An effective use of anodizing mud for treatment of tannery wastewater as a coagulation agent

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DOI: 10.29322/IJSRP.8.4.2018.p7659
http://dx.doi.org/10.29322/IJSRP.8.4.2018.p7659

Abstract: Treatment of Tannery effluent is challenging task as it is a biogenic matter of hides and a large variety of organic and inorganic chemicals. The objective of this present work is to study the application of aluminum anodizing mud as coagulant for the treatment of tannery wastewater. The anodizing mud was tested in two different forms: as powder and as mud suspension. A series of coagulation / flocculation tests were made, with subsequent optimization of important parameters such as pH, coagulant dose, stirring conditions (time and speed) and settling time. The effective coagulant capacity of the anodizing sludge was verified based on the pollutant i.e. total solids 59.8%, total dissolved solids 53.6%, total suspended solids 87.4%, grease and oil 100%, sulphate 32.9%, sulfide 100%, chromium 99.1%, C.O.D 70% and B.O.D 66.5% on composite sample was removed of the supernatant sample as a function of the coagulant dose and pH and found very effective method.

Keywords: Anodizing waste; tannery wastewater; aluminum; flocculation; coagulation.

Introduction:

Tannery wastewater treatment is a significant ecological and environmental issue, mostly in the developing countries delivering the majority of global leather production for the past two decades (Iqbal *et al.*, 1998). Beam house operation, tan-yard processes, re-tanning, and finishing are the stages of the tanning process that finishes leather; the process generates different kind and amount of wastewater depending on end products (K. Cooman, *et al.*, 2003; G. Lofrano *et al.*, 2013). Chemical oxygen demand (COD), suspended solids (SS), Cr, sulphide, oil and grease, total kjeldahl nitrogen (TKN), and pH ranges reported in the related literature to characterize wastewater from tannery industry varied greatly across and within the countries.
The use of aluminum in the clarification of water is common practice in wastewater treatment (Yu Zhou *et al.*, 2008). When aluminum salts are dissolved in water, dissociation into the constituents occurs. These ions are submitted to hydration reactions. The products of the hydrolyze reactions of the aluminum salts are the effective coagulant agents (Pratheesh, 2014).

Anodizing is a process for producing decorative and protective films on articles made from aluminum and its alloys. It is essentially a process where a thick film of aluminum oxide is built up on the surface of the aluminum through the use of a direct current electrical supply through an acid electrolyte bath in which the aluminum is immersed (Juan *et al.*, 2014).
Large quantities of waste (anodic mud) are generated in the manufacturing of refractory bodies, and the synthesis of useful minerals from the wastewaters arising from the etching, anodizing and brightening processes. In the industrial facilities there are normally two kinds of effluents clearly differentiated concentrated solutions, as well as washing waters. In most cases there are no treatments facilities in industries i,e recovery of caustic, sulphuric acid and the wastes are discharged directly in sewer or on land (Mihaela *et al.*, 2014; Ankur Pyasi., 2014). This anodic sludge is a big problem for many countries because it is relatively difficult to manage due to its complex nature.

The anodizing mud, which has a variable composition but contains three main constituents: aluminum hydroxide, oxy-hydroxides and basic sulphate, mainly of aluminum. Testing of mud mentioned in **Table-1.**
At present time the common practice in the Aluminium industries is that, if concentration of aluminum increase in the anodizing bath i,e 20 to 25% and in etching bath 50 to 60% than the 70- 80 % of volume dispose of in direct sever and huge quantity of mud formed and blockage of sever line and the cost of open sever line is high. Now a day this situation represents a really great environmental problem which must be resolved on urgent basis.

The use of aluminum mineral salts in wastewater treatment is much spread. "Coagulation-flocculation process could be considered as one of the most typical physicochemical processes used in water and wastewater treatments due to its easy operation, relatively simple design and low energy consumption (Teh and Wu, 2014; Feng-shan *et al.*, 2015; Abd-el-Kader *et al.*, 2014; Indrani *et al.*, 2014; Eduardo *et al.*, 2014; Varank *et al.*, 2014; Om and Kumar, 2014; Chai Siah *et al.*, 2014; Bartolomeu *et al.*, 1996). Research on aluminum as a coagulant is since long. In the current work we have studied anodizing sludge from one facility in the treatment of tannery wastewater instead of the conventional inorganic coagulants. In the same work anodizing sludge was selected due to its chemical composition of aluminum and two forms of the coagulants were tested: powder and mud suspension.

Coagulation is a well-known process associated with solid-liquid separation process. It is the removal of turbidity, color or micro-organisms that are present in the wastewater as colloidal suspensions (H. Effendi *et al.*, 2015; N. Muralimohan *et al.*, 2014; Sunita *et al.*, 2014; Priyanka *et al.*, 2014; Swathi *et al.*, 2014; Edris *et al.*, 2013; Brian and Charles, 1984). These suspensions are heterogeneous mixtures of particles with different size, shape and chemical composition. A colloid has been defined as a dispersion of distinguishable particles in the size range of 0.01-10 mm in a medium that may be regarded as a structure less continuum. Colloidal systems will usually scatter light, i.e. they exhibit turbidity, which is related to the sizes of the particles involved. Colloidal suspensions in aqueous media appear cloudy. The observed turbidity depends on both the particle size distribution and the mass concentration present. This type of particles tends to remain in suspension for a long period of time and due to its great stability colloids do not form aggregates (Er. Devendra *et al.*, 2014; Edris *et al.*, 2014; N.B.Prakash *et al.*, 2014; T. Sugumaran *et al.*, 2014).

The most important interactions affecting suspension stability are electrostatic repulsion and Van der Waals attraction. According to O'Melia (O'Melia C. 1972) four mechanisms of coagulation are recognized: compression of the diffuse layer, adsorption to produce charge neutralization, enmeshment in a precipitate and adsorption to permit inter particle bridging (B.Lekhlif *et al.*, 2014). The destabilization of colloids in water and wastewater is probably accomplished by adsorption of oppositely charged soluble and insoluble coagulant hydrolysis species on the colloid and subsequent destabilization, enmeshment of colloid within hydroxide or carbonate precipitates or both (Muhammad *et al.*, 2014; Asha *et al.*, 2011).

Apart from using aluminum salts as a coagulant, several natural coagulants, such as rice husk, rice starch (Swathi *et al.*, 2014; Teh *et al.*, 2014a; Teh *et al.*, 2014b), Cassia obtusifolia seed gum, Moringa Oleifera Seed (Aminu *et al.*, 2014; Shak *et al.*, 2014; Subramonian *et al.*, 2014), mustard seed extract (Bodlund *et al.*, 2014), Plantago major L (Chaibakhsh *et al.*, 2014) and others, were attempted in wastewater treatment. Several hydrolysis species can be formed depending on the pH, temperature and the concentration of mineral salts (Raul *et al.*, 2014; B.Lekhlif *et al.*, 2014; Rasha, 2014; Bhaskar *et al.*, 2014). These hydroxy-metal complexes adsorb on the particle surfaces and the charges they carry may cause charge reversals of the surfaces they adsorb on, contributing to the destabilization of the suspension. The hydrolysis reactions have a great tendency to release H^+, lowering the pH. A different but important effect of the coagulation characteristics of aluminum is the formation in the alkaline range of a hydroxide precipitate that appears as a fine colloidal dispersion. These particles tend to aggregate, forming hydroxide floc and then enmesh the colloidal particles present in the wastewater will occur depends on the concentration of aluminum and pH, as observed by Gregory (Gregory, 1978). It can be seen i.e. acid range predominates the coagulation mechanism of adsorption and charge neutralize and in alkaline range it happens the mechanism of sweep floc with formation of a precipitate and drags the suspended particles.

Experimental

Apparatus

A model 3510 pH meter Genway with glass electrodes was used for the pH
DR-4000, HACH Spectrophotometer was used.
Hot plate with stirrer (HS 10_2, Torry Pines Scientific, USA) was used for stirring.

Chemicals and reagents

All chemicals employed in this study were analytical grade. All solutions were prepared in distilled/de-ionized water made on each experimental day. Glassware used in this work was soaked with HNO_3 (~10%) for 24 h, and rinsed with distilled/de-ionized water prior to drying. Hydrogen per oxide used, was of analytical grade as 30% by wt.

Sampling

For the present investigation, the fresh mud was prepared and collected anodizing and etching solution from one industrial facility located at SITE Industrial Area Karachi.

Two different anodizing aluminum process baths were selected i.e. from etching and anodizing mixed in the ratio 1:1 which formed an anodizing mud. The etching wastewater is composed of caustic soda and aluminum whereas wastewater from anodizing consists of sulphuric acid and aluminum.

Analysis of physico-chemical parameters

All the pollutant parameters were analyzed following the procedure:

The pH value, total solids, total dissolved solids, total suspended solids, oil and grease, sulphates, sulfide, chromium, Chemical oxygen demand (COD) and Biological oxygen demand (BOD) before and after treatment of tannery effluent were determined according to Standard Methods for the Examination of water and wastewater 20th edition 1998.

In dry and suspension mud 1% solution was prepared and proceed to determine pH value, total sulphate%, total aluminum%, sodium%, calcium%, tin%, total chromium in mg/kg, chromium(VI) in mg/kg. the APHA methods were used respectively measured in HAACH DR-4000 spectrophotometer (HACH 1992).

Methodology

Chemical coagulation

For the preparation of anodizing mud (**Fig. 1**) selected from two different facilities having the operations of etching and anodizing aluminum bath, were well mixed and homogenized. The anodizing sludge was characterized and the results obtained are presented in the **Table 1**. It was observed that aluminum is one of the major constituents of the compositions of in the sludge along with the total sulphates.

When using the sludge as mud suspensions, water was added to the fresh mud in a way that the solids percentage was known. The total solids, in the mud suspension tested, was 19% of sludge.

In order to stabilize the anodizing sludge it was dried at room temperature for several days. The time needed for the stabilization process was dependent on particle / cake size, room temperature, air humidity and sludge moisture. Finally it was kept in an oven at 110^0C for six hours till constant weight is achieved. Then the dried sludge was grinded and passed through a screen of 292 mm so that a homogeneous powder of constant characteristics in stabilized form was produced for the treatment of tannery wastewater experiments.

Coagulation and precipitation studies were performed in a six-place conventional jar-test apparatus, equipped with 6 beakers of 2000 ml volume. Before coagulation process **(Fig. 2)** tannery wastewater sample was thoroughly shaken to avoid possibility of settling solids. The experimental process consisted of the initial rapid mixing stage that took place for 10 min at 300 rpm, the following slow mixing stage for 45 min at 100 rpm and the final settling step for 2 h. After 2 hour settling period, samples were withdrawn from supernatant for analyses (Muhammad *et al.*, 2014).

Results and Discussion:

A series of tests were programmed, being controlled important parameters such as coagulant dose, mixing and flocculation conditions (stirring time and speed and settling time). The coagulation process was effective for the tested mud and the two different forms, powder and mud suspension. The formations of flocs that settle rapidly were visible. The tests performed have demonstrated the efficiency of the anodizing mud as a coagulant being the optimal dose. The laboratory tests were performed using samples of 2000 ml of tannery wastewater in each experiment. The representative samples of tannery wastewater used in this study were collected from Korangi Industrial Area, Karachi at the entrance of treatment plant which recovers the tannery wastewater corresponding to 130 tanneries. The knowledge of the constituents of the tannery wastewaters is important for the quantification of the pollutants removal after the treatment. For this work, three different samples of tannery wastewater were collected in different time and dates. Relevant parameters of the tannery wastewaters were determined and prepare one composite sample presented in the **Table 2**. All parameters were tested in duplicates.

Coagulation / flocculation process consists in three steps: coagulation of the suspended solids, growing of the micro flocs and elimination of the floc aggregates formed as shown in (**Fig. 3**).

The degree of clarification obtained when chemical aids are used in tannery wastewater treatment depends on the chemicals quantity and in the control and monitoring of the process (G. Shebang. 2014; 2015). The use of aluminum salts in the treatment of wastewater is a common practice and the quantity added usually ranges between 0.05 and 0.3g/l.

In this work the coagulant dose varies between 0.5 and 5.0 g/l, stirring at 300 rpm and left over night, in order to detect the effect of the used dose in the coagulant performance (Djamel and Ahmed, 2015). The mud used greater than the recommended for aluminum salts, but this is due to the fact that the mud has aluminum in its composition but aluminum salts are not the only constituents in the mud.

In all performed tests the supernatant pH was greater than 7.8 for all the coagulant doses and for all the mud tested. Since the final pH is in alkaline range we have concluded that the predominant coagulation mechanism was the mechanism of sweep floc with formation of precipitate that involves and drags the suspended particles. During the wastewater treatment process hydroxide precipitates are formed. The suspended contaminants are removed by hetero coagulation or are enmeshed by the precipitates; destabilization mechanisms also mentioned by Brian Dempsey. The soluble contaminants are adsorbed on the precipitates.

The composite tannery wastewater tested has a COD, 4912 mg/l, BOD, 2690 mg/l and content in suspended solids ranged from 3312 mg/l. It is clear from the **Tables 3 and 4** that the anodizing mud tested have effectively, through coagulation process contributed the removal of the wastewaters total solids, total dissolved solids, total suspended solids, grease and oil, sulphate, sulfide, chromium, C.O.D and B.O.D reaching the removal of pollutants to maximum values 59.9%, 53.8%, 87.1%, 100%, 34.1%, 100%, 99.0%, 70.3% and 67.0% respectively.

The optimum pH ranges for anodizing mud, for treating tannery wastewater were 7.81 to 8.22.

For statistical validation it has been mentioned **Fig. 4 and 5**.

This coagulation process was effective and it was visible the formation of flocs which settled rapidly. The size of the flocs formed depends on the agitation conditions and mud dose used. The coagulation process observed with the mud occurred in pH zone between 7.8 and 8.22, which according to the coagulation diagram for aluminum salts proposed by Lofrano (Lofrano *et al* 2006), is the pH zone, there is predominance of the mechanisms in a precipitate.

The precipitate mechanism will act in the following way: precipitation of the metal hydroxide and contaminants removal by enmeshment in this precipitate. Soluble contaminants are adsorbed on the hydroxide and particles are removed by hetero coagulation (Duan and Gregory, 2003). Also according to Amirtharajah (Amirtharajah and Mills 1983) (the hydroxide is positively charged when the pH is less than 8.0, so, in the range of the tests the precipitate is positively charged and the enmeshment mechanism is enhanced by hetero coagulation between the precipitate and the negatively charged suspension. The sweep flocculation mechanism gives improved particle removal comparatively with the mechanism of charge neutralization. Hydroxide precipitates have a rather open structure having a higher probability of capturing other particles. This can explain the high removal rates achieved in the flocculation experiments with the anodizing sludge. All experiments were carried out in duplicates.

The results for the suspension mud that the same conditions of stirring, settling time and supernatant reduction. This is the fact that when dealing with a powder, the dissolution process is very important to ensure that the aluminum present acts as coagulant, and to make the maximum use of the coagulation substances present. The presence of a considerable percentage of aluminum in the chemical composition of the sludge solid fraction is the main factor that contributes to the sludge coagulation capacity.

Conclusion

This research presented results of an experimental study of flocculation/coagulation process used in tannery wastewater treatment. Coagulation efficiency was determined by COD, BOD, Suspended Solids, Sulfide, Oil & Grease and Chromium measuring of the supernatants in the Jar test. It was found that anodizing mud were more efficient as coagulants.

It is the least effective since 5.0 gm of the anodizing mud through the experimental work.

Floc formation is observed and flocs are easily separated from the supernatant by settling, when the amount of anodizing mud increased 5.0 gm, the floc settling times increased.

Also, for two tested sludge, the coagulant in suspension form presents better results for contaminants reduction.

The treated tannery wastewater was not suitable for discharge into receiving waters as the many residual pollutants greater than NEQS limits. Tannery wastewater efficiency was not achieved by anodizing mud. Therefore, further advanced or biological treatment is needed for tannery wastewater.

The work was carried out at lab scale and may be extended to large scale. The use of anodizing mud for treatment of tannery waste water will act as an effect coagulant on one hand and will prevent under discharge of the anodizing mud in sewer on the other hand.

References:

Abdelkader Anouzla., Younes Abrouki., Salah Souabi., Mohammed Safi., Hayat Loukili., Hicham Rhbal., Rachid Slimani. 2014. Optimization of coagulation process with SIWW is coagulant for colour and COD removal of acid dye effluent using central composite design experiment. *International Journal of Environmental Monitoring and Analysis*, 2(6-1): 1-5.

Aminu., M. D. Garba., Z. Y. Abba. 2014. Biosorption Potentials of Moringa Oleifera Seed in Textile Effluent Treatment. International Journal of Scientific & Engineering Research, Volume 5, Issue 8.

Ankur Pyasi. 2014. Value Added Metal Extraction from Red Mud. Master Thesis, Department of Metallurgical and Materials Engineering, National Institute of Technology, Rourkela.

Asha, G., Reena, Y,. Parmila D. 2011. Removal of Hexavalent Chromium using Activated Coconut Shell and Activated Coconut Coir as Low Cost Adsorbent. The Institute of Integrative Omics and Applied Biotechnology, 2, 8-12.

APHA, Standard Methods for the Examination of Water and Wastewater, 20th edition. Washington, DC. 1998.

Amirtharajah, A., Mills, K.J. 1983. *American Water Works Association*, 232-239.

B, Lekhlif., L, Oudrhiri., F, Zidane., P, Drogui., J.F, Blais. *2014.* Study of the electrocoagulation of electroplating industry wastewaters charged by nickel (II) and chromium (VI). *J. Mater. Environ. Sci. 5 (1) 111-120.*

Bodlund, I., Pavankumar, A.R., Chelliah, R., Kasi, S., Sankaran, K., Rajarao, G.K. 2014. Coagulant proteins identified in Mustard: A potential water treatment agent. *International Journal of Environmental Science and Technology*, 11 (4), pp. 873-880.

Bhaskar, G., Naidu, GRK., Madan, Iyengar. 2014. Laboratory Experiment of Advanced Oxidation Process Coupled Coagulation, Flocculation, and Biological Treatment. *J. Bioremediation & Biodegradation*, 5:7.

Bartolomeu, F., Chambino, T., Sota, L., Delmas, F. 1996. Use of Aluminium Anodizing Sludge in wastewater Treatment, in: *Congress on Characterization and Treatment of Clean-up Sludge from Dredging, Sewage Sludge, Drinking Water Sludge and CIPS, CATS III*, R.Vanbrabant. and G. de Schuster (eds.), Belgium, KVIV – Technologisch Institute Oostende, 389 – 398.

Brian, A.D., Charles, R.O. 1984. Removal of Naturally Occurring Compounds by Coagulation and Sedimentation. *Environmental Science and Technology*, 14, 311-331.

Chaibakhsh, N., Ahmadi, N., Zanjanchi, M.A. 2014. Use of Plantago major L. as a natural coagulant for optimized decolorization of dye-containing wastewater. *Industrial Crops and Products*, 61, pp. 169-175.

Chai Siah Leea., John Robinsonb., Mei Fong Chong. 2014. A review on application of flocculants in wastewater treatment. *Process Safety and Environmental Protection* x x x
www.elsevier.com

Djamel Ghernaout., Ahmed Boucherit. 2015. Review of Coagulation's Rapid Mixing for natural organic matter (NOM) Removal. *Journal of Research & Developments in Chemistry.*
www.ibimapublishing.com

Duan, J.. Gregory J. 2003. Coagulation of Hydrolyzing Metal Salts. *Advance Colloid Interface Science*, (100-102) 475-502.

Edris Bazrafshan., Amir Hossein Mahvi., Mohammad Ali Zazouli. 2014. Textile Wastewater Treatment by Electrocoagulation Process Using Aluminum Electrodes. Iranian journal of health sciences; 2(1):16-29.
http://jhs.mazums.ac.ir

Eduardo Alberto., López-Maldonado., Mercedes Teresita., Oropeza-Guzmán., Adrián Ochoa-Terán. 2014. Improving the Efficiency of a Coagulation-Flocculation Wastewater Treatment of the Semiconductor Industry through Zeta Potential Measurements. *Journal of Chemistry*, Article ID 969720, 10 pages.

Er. Devendra Dohare., Tina Sisodia. 2014. Applications of Electrocoagulation in treatment of Industrial Wastewater: A Review. *International Journal of Engineering Sciences & Research Technology.* ISSN: 2277-9655, 3(11).

Edris Bazrafshan., Hossein Moein., Ferdos Kord Mostafapour., Shima Nakhaie. 2013. Application of Electrocoagulation Process for Dairy Wastewater Treatment. *Journal of Chemistry*, Volume, Article ID 640139, 8 pages.

Feng-shan Zhou., XiWang., Lin Zhou., Yang Liu. 2015. Preparation and Coagulation Behavior of a Novel Multiple Flocculants Based on Cationic Polymer, Hydroxy Aluminum, and Clay Minerals. *Advances in Materials Science and Engineering,* Article ID 581051, 8 pages.

Gentiana Shebang. 2015. Cleaner Tannery Wastewater Using Chemical Coagulants. *International Journal of Science and Research (IJSR)*, Volume 4 Issue 1.
www.ijsr.net

G. Shebang. 2014. Treatment of Tannery Effluents by the Process of Coagulation. *International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering* Vol: 8, No: 4.

G. Lofrano., S. Meric., G.E. Zen gin. D. Orhon. 2013. Chemical and biological treatment technologies for leather tannery chemicals and wastewaters: a review, Sci. Total Environ. 461–462.

Gregory, J. 1978. Flocculation by Inorganic Salts, In: *The Scientific Basic of Flocculation*, K.J. Inves. (Eds), Sijthoff & Noordhoff, Aplhen aan den Rijn, 89-99.

H. Effendi., R. D. Sari., S. Hasibuan. 2015. Maringa oleifera as coagulant for batik effluent treatment. *International Association for Impact Assessment*, conference, 20-23 in Florence, Italy.

HACH, Water analysis handbook. HACH Company, U.S.A. 1992.

Indrani Khan, V., Sarith, N V., Srikanth Vuppala. 2014. Process Investigation and Optimization of Coagulation and Flocculation. *Indian Journal of Research* Volume: 3 | Issue: 5 |.

Iqbal, M., Izhar-ul-Haque. J. A. S. Berns. 1998. Leather Sector, Environmental Report.

Juan Asensio-Lozano., Beatriz Suárez-Peña., George F., Vander Voort. 2014
Effect of Processing Steps on the Mechanical Properties and Surface Appearance of 6063 Aluminium Extruded Products. *Materials*, *7*, 4224-4242,
www.mdpi.com/journal/materials

K. Cooman., M. Gajardo., J. Nieto., C. Bornhardt., G. Vidal. 2003. Tannery wastewater characterization and toxicity effects on Daphnia spp, Environ. Toxicol. 18 45–51.

Lofrano, G., Belgiorno, V., Gallo, M., Raimo, A., Meric S. 2006. Toxicity Reduction in Leather Tanning Wastewater by Improved Coagulation Flocculation Process. *Global NEST*, 8, 151-158.

Mihaela-Doina Niculescu., Laurentiu Filipescu. 2014. Red Mud as Multifunctional Material for Pollutants Capturing from Wastewater. ICAMS 5th International Conference on Advanced Materials and Systems.

Muhammad Ali., Suneela Sardar., S R Malik. 2014. Effect of Mixing Speed and Time on Dyes Removal through Coagulation and Flocculation from Dye bath Effluent. *International Journal of Innovation and Applied Studies*, ISSN 2028-9324 Vol. 8 No. 3 Sep., pp. 1158-1172.
http://www.ijias.issr-journals.org/

N. Muralimohan., T. Palanisamy., M. N. Vimaladevi. 2014. Experimental Study on Removal Efficiency of Blended Coagulation in Textile Wastewater Treatment. International Journal of Research in Engineering & Technology (IMPACT: IJRET) ISSN (E): 2321-8843; ISSN (P): 2347-4599, Vol. 2, Issue 2, 15-20.

N. B.Prakash., Vimala Sockan., P. Jayakaran. 2014. Waste Water Treatment by Coagulation and Flocculation. *International Journal of Engineering Science and Innovative Technology (IJESIT)* Volume 3, Issue 2.

Om Prakash Sahu., Parmesh Kumar Chaudhari. 2014. Physicochemical Treatment of Sugar Industry Wastewater: Coagulation Processes. *Environmental Quality Management*, Volume 23, Issue 4, pages 49–69.

O'Melia C.1972. Coagulation and Flocculation, Physicochemical Processes for Water Quality Control. 74 -125 Wiley Inter science, New York

Pratheesh Prasobhan. 2014. Comparison of Al/Fe/Zr Performance on Coagulation. Master Thesis, Norwegian University of Life Sciences.

Priyanka Pai H., Nagaraja M., Ranjani Chitrapur. 2014. Effective use of nanocrystalline and lime when used in combination of coagulants- Alum, $Fecl_3$ and $FeSO_4$ for suspended solids and COD removal from pharmaceutical industry effluents. International Journal of Scientific and Research Publications, Volume 4, Issue 5.

Raul Molina., Isabel Pariente., Ivan Rodríguez., Fernando Martínez., Juan Antonio Melero. 2014. Treatment of an agrochemical wastewater by combined coagulation and Fenton oxidation. Journal of Chemical Technology and Biotechnology Volume 89, Issue 8, pages 1189–1196.

Rasha Azeez Joudah. 2014. Effect of Temperature on Floc Formation Process Efficiency and Subsequent Removal in Sedimentation Process. *Journal of Engineering and Development*, Vol. 18, No.4, ISSN 1813- 7822.

Shak, K.P.Y., Wu, T.Y. 2014. Coagulation-flocculation treatment of high-strength agro-industrial wastewater using natural Cassia obtusifolia seed gum: Treatment efficiencies and flocs characterization. *Chemical Engineering Journal*, 256, pp. 293-305.

Swathi, M., Sathya Singh, A., Aravind, S., Ashi Sudhakar, P.K., Gobinath, R., Saranya devi, D. 2014. Experimental studies on tannery wastewater using cactus powder as an adsorbent. Int. Journal of Applied Sciences and Engineering Research, Vol. 3, Issue 2,
www.ijaser.com

Swathi, M., Sathya Singh, A., Aravind, S., Ashi Sudhakar, P.K., Gobinath, R., Saranya devi, D. 2014. Adsorption studies on tannery wastewater using rice husk. Scholars Journal of Engineering and Technology (SJET), 2(2B):253-257.
www.saspublisher.com

Sunita Singh Thakur., Sonal Choubey. 2014. Assessment of coagulation efficiency of *Moringa oleifera* and Okra for treatment of turbid water. *Applied Science Research*, 6 (2):24-30
(http://scholarsresearchlibrary.com/archive.html)

Subramonian, W., Wu, T.Y., Chai, S.-P. 2014. A comprehensive study on coagulant performance and floc characterization of natural Cassia obtusifolia seed gum in treatment of raw pulp and paper mill effluent. *Industrial Crops and Products*, 61, pp. 317-324.

Teh, C.Y., Wu, T.Y., Juan, J.C. 2014a Optimization of agro-industrial wastewater treatment using unmodified rice starch as a natural coagulant. *Industrial Crops and Products*, 56, pp. 17-26.

Teh, C.Y., Wu, T.Y., Juan, J.C. 2014b. Potential use of rice starch in coagulation-flocculation process of agro-industrial wastewater: Treatment performance and flocs characterization. *Ecological Engineering*, 71, pp. 509-519.

Teh, C.Y., Wu, T.Y. 2014. The potential use of natural coagulants and flocculants in the treatment of urban waters, *Chemical Engineering Transactions*, 39, pp. 1603-1608

T. Sugumaran., A. Ramu., N. Kannan. 2014. Characterization, correlation and electrocoagulation studies of leather processing industrial effluent. Journal of Chemical and Pharmaceutical Research, 6(3):1479-1489.
www.jocpr.com

Yu Zhou., Zhen Liang., Yanxin Wang. 2008, Decolonization and COD Removal of Secondary Yeast Wastewater Effluents by Coagulation using Aluminum sulfate. *Desalination*, 225, 301–311

Varank, G., Erkan, H., Yazýcý, S., Demir, A. and Engin, G. 2014. Electrocoagulation of Tannery Wastewater using Monopolar Electrodes: Process Optimization by Response Surface Methodology. *Int. J. Environ.* Res., 8(1):165-180.

Table – 1
Analysis of anodizing mud Suspension
(All analytical analysis was performed in duplicate)

Parameter	**Results**
Moisture%	81
Ph	7.4
Sulphate, total (SO_4) (%)	14
Aluminum, total (Al) (%)	22
Sodium, (Na) (%)	0.17
Calcium, (Ca) (%)	0.062
Tin, (Sn) (%)	5.0
Chromium total (Cr) (mg/ kg)	4.5
Chromium VI (Cr) (mg/ kg)	3.2

Table – 2
Analysis of tannery wastewater
(All analytical analysis was performed in duplicate)

Parameter	Results in ppm except pH				NEQS Limits Value (National Environmental Quality Standards)
	1st Sample	2nd Sample	3rd Sample	Composite	
pH value	8.36	8.35	8.12	8.28	6 – 10
Total solids	29878	12258	11654	17966	-
Total dissolved solids	23306	10560	10123	14654	3,500 mg/L
Total suspended solids	6275	1698	1531	3312	150 mg/L
Grease and oil	24	20	15	21	10 mg/L
Sulphate	6450	6302	5988	6376	600 mg/L
Sulphide	200	175	140	165	1.0 mg/L
Chromium	2052	1903	1862	1924	1.0 mg/L
COD	5360	4720	4585	4912	150 mg/L
BOD	3030	2860	2360	2690	80 mg/L

Table – 3
Influence on removal of pollutants from the Tannery effluent's composite sample with increasing dose of coagulant mud dry.
(All analytical analysis was performed in duplicate)

Parameters	**Fresh Composite Sample**	**Results in ppm except pH**											
		Coagulation dose (Dry)											
		0.5 gm	**Removal %**	**1.0 gm**	**Removal %**	**2.0 gm**	**Removal %**	**3.0 gm**	**Removal %**	**4.0 gm**	**Removal %**	**5.0 gm**	**Removal %**
pH value	8.28	8.09		8.01		7.96		7.91		7.86		7.81	
Total solids	17966	14856	17.3	14143	21.2	12656	29.5	10547	41.3	8371	53.4	7220	59.8
Total dissolved solids	14654	12376	15.5	11916	18.7	11104	24.2	9359	36.1	7635	47.9	6812	53.5
Total suspended solids	3312	2480	25.1	2227	32.7	1552	53.1	1188	65.6	736	77.7	408	87.7
Grease and oil	21	No Traces	100	No traces	100	No Traces	100	No traces	100	No Traces	100	No Traces	100
Sulphate	6376	6091	4.4	5826	8.6	5542	13.0	5245	17.7	5069	20.5	4372	31.4
Sulphide	165	No traces	100	No traces	100	No Traces	100	No traces	100	No traces	100	No traces	100
Chromium	1924	1456	24.3	243	87.4	122	93.7	61	96.8	42	97.8	14	99.2
COD	4912	4350	11.4	3836	21.9	2945	40.0	1874	61.8	1539	68.6	1489	69.7
BOD	2690	2374	11.7	1986	26.2	1678	37.6	969	64.0	939	65.1	911	66.1

Table – 4
Influence on removal of pollutants from the Tannery effluent's composite sample with increasing dose of coagulant mud suspension.
(All analytical analysis was performed in duplicate)

Parameters	Fresh Composite Sample	Results in ppm except pH											
		Coagulation dose (Suspension)											
		0.5 gm	**Removal %**	**1.0 gm**	**Removal %**	**2.0 gm**	**Removal %**	**3.0 gm**	**Removal %**	**4.0 gm**	**Removal %**	**5.0 gm**	**Removal %**
pH value	8.28	8.19		8.07		8.0		7.93		7.87		7.82	
Total solids	17966	14965	16.7	14133	21.3	12725	29.2	10724	40.3	8360	53.4	7195	59.9
Total dissolved solids	14654	12346	15.7	11906	18.7	11161	23.8	9539	34.9	7617	48.0	6769	53.8
Total suspended solids	3312	2619	20.9	2227	32.7	1564	52.7	1185	64.2	743	77.5	426	87.1
Grease and oil	21	No traces	100	No traces	100	No traces	100	No traces	100	No traces	100	No traces	100
Sulphate	6376	6112	4.1	5792	9.1	5388	15.5	5192	18.5	4651	27.0	4201	34.1
Sulphide	165	No traces	100	No traces	100	No traces	100	No traces	100	No traces	100	No traces	100
Chromium	1924	1691	12.1	280	85.4	146	92.4	72	96.2	48	97.5	19	99.0
COD	4912	4509	8.2	4185	14.8	2947	40.0	2067	57.9	1565	68.1	1457	70.3
BOD	2690	2347	12.7	2080	22.6	1725	35.8	1091	59.4	934	65.3	887	67.0

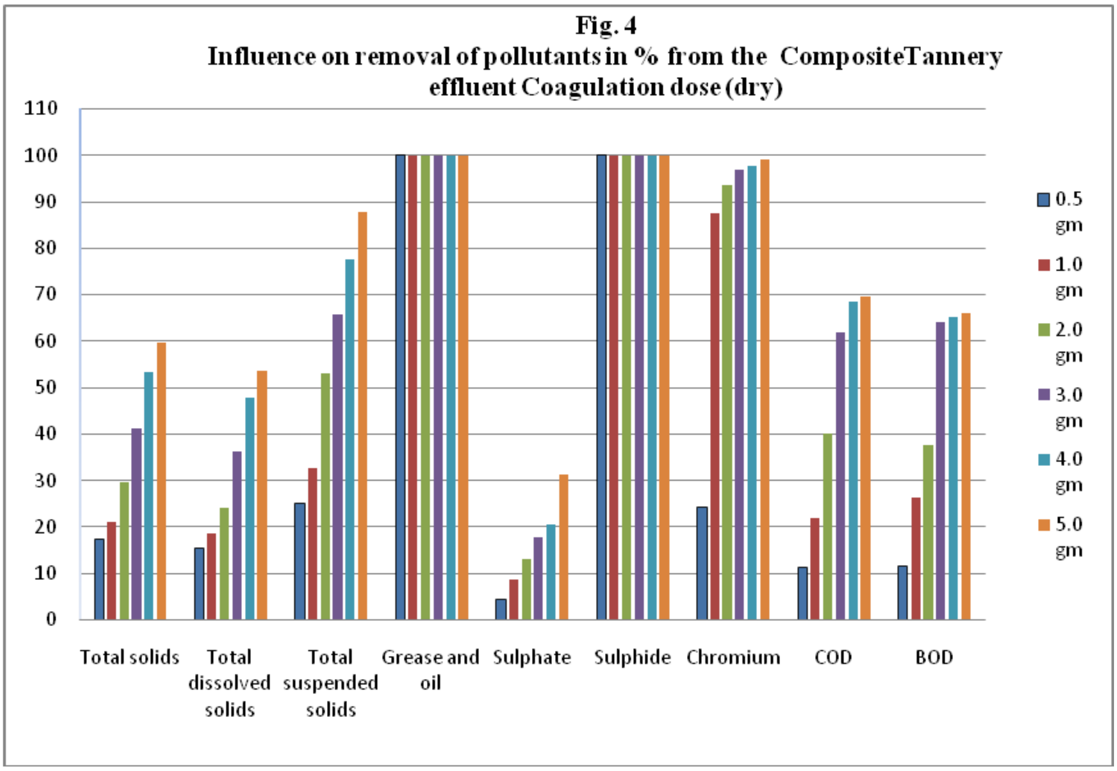
Fig. 4
Influence on removal of pollutants in % from the CompositeTannery effluent Coagulation dose (dry)
0 10 20 30 40 50 60 70 80 90 100 110
Total solids
Total dissolved solids
Total suspended solids
Grease and oil
Sulphate
Sulphide
Chromium
COD
BOD
0.5 gm
1.0 gm
2.0 gm
3.0 gm
4.0 gm
5.0 gm

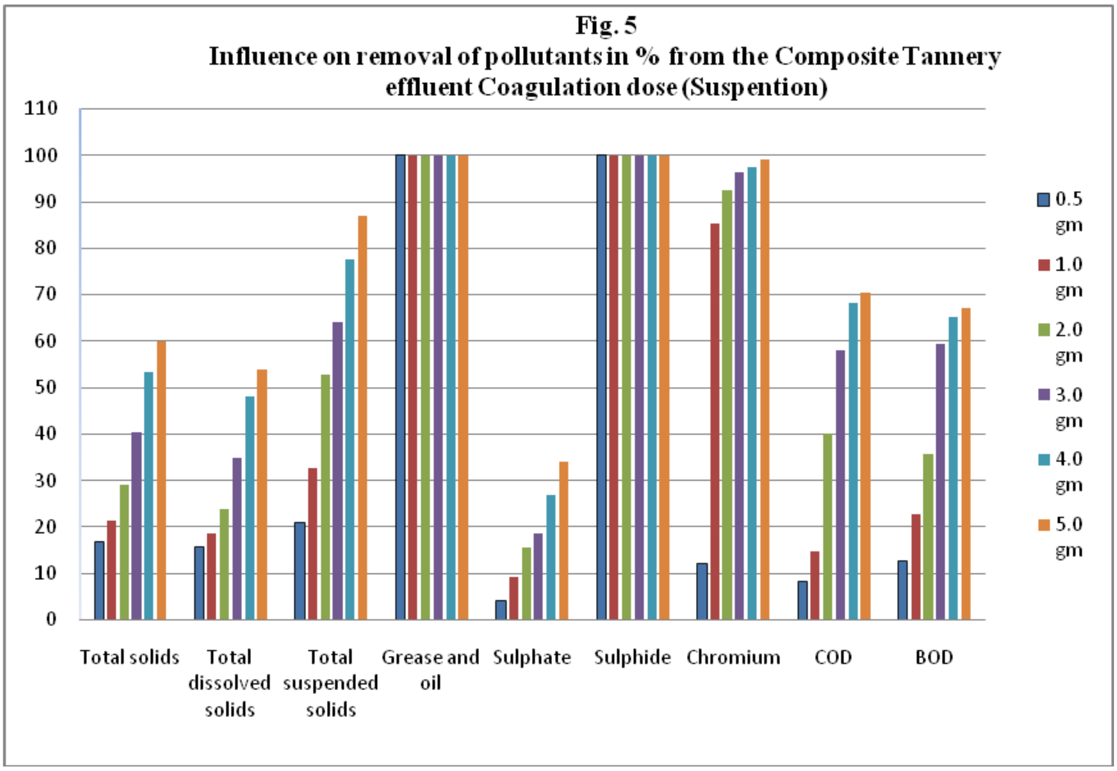
Fig. 5
Influence on removal of pollutants in % from the Composite Tannery effluent Coagulation dose (Suspention)
0 10 20 30 40 50 60 70 80 90 100 110
Total solids
Total dissolved solids
Total suspended solids
Grease and oil
Sulphate
Sulphide
Chromium
COD
BOD
0.5 gm
1.0 gm
2.0 gm
3.0 gm
4.0 gm
5.0 gm

Figure -1: Anodizing Mud (suspension)

Fig. 2

Stirring Machine

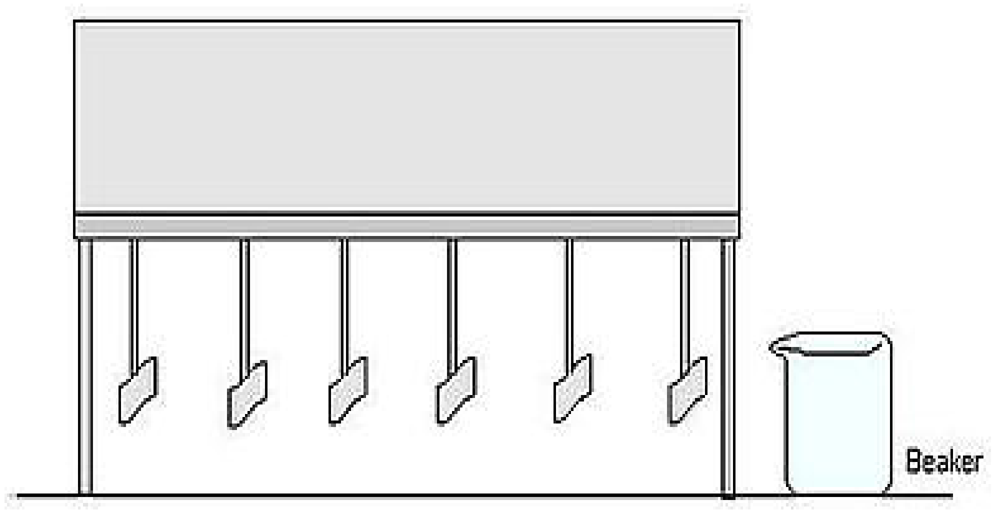

Fig. 3

Coagulation Process