EFFECTIVENESS OF *MORINGA OLEIFERA* FOR ABATTOIR WASTEWATER TREATMENT

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https://doi.org/10.62050/faic2024.bop24.012

ABSTRACT

Humans and the environment can be harmed by poor management of liquid effluents, solid waste, and offensive odour from meat processing. For five (5) weeks, the performance evaluation of *Moringa oleifera* seed as a coagulant for the treatment of abattoir wastewater was investigated. The treatment used a completely randomized design with loading dosages of 12, 14, 16, 18, 20, and 22g/500 mL of processed *Moringa oleifera* seed. A control group of wastewaters from the slaughterhouse located in Minna that had not been treated with *Moringa oleifera* was also included as a control. The chemical characteristics of abattoir wastewater were studied both before and after treatment with *Moringa oleifera*. In the fifth week, *Moringa oleifera* seeds appreciably removed turbidity with high percentage value of 56.6% from 17.80mg/l to 11.20mg/l using 22g/500ml. Total alkalinity concentration in the sample decreased rapidly in the first week from 216.67 mg/l for control to 63.67 mg/l at 22g which represents 70.61 % reduction which happens to be the optimum dosage based on the observations. *Moringa oleifera* reduced the total hardness efficiently to its minimum from 141mg/l at week 1 to 69.200mg/L at week 5 with removal efficiencies of 51.18% at 22g/500ml dosage concentration. The optimum dosage was 69.200 mg/L with 22 g/500ml observed at week 5. Decrease in the Dissolved Oxygen levels from 4.67 mg/L to 2.07mg/l at week 5 for 22g was observed showing a total decrease of 55.67%. Phosphate was reduced from 2.26 mg/l to a minimum of 0.57mg/l at weeks 4 and 5 at 16g/500ml with maximal removal efficiency of 74.78% below the NSDWQ of 10mg/L. Moringa reduced the Electrical conductivity of abattoir waste water from 1395.67mg/L to 652.67mg/L at week 1 below NSDWQ of 1000mg/L but increased with greater settling time (week 2 to 5) and dosage concentration. For Calcium, the natural coagulant *Moringa oleifera*, produced a substantial decrease in calcium contents of the wastewater at different concentrations with optimum removal efficiency of 70.09% at 16g/L dosage concentration in week 5. At optimum dosage of 22g/L concentration, Moringa at week 5 reduced the Zinc to 0.41mg/l with removal efficiency of 71.13%. The high content of zinc has been attributed to high blood volume found in wastewaters. *Moringa oleifera* has thus been confirmed as an effective natural coagulant which can be used in improving the physicochemical characteristics of water.

Key Words: Abattoir wastewater, *Moringa oleifera*, Physio-chemical parameters.

1.0 Introduction

Water is one of the essential element of life on earth. Owing to the countless man-made sources of pollution brought about by different industrial breakthroughs during the year, this essential resource is getting harder to find in its natural state. Water is an element of nature. Water

pollution is a serious problem that impacts everyone on the planet. Both the environment and human health have suffered as a result of it (Lasisi, 2021).
The processing of animal products for human consumption heavily contaminates surface water. While some contaminants can be handled by natural re-aeration processes, these mechanisms get overwhelmed when the concentration of wastewater from slaughterhouses increases, leading to pollution problems (Sighn, 2017). Raw abattoir effluent discharge into bodies of water has an effect on the quality of the water because it lowers dissolved oxygen (DO), which can kill aquatic life. Moreover, macronutrients that can cause eutrophication include phosphate and nitrogen. These nutrients are released and cause algae to proliferate and decompose.
The effects of the meat processing industry on general public health are associated with both direct and indirect human-environment interactions. The former can be negatively impacted by improper handling of liquid effluents, solid waste, and offensive odours (Lasisi, 2021). Conventional treatment phases had no effect on the amount of antibiotic-resistant Escherichia coli strain found in wastewater from slaughterhouses. In terms of the spread of harmful and antibiotic-resistant bacteria into the environment, (Adeniran, 2017), emphasizes the threats to public health associated with effluent from improperly treated abattoir processing houses.
Moringa oleifera, also known as (Saijan or drum stick), is a year-round tropical tree that can withstand drought and is well-known for its several pharmacological benefits, including its anti-inflammatory, analgesic, and anti-hypertensive properties (Tamilselvi, and Arumugam, 2019). Water treatment applications have made advantage of the coagulating qualities of *Moringa oleifera* seed powder. The primary aim of wastewater treatment is to eliminate particles from the treated water so that its quality and utility are not compromised when it is discharged into water bodies. Even with the many water treatment techniques used, a significant expenditure is still required for the majority of this wastewater (Eman *et al.*, 2017).

According to Subramanium *et al.* (2015), the most popular natural sources for wastewater treatment include rice, peanuts, beans, and *Moringa oleifera*. *Moringa oleifera* seeds have been used to treat wastewater since they are non-toxic to humans and have minimal drawbacks. There are several disadvantages of using chemical coagulants, such as high expense and pH variations. *Moringa oleifera*'s coagulant is safe to use, non-toxic, biodegradable, and non-corrosive (Eman *et al., 2017).* According to recent research, there are no harmful effects when *Moringa oleifera* seeds are used to remediate wastewater (Joshua and Edokpayi, 2017). Without further processing, wastewater can be treated immediately with *Moringa oleifera* seed cake residue.

2.0 Materials and Methods

2.1 Collection and preparation of coagulant (*Moringa oleifera*)

Mature pods of Moringa oleifera were selected from fruits with dry cracks (Plate III). After the harvested fruits were cracked and allowed to air dry for a few days, the seeds were extracted. To create a fine powder, the seed kernels were crushed in a mortar and pestle and then passed through a 600 m stainless steel sieve. The sterile plastic rubber containing the tiny powder was refrigerated.

2.2 Experimental Design

A fully randomized design was used for this experiment. A sample of wastewater from an abattoir diluted with distilled water served as the control, while the treatments included varying amounts of powder manufactured from Moringa seeds. The following factors affect the reaction differently for each therapy: total alkalinity, total hardness, turbidity, zinc, calcium, manganese, and conductivity; potential of hydrogen; biological oxygen demand; chemical oxygen demand; and dissolved oxygen. each experiment was repeated three (3) times.

2.3 Sample preparation

Forty (40) liters of wastewater from an abattoir were taken from the slaughterhouse in Anguwan Biri, Tayi village, Minna, Niger state. There were twenty-one beakers created out of it. Each of the eighteen (18) beakers contained 500 milliliters of the abattoir wastewater sample. In three (3) beakers, the control sample was 500 ml of wastewater from the slaughterhouse mixed with 500 ml of distilled water devoid of Moringa oleifera. Five distinct amounts of the stock solution for the loading dosage were obtained by weighing 12, 14, 16, 18, 20, and 22g of Moringa powder into beakers with 500ml of distilled water. The liquids were well combined in the beakers to produce a clear solution and was allowed to settled without any disturbances for an hour. The solution was separated from the settle sludge and quantified into a 500 ml sample of wastewater from the abattoir through sieving. After being recovered, the supernants were used in an experiment.

3.0 Results and Discussion

3.1 Physio-chemical properties of abattoir wastewater

The Physio-chemical properties of abattoir wastewater analyses and the two standards used in comparing the permissible limits are presented in Table 1.

Table 1: Result for Raw water analysis at week 1.

Parameter	Values	WHO	NSDWQ
Physical parameters			
pH	6.96	6.5 – 8.5	6.5 – 8.5
Turbidity (NTU)	17.80	<5	5
Total Alkalinity	216.67	300	500
Temperature (^oC)	25	NIL	Ambient
Electrical Conductivity (uS/cm)	1395.67	400	1000
Chemical parameters			
Calcium (mg/L)	30.53	100-300	100
Total Hardness (mg/L)	141.33	NIL	100
Phosphates (mg/L)	2.26	1	10
Dissolved Oxygen (DO) (mg/L)	6.67	250-500	250-500
Zinc (mg/L)	1.42	0.3	0.3

From the results presented in Table 1, it was observed that the values of the physiochemical properties of the waste water did not conform to the set limit the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ). The Turbidity of the sample is above the standard value of 5Ntu set by the Nigerian Standard for Drinking Water Quality (NSDWQ). So, the need for the treatment of the waste water was very obvious.

3.2 pH

The pH value 6.96 of the untreated waste water does not allow for maximum efficiency. Adjusters should be adapted when treating a pH of coagulants in treating the waste water.

p-ISBN: 978-978-774-670-7

Hence pH adjusters should be adapted when treating a pH range that is far from neutral. It is often necessary to adjust the pH of the water to optimize coagulation and flocculation. The average pH of the abattoir wastewater, without Moringa Oleifera treatment was found to be 6.96 mg/l at collection point and dropped to 6.80, 6.78, 6.76, 6.71, 6.65, 6.65 with 12, 14, 16, 18, 20 and 22g of Moringa oleifera treatment added respectively all in the first week. The capacity of Moringa oleifera as a coagulant resides in the presence of cationic water-soluble protein present in the seeds, which explains why the solution becomes more alkaline. This allows the alkaline amino acids in Moringa oleifera protein to absorb protons in water, resulting in the release of hydroxyl groups, causing the solution to become alkaline (Marzougui *et al*., 2021). The pH value was, however, observed to be increasing as weeks passed by from week 1 through week 5 across all the doses as shown in Figure 1.

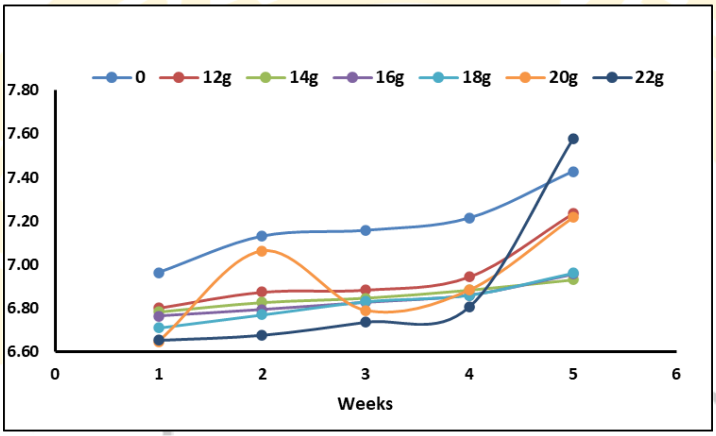


Figure 1: pH values with *Moringa oleifera* treatments.

This agreed with Desta and Bote (2021) which concluded that the increase in pH value leads to the increase in the removal efficiency of *M. Oleifera*. From Figure 1, the pH values got to its smallest in week 1 across all doses with the minimum of 6.65mg/l, using 20g/500ml and 22g/500ml of *Moringa Oleifera* dosage. The WHO recommended standard of pH for industrial wastewater discharge after treatment is between 7 to 8mg/L.

Table 2: Maximal Dosage of *M. Oleifera* with Optimum Result and effect on varying parameters

Parameters	Maximal Dosage with Optimum Result	Effect on Parameters	Duration
pH	20g and 22g	Reduction	Week 1
Turbidity	22g	Reduction	Week 5
Total Hardness	22g	Reduction	Week 3 & 5
Electrical Conductivity	22g	Increment	Week 4
Zinc	22g	Reduction	Week 5
Dissolved Oxygen	22g	Reduction	Week 3 & 4
Calcium	16g	Reduction	Week 5
Phosphates	16g	Reduction	Weeks 4 and 5
Total Alkalinity	14g	Reduction	Weeks 2 to 5

3.3 Turbidity

From the result obtained the optimum dosage in the jar test is the beaker with the least turbidity. The turbidity reduction efficiency was calculated using the equation:

$$Turbidity\ Reduction\ Efficiency\ \% = \frac{To - T1}{To}\ x\ 100$$

Where;

T_0 = Initial Turbidity

T_1= Final Turbidity

The addition of excess coagulant may reduce the turbidity beyond what is required and could also lead to the production of more sludge which would require disposal.

Turbidity of abattoir wastewater treated with coagulant Moringa Oleifera seed powder increased with increase in concentration of coagulant stock solution at week 1, from 17.80 to 19.73. But with greater settling time, the result showed a substantial turbidity decline from week 2 to week 5 (Figure 2). The decline observed showed that cationic protein in the Moringa oleifera dosage had started reacting (Vigneshwaran *et al*., (2020; Desta and Bote 2021). As a result of these interactions, the forces that stabilize the particles are disrupted, allowing it to attach to microscopic particulates and create precipitate. The optimal dosage of Moringa dosage was found to be 22g/500ml of Moringa Oleifera dose in week 5 where it went from 17.80 to 11.20 NTU which signified 56.6 % turbidity removal from the wastewater (Figure 2) as against 94.4 % turbidity reported by Vigneshwaran *et al*., (2020). There is a likelihood of the destabilized particles, probably as a result of overdosing.

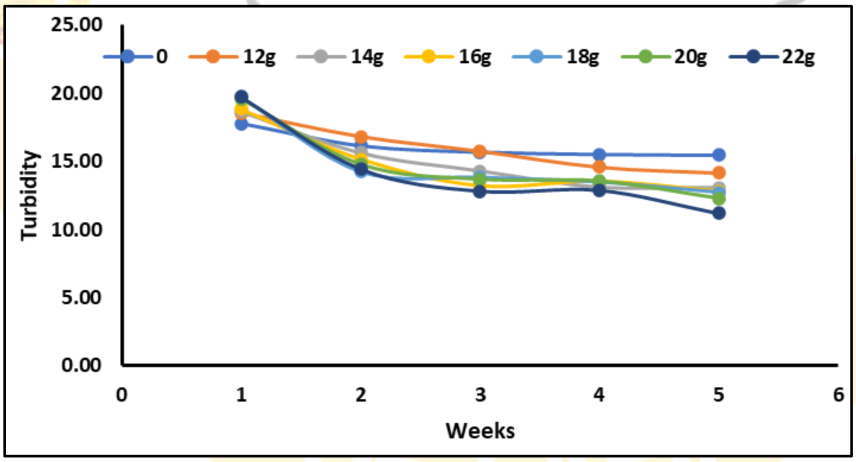


Figure 2: Turbidity values with Moringa oleifera

This was evident as shown in Figure 2 as there was an improvement in turbidity level from week 2 at 12g/500 ml. This has been attributed to the saturation of the polymer bridge (Megersa *et al*., 2016). However, *Moringa Oleifera* seeds have shown appreciable removal of turbidity with high percentage value of 56.6% from 17.80mg/l to 11.20mg/l at week 5 using 22g/L dosage of Moringa Oleifera. Although the treated water sample's turbidity did not meet the NSDWQ and WHO set limit of 5NTU and <5NTU respectively. However, the turbidity decreased greatly, confirming the theory that the natural coagulants are very effective in treating highly turbid water.

The effectiveness of natural coagulants in treating highly turbid water is dependent on several factors which include, The type, the dosage of the coagulant, the settling time and the initial turbidity of the water.

3.4 Calcium

Due to the nature and composition of the abattoir waste water, the presence of calcium was found to be in substantial quantity of 30.53mg/L below the safe limit of NSDWQ. The natural coagulant *Moringa Oleifera*, produced a substantial decrease in calcium contents of the wastewater at different concentrations with optimum removal efficiency of 70.09% at 16g/L dosage concentration in week 5 (Figure 3). The stock solution of *Moringa* has proven to be effective in the reduction of calcium with 70% removal efficiency.

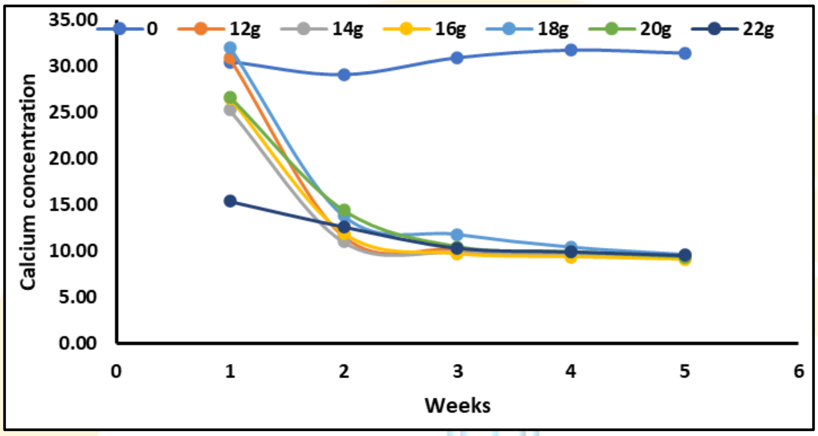


Figure 3: Calcium values with *Moringa oleifera*

3.5 Total hardness

The hardness level of the abattoir waste water was detected to be 141mg/L above the NSDWQ of 100mg/L as a result of the presence of calcium and a variety of other metals. The reduction in calcium from analyses above affirms the intermittent decrease in total hardness of the waste water effluent. Moringa reduced the total hardness efficiently to its minimum from 141mg/l at week 1 to 69.00mg/l at week 5 with removal efficiencies of 51.18% at 22g/L dosage concentration. There was general reduction in total hardness from weeks 1 to 5 and as the Moringa Oleifera doses increased as shown in Figure 4. Calcium salts tend to cause incrustations on cooking utensils and water heaters. Hence is essential to soften the portable water.

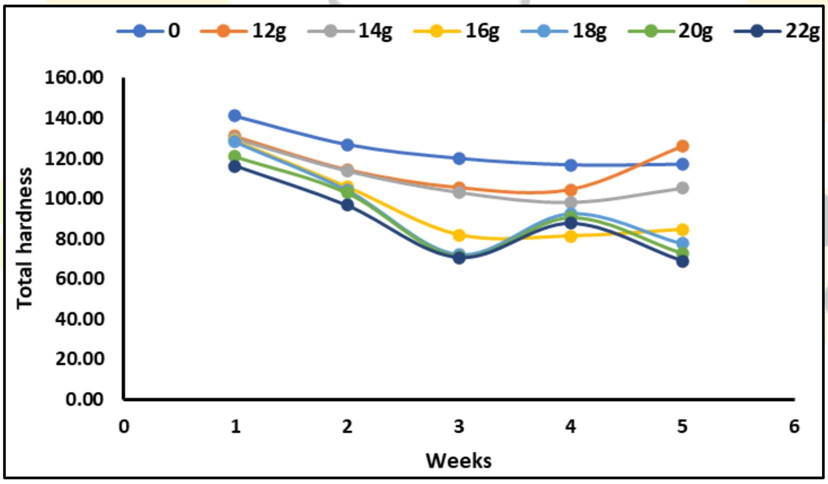


Figure 4: Total Hardness values with *Moringa oleifera*

This simply implies that as the number of hardness-causing species in the sample increases, the required Moringa Oleifera doses will also increases. The Initial total hardness of the samples at the point of collection was estimated to be 141.3 mg/l at Week 1. The result, therefore, showed that the higher the quantity of Moringa oleifera applied, the higher the hardness that was removed. As a result of this fact, 22g of Moringa oleifera had the highest potency in reducing hardness of wastewater.

3.6 Electrical conduct (EC)

The electrical conductivity analysis affirmed the presence of Total Dissolved Solids present in the abattoir wastewater before and after treatment. The conductivity of wastewater at the point of sampling (week 1) was observed to be 1395.67 µs/cm and decreased at minimum with increase in dosage concentration of 14g/L natural coagulant to 652.67uS/cm in the 1st week after treatment.

There was drastic increase in average value of conductivity after the first week across all the treatments. The value at the point of collection increased from 1395.67 208 µs/cm to 1886.67 µs/cm with 22g Moringa oleifera treatment at week 4 which is about 35.18 % increase (Figure 4). The level of percentage increase at 22g *M. Oleifera* treatment is common to all other treatments as observed. Generally, conductivity was observed to increase with time, though with gradual reduction with Moringa Oleifera treatments (Figure 4). The increase in the conductivity reading has been attributed to the ions formation in the water during the coagulation process as reported by Tunggolou and Payus (2017). Thus, higher coagulant dosage in the solution beyond optimum dosage will eventually lead to an increase in conductivity as observed due to the presence of unbound ions (Yuliastri *et al*., 2016). It is also important to note that Moringa is found to be effective in reduction of concentration and presence of dissolved ions such as sodium and calcium which bring about electrical conductivity. Moringa reduced the Electrical conductivity of the Abattoir waste water from 1395.67mg/L to 652.67mg/L at week 1 below NSDWQ of 1000mg/L but increased with greater settling time (week 2 to 5) and dosage concentration.

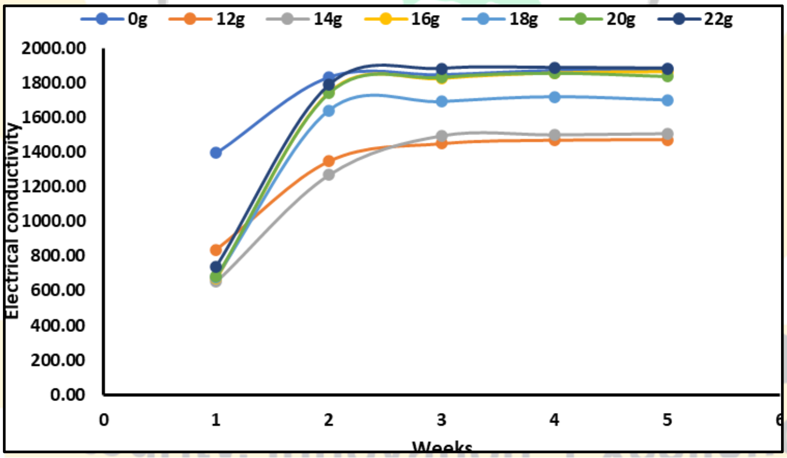


Figure 5: Electrical Conductivity values with *Moringa oleifera*

3.7 Heavy metal (Zinc)

The presence of Zinc as one of the heavy metals in abattoir waste water at collection point was 1.42mg/L which is below the World Health Organization (WHO) water safety limit of 5mg/l which reduced drastically to an extremely safety disposable level. Figure 6 shows the general decrease in zinc values from week 1 to week 5. At optimum dosage of 22g/L concentration, Moringa at week 5 reduced the Zinc to 0.41mg/l with removal efficiency of 71.13%. The high content of zinc has been attributed to high blood volume found in wastewater. Hence *M. Oleifera* used in this experiment have proven to be effective in reduction of Zinc in abattoir

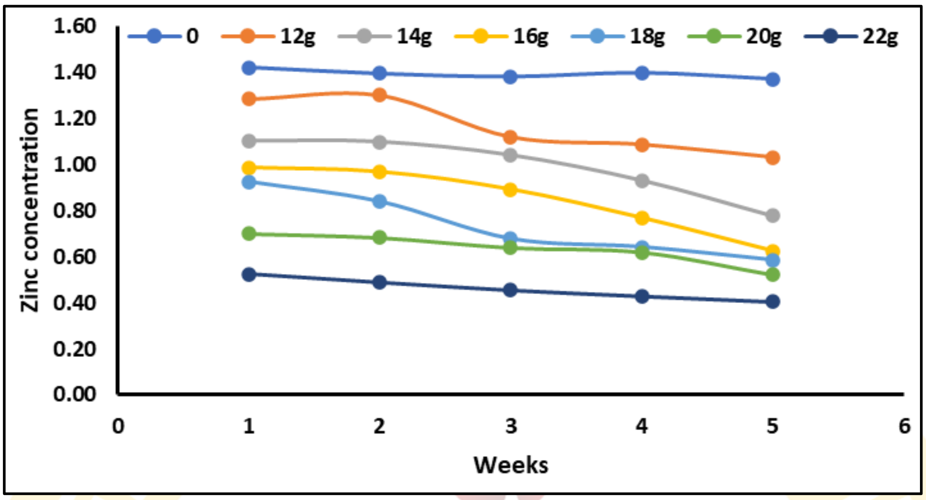


Figure 6: Zinc values with *Moringa oleifera* treatments.

waste water sample.

3.8 Phosphate

The phosphates present in the hospital waste water was 2.26mg/l below the NSDWQ for waste water 10mg/L. Moringa coagulants used reduced the phosphate level significantly far below the NSDWQ set limit (Figure 7). Phosphate was reduced from 2.26 mg/l to a minimum of 0.57mg/l at weeks 4 and 5 at 16g/500mL dosage concentration respectively. With greater settling time and increase in dosage concentration the phosphate level increased in the waste water. Moringa was found to be effective in the reduction of phosphates with maximal removal efficiency of 74.78% below the NSDWQ of 10mg/L.

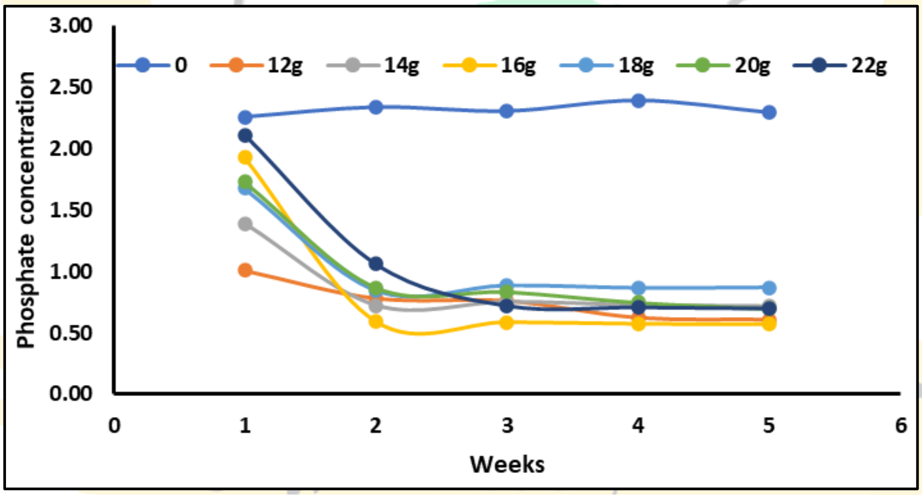


Figure 7: Phosphate values with Moringa oleifera

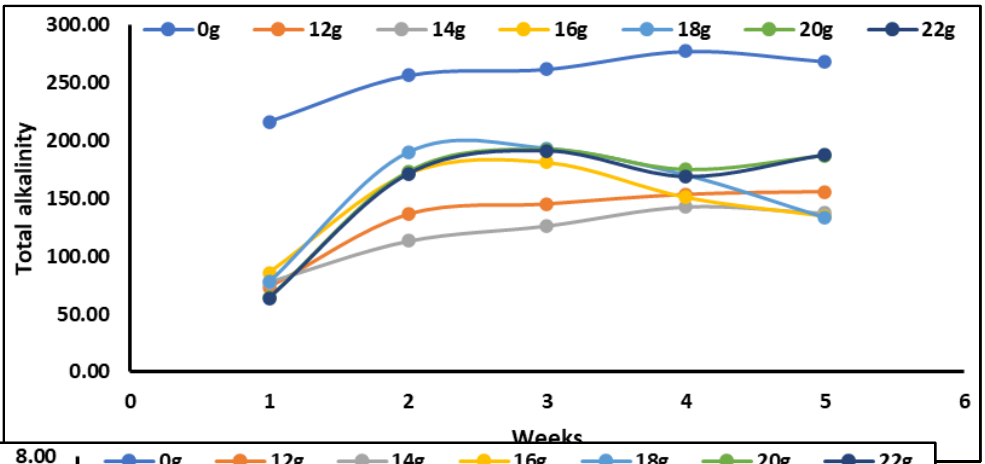
3.9 Total alkalinity

The presence of Alkalinity at the collection point was 216.67 mg/L. Figure 8 shows that it decreased rapidly in the first week from 216.67 mg/l for control to 63.67 mg/l at 22 g Moringa Oleifera treatment which represents 70.61 % reduction. From Figure 8, in all the weeks, there is general reduction in total alkalinity levels as Moringa oleifera content increased. As a result of this fact, 14 g of Moringa oleifera had the highest potency in reducing total alkalinity of

p-ISBN: 978-978-774-670-7

wastewater because from figure 8 below the wastewater treated with 14g dosage concentration of *M. Oleifera* had the lowest alkalinity in weeks 2, 3,4 and 5.

3.10 Dissolved oxygen



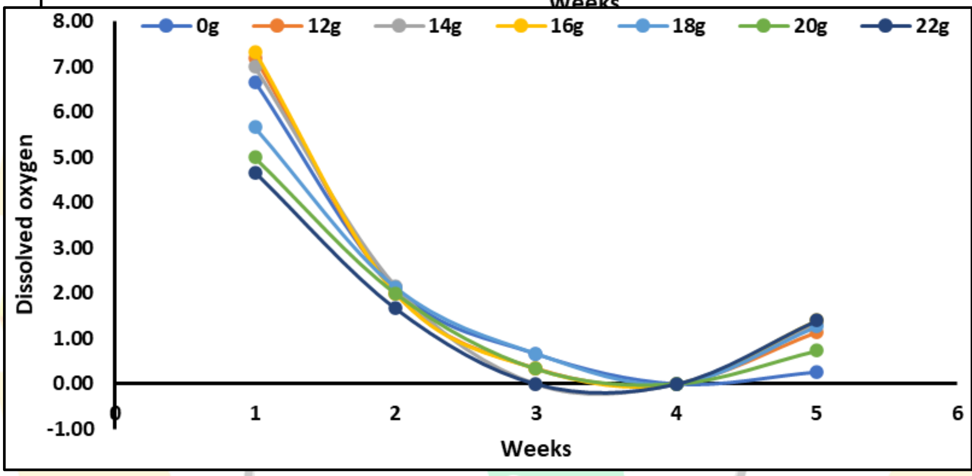


Figure 9: Dissolved Oxygen (DO) with *Moringa oleifera*

From Figure 9, the dissolved oxygen was 6.67mg/l at point of collection. It reduced to 5.67, 5.00 and 4.67mg/l with Moringa Oleifera treatment of 18, 20 and 20g. In week 2 and 3, there was also significant treatment of the dissolved oxygen but from 22g dosage concentration in week 3 proceeding to week 4 there was complete treatment across the samples, from 0.33mg/l to 0.00mg/l. The dissolved oxygen in the sample was totally evaporated by the Moringa Oleifera dosages in the abattoir wastewater. Decrease in the DO levels from 6.67 mg/L to 0.27 mg/L at week 5 for control and 4.67 mg/L to 2.07mg/l at week 5 for 22g Moringa Oleifera treatments respectively was observed showing the total decrease of 95.95% and 55.67% for both treatments respectively, which is in agreement with published observations (Yuliastri *et al.*, 2016). The decrease in DO levels has been attributed to the presence of natural and organic compounds present in Moringa Oleifera seeds (Verma *et al.*, 2020).

4.0 Conclusion

An attempt has been made to evaluate the effectiveness of natural coagulant *Moringa Oleifera*, in treating abattoir wastewater. Characterization of the abattoir waste water proven that there exist very high; turbidity, alkalinity, heavy metal (Zinc), Dissolved Oxygen (DO), Electrical conductivity and elements such as calcium and phosphates that constituted to total hardness.

From the results derived in the previous chapter a conclusion has been drawn to proven that at 14g dosage concentration of M. Oleifera the Total alkalinity of wastewater is reduced to its minimum, at 16g dosage concentration of M. Oleifera the Phosphates and Calcium are reduced to their minimum value and finally at 22g dosage concentration of M. Oleifera the pH, Total Hardness, heavy metal (Zinc) and Dissolved Oxygen are reduced to their minimal while Electrical conductivity is increased. It is therefore safe to conclude that the Optimum dosage for treatment of abattoir wastewater is 22g/500mL.

However, *Moringa* in this experimental study has shown appreciable reduction of Calcium, Phosphates, Electrical conductivity (EC) with high percentage values which indicates that the natural coagulant is highly effective for treatment of Abattoir waste water. The quality of abattoir wastewater treated with the use of this natural coagulant is comparable to the quality of waste water treated by commercial coagulant and hence can be used to replace aluminum sulphate as commercial coagulant. However, the effectiveness of natural coagulants may vary depending on several factors, including the type and concentration of natural coagulant, the characteristics of water being treated, pH of the water and the operating conditions of the treatment system. Therefore, it is important to conduct further research to optimize the use of natural coagulants in water treatment and to identify any potential limitations or drawbacks of this approach.

Moringa oleifera is an effective natural coagulant which can be used in improving the physicochemical characteristics of water in terms of pH, turbidity, total alkalinity, total hardness, Dissolved Oxygen (COD), calcium, phosphates, heavy metal (Zinc) and Electrical conductivity. Moringa oleifera seeds present a more efficient and cheaper way of treating abattoir wastewater which should be adopted as method of treatment before discharge into surface water body. Since 22g/500ml of *Moringa Oleifera* was able to treat abattoir wastewater more efficiently this thus confirms the suitability of using *Moringa Oleifera* seeds for abattoir wastewater treatment.

Conflict of Interest

The authors declare that no competing interest exists.

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