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The Efficiency and Application of Sole Coagulant and Combined Coagulants in Treating the Soap Wastewater

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Abstract

This paper is intended to give a broader understanding on the efficiency and application of sole coagulant and combined coagulants in treating the soap wastewater. Chemical pre-treatment in soap wastewater is common for improving the performance of primary settling facilities. In this experiment inorganic coagulant like alum, chitosan self and alum/chitosan blend were used at different pH for the treatment of soap wastewater by coagulant process and comparison has made between them in terms of performance. Jar test method has been used to identify the best selection of coagulant or combined coagulants in removing the organic matters. Measurement of turbidity, total suspended solid (TSS) and chemical oxygen demand (COD) were the parameters to justify the effectiveness of chemical pre-treatment on soap wastewater. The effect of coagulant aid in this experiment was also observed, where it would help in the effectiveness of coagulation process. Optimization of pH and dosage for coagulants were observed to ensure the optimum condition for the chemical per-treatment of soap wastewater.

Keywords: Coagulant; soap wastewater; alum/chitosan; wastewater treatment.

1. Introduction

The objective of wastewater treatment system is mainly to remove the unwanted and harmful impurities from discharging directly to the waterway. It is also aimed to improve the natural characteristic of water or wastewater by using physical, chemical, biological of them [1]. Only 1% of the total water resources in the world can be considered as fresh water and by 2025 it is estimated that nearly one-third of the population of developing countries, will live in regions of severe water scarcity [7]. As a result, the amount of water used in irrigation has to be reduced, in order for the domestic, industrial and environmental sector to survive [2]. Additionally, human interference causes water pollution, e.g. by industrial effluents, agricultural pollution or domestic sewage, which will increase. As a result the world's primary water supply will need to increase by 41% to meet the needs of all sectors which will be largely due to the increase in the world population [2]. Water reuse and recycling are the only solutions to close the loop between water supply and wastewater disposal. Within the past years, the cost of treating wastewater to a high quality has reduced to feasible [8]. Consequently, in many parts of the world reclaimed water is used as a water resource. Hence, wastewater could be regarded as a resource that could be put to beneficial use rather than wasted [3]. One of the major challenges facing humankind today is to provide clean water to a vast majority of the population around the world [7]. The need for clean water is particularly critical in Third-World Countries. Rivers, canals, estuaries and other water-bodies are being constantly polluted due to indiscriminate discharge of industrial effluents as well as other anthropogenic activities and

natural processes [8].
Highly developed countries, such as the US, are also experiencing a critical need for wastewater cleaning because of an ever-increasing population, urbanization and climatic changes [1]. Of course, the limitation on single process treatment to soap wastewater, the modification on wastewater treatment plant is necessary needed [4]. A solution will be study to treat the soap wastewater by using coagulation and flocculation processes. Coagulation and flocculation as a simple chemical treatment permit removal of organic colloids [1] .Coagulation is a term used to describe the process of aggregation of colloidal particles into large aggregates. Aggregation of particles occurs by two distinct mechanisms: particle transport to affect inter-particle contact, and particle destabilization to permit attachment when contact occurs. The effective of coagulation process is using alum, and lime as coagulants. Effective flocculants are usually linear polymers, which may be anionic in character [5]. Chemical treatment has the advantage that the result can usually be seen quickly and the amount of reagent adjusted to minimize costs. Moreover, chemical treatment plants always take less space than biological plants [6]. The coagulation and flocculation processes typically include the following four steps [5].

2. Material and Methods

The research experimental work designed to study the chemical formulation for the pre-treatment of soap wastewater. Overall work plan is given in Figure 2.1. At the first phase of the work, water was collected from the pit and needs to be cooled to room temperature before carrying out the characteristic test. Jar tests are than carried out in two categories, i.e. soap wastewater treated with a sole coagulant and flocculent and soap wastewater treated with combined coagulants and flocculent. Turbidity, chemical oxygen demand and total suspended solid are done to verify the efficiency of the jar test for chemical pre-treatment of soap wastewater. Finally, the optimization of the chemical dosage and operating condition are analyzed based on the best removal percentage oxygen demand.

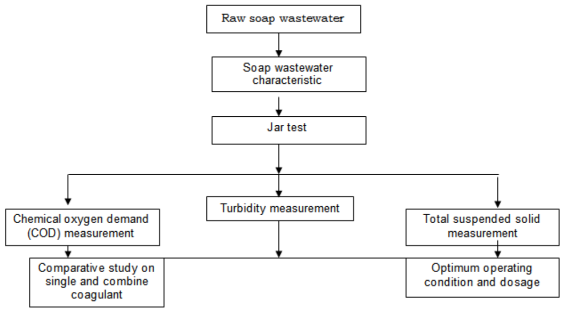

Figure 2.1: Overall work plan.

Table 3.1: Characteristic of Raw soap wastewater (average value).

Characteristics	Plant values
pH	8.21
Chemical oxygen demand (COD), mg/L	1450
Total suspended sSolid (TSS), mg/L)	860
Turbidity (NTU)	280

3. Results and Discussion

The general characteristics of soap wastewater were taken from the soap plant in Table 3.1. Soap wastewater was collected from the pit pond at the average temperature of 80 °C.
The experimental results obtained in this paper are presented in this section. In general, three phases of experiments were performed. In the first phase, jar test were conducted using a dosages of alum or chitosan with range from 25 mg/L to 300 mg/L for chitosan and 100 mg/L to 1000 mg/L for Alum dosage and initial pH. The results of these jar test were used to delineate the experimental condition, which affect the coagulation and flocculation processes. Than, a set of pH and dosage experiments for the different coagulant concentrations were selected. The performance for the coagulation and flocculation processes of particles before and at the end of the jar tests would be evaluated by measuring supernatant turbidity, chemical oxygen demand (COD), and total suspended solids (TSS) values of the soap wastewater. The second phase of the experiment was the coagulation and flocculation of soap wastewater to received the best range of the pH. The dosage for both of them was based on the result

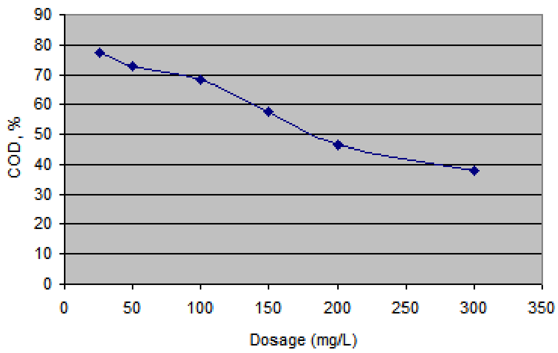

Figure 3.1: COD removal efficiency by chitosan with different dosage at initial pH (8.21).

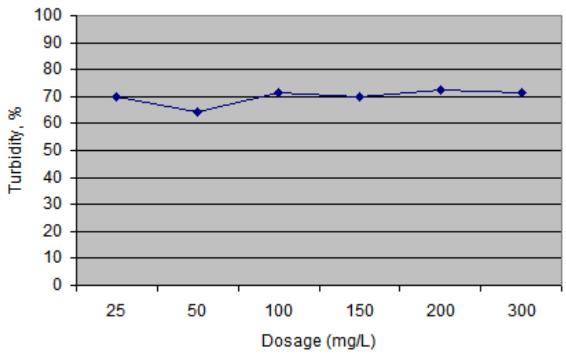

Figure 3.2: Turbidity removal efficiency by chitosan with different dosage at initial pH (8.21).

obtained from phase one mentioned. The selected result obtained from the phase one and two would then evaluated using two-type combinations of chemical used as coagulants and flocculent (Alum and chitosan) with specific pH were obtained from the phase two to get the best dosage of them to treated the soap wastewater.

3.1. Effect of COD removal efficiency

The removal of the COD at different range with the initial pH is show in Figure 3.1. Chitosan dosage at 25 mg/L produces the best reduction in COD, Turbidity and TSS removal efficiency either at initial pH. Approximately 77.46% of COD reduced, but if we increase the dosage of chitosan the removal of COD were decrease because its may be dissolution of chitosan in solvent at initial pH.

3.2. Effect of turbidity removal efficiency

Figure 3.2 shows that chitosan concentration at 25 mg/L produce the best reduction in turbidity removals efficiency either at the initial pH. Approximate 73.78 % of the turbidity has been reduced, respectively. Figure 3.2 also shows that the turbidity removal efficiency for 300 mg/L was slightly higher compared to the 25 mg/L. There were some tiny flocs observed on the surface of the supernatant Jar test after settling for one hour.

3.3. Effect of TSS removal efficiency

Figure 3.3 shows the effect of total suspended solid (TSS) removal efficiency of soap wastewater by chitosan as the sole coagulant. That chitosan

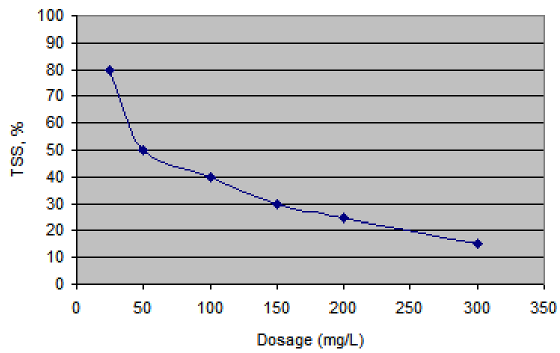

Figure 3.3: TSS removal efficiency by chitosan with different dosage at initial pH (8.21).

dosage 25 mg/L produces the best TSS removals efficiency at the initial pH. It is approximate 80% removal of TSS also shows that the lower TSS removals at 300 mg/L it was 15%.
A summary of the results when chitosan was used to treated the soap wastewater in the dosage of 25 mg/l can remove 73.78% of turbidity, 77.46 % of chemical oxygen demand (COD) and 80% of total suspended solids (TSS) in the condition of neutral pH that means the 25 mg/L of Chitosan is the best dosage that can be used to adjust the pH. The increase of chitosan did not increase but decrease the removal efficiency. This is because the removal colloids by chitosan can forms to the mechanism of bridging of polymers. When the polynculear polymers adsorb onto the active sites on the surface of colloids it will destabilize the colloids to form large particles. If the chitosan overdosed the active sites on colloid, so the colloid restabilized and the removal rate will be de-

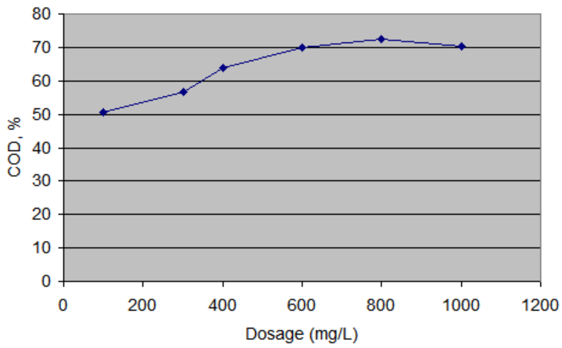

Figure 3.4: COD removal efficiency by Alum with different dosage at initial pH (8.21).

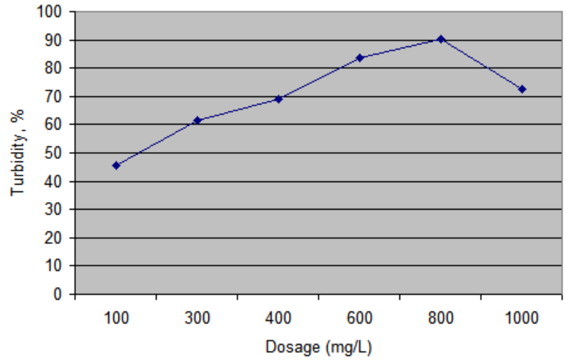

Figure 3.5: Turbidity removal efficiency by Alum with different dosage at initial pH (8.21).

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3.4. Using Alum as a sole coagulant and initial pH

Alum was used with dosage from 100 mg/L to 1000 mg/L. During the Jar tests the dosage added to the six beakers containing 1000 ml for each beaker. After settled, the reduction in residual chemical oxygen demand (COD), turbidity and total suspended solid (TSS) were measured.

3.5. Effect of COD removal efficiency

The removal of the COD at different range of Alum dosages with the initial pH is show in Figure 3.4. Alum dosage at 800 mg/L produces the best reduction in COD at initial pH. Approximately 72.62% of COD reduced. From the graph, there are quite similar removal efficiencies for dosage from 600 mg/L to 1000 mg/L.

3.6. Effect of turbidity removal efficiency

Figure 3.5 shows that Alum dosage of 800 mg/L produce the best reduction in turbidity removals efficiency either at the initial pH. Approximate 90.37% of the turbidity has been reduced, respectively. Figure 3.5 also shows that the turbidity removal efficiency for 100 mg/L was lower removal of the turbidity compared to the other dosages. There were some tiny flocs observed on the surface of the supernatant Jar test after settling for one hour.

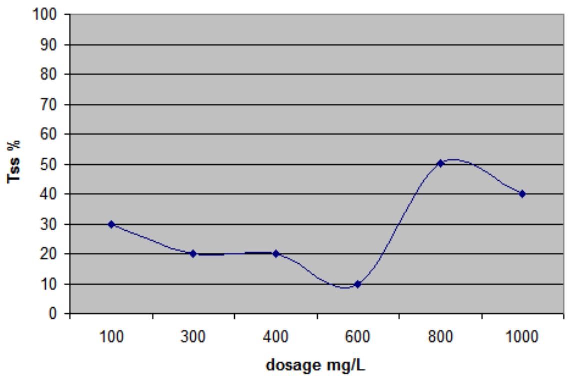

Figure 3.6: TSS removal efficiency by Alum with different dosage at initial pH (8.21).

3.7. Effect of TSS removal efficiency

The coagulation and flocculation efficiencies are expressed also in term of percentage of removal of the suspended solid. Figure 3.6 shows the That Alum dosage 800 mg/L produce the best TSS removals efficiency at the initial pH. It is approximate 50% also shows that the lower TSS removals at 600 mg/L it was 10%. A summary of the results for using alum as sole coagulant application in the pre-treatment of soap wastewater analysis for different dosages of alum shows the best dosage of alum to treat soap wastewater was 800 mg/L where it can remove 86.43% of COD, 90.37 % of turbidity and 50 % (TSS) with the initial pH.

3.8. Effect of pH using Chitosan

The results from the experiment when the Chitosan was used as the coagulant of 25 mg/L dosage

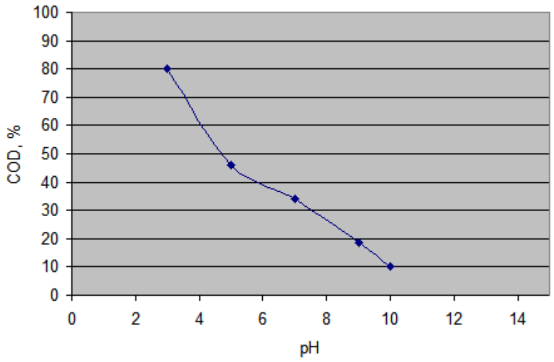

Figure 3.7: COD removal efficiency by Chitosan with 25 mg/L dosage at different pH.

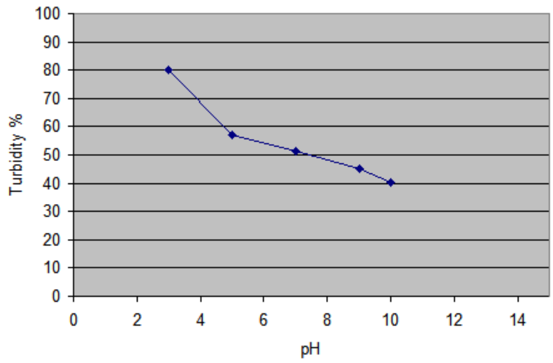

Figure 3.8: Turbidity removal efficiency by Chitosan with 25 mg/L dosage at different pH.

able to reduce the COD by 77.46% , 70% turbidity removal and the removal of TSS was 30%, means the 25 mg/L of Chitosan is the best dosage that can be used to adjust the pH. To determine the optimum pH for the 25 mg/L of chitosan, pH values ranging from 3 to 10 at fixed coagulant dose were examined.

3.8.1. COD removal for different pH

The graph in Figure 3.7 illustrates the effect of pH on the removal of COD by coagulation and flocculation using 25 mg/L of chitosan as coagulant. It showed clearly that COD removal at pH 3 gave a better result compared to the initial one. with 80% removal of the COD at pH 3.

3.8.2. Turbidity removal for different PH

Figure 3.8 shows that Chitosan at pH 3 produce the best reduction in turbidity removals efficiency more than the initial pH. Approximate 80% of the turbidity has been reduced, respectively. Figure 4.8 also shows that the turbidity removal efficiency for pH 10 was lower compared to the other pH.

3.8.3. TSS Removal for different pH

Figure 3.9 shows the effect of total suspended solid (TSS) removal efficiency of soap wastewater by 25 mg/L of chitosan as coagulant. It shows clearly that TSS removal at pH 3 was better result compared to the others. The 90% removal of the TSS at pH 3 showed a lower efficiency at pH 10.

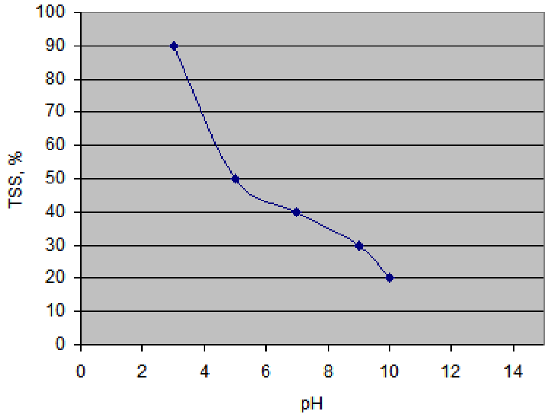

Figure 3.9: TSS removal efficiency by Chitosan with 25 mg/L dosage at different pH.

The result shows that the soap wastewater can have the best treatment efficiency at the coagulant dosage of 25 mg/L of chitosan in the pH 3. It can remove 80% of turbidity, 80 % of chemical oxygen demand (COD) and 90% of total suspended solids (TSS). The dominant mechanisms for chitosan to remove colloids in the wastewater are charge bridging and neutralization, and the later becomes less significant in the high pH. The coagulant of chitosan removed most of the colloidal form organic matter in the wastewater, but it has only little effect on the removal of dissolving organic matter. Chitosan is a natural material, Therefore, the loading to wastewater treatment plant and the cost of treatment could be reduced.

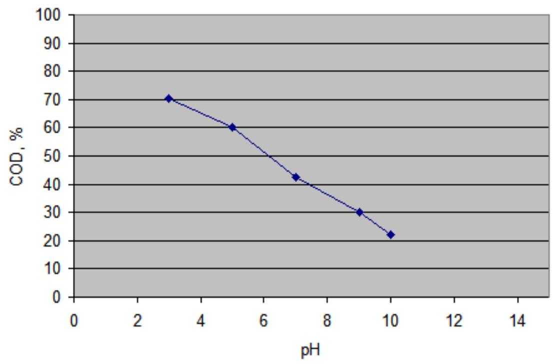

Figure 3.10: COD removal efficiency by Alum with 800 mg/L dosage at different pH.

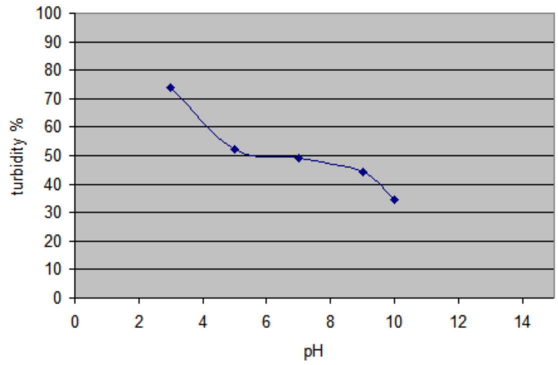

Figure 3.11: Turbidity removal efficiency by Alum with 800 mg/L dosage at different pH.

3.9. Effect of pH using Alum

The results from the experiment when the Alum is used as the coagulant of 800 mg/L dosage able to reduce the COD by 86%, 90% turbidity removal and the removal of TSS was 50% that means the 800 mg/L of Alum is the best dosage that can be used to adjust the pH . To determine the optimum pH for the 800 mg/L of Alum, pH values ranging from 3 to 10 at fixed coagulant dose were examined.

3.9.1. COD Removal for different pH

The removal of COD at fixed dosage of Alum with different pH is show in Figure 3.10. Alum dosage at pH 3 produces the best reduction in COD, where approximately 70.47 % of COD was reduced. From Figure 4.10, shows there is significant percentage of change in COD removed efficiency from Alum pH ranged 3 to 10.

3.9.2. Turbidity removal for different pH

Figure 3.11 shows that Alum dosage of 800 mg/L at pH 3 produce the best reduction in turbidity removals efficiency. Approximate 73.78 % of the turbidity has been reduced, respectively. Figure 3.11 also shows that the turbidity removal efficiency for 800 mg/L at pH 10 was lower removal of the turbidity compared to the other pH values.

3.9.3. TSS Removal for different pH

Figure 3.12 shows the effect of total suspended solid (TSS) removal efficiency of soap wastewater at Alum dosage 800, and pH 3 it produced the best TSS removals efficiency. It was approximate

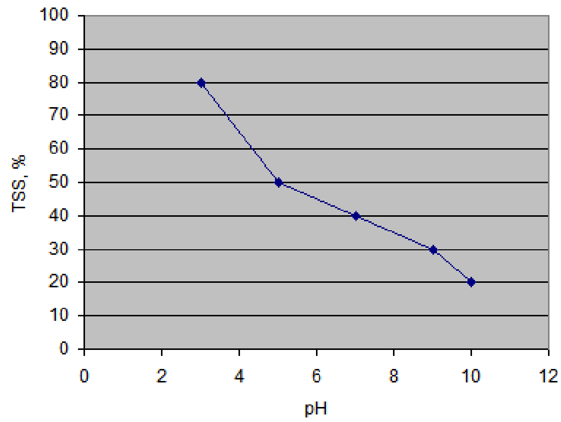

Figure 3.12: TSS removal efficiency by Alum with 800 mg/L dosage at different pH.

80 % also shows lower TSS removals at pH 10 it was 20%. Fixed dose of alum (800 mg/l). Results indicated that, at this dose, the highest achieved percent were at pH 3. Generally, treatment at pH 3 brought the levels of COD, turbidity and TSS. It removed 73.78% of turbidity, 70.47 % of chemical oxygen demand (COD) and 80% of total suspended solids (TSS).

3.10. Combined Coagulants (Chitosan and Alum)

3.10.1. Specific dosage of Chitosan with different dosages of Alum

Samples were chemically treated by coagulation in jar test experiments using 25 mg/L dosage of Chitosan with different dosages of Alum to determine the optimum dosages for both of the coagulants

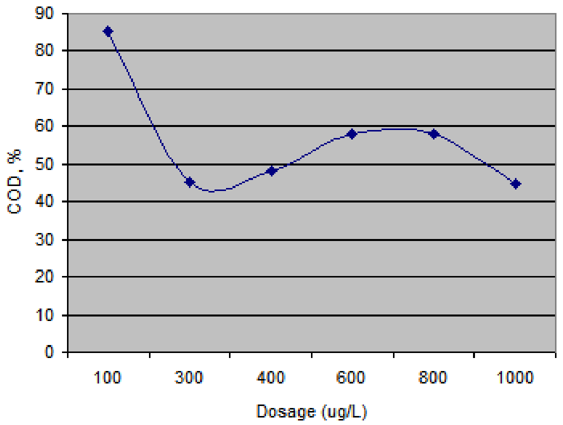

Figure 3.13: COD removal efficiency by Chitosan with different dosages of Alum at pH 3.

in the pH 3. During the treatment each sample was stirred rapidly (250 rpm) in the high speed while the combine coagulant was added slowly for 3 min. The speed was reduced to slow stirred (300 rpm) in the slow speed for 30 min for floc formation. The characteristic of the chemical treated effluent were determined after 30 min settlement.

3.10.2. COD removal by Chitosan with different dosages of Alum

Figure 3.13 shows the trend in removal of COD after the coagulation and flocculation processes for combined coagulants (Chitsan and Alum) at the pH 3. As seen in Figure 3.13 the concentration of 25 mg/L of Chitosan with 100 mg/L of Alum shows better removal of COD. The use of Chitosan with high dosage concentration did not have much improve on the COD removal. The COD removal efficiency obtained from the coagulation process for this combined was 85.37 %.

3.10.3. Turbidity removal by Chitosan with different dosages of Alum

The experimental results for the removal efficiency of turbidity for combined coagulants are shown in Figure 3.14. The result shown demonstrate the comparative results for turbidity removal efficiency for all the concentrations. The 25 mg/L of chitosan with 100 mg/L alum observed the highest turbidity removal at approximately 93.35 %. Figure 3.14 also shows the 25 mg/L chitosan with

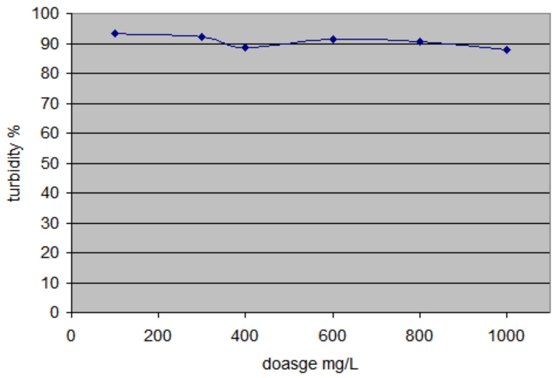

Figure 3.14: Turbidity removal efficiency by Chitosan with different dosages of Alum at pH 3.

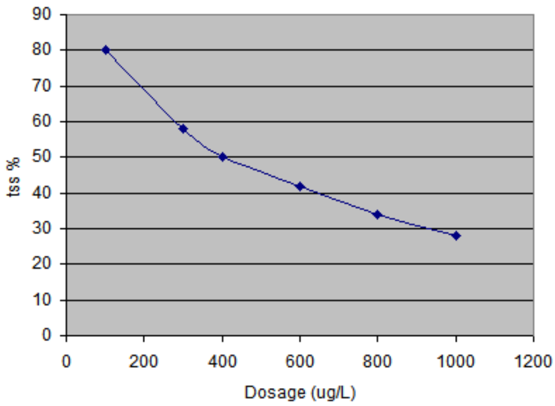

Figure 3.15: TSS removal efficiency by Chitosan with different dosages of Alum at pH 3.

1000 mg/L alum is slightly lower turbidity removal compared to the others.

3.10.4. TSS removal by Chitosan with different dosages of Alum

The removal of the TSS at 25 mg/L of chitosan with 100 mg/L of Alum and pH 3 produce the best of TSS removal efficiency. Approximately 80 % of TSS reduced. From the Figure 3.15 there are quite similar removal efficiencies for dosage from 50 mg/L to 300 mg/L.

3.11. Specific dosage of Alum with different dosages of Chitosan

The coagulation and flocculation process using 800 mg/L of alum with different dosages of chi-

tosan at the pH 3 are used to reduce the parameter of chemical oxygen demand (COD), Turbidity and total suspended demand (TSS).

3.11.1. COD removal by Alum with different dosages of Chitosan

Figure 3.16, shows that COD removal efficiency at 800 mg/L of alum with 50 mg/L of chitosan were achieved a higher removal of approximately 84.23 %. No further improvement in COD removal was obtained when the chitosan dosage was increased to 300 mg/L .The use of alum with high dosages of chitosan did not have much improve on the COD removal .

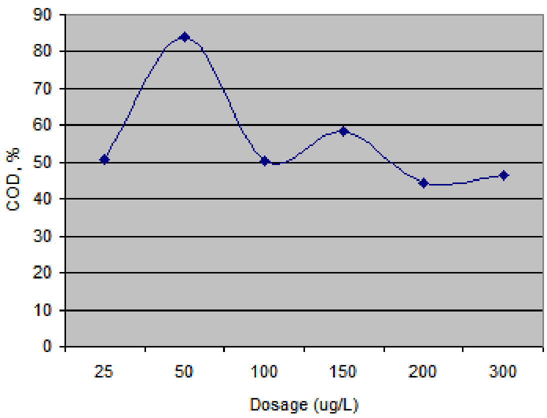

Figure 3.16: COD removal efficiency by Alum with different dosages of Chitosan at pH 3.

3.11.2. Turbidity removal by Alum with different dosages of Chitosan

Figure 3.17 shows that the turbidity removal efficiency for 800 mg/L alum with 50 mg/L of chitosan was slightly higher compared to the 800 mg/L alum with 25 mg/L of chitosan. 800 mg/L alum with 200 mg/L show slightly lower turbidity removal compared to the other dosages. For this dosage the turbidity removal achieved at 84.56 %.

3.11.3. TSS removal by Alum with different dosages of Chitosan

Figure 3.18 shows the effect of total suspended solid (TSS) removal efficiency at 800 mg/L of alum with 50 mg/L of chitosan and pH 3 shows clearly that TSS removal better result compared to the others. The 80% removal of the TSS achieved.

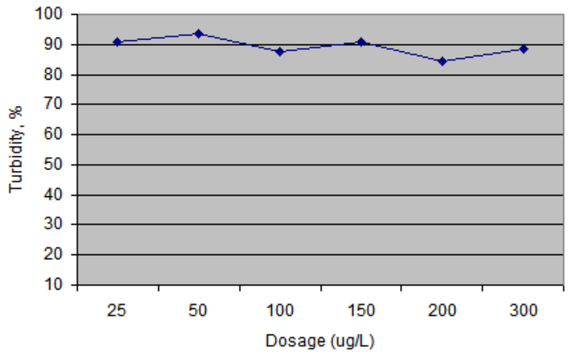

Figure 3.17: Turbidity removal efficiency by Alum with different dosages of Chitosan at pH 3.

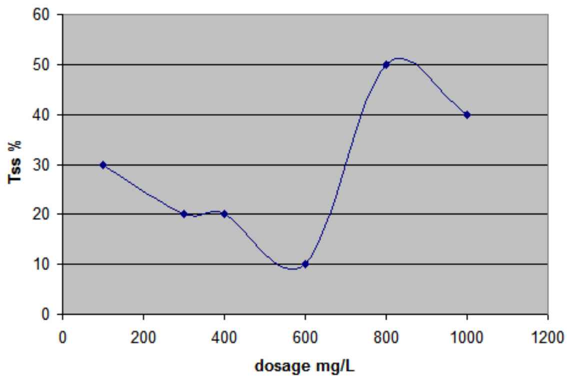

Figure 3.18: TSS removal efficiency by Alum with different dosages of Chitosan at pH 3.

The of different chitosan doses in the range of 25–300 mg/L and different alum doses in the range 100-1000 mg/L at pH 3. Results indicated that 25 mg/L of chitosan with 100 mg/L of alum achieved the highest removal of turbidity (93.35%), COD (85.37%) and (80%) TSS. While 800 mg/L alum with 50 mg/L of chitosan achieved (84.23%) COD, (84.56%) turbidity and (80%) TSS removal. However, 25 mg/L of alum doses in the range 100 mg/L at pH 3 can be considered as the optimum dose since it brought highest COD, turbidity and TSS removal.

Comparison between chitosan and alum efficiency in chemical treatment. In general, at their optimum dose and pH, chitosan achieved higher COD, TSS and turbidity for the PH 3. However, chitosan, is highly soluble at low pH and poses good efficiency for developing commercial applications.

It is also soft and has a tendency to agglomerate or form a gel in aqueous solutions. Under the condition of pH 3 and coagulant dosage 25 mg/l, the optimal efficiency was achieved, and the flocs formed can be settled down rapidly. The pretreatment of the soap wastewater can reduce the load to wastewater plant. The cost-benefit analysis showed that the use of chitosan will not increase the cost.

4. Conclusion

The performance of Chitosan, alum and blended Chitosan / alum at different pH by coagulation process has been tested and found to be capable of giving good removal in terms of percentages of removal for turbidity, TSS and COD and exhibit good performance. In particular, in the area of chemical pre-treatment by chitosan /alum blend at pH 3 is significantly different than chitosan alone or alum type of chemical coagulants and combination of coagulations because Conventional coagulation and flocculation processes, is an effective means of removal organic matter present in the wastewater before discharged, if the coagulant dosage, flocculants dosage and pH condition are adjusted into optimum condition. This research success shows that, by application of bland coagulants, i.e. 25 mg/L of chitosan with 100 mg/L of alum achieved the highest removal of turbidity (93.35%), COD (85.37%) and (80%) TSS at pH 3.

Acknowledgment

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