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Research Article

PHYSICOCHEMICAL ANALYSIS AND MICROBIAL DIVERSITY OF YAMUNA WATER AND INDUSTRIAL EFFLUENTS

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Abstract

Pollution has arisen as a serious environmental concern to the present world after industrialization of human societies. It has severely affected our air, soil and water sources. Looking to its global, national, regional and local dimensions, it is now imperative to check it at each and every level. In the present study, 8 samples (3 Yamuna water samples, 3 tannery effluent samples and 2 textile effluent samples), were collected from different sites of Yamuna and exit points of textile and tannery Industries. Water and effluent samples were analysed for various physicochemical parameters (pH, TDS, hardness, chloride and BOD) using conventional methods. Afterwards these samples were utilized for isolation of the native bacterial species. All the samples were showing higher than the standard values for TDS (500mg/l), hardness (80-100 mg/l), chloride (250mg/l) and BOD (30mg/l). It was observed that the tannery effluents were showing maximum TDS values(1190-1240mg/l), followed by textile effluents (1190 and 1210mg/l) and Yamuna water (530-1180mg/l).Similarly, in case of chloride content, highest concentration range(828.8-1598mg/l)was shown by tannery effluents. pH value was nearly neutral for Yamuna water, slightly acidic in case of textile effluents and more acidic for tannery samples. Highest range of hardness values were observed for the tannery effluents (860-880mg/l) followed by textile effluents (760 and 860mg/l). The BOD values were nearly similar for all the samples with maximum values being observed for tannery effluents (42-48 mg/l). Thus it can be inferred that all the samples were highly polluted and need to be treated by suitable methods. There were 11 cultures purified, that could be employed in bioremediation purposes.

Key Word: Biological oxygen demand (BOD); Chemical oxygen demand (COD); Tannery; Textile; River; Total dissolved solids (TDS).

Introduction

The paramount of pollution in our environment especially rivers, is a dire consequence of continually expanding population along with an exponential development in the industrial field. River Yamuna, with a total length of around 1370 km is the largest tributary of the Ganges. The pollution of river Yamuna is considered an international issue. There are many big industries, factories, and even peoples living in colonies, slums and rural areas at the bank of Yamuna. All these are polluting this river. Among these causes, industries are contributing majorly to increase pollution load in river Yamuna especially tanneries and textile printing units.

The tanning industry plays a significant role in Indian economy by generating exports and employment. However, tannery wastes are among the highest pollutant industrial wastes. Tannery waste is always characterized by its strong colour (reddish dull brown), high BOD, high pH, and high dissolved solids. Important pollutants associated with the tanning industry include chlorides,tannins, chromium, sulphate and sulphides as addition to trace organic chemicals and increasing use of synthetic chemicals such as pesticides, dyes and finishing agents, as well as from the use of newer processing chemical solvents (Chandravathanam, 2009). It has been recognized to interrupt agro-based activities like farmingand animal husbandry as well as pollute ground-water systems. Groundwater contamination occurs when waste water and chemicals seep through the soil from unlined ponds, pipes and drains, or from dumps and spills. Groundwater may take a long time to cleanse itself because it moves slowly and is out of contact with air. Consequently when the deposition of solids is considered ,it becomes apparent that raw unsettled tannery waste waters can cause encrustation (of calcium carbonate) and serious corrosion of metals as well as concrete sewers (due to H_2S biological oxidation to H_2SO_4) (Balusubramanian *et al.*, 2000).

Thus high pollutant loads, involving chromium, sulphates, chlorides etc could easily interfere with key biological processes used in sewage treatment plants. In addition these pollutants may also damage the ecology of the receiving terrestrial and aquatic systems in the vicinity of the discharge points (Mwinyihija *et al.*, 2010). Biological

decomposition of organic matter from Industrial waste, as well as sulphide emissions from wastewaters (also due to bacterial reduction of sulphate) (Balusubramanian *et al.*, 2000), are responsible for the characteristic objectionable odours from tanneries in the form of H_2S (Dorman *et al.*, 2000). Essentially it is now recognized that direct contact with some industrial chemicals can potentially cause disability, illness (toxigenic/carcinogenic) and even death in humans (Murti *et al.*, 1989). Human health can also be affected by toxic hazards through the unskilled and unprotected handling of pesticides, tanning chemicals and treated hides and skins (Mwinyihija, 2011).

Textile industry is one of the oldest industries in India. It is known for using large quantities of water and variety of chemicals (Qin *et al.*, 2007). Taking into account the volume and composition of effluent, the textile wastewater is rated as the most polluting among all industrial sectors (Robinson et al., 2001; Awomeso et al., 2010; Vilaseca et al., 2010; Baban et al., 2010). In general, the wastewater from a typical textile industry is characterized by high values of BOD, COD, colour and pH (Yusuff and Sonibare, 2004; Tufekci et al., 2007,). It is a complex and highly variable mixture of many polluting substances ranging from inorganic compounds and elements to polymers and organic products (Brown, 1983). Incomplete use and the washing operations give the textile wastewater a considerable amount of dyes (Mathur et al., 2005).

Considering these aspects the present study was designed to investigate the level of pollution in Yamuna water at Agra region due to selected industrial effluents (tannery and textile). The physicochemical properties was analysed for this purpose. The native bacterial cultures were isolated from the polluted water and effluent samples, so that it may be useful for biodegradation of various xenobiotic compounds (like various dyes and other human made non-degradable compounds) present in water.

Materials and Methods

Physicochemical analysis of Yamuna water, textile and tannery effluent samples

Sampling was carried out from 8 different places located in Agra, Mathura & Delhi as mentioned below:

1. Y1 = Poiya Ghat, Agra (Yamuna)
2. Y2 = Sikandarpur, Agra (Yamuna)
3. Y3 = Khelgaon, Near Dayalbagh, Agra (Yamuna)
4. Ta1 = Tannery factory, Gaon Mehel, Runakta, Agra (Tannery)
5. Ta2 = Tannery Factory, Runakta, Agra. (Tannery)
6. Ta3 = Tannery Factory, Agra (Tannery)
7. Tx1 = Textile Industry, Near Jai Gurudev, Mathura (Textile)
8. Tx2 = Textile Industry, New Delhi (Textile)

The water and effluent samples were collected in sterile plastic bags in two sets (Fig. 1). One set was utilized for physicochemical analysis and other for bacterial isolation. pH was recorded at the sampling point. Physico-chemical analyses of all the samples were done by standard methods (APHA, 1992).

Isolation & Purification of bacteria from Yamuna water & effluent samples

The indigenous bacterial cultures were isolated separately from all the 8 samples by Spread-plate method and then subsequently purified by repeated streaking (Quadrant Streaking). All eleven cultures were then allotted with suitable culture number and stored in Nutrient Agar slants for future use (Asthana et al 2014).

Characterization of the bacterial cultures

The purified bacterial cultures were then characterized on the basis of their colony morphology (Colour, Shape, Elevation and Optical Characteristics) and Gram's staining (Asthana et al 2014)

Fig. 1: Map of River Yamuna showing sampling points at Agra India.

Results

Physicochemical analysis of Yamuna water, textile and tannery effluent samples

The observations of the physicochemical analysis are presented in Table 1. Out of the 8 samples analysed only samples 1st and 2nd Yamuna were colourless without sediment, while remaining were coloured with sediment. Samples 1st, 7th and 8th were odourless and all the other samples were having foul odour.

In comparison to the standard value of T.D.S (500mg/L) all the samples (530-1240 mg/L) were showing higher values. It was observed that the tannery effluents (1190-1240mg/l) were showing maximum TDS values, followed by textile effluents (1190 and 1210mg/l) and Yamuna water (530-1180mg/l). Similarly chloride content of all the samples (277.9-1598 mg/L) was quite high in comparison to standard value of drinking water (250mg/L) and maximum values were obtained for tannery samples (828.8-1598mg/l) followed by textile samples (625.7 and 628.2 mg/l)and Yamuna water (277.9-491.3). pH was found to be near neutral (6.7-7.5) for Yamuna water samples, slightly acidic (6.3 & 6.5) in case of textile effluents and acidic (5.1-5.7) for tannery effluents. Except for the tannery samples pH of the other samples was found to be within the permissible range of drinking water. As in case of other parameters the hardness and BOD values for all the samples were higher than the standard values. Highest range of Hardness values were observed for the tannery effluents (860-880mg/l) followed by textile effluents (860 & 760mg/l) and lastly Yamuna water (540-680mg/l). The BOD values were nearly similar for all the samples with maximum values being observed for tannery effluents (42-48 mg/l) and lowest values observed for Yamuna water (31-35mg/l), which is quite closer to standard value (30mg/l).

Table 1: Physicochemical parameters of the water & effluent samples:

Sample ID	Location	Quantity taken	Colour and Appearance	Odour	T.D.S (mg/L)	Chloride (mg/L)	pH value	Hardness (mg/L)	B.O.D (mg/L)
Y1	Poiyaghat,Agra (Yamuna)	500 mL	Colourless, no sedimentation	Odourless	530	277.9	6.7	540	31
Y2	Bahadurpur, Khaspur, Agra (Yamuna)	500 mL	Colourless, no sedimentation	Foul odour	1160	466.5	7.5	680	33
Y3	Khelgaon, near Dayalbagh, Agra (Yamuna)	500 mL	Blackish with sedimentation	Foul odour	1180	491.3	7.1	650	35
Ta1	Tannery factory Gaon Mehel, Runakta, Agra (Tannery)	500 ml	Light Yellow, with dirty black sedimentation	Foul Odour	1230	828.8	5.7	875	42
Ta2	Tannery Factory, Runakta, Agra (Tannery)	500 ml	Brown, with dirty black sedimentation	Foul Odour	1240	1598	5.5	880	48
Ta3	Tannery Factory, Agra (Tannery)	500ml	Light Brown, with dirty black sedimentation	Slight Foul Odour	1190	1588	5.1	860	45
Tx1	Textile factory, Mathura (Textile)	500 mL	Blackish with sedimentation	Odourless	1210	625.7	6.3	860	38
Tx2	Textile factory, New Delhi (Textile)	500 mL	Blackish with sedimentation	Odourless	1190	628.2	6.5	760	35
Std	Standard values for drinking water	-	Colourless, no sedimentation	Odourless	500	250	6.5-8.5	80-100	30

Here:Y= Yamuna; Ta= Tannery; Tx= Textile; Std= Standard

Table-2: ***Sample dilution and number and type of colony present in Yamuna water &Textile effluent samples***

Sample ID	Dilution	No. of colony	Type of colony	Type of cultures purified	Name of purified cultures
Y1 (Yamuna)	1×10^{-4}	10	1	1	S.1.1
	1×10^{-5}	-	-		
Y2 (Yamuna)	1×10^{-4}	100	2	2	S.2.1
	1×10^{-5}	-	-		S.2.2
Y3 (Yamuna)	1×10^{-4}	65	1	1	S.3.1
	1×10^{-5}	-	-		
Ta1 (Tannery)	1×10^{-4}	200	1	2	S.4.1
	1×10^{-5}	50	1		S.4.2
Ta2 (Tannery)	1×10^{-4}	24	1	1	S.5.1
	1×10^{-5}	-	-		
Ta3 (Tannery)	1×10^{-4}	20	1	1	S.6.1
	1×10^{-5}	-	-		
Tx1 (Textile)	1×10^{-4}	34	1	1	S.7.1
	1×10^{-5}	-	-		
Tx2 (Textile)	1×10^{-4}	19	1	2	S.8.1
	1×10^{-5}	4	1		S.8.2

Here:Y= Yamuna; Ta= Tannery; Tx= Textile

Isolation & Purification of bacteria from Yamuna water and effluent samples

Sample no. 4 (tannery) and sample no. 8 (textile) were shown growth at 10^{-5} dilution (Table 2). In total 11 bacterial cultures were purified (Table 2). Yamuna water and tannery effluent samples contributed equal number of cultures (four each) and textile effluent contributed three cultures.

Characterization of the bacterial cultures

On the basis of colony morphology it was observed that the cultures from Yamuna water were either white, orange or pale yellow in colour, whereas cultures from Tannery effluent were white or colourless and cultures from textile were white or orange (Table 3). On the basis of the remaining parameters (shape, elevation & optical characteristics) the cultures were showing variable morphology (Fig. 2).

All four bacterial cultures purified from Yamuna water were Gram negative (Fig. 3). Of these, three were cocci and one was bacilli. All the cultures from Tannery effluent were Gram negative cocci (Table-3). In case of textile effluent two cultures were Gram negative cocci and one was Gram positive bacilli.

Discussion

The present study was carried out to determine the values of various physicochemical parameters in order to evaluate the level of pollution and to isolate bacterial cultures from Yamuna water and industrial effluents. On the basis of physicochemical analysis of the Yamuna and industrial effluent samples it was observed that the TDS were present at much higher concentration in the tannery and textile effluents in comparison to Yamuna water and standard value for drinking water. Similarly Gupta et al. (2012) reported high TDS Values (973mg/L – 1664 mg/L) for textile effluents. Higher TDS values can be due to many dissolved solids which might be undesirable for health of the receiving water body. Dissolved minerals and organic constituents may produce aesthetically displeasing colour and odour. Also the solids increase the turbidity of water, induce septic conditions in the water body by retarding the photosynthetic activity and also interface with oxygen transfer mechanism of air- water interface.

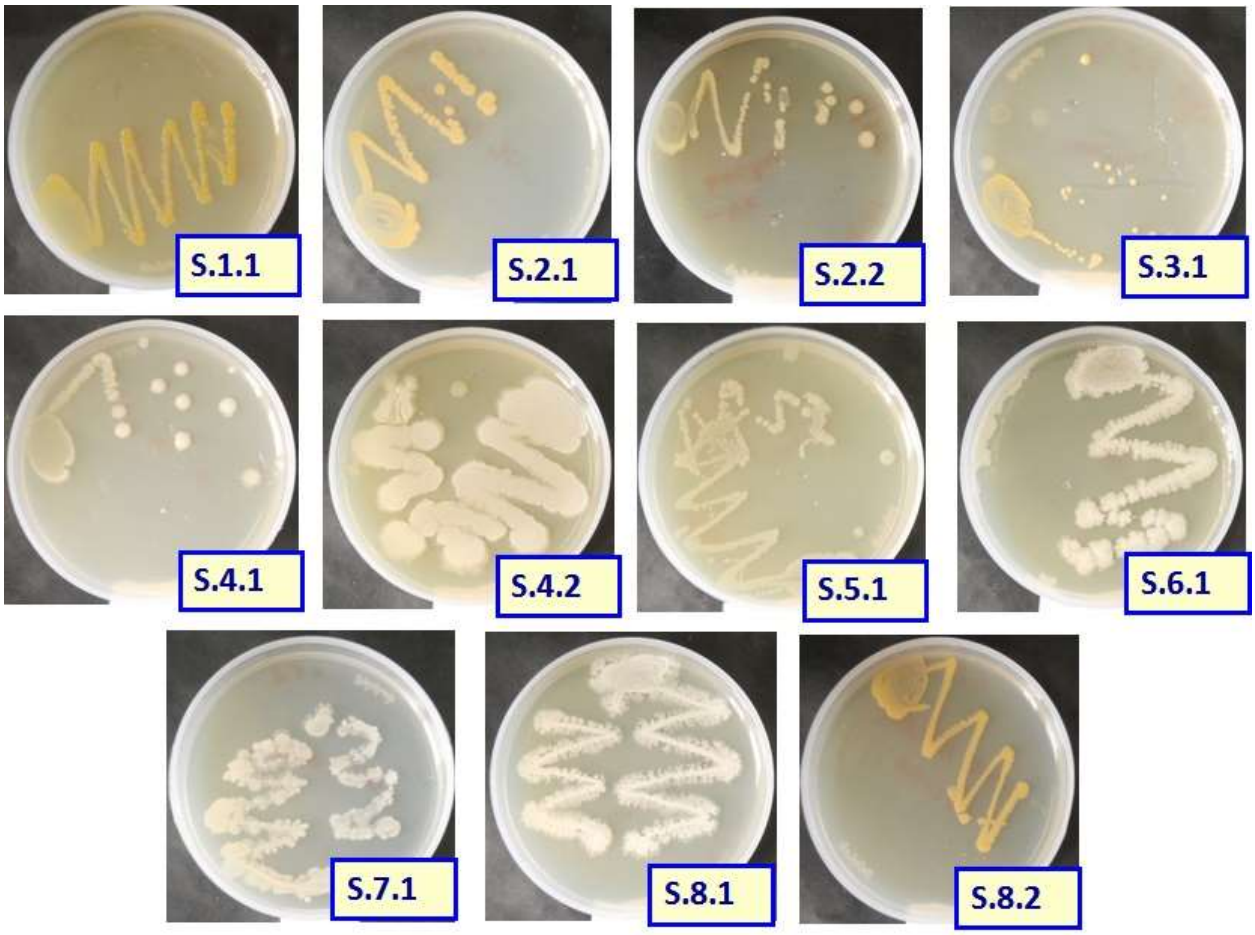

Fig. 2: Colony examination of purified cultures

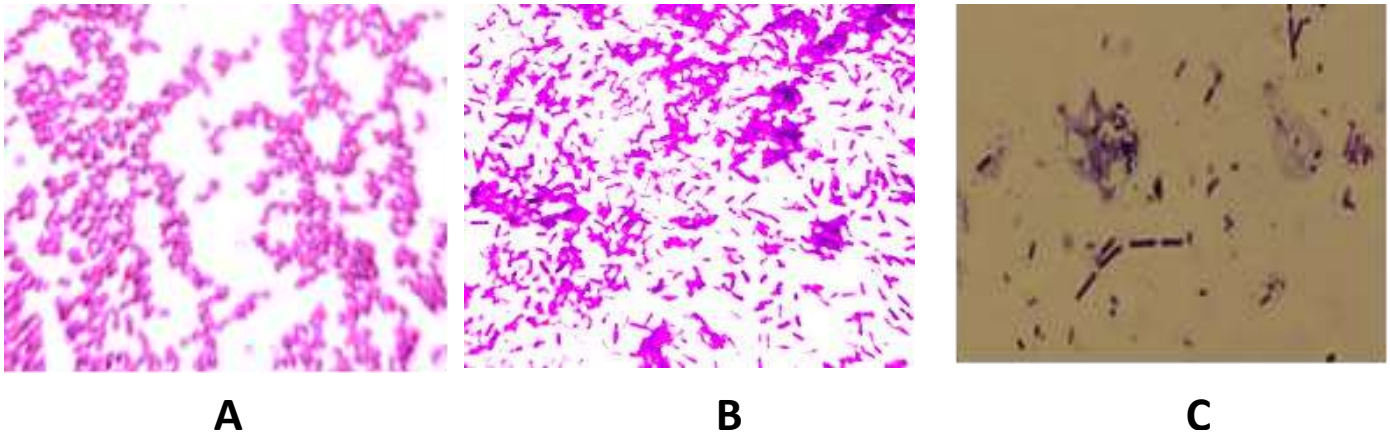

Fig. 3: Microscopic examination of purified cultures: (A) Gram negative cocci, (B) Gram negative bacilli (C) Gram positive bacilli

Maximum chloride content was observed in tannery samples and this might be because of the various chlorine based chemicals during the steps. Next in order were textile samples and this might be because of the various chlorine based chemicals used during the bleaching steps. Chloride content of Yamuna water was also higher than the standard value and this might be because it receives effluents from various industries. All the Yamuna water samples and textile effluent sample were showing near neutral to slightly acidic pH. All the tannery effluent samples were showing acidic value and it might be because of higher quantities of acidic chemicals in tannery units.

Hardness value of all samples was much higher than the standard value. It might be due to presence of cations (calcium, magnesium and sodium) in the samples. This in turn might be due to the use of various chemicals in the tannery, textile industry and in the other industries releasing their effluent in Yamuna.

Table 3: Colony morphology and Gram staining of isolated bacterial cultures from Yamuna water, tannery and textile effluent water

Culture Name	Gram's stain	Shape (Bacteria)	Colour	Shape (Colony)	Elevation	Optical Characteristics
S.1.1(Y1)	Gram Negative	cocci	Yellow	Spherical	Convex	Opaque
S.2.1(Y2)	Gram Negative	cocci	Orange	Spherical	Convex	Opaque
S.2.2(Y2)	Gram Negative	bacilli	White	Spherical	flat	Transparent
S.3.1(Y3)	Gram Negative	cocci	Pale yellow	Spherical	Convex	Opaque
S.4.1(Ta1)	Gram Negative	cocci	White	Spherical	Convex	Transparent
S.4.2(Ta1)	Gram Negative	cocci	White	Spherical	flat	Opaque
S.5.1(Ta2)	Gram Negative	cocci	Colourless	Spherical	Convex	Transparent
S.6.1(Ta3)	Gram Negative	cocci	White	Irregular	flat	Translucent
S.7.1(Tx1)	Gram Negative	cocci	White	Irregular	flat	Opaque
S.8.1(Tx2)	Gram Negative	cocci	white	Irregular	flat	Opaque
S.8.2(Tx2)	Gram Positive	bacilli	Orange	Spherical	Convex	Opaque

Here:Y= Yamuna; Ta= Tannery; Tx= Textile

It was observed that the BOD values of Yamuna water as well as the industrial effluents were higher than standard. This point towards the oxygen deficiency in the water bodies due to discharge of industrial effluents, rich in organic compounds. High values of this parameter indicate potential depletion of dissolved oxygen in the water body. Deficiency of oxygen in receiving water could cause adverse effects on aquatic life. In worst case, this can result in total depletion of oxygen in receiving water, causing an anaerobic environment, thus changing the habitat from aerobic to anaerobic life.

The physicochemical analysis of the Yamuna water and the effluents gives an idea about the severity, type and possible source of pollution, and can be used as an argument to emphasize on the treatment of Yamuna as well as the industrial effluents prior to their discharge on the open land or local water bodies.

After completion of purification step 11 bacterial cultures were obtained, which can be termed as native micro flora of the Yamuna and industrial effluent samples as no growth was obtained on control plates of Nutrient agar, and this ruled out any possibility of the laboratory contamination.

Yamuna water, tannery and textile effluents contributed nearly equal number of bacterial cultures (4, 4 and 3 cultures respectively). Presence of these cultures in the samples suggests that they are adapted to their polluted environment. In a similar study by Gupta et al. (2013) isolation of 26 bacterial cultures from textile effluents has been reported.

The 11 bacterial cultures obtained from Yamuna water and effluents were characterized on the basis of colony characteristics and Gram's reaction. When the isolates were compared on the basis of colony characteristics it was found that some isolates from Yamuna were showing quite different colony characteristics, but most of the isolates from tannery and textile effluents were found to be similar. This result indicates that there is more diversity in the bacterial micro flora of Yamuna due to dilution of the industrial effluents. It was observed that isolates from the Yamuna and effluents were showing quite different colony characteristics, which means that isolates obtained from Yamuna might be different from the isolates of effluents.

Yamuna water contributed majorly Gram negative cocci and only one Gram negative bacilli while tannery effluent contributed only Gram negative cocci (Verma et al 2011). Majority of the cultures obtained from textile effluent were

Gram Negative cocci while only one culture was Gram positive bacilli. It might be concluded that Gram negative cocci is more adapted to grow in the polluted environment and thus can be a very potent candidate in the field of bioremediation.

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