Journal of Advances in Microbiology Research

E-ISSN: 2709-944X
P-ISSN: 2709-9431
JRM 2024; 5(1): 199-212

www.microbiojournal.com
Received: 05-12-2023
Accepted: 13-01-2024

Preeti Chaurasia
Research Scholar, School of Basic and Applied Sciences Nirwan University, Jaipur, Rajasthan, India

Nakuleshwar Dut Jasuja
Professor, School of Basic and Applied Sciences, Nirwan University, Jaipur, Rajasthan, India

Correspondence
Preeti Chaurasia
Research Scholar, School of Basic and Applied Sciences Nirwan University, Jaipur, Rajasthan, India

Microbial approach in treatment, recycling and reuse of wastewater from tannery industry: A review

Preeti Chaurasia and Nakuleshwar Dut Jasuja

Abstract
Tannery wastewater is highly dangerous and it also creates a huge negative impact on entire environment. In order to reduce the toxicity of elements in wastewater, it is highly required to implement microbial approach for treatment of wastewater. In this part of the research, research background research rational, aim, objectives and research question have created to identify the major core factors of this research. Additionally, membrane separation process and bio inhibition process also has described to decrease the negative impact of toxic elements in wastewater from tannery industry. It has been found from this research that wastewater from tannery industry is making a huge problem in environmental system. Degradation of values can demolish equilibrium of the ecosystem and creates different problems in society and human health.
Thus, treating this wastewater is required to mitigate these issues and provide a suitable infrastructure for everyone. Bioassay helps to treat concentration effects in tissue and cells. On the other hand, coagulation and pre-polymerized coagulants help to reduce harmful components in wastewater that comes from tannery industrial products. In this paper review of tannery industry of India, different procedures are discussed such as process of bio-degradable treatment in this industry. As a propagation plan, wastewater treatment needs to be implemented in this industry, bio-assay and microbial approach is a major plan to purify wastewater of this industry.

Keywords: Tannery, bioremediation, wastewater, environment

Introduction
India is a developing and financially enriched country, where there is a huge demand for tannery industry in various parts of the world. There is a huge contribution of leather industry in entire financial field of India. Being a developing and growing industry, several negative sides can also be identified in this tannery industry in India. Despite being a major demandable and vital industry, the tannery industry is largely affecting the entire environment. Through all the functions and operation of the tannery industry toxic hexavalent chromium can be found in the wastewater of tannery industry. Sometimes, the toxic limits exceed the tolerable and permissible limits in the environment (Chaurasia *et al.*, 2023) [14]. This toxic water creates a huge negative impact on global agricultural system, water bodies and other living organisms in earth and water. To reduce the huge effect on the environment and also to save the natural components of the environment, it is highly essential to conduct psycho-chemical treatment in tannery wastewater (Huang *et al.*, 2019). This treatment is highly beneficial to purify the wastewater from tannery industry. In order to purify the toxic sludge from the wastewater microbial treatment and approach is highly effective to remove heavy toxic elements from the wastewater. Microbial approach is also eco-friendly and also it helps to eliminate heavy metals and chloro-organics from wastewater from tannery industry (Chaurasia *et al.*, 2022) [12-13].
Reuse and recycle of tannery wastewater is highly advantageous to get reutilized valuable metals for any further use. Additionally, the virus and microbes are highly useful to remove chemical toxins from tannery wastewater. The recycled water can also be used in agricultural fields in future. Moreover, it is also beneficial to solve the problem of water scarcity in various parts of India. The productivity also can be enhanced due to the reuse and recycling of tannery wastewater (Wudneh & Dagnew, 2020) [52].
There are huge toxic chemicals and heavy metals that can be found in tannery wastewater. For example, in the metallic compounds there are chromium, various organic and inorganic compounds, sodium chloride, sulphate, and all others (Gurreri *et al.*, 2020) [22]. The tanning industries discharge toxic materials and pollutants into the nearby water bodies.

The ecological balance in water is damaged and interrupted by the pollutants. Most of the living organisms in water have become endangered due to the discharge of heavy waste materials from tannery industry. It is evident that due to the huge negative impact of toxic elements and pollutants, almost 67% of living organisms have become endangered and almost 47.5% of living organisms have been permanently eliminated from water (Kokkinos & Zouboulis, 2020) [25]. As per the recent research report of 2020, it has been proved that levels of salinity and soluble ions are much higher in tannery wastewater than other wastewater, thus it can create a huge effect on entire environmental components (Zhao & Chen, 2019) [53].

2. Literature review

2.1 Membrane separation technology

Membrane separation process is used in tannery industry, mostly this technology is used without heating the materials. This process technology needs less energy than other thermal separation such as distillation, sublimation, and crystallization. Membrane separation technology is also used in food industry, biotechnique and pharmaceutical industries. In tannery industry, membrane separation technology is used widely to separate toxic particles, colloids and macromolecules. This technology is also used to disinfect the water in the same way. In order to reduce the huge impact on environment, this technology is highly beneficial to remove toxic substances from wastewater. The demand for membrane separation technology is increasing highly for permanent protection of environment. Additionally, in the energy recovery techniques membrane separation technology is used for fuel cells and also for osmotic power plants (Pal *et al.*, 2017) [34].

In all waste management enterprises, membrane separation technology is used. The membrane separation process basically depends on mechanisms and also on separated particles. Some of the membrane separation processes are microfiltration, reverse osmosis, dialysis, and electrodialysis, and it is also used in gas separation processes. In the water purification and wastewater treatment process, membrane separation technology is widely used to separate the toxic components from wastewater. The shape and structure of membrane pores strongly depend on the manufacturing process of materials (Boujelben *et al.*, 2019) [5].

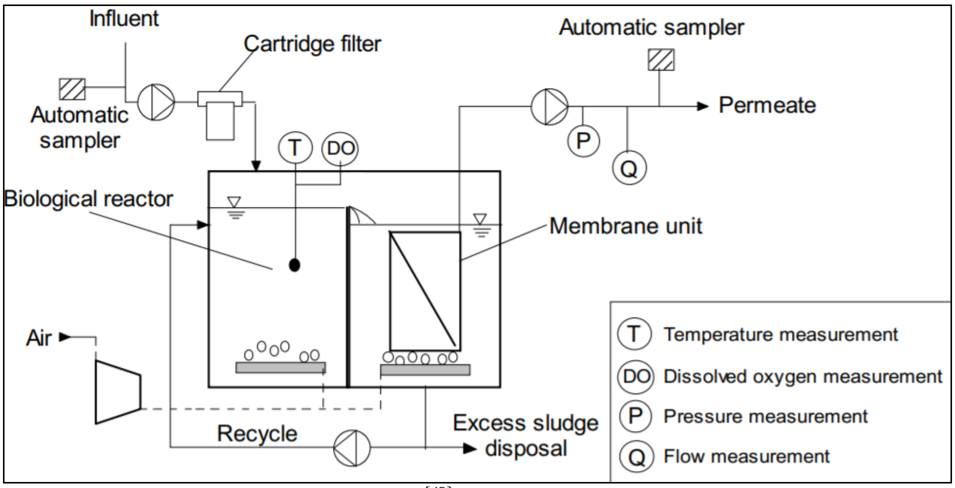
There is a huge potentiality of membrane separation technology that can be identified to solve various problems in environment.

This technology is also used to minimize the harm in atmosphere. In the "microfiltration and ultrafiltration pressure driven process" this membrane separation process is required to separate fine particles and emulsion droplets from wastewater. Mostly the membrane separation process is used in tannery wastewater to reduce the hydro-soluble and inhibiting compounds, which helps to increase the sludge age in wastewater. Membrane separation technology can help to remove the COD (Chemical Oxygen Demand) by almost 78%, also it helps to complete a proper nitrification system in tannery wastewater (Harding *et al.*, 2020) [23].

In order to separate the toxic materials from wastewater, firstly it is required to measure temperature in the wastes, after that it is required dissolved oxygen measurement and pressure measurement to filter the wastes from the water. In this process, cartridge filter helps to separate all toxic elements from the water. The automatic sampler and biological reactor are used to simplify the wastes and also h elp to separate it in membrane unit. After that in the flow measurement process, air helps to recycle the wastes and it also helps to separate excess sludge disposal (Ugwu & Agunwamba, 2020) [47].

In the tannery wastes, acids, alkalis, tanning oils, fats and salts can be found in the wastewater. It is evident that almost 90% of wastewater directly affect the nearby environment (Sunzid *et al.*, 2020) [44]. In order to separate and remove all harmful elements such as chromium, surfactants and other toxicities from wastewater, it is highly necessary to use membrane separate technology in tannery industry. In order to dissolve lime, sodium sulphide, high ammoniacal nitrogen and other organic matter from wastewater membrane separation technology is used (Shahid *et al.*, 2020). Overuse of synthetic chemicals, pesticides and dyes are highly harmful for human health and also for environment.

High concentration of chromium in cells can damage DNA and it also can cause several genotoxic effects on human body. Thus, the methods of membrane separation technology are highly essential and beneficial to eliminate toxic materials from tannery wastewater (Cetinkaya & Bilgili, 2019) [10].



(***Source***: Influenced by Suhad *et al.*, 2018) [42]

Fig 1: Membrane separation process

2.2 Bio-inhibition process

Tannery wastewater is highly complexed with huge toxic materials, organic, inorganic compounds and nitrogen compounds. In tannery wastewater, chromium, sulphates, suspended solids can also be found. In the presence of sulphides and chromium, levels of COD (chemical oxygen demands) are decreased in water. In order to remove all these toxic materials, it is highly necessary to implement a bio-inhibition process in treatment of tannery wastewater. In order to purify tannery wastewater, both aerobic and anaerobic processes are used for effective treatment of tannery wastewater. In order to reduce the effect of heavy metals, toxic chemicals and chlorides, lime, suspended salts, and other toxic pollutants, it is highly necessary to use biological methods in treatment of wastewater from leather industry (Bhatia *et al.,* 2020) [7].

In India, biological treatment is a highly popular and useful method in tannery wastewater, which is used and implemented by an activated sludge process. In order to enhance the performance of activated sludge process, the growth of microorganisms is highly required. It is evident that when the organic load rate becomes higher in wastewater, then oxygen demand efficiency needs to be increased for diluted wastewater in *Activated Sludge System* (Lage *et al.,* 2018) [26]. In wastewater, salinity is a major complication to treat this with a biological process. In that case, salt tolerant microbes can be used in saline conditions to reduce organic and inorganic materials from wastewater.

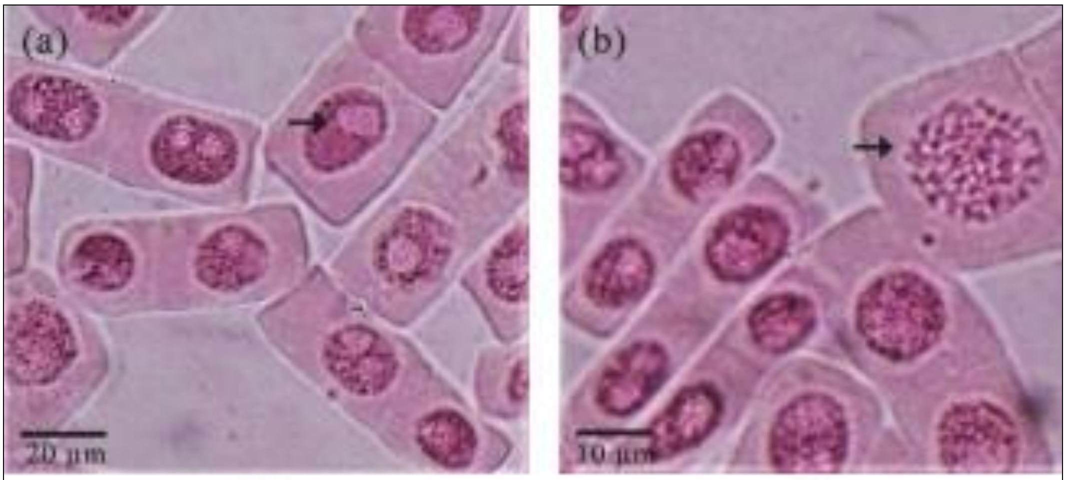
Additionally, the de-nitrification and nitrification process is used to remove nitrogen and organic substances from wastewater of tannery industries. It is evident that almost 80% to 85% toxic substances can be removed by implication of microbial approach in treatment of tannery wastewater (Luongo*et al.,* 2020) [28]. In wastewater from leather industry, it is also required to adjust PH in saline water to get a better result from microbial treatment. In aerobic biological treatment, high rates of sulphide concentration can create huge difficulties in wastewater. In that case, it is strongly required to remove sulphide to continue aerobic biological operations. In the biological process, microbes have huge potential to reduce the excessive contamination of toxic materials.

Biological wastes such as sawdust, rice busk; coir pith and charcoal are highly useful to reduce excessive concentration of harmful chemicals and toxics in wastewater (Maizatul *et al.,* 2017) [29].

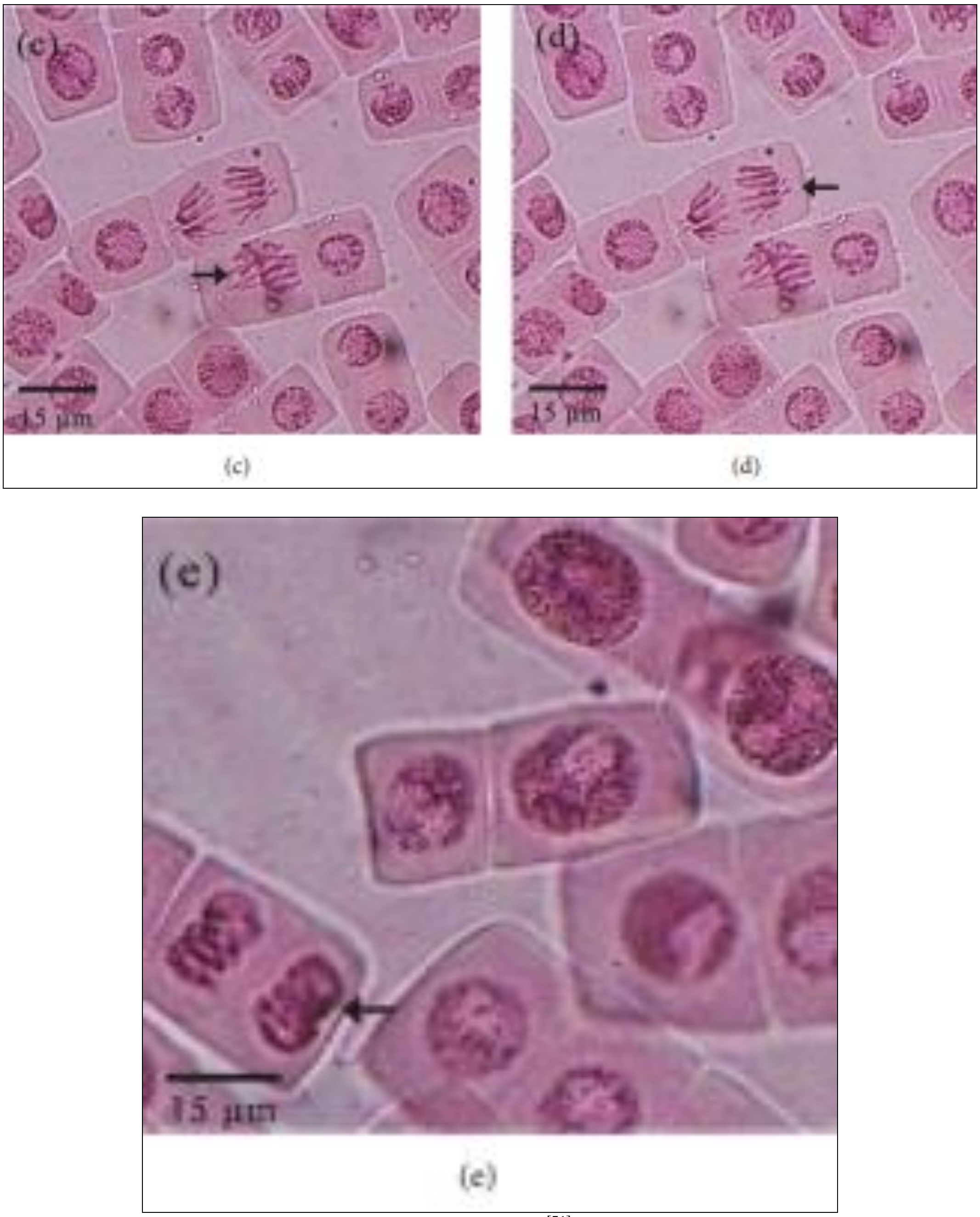
Some of the effective fungus and algae such as *Spirogyra, Condensate, Rhizoclonium and Hieroglyphicum* are used to eliminate chromium from tannery wastewater. The Trichoderma fungal species are highly beneficial to dissolve all chemical toxics from wastewater. In tannery wastes, most hazardous chromium's led to polluted soils and groundwater. Maximum amount of chromium is removed at pH6 at 30-degreeCelsius temperature. It is evident that almost 94% of chromium is dissolved by coir pith and vermiculite from tannery wastewater (Carrillo *et al.,* 2020) [9]. In chemical oxidation ozone plays a significant role in treatment of tannery wastewater. The combined treatment process of aerobic and anaerobic helps to characterize low sludge production. The level of ozonation is highly required to upgrade 97% to 99% of chemical wastes from water (Mahmood *et al.,* 2020) [8]. In the process of removing sulphide and organics, presence of activated carbon is also required to purify water from leather industry. In the process of biodegradation and microbial approach, it is highly necessary to remove efficiency of COD in activated sludge process. It helps to increase sludge retention time, which is useful to remove and separate chemical toxics from wastewater (Neyla & Peña Salamarca, 2019) [33].

2.3 Importance of bioassay in for wastewater tannery industry

Tanneries discharge "toxic hexavalent chromium" in environment through wastewater. It is beyond the limit which environment can absorb without causing any harm to human body. As stated by Verma *et al.,* (2019) [49], not only in human bodies, this wastewater harms agricultural lands which receive "higher toxicity" along with "high chemical oxygen demand (COD) and Biological oxygen demand (BOD) values", which eventually concern global values of sustainable society. Chemicals that produce toxicity can be absorbed by a particular manner and transform processes with sediments that cause "contaminants to the overlying water". Pollution is an issue in "aquatic ecosystems as both organic and inorganic toxic chemicals" that has been added by "intentional or unintentional human activities". As mentioned by Wijeyaratne, & Wadasinghe (2019) [51], Bioassay used to measure concentration of a substance that affects living tissue and cells. Bioassay determines strength of a substance with focus on relative effect of test organisms that are used in a standard preparation.



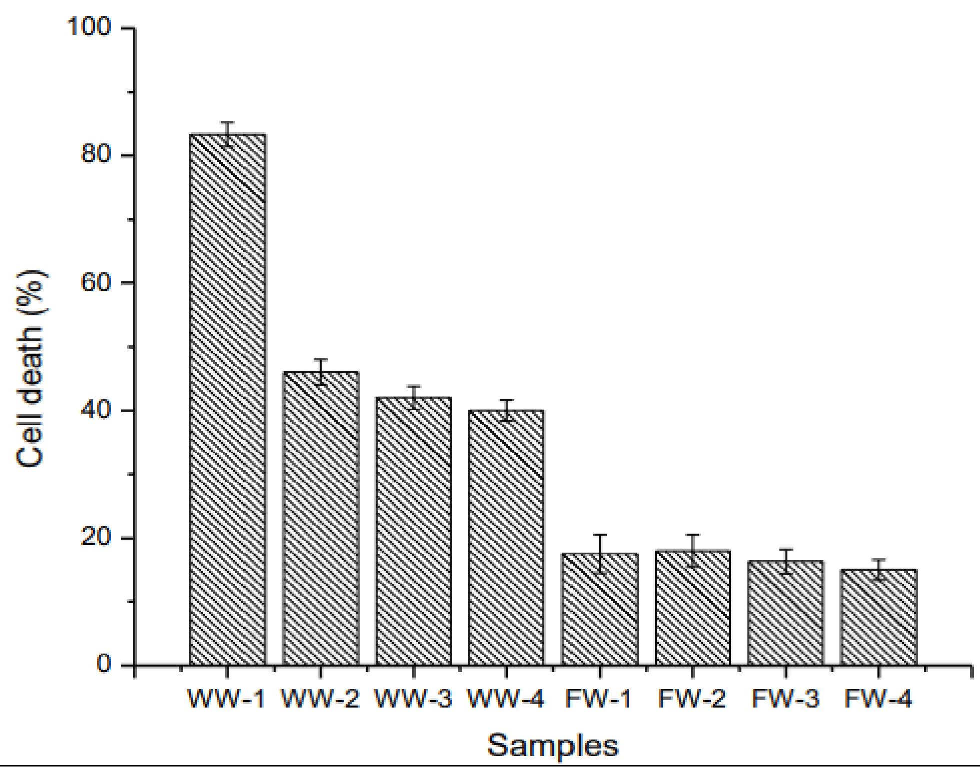
(a) (b)



(***Source*:** Wijeyaratne, & Wadasinghe, 2019) [51]

Fig 2: Microscope appearances of "((a): Interphase; (b): Prophase; (c): Metaphase; (d): Anaphase; (e): Telophase)"

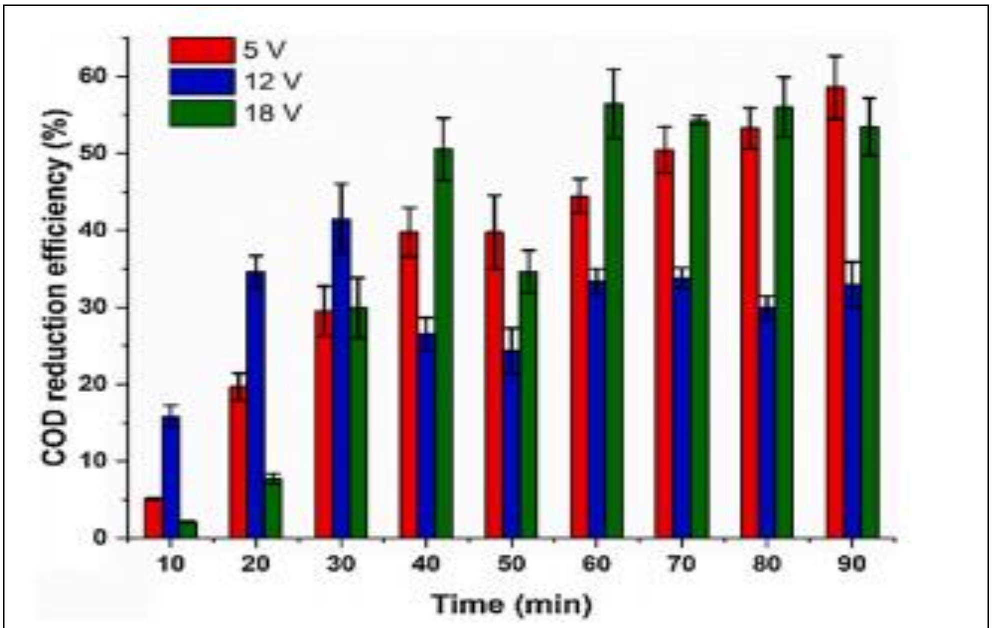
According to Verma *et al.* (2019) [49], Tannery is the third largest industry in India and significantly contributes to producing good quality leathers. It eventually increases the employment rate and contributes highly in Indian economy. It has been found that there are more than 3000 tanneries in India and 90% of them are contributing to "chrome tanning process" (Verma *et al.*, 2019) [49]. It has been found that 83 million hides along with 140 million skin pieces that processed tanneries annually and 501 effluent generate (Verma *et al.*, 2019) [49]. It has been found that during this tanning process around 40% chromium spent in this process fully discharges in environment (Verma *et al.*, 2019) [49]. This eventually creates less environmental sustainability and gives health problems to human bodies. However, as per argument by Basheer, & Umesh (2018) [6], development of bioassay secure quality and regulatory demands of customers innovating and "biosimilars, biologics and bio betters".



(***Source***: Nazir *et al.*, 2019) [32]

Fig 3: Death rate from wastewater of tanneries

Excessive use of heavy metal creates ecological contamination that attracts different polluting systems and ensures a major contributor of pollution to water. As augmented by Nazir *et al.*, (2019) [32], tannery industry produces tons of toxic waste each day which contribute in water pollution. Thus, it is a contributor to water waste and provides a sustainable component in creating different factors. Besides, different colours enhance use of different chemicals and dyes. It increases "amount of heavy metal (especially Cr+3 and Cr+6)" in water and "total dissolved solids (TDS), COD, sulphates, chlorides, and other minerals" (Nazir *et al.*, 2019) [32]. "Tannery wastewater (TWW)" normally eliminated through tanning industrial units which contain "organic and inorganic complexes" along with "oil and suspended solids" (Saranya, & Shanthakumar, 2020) [37]. It has been seen that, "Haemolytic assay" helps to collect blood samples and "isotonic saline solution of phosphate having pH 7.4" (Nazir *et al.*, 2019) [32]. It is used for buffers in time of collection chilled up to 4° C. It centrifuges at the rate of "4000 rpm for 3 times to separate the red blood cells (RBCs)" (Nazir *et al.*, 2019) [32].



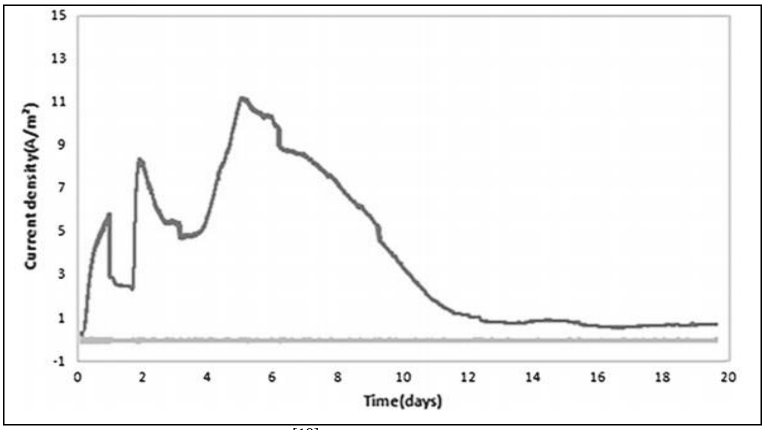
(***Source***: Jallouli *et al.*, 2020) [24]

Fig 4: Reduction of COD voltage in electrolysis time

Nazir *et al.*, (2019) [32] also stated that, "Brine shrimp assay" also perform this procedure more easily and "incubated at 30 °C for up to 48 h under continuous aeration". It focuses on giving 68% of cells death (Nazir *et al.*, 2019) [32]. Haemolytic process 81% of cell death of a living creature and produce different factors of this systematic method (Nazir *et al.*, 2019) [32]. Wijeyaratne, & Wadasinghe (2019) [51], argued that "Allium Cepa bioassay" use for accessing "cytotoxic and genotoxic endpoint" such as "chromosomal aberrations, nuclear alterations, root growth inhibition, and mitotic index alterations". In analysing water quality parameters, each sampling site along with different temperature, water pH, total dissolved solids (TDS) and salinity measurement were calibrated with digital multiparameter (Wijeyaratne, & Wadasinghe 2019) [51]. It contributes in "Dissolved oxygen concentration (DO)" as well as "biochemical oxygen demand 5 days after incubation (BOD5)", COD, "nitrate concentration", and "phosphate concentration" demands.

2.4 Theory of wastewater management and treatment

Management of wastewater is a huge process. As tannery industry is one of the strong contractors of this wastewater creation, it covers "broad spectrum of technologies", which describes the latest state of innovation that involves water chemistry applied in microbiology. As stated by Angelucci *et al.*, (2017) [3], it has been seen that, "two-phase partitioning bioreactor" which treats leather tannery wastewater management which helps in removing organic load as well as separate chromium from water. Bioreactor generally operates with "5.5 m of Hytrel 8206 polymeric tubing" which feds along with "synthetic tannery wastewater consisting of 4-chlorophenol (concentration in range of 1000e2500 mg L1)" as well as "potassium dichromate (100 mg L1 as Cr (VI))". It also includes a 4 L bioreactor that contains "microbial culture acclimatized" in its compound.

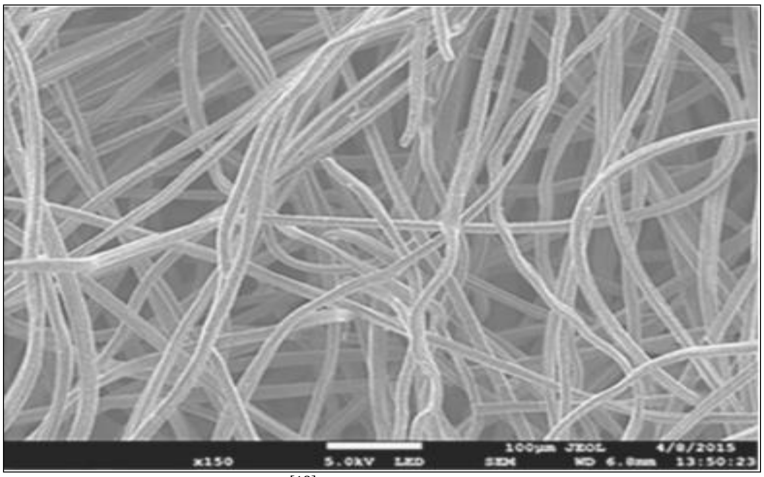


(***Source***: Elabed *et al.*, 2019) [18]

Fig 5: Density obtained through carbon felt anode polarized at 0.2 V/SCE in pre-treated raw tannery wastewater (light Gray) and tannery wastewater (dark Gray)

Tanning industry is one of the major sources of "noxious gases", which includes hydrogen sulfidic as well as solid waste and wastewater (Angelucci *et al.*, 2017) [3]. Thus, managing wastewater must be a big concern from Indian government as it is harming global sustainability of environment. It also creates huge problems in creating different obstacles that reduce works of agriculture, harming human bodies and reducing many other works as well.

Goswami *et al.*, (2018) [21], argued that "Chromium-rich tannery sludge (TS)" can be an effective solution for "remediation pathway". It follows "earthworm-mediated protocol" that helps in deploying sanitization of TS and provides "E. Eugenia". Thus, changes in "water pH, nutrients (NPK), TOC, metals (Cr, Cd)" as well as microbial diversity have been mentioned in different E. Eugenia medicines that are based on TS vermined.

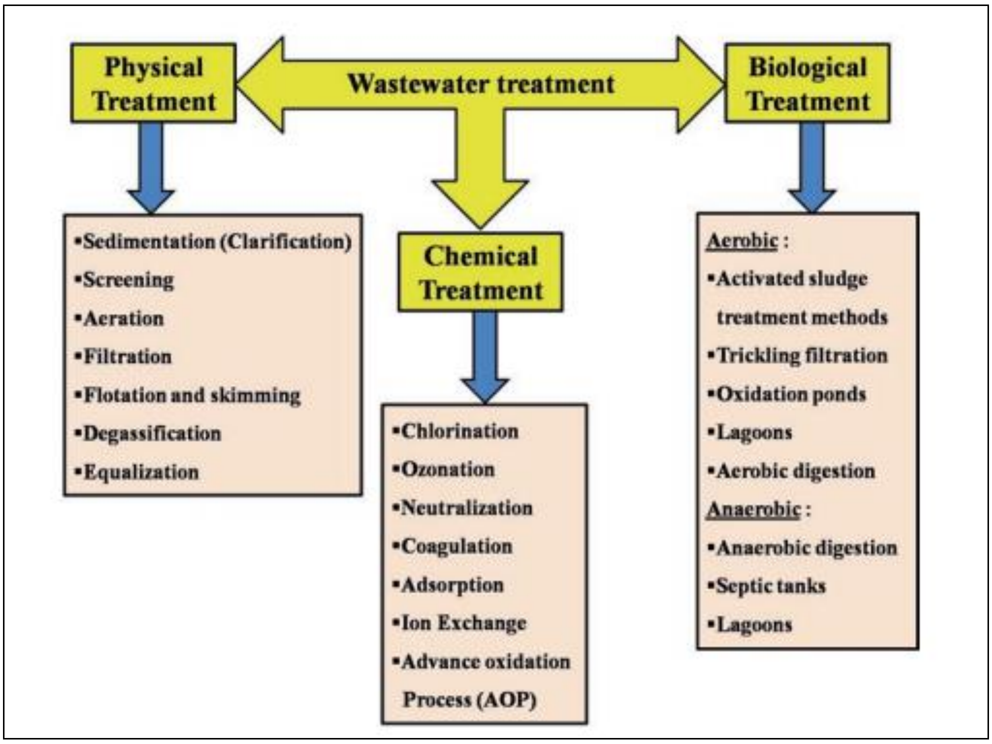


(***Source***: Elabed *et al.*, 2019) [18]

Fig 6: Scanning electron microscopy image for carbon felt anode in tannery wastewater

According to Elabed *et al.*, (2019) [18], treatment of tannery wastewater can be reduced through "bio electrochemical systems (BESs)" which includes economic, achievable and a sustainable process that includes a conventional method. There are two different experiments that are used for threatening this system. These use similar conditions of operations which are "temperature (30 ± 0.1 °C); acidophilic microenvironment (pH 4.5), constant potential - 0.2 V/ECS". These reactors introduce their operations along with microbial activities, raw tanneries.

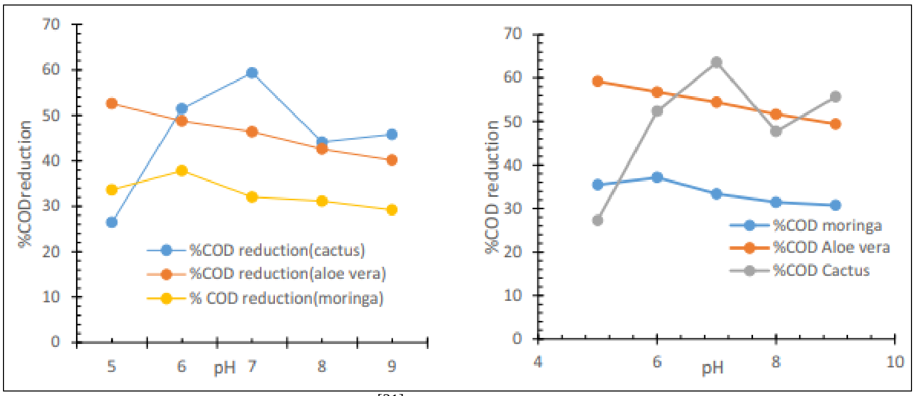
It also detects toxicity of tannery effluent that helps wastewater treatment and provide a sustainable society. There are different system uses for treating wastewater and these are "membrane processes", "advanced oxidation processes", "coagulation and flocculation", "electrochemical treatment", "aerobic and anaerobic processes" and others. Through inclusion of BOD, COD, chromium removal, sulphate removal pre-treated wastewater secure around 84%. 90%, 100% and 99% respectively (Elabed *et al.*, 2019) [18].



(***Source***: Singh, & Singh, 2019)

Fig 7: Wastewater treatment procedure

2.5 Development of coagulation theory and pre-polymerized coagulants: The chemical coagulation affects quality control of water along with its management process. It can be said that most "favourable coagulate species" along with "pre-polymerized inorganic coagulants" references to its appropriate coagulate chemistry. It evaluates the performances of different pre-polymerised coagulates, which input water treatment as well. Tannery industry has caused several serious problems which include drainage along with disposal problems. As stated by Muruganandam *et al.*, (2017) [31], it has been heard that coagulation mainly follows filtration, sedimentation and disinfection which can occur through wastewater of tannery. Different types of coagulation treat water pollution and make it usable for consumers. These can be distinguished by two different factors and these are "synthetic polymers", "inorganic coagulants" and "biological coagulants".

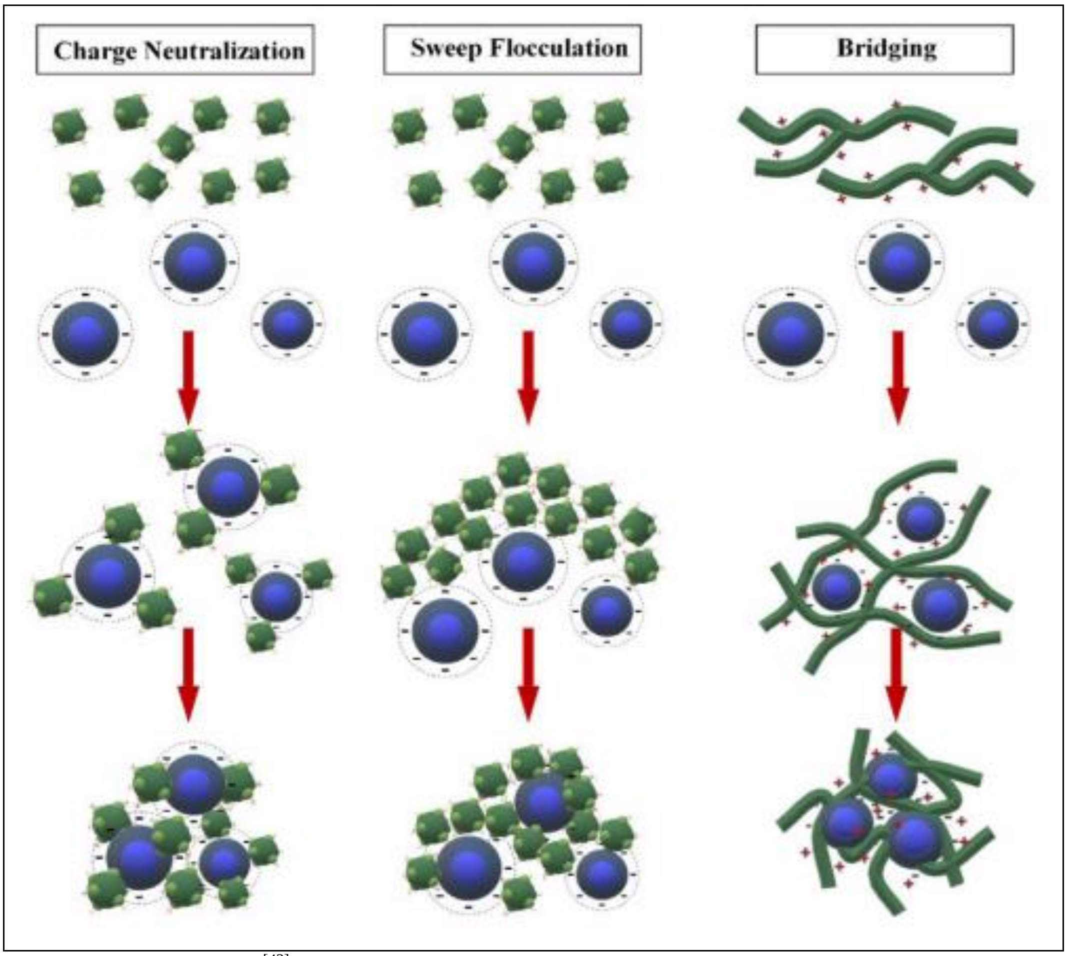


(***Source***: Muruganandam *et al.*, 2017) [31]

Fig 8: Effect of pH on % COD reduction in synthetic wastewater and tannery effluent

The origination of vegetables and seeds includes in water treatment which use in wide scales that use in chemical salts. It has been found that, displacing of chemical salts used in scientific grasp creates an effectiveness along with a mechanism of action that was lacking in contributing management of water waste. Biological coagulants use less due to its clarity issues in methods and creates issues in commercial use as well. They prefer using this system in a modernised method which involves only some developing countries. Coagulates are often needed to adsorb counter ions along with neutralising charges of particles that is well known as "biological flocculants". This helps in treatment of wastewater as it has particular "bio macromolecular structures" which has a huge number of functional groups along with contaminates interactions.

On the other hand, Sun *et al.*, (2019) [43], argued that coagulation technology is primarily used in water treatment which is widely employed in mass scale of domestic treatment. The two processes of primary treatment of wastewater are flocculation and coagulation. Conventional water treatment typically involves four factors and these are "coagulation, sedimentation, filtration, and disinfection". This operation focuses on ensuring bacteria, residual chronicles me*et al*ong with turbidity which forms insoluble compounds along with raw water after addition and oxidation of coagulant.

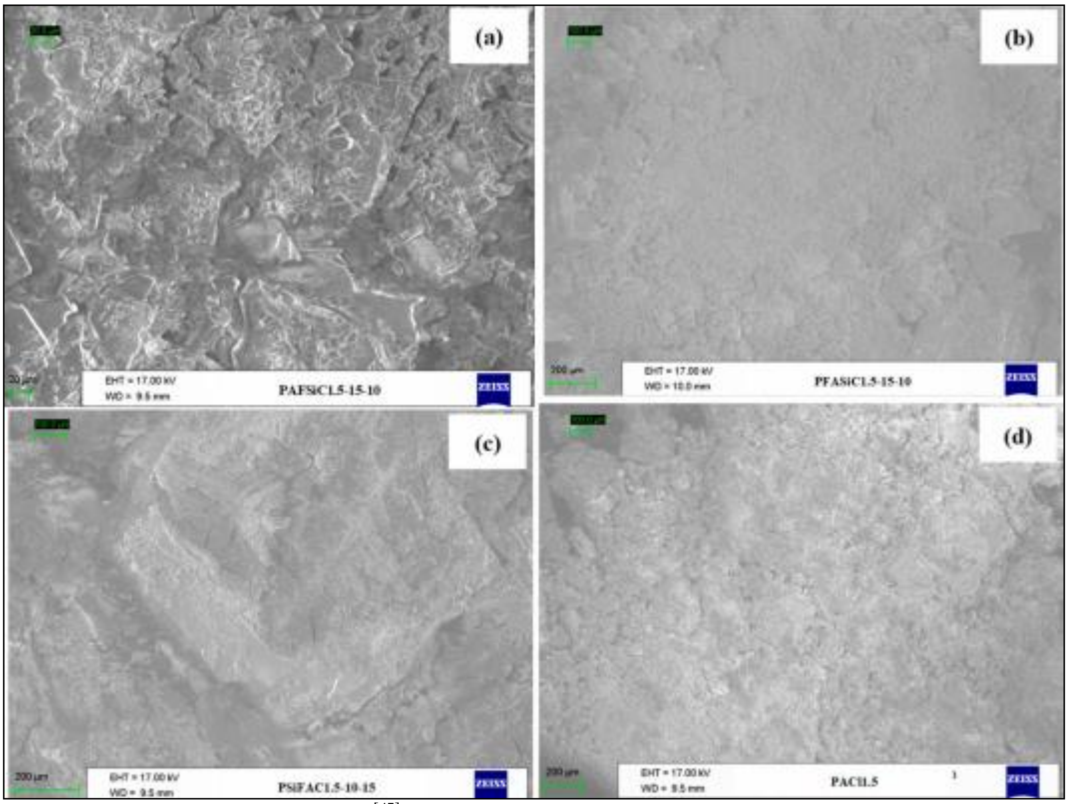


(***Source***: Sun *et al.*, 2019) [43]

Fig 9: Mechanism for enhancing coagulation to remove matter of organic

In argument of above writers, Tolkou, & Zouboulis (2020) [45], said that contribution of "polyelectrolyte" improves the effectiveness of coagulation in wastewater. It has denoted different variations of composite coagulation that includes, "PSiFAC1.5-10-15". Additionally, it separates structure of "co-polymerizing" from the "inorganic coagulant (denoted as PAPEFAC1.5-10-15)" (Ashraf *et al.*, 2018) [4].

For example, it can be said that from "80 mg Al/L in yeast production" sampling of wastewater resulted in a decrease of 56% of COD (Zhao & Chen, 2019) [53]. On the other hand, it also reduces 40% of turbidity, phosphates around 43%, and decreases extra 22% of "pre-treated anaerobically" (China *et al.*, 2020) [15]. "Inorganic polymeric flocculants (IPFs)" or more specifically, "pre-polymerized coagulants" such as "poly-aluminium chloride (PACl)" developed to increase the function of coagulation (Tolkou & Zouboulis, 2020) [45]. In composition of aluminium products which involves components such as "aluminium–silicate polymer composite (PASiC)" along with "polyferric silicate sulphate (PFSiS)" (Tolkou, 2017) [46]. Reduction of these products can reduce the chances of water waste and provide a sustainable society that will be helpful for treating high strength wastewater.

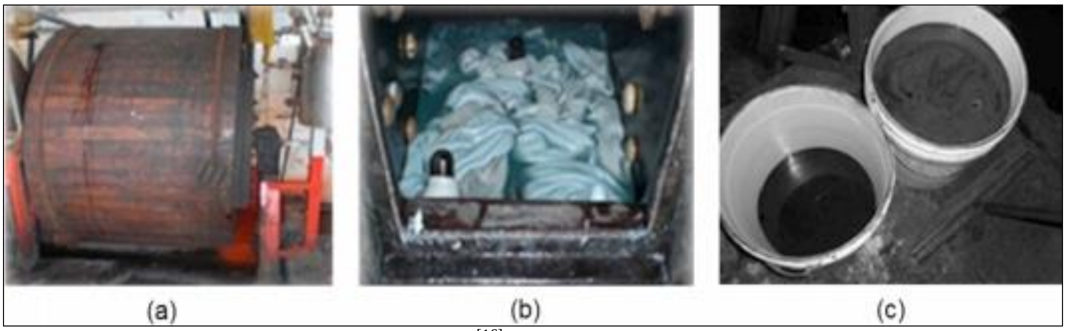


(***Source***: Tolkou, & Zouboulis, 2020) [45]

Fig 10: Composite coagulate samples after dying in low temperature

2.6 Wastewater and its impact on environment

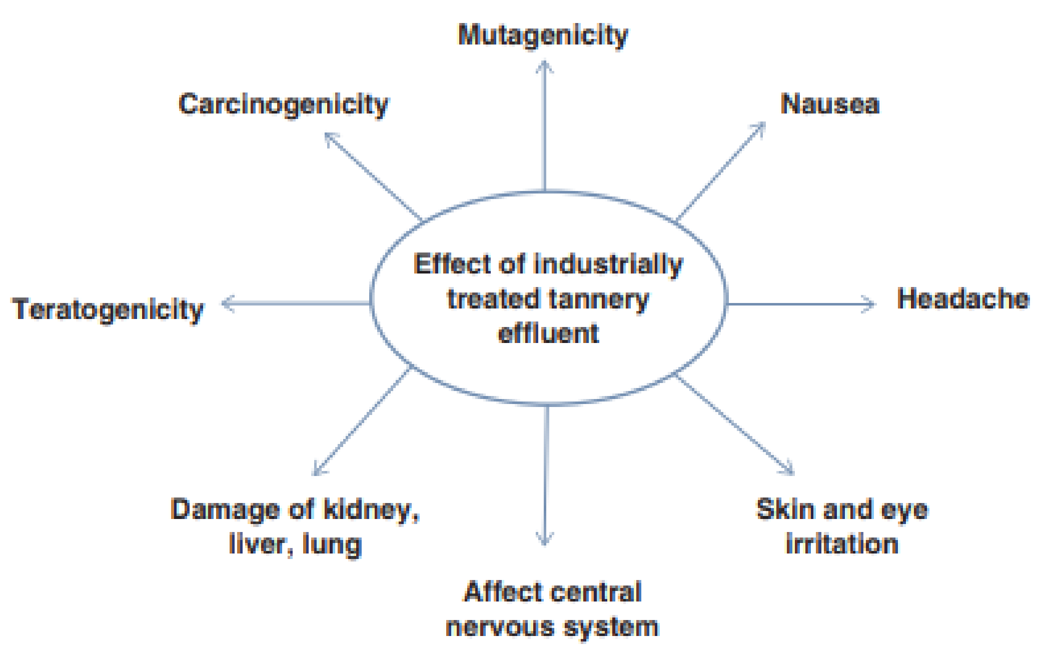
Toxic factors create effluents disruption in aquatic ecosystems. Wastewater eventually creates different factors of pollution environment that contributed in long time. According to Liu *et al.*, (2017) [27], large amounts of biodegradable substances start breaking organisms which use a huge amount of oxygen. This situation critically marine lives of thrives that is life threatening for fishes, different insects which live in water as well as for humans. Wang *et al.*, (2021) [50], arguments that heavy metal releases different materials that "anthropogenic sources" of different industries such as "nonferrous metallurgical industry, mining, mineral processing, electroplating, leather tanning, chemical industry" and others.



(***Source***: de Aquim, Hansen, & Gutterres, 2019) [16]

Fig 11: External and internal view of tanning water

On the other hand, de Aquim, Hansen, & Gutterres (2019) [16] stated that tanneries industries create a high impact rather huge amount of wastewater and invest in the operational cost of wastewater that involves different objectives to minimise its impact. System integration of water uses both consumption systems and discharge into plants. When untreated wastewater gets dumped, it evaluates the temperature of the water and provides a description of the ecosystem. The water animals' body temperature is regulated through the temperature of the water, which can increase through feeding of respiratory and body movement. Besides, it affects the amount of oxygen in that body due to enhancing water temperature (Chaurasia and Kumar, 2022) [12-13].



(*Source*: Verma *et al.*, 2019) [49]

Fig 12: Tannery effluent in human health

Shindhal *et al.*, (2021) [39], stated that waste also contains grease and oils which is harder to break down and settle in the water surface. This eventually blocks the needs of "photosynthetic aquatic plants" and suffocates the respiratory systems of water animals. If some animal drank different components from water waste then it could eventually create serious health problems among them (Agrawal *et al.*, 2020) [2]. Not only is that, drinking water mostly a purified form that serves human beings. Thus, huge amounts of waste in water can reduce the chances of purifying the water system required for human health.

2.7 Minimization of the environmental impact due to the leather industry

The microbial process is considered as a minimisation plan of wastewater risk in this tannery industry. Microbial approach used to reduce the percentage of lethal products in wastewater. Tannery wastewater used to release different types of high radiant material such as "aluminosilicate minerals" (Chandrasekaran *et al*. 2020) [1]. All these elements used to mix up with water through releasing by pipeline and contaminate water and soil. Thus, It is evident that wastewater has an adverse impact on enhancing cancer, death rate and diseases of a human blood cell. Microbial approach used to balance ecological components in water (Chaurasia *et al.*, 2022) [12-13]. This process is consisting of organic compounds.

Due to this organic compounding process, reduction of waste and heavy material in water can be done effectively (Mpofu, Oyekola & Welz, 2021) [30]. In this industry, there are different other processes as a minimisation plan such as the coagulation process, bioassay and bio-inhibition process. It is outlined that "raw zeolite" is the most harmful factor to nature, which can be reduced by all these processes. As a mitigation plan, there is a major process which is Ames test. This test used to help to balance the general modification of freshwater. As per view of Singh & Singh (2019) [40], "*Salmonella typhimurium*" is a major factor used to enhance the potentiality of freshness in water.

This Ames test used to improve the proportion of this element. As an immunisation plan, there is another method which is wastewater treatment, this process used to improve the PH value of water Nazir *et al*., 2019) [32]. It is evident that wastewater used to enhance polymer clay in our nature, which is harmful to soil construction and layer. As per the view of Abd El-Azeem Sallam *et al*., (2017) [1], 45% of the polymer clay is deposited by tannery industry of India, which needs to be reduced. Usage of *natural bio-sorbent model* is much needed in this tannery industry to reduce impact of wastewater.

This sorbent process has major benefits to reduce heavy metal from water (Goswami *et al*., 2018) [21]. Moreover, it is a process of bacteria resistance. As an example, it needs to say that tannery industry as well as the plastic, paper and textile industry used to implement this process. As per the view of Elabed *et al.* (2019) [18], in an environmental aspect, there are three different factors as "Measurement of physicochemical parameters and Preparation of bio-sorbent materials". As a minimisation plan, there is a major process which is the usage of the coagulation process; it used to reduce the discolouration process and less effect on colour in nature. Thus, it can be concluded that all above-mentioned risk management plan needs to be propagated in order to manage environmental impact.

2.8 Impact of microbial approach and its risk assessment

Microbial approach is a majorly used, simple and reliable process to recycle the wastewater treatment of tannery industry, under this context; this process has a high level of bacterial resistivity in water. As per the view of Saranya & Shanthakumar (2020) [37], this process is constant of "14 broad spectrum antibiotics". This microbial process is acted as a mitigation and assessment plan because it used to reduce cytotoxicity in nature. This microbial approach used to play the role of dye solution in this tannery industry of India (Jallouli *et al*., 2020) [24].

In the Tannery industry, the wastewater bacteria detection rate is high which nearly 80% is. This process is also known as a strategy of metal resistance in nature. It has been identified that, in the tannery industry, there is a usage of Soda material. Impact of soda can be reduced by this microbial approach. Therefore, there is an adverse effect which is known as Mutagenicity (De Aquim, Hansen & Gutterres, 2019) [16]. This generosity has three types of the stage such as lower, mild and hyper. Mild muta-generosity can be resisted by this microbial approach (Durga *et al*., 2017) [17]. Under this approach, bio-assay is a process to purify polluted water. This microbial approach can be done "at 37 °C for 24 h."

Chromium is the most dangerous element which can be reduced by this microbial process. It is evident that in the product of 250 kg lather weight, there may have 3 kg of chromium. Microbial process us to implement a different process of leather industry such as "re-chroming, neutralization, re-tanning, dyeing, fat liquoring, filling, stuffing, stripping, whitening, fixating, setting, drying, conditioning, milling and staking". In this microbial method, there is a major process which is known as the conventional process. It is evident that the microbial process has a major benefit to balance water level and PH level in water (Parveen, Bharose & Singh, 2017) [35].

Approximately 75% of the "Oxygen demand" in water can be healed by this microbial process. There is another more demand which is a demand for biochemical oxygen. It has been analysed that, there is an element that is swimmable and liquid waste in water, Microbial approach can also kill this germ. In this assessment plan of tannery industry of India, Microbial approach worked as a "Volatile Organic Compounds" (Sivaram & Barik, 2019) [41]. It has been outlined that, it used to reduce all types of emission in water such as toxic chemicals. This process needs to be procured in this tannery industry because it tends to recover 90% of the Sulphur in water.

Thus, a microbial approach used to enhance water recycling, reunifying and reusing process for our nature as well as environment-digestible. As India is suffering from water pollution, in this situation it is worked as a biodegradable method.

Analysis

Theme 1: Surveillance plan of the wastewater reduction plan: There are different types of surveillance plan in this tannery industry such as bioassay, bio inhibition process, microbial process and many others. In addition to this, wastewater treatment is a major plan which worked as a surveillance plan in this tannery industry of India. Bioassay is a process that involves consulting of different processes such as "bacterial test, Algal test, Magna test and Lemna test" (Maizatul *et al*., 2017) [29]. All these processes used to margin different types of elements such as sodium and aluminium in water. It has been analysed that due to this wastewater, cell death of the human body can be affected by nearly 46%. All these processes used to reunify seawater also. In this review, it is outlined that UASB is a major technology that used to work as a sulphur recovery plan in water (Neyla & Peña Salamarca, 2019) [33].

This process is used to rectify all kinds of granules in a tannery industry. It is evident that all these firms used to implement this process as their water purification. In the tannery industry of India, there is a major process which is known as "Biomethanation". This process is organic in nature under the plan of surveillance. Moreover, it used to make a conversion process, which can be generated microbiologically (Boujelben *et al*., 2019) [5]. It is evident that, in this process, microbes are a major element. Microbes are a major benefit in nature due to microorganism culture. Moreover, Biomethanation is used to convert solid waste material water under these "anaerobic conditions". As well as it used to produce biogas in nature. Thus, it can be said that all these processes are considered as detoxification of water.

Theme 2 Process of bio-assay and inhibition in the recycling of wastewater plan

Bioassay has different types of plans for fostering the recycling process of wastewater such as a generosity plan and an ecological plan of reducing toxicity. In addition to this, there is a major conventional method which is "cytotoxicity and phytotoxicity" (Ashraf *et al.*, 2018) [4]. All these processes are majorly used in India. This bioassay process has major benefits such as it replicates essential drugs in water. The major focus goes on this process considering the issue of genomic damage and trying to resolve it in nature. Under this process of bio-assay, eco-toxicity is a major plan of "degradation of ampicillin (AMP)" (Maizatul *et al*., 2017) [29]. This process is also known as the immobilisation process of this tanned product of India.

In addition to this, this bioassay process is less time-consuming in nature, approximately 48 hours. "Up flow anaerobic sludge blanket reactor" is a major plan of this bioassay, which used to produce gas as well. This up-flow anaerobic sludge blanket reactor tried to dilute the wastewater cycle by 3%. In this process, it has been analysed that recycling and reusable processes of process-flow need to be continued in order to manage wastewater issues from the tannery industry. The removal process of chromium needs to be implemented under this bioassay plan of India. It is evident that this process used to reduce contamination from 76% to 100% (Carrillo *et al.*, 2020) [9].

Bio-inhibition is a process that is identified as a "bioluminescence inhibition" process. It used to reduce the adverse impact on cell on human body. Thus, bio-assay used to foster this water recycling process.

Theme 1 Surveillance plan bacterial test, Algal test, Magna test and Lemna test"	**Theme 3** Toxic waste Solid waste Non-organic waste Liquid waste
Theme 2 Bioassay process UASB process "Biomethanation" process Bio-inhibition process Ecological plan	**Theme 4** Coagulation and pre-polymerized coagulants Pre-treated anaerobic" and "Post-treated anaerobic

Table 1: Table of four different themes

Theme 3 Toxic waste in tannery industry

Toxic waste of tannery or leather industry is a major issue in India. There are different types of waste in this water such as solid waste, liquid waste such as liquid colour and municipal waste and many others. In addition to this, there is the usage of different types of a chemical such as $K_2Cr_2O_7$, Chromium and heavy material. Polymerized zeolite and raw clay, raw zeolite is the main material to make a toxic waste. All these materials used to contaminate the water by more than 50%. In addition to this statement, polymerised used to contaminated water by 90.1%. Hydrogen producers consist as a toxic waste of this industry.

This toxic waste has a major effect on the depletion of oxygen fie to all these harmful entities. It is evident that usage of high radiant material and chemical needs to be reduced in this industry. From a global perspective, nearly 160, 000 health issues can be generated due to this effect of tannery industry. It used to impact skin disease and excessive waste (Wang *et al*. 2021) [50]. Due to harmful colour of tanning products, it used to pollute water of the Ganges in India. In a particular area, of India, Kanpur has nearly 300 tannery factory, which used to produce a huge tanned product. It has been analysed that, tannery industry of India used to produce 92% of the suspended waste from tannery industry.

Theme 4 Implementation of coagulation and pre-polymerized coagulants

Coagulation and pre-polymerized coagulants is a process of contamination in India. It is a high strength process in nature. 50% of waste in water reduction can be done by this coagulation and pre-polymerized coagulants methods. Moreover, there is another major element under this content such as turbidity. 40% of the turbidity can be controlled by its particular process in India. "Pre-treated anaerobic" and "Post-treated anaerobic" is a major process under this context. 38% of the pre-treated water can be effectively managed by this process. Different types of the process can be regulated managed by this princess such as "salinity, conductivity, chemical oxygen demand (COD), biological oxygen demand (BOD), inorganic matter, suspended solids (SS), total dissolved solids (TDS) and heavy metals".

Toxic organic matter can be reduced by this process. It is also evident that the water purification and filter process can be effectively managed in this coagulation process in a tanned industry. India used to produce 6, 227.8 tanned product and pollution from a tannery area. It can be concluded that India needs to propagate a plan to implement a wastewater treatment plan in a tannery industry band area. It is evident that "composite polymeric aluminium products, such as Pasic (aluminium–silicate polymer composite)" can be purified by this coagulation and pre-polymerized coagulants in India.

3. Conclusion

It can be concluded that though tannery industry influences and highly contribute in Indian economy, it is highly necessary to build a strong concern on the effects of wastewater which is discharged by industry. As per the present condition almost half of the living organisms have become endangered and half are eliminated from water bodies. Thus, it has started to affect the biological balance in environment. In order to save all creatures in environment and also to reduce harmful impact on human health, wastewater needs to be purified before discharging it in other fields. Several impactful and effective measures need to be taken to resolve the issue of tannery wastewater. In order to reduce pollutants from wastewater bio inhibition process, membrane separation technology needs to be implemented in treatment of wastewater from tannery industry. It is highly necessary to minimize environmental impact and further risks from leather industry.

Conflict of Interest
Not available.

Financial Support
Not available.

References

1. Abd El-Azeem Sallam, Al-Zahrani M, Al-Wabel M, Al-Farraj A, Usman ARA. Removal of Cr (VI) and toxic ions from aqueous solutions and tannery wastewater using polymer-clay composites. Sustainability: The Journal of Record. 2017;9(11):1993. DOI: http://dx.doi.org/10.3390/su9111993
2. Agrawal K, Bhatt A, Bhardwaj N, Kumar B, Verma P. Integrated Approach for the Treatment of Industrial Effluent by Physico-chemical and Microbiological Process for Sustainable Environment. In: Combined Application of Physico-Chemical & Microbiological Processes for Industrial Effluent Treatment Plant. Singapore: Springer; c2020. p. 119-143.
3. Angelucci DM, Stazi V, Daugulis AJ, Tomei MC. Treatment of synthetic tannery wastewater in a continuous two-phase partitioning bioreactor: Biodegradation of the organic fraction and chromium separation. Journal of Cleaner Production. 2017;152:321-329.
4. Ashraf S, Afzal M, Naveed M, Shahid M, Ahmad Zahir Z. Endophytic bacteria enhance remediation of tannery effluent in constructed wetlands vegetated with Leptochloa fusca. International Journal of Phytoremediation. 2018;20(2):121-128.
5. Boujelben R, Ellouze M, Sayadi S. Detoxification assays of Tunisian tannery wastewater under nonsterile conditions using the filamentous fungus Aspergillus niger. BioMed Research International; c2019. DOI: http://dx.doi.org/10.1155/2019/9020178
6. Basheer T, Umesh M. Valorization of tannery solid waste materials using microbial techniques: microbes in tannery solid waste management. In: Handbook of Research on Microbial Tools for Environmental Waste Management. IGI Global; 2018. p. 127-145.
7. Bhatia RK, Sakhuja D, Mundhe S, Walia A. Renewable energy products through bioremediation of wastewater. Sustainability. 2020;12(18):7501. DOI: http://dx.doi.org/10.3390/su12187501
8. Bibi SZ, Mahmood Q, Jadoon S, Pervez A, Irshad M, Bilal M, *et al*. Corrigendum to "Combined industrial wastewater treatment in anaerobic bioreactor post-treated in constructed wetland". BioMed Research International; c2020. DOI: http://dx.doi.org/10.1155/2020/6102379
9. Carrillo V, Fuentes B, Gómez G, Vidal G. Characterization and recovery of phosphorus from

wastewater by combined technologies. Reviews in Environmental Science and Biotechnology. 2020;19(2):389-418.
DOI: http://dx.doi.org/10.1007/s11157-020-09533-1
10. Cetinkaya AY, Bilgili L. Life cycle comparison of membrane capacitive deionization and reverse osmosis membrane for textile wastewater treatment. Water, Air, & Soil Pollution. 2019;230(7):01-10.
DOI: http://dx.doi.org/10.1007/s11270-019-4203-0
11. Chandrasekaran K, Selvaraj H, George HS, Sundaram M, Khaleel TM. A hybrid treatment process for product recycling from tannery process effluent and soak liquor. Journal of Environmental Chemical Engineering. 2020;8(2):103516. Available from:
https://www.sciencedirect.com/science/article/pii/S2213343719306396
12. Chaurasia P, Jasuja ND, Kumar S. Bioremediation Assessment in Industrial Wastewater Treatment: The Omics Approach. In: Kumar V, Thakur IS, editors. Omics Insights in Environmental Bioremediation. Singapore: Springer; c2022. p. 405-432.
DOI: https://doi.org/10.1007/978-981-19-4320-1_20
13. Chaurasia P, Kumar S. Treatment, Recycling, and Reuse of Wastewater from Tannery Industry: Recent Trends, Challenges, and Opportunities. In: Kumar V, Thakur IS, editors. Omics Insights in Environmental Bioremediation. Singapore: Springer; c2022. p. 273-302. DOI: https://doi.org/10.1007/978-981-19-4320-1_14
14. Chaurasia P, Jasuja ND, Kumar S. Textile Effluent Treatment Methods and Limitations: A Sustainable and Ecological Aspect. Suranaree Journal of Science & Technology, 2023, 30(6).
15. China CR, Maguta MM, Nyandoro SS, Hilonga A, Kanth SV, Njau KN. Alternative tanning technologies and their suitability in curbing environmental pollution from the leather industry: A comprehensive review. Chemosphere. 2020;126804.
16. de Aquim PM, Hansen É, Gutterres M. Water reuse: An alternative to minimize the environmental impact on the leather industry. Journal of Environmental Management. 2019;230:456-463.
17. Durga J, Ramesh R, Rose C, Muralidharan C. Role of carbohydrases in minimizing use of harmful substances: Leather as a case study. Clean Technologies and Environmental Policy. 2017;19(5):1567-1575.
18. Elabed A, El Abed S, Ibnsouda S, Erable B. Sustainable approach for tannery wastewater treatment: bioelectricity generation in bio-electrochemical systems. Arabian Journal for Science and Engineering. 2019;44(12):10057-10066.
19. Fan W, Shahid MJ, Ghalia SHA, Afzal M, Khan A, El-Esawi M, *et al*. Implementation of floating treatment wetlands for textile wastewater management: A review. Sustainability. 2020;12(14):5801.
DOI: http://dx.doi.org/10.3390/su12145801
20. Fouda A, Hassan SED, Abdel-Rahman MA, Farag MM, Shehal-Deen A, Mohamed AA, *et al*. Catalytic degradation of wastewater from the textile and tannery industries by green synthesized hematite (α-Fe_2O_3) and magnesium oxide (MgO) nanoparticles. Current Research in Biotechnology. 2021;3:29-41.
21. Goswami L, Mukhopadhyay R, Bhattacharya SS, Das P, Goswami R. Detoxification of chromium-rich tannery industry sludge by Eudrillus eugeniae: insight on compost quality fortification and microbial enrichment. Bioresour Technol. 2018;266:472-481.
22. Gurreri L, Tamburini A, Cipollina A, Micale G. Electrodialysis applications in wastewater treatment for environmental protection and resources recovery: A systematic review on progress and perspectives. Membranes. 2020;10(7):146.
DOI: http://dx.doi.org/10.3390/membranes10070146
23. Harding G, Chivavava J, Lewis AE. Challenges and shortcomings in current South African industrial wastewater quality characterisation. Water SA. 2020;46(2):267-277.
DOI: http://dx.doi.org/10.17159/wsa/2020.v46.i2.8242
24. Jallouli S, Wali A, Buonerba A, Zarra T, Belgiorno V, Naddeo V, *et al*. Efficient and sustainable treatment of tannery wastewater by a sequential electrocoagulation-UV photolytic process. J Water Process Eng. 2020;38:101642.
25. Kokkinos E, Zouboulis A. Hydrometallurgical recovery of Cr(III) from tannery waste: Optimization and selectivity investigation. Water. 2020;12(3):719.
DOI: http://dx.doi.org/10.3390/w12030719
26. Lage S, Gojkovic Z, Funk C, Gentili FG. Algal biomass from wastewater and flue gases as a source of bioenergy. Energies. 2018;11(3):664.
DOI: http://dx.doi.org/10.3390/en11030664
27. Liu B, Qu F, Guo S, Yu H, Li G, Liang H, *et al*. A Pilot Study of the Sludge Recycling Enhanced Coagulation-Ultrafiltration Process for Drinking Water: The Effects of Sludge Recycling Ratio and Coagulation Stirring Strategy. Water. 2017;9(3):183.
28. Luongo G, Previtera L, Ladhari A, Fabio GD, Zarrelli A. Peracetic acid vs. sodium hypochlorite: Degradation and transformation of drugs in wastewater. Molecules. 2020;25(10):2294.
DOI: http://dx.doi.org/10.3390/molecules25102294
29. Maizatul AY, Radin Mohamed R, Maya Saphira, Al-gheethi A, Hashim MK, A. An overview of the utilisation of microalgae biomass derived from nutrient recycling of wet market wastewater and slaughterhouse wastewater. Int. Aquat. Res. 2017;9(3):177-193.
DOI: http://dx.doi.org/10.1007/s40071-017-0168-z
30. Mpofu AB, Oyekola OO, Welz PJ. Anaerobic treatment of tannery wastewater in the context of a circular bioeconomy for developing countries. Journal of Cleaner Production. 2021;126490.
31. Muruganandam L, Kumar MS, Jena A, Gulla S, Godhwani B. Treatment of wastewater by coagulation and flocculation using biomaterials. In: IOP Conference Series: Materials Science and Engineering. Vol 263. No. 3. IOP Publishing; c2017 Nov. p. 032006.
32. Nazir A, Iftikhar S, Abbas M, Iqbal M, Ahmad I. Toxicity evaluation of tannery effluents using bioassays. Curr. Sci. Perspect. 2019;5(3):29.
33. Neyla BC, Peña Salamarca EJ. Selección de una alternativa sostenible para la reducción de la contaminación por cromo en aguas residuales de curtiembres/Selection of a sustainable alternative for the reduction of chromium pollution in leather tanning wastewater. Dyna. 2019;86(209):188-197.
DOI: http://dx.doi.org/10.15446/dyna.v86n209.73585
34. Pal P, Chakrabortty S, Nayak J, Senapati S. A flux-enhancing forward osmosis–nanofiltration integrated

treatment system for the tannery wastewater reclamation. Environmental Science and Pollution Research International. 2017;24(18):15768-15780. DOI: http://dx.doi.org/10.1007/s11356-017-9206-z
35. Parveen S, Bharose R, Singh D. Assessment of physico-chemical properties of tannery wastewater and its impact on fresh water quality. International Journal of Current Microbiology and Applied Sciences. 2017;6(4):1879-1887.
36. Parvin S, Mazumder LT, Hasan S, Rabbani KA, Rahman ML. What should we do with our solid tannery waste? IOSR J Environ Sci. Toxicol. Food Technol. 2017;11(4):82-89.
37. Saranya D, Shanthakumar S. An integrated approach for tannery effluent treatment with ozonation and phycoremediation: A feasibility study. Environmental research. 2020;183:109163.
38. Shi L, Huang J, Zeng G, Zhu L, Gu Y, Shi Y, *et al*. Roles of surfactants in pressure-driven membrane separation processes: A review. Environmental Science and Pollution Research International. 2019;26(30):30731-30754. DOI: http://dx.doi.org/10.1007/s11356-019-06345-x
39. Shindhal T, Rakholiya P, Varjani S, Pandey A, Ngo HH, Guo W, *et al*. A critical review on advances in the practices and perspectives for the treatment of dye industry wastewater. Bioengineered. 2021;12(1):70-87.
40. Singh RL, Singh RP, eds. Advances in Biological Treatment of Industrial Wastewater and their Recycling for a Sustainable Future. Singapore: Springer, 2019, 225.
41. Sivaram NM, Barik D. Toxic waste from leather industries. In: Energy from toxic organic waste for heat and power generation. Woodhead Publishing; c2019. p. 55-67.
42. Suhad AAANA, Abed SN, Scholz M. Wetlands for wastewater treatment and subsequent recycling of treated effluent: A review. Environmental Science and Pollution Research International. 2018;25(24):23595-23623. DOI: http://dx.doi.org/10.1007/s11356-018-2629-3
43. Sun Y, Zhou S, Chiang PC, Shah KJ. Evaluation and optimization of enhanced coagulation process: Water and energy nexus. Water-Energy Nexus. 2019;2(1):25-36.
44. Sunzid A, Salma A, Sharmin Z, Jahan RA, Latiful BM. Use of natural bio-sorbent in removing dye, heavy metal and antibiotic-resistant bacteria from industrial wastewater. Applied Water Science, 2020, 10(5). DOI: http://dx.doi.org/10.1007/s13201-020-01200-8
45. Tolkou AK, Zouboulis AI. Application of composite pre-polymerized coagulants for the treatment of high-strength industrial wastewaters. Water. 2020;12(5):1258.
46. Tolkou A. Use of Novel Composite Coagulants for Arsenic Removal from Waters - Experimental Insight for the Application of Po; c2017.
47. Ugwu EI, Agunwamba JC. A review on the applicability of activated carbon derived from plant biomass in adsorption of chromium, copper, and zinc from industrial wastewater. Environmental Monitoring and Assessment, 2020, 192(4). DOI: http://dx.doi.org/10.1007/s10661-020-8162-0
48. Verma SK, Sharma PC. NGS-based characterization of microbial diversity and functional profiling of solid tannery waste metagenomes. Genomics. 2020;112(4):2903-2913.
49. Verma T, Tiwari S, Tripathi M, Ramteke PW. Treatment and recycling of wastewater from tannery. In: Advances in Biological Treatment of Industrial Wastewater and their Recycling for a Sustainable Future. Springer, Singapore; c2019. p. 51-90.
50. Wang S, Liu T, Xiao X, Luo S. Advances in microbial remediation for heavy metal treatment: a mini review. Journal of Leather Science and Engineering. 2021;3(1):01-10.
51. Wijeyaratne WM, Wadasinghe LGYJG. Allium cepa bio assay to assess the water and sediment cytogenotoxicity in a tropical stream subjected to multiple point and nonpoint source pollutants. Journal of toxicology; c2019.
52. Wudneh AS, Dagnew M. Revisiting chemically enhanced primary treatment of wastewater: A review. Sustainability. 2020;12(15):5928. DOI: http://dx.doi.org/10.3390/su12155928
53. Zhao C, Chen W. A review for tannery wastewater treatment: Some thoughts under stricter discharge requirements. Environmental Science and Pollution Research International. 2019;26(25):26102-26111. DOI: http://dx.doi.org/10.1007/s11356-019-05699-6

How to Cite This Article
Chaurasia P, Jasuja ND. Microbial approach in treatment, recycling and reuse of wastewater from tannery industry: A review. Journal of Advances in Microbiology Research 2024; 5(1): 199-212.