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Effectiveness of Moringa Oleifera and Blends of Both Alum and Moringa as Coagulant in the Treatment of Dairy Wastewater

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Effectiveness of *Moringa Oleifera* and Blends of Both Alum and *Moringa* as Coagulant in the Treatment of Dairy Wastewater.

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Abstract. Food processing industries can cause some serious problems for the environment through the discharge of wastewater. There is little information on the effectiveness of *Moringa Oleifera* (*MO*) seeds on the treatment of dairy wastewater, this study therefore evaluated the effectiveness of *MO* seeds and blends of both alum and *MO* in the coagulation of dairy wastewater. Wastewater collected from oriental food industry limited was kept in a 10L capacity plastic container covered using a black polyethene bag containing ice blocks and conveyed to the laboratory where it was kept in a refrigerator. Six different beakers (Nos 0-5) were filled with 200 mL of wastewater and different doses of the selected coagulant (alum, *MO* and a blend of both) was added to the six beakers ranging from 0-10mL at an increment of 2mL to treat the wastewater. The beaker with number 0 served as the control (no dosage) and this whole process was applied to both coagulants. This test was carried out at a settling time of 1 hour. The physicochemical characteristics of the treated dairy wastewater were determined using the standard methods. Data were analyzed using descriptive statistics and ANOVA. The analysis indicated that the raw wastewater had values of 932 NTU, 1690.99 mg/L, 7.2 and 685 mg/L for turbidity, BOD, pH and TSS respectively. The results revealed that at an optimum dosage and settling time of 10mL and 1hr respectively, the TSS removal efficiencies of 88.76, 82.63 and 86.42 % were obtained for blend of moringa and alum, alum and moringa respectively. The three types of coagulants did not have much effects on the BOD and there were no significant differences in the values. The use of the blend of moringa and alum is effective in the treatment of dairy wastewater.

KEYWORDS: *Moringa Oleifera*, Blend of coagulants, dairy wastewater

1. Introduction

Speedy growth of human population and industrial development in the world's nations are destroying the environment through unchecked urbanization growth and rapid industrialization, and leading to the loss of natural habitats. The rising population and the degradation of the climate face the challenge of sustainable growth without harming the ecosystem. Chemical compounds are increasingly being used in industrial production today. Many of these chemicals have made their way into nature with harmful effects that can slowly impact the environment negatively [1]. The dairy industry is generally considered in many countries to be the main source of wastewater for food processing [2]. These dairies extract milk from the products and either simply bottle it for marketing purposes or manufacture specific milk products depending on their capabilities. Due to various processes in food production, large volume of effluents is produced. The biodegradable components in the effluents are available in the state they are



present in the milk or in a deteriorated state due to further processing. Therefore, the effluents although organic are very persistent in nature [3]. The characteristics of the effluents are dependent on the by-products and plant processing capabilities. It comprises of a number of disinfecting substances and numerous acidic and basic cleansing agents. Therefore, the pH of effluents can differ significantly depending on the scrubbing method used. Dairy effluents are categorised by high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) concentrations [4]. Coagulation process can effectively be used in reducing some pollutants such as turbidity, colour and organic matter present in water. This process is aided by sedimentation employed for the removal of the formed flocs. Some of these methods involve the use of chemicals which are relatively expensive and may have immediate or later effect on the environment. Thus, there is the need to actually look into the use of natural method for the reclamation of industrial effluent. The two main coagulants most widely used in the past are salts of aluminum and iron [5]. A lot of less costly materials have been used, these include application of industrial and agricultural wastes in the removal of different contaminants from the industrial wastewaters for their safe dumping into the environment [6]. Several plants have been applied in the clarification of water and these include *Moringa Oleifera*, *Moringa stenopetala*, *Vicia faba* [6]. Recently, more attention has been focused in the advancement of natural coagulants such as *Moringa Oleifera* (MO) and Chitosan. Naturally occurring coagulants are usually considered safe for man's wellbeing. While several preceding papers had examined the application of MO as a natural adsorbent for the special removal of contaminants [7], little has been done in the utilization of MO and Alum as a blend. This paper therefore assessed the effectiveness of MO and blends of both alum and *moringa* as coagulant in the treatment of dairy wastewater.

2. Materials and methods

2.1. Collection of dairy effluent

The dairy wastewater used for this study was collected from the Fan Milk PLC located at Eleyele, Ibadan. The wastewater sample was collected in a 10L capacity plastic container and conveyed immediately in a bag containing ice blocks to the Environmental Engineering Laboratory of the University Ibadan and kept in a refrigerator.

2.2. Moringa Preparation

The MO seeds used for this experimental work were obtained from the Bodija market, Ibadan. The seeds were shelled while seeds showing signs of deterioration were removed after the shelling process. The good ones were dried in an oven at 65 °C for 20 hours. The dried seeds were milled and oil extraction process was carried out on the powdered MO seeds in order to increase its coagulation properties as recommended by other Researchers [1]. The oil extraction process was achieved using a solvent called n-hexane in a soxhlet extractor. In this process, 20g of the seed powder was wrapped with a white cloth and placed in the soxhlet extractor chamber, and then a conical flask containing 250mL of n-hexane was placed in a water bath which was the heating chamber.

2.3. Preparation of Stock Solution (MO and alum)

Stock solution of both coagulants (*Moringa Oleifera* and alum) was prepared by dissolving 15g of the coagulants at the ratio of 2: 1 in 100mL of distilled water and each was blended using the stirrer for 5min to extract the active ingredients after which the solution was filtered using Whatmans filter paper of 12.5mm in order to remove some of the suspended or undissolved solids. The alum was grounded into powder using the laboratory mortar and pestle. Each stock solution formed after filtration was 100,000mg/L.

2.4. Treatment of Dairy waste water with the coagulants

A stirrer having 4 paddles with varying rotational speed was used. Six 250 mL different beakers (Numbered 0-5) were washed and rinsed with distilled water after which they were filled with 200mL of wastewater. Different doses of the selected coagulant were added to the six beakers ranging from 0-10mL at an increment of 2mL to treat the wastewater. The beaker with number 0 served as the control (no dosage) and this whole process was applied to both coagulants. After dosing each of the wastewater with different concentrations of the coagulants, the solution was stirred rapidly for 5min at 80 rpm in order to achieve thorough mixture. This was then followed by 10min of gentle stirring at 20 rpm. Gentle stirring was to aid the formation of flocs through the collision of particles in the wastewater. As for the blends, moringa was first added to the wastewater and stirred for 2min before alum solution was then added and stirred for another 10min so as to achieve proper mixing. Settling phase was initiated immediately after stirring by allowing the suspension in a quiescent condition. After the settling phase, the supernatants formed in the beakers were extracted using a pipette at a depth of 2cm below the water surface for analysis of the physico-chemical parameters as per standard methods [8]. Table 1 shows the coagulant doses for the treatment of wastewater, while Figures 1 and 2 shows the treatment process using jar test apparatus and coagulants.

2.5. Data Analysis and Management

The data analysis was carried out by means of the SPSS software Version 21.0 while ANOVA was used to compare physicochemical parameters from the treatment by different coagulants using a 5% significance level ($p < 0.05$). Descriptive statistics was used to analyse the data which were associated with the standard limits as set by the World Health Organization [9].

Table 1: Coagulant dosage for Treatment of Wastewater

Blends (mL)	Alum (mL)	<i>Moringa Oleifera</i> (mL)
2	1	1
4	2	2
6	3	3
8	4	4
10	4	6

3. Results and Discussion

3.1. Raw Dairy Wastewater Characteristics

Table.2 shows the physicochemical characteristics of the wastewater from the yoghurt producing industry studied. From the Table the wastewater has a very high BOD content of 1690.99 mg/L which is greater than the discharge standard of 30 mg/L according to National Environmental Standard and Regulation Enforcement Agency (NESREA). From the Table, the wastewater was extremely turbid with a value of 932 NTU which does not meet the World Health Organization (WHO) discharge standard of 5 NTU [10]. The pH of the wastewater was 7.2 which fell within the above stated guideline of 6.0 – 9.0. The total suspended solid of 685 mg/L was also above NESREA standard of 100 mg/L. The value of the total dissolved solids was 810 mg/L which met the NESREA standard of 2,000mg/L but the alkalinity was 308 mg/L, which is above the WHO standards of 120 mg/L. the results are consistent with the findings of [11]. The values of the Total dissolved solids and total suspended solids are in line with that of [12].



Figure 1: Coagulation/flocculation using the Jar test apparatus



Figure 2: Treatment process using alum

Table 2: Physicochemical analysis of the wastewater sample

Parameters	Concentration	NESREA	WHO
pH	7.2	6-9	6.5-8.5
TDS (mg/L)	810	2000	500
TSS (mg/L)	685	30	<10
Conductivity ($\mu\text{S}/\text{cm}$)	1161	-	-
Turbidity (NTU)	932	5	5
Alkalinity (mg/L)	308	120	120
DO (mg/L)	4.83	8-10	8-10
BOD (mg/L)	1690.99	30	30

NESREA (2000) - National Environmental Standard Regulation and Enforcement Agency

3.2. Treatment of dairy effluent by various coagulants

Table 3 shows the values obtained of selected physicochemical parameters after treatment of the wastewater using Alum, *Moringa oleifera* and *Moringa oleifera* blends (alum + *Moringa oleifera*) at different concentrations after 2 hours retention time.

3.2.1. pH

The values of pH ranged between 6.6 ± 0.19 to 6.0 ± 0.29 ; 7.2 ± 0.26 to 7.0 ± 0.51 and 6.8 ± 0.56 to 6.2 ± 0.07 at dosages of 2mL to 10 mL using Alum, *Moringa oleifera* and *Moringa oleifera* blends (alum + *Moringa oleifera*) respectively. It was found that after treatment of the wastewater with all the coagulants, the pH was found to decrease. The results were consistent with [10] but at variance with some research works conducted previously [13]. The pH of the wastewater was also more acidic at 10 mL dosage for all the coagulants and did not meet NESREA and WHO standard at that dosage for 2-hour retention time. There is no need to further treat the wastewater because the values of pH fall within the acceptable values of pH [14].

3.2.2. Total Dissolved Solids (TDS) and Total Suspended Solids (TSS)

The values of TDS ranged between 226.00 ± 10.00 to 175 ± 0.42 ; 209 ± 5.00 to 140 ± 7.52 and 199 ± 4.10 to 123 ± 5.64 mg/L at dosages of 2 mL to 10 mL using Alum, Moringa oleifera and Moringa oleifera blends (alum + Moringa oleifera) respectively. The result agrees with [6] that all the types of coagulants have an effect on the TDS with the best performance from the blend of Alum and Moringa oleifera. The TDS of the wastewater was lowest at 10 mL dosage but did not meet NESREA and WHO standard at that dosage for 2-hour retention time. The values of TSS ranged between 177 ± 3.50 to 135 ± 10.12 ; 191 ± 5.86 to 94.64 ± 7.92 and 169.10 ± 10.15 to 82.54 ± 6.18 mg/L at dosages of 2 mL to 10 mL using Alum, Moringa oleifera and Moringa Oleifera blends (alum + Moringa oleifera) respectively. The result agrees with [15] that all the types of coagulants have an effect on the TDS with the best performance from the blend of Alum and Moringa oleifera. The TSS of the treated wastewater was lowest at 10 mL dosage but did not meet NESREA and WHO standard at that dosage for 2-hour retention time. The high values of suspended and dissolved solids available in raw effluent could be adduced to the availability of biodegradable organic matter in high concentrations in the dairy waste water [12]. There is therefore the need for further treatment of the dairy effluent before final disposal.

3.2.3. Biochemical Oxidation Demand (BOD)

The BOD content of raw dairy waste water was 1690.99 mg/L. The values ranged from 1216.26 ± 24.24 to 1317.60 ± 25.13 ; 1236.52 ± 42.58 and 1175.71 ± 37.56 to 1033.81 ± 27.65 mg/L at dosages of 2 mL to 10 mL using Alum, Moringa oleifera and Moringa oleifera blends (alum + Moringa oleifera) respectively. The result agrees with [15] that all the types of coagulants have an effect on the BOD with the blend of Alum and Moringa oleifera having the best result. The BOD of the wastewater was lowest at 10 mL and did not meet NESREA and WHO standards at that dosage for 2-hour retention time. From the results it could be seen that the application of the blend of Moringa oleifera with Alum coagulant is more effective than the other coagulants. It is also seen that as the quantity of dosage is increased, there is greater efficiency in the rate of removal. The implication of this is that with the high after-treatment BOD, there are still organic materials and active microorganisms therefore there is need for further treatment of the wastewater before final disposal of the dairy wastewater [16][17]

Table 3: Treatment of dairy effluent with *Moringa Oleifera* and *Moringa Oleifera* blends (Alum + *Moringa O*) at different concentrations

S/N	Parameter	Coagulant	Dosage (mL)					
			0	2	4	6	8	10
1	pH	Alum	7.0	6.6 ± 0.19^a	6.3 ± 0.34^a	6.1 ± 0.27^a	6.1 ± 0.25^a	6.0 ± 0.29^a
		Monringa		7.2 ± 0.08^b	7.2 ± 0.26^b	7.1 ± 0.36^b	7.1 ± 0.58^b	7.0 ± 0.51^b
		Moringa + Alum		6.8 ± 0.56^a	6.5 ± 0.06^a	6.4 ± 0.21^c	6.3 ± 0.20^a	6.2 ± 0.07^a
2	TDS (mg/L)	Alum	724	226.00 ± 10.00^c	220.00 ± 6.75^c	190.00 ± 9.82^c	184.00 ± 10.25^c	175.00 ± 9.42^c
		Monringa		209.00 ± 5.00^b	186.00 ± 5.52^b	173.00 ± 4.21^b	160.00 ± 5.92^b	140.00 ± 7.52^b
		Moringa + Alum		199.00 ± 4.10^a	167.00 ± 6.72^c	150.00 ± 8.25^a	125.00 ± 7.89^a	123.00 ± 5.64^a
3	TSS (mg/L)	Alum	194	177.00 ± 3.50^a	131.00 ± 7.34^a	132.00 ± 5.45^b	134.00 ± 3.72^b	135.00 ± 10.12^c
		Monringa		191.00 ± 5.86^b	180.00 ± 10.21^c	116.00 ± 7.52^a	97.00 ± 6.12^a	94.64 ± 7.92^b
		Moringa + Alum		169.10 ± 10.15^c	145.32 ± 6.75^b	129.25 ± 4.27^b	99.15 ± 5.17^a	82.54 ± 6.18^a
4	BOD (mg/L)	Alum	147	1317.60 ± 25.13^b	1277.07 ± 16.02^b	1216.26 ± 25.12^b	1216.26 ± 24.24^b	1094.61 ± 32.10^b
		Monringa		1439.25 ± 42.58^c	1358.16 ± 6.25^c	1337.99 ± 26.92^c	1256.79 ± 45.21^c	1236.52 ± 32.23^c
		Moringa + Alum		1195.98 ± 19.70^a	1175.73 ± 16.20^a	1175.71 ± 37.56^a	1137.88 ± 23.78^a	1033.81 ± 27.65^a

For each parameter, means with the different letters (superscripts) are significantly different ($p < 0.05$), using Duncan's multiple range test.

3.3. Optimum dosage and reduction efficiencies for turbidity

3.3.1. Optimum dosage and reduction efficiencies for turbidity by the coagulants

Figures 3 and 4 showed the turbidity removal in the wastewater using Alum, *Moringa Oleifera* and blend at 1 hour and 2 hours retention time. It was shown that the initial turbidity of the raw wastewater was 932 NTU. The effects of coagulant dosage for the three coagulants at different settling time are shown in the figures. These figures show that turbidity was reduced as the coagulant's dosage was increased at both settling time of 1 and 2 hours. The results indicated that the optimum dosages in the reduction of turbidity of the wastewater using alum, *moringa* and blends were achieved at 8, 10 and 10 mL respectively at both 1 hour and 2 hours settling time respectively. Figure 5 showed the removal efficiencies for turbidity at optimum dosage of each coagulant in different retention time. At those optimum dosages, the turbidity was reduced to 117, 107 and 95 NTU for alum, *moringa* and blends respectively. The removal efficiencies of 87.45, 88.52 and 89.81% for alum, *moringa* and blends respectively at a settling time of 1 hour. At a settling time of 2 hours, the optimum dosage reduced the initial turbidity of the wastewater to 131, 102 and 102 NTU for alum, *Moringa* and blend respectively representing a removal efficiency of 85.94, 89.06 and 89.06 % alum, *moringa* and blends respectively. Removal efficiencies for turbidity at these optimum dosages for both times are represented in Figure 3 and it can be seen from the results that the blend of Alum and *Moringa Oleifera* gave the best removal efficiency of 89.81 % at 10 mL in a settling time of 1 hour. The result was in line with the reports of [1]; [18] who stated that all the coagulants removal values of turbidity were high and greater than 60%. The implication of this is that since the removal rate of turbidity is very high, there is no need for further treatment.

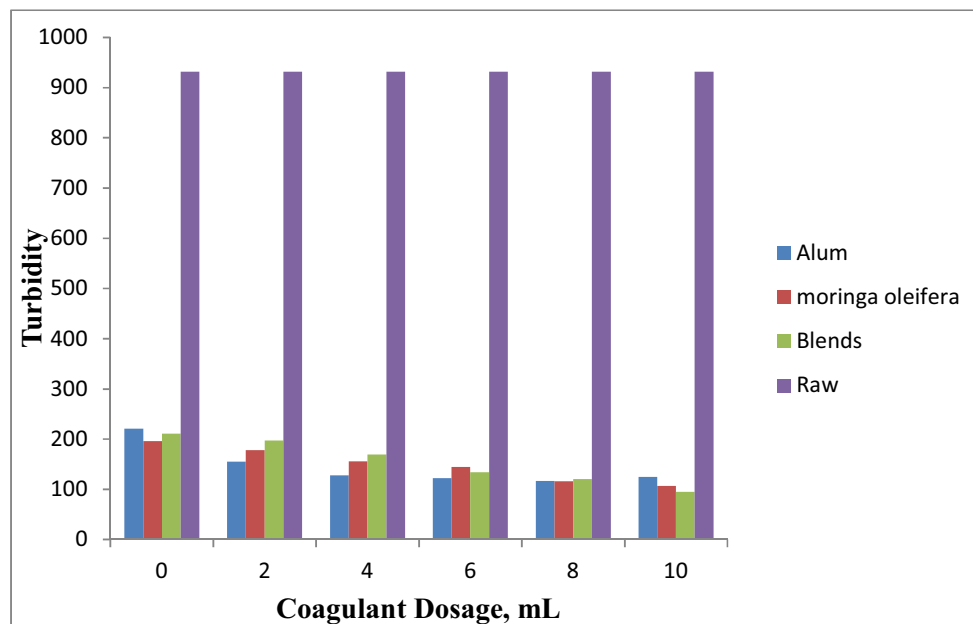


Figure 3: Turbidity removal in the wastewater using Alum, *Moringa Oleifera* and blend at 1 hour retention time.

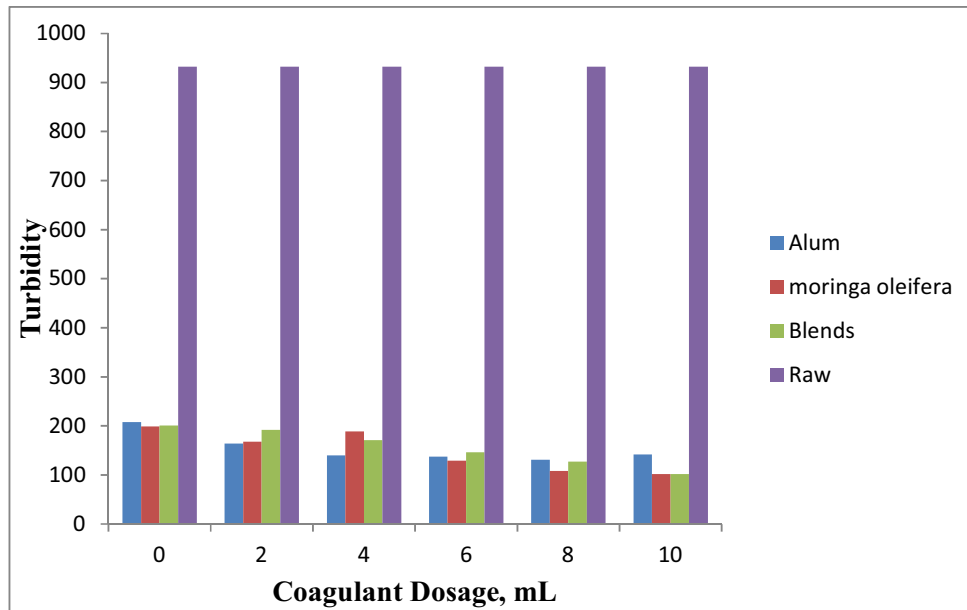


Figure 4: Turbidity removal in the wastewater using Alum, *Moringa Oleifera* and blend at 2 hours retention time.

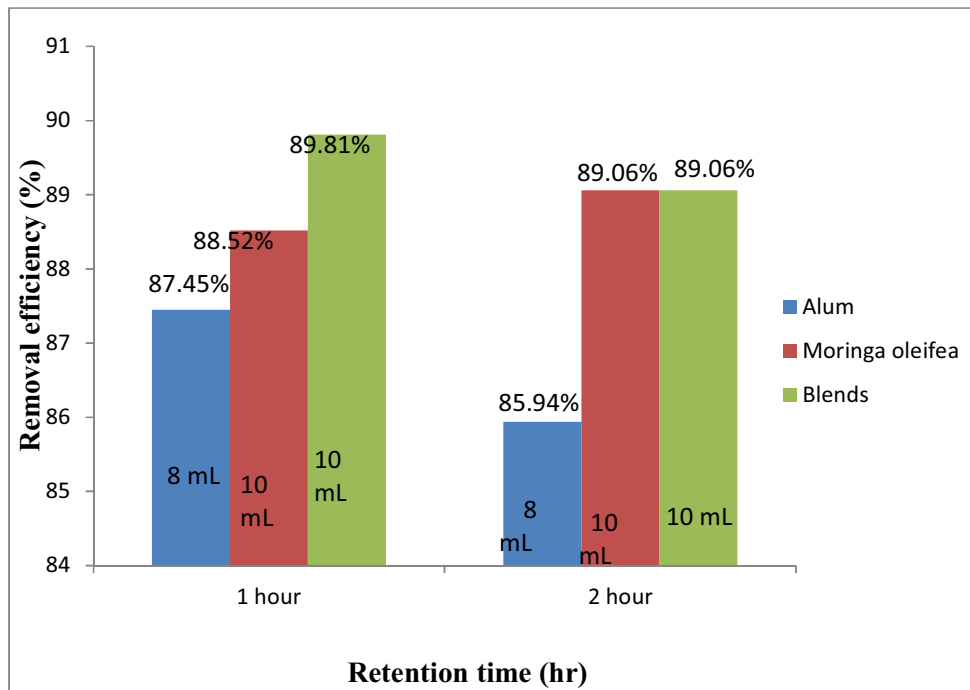


Figure 5: Removal efficiencies for turbidity at optimum dosage of each coagulant in different retention time

4. Conclusion

From the study it is shown that all coagulants possess properties for wastewater treatment. The treatment of dairy wastewater shows significant reduction in values of parameters like TDS and TSS. The values for TDS and TSS were 824, 140, 135 and 123 mg/L for control, Alum, *Moringa Oleifera* and Blend respectively and 194, 135, 94 and 82mg/L for control, Alum, *Moringa Oleifera* and Blend respectively. The study also showed that these coagulants are not very effective in BOD (Biochemical oxygen demand) removal. They were very useful in turbidity removal as well as reduction in the total suspended solids. *Moringa* and blend (alum + *moringa*) at a dosage of 8 mL and 10mL gave the best turbidity removal efficiencies of 89.06 % and 89.80 % making the blend the best. It can therefore be concluded that blending alum and *M. oleifera* seed powder showed characteristic synergies in water treatment than using alum alone or *Moringa* alone. The turbid and polluted water can also both be treated with *moringa* extract and blend of both alum and *moringa* but the best result in terms of turbidity removal are achieved using blends.

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