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Optimization of Chemicals Usage-A Case Study

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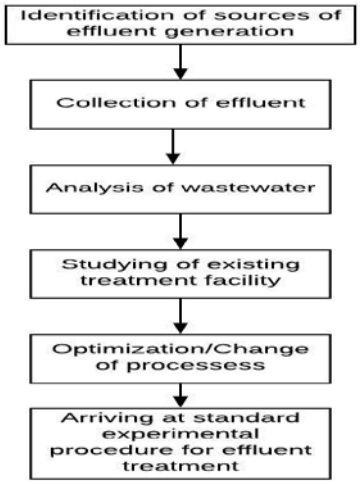
Abstract
The study deals with optimization of chemicals usage that arrived to increase efficiency of the existing treatment plant in an industry specialized in manufacturing of automotive parts. Lab scale study are performed to arrive at optimal pH, dosage of alum, lime and polyelectrolyte for the taken concentration and implemented in the Plant operation. Thus, this method reduces quantity and cost of the chemicals used.
Keywords: *Optimization, Chemical usage.*

1. Introduction

The treatment of wastewater includes various physical and chemical units. The chemicals used are sizable in accordance to the cost. Various challenges arise regarding settling time, chemical dosing rate and pH. Chemical optimization means usage of chemical in exact extent to obtain required output. The chemical optimization ensures the amount of chemicals to be applied to run the plant safely. This also reduces production of sludge disposal cost, chemical cost and ensures regulatory compliance. By adopting optimization some dependent parameters almost constant reduction in the independent parameters can be expected.

2. Methodology



Identification of sources of effluent generation
Sources of effluent generation are; disposed coolant from different machineries; grinding, Milling, Hardening, Drilling, Turning machines and Bin Washing operations. Used oil from Broaching, Shaving, Honing, Annealing operations, Floor wash water that includes spilled oil, coolant and grease.

Collection of Effluent
Different types of coolants, oil and wash water are collected in a large tank of capacity 20kld.

Analysis of wastewater
Various parameters of the wastewater generated are analyzed that includes; Chemical oxygen demand, Total Suspended solids, Total dissolved solids, pH, Oil and grease. Various ranges of influent parameters are listed below.

Table 1- Observed range of parameters of influent waste water

Parameters	BOD	COD	TDS	TSS	Oil and grease
Effluent Characteristics	450-2500	10000-110000	350-3500	600-6500	800-4000

All parameters are in mg/ltr.

Study on existing treatment facility

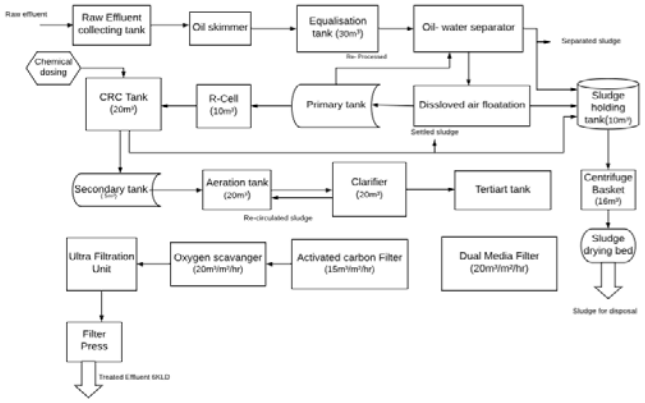


Fig. 1 Flowchart representing the existing treatment plant

The above flow chart shows the effluent treatment plant. here, the effluent is passed through the oil skimmer, then through equalization tank where alum is dosed in the flow to the oil-water separator. Diffused air floatation unit removes solids, oil and grease. then a batch of effluent is passed through R-Cell where Electro-coagulation system diminishes the odor, emulsified oil; chemical reaction chamber further reduces solids and thus turbidity minimizes at optimal pH by coagulation and flocculation method using lime(hydrated lime), alum(aluminum sulphate) and poly acrylic as polyelectrolyte. Aeration tank with 12hr of retention reduces COD based on added supplemental BOD. Further plant is facilitated with filters to reduce the solids. Treated effluent is used for gardening.

Optimization/Change of processes

In above shown units; the chemicals are dosed at two units; one in the flow between equalization tank and oil-water separator, second one in the chemical reaction chamber. In present system chemical dosage is not appropriate with respect to the influent characteristics. Thus, chemical dosage can be varied according to it. .

Methods-The method adopted to determine total dissolved solids and pH is through meter. Total suspended solids and oil- grease are analyzed by gravimetric method. Chemical oxygen demand is determined through closed reflux arc method; colorimetric analysis. (IS5220).

a. Alum dosage at the flow between equalization tank and oil-water separator;

About 100ml of sample is taken for analysis. Depending on the effluent oil and grease the concentration of the alum to be added is be varied. A stock solution known alum solution is prepared that is used constantly in the treatment plant. This alum solution is added in the volume basis like 1ml, 2ml, 3ml, 4ml and so on until a maximum removal of oil and grease is achieved .Settling time of 1 hour is given in bench scale. Alum has its capacity to reduce the pH, for the incoming effluent the pH is reduced from 6.85-7.3 to 4.

b. Lime and alum dosage for effluent passed from R-Cell to chemical reaction chamber;

Initially sample of pH 6.89 with Total dissolved solids 1200mg/ltr. About seven samples of 100ml volume is taken for analysis. Irrespective of the influent characteristics except pH are neglected. Based on the pH of influent water 1% (1g in 100ml of water) lime is dosed. A constant volume of 1% (1g in 100ml of water) alum is dosed. About 0.1 ml of polyelectrolyte is added. At a particular range of pH, turbidity is less and a fluffy sludge is produced. Settling time of about 1hr is given. thus, pH is optimized.

Roughly the dosing started from 50mg of lime diluted in 4ml of water. then increasing the concentration of lime, similarly the alum is added in increasing concentration from 22mg diluted to 1ml.then constant concentration of 1ml of polyelectrolyte is dosed. Settling time of about 1hr is given. Lime is used as a coagulant aid. The sample shows decreased value in various parameters but, in study Chemical oxygen demand is taken as reference; as reduction in solids and oil-grease reduces Chemical oxygen demand.

Fig. 2. Settling in process after addition of chemicals.

Standardization of experimental procedure

Optimal pH is based on concentration of chemicals dosed. At constant concentration the pH remains same.

For the present concentrations of lime, alum and polyelectrolyte the optimal pH is to be maintained at 9.5 to 12 on addition of lime; alum and Polyelectrolyte are active at neutral pH (6.5 -8).

Alum addition to equalization tank effluent is active at 4 for the taken concentration.

a. Excessive alum induces turbidity, less dosing is inefficient in removal of solids and oil-grease. Hence, an optimal dosage is required to increase the efficiency at the flow of effluent to oil-water separator.

b. Excess lime dosage vary the pH and mainly lime undergoes batch settling hence, when excess lime is dosed, itself settles more. Alum when dosed insufficiently do not reduce turbidity, increased dose increase turbidity.

3. Results and Discussions

a. Alum dosage

The variation in the oil and grease of influent wastewater is shown below; the corresponding dosage of alum of concentration 12500mg/ltr for the incoming oil and grease is found(volume of sample is 100ml).The Reduced oil and grease is tabulated for Retention time of 1 hour. Effluent in the equalization tank are diluted with backwash water of filters.

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Table 2- Effect of alum dosage on influent oil and grease

Oil and Grease (mg/ltr)	*Alum Dosage (ml)*	*Oil and Grease (mg/ltr)*
330	0.3	130
524	0.7	240
609	0.9	310
810	1.2	450
920	1.5	560
967.7	1.7	580
1100	2	585
1750	2.5	810
2000	2.8	980
3900	3.5	1200
4800	5	1500
5550	6.3	1740

In present system 6ltr/hr of alum is dosed for batch volume of 4kl-5kl of influent water. But, when the oil and grease of influent water is altered a variation in the dosing is to be done.

Alum is found effective at pH 4; thus, the reduction of oil and grease also depends on the pH of influent waste water. If pH increase or decreases around 4 the efficiency of alum decreases.

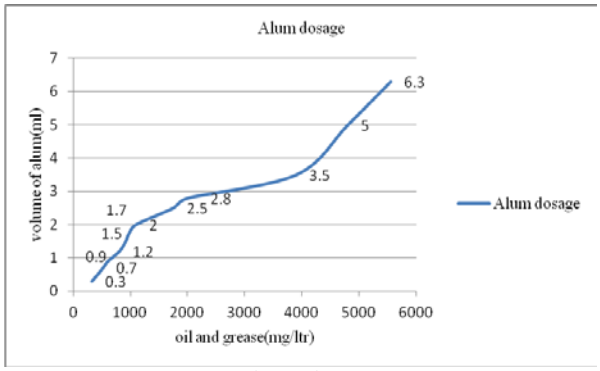

Fig. 3 Volume of alum for various oil and grease

b. Dosing of lime, alum and polyelectrolyte

Table 3: Reduction of total dissolved solids at particulr pH

pH	*Total Dissolved Solids(mg/ltr)*
8	910
9	780
10	570
10.5	585
11	600
11.5	610
12	625
13	1280
14	1300

In present study the pH range arrived to be 9.5 to 12. It is clear from above table, there is a constant reduction of total dissolved solids from above pH 10-12. Hence lime dosage is carried until pH increases to optimal value that induces settling at constant alum dosing the settling time given here was one hour. Sometimes with increased settling time, more settling happens.

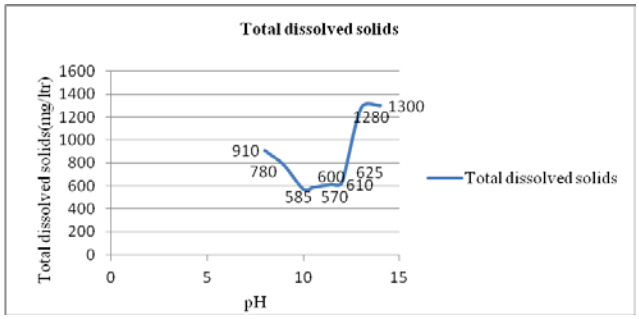

Fig. 4 Representation of reduction of total dissolved solids at varying pH

The following table shows the influent COD. Various samples of 100ml dosed with lime, alum and polyelectrolyte. Accordingly, the lime and alum to be added for the taken 100ml of R-Cell outlet. The concentration of lime added is 12500mg/ltr, alum added is 22222.2mg/ltr and polyelectrolyte of 2000mg/ltr. R-Cell influent has COD of range 2500mg/ltr to 6000mg/ltr.

Table 4: Variation of COD for Optimal Dosage of Lime and Alum

COD(mg/ltr)	*Lime volume (ml)*	*Alum (ml)*	*Reduced COD (mg/ltr)*
5300	10	4.5	3917
5164	9	3.5	3874
4600	6	2	3824
3816	5	1	1800

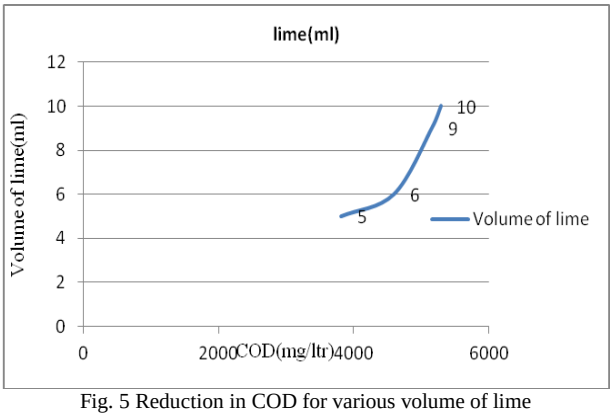

Fig. 5 Reduction in COD for various volume of lime

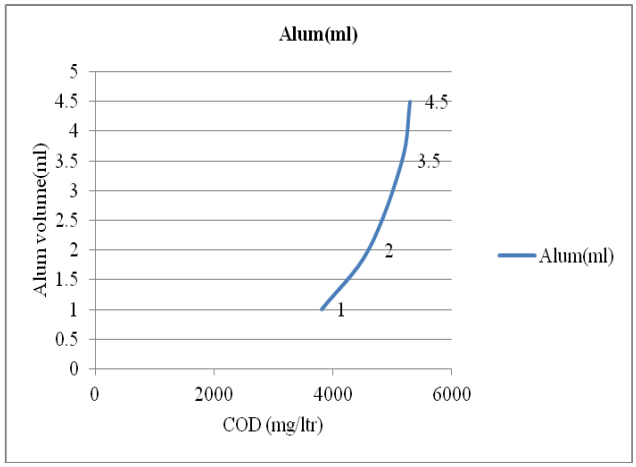

Fig.6. Reduction in COD for various volume of alum

4. Conclusions

Based on the study, the following conclusions are drawn:

Alum when dosed in an optimal volume of taken concentration removes oil and grease. Present dosage of 6lph is insufficient for higher concentration of oil and grease.

Optimal pH of 9.5 to 12 is required for effective settling process .same concentration of lime and alum when dose for a batch of sample of effluent with polyelectrolyte based on influent Chemical oxygen demand can induce maximum settling with maximum reduction in Chemical oxygen demand. Increase lime and alum dosing induces additional turbidity. It works effectively for plant operation for output from R-Cell; the flow to Chemical reaction chamber is about 4500ltrs.The volume of dosing when projected is found effective in reduction of COD.

Optimization thus reduces the plant operational cost by reducing sludge generation, cost of chemicals, and cost of disposal of sludge.

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