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Characterization and Impact of Physicochemical Parameters of Tannery Effluent on the Aquatic Environment

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One of India's oldest and fastest-growing sectors is tannery production. The tanneries produce various types of pollutants in the environment depending upon the procedure that has been used. The present study investigated the physicochemical parameters of tannery effluents and its impact on the aquatic environment. Tannery effluent contains a variety of hazardous compounds, including chromium, calcium, sodium, potassium, chloride, sulphate, electrical conductivity, colour, odour, pH, temperature, TSS and TDS. All physicochemical parameters was found higher [chromium 1.17-1.52 (1.327±0.132), calcium 800 (713.83±50.33), sodium 1805 (1634.83±75.06), potassium 38-112 (78.44±9.05), chloride 2330-4210 (3334.22±241.92), sulphate 830-1008 (952.17±15.06), EC 1148-2905 (2378.61±124.27), temperature 29.3-38.0 (31.21±1.45), TSS 710-1623, (1199.39±137.99), TDS 7049-8500 (7669.17±141.99), BOD 1060–1664 (1347.17±73.68), COD 3025-4982 (4029.83±163.56), TH 2200-3417 (2794.50±136.49) and only pH levels were lower 4.4-8.8 (7.01±0.491) in tannery effluent]. The high levels of heavy metals were analyzed that might become a major source of pollution which affect the aquatic environment. The management of tannery effluent's physicochemical parameters and its impact on the aquatic environment involves a combination of regulatory, technological, and educational approaches. It requires a multi-faceted effort to mitigate environmental harm while supporting the tanning industry's sustainable development.

Keywords: Aquatic Environment; Heavy metals; Physicochemical parameters; Tannery effluents.

The tannery industry has shown remarkable extension and increasing pollutants to the aquatic environment during the last three decades. Total hardness (TH), biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), calcium, sodium, potassium, chloride, sulphate, and chromium are some of the component present in tannery effluent. The majority of underdeveloped nations do not treat the tannery effluents before they are dumped into the water supply. [1,2] The survival of aquatic species that

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breathe through their gills will be harmed by high BOD levels, while high COD levels indicate that the wastewater is hazardous and contains organic material that is resistant to biological processes. Eutrophication may result from the high levels of electrical conductivity (EC) and nitrogen, which are hazardous to aquatic species[3,4].

One of the main new environmental issues in the production and disposal of chromium-contaminated sludge is the tanning sector. Nearly three thousand tonnes of chromium are emitted into the environment each year from tanneries in India, with a level of 3000-5000 mg/L in the aqueous effluent[5]. While the toxicity of a substance to small animals, fish, or other wildlife can be assessed by simply subjecting a small number of them to varying doses of contaminants in a laboratory setting. The most popular method is to expose animals that can be produced for commercial purposes and made widely available to pollutants that are of concern to humans. The indestructibility of heavy metals during bioremediation, unlike organic contaminants, and their negative consequences as pollutants are two of the most significant factors.

As industrialization grows, untreated garbage is dumped into aquatic environments, contaminating natural water with different metals and cause harmful impacts[6]. Since heavy metals are not biodegradable, understanding how they are absorbed, distributed, and remain in biological tissues is essential[7]. The most popular tanning agent is chromium. Because chromium is harmful, it must be determined in environmental sample because it is used to tan about 90% of all leather manufactured. Even though it is thought to be necessary for mammals to maintain metabolism, its biological, geochemical, and toxicological properties differ greatly from one another[8,9]. The tanning process creates an extremely offensive-smelling waste that also contains a significant amount of salts, including chromium, sulphur dioxide, ammonia chlorides, and other salts. The wastewater has been dumped to open land or into waterways, heavily contaminating them with hazardous compounds and suspended and dissolved pollutants.

The aquatic organisms may take up pollutants from sediments, water, suspended particle and food items. In addition to fish infections, other factors that contribute to fish mortality include deteriorating water quality, industrial effluent, metallic contaminants, and pesticide residues. Fishery experts are of the opinion that the continuous discharge of persistent industrial pollutants is likely to cause serious damage to fishes in view of their toxic effect on respiration, growth, reproduction, spawning behaviour, egg mortality and fish survival[10,11]. *Channa punctatus*, a freshwater fish, was chosen for the inquiry primarily because it is a crucial biological indicator of freshwater quality and is impacted by environmental deterioration on a global scale[12,13].

The significance of present research lies in addressing these gaps and contributing to a more comprehensive and up-to-date understanding of the issue. Researchers can provide a more accurate assessment of the environmental and public health risks associated with tannery effluents, as well as the efficacy of treatment technologies and the impact of regulatory measures. This knowledge can inform policy decisions, support sustainable practices in the tanning industry, and protect both aquatic ecosystems and human communities from the harmful effects of tannery effluents.

MATERIAL AND METHODS

Study Area: In the present study, the selected area was Sempatu in Tiruchirappalli district, which is situated between $10^{o}10'$ and 11^{o} $20'$ North and 78^{o} $10'$and 79^{o} $0'$ East in the centre part of the Tamil Nadu. There are about fifteen tanneries situated in this area among them the NM tannery is selected for the present research work. Untreated sewage and effluent from the tannery business contaminate the water

Collection of Samples: Samples were taken straight from the collection tank in a plastic container, transported to the lab with due care, and held at $20^{o}C$ for additional examination in order to determine the contamination status of tannery effluent water. A total of 18 months were spent collecting the water samples *see in* Figure 1.

Physicochemical Parameters: The samples' physicochemical characteristics, including things like colour, odour, water temperature, pH, EC, TSS, TDS, BOD, COD, TH, calcium, sodium, potassium, sulphate, chloride and chromium.

Colour: The colour of the site's effluent water samples was visually assessed and noted. Odour: The odour of effluent water samples from the site was detected by smelling directly from water cans. Water temperature: Using a field thermometer, the temperature was determined at the time of sample collection. pH: The pH meter (Model Eltek Mx 61-A) was calibrated using different standard (pH 4.0, 7.0 and 9.2) solutions, thereafter the pH of samples were recorded. EC: It was measured using an EC metre from Elico, India; EC is a numerical indication of a sample's capacity to conduct an electric current in soil and water.

TSS and TDS: The TSS and TDS were calculated by using standard procedure.

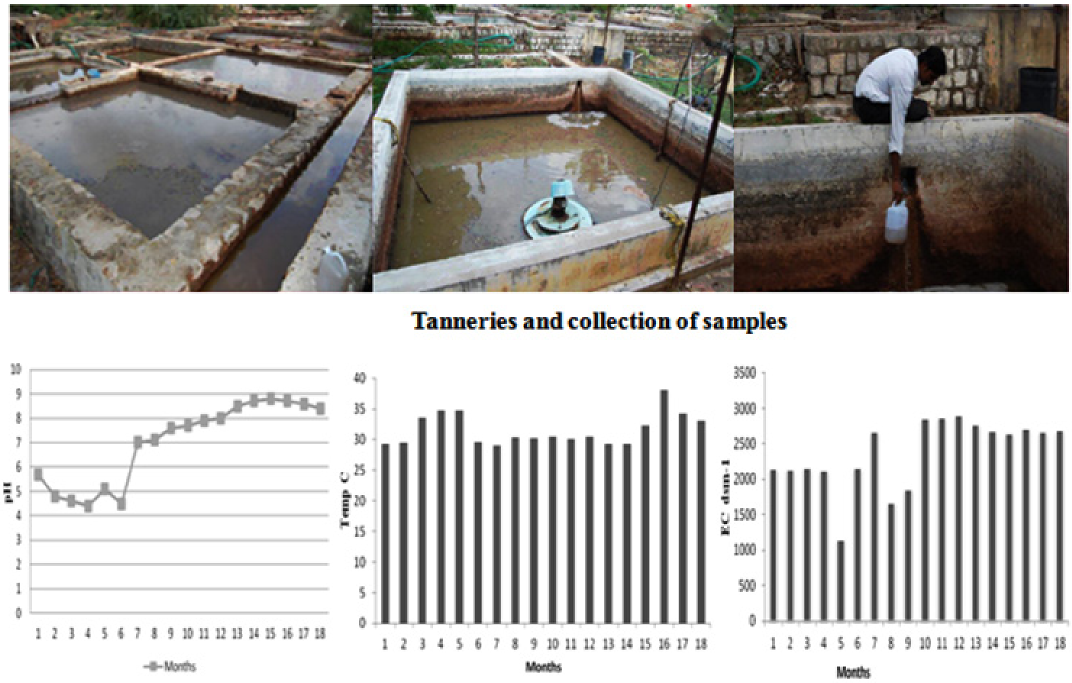
TSS or TDS = [(A-B) X 1000] / Sample volume (mL)

Whereas: A=Weight of filter and residue (g), B=Weight of crucible (g) and 1000 is constant.

BOD: The relative oxygen requirement of wastewater is assessed using standardised laboratory procedures in the BOD test. In this study, we adopted Winkler's method[14]. COD: The COD is a measurement of the amount of organic material in the sample that is capable of being oxidised by a potent chemical oxidant[14]. TH: Using American Public Health Association Colour Scale techniques, the total hardness was determined and monitored[14]. Calcium, sodium, potassium, and sulphate: Using a flame photometer (Model Chemito-1000) and the Jackson method, the calcium, sodium, potassium, and sulphate of the samples were determined[15]. Chloride and chromium: The chloride and chromium contents of the effluent were estimated by argentometric method[14,16,17].

RESULTS

Physico-chemical Parameters: Table 1 shows the information that was gathered regarding the physicochemical quality of the tannery effluent water samples. The visually observed colour of the effluent water samples from the site are shown in Table 1. The odour of tannery effluent is found to possess sewage smell throughout the period of study (Table 1). The pH of aqueous solution represents the concentration of H+ ions. During the study period, the effluent's pH fluctuated

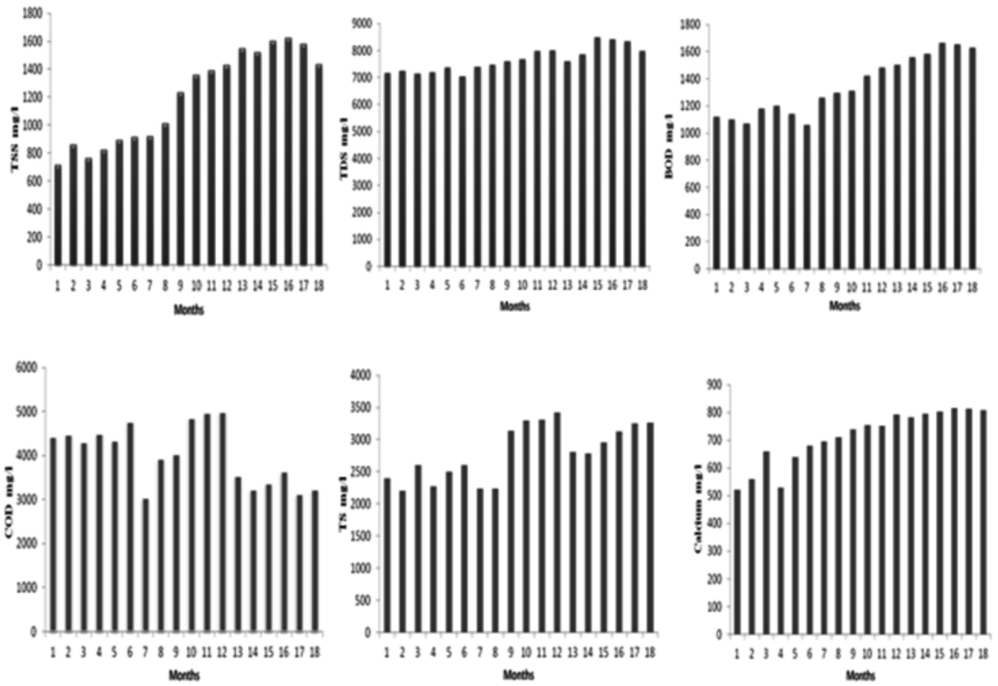


(Temp- Temperature; EC- Electrical conductivity)

Fig. 1. Show PH, Temp and EC values of tannery effluent

from 4.4-8.8, mean value 7.01±0.491 (Table 1 and Figure 1a). The pH range was found to be acidic to basic, not good for the aquatic life. The water temperature of tannery effluent was found to vary from 29.3-38.0^{o}C, mean value 31.21 ± 1.45 (Table 1 and Figure 1a). The minimum and highest recorded temperatures occurred in January and April, respectively. The EC of effluent water samples were found to vary from 1148-2905 micro/mho/cm, mean value 2378.61±124.27 (Table 1 and Figure 1a) during the study period. The values increased between August 2007 and June 2008, while the TSS in samples of tannery effluent water throughout the study period ranged from 710-1623 mg/L, mean value 1199.39±137.99 (Table 1 and Figure 1a).

The TDS was high in all months, ranged from 7049-8500 mg/L, mean value 7669.17±141.99 (Table 1, Figure 2). The BOD value of samples ranged started 1060-1664 mg/L, mean value 1347.17±73.68 (Table 1 and Figure 2). High BOD values were recorded during the study period, which indicates the quality of tannery water was unfit for the use of people. The water samples' COD values ranged from 3025-4982 mg/L, mean value 4029.83±163.56 (Table 1 and Figure 2). High COD values were recorded during the study period that indicates the bad quality of tannery water for any humans use. The TH of water samples were found to be ranging from 2200-3417 mg/L, mean value 2794.50±136.49 during entire period of research (Table 1 and Figure 2). Because of how hard it is, no home use is possible with the water. The total hardness of the samples was discovered to be extremely high during the post-monsoon period. Among the chemical properties especially the dissolved substances such as calcium and sodium was encountered in the water samples of the tannery effluent (Table 1). The calcium was found to be high from March to June 2008 (<800 mg/L) while it was (>800 mg/L), mean value 713.83±50.33 during the rest of the research time (Table 1 and Figure 2). Sodium was bring into being to be high (1200-1805 mg/L), mean vale

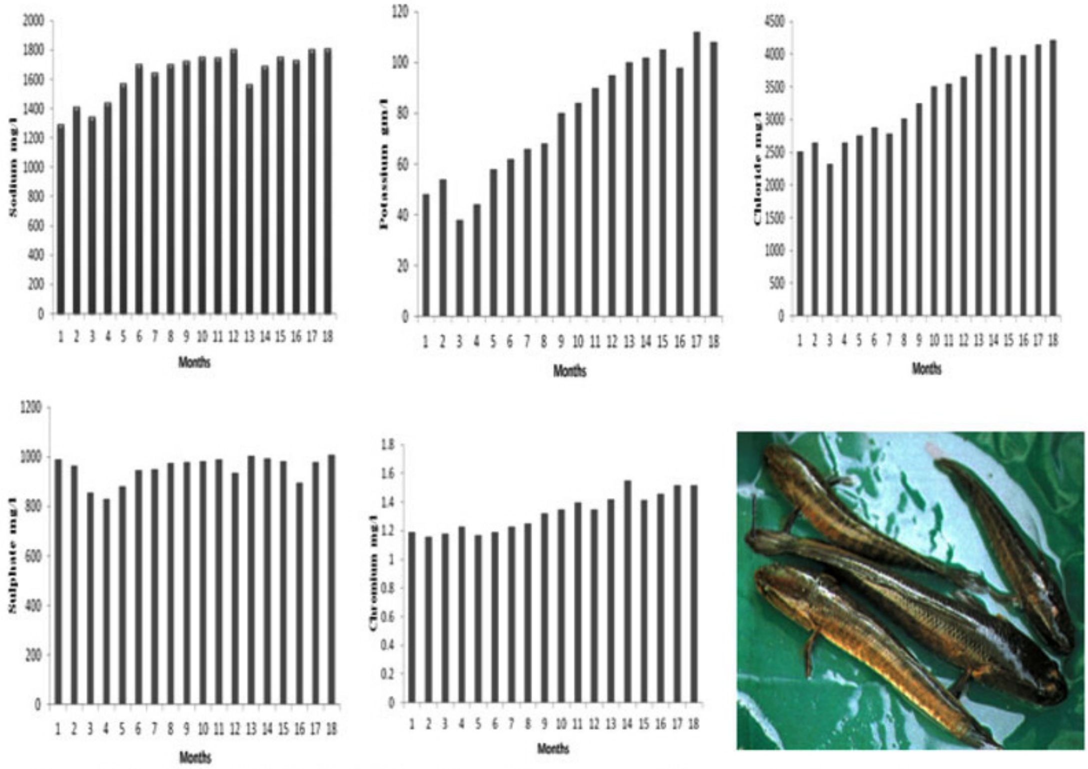


(TS- Total dissolved solids; BOD- Biological oxygen demand; COD- Chemical oxygen demand; TH- Total hardness; Ca- Calcium; Na- Sodium; K- Potassium Cl- Chloride; S- Sulphate; Cr- Chromium).

Fig. 2. Shows TSS, TDS, BOD, COD, TS and Ca values of tannery effluent

1634.83±75.06 in the month of June 2008 (Table 1 and Figure 2).

Among the chemical properties, especially the dissolved substances like potassium and chlorides were encountered in the water samples of the tannery effluent (Table 1). The potassium (Table 1 and Figure 2) was also high during May 2008 (112 mg/L) and low in the month March of 2007 (38 mg/L), mean value 78.44±9.05. The chloride range (Table 1 and Figure 2) was from 2330-4210 mg/L, mean value 3334.22±241.92 during the time of research, being high in the month of June 2008. Among the chemical properties especially the dissolved substances like sulphate and chromium was encountered in the water samples of the tannery effluent (Table 1). The sulphate content (Table 1 and Figure 2) varied from 830-1008 mg/L, mean value 952.17±15.06 respectively. The sulphate content was found to be high in January (1005 mg/L) and June (1008 mg/L) months respectively. The analysis of various metal content showed that the range of chromium was started 1.17-1.52 mg/L, mean value 1.327±0.132 (Table 1, Figure 2). The most significant behavioural pathology of *Channa punctatus* included restlessness, erratic darting movements occasionally, movement displays towards the aquarium's bottom, and gradual loss of buoyancy that resulted in fish floating upside down and horizontally with their open mouths and gill opercula (Figure 2a). It is found that the symptoms and mortality rate was increased with the increase in the dose and the pathological incidence was directly related to dose and duration of exposure. It indicate the loss of equilibrium due to Irregular and erratic movements that might be due to the damage in the brain associated with the maintenance of equilibrium. The symptoms were depending upon the nature of the toxicant and the dose dependent manner.



(TS- Total dissolved solids; BOD- Biological oxygen demand; COD- Chemical oxygen demand; TH- Total hardness; Ca- Calcium; Na- Sodium; K- Potassium Cl- Chloride; S- Sulphate; Cr- Chromium).

Fig. 3. Shows Na, K, CI, S and Cr values of the tannery effluent and Effect on *Chenna punctatus*

Table 1. Physico-chemical parameters of Tannery effluent collected from Sembattu area, Trichy, Tamilnadu

No	Parameters	Jan 2007	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2008	Feb	Mar	Apr	May	Jun	Mean±SD	Desirable limit
1	Colour	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	Gray	-	-
2	Odour	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	UPO	-	-
3	pH	5.7	4.8	4.6	4.4	5.1	4.5	7.0	7.1	7.6	7.7	7.90	8.0	8.5	8.7	8.8	8.7	8.6	8.4	7.01±0.491	6.5 to 8.5
4	Water Temperature	29.3	29.5	33.5	34.7	34.8	29.6	29.0	30.3	30.2	30.5	30.1	30.5	29.3	29.2	32.3	38.0	34.3	33.0	31.21±1.45	32C
5	EC (dsm^{-1})	2142	2138	2157	2122	1148	2154	2658	1665	1855	2855	2868	2905	2769	2680	2642	2715	2660	2682	2378.61±124.27	50-1500
6	TSS (mg/L)	710	860	760	818	892	912	920	1012	1234	1355	1390	1425	1544	1521	1601	1623	1580	1432	1199.39±137.99	<200
7	TDS (mg/L)	7168	7250	7150	7190	7380	7049	7400	7478	7610	7689	7993	8006	7599	7852	8500	8405	8332	7994	7669.17±141.99	<2000
8	BOD (mg/L)	1120	1100	1070	1180	1200	1140	1060	1263	1298	1311	1425	1485	1506	1558	1582	1664	1655	1632	1347.17±73.68	<800
9	COD (mg/L)	4420	4470	4300	4480	4320	4760	3025	3915	4022	4845	4965	4982	3520	3210	3352	3620	3110	3221	4029.83±163.56	<1500
10	TH (mg/L)	2400	2200	2600	2270	2500	2600	2232	2240	3132	3300	3310	3417	2802	2785	2955	3128	3255	3265	2794.50±136.49	600
11	Calcium (mg/L)	520	560	660	530	640	680	695	710	740	755	751	793	782	795	802	815	813	808	713.83±50.33	75-200
12	Sodium (mg/L)	1288	1406	1340	1440	1570	1700	1640	1699	1720	1750	1745	1799	1562	1685	1752	1726	1800	1805	1634.83±75.06	200
13	Potassium (mg/L)	48	54	38	44	58	62	66	68	80	84	90	95	100	102	105	98	112	108	78.44±9.05	8.3
14	Chloride (mg/L)	2520	2650	2330	2656	2760	2880	2790	3012	3255	3512	3554	3658	4002	4102	3985	3990	4150	4210	3334.22±241.92	200
15	Sulphate (mg/L)	990	964	854	830	880	948	950	975	980	981	989	935	1005	995	982	895	978	1008	952.17±15.06	200
16	Chromium (mg/L)	1.19	1.16	1.18	1.23	1.17	1.19	1.23	1.25	1.32	1.35	1.40	1.35	1.42	1.55	1.412	1.455	1.52	1.52	1.327±0.132	0.05

UPO-unpleasant odour, EC-electrical conductivity, TSS-total suspended solids, TDS- total dissolved solids, BOD-biological oxygen demand, COD-chemical oxygen demand and TH- total hardness

DISCUSSION

One of the most terrible ecological crises to which we are currently vulnerable is environmental pollution. India, which ranks seventh among the world's industrialised developing nations, has a robust industrial infrastructure in a number of sectors, including chemicals, power, nuclear energy, petroleum, plastics, food, and pesticides[18]. The issue of environmental degradation is not limited to industrialised nations; it is now spreading to India[19]. The toxicants and other unfavourable chemicals eventually enter water bodies with rainwater and degrade the water media, creating an imbalance in the environment that causes ecosystems, particularly aquatic ones, to slowly deteriorate and result in unabated aquatic fauna mortality[20]. The results of the current research demonstrate that the tannery effluent had a brownish and blackish appearance and an unpleasant scent. A similar study found that the tannery wastewater leaves behind a dark colour and pungent smell[21]. In a similar vein, Jamal[22] findings showed that a significant proportion of contaminants might transfer colour and odour to the receiving water. The wastewater was described as brownish and odourless in another study[23].

Aquatic toxicity testing is now an essential step in the process of determining environmental danger and the evaluation of toxic compounds since the aquatic environment serves as the final sink for all contaminants. International organisations, such as the Environmental Protection Agency[19], have advised understanding a variety of bioassays to evaluate the ecotoxic hazards to non-target creatures and their surroundings. Pollution's toxic effects result from disruption of an organism's normal morphological and physiological processes. Pathogen, pesticide, and heavy metal stress all cause changes in the biochemical components of tissues, and these changes follow a certain pattern. An organism's metabolic activity shows how biochemical energy is used to combat toxic stress[24]. The use of fish as bio indicators for detecting pollution in the aquatic environment is common because fish are known to bio collect, concentrate, and biomagnify toxicants in their tissue[25].

The tannery effluent's pH was found to be lower range. The water temperature level was found to be higher range. Similarly, Rabah and Ibrahim[26] reported a similar average pH of tannery effluent. This means in such level of pH the counts of microorganism high because most of them blooms well[26]. According to a study, Varadarajan and Sneha[27] The reported pH of the tannery effluent was 7.5. Therefore, The tannery effluent has a pH that is just barely alkaline. Fish do not thrive in the aquatic environment when tannery effluent with an alkaline pH is dumped into lakes, ponds, rivers, and other natural sources. The presence of carbonates, bicarbonates, hydroxides, borates, silicates, and phosphates in tannery effluent may be the cause of the substance's alkaline nature[28, 29].

In this investigation, the level of EC in the effluent was found higher range, whereas the acceptable limit is 1500, this shows that the tannery effluent had a larger discharge of chemicals in the form of cations and anions. This might be caused by the tannery effluent's high levels of acid-base and salt[22]. The tannery effluent's chelating capabilities are altered by the higher EC, which also affects how readily available free metals are to aquatic species[30].

One important metric used to assess the effects of tannery effluent on water contamination is the estimation of BOD. Due to the significant amount of organic matter present, the effluent in the current study had found high levels of BOD. According to Noorjahan[21] a high point of BOD was experimental in the tannery effluent. In another similar study high level of BOD was reported[31].

To estimate organic matter the best method is COD test and total oxygen demand, determination by rapid test in the existence of organic matter. In current research, the level of COD was recorded higher range. The study of Noorjahan[21] reported higher range of COD from the tannery effluent. The results of present study support the previous study[32]. Due to the high concentration of organic molecules in the effluent, which may not be affected by bacterial breakdown, the quantity of COD may have increased[33].

In the current study, the level of TDS was recorded for tannery effluent higher range value. Similarly, Noorjahan[21] reported the higher range of TDS value. Similar findings from a different study with high levels of physicochemical factors, including TDS, COD, TSS, chloride, sodium, nitrate, pH, the high colour intensity in tannery effluent[34]. TDS are mainly due to carbonates, bicarbonates, phosphates, sulphates, nitrogen, calcium, chlorides, iron and potassium[35]. The high levels of TSS and TDS may be caused by the presence of insoluble organic and insoluble inorganic materials in the tannery effluent[36].

The level of TSS in the tannery effluent was measured in the current investigation found higher range, which exceeded the permissible levels less than two hundred. The tannery effluent becomes murky due to these TSS contaminants. The quality of the hides and skins treated in the tannery largely determines the composition of TSS found in tannery effluent[29]. When compared to the allowed limit of two hundred for effluent discharge, the TSS level in the effluent was found to be greater. High TSS concentrations harm aquatic species, limit the variety of life in the aquatic system, and hasten oxygen depletion[37]. A report claims that charges on the surface of small particles in the tannery effluent force the bigger TSS particles to remain suspended[38].

The studies shows TH of tannery effluent level was found high range was observed, which exceeded the permissible limit of six hundred. In the investigation, the level of calcium was found higher in the effluent, although the permissible limit is 75-200. The level of sodium was recorded higher range in the effluent, however the acceptable limit two hundred. In the present research, the higher range of potassium was found in the effluent, whereas the permissible limit is less the 8.3. This is lower than the previous study[23]. In the previous research, it was discovered that the soil watered with tannery water had significant levels of exchangeable calcium, sodium, and potassium[23].

In the current study, the level of chloride was observed higher range in tannery effluent, whereas the permissible limit is two hundred. Chlorides are added to tannery effluent, which slows the growth of aquatic organisms and, at high concentrations, can cause cell structure to break down. Rain-induced soil chloride loss causes it to re-enter the ecosystem and could end up in groundwater[39].

The level of sulphate was found higher range in the effluent samples, whereas the permissible limit is two hundred. The level of sulphates were exceeded the limit. Sulphate is a component of tannery effluent, according to the earlier study, and it results from the use of sulphuric acid or goods with a high sulphate level[39]. Similar to this, Vijayanand[40] reported that the association of organic matter, calcium, magnesium, carbonates, bicarbonates, sulphates, chlorides, and nitrates increases the hardness of water.

One of the most serious new environmental problems brought on by wastewater treatment by-products is the disposal of chromium in the tanning industry. Chromium, iron, nickel, cadmium, zinc, manganese, and copper are among the elements that are contaminating the aquatic environment at increasing quantities in the tannery effluent. In the present study, the level of chromium was found higher range, although the permissible limit is 0.05. According to Rabah and Ibrahim's analysis, the tannery effluent contained (0.26) milligrammes of chromium[26]. High levels of chromium concentration are still hazardous to aquatic organisms and have been shown to change their food chains[41].

In this study, *Channa punctatus* exposed to the tannery effluent at different concentrations showed severe and varied pathological symptoms depending upon the dose and nature of the toxicant. The most significant behavioural pathologies was restlessness, sporadic erratic darting movement, migrating to the aquarium's bottom, rapid opercular motions, and gradually losing buoyancy, which led to fish floating upside down horizontally with their open mouth and gill opercula. Similar behavioural responses of *Cyprinus carpio* to industrial effluent were observed[42,43]. Irregular and erratic movements indicate the loss of equilibrium that might be due to the damage in the brain associated with the maintenance of equilibrium.

CONCLUSION

The current analysis has confirmed that the tannery effluent's physicochemical characteristics exhibit high concentrations of EC, TSS, TDS, BOD, COD, TH, sodium, calcium, chlorides, sulphates and chromium that exceed the permissible levels. The physicochemical analysis showed that the morphological changes in the appearance of fish within tannery effluent water samples are because of variation in the salinity, odour and pH. Large volumes of mucous and excrement were discharged from the body, and behaviour changes like widely opened mouths, erratically moving operculums, and frequent up-and-down motion were noticed. The skin was also a poor shade. The current investigation thus showed the detrimental effects of tannery effluent on the aquatic ecosystem.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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