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Case Study

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Energy and Water conservation by Coagulant Change over from Aluminum Sulfate to Poly Aluminum Chloride (PAC) at a Conventional Water Treatment Plant

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Abstract

In industrial water treatment process coagulation process is used to destabilized suspended particles and to reacts with dissolved organic materials in raw water. Proper coagulation is essential for good filtration performance and for disinfection by product control. Improper coagulation can cause high aluminum residuals in the treated water and the post-treatment precipitation of particles causing turbidity, deposition and coating of pipes in the water distribution system. Minimizing the solid residuals produced from coagulation has also become a more important part of utility operations due to increased disposal costs and land filling restrictions. Choice of a suitable coagulant for maximum contaminant removal and reduction in costs is the most important parameters of water treatment. Sludge handling, conservation of water, saving energy and cost effective water treatment continue to be major hurdles in effective and efficient management of water treatment across the industries.

In this case study the feasibility of using poly aluminum chloride instead of Alum has been studied.

This paper covers following topics

- Problems related to sludge handling/chemical handling across various industries and their adverse affects; significance of water treatment.
- A unique cost effective solution- modern polymer product (Poly aluminium chloride).
- Methodology, working principles' of the treatment and its application, monitoring parameters.
- Advantages such as energy/Water conservation, cost effectiveness and other operational benefits.
- Successful implementation in NRL.

Introduction

The Resent global trends across refining/other sectors plants reveal a greater preference for polymer based i.e. Poly aluminum chloride (PAC) treatment to minimized multi-chemical use. Sludge reduction, conservation of water and minimization of aluminum in potable water. In India already more than 200 industries already implements Poly aluminum chloride based treatment and benefiting through this.. As Poly aluminum chloride (PAC) hydrolyses with great ease as compared to alum, emitting poly-hydroxides with long molecular chains & greater electrical charge in the solution, thus contributing to maximize the physical action of the flocculation. Better coagulation is obtained with PAC as compared to alum at medium & high turbidity waters. Floc formation with PAC is quite rapid. The sludge produced by PAC is much less and compact than that produced by alum. Hence the energy and water wasted due to less de-sludging and filter back washing can be conserved to a great extent. Due to these benefits, many industries have switch over to polymer based treatment from the conventional alum based treatment. In NRL we are also facing the problems of post-treatment precipitation, scaling, high volume of sludge generation; to overcome these problems polyamine based program initiated.

Reasons for Change in Treatment

- Reduction in the finished water Aluminium residual content.
- 30% less sludge generation. =reduction in disposal cost, water saving due to less de-sludging.
- Very less/no requirement of neutralizing agent (soda, lime)= less exposure to chemical, manual handling.
- Reduction of cleaning frequencies of the filters (longer runs in the sand filters)-saving water and energy.
- Reduction of So_4 in treated water. This has major impact on SO_4 levels in the sewage.
- Less coagulant being dosed = less chemical deliveries
- Higher quality of the treated water=lower amount of chlorine dosing to achieved residual.

Traditional Approach and Drawbacks

Aluminum has long been used as a primary coagulant to clarify water for drinking and industrial process uses. Historically, the main delivery mechanism for Aluminum ions came in the form of Aluminum Sulfate (Alum). The main reason alum was so widely used was availability and lack of low-cost alternatives. However,

there are other costs and problems associated with the use of alum. Alum is extremely acidic and can dramatically drop pH even when used at normal dosages. This creates the need to feed additional chemicals (lime or caustic soda) to compensate for the decline in pH. The use of Alum also produces relatively large amounts of aluminum hydroxide sludge. Therefore, when considering the whole picture, the cost of using Alum also includes:

- Pre and Post pH Adjustment (lime, caustic, etc.)
- Sludge Treatment (flocculation / dewatering)
- Solids Disposal

Poly-Aluminium Chloride (PAC) Treatment

Poly-aluminium chlorides are synthetic polymers dissolved in water. They react to form insoluble aluminum poly-hydroxides which precipitate in big volumetric flocs. These compounds have the general formula (Aln(OH)mCl(3n-m))x and have a polymeric structure, totally soluble in water. The length of the polymerized chain, molecular weight and number of ionic charges is determined by the degree of polymerization. On hydrolysis, various mono- and polymeric species are formed, with $Al1_3O_4(OH)247+$ being a particularly important cation. A less predominant species is $Al_8(OH)204$. Highly charged aluminium results to lower dosages & reduce sludge volume.

The specification PAC (KANPAC10 which is used in NRL, given below)

Product Identification:

Product Name: Poly Aluminium Chloride (KANPAC10)
Synonyms: PAC, Poly Aluminium Hydrochloride
Molecular Weight/ Chemical Formula: Formula {Aln (OH)m Cl3n-m}x containing
10.2-10.8 W/W Al_2O_3 minimum
Molecular Weight: Formula {Aln (OH) m Cl_3n-m} x containing 10.2W/W Al_2O_3 minimum
Chemical Characteristics: Olygomer, Aluminium Poly Chloride Compound.
Solubility: Highly soluble, miscible in all proportion
Melting Point: -
Freezing Point: (-) 10 degree C
Flash Point: Non Flammable
Ignition Temperature: Not Applicable
Explosive Properties: Not Applicable
Partition coefficient (Water): Not Known
Viscosity: 3 ± 0.3 cSt at 20 degree C

Composition/ Information on Ingredients

Chemical Family: Acid
Ingredients contributing to the hazard: Poly Aluminium Chloride
Chemicals abstract registry number: 12042-91-0 W/W Al2O3 minimum

Toxicological Information

Skin/Eye: Causes Irritation
Skin absorption: Repeated skin exposure may cause Dermatitis
Ingestion: Irritation of mucous membrane brought into direct contact.
Toxicity: Acute oral toxicity in mice 34.5 g/kg. The product undergone tests with various
Concentrations, proved to be entirely harmless to aquatic life up to concentration of 200 mg/l expressed as Al2O3 (corresponding to 2 g/l of PAC AC/100 S).

Toxic Substance present PPm (Max)

Hg	0.2PPM
As	5PPM
Cd	6 PPM
Pb	30PPM

Pac has been introduced at NRL to Replace Ferric Alum for Following Reasons

- To reduce manual handling of Chemicals.
- Dosing of chemicals through system like pump, tank etc.
- Optimizing the chemicals to improve the quality of treated water.

Advantages of PolyAluminium Coagulants

An important property of polyaluminium coagulants is their basicity. This is the ratio of hydroxyl to aluminium ions in the hydrated complex and in general the higher the basicity, the lower will be the consumption of alkalinity in the treatment process and hence impact on pH.

The polyaluminium coagulants in general consume considerably less alkalinity than alum. They are effective over a broader pH range compared to alum and experience shows that PAC works satisfactorily over a pH range of 5.0 to 8.0.

Other advantages of Polyaluminium Coagulants include the following

- low levels of residual aluminum in the treated water can be achieved, typically 0.01-0.05 mg/L,
- Less pH fall, no need of pH booster(lime)
- PAC work extremely well at low raw water temperatures. Flocs formed from alum at low temperatures settle very slowly, whereas flocs formed from polyaluminium coagulants tend to settle equally well at low and at normal water temperatures,
- less sludge is produced compared to alum at an equivalent dose,
- Lower doses are required to give equivalent results to alum. For example, a dose of 12 mg/L PAC (as 100%) was required for treatment of a coloured, low turbidity water (Otway region, Victoria) compared to similar performance obtained when using an alum dose of 55 mg/L, and
- The increase in chloride in the treated water is much lower than the sulphate increase from alum, resulting in lower overall increases in the TDS of the treated water.
- The removal efficiency of PAC is around (80% efficiency) 30 times higher than alum at various turbidity levels.

R.N0.	DESCRIPTION	PAC	ALUMINUM SULFATE
1.	Consumption	Low Quantities	High quantities
2.	Price	Fare	Fare
3.	Reduction in PH	Moderate	High
4.	Acid fraction	Moderate	High
5.	Salinity of system	Low	High
6.	COD,BOD Reduction	High	Low
7.	Gypsum formation	Nil	Sludge formation

8.	CO_2 development	Nil	Yes
9.	Odor	No Annoyance	No Annoyance
10.	Sludge formation of SO_4	Nil	High

How PAC works

PAC hydrolyses with great ease as compared to alum, emitting poly-hydroxides with long molecular chains & greater electrical charge in the solution, thus contributing to maximize the physical action of the flocculation. Better coagulation is obtained with PAC as compared to alum at medium & high turbidity waters. Floc formation with PAC is quite rapid. The sludge produ ced by PAC is more compact than that prod uced by alum.

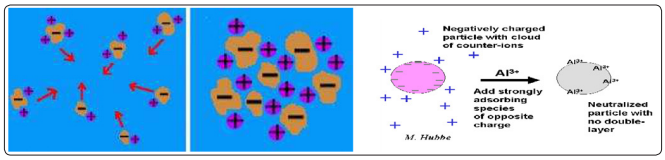

Figure 1: Coagulation process

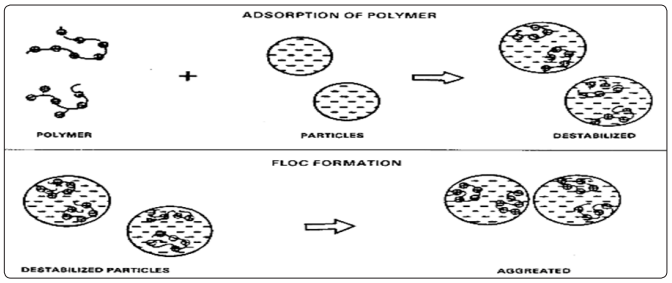

Figure 2: Floc formation process

Evaluation of Optimum Coagulant Dose (OCDS) of PAC in actual Treatment Plant for Different Turbidities

For turbidities of raw water (Cauvery water) at the treatment plant, say 1 to 70 NTUs, PAC of dose ranging between 0.5 to 30 mg/l were added in clariflocculators and the performances of it were assessed based on treated water turbidities, pH, alkalinity, and filter bed performances

It is seen that there is considerable reductions of Turbidity in PA C treated Jars than Alum. The removal efficiency of PAC from 150 to 7.9 NTU is around 94.7% for higher turbidities, where as in case of Alum treated Jars the removal efficiency (150 – 130.7) is lower than that off. The two parameters pH and TDS were monitored as. The initial level of pH 6, 8 at a concentration of Alum dose 10 mg/l. The reduction pH was 5.85 with respective dosage of alum. For initial level of TDS were 40 PPT (Parts per Trillion). These were no significant reduction at dosage of Alum 10 mg/l. For PAC the initial level of pH was 6.46 at a dosage of 10 mg/l. The reduction level of pH was 5.95 with respective dosage. In TDS there was no significant reduction. It was inferred that the sludge generated was about 0.5582 g/l for Alum for PAC the sludge generated was about 0.1739 g/l.

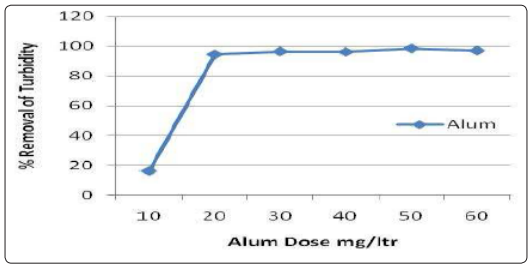

Figure 3: The graphical representation of % of removal of turbidity At 150 NTU (Alum)

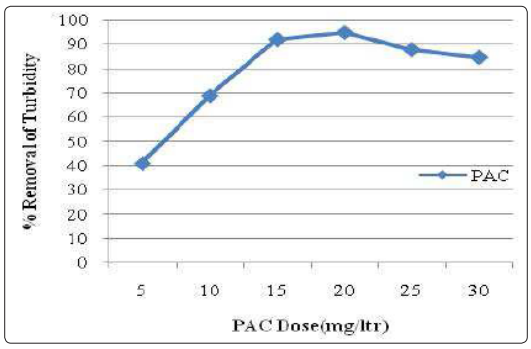

Figure 4: The graphical representation of % of removal of Turbidity At 150 NTU (PAC)

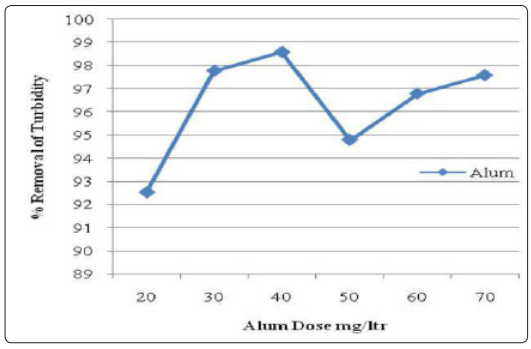

Figure 5: The graphical representation of % of removal of turbidity At 250 NTU (Alum)

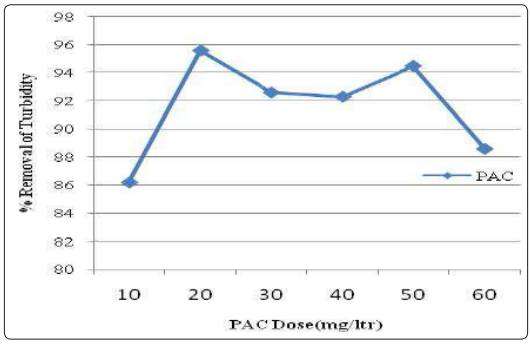

Figure 6: The graphical representation of % of removal of turbidity At 250 NTU (PAC)

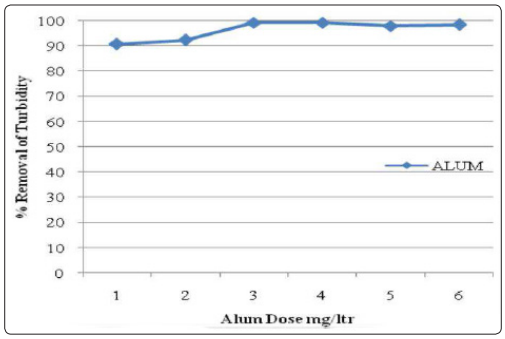

Figure 7: The graphical representation of % of removal of turbidity At 712 NTU (Alum)

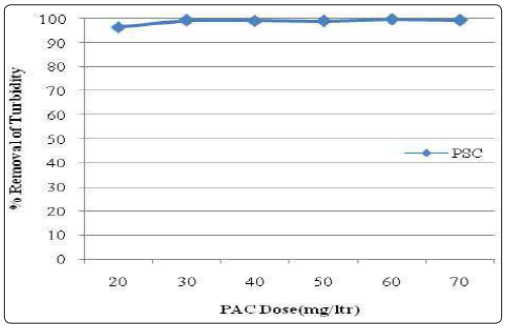

Figure 8: The graphical representation of % of removal of turbidity At 712 NTU (PAC)

Savings on Chemicals Cost

Coagulant	Requirement (MT/Annum)	Land cost (Rs./MT)	Total cost (Rs./Annum)
Alum	250	7500/-	1875000/-
PAC	170	7200/-	1224000/-
Lime reduction due to PAC dosing	20	11400/-	228000/-
Total Annual Savings in chemical cost with use of PAC			879000/-

Savings in Labor Cost

Coagulant	Nos of labor required per day	Cost of labor per day	Cost of labor per year
Alum	05	1960.00	705600/-
PAC	01	392.00	141120/-
Total Annual Savings in Labour cost with use of PAC			564480/-

Total Savings with use of PAC

Type of savings	Nos of labor required per day
Chemical Cost	897000/-
Labour Cost	564480/-
Total Annual Savingswith use of PAC	1443480/-

Conclusions

In the context of energy and water conservation, reduction of Aluminum level in drinking water, reduction in sludge production, less post pH dosing, lower TDS and Sulphate level, the experience with PAC dosing has been encouraging. A PAC based treatment program can be a worthwhile alternative wherein it not only conserves water and energy but also element requirement of multiple chemical dosing and handling system. Moreover PAC dosing will be cost effective and the hazards associated with conventional treatment would reduce drastically benefitting the health of those directly related with it. Thus polymer based treatment in water treatment plant would lead to more efficient and reliable operation.