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Coagulation Flocculation Based Biological Treatment of Tannery Industry Wastewater using Potash Alum and Drewfloc

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ABSTRACT

The tannery industry is considered to be a vital industry from economic point of view. But its wastewater is an important source of water pollution as it contains high concentration of both organic and inorganic pollutants. Disposal of such untreated wastewater is a serious environmental threat. It is therefore necessary to treat this wastewater before the final disposal. In this research work, coagulation and flocculation followed by biological treatment is used to treat the wastewater of tannery. Potash alum was used for coagulation and Drewfloc 270 was used for flocculation. Different dose rates of coagulant and flocculent were adjusted and their effects on different parameters were observed. It was concluded that this treatment method was found successful in reducing the pollutant concentration of the tannery effluent to achieve National Environmental Quality Standards (NEQS).

Key words: Wastewater, Flocculation, Sludge, Coagulation, NEQS, TSS, TDS, pH, BOD5, COD

INTRODUCTION

Tanning is the process in which collagen fibres present in the animal skin react with tannins or other chemical agents to form a stable product called leather [1-8]. Approximately 30 – 35 litres water is used in the processing of a kg of hide/skin [9]. Tannery wastewater can be categorized as follow:

- Effluents discharged from pre-tanning process. The operations include liming, deliming/bating, water from fleshing and splitting machines. Such effluents contain sulphides and have high pH, but they are chrome-free.
- Effluents discharged from tanning process. The operations include tanning and re-tanning, sammying. Such effluents contain high Cr content and are acidic.
- Effluents discharged from post-tanning process. The operations include fat-liquoring, dyeing. Such effluents contain low Cr content.

Wastewater treatment is a process comprised of different stages, aiming to purify wastewater before it is discharged to natural waters, applied on land or reused. In wastewater treatment, pollutants do not disappear; rather they are just converted into the form which is acceptable to the environment and easy to dispose of. Removal or reduction of organic matter, solids, nutrients, Cr and other pollutants is the main aim of wastewater treatment. Every effluent treatment plant has to meet the standards set by the relevant environmental authority for the allowable levels of pollutants expressed as BOD5, COD, suspended solids (SS), Cr, total dissolved solids (TDS) and others. Different phases of tannery wastewater treatment are as follows:

- Preliminary treatment
- Primary treatment (Physical-chemical treatment)
- Secondary treatment (Biological treatment)
- Tertiary treatment (advanced treatment)
- Sludge treatment and handling
- Utilization and disposal

Preliminary treatment is done to remove coarse particles, sand/grit and grease from the effluent. It also reduces chrome and sulphide contents before discharging of the effluent into the collection network. Different types of screens are used to remove large particles. After that the effluent is sent to the next section for primary treatment. Primary treatment aims to remove settle able organic and inorganic solids by sedimentation and floating materials by skimming.

At this process stage bio-chemical oxygen demand (BOD5) is reduced by 25-50%, total suspended solids (SS) by 50-70%, and oil and grease by 65% approximately. The effluent and sludge obtained after primary treatment are known as primary effluent and sludge respectively. Primary treatment is a two-step process:

1. Equalization and 2. Primary sedimentation

The objectives of equalization are to homogenize the effluent and to eliminate sulphides. For this purpose, the settling of solids should be avoided i.e. all the particulate matter should be kept in suspension. For this purpose, equalization tank is used. Mixing-cum-aeration devices are used to avoid settling. In primary treatment, chemicals are added which improve and accelerate the settling of suspended solids. This enhances the separation of colloidal in downstream processes such as sedimentation and filtration. Following processes are employed to separate suspended solids from water.

1. Coagulation 2. Flocculation

In coagulation, colloids are destabilized by neutralizing the forces that keep them apart. Finely dispersed solids (colloids) which are suspended in wastewater contain negative electric charges on their surfaces. The negative charge of the colloids is reduced by the cationic coagulants which provide positive electric charges. Consequently, larger particles (flocs) are formed due to the collision of the particles. Flocculation is the polymeric action in which bridges are formed between the flocs, and destabilized particles are bind into large agglomerates or clumps. Flocculent should be added slowly and mixed gently to ensure proper contact between the small flocs and their agglomeration into larger particles. Flocs can be removed from the liquid by different operations like sedimentation, filtration, floatation etc. Primary sedimentation aims to remove suspended solids mainly along with fats, waxes, mineral oils, floating non-fatty materials, etc. which could not be removed in the grit-and- oil chamber. It is done in Primary settling tanks. As the wastewater enters a sedimentation tank, it slows down. Thus the suspended solids gradually sink to the bottom under the effect of gravity. Primary settling tanks are commonly circular with a mechanism to remove grease (scum) from the top and sludge from the bottom. After primary treatment, BOD, COD and SS content of the effluent are reduced to a large extent.

In secondary treatments, aerobic biological treatment processes are employed to remove biodegradable dissolved and colloidal organic matter left after primary treatment. Up to 90% of the organic matter in wastewater can be removed by using biological treatment processes. Aerobic micro-organisms consume organic matter present in the wastewater to produce more micro-organisms and inorganic end products (principally CO_2, NH_3, and H_2O). This process is carried out in the presence of oxygen. Secondary treatment is a two-step process:

1. Aeration 2. Secondary sedimentation

Aeration is the process of bringing contact between air and the wastewater. In the aeration tank, the wastewater containing microorganisms is mixed vigorously with air. Proper supply of oxygen is necessary to maintain aerobic conditions and to the keep the active biomass suspended. Activated sludge treatment with extended aeration is commonly used for tannery wastewater treatment. In activated sludge process, metabolism of micro-organisms is used to remove substances causing oxygen demand. In short micro-organisms consumes (eat and digest) harmful and oxygen-demanding organic compounds and convert them into environmentally more acceptable form i.e. micro-organisms and stable and low-energy compounds like carbon dioxide and water. In Secondary sedimentation tank, the flocs formed in the aeration basin are allowed to settle down. The effluent obtained after sedimentation is fully treated effluent which is ready for final discharge or further treatment if required. The sludge is removed from the bottom which is bulkier and difficult to dewater. A part of it is then recycled back to the aeration tank while the rest is send to the sludge handling section for further processing.

Tertiary treatments are used when effluent does not meet the allowable discharge limits even after primary and secondary treatments. The reason behind is COD. This situation arises when the micro-organisms present in the floc could not decompose certain compounds. In such cases, more sophisticated and expensive treatments are employed to further reduce the solids and organic content of the effluent. In short, tertiary treatments are used when specific constituents of the effluent are not removed by previous treatments. Tertiary treatment includes absorptive processes like use of activated carbon, more efficient oxidation as with ozone, foam separation of impurities, and demineralization using distillation or reverse osmosis etc. Sludge from different sections of the plant is send to the sludge handling section. Water content of the sludge is reduced for its easy handling and disposal. This can be achieved by different means i.e. using sludge thickeners, mechanical dewatering in filter presses etc. or natural drying in sludge-drying beds. The tannery sludge has greater inorganic matter and heavy metal (i.e. chromium and sulphur compound) content. A variety of methods for utilization and/or safe disposal of tannery sludge have been used. They include landfill, land application, vitrification, composting, anaerobic digestion, thermal treatment, pyrolysis, brick making, etc. [10-18].

EXPERIMENTAL SETUP

The experimental set up is a wastewater treatment plant of a tannery industry. The plant treats 600 m^3 of tannery effluent per day. The tannery wastewater treatment plant consists of the following Equipment's: Equalization Basin, Primary Clarifier, Aeration basins, Secondary clarifier and Sludge drying beds etc. The wastewater from different sections of the tannery is collected in the equalization basin. Equalization basin is equipped with surface aerator and air diffuser to allow proper mixing. As the poor settling is caused by the stability of the colloidal present in the tannery effluent, a coagulant tank was installed on the equalization basin. The coagulant used was potash alum. This tank was used to introduce coagulant solutions of different concentrations into the equalization basin. Proper mixing minimizes the variations in wastewater flow rates and composition. From the equalization basin, the wastewater is sent to the primary clarifier through a pump. A flocculent was introduced into the primary clarifier in order to improve the settling of the suspended solids. The flocculent used was Drewfloc 270. For this purpose, flocculent tank was installed on the primary clarifier. This tank was used to introduce flocculent solutions of different concentrations into the secondary clarifier. Slow mixing of the flocculent was required in order to avoid the breakage of the flocs. The velocity of the water coming to the secondary clarifier was sufficient enough for the required mixing. Here the sludge is allowed to settle at the bottom of the clarifier while the wastewater overflows towards the next section of the plant under the effect of the gravity. Sludge collected from the primary clarifier is sent to the primary sludge drying beds. The next section of the plant comprises of two aeration basins. Here activated sludge method is employed for the treatment of the wastewater. These basins are provided with the surface aerators to ensure proper aeration. Proper aeration is very important to maintain aerobic conditions and to the keep the active biomass suspended. MLSS concentration is maintained at 4,500 to 5,000 mg/L in the aeration basins. From the aeration basins the wastewater moves towards the secondary clarifier under the effect of gravity. Here the sludge is allowed to settle down. Clear water overflows from the secondary clarifier towards the final disposal. A part of the sludge collected from the bottom of the secondary clarifier is sent to the aeration basins to maintain MLSS concentration while the rest of the sludge is sent to the sludge thickener. From sludge thickener, the sludge is sent to the sludge drying beds. After getting dried, sludge is used for land filling.

RESULTS AND DISCUSSIONS

The tannery wastewater contains a high concentration of pollutants. In the experimentation, different dose rates of coagulant and flocculent were used to treat the tannery effluent. The effect of varying the dose rates on the tannery effluent was examined. Following parameters were studied i.e. pH, chemical oxygen demand (COD), total dissolved solids (TDS) and total suspended solids (TSS). After the treatment, wastewater comes to the secondary clarifier. The samples were collected from the secondary clarifier to perform analysis. Table -1: shows the limits of different parameters prescribed by National Environmental Quality Standards (NEQS). These standards should be met for the safe disposal of the tannery effluent. Table -2: shows the concentration of the pollutants in the tannery wastewater before the chemical treatment. It shows that tannery wastewater is highly polluted. This wastewater is extremely harmful if exposed to the environment. It may affect the soil as well as water bodies. It is, therefore, necessary to treat this wastewater so that its harmful effects could be reduced.

In the chemical treatment, coagulant used was potash alum and flocculent was Drewfloc 270. The chemical treatment was followed by biological treatment. Different dose rates for coagulant and flocculent were adjusted to study the effect on different parameters. Table -3 shows the results of different parameters against different dose rates.

The variations in pH of the wastewater against different dose rates of coagulant and flocculent are tabulated below in Table -3. NEQS for pH of tannery effluent were achieved using chemical & biological treatment methods. There are not many variations in pH with the change in dose rates of coagulant and flocculent. pH values for all the samples lie within the limits prescribed by NEQS. Results for pH of the wastewater against different dose rates are shown in Fig. 1. The variations in COD values of the wastewater against different dose rates of coagulant and flocculent are tabulated in Table -3. The data shows that there is a gradual variation in the COD values against different dose rates of coagulant and flocculent. The lowest value of COD was achieved at dose rate of 100 ppm and 2 ppm for coagulant and flocculent respectively as shown in Fig. 2. Results for COD of the wastewater against different dose rates are shown in Fig. 2.

The variations in TDS values of the wastewater against different dose rates of coagulant and flocculent are tabulated below in Table -3. The data shows that TDS values are dependent upon coagulant and flocculent dose rates. Results for TDS of the wastewater against different dose rates are shown in Fig. 3. The variations in TSS values of the wastewater against different dose rates of coagulant and flocculent are tabulated below in Table -3. All the values lie within limits prescribed by NEQS. Higher dose rates may affect settling and floc formation of the suspended solids. Lowest value for TSS was achieved at dose rate of 100 ppm and 2 ppm for coagulant and flocculent respectively as shown in Fig. 4.

Table -1 Nation Environmental Quality Standards (NEQS) for Water

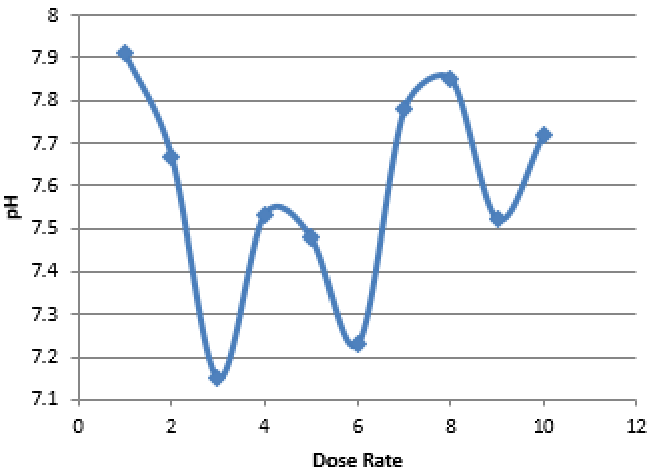
Parameters	NEQS (For Inland waters)
pH	6 – 9
COD (ppm)	150
TSS (ppm)	200
TDS (ppm)	3,500

Table -2 Influents Results before Treatment

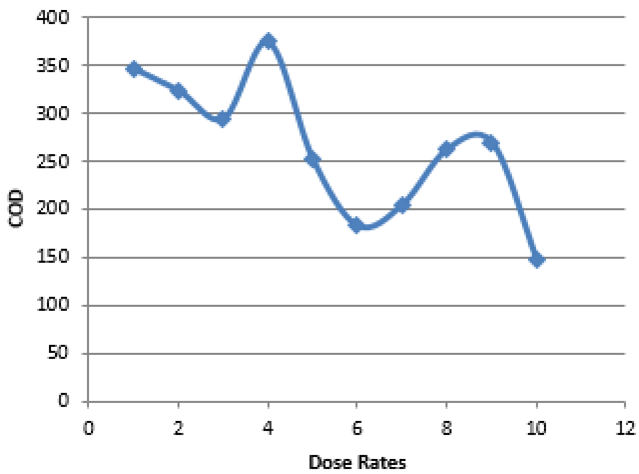
Parameters	Influents
pH	10.29
COD (ppm)	2594
TSS (ppm)	1026
TDS (ppm)	5512

Table -3 Variations in pH, COD, TDS and TSS against Different Dose Rates

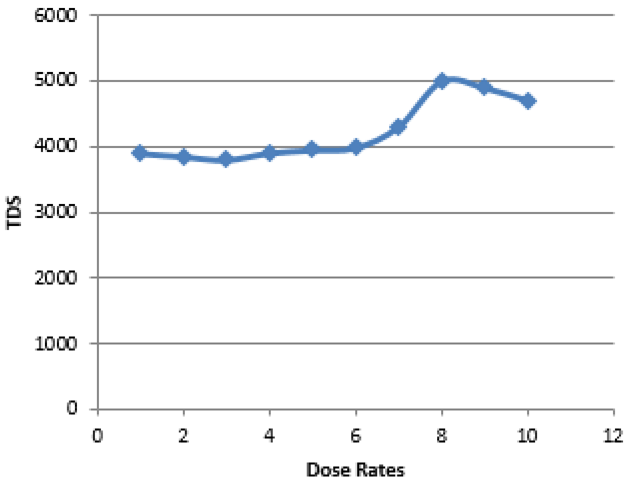
Dose Rate (ppm) (Coagulant + Flocculent)	pH	COD	TDS	TSS
DR – (20+1)	7.91	347	3902	86
DR – (40+1)	7.67	324	3853	79
DR – (50+1)	7.15	295	3803	74
DR – (60+1)	7.53	375	3907	83
DR – (60+2)	7.48	252	3952	62
DR – (80+2)	7.23	183	3988	53
DR – (80+4)	7.78	205.2	4307	55
DR – (100+6)	7.85	263	4998	64
DR – (100+4)	7.52	270	4896	67
DR – (100+2)	7.72	148	4705	43.5



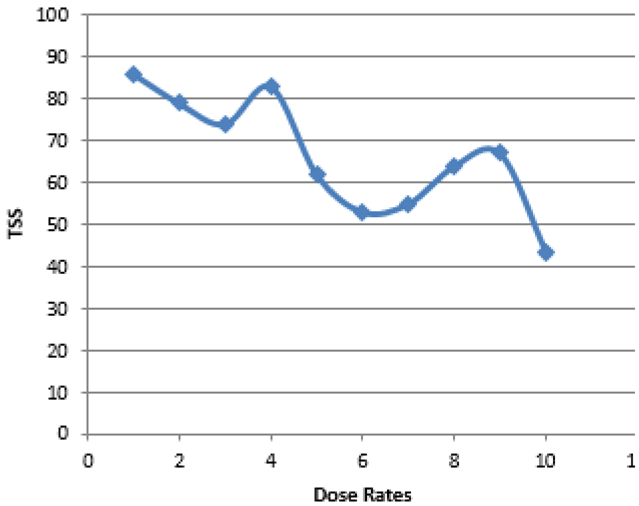
Graph -1 Variations in pH against Different Dose Rates



Graph -2 Variations in COD against Different Dose Rates



Graph -3 Variations in TDS against Different Dose Rates



Graph -4 Variations in TSS against Different Dose Rates

In the chemical treatment, coagulant used was potash alum and flocculent was Drewfloc 270. The chemical treatment was followed by biological treatment. Different dose rates for coagulant and flocculent were adjusted to study the effect on different parameters. Table -4: shows the results of different parameters against different dose rates. Table -4: shows that chemical treatment followed by biological treatment has been found successful for the treatment of tannery wastewater. Best results have been achieved at the DR-10, i.e. coagulant 100 ppm and flocculent 2 ppm. All the values have been reduced to NEQS except TDS. TDS value is high due to coagulant and flocculent added.

Table -4 Wastewater Treatment Analysis against Different Dose Rates

Dose Rate	Dose Rate (ppm)		pH	COD (ppm)	TDS (ppm)	TSS (ppm)
	Coagulant (Potash Alum)	Flocculent (Drewfloc 270)				
DR – 1	20	1	7.91	347	3902	86
DR – 2	40	1	7.67	324	3853	79
DR – 3	50	1	7.15	295	3803	74
DR – 4	60	1	7.53	375	3907	83
DR – 5	60	2	7.48	252	3952	62
DR – 6	80	2	7.23	183	3988	53
DR – 7	80	4	7.78	205.2	4307	55
DR – 8	100	6	7.85	263	4998	64
DR – 9	100	4	7.52	270	4896	67
DR–10	100	2	7.72	148	4705	43.5

CONCLUSIONS

This research work aims to suggest some techniques to reduce pollution concentration in the wastewater of tannery industry. The main findings of this work are: Chemical treatment followed by biological treatment has been found successful for wastewater treatment of tannery industry. pH of the wastewater before the treatment was 10.29. After treatment it was reduced to 7.72 COD before the treatment was 2594 and it was reduced to 148 after the treatment. Initial value of TSS was 1026 before the treatment. After treatment it was 43.5. TDS valued prior to the treatment was 5512. After treatment it was reduced to 4705. But it is still high. The reason behind high TDS is addition of coagulant and flocculent. This value of TDS can be reduced by using some tertiary treatment methods. Overdosing of the coagulant/ flocculent should be avoided as it may disturb the settling of the flocs.

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