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Toxicity analysis of aqueous waste of textile industry: Effects on human, Aquatic and Agriculture system.

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ABSTRACT

Humans rapidly devour environmental riches for their growth; among the resources they consume, water is being consumed at an alarming rate owing to unregulated and unsustainable usage. A massive volume of wastewater is produced across the world as a result of industrialization and domestic usage as a result of urbanization. Numerous contaminants identified in water bodies have been reported to be generated major health difficulties and studying the release mechanism, degradation process, and execution of their removal procedure before discharging into natural water bodies is required. Temperature, pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), color, alkalinity, total dissolved solids (TDS), and heavy metal ions were used to characterize the substance of textile wastewater quality (cadmium, copper, forum manganese, lead, and zinc). The results also showed that several of the conditions for the ultimate discharge of textile wastewater could not be properly discharged because textile wastewater had been shown to include a high level of contaminants, including excessive TDS and suspended particles. Due to dyestuff and suspended particulates, the wastewater is intensely colored and viscous. Because of the large use of sodium salts in processing facilities, sodium is the dominant important cation. Although chloride is the most abundant anion in wastewater, bicarbonate, sulphate, and nitrate concentrations are also significant (>100 mg/L). In most cases, sodium salts of these anions are utilized in the procedure. Chromium is the most abundant toxic metal, although other toxic substances such as iron, zinc, lead, copper, and manganese are also found. The wastewater also contains high BOD and COD levels, indicating that it is polluting. Toxicity effect on human health, aquatic life, agriculture fields, and soil fertility.

KEYWORDS: Industrialization, textile wastewater, wastewater qualities, hazardous effect, natural water bodies

Introduction:

Any country's progress is built on the rising formation of various industries. At the time, we developed various industries without regard for long-term development. The textile industry itself is a substantial pillar of every country's economy for industrial establishment. The discharge of various release dyes from the textile industry is a key source of concern these days. In the textile sector, 700,000 million tonnes of dyes are being used each year. [1].

The increased demand for textile products has resulted in the development of the textile industry, particularly in emerging countries. The most visible environmental effect of textile production operations is the significant consumption of water and wastewater discharge, with the processes generating roughly 115–175 kg of chemical oxygen demand (COD) per tonne of the final product [2]. In general, wastewater from textile manufacturing operations contains a diverse and complex combination of contaminants, including organic and inorganic chemicals, polymers, and color [3,4]. Because of its contaminated industrial effluent, the phenomenon has also had a harmful consequence on human and environmental health generally [5]. The textile processing industry is one of the most water-intensive manufacturing industries because freshwater has been applied at almost every stage of the manufacturing process [6].

Textile dyeing is the world's second-largest polluter of water, and the fashion sector accounts for 20% of global wastewater production. When it comes to making apparel and home goods, manufacturers consume a lot of water, and the resulting effluent has a detrimental impact on the environment. It has an impact on the environment, wildlife, human food discipline, and soil/groundwater contamination. According to a World Bank analysis from 2019, "some research has revealed that the textile sector is responsible for around one-fifth of worldwide water contamination." Water is still utilized heavily throughout the textile industry for scrolling, bleaching, and dyeing operations. The major source of contamination is wastewater. If this polluted water is not cleaned before entering the reservoir, it might diminish the quantity of oxygen, which could be damaging to both aquatic life and the aquatic ecosystem in general.

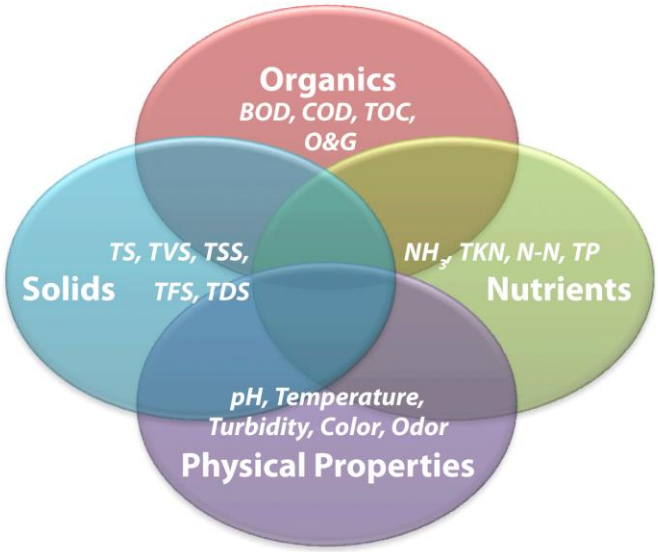

Figure 1. Interaction of wastewater analytical categories and laboratory tests.

Although wastewater analytical tests are frequently classified, it is critical to recognize that these tests are not mutually exclusive **(Figure 1)**. In other words, a contaminant detected by one test in one category can also be recognized by another study inside a different category. Organics in a wastewater sample, for example, will be expressed in the spectrum of solids as suspended (TSS) or dissolved (TDS) particles. For most persons, a thorough grasp of the standard methodologies required to properly conduct crucial wastewater analytical tests is not required. A fundamental grasp of the theory underlying every testing, as well as practical knowledge of the basic techniques used for each test and answers to frequently asked questions about each test, may be a helpful tool for anybody engaged in the generation, monitoring, treatment, or discharge of process wastewater.

The current study focuses on water contamination caused by fast industrialization and its negative health implications. Industrial wastewater is now considered the most significant cause of water pollution affecting surface water bodies like rivers, lakes, reservoirs, and seas, and even the situation is worse due to increased industrialization. According to the AQUASTAT database, 3928 km3 of worldwide freshwater is removed each year, 22 percent (865 km3) of which is consumed by industry. Industrial effluents are one of the leading sources of irreversible environmental degradation. Improper treatment and direct discharge of these toxic effluents into the sewage drain eventually pollute groundwater and other significant water bodies, endangering the health of animals and aquatic life. Under-treated effluents can also pollute the air, lithosphere, soil, and other environments. The careless disposal of industrial effluent used in crop irrigation can seriously harm crop quality and even enter the food chain. Water pollution causes waterborne illnesses such as diarrhea, giardiasis, typhoid, cholera, hepatitis, jaundice, and cancer. Several nations are currently developing water quality management regulations. The quantity of contaminants that may be safely digested in certain water bodies such as rivers and lakes is being established logically.

The true issue with industrial textile wastewater is that it would be exceedingly carcinogenic, causes allergies, and creates hazardous substances, in addition to causing other environmental difficulties. Textile dyes are important because they are colorful; also, various dyes contain unique meanings in communities, and their usage is a crucial problem in the modern world. However, when wiping or washing fibrous materials once the color is applied, such colorants cause tremendous environmental damage. The wastewater contains not only the colorful dye, but also other metallic particles, a high changing pH, suspended solids with a high chemical oxygen demand (COD), and other contaminants [7,8]. As a result, today's textile wastewater from the textile and dyeing sectors is a key cause of worry for textile wastewater treatment. Because of the high biological oxygen demand (BOD), pH, color, COD, and the presence of solid metal particles, this is reused for textile processing [9,10,11,12,13]. Other studies, however, have reported on the toxicity of wastewater effluents using biological systems and sought to lessen the harmful impact [14,15].

Material and Methods:

Sample collection:

The textile industry's water waste in Jaipur (India) after all dying processes thrown out in freshwater bodies was singled out for an investigation into the characterization of wastewater in pre-cleaned polypropylene bottles using the relevant measures [16]. Total hardness (TH), nitrate (NO_3), fluoride (F-), sulphate (SO_4^{2-}), chloride (Cl-), sodium (Na+), calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K+), and total dissolved solids (TDS) were measured at sample locations, whereas total hardness (TH), nitrate (NO_3), fluoride (F-), sulphate (SO_4^{2-}), potassium (Samples were gathered in pre-cleaned polypropylene containers and acidified (to pH 2.0) using concentrated ultra-pure nitric acid for stabilization shortly after collecting during heavy metals analysis. The samples were digested with strong nitric acid, and the metal content was determined using an Atomic Absorption Spectrometer. (AAS)

Methods:

BOD Test Procedures

1. To guarantee appropriate biological activity during the BOD test (Table.1), a wastewater sample:

   o Must be chlorine-free. If there is chlorinated in the sample, a dechlorination agent (such as sodium sulfite) must be applied before testing.

   o The pH should be between 6.5 and 7.5 S.U. If the sample falls outside of this range, acid or base must be supplied as necessary.

   o An appropriate microbial population must already exist. If the microbial population is insufficient or unknown, a "seed" solution of bacteria is introduced along with an important nutrient buffer solution to ensure the viability of the bacteria population.

2. Specialized 300 mL BOD bottles with no air space and an airtight closure are employed. The bottles are filled with the test sample or dilution (distilled or deionized) water, then varying volumes of the wastewater sample are added to represent different dilutions. As a control or "blank," at least one bottle is filled just with diluting water.

3. A dissolved oxygen meter (DO meter) is utilized to determine the actual dissolved oxygen concentration (mg/L) within every container, which also has to be at least 8.0 mg/L. Each bottle was put in a dark incubator at 20°C for five days.

4. After five days (three hours), the DO meter is used again to determine the final dissolved oxygen concentration (mg/L), which should be less than 4.0 mg/L.

5. The BOD concentration (mg/L) would then be calculated by deducting the final DO value from the starting DO reading. If the wastewater sample was diluted, double the BOD concentration measurement by both the samples was diluted.

Table.1 APHA Standard Methods for BOD Measurement

5210 B.	**5-Day BOD Test [1, 2]**
5210 C.	**Ultimate BOD Test**
5210 D.	**Respirometric Method**

[1] *5210 B. is the only EPA approved BOD method[18]*
[2] *Most popular method[19]*

DO (dissolved oxygen) Test Procedures

• The concentration of DO in a water sample is altered greatly by:

O Temperature: As water temperature rises, DO falls (as the water warms, it carries less oxygen) (Table.2).

O Salinity: As water salinity rises, DO falls (i.e., as the water gets saltier, it holds less oxygen).

O Atmospheric Pressure: As pressure rises, so does DO (i.e., water holds less oxygen as you increase altitude).

Table 2. Effect of temperature on oxygen saturation at 1 atmospheric pressure (i.e., sea level)*

Temperature		Concentration of DO at Saturation (mg/L)
°C	°F	
0	32	14.6
5	41	13.1
10	50	11.3
15	59	10.1
20	68	9.1**
25	77	8.2

* *Adapted from Metcalf & Eddy, 2003[20]*
*** BOD test method temperature*

COD Test Procedures

To achieve sufficient biological activity during the COD test (Table.3), a wastewater sample:

1. Prior to finishing the COD test, a set of recognized standards are prepared using KHP (potassium hydrogen phthalate). Because most wastewater samples will be in the high range, standards of 100, 250, 500, and 1000 mg/L are routinely developed. COD standards are also available for purchase.

Table.3 APHA Standard Methods for COD Measurement

5220 B.	**Open Reflux Method**
5220 C.	**Closed Reflux, Titrimetric Method [1]**
5220 D.	**Closed Reflux, Colorimetric Method [1, 2]**

[1] EPA Approved Method[18]
[2] Most popular method[19]

2. The COD reactor/heating (150°C) brick and a colorimeter are both switched further to allow both instrumentations to stabilize.

3. Pre-prepared low-range (3-50 ppm) or high-range (20-1500 ppm) vials are chosen for the COD test based on predicted findings. If the predicted outcomes are unknown, both ranges can be used.

4. One vial is labeled "blank," while the other three or four are labeled with recognized standard values. Each wastewater sample is therefore divided into 2 containers in order to repeat the run. It should be noted that when several wastewater samples are collected, at least 10% of the samples are duplicated.

5. Every container receives 2 mL liquid solvent. 2 mL of DI water is supplied in the case of the "blank." 2 mL of each standard is added to the appropriate containers. If the wastewater sample is analyzed at its full strength, 2 mL is added to the appropriate container. If dilution is necessary, repeated dilutions are done, and 2 ml of the diluted material is put into the appropriate container.

6. After thoroughly mixing each vial, it is placed in the reactor block for two hours. After two hours, the vials are taken from the block and placed on a cooling rack for around 15 minutes.

7. The colorimeter is configured and calibrated according to the unit's particular instructions (i.e., appropriate wavelength, blank, and standards), then each vial is inserted into the device and the COD concentration is read.

8. If the sample was diluted, the appropriate multiplication is performed.

TOC Test Procedures

TOC test protocols (Table.4) are basic and straightforward, however, they are dependent on the type of carbon-analyzing equipment used in the laboratory. As a result, there is no such thing as a "typical" TOC method. To find the most effective results, the instruments vendor's protocols must be strictly followed.

Table.4 APHA Standard Methods for TOC Measurement

5310 B.	**High-Temperature Combustion Method**
5310 C.	**Persulfate-Ultraviolet or Heated-Persulfate Oxidation Method**
5310 D.	**Wet-Oxidation Method**

O&G Test Procedures

The wastewater sampling is needed to make sure appropriate O&G analysis (Table.5).

1. A clean flask is dried, chilled, and weighed.
2. An 1L wastewater sample is acidified with a pH = 2.0 (typically utilizing hydrochloric or sulfuric acid).
3. After that, the acidified wastewater sample is transported to a 2L separatory funnel.
4. Add 30 ml of the extraction chemical (e.g., n-Hexane) to the funnel and aggressively mix for two minutes.
5. The wastewater/chemical extraction different layers get allowed to be separated throughout the funnels (the lighter water layer will be on the top and the heavier extraction chemical layer will be on the bottom). The bottom layer of the extraction chemical is drained into the flask created in Step 1.
6. Steps 4 and 5 are done twice more to extract the O&G.
7. The components of the flasks (the extraction chemical containing O&G) are then heated, allowing the extraction chemical to be distilled into another container.
8. Reweigh the flasks bearing the extracted O&G. The flask's initial weight is deducted, and the total O&G weight in mg is determined. The findings show the O&G concentration in milligrams per liter.

pH Measurement

The pH of wastewater before and after treatment was determined using the potentiometric technique. The measureme nts were taken using a tabletop pH meter on the same day that the samples were collected (PHS-25).

Total Dissolve Solid (TDS) Measurement

TDS levels in the samples were assessed using the APHA-2540 C 22nd edition (2012). Filtration sheets were used to filter the gathered samples. Total filtrate and washing solution were transferred to an evaporating dish and dried in a steam bath. Processes of drying, chilling, and weighing were done until a steady weight was reached**.**

Total Suspended Solid (TSS) Measurement

TSS values were calculated using the APHA-2540 D 22nd edition (2012). GFC Whatman filter paper was dried in an oven at around 105° C for 1 hour before being chilled in a desiccator for 15 minutes. The dry weight of the filter paper was then determined, and the filter paper was placed on the filtering device. 100 mL of material was filtered via filter paper before being washed with 10 mL of deionized water. The filter paper was carefully removed from the filtering device and dried for two hours inside ovens at around 105° C. Finally, the filter paper was cooled in a desiccant before being weighed at a consistent weight.

RESULT & DISCUSSION:

For the investigation of the features of composite wastewater in textile industries, wastewater sampling from various textile processing plants totalling from were gathered for their general properties. **Table.6** displays the exam outcomes.

Table.6: Result of composite textile wastewater and effect on human health

S.No.	Particular	Testing sample	Minimum range	Maximum range	Average range	Worsen impact on planet Environment
1	**pH**	8.99	7.0	9.0	8.25	**(Humans) kidney stones, urinary tract infections (UTIs), kidney-related disorders, Nausea, vomiting, muscle twitching, fertility**
2	**EC((µmhos/cm)**	8709	4430	8710	6709.17	**(aquatic organisms) exert energy in maintaining osmoregulatory balance**
3	**Total dissolved solids**	7470	4040	7500	5738.33	**(Human) Cancer of the bladder, lungs, skin, kidneys, liver, and prostate**
4	**Suspended solids**	1571	830	1580	1166.67	**Erosion reduces habitat quality for fish and other organisms, reduces light penetration**
5	**Dissolved solids**	5917	3210	5920	4571.67	**the flow of water in and out of an organism's cells cause limit the growth and may lead to the death of many aquatic organisms**
6	**Total Hardness**	147	120	150	136.25	**(Humans) increased risk of cardiovascular disease**
7	**Carbonate**	119	110	120	87.50	**(Aquatic organisms) the faster the shells and skeletons dissolve.**
8	**Bicarbonate**	1462	555	1464	913.25	**accumulate in irrigated areas, calcium out of the solution, reducing the presence of calcium on soil exchange sites.**

9	**Chloride**	2178	980	2185	1697.50	**inhibit plant growth, impair reproduction, and reduce the diversity of organisms in streams**
10	**Sulphate**	611	307	620	509.67	**(Humans) flushing, fast heartbeat, wheezing, hives, dizziness, stomach upset and diarrhoea, collapse, tingling or difficulty swallowing.**
11	**Nitrate**	452	120	627	354.67	**methemoglobinemia (also known as a blue baby syndrome in Humans), accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream.**
12	**Fluoride**	2.1	0.7	2.2	1.25	**(Humans)skeletal fluorosis; decreased plant growth and yield**
13	**Calcium**	26	12	28	19.00	**(Humans) weaken your bones, create kidney stones, and interfere with how your heart and brain work.**
14	**Magnesium**	23	13	29	21.25	**Lithium therapy, hypothyroidism, Addison's disease, milk-alkali syndrome, familial hypocalciuric hypercalcemia**

15	**Sodium**	2183	975	2185	1672.00	**Enlarged heart muscle, headaches, heart failure, high blood pressure, kidney disease, kidney stones, osteoporosis, stomach cancer, and stroke.**
16	**Potassium**	18	11	19	14.00	**Heart palpitations, shortness of breath, chest pain, nausea, or vomiting.**
17	**Copper**	0.309	0.006	0.311	0.07	**Vomiting, diarrhea, stomach cramps, nausea, liver damage, and kidney disease.**
18	**Chromium**	7.782	0.0 15	7.854	1.37	**allergic and asthmatic reactions, carcinogenic, stomach and intestinal bleedings, cramps, and liver and kidney damage**
19	**Manganese**	0.019	0.001	0.022	0.01	**Generalized oxidative stress in the fish, aids digestion, increases bone strength and strengthens immune system function, problems with memory, attention, and motor skills.**
20	**Iron**	0.153	0.017	0.163	0.018	**Diabetes, hemochromatosis, stomach problems, nausea, liver, heart, pancreatic damage**
21	**Lead**	0.051	0.011	0.061	0.03	**mental retardation, behavioral disorders,**

						ataxia, seizure, coma even death,
22	**BOD**	1001	500	1010	713.33	**aquatic life and organism become stressed, suffocate, and die**
23	**COD**	3187	1600	3200	2125.00	**Indicates the presence of all forms of organic matter in surface water, both biodegradable and non-biodegradable pollution in waters.**

Note: Not analyzed due to high colored sample. All values except pH in mg/l

pH is really a significant element all throughout the manufacturing textiles processing unit. To get better outcomes, it is controlled at several stages. The pH is also crucial in the dyeing stage since that influences the solubility of the dyes. The pH also varies depending on the type of fabric used. My testing wastewater sample has a pH of 8.99. Because caustic and other alkali cleansers are used in substantial quantities in almost all of the phases, the resulting drainage from the textile industry becomes neutral to strongly alkaline. Increased pH levels induce human ailments such as kidney stones, urinary tract infections (UTIs), kidney-related problems, nausea, vomiting, muscular twitching, and infertility.

The electrical conductivity of wastewater varies according to the amount and kind of fabric treatments employed, but it was discovered to be significantly greater (more than 16 times) than that of water utilized. The textile industries' tot al dissolved solids were determined to be 8709 mg/L. This is determined by the type of fabric and the overall output. Increased EC effect on aquatic creatures that expend energy in order to maintain osmoregulatory balance.

The wastewater has a heavy concentration of suspended particulates, which causes the wastewater to become viscous. My experimental wastewater sample showed 1571 mg/L suspended particles from the textile industry. The suspended solids are caused by the removal of non-soluble solid particles from the fabric. Sometimes the chemicals utilized precipitate as a result of a pH shift, which increases the suspended particles. The effect of increased suspended particles on erosion lowers habitat quality for fish and other species as well as light penetration.

Chloride from industries had been identified in my sampling wastewater at 2178 mg/L. Chloride levels in textile wastewater rise as a result of the water softening process, which uses sodium chloride to replenish softeners. Furthermore, several chloride-containing chemicals are employed in fabric wet processes. The higher chloride in water shows an impact that influences plant growth, reproduction, and the variety of species in streams.

Throughout testing water waste sampling, I discovered 452 mg/L of nitrate from industrial water waste. The pollutants included in the compounds work in different procedures that cause nitrate in wastewater. Nitrate levels rise as a result of the colors employed. This ion serves as a functional group in a variety of colors. Increased Nitrate causes methemoglobinemia (commonly known as a blue baby syndrome in humans), speeding eutrophication as well as producing substantial increases in aquatic plant growth as well as changes in the species of plants and animals that reside in the stream.

The overall hardness of the wastewater industries was determined to be 147 mg/L. The hardness of said waters is represented by calcium and magnesium. Hardness is another key element in the dyeing process since most colors precipitate in the presence of calcium and magnesium ions. In conclusion, water softening is performed in all industries, resulting in a significant reduction in concentration. Calcium was found to be 26 mg/L, whereas magnesium was found to be 23 mg/L. Owing to the increased solubility of calcium and magnesium, the magnesium concentration remained low than the calcium concentration. The softening in waters seems to be the reason for poor calcium and magnesium concentrations. Water softening is used in all sectors to replace calcium and magnesium with sodium. The increased overall hardness, calcium, and magnesium impact indicate a greater risk of cardiovascular disease in humans, weakening your skeletons, causing kidney stones, and interference by how the heart and brain function.

Total sodium content in the effluent was determined to be 2183 mg/L. The greater sodium content in wastewater was caused by sodium compounds, which are employed in practically all phases of wet processes. Sodium chloride is wid ely used in water softening, replacing calcium and magnesium. Sodium compounds are favored over potassium mole cules in all processes. As a result, the potassium concentration in industrial effluent is 18 mg/effect of increased sodiu m

The concentration of sulphate in the wastewater was determined to be 611 mg/l. The wide variation in sulphate conte nt was caused by the various fabric techniques and chemicals utilized in the process. Flushing, rapid heartbeat, cough ing, hives, disorientation, stomach trouble and diarrhea, collapse, tingling, or difficulty swallowing are all symptoms of increased sulphate exposure in humans.

Bicarbonate has been discovered in the effluent at 1462 mg/L due to a larger range caused by the chemical (sodium bicarbonate) utilized in several phases of the textile process. The carbonate concentration was measured at 119 mg/L. However, it is conceivable that the carbonate content in wastewater is related to bicarbonate oxidation within carbonate. Increased Bicarbonate effect on the accumulation in irrigated regions, calcium out of solution, lowering calcium availability on soil exchange sites.

The biochemical oxygen demand (BOD) of textile wastewater was determined to be 1001 mg/l. The presence of oxidized organic matter causes the wastewater's BOD. Cotton is a cellulose-containing natural plant fiber. It is processed in several processes, each of which removes a portion of the cotton. The fabric is treated with starch, gum, and enzymes throughout the sizing and desizing processes, which eventually end up in the wastewater. This is the cause of the increased biochemical oxygen requirement. In the case of synthetic fiber-made clothes, the biochemical oxygen demand values fall. Increased BOD levels have an impact on aquatic life, causing organisms to become stressed, suffocate, and die.

The COD (Chemical Oxygen Demand) of textile wastewater was determined to be 3187 mg/L. It is more than the figures for biological oxygen requirement. The presence of oxidizable substances, which are employed in various phases, causes the effluent to get an increased chemical oxygen demand. Higher chemical oxygen requirement suggests chemical pollution caused by the textile sector rather than biological contamination. Increased COD impact indicates the presence of all types of organic matter in surface water, including both biodegradable and non-biodegradable pollutants.

Conclusion

The effluent from the textile sector is very viscous, with high suspended particles and total dissolved solids, as seen by the preceding discussion. The total dissolved solids are high due to the application of high solubility chemicals, and the suspended solids are due to the precipitation of salts and undissolved impurities separated by grey cloth. It is found that textile effluent has a high concentration of chloride, sodium, and bicarbonate. Sulphate concentrations were also found to be excessive. The total heavy metal content is fairly low. Due to the usage of chromium salts and chromium-based dyes, wastewater show chromium is the most abundant heavy metal. The manganese content is really low. Sodium is the most abundant cation, whereas the concentrations of the other cations are modest. The sodium compounds are often utilized in the process because they aid to regulate the pH. Sodium hydroxide is also utilized in both scour and cleaning. Sodium chloride is also utilized in water softening. Chloride is the most abundant anion; sulphate and bicarbonate concentrations are also sufficient. Textile wastewater has an environmental influence on water resources such as rivers, ponds, and agricultural land, affecting numerous human illnesses, soil degradation, and aquatic life.

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