OPTIMIZATION OF ADSORPTION-COAGULATION PROCESS FOR TREATMENT OF PALM OIL MILL EFFLUENT (POME) USING ALTERNATIVE COAGULANT

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ABSTRACT

Activated carbon has been using as an adsorbent for wastewater treatment for decades. It has also been reported that use of fly ash to adsorb impurities in waste water treatment .The main objective of this study is to optimize hybrid adsorption-coagulation method for removal of color and other impurities presence in palm oil mill effluent (POME).Mango pit is a natural environmental friendly coagulant and have many advantages over commercially available aluminum and ferric salts used for water and wastewater treatment. On the other hand fly ash can be distinguished from other adsorbent in the way it desorbed and re used for the same purpose. This study further investigates the combination of fly ash with mango pit as coagulant agent for removal of color and other effluent quality parameters as TSS, TDS, COD and BOD. Palm oil mill wastewater after aeration process was collected and characterized in order to determine input conditions. Two sets of experiments were performed using jar test method namely; only adsorption using fly ash and the second is using fly ash in combination with mango pit in hybrid adsorption-coagulation system. In the first set of experiments only adsorption process was studied using fly ash as an adsorbent by varying parameters affecting the process. Samples of 300ml wastewater were used with variable fly ash particle size ranging from 355µm and 500µm and operated at 200rpm. Results showed that with decrease in particle size the amount of pollutant adsorbed increased and the amount of BOD_5, color, TDS, COD and TSS adsorbed increased as the weight of the boiler fly ash used was increased, therefore process was optimized using 355 µm granule size and 90g of dose which gave results in color reduction up to 91%, COD 82%, BOD_5 83%, TDS 74%, TSS 78% and turbidity 93% respectively. Further in the second set of experiments equal amount of wastewater samples were investigated using hybrid adsorption-coagulation method by varying concentration of adsorbent-coagulant as (50g-0.6ml, 70g-0.8ml, 90g-1.2ml). Finally both results obtained from first and second sets of experiments were compared at optimum point, an improved trend was recorded when hybrid system was applied towards the reduction in Color from 91% to 97%, COD from 82% to 89%, BOD from 83% to 94%, TDS from 84% to 93% and TSS from 88% to 96% respectively. Hybrid coagulation-Adsorption method has not only positive impact on reduction of water quality parameters but also very cost effective and environmental friendly process. Both ingredients used in this process can be obtained easily; other advantages include low sludge production and the less amount of coagulants used.

***Key words*:** POME, fly ash, Adsorption, Coagulation, Hybrid, Mango pit.

1. INTRODUCTION

Apart from being a sign of famous crop into global trade market, Palm oil has the tremendous economic and social impact in Sri Lankan context. Beside this the Palm Oil Mill Effluent (POME) generated from palm oil mill contains many organic and inorganic impurities which need to be treated before discharging to the river or sea or to be used in irrigation purpose. Mostly the color of POME cannot be removed after initial biological treatments and it contains still higher range of other parameters as BOD_5, COD, TDS, TSS, Turbidity and color respectively. Palm oil mill boiler fly ash (POBFA) is produced in palm oil mills by burning of the fiber and shell in the boiler as a fuel [1]. Most of the time the POBFA obtained is thrown as a waste or otherwise used as a fertilizer. The use of POBFA for wastewater treatment can reduce the harmful environmental impact and meanwhile it can reduce the overall operational cost of industry. "Every tone of fresh fruit bunches (FFB) produces about 4kg to 6 kg of boiler ash. This porous ash contains about 0.28% -1.33% phosphorous, 1.2% to 4.31% potassium, 0.39% - 3.24% calcium and 0.29% - 2.60% magnesium" according to the studies conducted by Rusnani

[6]. Fly ash generates in palm oil industry due to burning solid remains such as pressed bunches. Previous studies has indicated the possibility of using boiler fly ash to adsorb impurities and color in POME treatment[2] .Mango Kernel on the other hand was proved to be a good alternative coagulant enriched with natural ingredients. It is generally accepted that Mango kernel works as a coagulant due to positively charged, water soluble proteins, which bind with negatively charged particles (salt, clay, bacteria, toxins etc.) allowing the resulting "flocs" to settle to the bottom or to be removed by filtration. .A combine coagulation/ carbon adsorption process for the treatment of reactive dyes in the synthetic wastewater was proposed by Papic et al [3]. Mixture of POBFA and mango pit coagulant is together used in this study to optimize the percentage removal of pollutants and minimize the environmental risks.

2. METHODOLOGY

2.1. Development of Coagulant

Mango pit (Magnifera indica) commonly known as (kernel, seed or embryo) [5] were collected from fruit juice industry. To get the coagulant, active part the seed inside were removed and the kernel inside was cut into small pieces, cleaned and washed using distilled water and dried at 130^{o}C for 1hour. Dried mango seeds were cooled and crushed using ball mill to particle size 0.44mm. The sieved mango seed granules were dissolved in distilled water (50g/liter) as proposed by Qureshi, et al. [5] and kept inside refrigerator for further use.

2.2 Activation of boiler fly ash

Palm oil boiler Fly ash (POBFA) was directly collected from the boiler at AEN palm oil processing unit, located in Muhameddi estate, Sri Lanka.POBFA ash was obtained from burning the palm kernel and fiber shell where it consist of clinkers and ash. The large particles of POBFA obtained were ground and sieved In order to reduce the sizes up to 355 and 500µm respectively for future comparison. POBFA after sieving was washed with warm distilled water and activated using 3% v/v nitric acid solution by keeping them soaked overnight. The total weight loss observed was 10-15% due to nitric acid solution. The activated granules were then air dried and kept under dry condition till further use.

2.3. Experimental Procedure

Sample of wastewater collected from AEN palm oil Processing unit following biological treatment was characterized and results are shown in Table 1.

Table 1: Characteristics of POME after aeration

Parameters	values
Color(Pt-Co)	3560
TDS(mg/l)	5400
TSS(mg/l)	700
BOD(mg/l)	560
COD(mg/l)	890
TURBIDITY(FAU)	1275

Different samples of 300ml wastewater were taken into beaker and pH was adjusted by using dilute acid or base according to the required values 4, 5, 6 respectively. After putting prescribed amount of coagulant and adsorbent into it, Samples were processed using Jar test method for 1 hour at 200rpm and ambient temperature. After Agitating samples were kept for 1 hour to let the flocs and sludge settles. Amount of sludge and flocs left are then further processed by passing through gravity sand filter and micro filter (Figure 1) to remove the dissolved and suspended part of adsorbent and coagulant. Samples collected after filtration was analyzed for results.

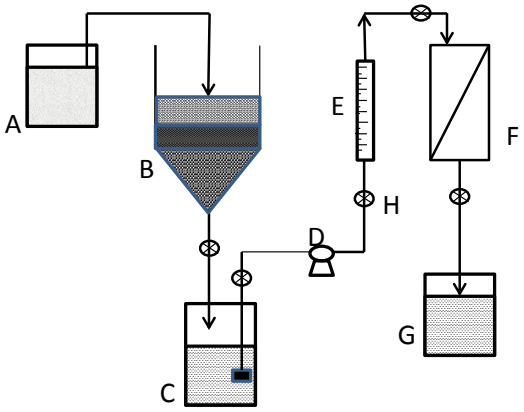

Figure 1: Schematic diagram of physical treatment system developed in this study : (A) Solution obtained after jar test chemical treatment ; (B) dual media gravity filter ; (C) Water collection tank after gravity filter ; (D) Centrifugal pump of 0.5hp ; (E) Rota meter to adjust the exit flow rate ; (F) Micro filter ; (G) Product collection tank ; (H) Valves

3. RESULTS

Effect of initial pH, Concentration of Coagulant and Adsorbent and the particle size of adsorbent

are studied. Experimental results obtained from the first set of experiments are shown in Figure 2.According to these results, when the weight of the pure fly ash increases percentage removal increases, at 90 g of pure fly ash which possesses 355 µm particle sizes gives reduction in color up to 91%, BOD 83%, COD 82%, TDS 74% and TSS 78% respectively.

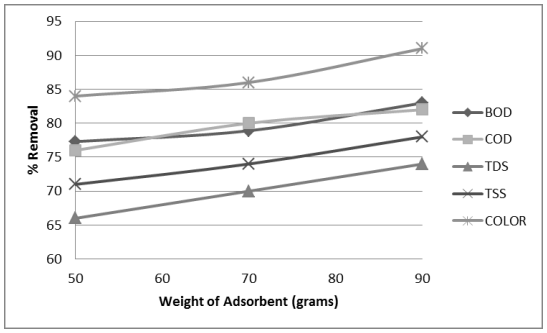

Figure 2: Weight (g) of 355 µm Adsorbent against the % removal of BOD, COD, TDS, TSS and color

To further investigate the effect of granule size on the rate of adsorption, experiment was conducted using 500µm adsorbent.

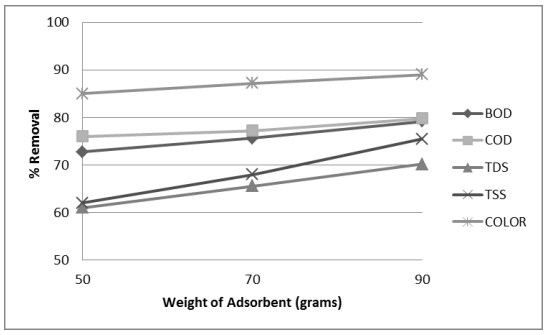

Figure 3: Weight (g) of 500 µm Adsorbent against the % removal of BOD, COD, TDS, TSS and color

Figure 3. Shows that using 500µm and same amount of adsorbent, the percentage reduction is lower than using smaller particle size. This can be explained by increase of surface area due to small particle size and thereby enhancing adsorption process.

Furthermore a slight increase in the reduction of above parameters were observed in Figure.4 when using fly ash and mango pit together by varying concentration of adsorbent (50,70, 90g) With a constant concentration of Coagulant as 1.2ml. For all samples initial pH was adjusted to 4. Reduction efficiency improved in terms of color; 97%, TDS; 93%, TSS; 96%, $BOD_{5;}$ 94% and COD; 89%.

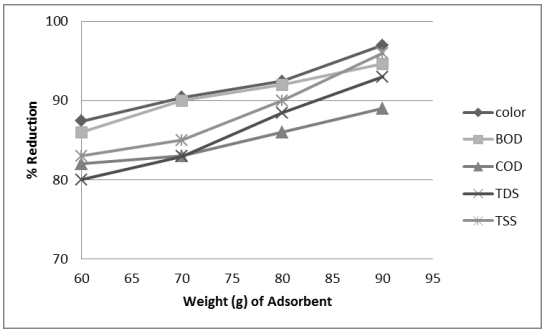

Figure 4: Concentration of adsorbent as weight (g) against the % removal of BOD, COD, TDS, TSS, and Color at constant pH and Coagulant concentration

Graph shown in Figure 5 indicate that with the decrease in initial pH the amount of color, BOD_5, COD, TDS and TSS also decrease and when initial pH is set to 4 the highest reduction in color, BOD, COD, TDS and TSS were recorded.

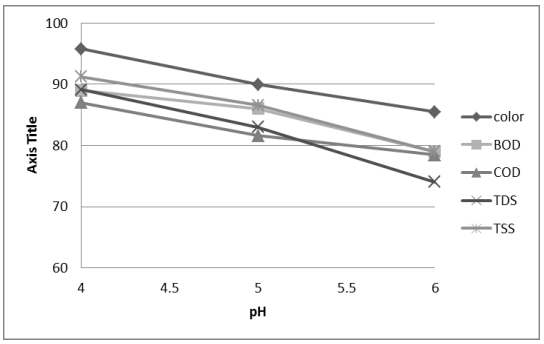

Figure 5: Initial pH against the % removal of BOD, COD, TDS, TSS, and Color using 1.2ml and 90g of coagulant-adsorbent

Overall, results indicate that the efficiency of the process in terms of color, BOD, COD, TDS and TSS reduction is higher at optimum values of initial pH; 4 and combined coagulant (1.2ml)-adsorbent(90g) dose.

In comparison with previously done research work for the purification of turbid water with mango pit by K.Qureshi [5] This work shows improved results in terms of Color , COD,BOD,TDS and TSS reduction specially for wastewater treatment. Similarly when comparing with research work of Igwe [2] an increase towards the reduction of above parameters was obtained, this shows the positive trend in POME treatment.

4. CONCLUSION

Mango pit is considered as an excellent natural coagulant for waste water treatment, its

efficiency was found higher when compared with other proven natural coagulants. Meanwhile POBA has also proved to be the best adsorbent for wastewater treatment. It was found that separate adsorption or coagulation process is not the most effective methods for the treatment of color, BOD, COD, TDS and TSS present in POME. Combined coagulation-adsorption processes are the most effective method for the color removal of POME in particular and BOD_5, COD, TSS, TDS in general at effective cost. Hybrid process gave overall removal rate as 97,96,94,93, and 89% for the color, TSS, BOD_5, TDS and COD respectively. Environmental pollution problems related to fly ash and POME can be solved by processing fly ash in this manner. Sludge produced from hybrid process can be further utilized as a fertilizer. Moreover hybrid coagulation-adsorption process produces the best results when followed by a gravity sand filter of different granule size.

5. ACKNOWLEDGEMENT

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