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Comparative Study on the Use of *Moringa Oleifera* as Natural Coagulant and Aluminium Sulphate in Restaurant Wastewater Treatment

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ABSTRACT

The enormous amount of wastewater generated by restaurants often require some level of treatment before disposal. This is partly achieved by using synthetic coagulants with its attendant environmental risk. This study is aimed at investigating the use of Aluminium Sulphate (AS) and Moringa oleifera (MO) for treating restaurant wastewater (RW). Different doses (0, 50, 100, and 150 mg/l) of the prepared stock solution of AS and MO were applied to 1000 ml of RW collected from a University restaurant. The result showed that the treated sample pH reduced from 7.55 to 6.86 and 7.0 at an optimum dose of 150 and 50 ml for AS and MO while conductivity increased from 1.03 to 2.22 mg/l and 1.74 mg/l for AS and MO, respectively. Turbidity reduced from 44.73 mg/l to 5.20 mg/l for MO and 5.77 mg/l for AS; dissolved oxygen increased from 0.35 to 0.51 mg/l and 0.70 mg/l for MO and AS; Magnesium reduced from 21.11 to 14.77 mg/l for MO, but increased to 29.07 mg/l for AS; Zinc increased from 1.19 to 6.15 mg/l for MO and 7.10 mg/l for AS, while Calcium increased from 2.02 mg/l to 5.09 mg/l for MO, and 3.09 mg/l for AS. The MO seed extract achieved a better reduction of pH and turbidity at higher dose while no distinct trend was observed in all the parameters when AS was applied. Doses of MO seed extract can be further optimized and applied as a low cost option for RW treatment.

Keywords: Moringa oleifera; aluminium sulphate; natural coagulant; restaurant wastewater; dosage

INTRODUCTION

Water is a key commodity essential for sustenance of life on earth, it is useful for domestic and industrial activities. World Health Organization WHO (1971), reports that wholesomeness of water means the absence of suspended solids, inorganic solids, and pathogens.

The purity of drinking water is expected to be very high since it has a direct effect on human health. In many developing countries, access to clean and safe water is a major problem (Teow et al. 2018). It was reported by the United Nation that 1.1 billion people still do not have access to an adequate supply of drinking water and this has made these people to be classified among the world poorest. The limited availability of quality water has resulted in poor livelihood and health with 80% of all diseases in developing countries being water-related (OECD 2006). The growing population in Nigeria is putting pressure on clean water resources resulting in the generation of a high volume of wastewater (Adegoke et al. 2020). Pollution of clean water sources also occurs due to the discharge of spent water from the food processing factory into the watercourse (Nurul et al. 2017).

Wastewater generation could be as a result of activities from the domestic environment or from the various industries. The major source of water is surface water which is usually obtained from stream, rivers, and lake. A different approach has been adopted for the treatment of wastewater. Treated wastewater has high quality and can be reused for other purposes (Teow et al. 2018). There are different methods that can be adopted for the treatment of wastewater, some of these treatments could be conventional such as wetlands, chemical precipitation, filtration, disinfection, softening, electro-coagulation, pH regulation, oxidation and reduction, electrochemical treatment, reverse osmosis and ion exchange are used to improve water quality. However, these methods are economically non-viable due to the high cost of chemicals, plant maintenance and the requirement for expertise (Volesky 2003; Basu et al. 2003; Glenda and Gregory 1996). The chemical treatment which involves coagulation and flocculation is widely considered in developing country as a result of its cost (Tan et al. 2017). Koohestanian et al. (2008) explains coagulation as a process when a coagulant is added to water to "destabilize" colloidal suspensions. In a colloidal suspension, particles will settle very slowly or not at all because the colloidal particles carry surface electrical charges that mutually repel each other. While flocculation is a physical process that does not involve the neutralization of charge but could be used in conjunction with coagulation to assist in water clarification during water treatment.

Synthetic coagulants of chemical origin such as soda ash, AS, and ferric acid are often considered and used for the treatment of water, but the negative effect of the coagulant which is released into the water bodies and their efficiency is increasingly becoming a major source of concern to the society. Different researchers have expressed their concern on the use of synthetic coagulants in water treatment, due to their adverse effect on the end users in the society such as Alzheimer's disease (Crapper et al. 1973). The problem is more pronounced in the rural and semi-urban communities due to low sensitization on sustainable water treatment options, lack of social amenities and inadequate infrastructural facilities such as good roads (Mangale et al. 2012). Such communities depend on low quality water from rivers, ponds and/or streams for their daily activities, thereby making them prone to water-borne diseases (Onokerhoraye et al. 1995; and Faith et al. 2012; Lawal et al. 2020).

In this regard, the use of substitute materials with fewer harmful effects can be a step taken to protect the environment and human health (Mohsen and Mohammad. 2016). The search for alternative, low cost, effective and safe methods of water treatment is therefore timely. In reaction to this, locally available materials are being considered as a sustainable substitute. The use of MO seeds extract has been a reported in many literatures. The dry seed suspension obtained from MO fruit is known to have a good tendency to serve as coagulant and coagulant aid (Folkard et al. 1989).

Different researches relating to natural coagulants for the treatment of water have been carried out (Ganjidoust et al. 1997; Kawamura 1991). MO seed powder is one of the best natural coagulants. Kalogo et al. (2000) reported that crushed seeds are a viable replacement for synthetic coagulants. Yusuf et al. (2015) researched on the use of MO as a coagulant for domestic water purification and reported that MO increases the level of concentration of Zn and Ca.

MO seeds are good coagulants, and also has the same treatability potentials as AS (Egbuikwem and Sangodoyin 2013). Using MO for the treatment of wastewater increased the turbidity, and also increased the DO present in the water, therefore making the water habitable for living organisms (Tan et al. 2017). Adeniran et al (2017) also reported that MO is a good natural coagulant that is useful for the removal of turbidity in wastewater.

A different approach has been adopted for wastewater treatment, which includes different wastewater treatment technology, but research on restaurant wastewater treatment using *MO* has not been carried out. As a result of this, the cost of treating water as well as wastewater is on the high side which invariably has resulted in not treating wastewater before discharging into the nearest watercourse. This research was carried out to experiment with the use of MO as a natural alternative source of water treatment to save cost and also to investigate the effect of MO and AS on restaurant wastewater generated in Ayetoro, Ogun State Nigeria.

METHODOLOGY

SITE DESCRIPTION

Ayetoro lies on the latitude 7° 12'N and longitude 30° 3'E in a deciduous-derived savannah zone of Ogun state. The experiment was conducted at the laboratory of the Department of crop production, Olabisi Onabanjo University.

THE PREPARATION OF *M. OLEIFERA* SEEDS POWDER

Dried MO was collected from farmers in Yewa North, Ayetoro, Ogun State, Nigeria. The collected seeds were peeled to obtain the nuts and it was air-dried for a week. Thereafter, the dried nuts were pulverized to a fine powder and sieved with a mesh size of 140µm so as to obtain the seed powder (Folkard *et al.* 2005).

COLLECTION OF WATER SAMPLES

Five litres jerry was used to collect restaurant wastewater samples from the restaurant in the university environment. The water samples were analyzed to determine the pH, Temperature, Conductivity, Turbidity and DO as recommended by APHA (2005).

JAR TEST

A concentration stock solution (1 g/L) was prepared by weighing one gram (1g) of the seed powder of *MO* and transferred into a 1000 ml flask, made up to the mark with distilled water and shook vigorously for 15minutes. The collected wastewater was then aerated for a period of 10 minutes to allow flocculation of oil and grease which was then skimmed from the wastewater. Doses of 0, 50, 100, and 150 mg/l of the stock solution were measured and transferred into the beakers respectively. Similar procedure of producing concentrated labelled A to D solution was carried out for AS, using powdered AS. Each beaker was made up to 1000ml with the water sample collected and placed under the stirring paddles, the jar test mixer was turned on and a flash fast mixing was done for 1minute at a speed of 120rpm, followed by slow mixing for 15minutes at 30rpm. The jar test mixer was turned off and the optimum dosage of the sample that started flocculating and settling among the labelled samples was recorded under 30minutes. The coagulation took place and the floc settles at the bottom leaving the transparent medium at the top due to the presence of a water-soluble cationic coagulant protein

(Folkard et al 2005).

DETERMINATION OF WATER QUALITY PARAMETERS AND HEAVY METALS

Sample pH was determined using AD14 pH meter (Adwa Instrument, Hungary), Turbidity was measured using 2100P portable turbidity meter (Hach company, USA), Conductivity was measured using Sension1 portable conductivity meter (Hach company, USA), the temperature was determined using mercury-in-glass thermometer (B60770-1800, SP Scienceware, USA) and determination of chemical pollutants such as Mg, Zn, and Ca using Atomic Absorption Spectrometer (AAS) SP-AA 3000 Atomic Absorption Spectrometer, (Shanghai Yanhe, China).

RESULTS AND DISCUSSION

EFFECT OF *MO* ON WASTEWATER TREATMENT

The pH and other physiochemical parameters of the wastewater are presented in Table 1. The pH of the wastewater was slightly alkaline (7.55), this was reduced to neutral (7.0±0.05) at 150 mg/l dosage. The slight increase in the dosage turned the effluent to be acidic at 50 mg/l (6.6±0.01) and at 100 mg/l (6.5±0.01) which suggests that MO has the acidic properties because it falls within the acidic group. The result also shows that an increase in the coagulant dose does not increase in the acidic state of the water. High acidic concentration was observed at 100 mg/l, but the best dosage was administered at 150 mg/l which made the water turn neutral and safe for discharge. The turbidity of the raw water was high (44.73 NTU) which revealed that the water was turbid at the point of collection. After the slight chemical treatment of 50 mg/l, a significant reduction was observed from the result (5.45±0.25) NTU, this correspond to what was reported by Adeniran et al (2017). The best level of water treatment was at 100 mg/l of dosage (5.20±0.01) and later turned colourless in the jars due to the effect of *MO* powder. The turbidity reduced from 44.73 to (5.45 ± 0.25) NTU. There was a further reduction in the dosage of 100 mg/l after which an increase in the dosage leads to a slight increase in the turbidity (5.30± 0.1) NTU. An increase in DO was observed at 150 mg/l dosage which shows an increase in the oxygen level of the water, showing that the aquatic life will be better. There was a slight reduction in the DO at 100 mg/l which suggests a threat if the effluent at the dosage is discharged to open water bodies. There was an increase in the conductivity when carrying out the jar test in the laboratory. This result agreed with what had been found by Tan et al. (2016).

EFFECT OF ALUMINUM SULPHATE ON WASTEWATER TREATMENT

From Table 2, the pH of the water was slightly alkaline prior to treatment (7.55) but the dosage administered during the treatment changed the pH content to slightly acidic in all treatment concentrations. This could be attributed to the fact that the coagulant has some alkaline features. The temperature of the influent was high (36^{o}C). The effect of the treatment showed that the temperature of the water reduced from 36^{o}C to 32.7^{o}C in Jar A. An increase in the dosage to 100 mg/l further reduced the temperature of the water, which makes it beneficial for agricultural purposes. The conductivity of the water increased from 1.03 mg/l to 1.91 mg/l in Jar A. A similar trend was obtained in B and C.

The water was turbid (44.73NTU). After subjection to treatment, a clear solution was obtained which varied as a result of the dosage. The least removal was observed in Jar C (5.77±0.03) NTU. Dissolved Oxygen increased in Jar A and C (0.57 and 0.70) mg/l which shows that there is a level

TABLE 1. Physiocochemical Properties of the wastewater effluents for *Moringa oleifera*

Parameters	Untreated samples	A 50 mg/l	B 100 mg/l	C 150 mg/l
pH	7.55	6.6±0.01	6.5±0.01	7.0±0.05
Temperature (°C)	36	36.2±0.02	36.4±0.02	27.7±0.02
Conductivity (µS/cm)	1.03	1.74±0.13	1.61±0.05	1.56±0.05
Turbidity (NTU)	44.73	5.45±0.25	5.20±0.01	5.30±0.1
Dissolve Oxygen (mg/l)	0.35	0.50±0.38	0.12±0.03	0.51±0.39

TABLE 2. Physicochemical Properties of the wastewater effluents for Aluminum Sulphate

Parameters	Untreated samples	A 50 mg/l	B 100 mg/l	C 150 mg/l
pH	7.55	6.86±0.09	6.75±0.05	6.75±0.03
Temperature (°C)	36	32.7±0.33	30.1±0.03	33.4±0.33
Conductivity (µs/cm)	1.03	1.91±0.21	2.12±0.01	2.22±0.1
Turbidity (NTU)	44.73	8.99±0.17	7.82±2.05	5.77±0.03
Dissolved Oxygen (mg/l)	0.35	0.57±0.37	0.20±0.050	0.70±0.05

of treatment in the effluent. On th e contrary, Ja r B ha d a reduced Dissolved Oxygen.

EFFECTS OF TREATMENT ON CHEMICAL POLLUTANTS

Water analysis carried out before the Jar test showed that the influent contains some heavy metals which if not treated will affect aquatic life. Figure 1 shows the level of pollutant removal in magnesium. The result revealed that heavy metals are present in the wastewater collected and treated. The raw wastewater (21.11 mg/l) indicated a high concentration of mg which is discharged into the watercourse could pollute the water. The best treatment was observed with AS coagulant at 50 mg/l dosage, while the highest concentration of pollutants for mg was at 150 mg/l of the same coagulant (AS). Despite the treatment, high mg content was obtained for 100 mg/l and 150 mg/l dosage, which does not agree with what was reported by Yusuf et al. (2015). This indicates that increasing the concentration of the dosage does not correspond to better treatment. Treatment using MO shows some level of treatment, which also reveals that the addition of MO removes magnesium pollutants in water.

From Figure 2, Ca pollutant was low in the water but despite this, after subjecting to treatment, an increase in Ca concentration was observed which is beneficial to the soil. This implies that the discharge of the water to the soil is beneficial for the soil. The highest pollutant concentration (5.09±0.09 mg/l) was observed at 150 mg/l dosage of MO after treatment. All samples subjected to treatment reveal some level of Ca deposit which suggests that MO and AS coagulants possesses some level of calcium. A slight increase was observed at 100mg/l of both coagulants (AS and MO). Also, at this dosage, the same level of pollutant treatment was observed, which reveals that the two coagulants at 100 mg/l have the same treatability effect on the wastewater when considering calcium treatment, which agrees with Egbuikwem and Sangodoyin (2013).

Figure 3 revealed the concentration of Zn in the wastewater. The highest concentration of Zn was observed at 150 mg/l of MO (6.15±0.43 mg/l). Also, an increase in Zn concentration was observed in all the dosage for both coagulants except at 50 mg/l dosage of AS which was considered to have a slight reduction. The treatment at 50 mg/l is within the WHO discharge limit (3 mg/l) for water discharge safety. The increment in the Zn concentration could be attributed to some chemical reactions taking place between the AS and the wastewater, and also MO and wastewater. There was no positive effect of MO on the treatment of Zn. The increase in Zn concentration as a result of MO coagulant agrees with what was reported by Yusuf et al. (2015).

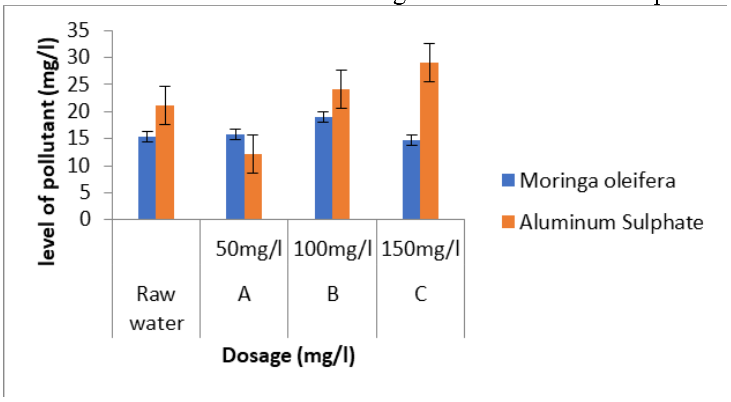

FIGURE 1. Effects of Moringa oleifera and Aluminium Sulphate on Magnesium

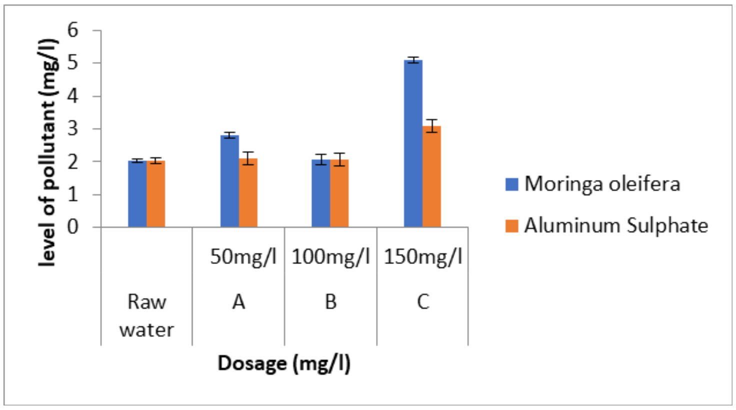

FIGURE 2. Effects of Moringa oleifera and Aluminium Sulphate on calcium

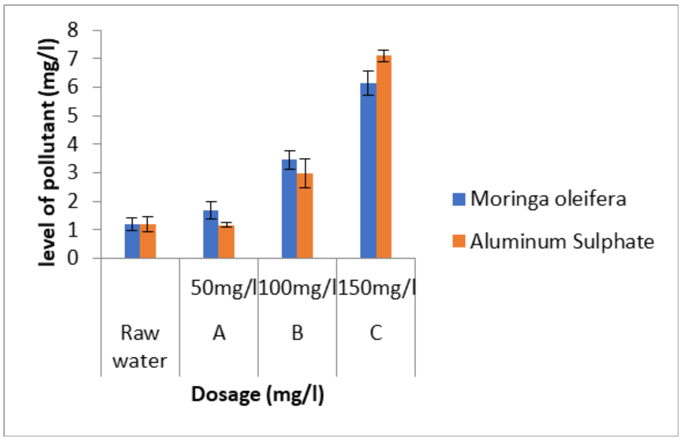

FIGURE 3. Effects of Moringa oleifera and Aluminium Sulphate on Zinc

CONCLUSION

The study investigated the effect of MO and AS as coagulant for restaurant wastewater treatment. Turbidity, DO, Zn, Ca and Mg are the major analysis that was conducted. From this research, it was discovered that MO has the highest removal level for turbidity, DO at 150 mg/l, Mg at 150 mg/l, and Zn at 50 mg/l, which is similar to AS. It was observed that *Moringa oleifera* and Aluminum Sulphate can be used as a good coagulant because they are readily availabe. This will help in reducing the cost of treating restaurant wastewater when compared with current treatment methods.

DECLARATION OF COMPETING INTEREST

None.

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