EXPERIMENTAL STUDY ON EFFECT OF POLY ALUMINIUM CHLORIDE (PACL) IN INDUSTRIAL WASTEWATER TREATMENT

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Abstract*—Industrial wastewater contains lot of industrial wastes and which have high amount of toxic compounds and pollutants. The removal of this compounds is very essential. The main process used in treatment plant of wastewater is coagulation/flocculation. In this project Poly Aluminium Chloride (PACl) is suggested as a new coagulant with the help of experimental studies. Generally in treatment plants the chemicals used for coagulation and flocculation are Ferrous Sulphate and Alum. For this treatment the pH required is 11. The main problem of this flocculation process is that the conductivity of water increases. For reducing the pH level of water generally add HCL into water. By adding HCL conductivity of water again raises. High conductive water is harmful. When PACl is used for treating wastewater, treatment can be done at a pH of 5-9 itself. It reduces the conductivity and increase the quality of water. For this Project the sample of industrial wastewater collected from Cochin Special Economic Zone (CSEZ) Kerala, Kakkanad. CSEZ currently have 160 industrial units. CSEZ having a common Wastewater Treatment facility. Thus Zone units are required to send all their sewage and effluent to this treatment plant. These wastewater contain all organic, inorganic, hazardous and non-hazardous waste. So the experimental study was done in this sample of wastewater. Primly the coagulant dosages were optimized. Further the treatment efficiency was evaluated on the basis of pH, Turbidity, Total Suspended Solids, Total Dissolved Solids, and Dissolved Oxygen for sample treated with Alum, Ferrous Sulphate and PACl. The obtained results shown that PACl is more effective than Alum and Ferrous Sulphate for the treatment of Industrial wastewater.*

Keywords—Coagulation, Alum, Ferrous Sulphate, Poly Aluminium Chloride (PACL), pH, Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and Dissolved Oxygen (DO).

1. INTRODUCTION

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities. Among the various environmental challenges of that India is facing this century, fresh water scarcity ranks very high. The key challenges to better management of the water quality in India are temporal and spatial variation of rainfall, improper management of surface runoff , uneven geographic distribution of surface water resources, persistent droughts, overuse of groundwater, and contamination, drainage, and salinization and water quality problems due to treated, partially treated, and untreated wastewater from urban settlements, industrial establishments, and run-off from the irrigation sector besides poor management of municipal solid waste and animal dung in rural areas.

Industrial activities contribute a lot of toxic wastes to the environment. It contains lot of industrial wastes and, which have high amount of toxic compounds and pollutants. The removal of this compounds are very essential. There are many different ways of treating industrial effluent. The most important method is chemical wastewater treatment. The main process used in chemical wastewater treatment is coagulation/flocculation.

Coagulation and flocculation processes are used to separate the suspended solids portion from the water. By addition of some chemicals, the surface property of colloidal particles can be changed or dissolved material can be precipitated so as to facilitate the separation of solids by gravity or filtration. Generally in treatment plants the coagulants used are Alum, Ferrous Sulphate and PACl. Alum is the most common water treatment coagulant. Ferrous Sulphate is also used commonly. But PACl is a relatively new polymetric aluminium coagulant.

A. Need For The Study

Water pollution has many sources. The most polluting of them are the city sewage and industrial waste discharged into the rivers. Industrial waste is defined as waste generated by manufacturing or industrial processes. The types of industrial waste generated include cafeteria garbage, dirt and gravel, masonry and concrete, scrap metals, trash, oil, solvents, chemicals, weed grass and trees, wood and scrap lumber, and similar wastes. Industrial solid waste - which may be solid, liquid or gases held in containers - is divided into hazardous and non-hazardous waste. Hazardous waste may result from manufacturing or other industrial processes. Certain commercial products such as cleaning fluids, paints or pesticides discarded by commercial establishments or individuals can also be defined as hazardous waste.

Non-hazardous industrial wastes are those that do not meet the EPA's definition of hazardous waste - and are not municipal waste. Industrial waste has been a problem since the industrial revolution. Industrial waste may be toxic, ignitable, corrosive or reactive. If improperly managed, this waste can pose dangerous health and environmental consequences.

This waste is generated at every stage in the production process, use and disposal of manufactured products. Thus, the introduction of many new products for the home and office - computers, drugs, textiles, paints and dyes, plastics - also introduced hazardous waste, including toxic chemicals, into the environment. These, too, must be managed with extreme care to avoid adverse environmental or human health impacts..

The human health and environmental impacts of many of these chemicals are largely unknown. High levels of toxic contaminants have been found in animals and humans, particularly those, like farm workers and oil and gas workers, who are continually exposed to such waste streams. Wastewater from manufacturing or chemical processes in industries contributes to water pollution. Industrial wastewater usually contains specific and readily identifiable chemical compounds.

PACl is an industry standard primary coagulant which is relatively a new coagulant in India in the treatment of drinking water, sewage and industrial effluents. So an experimental study is done for the effect of Poly Aluminium Chloride in industrial wastewater treatment.

B. Objectives And Scope Of The Work

The major objectives of this experimental study are, study the effect of PACl as coagulant for treating industrial wastewater, conduct different test to determine the effectiveness of PACl on principle characteristics of wastewater, compare the effect on industrial wastewater using PACl, Alum and Ferrous Sulphate and compare the efficiency of using PACl with Ferrous Sulphate & Alum.

Scopes of the study are to control the water pollution, reduce the scarcity of water, increase the efficiency of wastewater treatment and reduce the time required for wastewater treatment.

2. MATERIALS

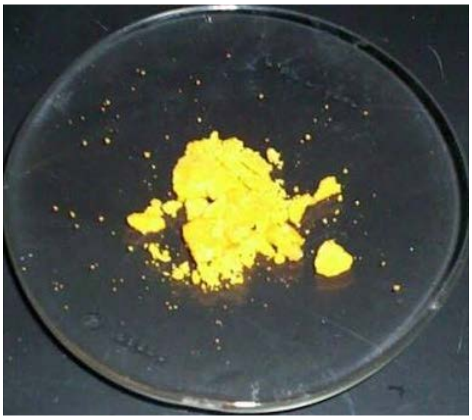
A. Alum

Aluminium sulphate or “alum” is the most common water treatment coagulant. As alum is added to water the hydrolysis reactions form a number of dissolved monomeric aluminium species and aluminium hydroxide precipitates. The theoretical effective hydrolyzing pH range for alum is 5.5 to 7.7 with optimal pH values near 6.0. At the optimum pH, the solubility is minimal and the maximum amount of coagulant is converted to solid flocs particles. As pH decreases from 6.0, dissolved positively charged aluminium species are formed. As pH increases above 6.0, the concentrations of negatively charged aluminium species increase. Researchers have found the distribution of aluminium species to be greatly affected by pH and temperature.

B. Ferrous Sulphate

Ferrous chloride, Ferrous Sulphate, and aluminium sulphate are available commercially in both liquid and solid forms. Typical dosages of ferrous chloride range from 5 to 150 mg/L depending on multiple factors including NOM concentrations and raw water quality. Studies have found the optimum pH range for iron-based coagulants to be between 5 and 8.5 which is slightly larger than that of aluminium sulphate. NOM removals of up to eighty percent using iron salts have been achieved at low pH values. However, determination of the optimum pH range and coagulant concentration ultimately depends on the raw water characteristics, and differs for each water source.

C. Poly Aluminium Chloride (PACl)



PACl is a relatively new polymetric aluminium coagulant. It is produced under controlled conditions by the partial neutralization of aluminium salts. It shall be in the form of liquid or powder, each of two types: (a) Medium basicity, and (b) High basicity, both grades are effective coagulant for the treatment of low to high turbidity surface raw water for drinking purposes.

Molecular Formula: $[Al_2(OH)_n Cl_{6-n} \cdot xH_2O]_m$ ($m \leq 10$, $n=3\sim5$) and Molecular Weight: 174.45.

Advantages of PACl over other coagulants are: Excellent stability, Quick hydrolysis speed, Strong adsorption capacity, Low effluent water turbidity etc.

3. METHODOLOGY

A. Sampling Of Water

5 litres of sample of industrial wastewater collected from Cochin Special Economic Zone (CSEZ) Kerala, Kakkanad. The CSEZ is a multi- product Special Economic Zone is

established in an area of 41.7 hectares. It is a multi-product zone, with industrial units operating in Electronics Hardware, Engineering, Gem & Jewellery, Agro & Food Processing, Textile and garments, Plastic and Rubber etc.

CSEZ was originally started as one of the first Export Processing Zone in India, and was later converted into a Special Economic Zone in 2003, when that system was introduced. It is operated by the Government of India, Ministry of Commerce, under the CSEZ authority, and headed by a Development Commissioner. It is the first integrated industrial park in Kerala.

CSEZ offers standard design factory floors, and plots of land for building custom building. There is a dedicated building for IT/ITES units, built with private participation. Power distribution, Telephone connectivity, water supply and sewage processing are managed by the zone authority. There is on site customs facilities for easy processing of import and export.

The zone is originally supported industries operating in the field of Electronics, Computer software, Readymade garments, Spices, Glass products, wood products, leather products, rubber products, coir-based products, food-processing, Pharmaceuticals, light engineering goods, sports goods, printing, gems and jewellery, electrical applicances, hand tools, automobile parts etc.

B. *Experiments*

For finding the effect of Poly aluminium chloride in the industrial wastewater first found the Optimum Coagulant Dosage of alum, ferrous sulphate and poly aluminium chloride with the help of Jar test. Then pH, Turbidity, Total Suspended Solids, Total Dissolved Solids, and Dissolved Oxygen of the collected sample, the sample treated with alum, the sample treated with ferrous sulphate and the sample treated with Poly aluminium chloride are find out.

1. Jar Test

Different doses of coagulant are added to measured volume of samples. The minimum dose of coagulant that produces the lowest residual turbidity is taken as the optimum dosage. From the experiment the Optimum Coagulant Dosage of alum, ferrous sulphate and PACl are 100mg/l, 80mg/l and 40mg/l.

2. pH

pH refers to the hydrogen ion activity. It is expressed as the negative logarithm of the reciprocal of the hydrogen ion activity in moles per litre. It can be measured by pH meter or using a standard hydrogen electrode and a reference electrode. The obtained pH of sample of wastewater is 6.5, the treated water with Alum is 8.72, the treated water with Ferrous Sulphate is 8.5 and pH of the treated water with Poly aluminium Chloride is 6.87.

3. Turbidity

Turbidity is a measure of resistance of water to the passage of light through it. It is due to the presence of suspended mineral matters. The turbidity can be measured using Nephelometer or Turbidity meter. The obtained turbidity of sample of wastewater is 8 NTU, the treated water with Alum is 7.5NTU, the treated water with Ferrous Sulphate is 7 NTU and the treated water with Poly aluminium Chloride is 4.5 NTU.

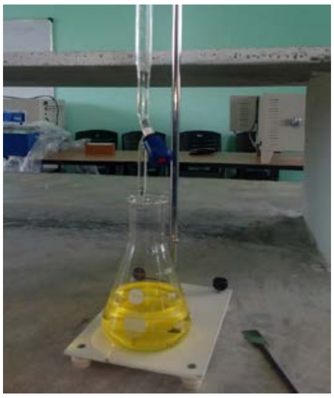
4. Total suspended solids

The amount of solids retained in the filter paper is Total suspended solids. The obtained results of Total suspended solids of sample of wastewater is 1008 mg/l, the treated water with Alum is 12 mg/l, the treated water with Ferrous Sulphate is 4 mg/l and the treated water with Poly aluminium Chloride is 0.

5. Total dissolved solids.

The amount of solids passed through the filter paper is Total dissolved solids. The obtained results of Total dissolved solids of sample of wastewater is 2520 mg/l, the treated water with Alum is 1820.7 mg/l, the treated water with Ferrous Sulphate is 1490 mg/l and the treated water with Poly aluminium Chloride is 90.1 mg/l.

6. Dissolved Oxygen



Dissolved oxygen is the quantity of oxygen is dissolved in the sample. The Winkler (or iodometric) test is the most precise and reliable titrimetric procedure for D.O. analysis. The test is based on the addition of divalent manganese solution, followed by strong alkali to the water sample in a glass-stoppered bottle. D.O. present in the sample rapidly oxidizes in equivalent amount of the dispersed divalent manganous hydroxide precipitate to hydroxides of higher valency states. In the presence of iodide ions and upon acidification, the oxidized manganese reverts to the divalent state, with the liberation of iodine equivalent to the original D.O. content in the sample. The iodine is then titrated with a standard solution of thiosulphate. The obtained results of Dissolved oxygen of sample of wastewater is 8mg/l, the treated water with Alum is 6.4 mg/l, the treated water with Ferrous Sulphate is 6.8 mg/l and the treated water with Poly aluminium Chloride is 7.4 mg/l.

4. RESULT AND DISSCUSION

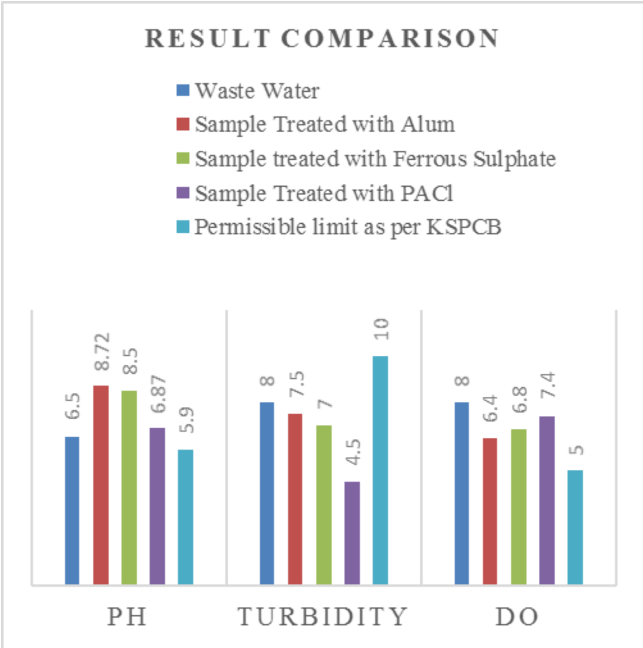
A. Comparison of Characteristics with the help of Table

TABLE I. COMPARISON OF RESULTS

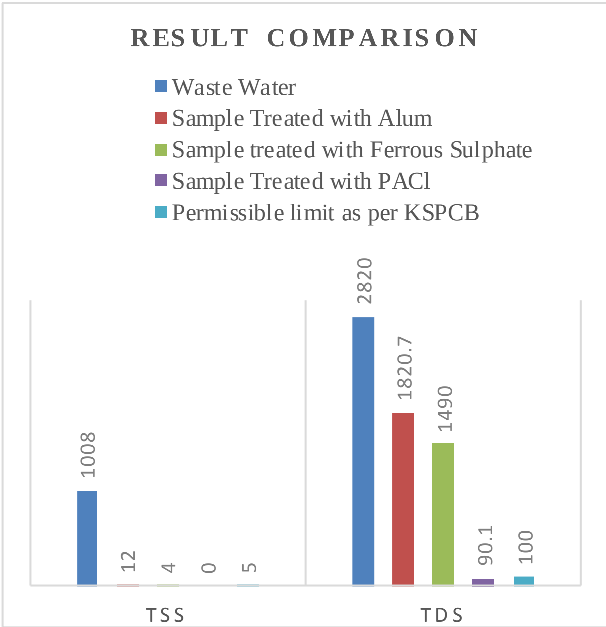
Sample	pH	Turbidity	TSS	TDS	DO
Wastewater	6.5	8 NTU	1008 mg/l	2820 mg/l	8 mg/l
Treated with Alum	8.72	7.5 NTU	12 mg/l	1820.7 mg/l	6.4 mg/l
Treated with Ferrous Sulphate	8.5	7 NTU	4 mg/l	1490 mg/l	6.8 mg/l
Treated with PACl	6.87	4.5 NTU	0	90.1 mg/l	7.4 mg/l
Permissible Limit as per KSPCB	5.5-9	10 NTU	5 mg/l	100 mg/l	>5 mg/l

B. Comparison of Characteristics with the help of Graph

GRAPH I -COMPARISON OF PH, TURBIDITY, DO



GRAPH II -COMPARISON OF TSS AND TDS



Above table and graph showing the effect of pH, Turbidity, Total Suspended Solids, Total Dissolved solids and DO, if treated sample with Poly Aluminium Chloride, Alum and Ferrous Sulphate. If wastewater treated with a coagulant the pH of water is slightly increased. In treatment plants when ferrous sulphate/ alum as used as coagulant the pH required is 11. For reducing the pH level of water generally add HCL into water. By adding HCL conductivity of water again raises. High conductive water is harmful. But from the experimental data we can see that if PACl is used as coagulant a slightly change in pH only occur. Thus we can avoid the use of HCL.

In case of turbidity the values from above table shows that PACl is more effective than other coagulants to reduce the turbidity of water. From values of Total suspended solids PACl can remove it with very high efficiency. Total dissolved solids is one of the important parameter to show the quality of water. From above tables PACl give high quality water. In case of Dissolved oxygen, the treated water with PACl give more quality water.

5. CONCLUSION

PACl is an effective & useful coagulant in the wastewater treatment plants. It can cause rapid coagulation of water at different turbidities, produces less sludge & leaves less amount of residuals. Also it works over a wide range of pH. Post-treatment pH adjustment using an alkali is not required. Reducing the overall capital cost of the plant as well as improving operator amenity and reducing maintenance requirements. With increased competition in the marketplace, the unit cost of poly aluminium coagulants will probably decrease in the future. Jar test also shows that less amount of PACl is need for good coagulation compared to alum and ferrous sulphate. So from our studies we suggests that PACl can replace ordinary coagulants for the treatment of industrial wastewater.

REFERENCES

[1] Yun-Hwei Shen And Brian A. Dempsey (1998), “Synthesis And Speciation Of Poly aluminum Chloride For Water treatment”, Environment International, Vol. 24, pp. 899-910.

[2] Tridib Tripathy and Bhudeb Ranjan De (2006), “Flocculation: A New Way to Treat the Wastewater”, Journal of Physical Sciences, Vol. 10, pp. 93 – 127.

[3] Irene Nansubuga, Noble Banadda, Mohammed Babu, Willy Verstraete and Tom Van de Wiele (2013), “Effect of poly aluminium chloride water treatment sludge on effluent quality of domestic wastewater treatment”, Journal of Environmental Science and Technology, Vol. 7(4), pp. 145-152.

[4] Ramune Albrektiene, Mindaugas Rimeika, Ernesta Lubyte (2011), “The Removal Of Iron-Organic Complexes From Drinking Water Using Coagulation Process”, Environmental Engineering, Vol. 3, Pp. 827-978.

[5] Fenglian Fu, Qi Wang (2011), “Removal of heavy metal ions from wastewaters: A review”, Journal of Environmental Management, Vol. 92 pp. 407-418.

[6] O.P.Sahu; P.K.Chaudhari (2013), “Review On Chemical Treatment of Industrial Wastewater”, Journal of Applied Science Environmental Management, Vol. 17 (2), pp. 241-257.

[7] Hossam Altaher*, Emad ElQada, Waid Omar (2011), “Pretreatment of Wastewater Streams from Petroleum/Petrochemical Industries Using Coagulation”, Advances in Chemical Engineering and Science, Vol. 1, pp. 245-251.

[8] Egwuonwu C.C., Uzoije A.P., Okafor V.C., Ezeanya N.C. And Nwachukwu M.U (2012), “Evaluation of the Effects of Industrial Wastewater”, Greener Journal of Physical Sciences, Vol. 2 (3), pp. 056-063.

[9] N.B.Prakash, Vimala Sockan, P.Jayakaran (2014), “Wastewater Treatment by Coagulation and Flocculation”, International Journal of Engineering Science and Innovative Technology, Vol. 3, pp. 124-130.

[10] Kokila A. Parmar, Sarju Prajapati, Rinku Patel and Yogesh Dabhi (2011), “Effective Use of Ferrous Sulphate and Alum as A Coagulant in Treatment of Dairy Industry Wastewater”, Journal of Engineering and Applied Sciences, Vol. 6, pp. 84-95.

[11] Nona Jesmanitafti, Seyed Ali Jozi, Seyed Masoud Monavari, (2014), “Review the Environmental Effects of Industrial Wastewater Effluent”, Journal of Environmental Protection, Vol. 5, pp. 874-885.

[12] Arun K. Vuppaladadiyam, Sowmya V., Pallavi Dasgupta (2013), “Comparative Study on Coagulation Process for Vellore Municipal Drinking Water Using Various Coagulants”, Universal Journal of Environmental Research and Technology, Vol. 3(1), pp. 119-126.