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Waste Water Treatment by Coagulation and Flocculation

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Abstract: All waters, especially surface waters, contain both dissolved and suspended particles. Coagulation and flocculation processes are used to separate the suspended solids portion from the water. The suspended particles vary considerably in source, composition charge, particle size, shape, and density. Correct application of coagulation and flocculation processes and selection of the coagulants depend upon understanding the interaction between these factors. The small particles are stabilized (kept in suspension) by the action of physical forces on the particles themselves. One of the forces playing a dominant role in stabilization results from the surface charge present on the particles. Most solids suspended in water possess a negative charge and, since they have the same type of surface charge, repel each other when they come close together. Therefore, they will remain in suspension rather than clump together and settle out of the water. The present study aims to treat a sample of sea water for the removal of impurities by various coagulants such as Alum, Ferric Chloride and Ferrous Sulphate. The treatment efficiencies of coagulants have been compared for maximum removal of impurities under optimum pH and optimum dosage of coagulant. The optimum pH and dosage were observed to be 7.0 and 120 mg/L respectively.

Index terms **– Coagulation, waste water, coagulant, optimization.**

I. INTRODUCTION

Groundwater and surface water contain both dissolved and suspended particles. Coagulation and flocculation are used to separate the suspended solids portion from the water. Suspended particles vary in source, charge, particle size, shape, and density. Correct application of coagulation and flocculation depends upon these factors. Suspended solids in water have a negative charge and since they have the same type of surface charge, they repel each other when they come close together. Therefore, suspended solids will remain in suspension and will not clump together and settle out of the water, unless proper coagulation and flocculation is used.

Coagulation and flocculation occurs in successive steps, allowing particle collision and growth of floc. This is then followed by sedimentation. If coagulation is incomplete, flocculation step will be unsuccessful, and if flocculation is incomplete, sedimentation will be unsuccessful. Flocculation, a gentle mixing stage, increases the particle size from submicroscopic microfloc to visible suspended particles. Microfloc particles collide, causing them to bond to produce larger, visible flocs called pinflocs. Floc size continues to build with additional collisions and interaction with added inorganic polymers (coagulant) or organic polymers. Macroflocs are formed and high molecular weight polymers, called coagulant aids, may be added to help bridge, bind, and strengthen the floc, add weight, and increase settling rate. Once floc has reached it optimum size and strength, water is ready for sedimentation. The use of Almonds to clarify water was in practice in the early years of 2000 BC by the Egyptians and the usage of Alum was noticed by early Romans even though it was not specifically used for waste water treatment [1].

Coagulant chemicals with charges opposite those of the suspended solids are added to the water to neutralize the negative charges on non-settlable solids (such as clay and color-producing organic substances). Once the charge is neutralized, the small suspended particles are capable of sticking together. These slightly larger particles are called microflocs, and are not visible to the naked eye. Water surrounding the newly formed microflocs should be clear. If not, coagulation and some of the particles charge have not been neutralized. More coagulant chemicals may need to be added.

Wastewaters often contain pollutants that are present is colloidal form. In such cases the colloidal suspension may contain organic materials, metal oxides, insoluble toxic compounds, stable emulsions and material producing turbidity. The primary purpose of the coagulation/flocculation process is the removal of turbidity from the water. The chemical and electrical means of water and waste water treatment was achieved by using coagulation as the most important physicochemical operation [2].

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In addition to removing turbidity from the water, coagulation and flocculation is beneficial in other ways. The process removes many bacteria which are suspended in the water and can be used to remove color from the water. Turbidity and color are much more common in surface water than in groundwater. As surface water flows over the ground to streams, through streams, and then through rivers, the water picks up a large quantity of particles. As a result, while aeration is more commonly required for groundwater, treatment involving coagulation and flocculation is typical of surface water.

The mechanism of Brownian movement in water where there is a repulsion of negatively charged surfaces to form a stable dispersed suspension was reported [3]. The commonly used metal coagulants fall into two general categories: those based on aluminum and those based on iron. This paper deals with the aluminum based coagulants, The most widely used metal coagulant is probably the aluminum sulfate ("alum"), which has been used for water treatment during the past decades The application of simple metal coagulants (conventional) is widespread, especially due to the relatively low cost and the simpler application route. However, they exhibit several disadvantages, such as the need for pH adjustment before or after treatment, the sensitivity to temperature changes, the need for higher dosages because the charge neutralization is not usually sufficient, the sensitivity to sample specific characteristics and composition, as well as the excessive sludge production. The work on flocculation reported that the agglomeration of colloidal particles bridge together to form microflocs which turned into visible floc masses [4].

II. MATERIALS AND METHODS

The jar test procedures was adopted during the present study which involved the following steps: Each beaker contained 500mL of river water. After adding appropriate volume of the alum solution, the water was mixed at 160 rpm for 2 min, 70 rpm for 15 min, 30 rpm for 35 min and settled for 2 hours. Then the top layer of water in each beaker was collected with a Pasteur pipette and measured in terms of absorbance, turbidly and pH.

Fig 1. Jar Test Equipment

The jar testing apparatus containers were filled with sample water. One container was used as a control while the other 5 containers were adjusted depending on what conditions are being tested. The pH of the jars were adjusted at different pHs between 5.0 and 7.5 with sulfuric acid 1N. The Turbidity values were measured against each pH and the optimum pH was noted.

The coagulant dosage ranging from 40mg/L to 180 mg/L was added to each container and stirred at approximately 100 rpm for 1 minute. The rapid mix stage helped to disperse the coagulant throughout each

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container. The mixers were turned off and allowed the containers to settle for 30 to 45 minutes. Then the final turbidity in each container was measured. The stirring speed was reduced to 25 to 35 rpm and continued mixing for 15 to 20 minutes. This slower mixing speed helped promote floc formation by enhancing particle collisions which led to larger flocs.

Residual turbidity vs. coagulant dose was then plotted and optimal conditions were determined. The values that were obtained through the experiment were correlated and adjusted in order to account for the actual treatment system. The equipment used for Jar test is shown in figure 1.The water was obtained from sea water near salalah. The coagulant we chose is aluminum sulfate octadecahydrate ($Al_2(SO4)_3.18H_2O$). The stock solution was 10 mg/mL and different alum dosage was prepared.

III. RESULTS AND DISCUSSION

The characteristic properties of waste water sample was shown in table-1. The waste water is alkaline with brown colour having high BOD, COD, and turbidity values which needs to be treated before being discharged. It was reported that the neutralization of the electrical charges of particles into the water which causes the particles to clump together [5]. The waste water sample has been treated with different concentrations of alum ranging between 0 and 200 mg/L. The pH of the water has been adjusted with sulfuric acid/ lime from 5.0 to 8.0 to obtain the optimum pH. The optimization of pH was shown in table 2 and it was observed that the optimum pH was 7.0 as shown in figure 2.

Table 3 shows the optimization of Alum dosage and this was done with different dosage of Alum from 60 mg/l to 180 mg/L. It was observed that the optimum dosage of Alum was noted to be 120 mg/L as shown in figure 3. The absorbance (at 254 nm) and the final turbidity have been measured and then, have been plotted as a function of the alum concentration as shown in figure 4. This experiment has only been done for the river water with the optimal concentration of 120 mg/L of alum. We can see on those graphs that the pH which allows the best either color and turbidity removal is around 7.0. At this pH the color removal is more than 76% when the turbidity removal is around 80 %.

Table 1 Characteristics of Tannery waste water

S.No.	Parameter	Values
1	pH	7.6
2	Colour	Dark brown
3	Turbidity	140 NTU
4	Total Suspended solids	1040
5	Alkalinity	2450
6	BOD	1520
7	COD	3640
8	Sulphide	210
9	Total Nitrogen	257
10	Ammonical Nitrogen	85
11	Total Chromium	10.0
12	Total Phosphate	16
13	Total Kjeldahl Nitrogen	144

Except pH and turbidity all the values are in mg/L

Table 2 Optimization of pH

S.No.	pH	Turbidity (BTU)
1	5.0	13.4
2	5.5	9.8
3	6.0	7.0
4	6.5	6.1
5	7.0	5.7
6	7.5	6.4
7	8.0	8.0

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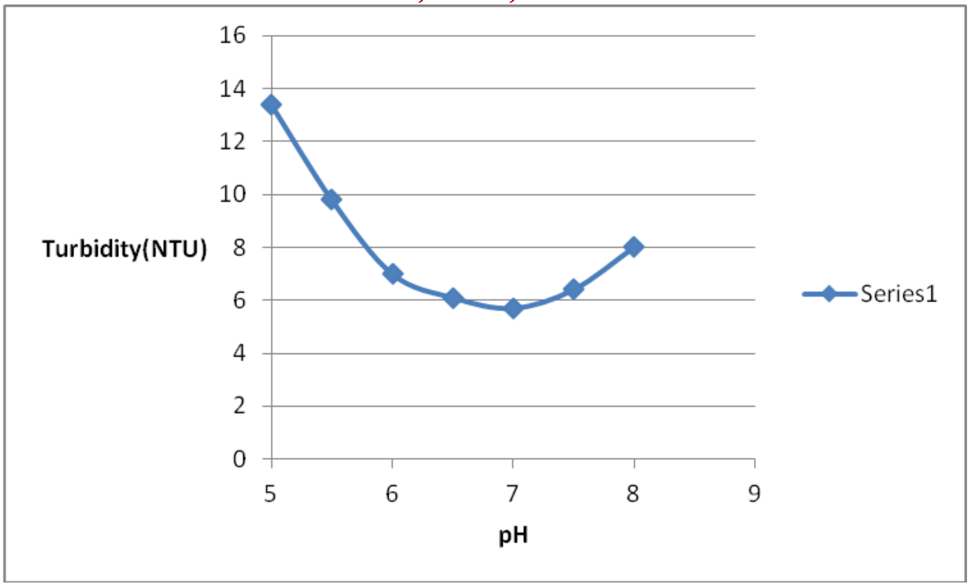

Fig. 2 pH Optimization

Table 3 Optimization of dosage

S.No.	Dosage(mg/L)	Turbidity(NTU)
1	60.0	10.2
2	80.0	8.0
3	100.0	6.3
4	120.0	5.4
5	140.0	6.0
6	160.0 `	6.9
7	180.0	8.7

This experiment has only been done for the river water with the optimal concentration of 120 mg/L of alum. Since we want to use the fewer amounts of alum as possible (for economic reasons) and the best efficiency as possible we decided to use the alum concentration of 120mg/L.Table 4. The treatment efficiency of various coagulants at their optimum pH is represented in table 5. The purpose of adding coagulant aids was repotted to increase the density to slow-settling flocs and toughness to the flocs so that they will not break up during the mixing and settling processes [6]. Several studies have been reported on the examination of coagulation–flocculation for the treatment of industrial waste-water treatment, aiming at performance optimization, i.e. selection of the most appropriate coagulant, determination of experimental conditions, and assessment of pH effect and investigation of flocculants addition. Early studies on coagulation indicated that the Dissolved organic can be removed by adsorption on aluminum precipitation [7]. Literature indicated that the mechanism of coagulation for aluminum salts is controlled by the hydrolysis speciation [8]. It was observed from the table that Alum was found to be more efficient than Ferric Chloride and Ferrous Sulphate for the same sample under the same experimental conditions. Organic removal increased with an increasing alum dose and alum doses higher than the normally used for turbidity removal, are needed to obtain the best organic removal [9].

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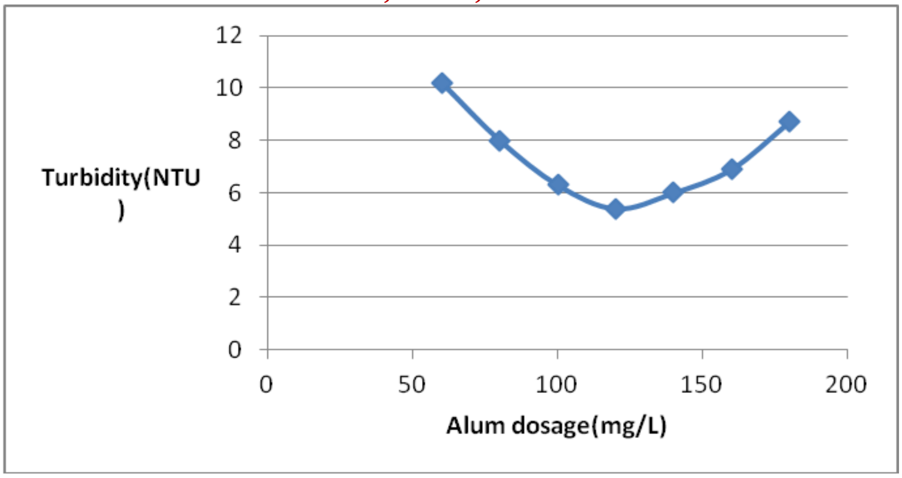

Fig 3. Dosage Optimization

Table – 4 Absorbance and Turbidity

S.No.	pH	Absorbance	Turbidity(NTU)
1	4.0	0.40	16.0
2	4.5	0.31	14.2
3	5.0	0.23	13.4
4	5.5	0.11	9.8
5	6.0	0.06	7.0
6	6.5	0.07	6.1
7	7.0	0.07	5.7

Table 5 Treatment efficiency

Coagulant	optimum dosage	optimum pH	% Removal efficiency
Alum	2 g	6.7	98.9
Ferric Chloride	2g	6.9	97.0
Ferrous Sulphate	2g	7.3	96.6

IV. CONCLUSION

- The optimum pH based on turbidity was observed to be 7.0 for the sample of sea water.
- The optimum coagulant dosage based on turbidity measurement was found to be 120 mg/L.
- Alum was found to be more efficient with removal percentage of 98.9 under optimum conditions.

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