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ASSESSING THE EFFECTIVENESS OF *MORINGA OLEIFERA* SEED AS A COAGULANT IN DOMESTIC SEWAGE TREATMENT

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ABSTRACT

The effectiveness of Moringa oleifera seed as a natural coagulant for domestic sewage treatment was investigated in this study. A completely randomized design (CRD) was adopted for the treatment process. The treatments included the control culture (no-Moringa seed), 2 g, 4 g, and 6 g of Moringa oleifera. Physical, bacteriological and chemical properties of domestic sewage were investigated before and after treatment. The turbidity, water hardness, suspended solids, dissolved solids, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) showed reductions while dissolved oxygen (DO) showed some increase indicating that some level of treatment was achieved. There was no significant difference between the pH, BOD and COD obtained for the 2 g, 4 g and 6 g treatments. The study has revealed that Moringa oleifera as a natural coagulant shows potential in the treatment of the domestic sewage.

1. INTRODUCTION

Increase in population has led to an increase in pollution and degradation of the environment resulting to a number of challenges for policy makers in most developing countries. This is because of the slow pace of infrastructural development, increased demand for freshwater and conversion of watersheds into residential or industrial facilities as well as the impact of wastes resulting from agricultural activities (Amagloh and Benang, 2009). As a result, the quality of freshwater within these vicinities is highly compromised. The threat resulting from the aforementioned has caused a stir and that has been a source of concern to researchers in recent times. Because of this, the focus of most researches in recent times has been to develop appropriate sewage treatment methods and techniques. This trend is tending towards natural treatment methods and techniques.

Domestic sewage is about 60% suspended and dissolved solids (Painter and Viney, 2004). This suggests that the most effective method of removal of these solids is by causing these particles to coagulate using natural or chemical coagulants. Coagulants are substances which when added to water increases inter-particle collision between dissolved and suspended solids due to Brownian motion (Ghebremichael et al., 2005). This process results to denser particles, which settle at the bottom of the settling tank. The removal of turbidity in water during treatment is essential because suspended particles are transport vehicles for undesirable organic and inorganic contaminants such as taste, odour and colour-imparting compounds and pathogenic organisms (Ali et al*.,* 2004). In recent years, there has been considerable interest in the development of natural coagulants such as *Moringa oleifera*. The use of natural coagulants could result to considerable savings in chemicals and sludge handling cost (Amagloh and Benang, 2009). *Moringa oleifera* seed kernels are biological coagulant consisting of significant quantities of low molecular weight water-soluble proteins, which in solution carry an overall positive charge. Apart from the turbidity removal properties, *Moringa oleifera* has been reported to have antimicrobial properties in water and also the ability to remove metals from water (Sotheeswaran et al., 2011). The aim of this study was to investigate the effectiveness of using *Moringa oleifera* seeds for the treatment of domestic wastewater.

2. MATERIALS AND METHODS

2.1. Materials

The study was carried out in Ilorin, Kwara State, Nigeria. The domestic wastewater used in this study was obtained from randomly selected households within Ilorin metropolis. The other materials used in this study included: *Moringa oleifera* seed, weighing balance, plastic containers and other required reagents.

2.2. Experimental Design

The experiment was design based on completely randomized design (CRD) and the experiments were carried out in triplicate. Domestic sewage water was collected in twelve 2 litres capacity plastic containers Three of the plastic containers served as control (i.e. with no *Moringa oleifera*), while the others had varying amounts of (2 g, 4 g and 6 g) of *Moringa oleifera*. The plastic bottles were thoroughly washed and rinsed before collecting the sample in order to avoid sample contamination. Each of the containers was weighed before the addition of samples and were weighed after the addition of the samples in order to determine the weight of the samples.

2.3. Samples and Measurement of Parameters

The plastic containers containing the samples were stored in a cool dry place and the analysis of the sewage commenced two hours after collection. The following parameters: temperature, water hardness, the volume of sewage produced, odour, conductivity, total solids, suspended solids, dissolved oxygen, dissolved solids, chemical oxygen demand (COD), biological oxygen demand (BOD), pH, *Escherichia coli* and faecal coliform were determined. BOD and DO were determined in accordance ISO 5815-1 (2003) and ISO 5814 (2012). The COD was determined in accordance with ISO 6060 (1989), while total hardness was determined in accordance with ISO: 3025-21 (2009). Total solids and suspended solids were determined in accordance to ISO 7027-1 (2016). The odour as determined by physical observation. The temperature and volume of the sewage consumed were measured using a thermometer and measuring cylinder, respectively, while Escherichia coli and faecal coliform were determined using the multiple fermentation tube technique (Painter and Viney. 2004). The pH of the sample was read using a Crison pH meter Basic C20. A Crison Conductometer Basic C30 was used to determine the conductivity of the samples. Turbidity was determined in accordance with ISO 7027-1, 2016.

3. RESULTS AND DISCUSSION

3.1. Hardness

Initial hardness of all samples at the point of collection was 64 mg/l. At the end of the treatment, the hardness of the wastewater range between 57 – 64 mg/l, 40 – 53 mg/l, 35 – 64 mg/l, and 33 – 65 mg/l for the control, 2 g, 4 g and 6 g, respectively. The average values obtained are shown in Figure 1. These results agree with the findings of Onwuliri and Dawang (2006), who reported that hardness removal efficiency of *Moringa oleifera* was found to increase with increasing dosage and duration of treatment. The United States Geological Survey (2016) reported that the general guidelines for classification of waters are: 0 to 60 mg/L as calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard. The study shows that as the quantity of the bio-coagulant increases the water hardness reduces.

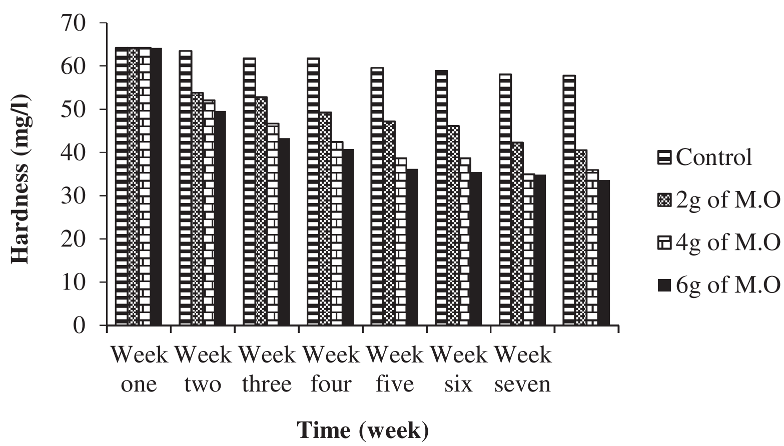

Figure 1: Effect of treatment on hardness

3.2. Alkalinity and Acidity

Alkalinity and acidity at the collection point were 148 mg/l and 0.8 mole/litre, respectively. Figures 2 and 3 present the results obtained after treatment. It can be observed from both Figures that alkalinity decreased with increasing dosage (136.8 mg/l, 113.3 mg/l, 114.0 mg/l and 114.2mg/l for the control, 2 g, 4 g, and 6 g Moringa oleifera seed treatment, respectively), while acidity increased to 2.29 and 2.02 mole/litre for 2 g and 4 g Moringa oleifera treatment and then sharply increased to 3.12 mole/litre for 6 g of Moringa oleifera treatment. However, there was no significant difference in the alkalinity between 2 and 4 g the treatments, but there was between the 6 g, 2 g and 4 g treatments in terms of the acidity. The 6 g treatment had the highest acidity of 3.12 mole/litre, while 4 g had the least value of 2.02 mole/litre. Vikashni et al. (2012) also reported this same trend in acidity with respect to the dosage.

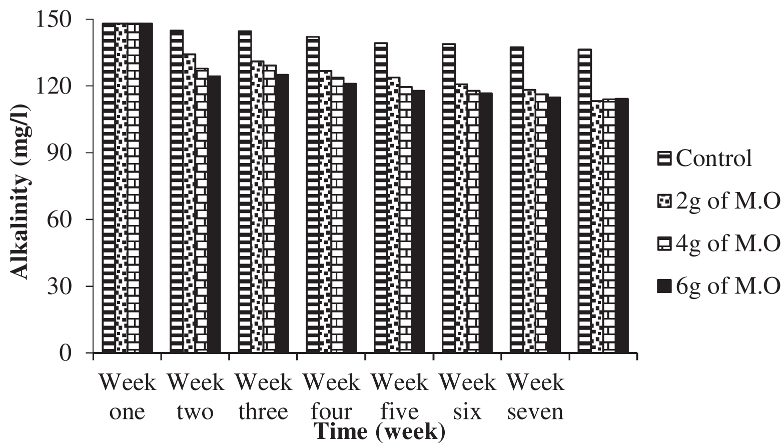

Figure 2: Effect of treatment on alkalinity

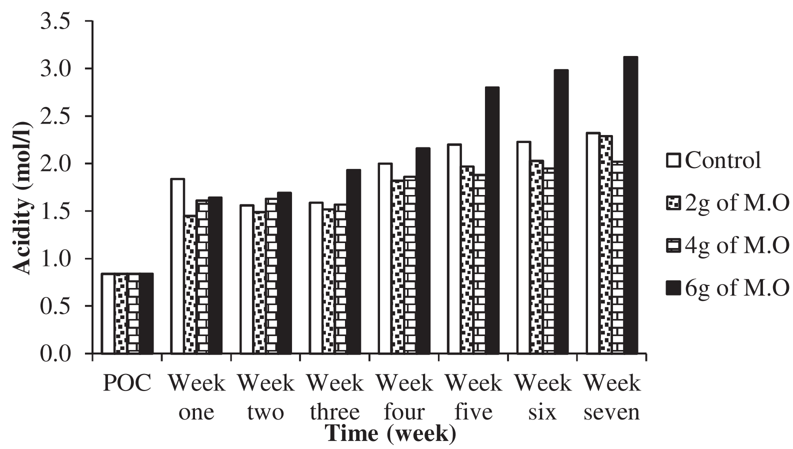

Figure 3: Effect of treatment on acidity

3.3. Total Solids (Suspended solids and Dissolved Solids)

The concentration of suspended solids (SS) at the point of collection was 384 mg/l while the concentration of dissolved solids (DS) at the point of collection was 896 mg/l. Figures 4 and

5 show the trend observed in the course of treatment for SS and DS. The percentage of suspended and dissolved solids removal was 6.51%, 17.37%, 20.23% and 20.66%, and 7.48%, 7.85%, 8.45% and 8.67% for the control, 2 g, 4 g and 6 g of *Moringa oleifera* respectively. This level of removal was small and the percentage of DS remaining was above that required by World Health Organisation (WHO, 2006). The percentage removal of solids was low because *Moringa oleifera* only removes particles through contact collision. This explains why there was a higher removal of suspended solids than dissolved solids. This trend supports the earlier findings regarding the use of *Moringa oleifera* seeds powder as a coagulant in water purification system (Ghebremichael et al., 2005).

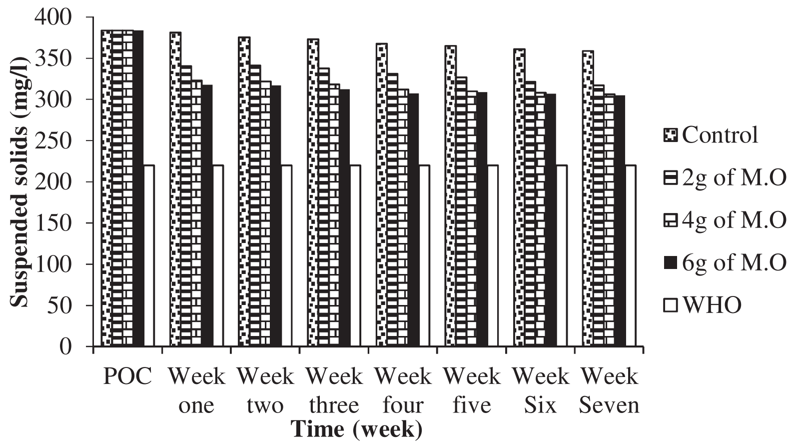

Figure 4: Effect of treatment on suspended solids

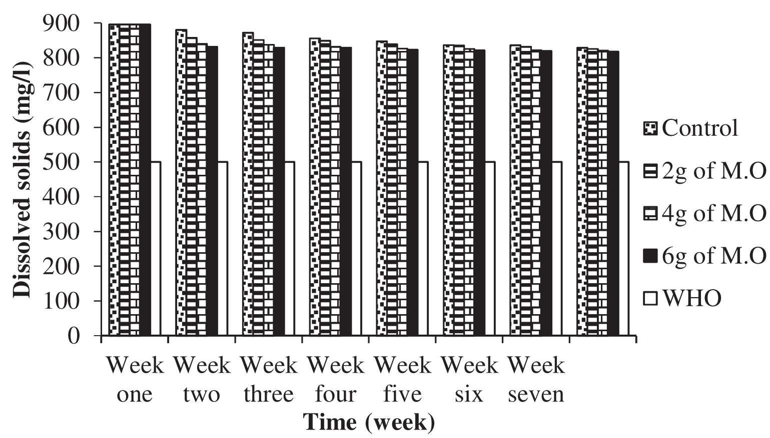

Figure 5: Effect of treatment on dissolved solids

3.4. Dissolved Oxygen

There was a rapid increase in the dissolved oxygen concentration when the dosage of *Moringa oleifera* was increased from 2 g to 4 g in the first four weeks as shown in Figure 6. The control culture had the least DO of 110 mg/l after the seven weeks of the experiment, while 2 g *Moringa oleifera* treatment had 118.2 mg/l. The 4 g *Moringa oleifera* treatment had

125.17 mg/l and 124.3 mg/l at week two and three, respectively. The 6 g treatment had DO values reduced from 125 mg/l to 18.6 mg/l. The increase in DO for the 2 g and 4 g could be attributed to the fact that *Moringa oleifera* is a biological material and tends to deteriorate with time. As a result, it causes a reduction in percentage DO. This could also result in an increase in the BOD and CO_2 because of increased microbial activities.

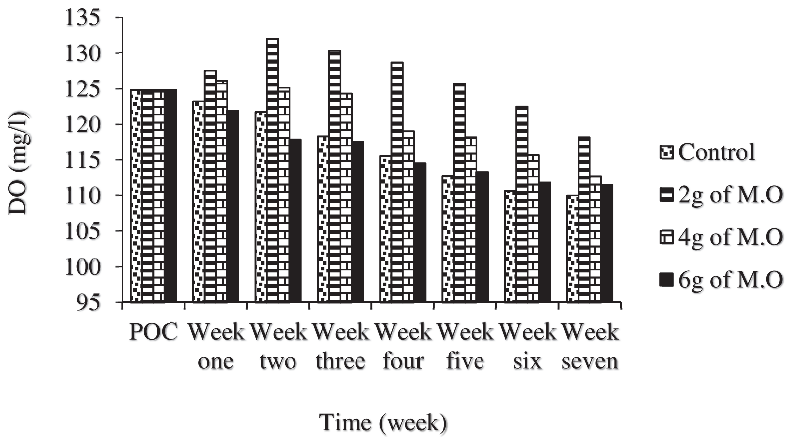

Figure 6: Effect of treatment on DO concentration

3.5. Conductivity

The initial conductivity (*k*) at the point of collection was 1868 ɥs^{-1}. The average reduction of conductivity after seven weeks of analysis was 1841.7 µs^{-1}, 1828 µs^{-1}, 1828.3 µs^{-1}, and 1820 µs^{-1} for the control culture, 2 g, 4 g and 6 g of *Moringa oleifera*, respectively. This shows that *Moringa oleifera* treatment had no effect on conductivity.

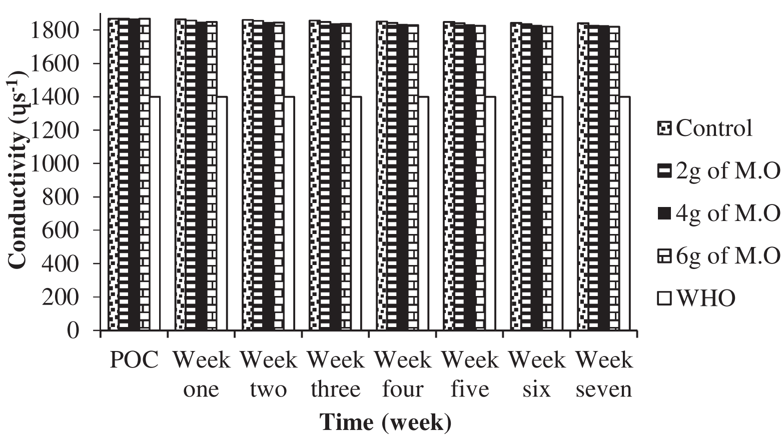

Figure 7: Effect of treatment on conductivity

3.6. Turbidity

The turbidity at the point of collection was 5.94 NTU. From Figure 8, the turbidity level was observed to reduce when the coagulant dosage was increased from 2 g to 6 g. This could be taken as an indication of some level of treatment occurring during the process.

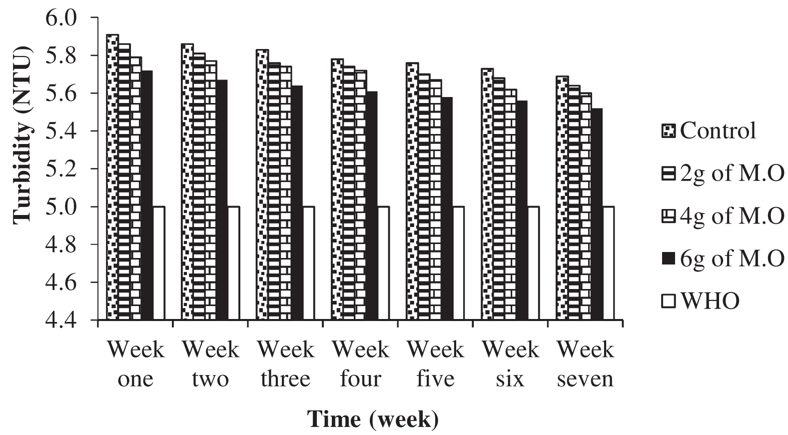

Figure 8: Effect of treatment on turbidity

3.7. pH

The pH of the domestic sewage at the point of collection was 9.6 and after treatment, the pH value dropped to an average of 9.21, 7.8, 7.57 and 7.1 for the control, 2 g of *Moringa oleifera*, 4g of *Moringa oleifera*, and 6g of *Moringa oleifera* treatments. The recommended acceptable range of pH for effluent from a treatment plant as specified by WHO is between 6.0 and 8.0 (WHO, 2006). The pH decreased with increasing concentrations of the *Moringa* coagulant. Ndabigengesere and Narasiah (1998) reported that the action of *Moringa oleifera* as a coagulant lies in the presence of water-soluble cationic proteins in the seeds. This suggests that in domestic wastewater, the amino acids present in the protein of *Moringa* would accept a proton from domestic wastewater, which is basic in nature due to the presence of salts, resulting to neutralisation. Onwuliri and Dawang, (2006) reported that the seeds from *Moringa oleifera* are effective in the treatment water in the rural communities in comparison.

3.8. Biochemical Oxygen Demand

The initial BOD of influent was recorded to be 96.5 mg/L, but after seven weeks of treatment, the following BOD readings were obtained 93.5, 80.6, 82.5 and 76.3 mg/l respectively for the control, 2 g, 4 g and 6 g of *Moringa oleifera* treatments as shown in Table 1. Presented in Table 2 is the analysis of variance result and it shows that a higher concentration of *Moringa oleifera* is required for better removal of BOD. The results also revealed that the removal of BOD by *Moringa oleifera* was significantly different at $p < 0.05$ with respect to the dosage.

Table 1: Effect of treatment on BOD

Time (weeks)	Amount of coagulant			
	Control	2 g/l	4 g/l	6 g/l
1	96.2	94.0	89.3	87.3
2	95.9	93.3	89.0	86.5
3	95.4	87.0	88.0	85.0
4	94.5	89.0	86.4	83.5
5	94.5	83.0	84.1	81.0
6	94.2	83.0	83.4	77.9
7	93.5	80.6	82.5	76.3

Table 2: ANOVA results for BOD

	SS	df	MS	F	Significance
Treatments	423.236	3	141.079	11.070	<0.05
Errors	305.864	24	12.744		
Total	729.100	27			

3.9. Chemical Oxygen Demand

The initial COD of the influent was 51.5 mg/l. After the treatment, the following results were obtained: 78.3 mg/l, 75.3 mg/l, 72.5 mg/l and 68.7 mg/l for the control, 2 g, 4 g and 6 g of *Moringa oleifera* treatments respectively. Tables 3 and 4 are the result obtained from the determination of COD and the ANOVA result. The ANOVA result reveals that the effect of dosage was statistically significant.

Table 3: Effect of treatment on COD

Weeks	Control	Amount of coagulant		
		2 g/l	4 g/l	6 g/l
1	81	79.2	77.4	75.5
2	80.7	78.9	76.9	74.7
3	80.2	78.8	76	74
4	79.2	78.5	75.9	73.4
5	79	77.6	75	71.7
6	78.6	77.3	74	69.1
7	78.3	75.3	72.5	68.7

Table 4: ANOVA results for COD

	SS	df	MS	F	Significance
Treatments	227.679	3	75.893	23.802	<0.05
Errors	76.526	24	3.189		
Total	304.205	27			

3.10. Microbial Analysis

At the end of the experiment, there was a slight reduction of coliform counts for both 4 g and 6 g *Moringa oleifera* treatment. However, the total faecal coliform count for all the treatment was greater than 300 cfu/ml. Table 5 shows the comparison of the average faecal coliform count of the various *Moringa oleifera* treatments and control culture.

Table 5: Average bacterial count

Description	Colonies on Nutrient Agar (cc)	Coliform org. in 100 cc	*E. coli* per 100 cc
Point of collection	350	250	20
Sample with 2g of *Moringa oleifera*	330	240	10
Sample with 4g of *Moringa oleifera*	310	210	5
Sample with 6g of *Moringa oleifera*	300	185	5

4. CONCLUSION

Moringa oleifera has been established to be coagulant suitable for the treatment of domestic wastewater. *Moringa oleifera* being a natural plant makes it environmentally-friendly and has an added advantage of having antimicrobial properties. The turbidity, water hardness, suspended solids, dissolved solids, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) showed reductions while dissolved oxygen (DO) showed some increase indicating that some level of treatment was achieved. The coagulating effectiveness of *Moringa oleifera* increases as the dosage increased. *Moringa oleifera* seeds present a viable alternative coagulant for the treatment of domestic wastewater.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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