03	12.63 ±0.16	0.09 ±0.00
Site 2	Control	7.46 ±0.03	0.98 ±0.00	501.66 ±4.40	238.00 ±1.15	259.66 ±0.88	87.00 ±1.15	6.96 ±0.04	1.91 ±0.03	12.33 ±0.16	0.09 ±0.00
Site 1	5% TWW	8.43 ±0.07	1.58 ±0.02	1309.00 ± 3.78	662.66 ±3.52	853.66 ±2.02	338.66 ±1.20	6.29 ±0.28	10.75 ±0.05	118.00 ±3.05	3.15 ±0.00
Site 2	5% TWW	8.10 ±0.02	1.18 ±0.01	747.33 ±2.40	354.33 ±2.60	588.33 ±1.20	220.66 ±3.17	6.62 ±0.29	3.68 ±0.01	98.66 ±5.20	2.31 ±0.00
Site 1	10% TWW	8.62 ±0.07	2.48 ±0.00	1857.33 ± 3.71	863.33 ±1.20	896.66 ±1.20	833.66 ±1.85	5.57 ±0.19	31.81 ±1.21	123.27 ±1.96	4.92 ±0.00
Site 2	10% TWW	8.52 ±0.03	2.42 ±0.03	987.33 ±2.40	556.00 ±3.46	616.00 ±1.52	657.66 ±1.45	6.07 ±0.02	5.86 ±0.04	175.33 ±3.52	3.12 ±0.00
Site 1	15% TWW	9.53 ±0.02	3.65 ±0.03	3155.00 ±2.88	1083.33 ±4.80	962.33 ±1.45	1140.00 ±3.78	5.19 ±0.04	45.37± 2.33	325.33 ±2.90	7.71 ±0.00
Site 2	15% TWW	8.65 ±0.01	3.04 ±0.04	1322.00 ±5.03	683.33 ±2.40	649.00 ±1.52	754.00 ±2.08	5.83 ±0.08	10.56 ±0.78	289.33 ±1.33	5.48 ±0.00
Site 1	20% TWW	10.15 ± 1.03	3.73 ±0.02	5806.33 ±1.85	1219.33 ±2.96	986.00 ±4.63	1232.66 ±1.78	5.09 ±0.01	58.64 ±1.16	424.33 ±1.20	13.89 ±0.03
Site 2	20% TWW	9.13 ±0.06	3.14 ±0.03	1874.00 ± 6.42	876.66 ±2.84	686.00 ±1.57	943.66 ±2.33	5.76 ±0.03	11.75 ±0.62	335.66 ±2.96	8.82 ±0.00

Site 1= Kanpur, Site 2= Unnao, TWW= Tannery Waste Water, pH= potentio Hydrogeni, EC=Electrical conductivity(dSm⁻¹), TDS=Total Dissolved Solids (mgL⁻¹), TH=Total Hardness (mgL⁻¹), TA=Total Alkalinity (mgL⁻¹), Cl=Chloride (mgL⁻¹), DO=Dissolved Oxygen (mgL⁻¹), BOD=Biological Oxygen Demand (mgL⁻¹), COD=Chemical Oxygen Demand (mgL⁻¹), Cr=Chromium (mgL⁻¹)

Fig.1 Map of study area



Dissolved oxygen

DO is the amount of oxygen present in water. The maximum amount of DO in the present study was 6.96 mgL^{-1} in control and minimum DO was observed 5.09 and 5.76 mgL^{-1} in both sites-1 and 2 respectively. The presence of high amount of organic contents in tannery waste water causes an increase in microbial activity which consumes dissolved oxygen in their biological activity of decomposing organic matter. Noorjahan (2004) and Sugasini and Rajgopal (2015) have also reported similar results.

Biological Oxygen Demand

In the present study, the maximum BOD was observed 58.64 and 11.75 mgL^{-1} in 20% TWW at both sites-1 and 2 reflecting presence of organic substances (skins and hides) used as raw materials in tannery industry. High level of dissolved organic matter consumes large amount of oxygen and increase BOD level, which undergoes anaerobic processes leading to the formation of ammonia and organic acids (acetic acids and butyric acid). The main problem of BOD

is the depletion of the dissolved oxygen content of stream waters caused by microbial decomposition encouraging anaerobic activity, which leads to release of noxious gases (Song *et al.*, 2000). Similar results were reported by Mwinyihija *et al.*, (2006).

Chemical Oxygen Demand

The COD values observed was 424.33 and 335.66 mgL^{-1} in 20% TWW at both sites 1 and 2 respectively, COD test is commonly used to measure the amount of organic compounds in water which is not degraded by microbial activity. Islam *et al.*, (2014) have also reported increased amount of COD due to the high amount of organic compounds which are not affected by the bacterial decomposition.

Cr

Cr is one of the most important pollutants released from the tanning industries in the effluent. According to Saritha and Meikandaan (2013) chrome tanning processes originates toxic metals and regular treatment systems are not eligible for the elimination of

it. Maximum Cr concentration was observed 13.87 and 8.82 mgL⁻¹ in 20% TWW at both sites respectively. The wastewater generated by tanneries is the major source of Chromium pollution. The chromium (Cr) is well-known to be toxic to living organisms due to their bioaccumulation and non-biodegradable properties. The similar result of Cr was reported by Farhad ali *et al.*, (2015)

It was concluded that the tannery waste water in different concentration (5%, 10%, 15% and 20% concentration of tannery wastewater) showed a significant effect on the physico-chemical parameters of fresh water (pH, EC, TDS, hardness, alkalinity, BOD, COD, chloride and Cr). The parameters were also found to be higher than the prescribed discharge limits of BIS standard. The disposal of such type of tannery waste water is not safe to discharge into water bodies without proper treatment because they alter the physico-chemical properties of the water creating harmful effect to aquatic ecosystem and the people residing in tanning industrial area are at high risk facing deleterious health effects even on dilution.

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