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STUDY AND DEVELOPMENT OF METHODOLOGY OF TOTAL SUSPENDED SOLIDS REDUCTION FROM TREATED PHARMACEUTICAL WASTE WATER

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***Abstract** - Industrial waste water after primary and secondary treatment is disposed in CETPs. Most of the industries are making their plant Zero discharge by tertiary treatment due to scarcity of water, its future impact and strict pollution control norms. The report has been prepared for a pharmaceutical company waste water. The conventionally treated wastewater is further treated for Total Suspended Solids (TSS) reduction prior to tertiary treatment like Reverse Osmosis. Combination of various coagulants (Alum, PAC, FeCl3), coagulant aid (polyelectrolyte) and pretreatment (Lime, Bentonite clay, activated carbon), ballasted flocculation (micro sand) was used to reduce TSS. This was done by regular coagulation flocculation method at optimum pH. The most suitable method was adopted based on maximum TSS reduction, cost comparison and feasibility of operation for treating 100 Kl/day of waste water.*

***Key Words:** Total suspended solids (TSS), Coagulant, Polyelectrolyte, Pre-treatment, Total dissolved solids (TDS), Turbidity, Reverse Osmosis*

I. INTRODUCTION

Reverse Osmosis process is widely used to remove TDS and as a treatment for reuse of waste water. The feed water has certain desirable limits of TSS and turbidity for running the process efficiently. If not maintained then Reverse Osmosis membranes are subjected to choking and fouling. The desirable limit for TSS and turbidity is 50 ppm and ≤20 NTU respectively. The CETP disposal limit for treated TSS is 600 ppm. So conventionally treated waste water requires further removal of TSS. TSS includes both the suspended and colloidal solids. Dissolved solids removal is achieved by Reverse osmosis process.

This report has been prepared for a pharmaceutical company located near Vadodara. The wastewater is generated from produce of active pharmaceutical ingredients (API), antibiotics and anti-TB and contains trace amount of inorganic and organic components, ammonia salt, phosphorous, sulphur, alcohols etc. In general, the treatment of effluent often involves combinations of various techniques. They include aerobic and anaerobic biological treatments, membrane processes, chemical oxidation and precipitation, activated carbon and adsorption, coagulation and flocculation. Therefore a combination of physical, chemical and biological treatment is often required for the efficient treatment of the effluent. *(Priyanka Pai H. et.al; 2014*). Chemical treatment is effective enough to treat pharmaceutical effluents and decrease considerable TSS and color. Coagulation process is effective for removing high concentration organic pollutants (in colloidal form). Different coagulants provide different degrees of destabilization. The higher the valance of the counter ions, the more will be the destabilization effect and less amount of dose required for coagulation. *(Priyanka Pai H. et.al; 2014*). The waste water characteristics and disposal limits are tabulated below:

Parameter	*Raw waste water (ppm)*	*Treated waste water (ppm)*	*Disposal limits, CETP (ppm)*	*RO Requirement (ppm)*
COD	8000-10000	800-1000	2000	-
BOD	5000-7000	200-300	500	-
pH	8.5-9.0	7.0-8.5	6.5-9.0	
NH3-N	70	40-45	50	-
TSS	1000-1250	500	600	50
TDS	5000-6000	4500-5500	-	-
Turbidity		208 NTU		≤20 NTU

Note – Values indicated are average values

Table 1. Waste water characteristics and disposal limits

II. MATERIALS AND METHODS

Effluent samples were taken from outlet of conventionally treated wastewater of a pharmaceutical company located near Vadodara. Every time fresh grab samples were taken for the experiment. Chemicals were purchased from a local supplier of industrial category. It includes alum, poly aluminium chloride (PAC), ferric chloride (FeCl3), anionic polyelectrolyte (Zetag 4145), clay, activated carbon, lime, microsand (100-150µm size) ,(ballasted flocculation).

Stock solution of 5% strength (5 ml in 100 ml distilled water) of alum, PAC and FeCl3 , 0.05% strength (0.05 gm in 100 ml distilled water) of polyelectrolyte was prepared. Feed solution of lime 10% strength (10 gm in 100 ml) and clay, activated carbon, micro sand were added by weight.

Most of the experiment were conducted using magnetic stirrer and occasionally jar test apparatus to determine optimum pH and coagulant dose. Beakers of 500 ml capacity were used for coagulation. Experiment were carried out at optimum pH of 7.5 to 8.5

A. COAGULATION AND FLOCCULATION

Coagulant PAC, alum was mixed rapidly at 200 rpm for 1 minute. At the end of rapid mixing polyelectrolyte was mixed followed by slow mixing/flocculation for 10 minutes at 30-50 rpm speed. The generation of flock could be watched during this process. Flock was allowed to settle for 30 minutes before withdrawing the samples for analysis. These procedures were performed several times so that the optimum dose of the adsorbent, coagulant and flocculent can be determined.

B. COAGULATION AND FLOCCULATION WITH PRETREATMENT

Desired amount of pretreatment material (clay, lime, activated carbon was added) and mixed with waste water at 200 rpm for 1 minute. Contact time of 15 minutes for lime and clay and 30 minutes for activated carbon was provided. Further addition of coagulant, flocculent was followed as per above coagulation and flocculation process.

C. BALLASTED FLOCCULATION

Ballasted flocculation was carried using rapid mixing of coagulant at 200 rpm for 1 minute, Polyelectrolyte addition followed by flocculation for 5 minutes. Microsand by weight was added after that for larger flocs and polyelectrolyte was again added to enhance formation of larger flocs by particle bridging followed by flocculation for 5 minutes at 30-50 rpm speed and then sedimentation for 30 minutes.

D. ANALYTICAL ANALYSIS

25 ml sample of coagulated waster water was filtered through whatman 42 filter paper for TSS measurement. Final pH and turbidity was measured by pH and turbidity meter respectively. The residue on the filter paper was dried at 103°C for 1 hour. The increase in the weight of the filter paper represents the TSS.

Calculation

$$\text{mg total suspended solids/L} = \frac{(A-B) \times 1000}{\text{sample volume, mL}}$$

where: A = weight of filter + dried residue, mg, and B = weight of filter, mg.

III. RESULTS AND DISCUSSION

Optimum pH: - 7.0 to 8.5

A. COAGULATION AND FLOCCULATION

a. Alum+polyelectrolyte

Optimum dose was 300(alum)+3 (poly) ppm. TSS was reduced from 500 to 160 ppm.

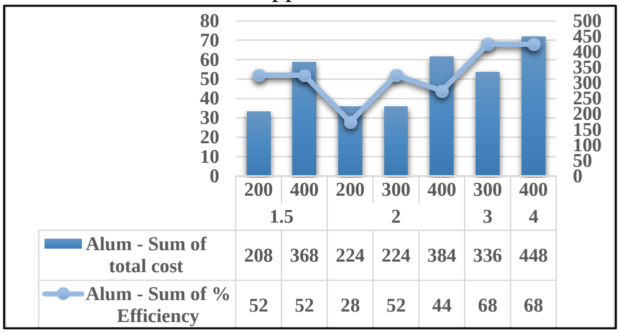


Fig 1. Alum+polyelectrolyte result and cost chart

b. PAC+ Polyelectrolyte

Optimum dose was 250(PAC)+1.5(poly) ppm. TSS was reduced from 500 to 120 ppm. An enhanced dose was also tried i.e.450 (PAC)+3.0(poly)for reduction of turbidity also. 84% TSS reduction was observed.

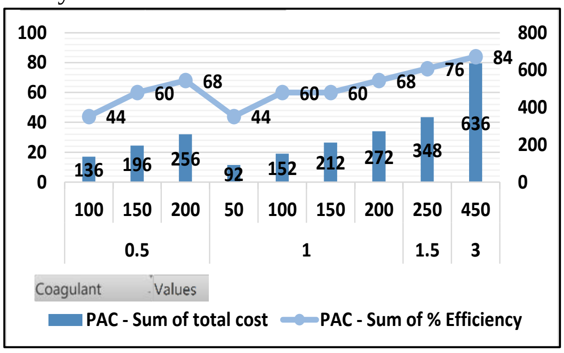


Fig 2. PAC+polyelectrolyte result and cost chart

B. COAGULATION AND FLOCCULATION WITH PRETREATMENT

a. Bentonite clay+*PAC+polyelectrolyte*

Optimum dose was 150(clay)+300(PAC)+1.5(poly) ppm. TSS was reduced from 500 to 80 ppm.

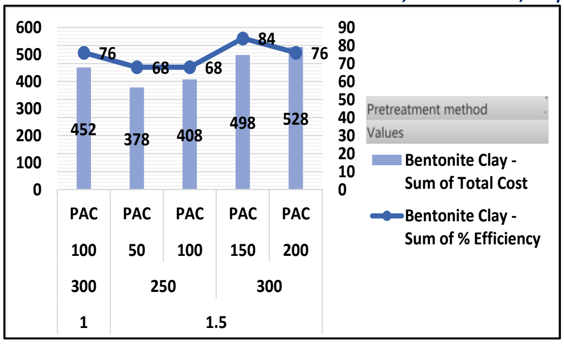


Fig 3. **Bentonite clay+*PAC+polyelectrolyte result and cost chart***

b. ***Lime+PAC+polyelectrolyte***

Optimum dose was 350(Lime)+300(PAC)+2.0(poly) ppm. TSS was reduced from 500 to 80 ppm.

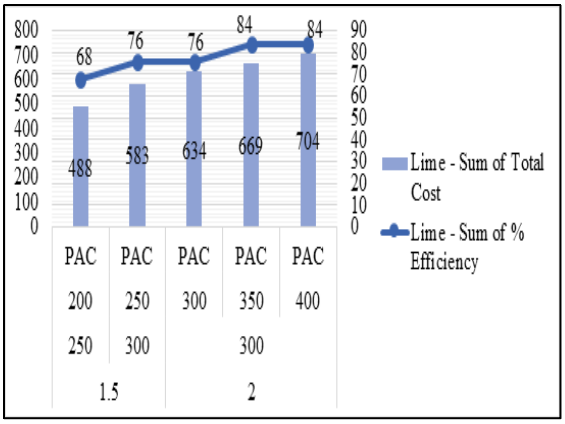


Fig 4. **Lime+*PAC+polyelectrolyte result and cost chart***

c. ***Lime+alum+polyelectrolyte***

Optimum dose was 325(lime)+300(alum)+3.0(poly) ppm. TSS was reduced from 500 to 80 ppm.

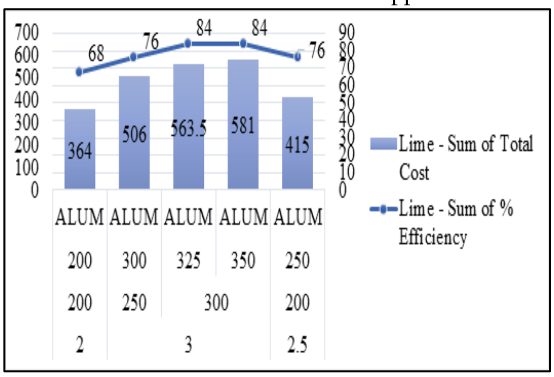


Fig 5. **Lime+alum+*polyelectrolyte result and cost chart***

d. ***Powdered activated carbon+PAC+polyelectrolyte***

Optimum dose was 30(powdered activated carbon)+300(PAC)+3.0(poly) ppm. TSS was reduced from 500 to 80 ppm.

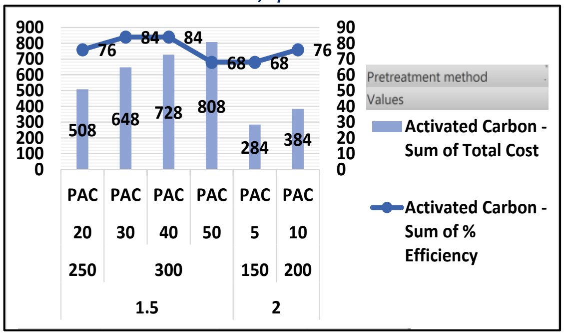


Fig 6. Powdered activated carbon+PAC+polyelectrolyte result and cost chart

C. BALLASTED FLOCCULATION

a. FeCl3+polyelectrolyte+microsand

Optimum dose was 30(FeCl3)+2.0(poly)+ 40(microsand)ppm. TSS was reduced from 500 to 80 ppm.

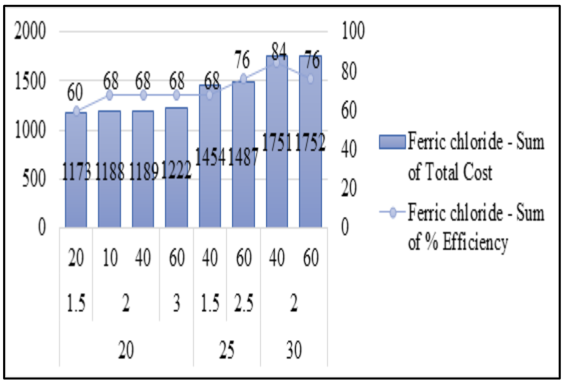


Fig 7. FeCl3+polyelectrolyte+microsand Result and cost chart

b. PAC+polyelectrolyte+microsand

Optimum dose was 300(PAC)+2.0(poly)+ 40(microsand)ppm. TSS was reduced from 500 to 80 ppm.

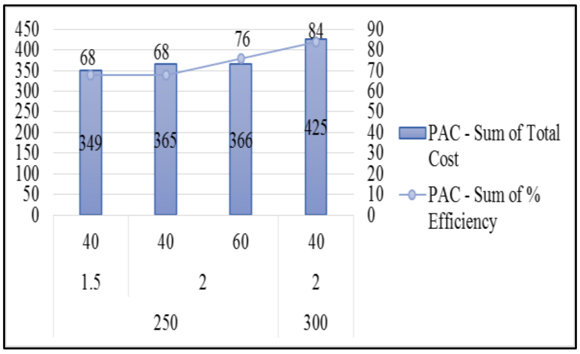


Fig8.. PAC+polyelectrolyte+microsand result and cost chart

D. SAMPLE COST CALCULATION:

For Lime+PAC+Polyelectrolyte (Optimum Dose)

Pretreatment/coagulant	Dose (ppm)	Dose (kg) for 100 kl/day	Rate (Rs/kg)	Cost per day (Rs.)
Lime	350	35	7	245
PAC	300	30	12	360
Polyelectrolyte	2	0.2	320	64
Total cost				669

Table 2. Sample cost calculation

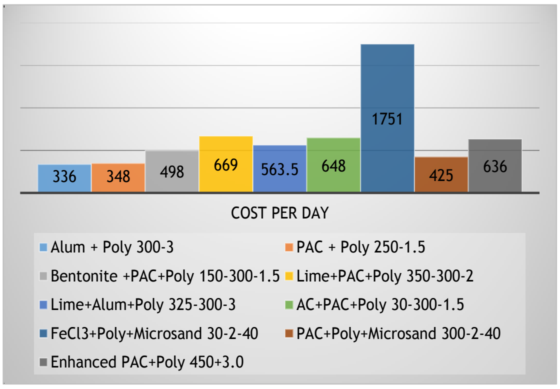
VI. SUMMARY

A. TSS AND TURBIDITY SUMMARY:

Initial TSS – 500 ppm

Treatment	Final TSS (ppm)	Turbidity (NTU)	% TSS Reduction
Alum+poly	160	64	68
PAC+poly	120	37	76
Enhanced PAC +poly (450+3.0)ppm	80	20	84
Clay+PAC+poly	80	35	84
Lime+alum+poly	80	37	84
Lime+PAC+poly	80	37	84
AC+PAC+poly	80	25	84
FeCl3+poly+microsand	80	38	84
PAC+poly+microsand	80	38	84

B. COST SUMMARY OF ALL METHODS:



Enhanced coagulation, in which PAC (450)ppm+(3.0)polyelectrolyte ppm was adopted at plant level looking to the feasibility in mixing, operation and TSS reduction. The coagulants were mixed by hydraulic mixing. Desired reduction in TSS i.e 80 ppm and turbidity 20 ppm was achieved. Though exact 50 ppm TSS was not achieved, operation of Reverse osmosis with 80 ppm is possible.

V. CONCLUSION

It can be concluded that the combination of enhanced PAC+polyelectrolyte (450+3.0) ppm was most suitable at 7.0-8.5 for TSS reduction. Reduction in turbidity was observed from 208 NTU to 20 NTU. pH was reduced to **6.9** from 8.0 which is acceptable for reverse osmosis. Under optimal conditions of process parameters, like suitable pH, coagulant dosage, agitation speed and retention time the above combination works at its best. The study also indicates that coagulation and flocculation process is vital in the overall assimilated treatment system.

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