Characterization of Bacterial Strains from the Polluted Ganga Water for Sewage Degradation

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***Abstract*- The present study was undertaken to determine the feasibility of Advanced Oxidation Processes (AOPs) in treatment of textile dyes in wastewater. Acid Orange (AO7) is an azo dye with potential ecotoxicity to the exposed organisms. Natural attenuation by sunlight, and photo-catalytic degradation (with TiO2) was studied for colour removal and effective degradation of AO7. The experimental results confirmed that natural attenuation under sunlight and shade is not an effective process for degradation of AO7. It was observed that a fraction of dye (5%) is degraded/transformed during the day time with exposure to sunlight but the colour was regenerated during night. Photocatalytic degradation of AO7 under UV light (30W) with TiO2, and without TiO2 was found be effective in degradation of dye with an initial concentration of 50mg/L. Experiments with TiO2 were found to be higher than without TiO2 but the rate of degradation was quite low. The dose of photo-catalyst regulates dye degradation and it was found to be maximum at a dose of 1.0g/L of TiO2 with the degradation efficiency of 76% in a period of about 32 hours. Complete degradation of AO7 was observed in a period of about 127 hours. The recovery of photocatalyst was found to be 62% for its reuse.**

Keywords: Advance oxidation processes, photocatalysis, TiO_2, Acid Orange 7

I. INTRODUCTION

Environmental pollution is one of the major challenges of today's civilization [1]. In India, it is found that one-third of total water pollution comes in the form of industrial effluent discharge, solid wastes and other hazardous wastes. Industrial wastewater presents a potential hazard to the natural water system [2]. This wastewater contains many inorganic and organic matters, which are toxic to the various life forms of the ecosystem[1]. Several research investigations have shown the widespread occurrence of these pollutants in wastewater, surface water and ground water [3].
Presently, 3.4 million people die each year in the world from waterborne diseases owing to rapid industrialization [4]. The surface water is the main source of industries for wastewater disposal [5]. It is found that almost all rivers are polluted in most of the stretches by some industries [6]. The level of wastewater pollution varies from industry to industry depending on the type of processes and the size of the industries [7]. Sewage and not the industrial pollution accounts for more than 75 per cent of the surface water contamination in India. In India less than 50 per cent of the urban population has access to sewage disposal system. Garbage, domestic and other wastes are directly dumped into water bodies or roadside, which often get washed into streams and lakes [8].
The municipalities dispose off their treated or partially treated or untreated wastewater into natural drains joining rivers or lakes or use it on land for irrigation or fodder cultivation or into sea or combination of these. Toxic chemicals from sewage water get transferred to plants and enter the food chain and affect public health. In addition, untreated wastewater usually contains numerous pathogenic microorganisms that stay in the human intestinal tract called as enterobacteria [9;10]. Pathogens sustaining in the sewage water directly affect the mammals causing severe diseases. Much of the river pollution problem in India comes from untreated sewage. A growing number of water bodies in India are getting unsuitable for human utilisation a growing number of water bodies in India are unfit for human use, in the River Ganga, holy to the country's 82 percent Hindu majority, is dying slowly due to unchecked pollution
The role of microorganisms in the decomposition of sewage and other waste materials has long been recognized. Conventional sewage treatment involves the use of microorganisms within the sewage treatment systems. In some newer approaches, however, the sewage is inoculated with a specific microorganism, which has been specially selected for that particular sewage treatment process. Such organisms might be called 'starter cultures' [11]. Certain bacteria belonging to the Bacillus and Pseudomonas have some desirable characteristics. They deplete organic wastes thousands times quicker than those which are already present in waste. Bacteria Arthobacteria, Flavobacterium, Pseudomonas and Sphingomonas have been isolated and applied for the degradation of chlorinated phenol and other toxic compounds.
Heavy metals which are relatively abundant in the Earth's crust and frequently used in industrial processes or agriculture are toxic to humans. These can make significant alterations to the biochemical cycles of living things. Most of the point sources of heavy metal pollutants are industrial wastewater from mining, metal processing, tanneries, pharmaceuticals, pesticides, organic chemicals, rubber and plastics, lumber and wood products etc.
Heavy metals are not biodegradable and tend to be accumulated in organisms and cause numerous diseases and disorders [12]. Heavy metals from industrial processes are of special concern because they produce water or chronic

poisoning in aquatic animals [13]. While some heavy metals are purely toxic with no cellular role [14], other metals are essential for life at low concentration but become toxic at high concentrations [15], high concentration of all heavy metals inhibits activity of sensitive enzymes [16]. Heavy metals can damage the cell membranes, alter enzymes specificity, disrupt cellular functions and damage the structure of the DNA. Bioremediation processes are very attractive in comparison with physico-chemical methods. There are a number of bio-materials that can be used to remove metal from waste water such molds, yeasts, bacteria, and seaweeds. The ability of microbial stains to grow in the presence of heavy metals would be helpful in the waste water treatment where microorganisms are directly involved in the decomposition of organic matter in biological processes for waste water treatment because often the inhibitory effect of heavy metals is a common phenomenon that occurs in the biological treatment of waste water and sewage. The application of heavy metal tolerant microorganisms is a promising approach for increasing heavy metal bioavailability in heavy metal amended waste water.

II. MATERIALS AND METHODS

Sample collection

Water sample were collected from polluted site of Ganga River Water from Sidkul, Ram Teerath Ghat (Haridwar) Triveni Ghat, Beraj Ghat (Rishikesh) and Devprayag, Uttrakhand.

Physicochemical analysis of polluted Ganga Water

The sampling started after a few minutes of arrival at the sampling station, to minimize the disturbance in water for the analysis of chemical characteristics samples are collected from the fixed stations of the site which were being investigated. The samples were brought to Laboratory and were studied within 24 hours of collection. For the collection and preservation of water samples for different laboratory analysis we always carried with us separate pre-labeled bottles and preservatives and all other requirements for this study. The water temperature was recorded at the site using a sensitive mercury thermometer and pH was measured in-site using pH meter. The Electrical Conductivity, TDS, chlorides, DO, BOD, phosphate were analyzed in the laboratory using standard methods. The samples were acidified using 6N nitric acid for sample preservation (APHA WWA, 1998). These preserved samples were used for the determination of BOD and DO values. For calculating the BOD values the method used was that of Trivedi and Goel [17].

Temperature

Temperature measurements were usually made with mercury filled thermometer. The reading was recorded by dipping the thermometer in the sample. Sufficient time had to be elapsed before constant reading was obtained. The temperature was expressed to the nearest degree centigrade. The temperature of water samples was measured in the field at the sampling site itself using thermometer having least count of 0.1°C [17]

pH value (Hydrogen ion concentration)

The pH value of the water samples was determined at a constant temperature 25° C by making use of battery operated digital pH meter of Pentax make calibrated with standard buffer solution of strength pH=4.0 and pH=7 respectively.

Total Alkalinity

The total alkalinity was determined by titrating the known volume of sample with (.02 N) sulphuric acid as per the procedure laid down in standard methods (APHA, AWWA & WPCF, 1998).

Dissolved Oxygen

It was analyzed using Winkler's method: The samples of surface and middle water were collected in 200 ml Winkler's bottles and immediately Winklerize by manganese Sulphate and alkaline potassium Iodide solutions. The resultant Brown coloured precipitate was dissolved by one ml of cone H_2S0_4. 50 ml of these treated samples was created against N/40 Sodium thiosulphate Solution using starch an Indicator (APHA 1998).

$$\text{DO mg/l} = \frac{T * M}{0.025} \qquad (1)$$

Where, T= Titrant used, M= Molality of thiosulphate titrant

Biochemical Oxygen Demand (BOD)

For calculating the biochemical oxygen demand (BOD) water samples were collected in 200 ml of Winkler's bottles and immediately Winklerized by Magnesium sulphate and alkaline potassium iodide (KI) solutions. A brown coloured precipitate was appeared. To this precipitate one ml of concentrated sulphuric acid (H_2S0_4) was added. 50 ml of this sample was titrated against N/40 solution of sodium thiosulphate solution using starch as indicator. (By the above method DO of the samples was determined).The other samples were incubated at 20°C for five days. Dissolved oxygen of these samples was estimated as above. The difference between the two values will give biochemical oxygen demand (BOD).

$$\text{BOD (mg/l)} = D_1 - D_2 \qquad (2)$$

Where, D_1 = Initial DO in sample (mg/l), D_2 = DO after 5 days of incubation (mg/l)

Electrical Conductivity

The Electrical Conductivity of the collected water samples had been determined at 25°C with the help of a battery operated digital conductivity meter of Pantex make calibrated by 0.01 N Solution of KCI (Potassium Chloride) as per the standard methods given in (APHA, WWA & WPCA, 1998).

Hardness

Water hardness is a concern; water softening is commonly used to reduce hard water's adverse effects. Hardness can be quantified by instrumental analysis. The total water hardness is the sum of the molar concentrations of Ca^{2+} and Mg^{2+}, in mol/L or m mol/L units. Although water hardness usually measures only the total concentrations of calcium and magnesium (the two most prevalent divalent metal ions), iron, aluminum, and manganese can also be present at elevated levels in some locations. The presence of iron characteristically confers a brownish (rust-like) color to the calcification, instead of white (the color of most of the other compounds).

Hardness (EDTA) as

$$CaCO_3/l = \frac{A*B*1000}{C} \quad (3)$$

Where, A = ml of titration for sample, B = mg $CaCO_3$ equivalent to 1.00ml EDTA tartan.,C = ml of sample.

Heavy metal tolerance of isolated strains

To examine the ability of the isolates to resist heavy metals, cells of overnight grown cultures were inoculated on nutrient agar plates supplemented with different concentrations (0.5, 1.0, 3.0 and 5.0 mM) of heavy metals (magnesium in magnesium sulphate, Lead in Lead acetate, Mercury in Mercurric(II)chloride, Zinc in Zinc sulphate, cobalt in *Cobalt(II)sulphate*, Arsenic in *Arsenic(III)chloride* and Copper in Copper(II)sulphate). Cultures were incubated at 37°C for 24 hours and cell growth observed.

Treatment with selective bacterial inoculums for sewage degrades

Degradation of tannery effluent was carried out in three different conditions. The pH of effluent was adjusted to 7.0 and taken in Erlenmeyer flasks (250ml) containing 100 ml of effluent and autoclaved. In the first set of experiment only crude effluent was taken. In second set of experiment, sterilized glucose solution was added in tannery effluent aseptically to maintain the final concentration 1.0 % (w/v). In another set, 20 % (v/v) of mineral salts medium (MSM) (g/l): $MgSO_4·7H_2O$: 0.005; $CaCl_2·2H_2O$: 0.005; $NH_4H_2PO_4$: 0.5; $FeSO_4·7H_2O$: 0.001; $CuSO_4·5H_2O$: 0.02; $MnSO_4$: 0.001) sterilized separately and then mixed with tannery effluent (80 ml effluent+ 20 ml MSM) aseptically in a laminar flow. Control samples for each set of experiment were also maintained separately without inoculation of bacterial strain. All experiments were carried out in duplicates. After incubation period, the treated effluents were centrifuged at 5000 rpm for 15 min. The supernatants were used for analytical determinations. Color reduction was measured at 465 nm in a UV-Vis spectrophotometer [18] . Other physicochemical parameters like pH, TS, TDS, BOD, COD, total alkalinity and dissolved oxygen were carried out before and after treatment. The concentration of each of the component was determined as per the procedure outlined in APHA (American Public Health Association) [19].

III. RESULTS AND DISCUSSION

Pollution is contamination of the natural environment with harmful substances often as a consequence of human activities. The amount of pollution that has entered our environment has been greatly increased by human activity and can have a negative impact on human quality of life and the health of the environment. There are a number of different types of pollution that have a large cumulative impact on our local environment among them water pollution is a major global problem. Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds. It affects plants and organisms living in these bodies of water; and, in almost all cases the effect is damaging not only to individual species and populations, but also to the natural communities.

An analysis of Physico-chemical parameters including estimation of heavy metal was carried out for all water samples. The pH values analyzed using pH meter was found to be more or less similar for each sample, where values were ranging from 6.5 to 8.1. pH should be in the range of 6.5 to 8.5 for drinking and domestic purposes.The pH ranged from at all locations 6.9 to 8.1 in summer and 6.5 to 7.5 in rainy season. The pH value of Ganga water falls between slightly acidic to moderately alkaline and has relationship with the solubility and accumulation of heavy metal in river water as well as sediments according to Tesssier et al **[20]**. Because most of the chemical and biochemical reaction are influenced by the pH it is of great practical importance. The adverse affect of most of the acids appear below 5 and of alkalis above the pH 9.5. The pH values were significantly higher in summer season with the highest value 8.1 in at Haridwar sidkul and lower in rainy season with lowest value 6.5 in at Devprayag.

The water temperature of the Ganga at Hardwar ranged between 18ºC to 29ºC at rainy season and 21.6ºC to 32ºC at summer season. The maximum water temperature started decreasing due to the melting of snow at the peaks of the Himalaya. The water temperature showed an upward trend from winter season to summer season followed by a downward trend from rainy season onwards. It is the important factor which influences the chemical, biochemical and biological characteristic of the aquatic system. The Temperature values were significantly higher in April and lower in September. Total Hardness ranged from 90 to 200 ppm which crosses the WHO limit of 100 mg/L indicating that the water of all sites as fairly hard, which may affect the potability of water. The hardness was higher in the rainy season 112 mg/L to 192 mg/L and lower in the summer season between 97 mg/L to 182 mg/L. Calcium ions make major contribution to the hardness of river water. Similarly, Khare *et al.*, [21] evaluate physico-chemical parameters of water samples of Ganga river at Kanpur. Water samples under investigations were collected from the different sites of Kanpur and its adjoining areas during Pre monsoon (April-May) year 2010. Correlation coefficiets were calculated between different parameters to identify the highly correlated and interrelated water quality parameters and t-test was applied for checking significance. The observed values of different physico-chemical parameters like pH, temperature, turbidity, total hardness(TH), Iron, total alkalinity (TA), oxygen consumption (OC) and suspended solids (SS) of samples were compared with standard values recommended by world health organization .

Dissolve oxygen ranged from 5.6 to 6.79 mg/L in summer season and 6.1 to 7.2 mg/L in rainy season which was below as well as above the permissible limit assigned by BIS. The Ganga water contained highest dissolved oxygen during summer season. The higher concentration of dissolved oxygen during rainy season was probably due to low water temperature. The maximum 7.2 mg/L oxygen content of water was recorded in rainy season and minimum 5.6 mg/L in summer season. From monsoon season the water of Ganga starts becoming turbid which reduces the photosynthetic activity of the algae and thus decreases oxygen concentration. Biological oxygen Demand is a measure of oxygen in the water that is required by the aerobic organisms. The biodegradation of organic materials experts' oxygen tension in water and increases the biochemical oxygen demand [22]. BOD has been fair measure of cleanliness of any water on the basis that values less than 1-2 mg/L are considered clean, 3 mg/L fairly clean, 5 mg/L doubtful and 10 mg/L definitely. During the study period the minimum value of BOD was 8.3 mg/L and maximum value of BOD is 9.5 mg/L in month of April at site Beraj Ghat. BOD ranged from 8.3 to 9.3 mg/L in rainy season and 8.5 to 9.5 mg/L in summer season.

The COD ranged from 17.7 mg/L to 24.5 mg/L in rainy season and 20.9 mg/L to 25.3 mg/L in summer season. The minimum COD was recorded in rainy season and maximum in summer season. COD is an oxygen demand to decompose the biodegradable as well as non biodegradable organic waste. The measure of COD determines the quantities of organic matter found in water. This makes COD useful as an indicator of organic pollution in surface water [23]. COD pointing to a deterioration of water quality likely caused by discharge of municipal waste water [24].

Total alkalinity throughout the year ranges from rainy season between 72 mg/L to 96 mg/L in summer season between 76 mg/L to 96 mg/L in summer season. The turbidity in the river Ganga at Haridwar was lowest during rainy season. From summer season onwards the water became turbid due to melting of snow and rains. During the study the maximum turbidity 138.6 NTU was observed in summer season and minimum 83 NTU was observed in rainy season. Water transparency is an important factor that controls the energy relationship at different tropic levels. It is essentially a function of reflection of light from the surface and is influenced by the absorption characteristics of both water and of its dissolved and particulate matter [25]. Similarly, Trivedi *et al.* [26] investigate of physico-chemical parameters of water samples of Ganga River at Kanpur. The observed values of different physico-chemical parameters like pH, temperature, turbidity, total hardness(TH), Iron, Chloride, total dissolved solids(TDS), Ca^{2+}, Mg^{2+}, $SO4^{2-}$, $NO3^{-}$, F^{-}, total alkalinity(TA), Oxygen consumption (OC) and Suspended solids (SS) of samples were compared with standard values recommended by world health organization (WHO). It is found that significant positive correlation holds for TA with Cl^{-}, Mg^{2+}, Ca^{2+}, TH, TDS, fluoride and OC. A significant negative correlation was found between SS with chloride, Mg2+, TDS, fluoride and OC.

Bhargava *et al.*,[27] reported some improvement in water quality parameters such as BOD, DO, total phosphate and nitrate as compared to the previous study. In their observation they found that despite high organic pollution load in river Ganga, the DO levels in the river were high and background BOD levels in the river are low [28].

Similarly, Matta, [29] examined impact of pollution on River Ganga at Rishikesh with two different sites i.e. Site 1 (Shivpuri) control site and Site 2 (Pashulok Barrage) with loads of pollution from dense commercialized waste water discharging areas from Rishikesh. While monitoring samples were collected monthly (2011-2012) from sampling sites to evaluate relative differences in physico-chemical properties of river water such as Temperature (8.14%) higher, Turbidity (29.39%) higher, Transparency (13.93%) lower, Velocity (4.34%) lower, Total solids (27.40%) higher, pH (1.40%) higher, Dissolved Oxygen (6.20%) lower, Free CO2 (11.76%) higher and Total Hardness (18.83%) higher at site 2 in comparison to Site 1. The mean values of these parameters were compared with WHO and ISI standards. Turbidity on both sites was observed above the permissible lim it but, was found much higher on Site 2 in comparison to Site 1 due to pollution in Rishikesh.

Similarly Rai *et al*. [30] evaluated Ganga river water quality at different ghats of Haridwar, showed high TDS (782.15 mgL^{-1}) and BOD (21.76 mgL^{-1}) levels at the mixing points of sewage discharge channels and the water was found to be contaminated with appreciable amounts of toxic metals; Cu, Pb, Zn, Cr and Mn (0.178, 0.566, 0.199, 0.177 and 0.160 mgL^{-1}). The Ganga water supported exuberant growth of algae and aquatic macrophytes in littoral zone of river, which accumulated appreciable amount of metals in their tissues. Results showed possibility of using metal accumulation potential of plants and algae for monitoring low level of metal contamination and their use in renovating sewage by treating into especially designed constructed wetland.

Isolation of heavy metal resistant bacteria

Toxic metals in air, water and soils are global problems that are growing threat to humanity. There are hundreds of sources of heavy metal pollution including the coal, gas, paper and chlor alkali industries. Some of them are dangerous to health or to the environment (e.g. mercury, cadmium, lead, chromium). Some may cause corrosion (e.g. zinc, lead), some are harmful in other ways (e.g. arsenic may pollute catalysts).

In the present study heavy metal resistant bacteria species were isolated from the wastewater by method using Nutrient agar supplemented with different heavy metal salts such as (magnesium in magnesium sulphate, Lead in Lead acetate, Zinc in Zinc sulphate, cobalt in Cobalt(II) sulphate, and Copper in Copper(II)sulphat in different concentration around 50ppm. Sinha and Paul, [31] observed heavy metal tolerant bacteria isolated from the metal factory effluent. The three potential metal tolerating isolates were morphologically, physiologically and biochemically characterized. All isolates were found to be Gram positive cocci demonstrating physiological characteristics primarily indicative of the genus Aerococcus, though it needs further characterization. The study indicated the potentiality of the isolate GM1 to tolerate and accumulate significance amount of lead, which is indicative of use of this strain for bioremediation of lead pollution in the river Ganga in those metal contaminated area.

Table 1: Physico-chemical parameter from different polluted Ganga water at different season

		BD	BRH	BSH	BTR	BBR
pH	Autumn	6.5	6.7	6.6	7.5	6.8
	Spring	6.9	7.3	7.6	8.1	7.4
Temperature	Autumn	18	24	29	22	20
	Spring	22	28.6	32	24	21.6
Hardness	Autumn	192	158	127	112	129
	Spring	182	138	113	97	106
DO	Autumn	6.3	6.7	7.2	6.4	6.5
	Spring	5.7	5.8	6.79	5.8	5.86
BOD	Autumn	8.3	8.9	9.3	8.5	8.8
	Spring	8.5	8.7	9.4	9.2	9.5
COD	Autumn	17.7	22.6	24.5	21.7	23
	Spring	21.8	20.9	25.3	22.6	23.7
Total Alkalinity	Autumn	94	72	96	86	72
	Spring	96	84	83	89	76
Turbidity	Autumn	89.6	104	129	94	83
	Spring	96	116.9	138.6	98.5	114

Fig1: Isolation of heavy metal tolerance bacteria

Name of bacterial isolates	Metal concentration (10x ppm)																			
	Cobalt				Copper				Zinc				Magnisium				Lead			
	15	20	25	30	35	40	45	50	30	35	40	45	30	35	40	45	15	20	25	30
BD	+	+	-	-	+	+	+	±	+	+	+	-	+	+	+	±	+	+	±	-
BRH	+	±	-	-	+	+	+	+	+	+	±	-	+	+	+	-	+	+	+	-
BTR	+	+	±	-	+	+	±	-	+	+	+	+	+	+	-	-	+	+	±	-
BSH	+	+	-	-	+	-	-	-	+	+	-	-	+	+	+	-	+	±	-	-
BBR	+	+	-	-	+	+	+	-	+	+	-	-	+	+	-	-	+	±	-	-

Table 2 Evaluation and screening of heavy metals tolerance bacteria:

+ means bacterial strain shown good result, ± means bacterial strain shown low result, -means no growth of bacterial strain

Treatment with selected bacterial inoculation for sewage degradation

Biodegradation is defined as the biologically catalyzed reduction in complexity of chemical compounds 32). Indeed, biodegradation is the process by which organic substances are broken down into smaller compounds by living microbial organisms [33]. When biodegradation is complete, the process is called "mineralization". However, in most cases the term biodegradation is generally used to describe almost any biologically mediated change in a substrate [34]. So, understanding the process of biodegradation requires an understanding of the microorganisms that make the process work. Only 3 bacterial isolates and a consortium all these bacteria were taken for treatment of sewage water. During the present study pH check regular 5 days it was slightly changed to acidic (6.8) from initial pH (6.6). The value of DO, BOD, total alkalinity, total hardness and turbidity were also reduced after treatment, signifying the degradation of toxic solid components in the effluent. The decrease in level of COD indicates the reduction of biologically oxidisable and inert organic materials as result of the degradation by the isolates. Reduction in physicochemical parameter from the effluent after treatment makes it less toxic. In second set of experiment, when 20% (v/v) MSM was added in effluent. The MSM contains microelements and the trace elements that are important for bacterial growth in the tannery effluent. The other physico-chemical parameters were also reduced after treatment. Bacterial strain was able to grow more efficiently when MSM added to tannery effluent. No extra carbon source was necessary, indicating that the concentrations of trace element present add in the tannery wastewater effluent was sufficient for the bacterial growth and to decrease the COD values. The results revealed that the bacterial strain is efficient enough to degrade the tannic components and detoxification of tannery effluent. Several microorganisms, including fungi, bacteria and yeasts are involved in biodegradation process. Algae and protozoa reports are scanty regarding their involvement in biodegradation [35]. Biodegradation processes vary greatly, but frequently the final product of the degradation is carbon dioxide [36]. Organic material can be degraded aerobically, with oxygen, or anaerobically, without oxygen.

Table 3: Physiochemical analysis of polluted Ganga water after treated with bacterial inoculums

		BD	BRH	BTR	BDRT
Ph	1 day	6.6	6.61	6.6	6.63
	2 day	6.62	6.65	6.67	6.8
	3 day	6.7	6.72	6.73	6.89
	4 day	6.83	6.78	6.87	7.21
	5 day	7.12	6.98	7.25	7.44
Total Alkalinity	1 day	96	96	98	95
	2 day	94	93	95	90
	3 day	91	88	92	85
	4 day	87	86	88	83
	5 day	84	82	85	80
DO	1 day	7.1	6.9	7.21	6.9
	2 day	7.34	7.2	7.44	7.2
	3 day	7.5	7.57	7.59	7.61
	4 day	7.69	7.76	7.83	8.03
	5 day	7.96	7.9	8.1	8.4
Total Hardness	1 day	188	195	193	186
	2 day	185	191	187	180
	3 day	181	183	179	175
	4 day	170	177	172	168
	5 day	163	165	161	152
Turbidity	1 day	152	148	150	147
	2 day	140	143	142	138
	3 day	132	141	138	126
	4 day	129	136	131	123
	5 day	124	129	126	114
BOD	1 day	9.5	9.46	9.43	9.3
	2 day	9.38	9.26	9.31	9
	3 day	8.7	8.4	8.5	8.6
	4 day	8.2	8	8.1	7.8
	5 day	7.9	7.8	7.69	7.2
COD	1 day	20.3	21.1	21.5	22.5
	2 day	21.2	21.53	21.78	21.41
	3 day	20.8	20.6	20.5	19.6
	4 day	20.6	20.1	20.71	20.98
	5 day	20.54	20.34	20.19	19.44

IV. CONCLUSIONS

The present study also reveals that metal ions not only have direct effect on survival of microorganism but have the partial effect on physico-chemical parameters. Bacteria which were found to be tolerate towards metals including Cr, Co, Mg, Zn and Pb will have great scope for their application in bioremediation of toxic from contaminated environments. The isolated bacterial strains are capable of degrading the easily assimilable organic compounds present in sewage wastewater. These isolates are capable of effectively reducing the pollutional load of the sewage wastewaters, in terms of COD, BOD, DO, total hardness, turbidity, pH and total alkalinity. The use of such isolates can overcome the inefficiencies of the conventional biological treatment facilities currently operational in sewage treatment plants. These three isolates; BD, BTR, BRH and consortia BRTD is efficient enough to degrade the tannic components and detoxification of metal in tannery effluent. The study establishes the potential use of isolates making the effluent non toxic after treatment, and the waste waters can be reused. This bioremediation study will be helpful to some extent to address the environmental pollution.

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