FUDMA Journal of Sciences (FJS)
ISSN Online: 2616-1370
ISSN Print: 2645-2944
Vol. 2 No.3, September, 2018, pp 241 - 249

ASSESSMENT OF THE ROLE OF *MORINGA OLEIFERA* SEEDS POWDER IN THE PURIFICATION OF WASTEWATER FROM THE NIGERIAN BREWERIES, KADUNA NIGERIA

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ABSTRACT

Brewery wastewater produces effluent that is characterized with high turbidity, pH, biological oxygen demand, chemical oxygen demand and brownish black colour, this effluent is released into the environment indiscriminately. The study investigated the effectiveness of *Moringa oleifera* seeds powder in purification of Breweries wastewater. Laboratory jar test experiment was carried out on the wastewater using the coagulation - flocculation – sedimentation sequence. The descriptive statistics using mean and graphs was used. Results were obtained from the different dosages of *Moringa oleifera* seeds powder ranging from 20 g to 120 g in the wastewater. Optimum dosage for Turbidity, pH, biological oxygen demand, chemical oxygen demand and colour reduction in the treated water was determined. It was observed that at 120 g dose, the *Moringa oleifera* seeds powder possesses greater efficiency in reducing the tested parameters. The results show that the initial brownish black colour of the raw water has changed to colourless after treatment. The initial pH, turbidity, biological oxygen demand and chemical oxygen demand, of 4.17, 29 NTU, 2177.8 5mg/l and 7137.67 mg/l also reduces to 6.85, 9 NTU, 20 mg/l, and 890 mg/l respectively. This shows that the *Moringa oleifera* seeds powder has the potentials for treatment of wastewater; and is effective in purifying wastewater from the Nigerian Breweries, Kaduna. For cheaper coagulant, it is therefore more economical to use *moringa oleifera* in treatment of wastewater

***Keywords**: Brewery, coagulation Moringa oleifera, treatment, wastewater.*

INTRODUCTION

The treatment of wastewater by the usual physical and chemical methods is usually retarded by high financial cost and other implications on human's health and the environment. Consequently, the utilization of organic materials from natural plant source for the treatment of wastewater becomes imperative. Although dearth of knowledge on type of organic material and how these materials can be harnessed and utilized made their adoption less popular in competition to the usual or conventional processes of treatment. The utilization of natural coagulants obtained from natural plants origin like seed, root part and leaves is dated back to many years. The various natural ingredients of organic polymer are useful beacause they contain acryl amide monomers (Hegazy *et al.,* 2011; Ghebremichael, 2004). Ali *et al.,* (2009) also observe that coagulation-flocculation using organic coagulant was one of the earliest methods of water purification but is given less attention due to technological development in recent time

Considering the high potentials of natural coagulants to be an excellent alternative solution to purify wastewater, a good number and types of organic substances have been evaluated for their coagulation characteristics. Many studies have shown that organic substances from *Moringa oleifera, Cactus latifaira and Prosopis jaliflora* are good coagulants in the treatment of wastewater (Ghebremichael, 2004). It is also observed that the utilization of naturally obtained compounds could result to minimization of cost and chemicals. In addition, natural products are easily biodegradable and environmental friendly and safe to humans (Ghebremichael, 2004). *Moringa oleifera* seeds contain several useful properties in the medicinal field for example the antimicrobial properties and buffering capacity (Ferreira *et al*., 2008; Dalen, Pam Izang and Ekel, 2010). These factors are useful contributors for remediation of wastewater through elimination of microbes, suspended matters and high turbidity in water (Gheldof *et al.,* 2002). Hendrawati *et al.,* (2016) also observe that *Moringa oleifera* coagulant have high ability and very effective in purification of wastewater and ground water resources.

Moringa oleifera tree originated from Himalayas in the North-Western India. The tree is found in the sub-Himalayan region between the River Chenad and the Eastwards Sarda and at a region of Uttar Pradesh in India. This tree was cultivated at other parts of the continent including Malaysia, Philippines, Singapore, Sri-lanka, Cuba, Burma and Cuba. The *Moringa oleifera* tree is now found in most African Countries like Nigeria, Egypt and Sudan. It is also found Central America, South America, Peru Mexico, Paraguay and other cities of the world (Ramachandran *et al.,* 1980; Mishra *et al.,* 2011). In Nigeria, the plant is called *Zogale* in Hausa, *Odudu oyibo* in Igbo and *Adagba malero* in Yoruba language.

In recent time *Moringa oleifera* is one of the most highly valued and cultivated plant in the world, because of its nutritional and medicinal uses. The plant belongs to the single-generic family called *Moringaceae*. The *Moringa oleifera* plant has fourteen species, comprising shrubs and trees. The actual botanical name of the species is *Moringa oleifera (Moringa oleifera Lam)*. (Ghebremichael (2004) and Nand *et al.,* (2012) are of the view that the plant has several other names such as Ben oil tree (because of the 'Ben oil' produce from its seeds), Horseradish tree (because of horseradish mild taste of its leaf) and drumstick tree (drumsticks fruit resemblance). The seeds of *Moringa oleifera* are among the most essential, nutritious botanical product with high economic values. It is also known to have a lot of medicinal and herbal remedies for several illments. The *Moringa oleifera* seeds contain proteins with antioxidant properties known to be very effective in purification of water. The seed possesses the ability to remediate water pollution (Amagloh and Benang, 2009). After coagulation activity, the residue of the seed can be useful as organic fertilizer on farms or as livestock fodder (Ghebremichael, 2004). Ali *et al.,* (2010) are also of the view that *Moringa oleifera* has bioactive constituents that have high coagulation activity and further pointed out that *Moringa Oleifara* seeds are excellent in the purification of drinking water and the best alternative to synthetic coagulants like aluminum sulphate (alum).

Amagloh and Benang (2009) and Bhuptawat *et al.,* (2007) are of the view that *Moringa oleifera* seeds are efficient in the treatment of rheumatism, urinary infections, sexually transmitted diseases, epilepsy and gout. Ghebremichael (2004) and Nand *et al.* (2012) also observe that the parts of *Moringa oleifera* plant such as roots, seeds, flowers and leaves are used as medicines and are often lifesaving. The multiple values and functions of *Moringa oleifera* tree show that it is very important for commercial utilization and can generate income where the species are available. The extract from the seed is a natural organic coagulant, often used for domestic purification of water in some villages in Africa such as Sudan.

The coagulation ability of *Moringa oleifera* seeds has been experimented at industrial scale for treatment of industrial wastewater such as palm oil mill effluent; and the advantages of the seeds for high effluent reduction and removal has been pointed out by scholars like Babu and Chaudhuri (2005) and Chanda and Dave (2009). Different methods of palm oil mill wastewater have been reported by Oswal *et al.,* 2002), however *Moringa oleifera* seeds have proven to be effective in water treatment and a cheap raw material that is useful in many ways, good utilization of *Moringa oleifera* will be beneficial to improve the purification of industrial wastewater. Tuggolou and Payus (2013) strongly observe that *Moringa Oleifera* has cheaper and safer coagulant to purify water for human consumption than the usage of aluminum sulphate that has health complications on human. It is a sustainable substitute to the conventional synthetic coagulants system and could help to upgrade economic level of a country that possesses the species abundantly (Vieira *et al.,* 2010). This paper is therefore targeted at assessing the role of *Moringa oleifera* seeds powder in the purification of wastewater from the Nigerian Breweries, Kaduna especially the physicochemical parameters.

STUDY AREA

The Nigerian Breweries Plc. Kaduna is located along Makera Road, Kudenda in the Industrial Layout of Kaduna South Local Government Area of Kaduna State. The study area is located in the Northwest geopolitical zone of Nigeria. It lies between latitudes 10^0 20'47" N and 7^0 45' 54" E and between longitude 10^0 3' 33" N 7^0 7' 50" and at an altitude of 650m above sea level. Kaduna metropolis is the capital of Kaduna state, the state is sandwiched between Katsina and Kano state to the north-east, Plateau to the south-east and Abuja to the south, Niger to the south –west and Zamfara to the west. It is divided into 23 LGA's with Kaduna North and South, Chikun and Igabi LGA's forming the metropolis.

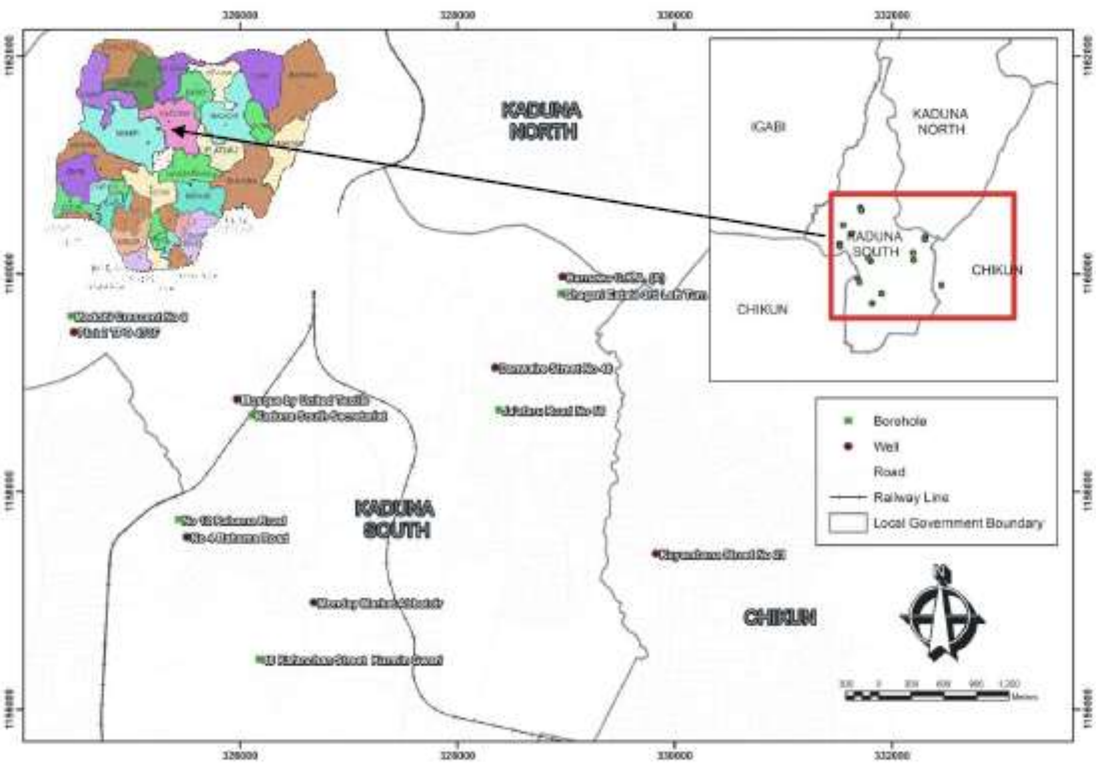

Figure. 1: The Study Area Kaduna South LGA, Kaduna

MATERIALS AND METHOD

The main type of data for the study was the wastewater samples discharged from the Breweries. The main source of data was primary data. The wastewater was collected from the Nigerian Brewery, Kaduna in October, 2016; and was stored in the laboratory at $4^{O}C$ prior to analysis. The matured *Moringa oleifera* seeds were collected from the Forestry Research Institute of Nigeria (FRIN), Zaria in October, 2016. The wastewater was collected in a plastic container using the grab method from the Nigerian Breweries, Kaduna. The *Moringa oleifera* seeds were processed manually. The kernel from the pods were completely dried under the sun and grounded to powder using a mortar and pestle. 200 g of the dried seeds powder was put in 1litre of water and allowed to fully soaked for 48 hours with stirring from time to time using a magnetic stirrer to de-fat the seeds powder. The defatted powder (cake) was obtained by filtering the raffinate using Whitman filter paper. This was allowed to dry at room temperature and the dried sample was stored under laboratory condition.

The jar test apparatus used in the study was the Aqua Lytic jar test apparatus with six 1 litre glass jars labeled A to F. 500 ml Brewery wastewater was measured with measuring cylinder and transferred into the beakers labeled A to F. Different dosages of 20 g, 40 g, 60 g, 80 g, 100 g, 120 g of the dried *Moringa oleifera* seeds cake was weighed using the weighing balance and introduced into the 6 labeled glass jars respectively. The glass jars (containing the wastewater and cake) were placed on the jar test apparatus and the jar test apparatus stirrer was adjusted at the centre of each of the beakers and the jar test processor was switched on. The wastewater was agitated for 30 minutes at 2000 rpm followed by slow mixing at 50 rpm for 60 minutes. The processor was put off and subsequently the samples were allowed to settle for 120 minutes and then decanted to obtain supernatant. The supernatant in each beaker and the raw Brewery Wastewater was sampled and tested for Turbidity, pH, colour, biological oxygen demand (BOD) and chemical oxygen demand all these procedures were done in line with standard Method of Examination of water and wastewater as stipulated by APHA (1992).

Determination of the physicochemical properties of Wastewater and Supernatant: Selected physicochemical parameters were assessed as following:

i. Determination of pH: The pH of the wastewater sample was taken using a calibrated Crison pH meter Basic C-20. A 250 ml of the water sample was measured and collected in a standard beaker. The pH meter calibration was properly adjusted; and the pH meter probes was then dipped into the beaker containing the sample ensuring also that it did not interfere with the beaker. The reading of the pH was then taken from the LCD display after allowing it to stabilizer. This procedure was done for both raw water and supernatant.

ii. Determination of Turbidity: This was carried out based on Nepholometric method which is based on comparison of the intensity of the scattered light by the sample under defined conditions with the intensity of light of a standard reference suspension under the same stable conditions. The turbidity increased as the intensity scattered light. The primary standard reference suspensions were the Buffer pH 4.7 solution. The instrument was switched on for 20 minutes to warm and scale was adjusted to zero reading (calibration of turbidity) before the standard test tube was dipped into distilled water in a beaker

iii. Determination of Colour: The colour of the wastewater was determined by visual analysis. The raw water was brownish black in colour before treatment. After application of the different dosage of the seed powder of *Moringa oleifera*, the colour continues to be clear with increase in dosage. At 120 g dosage, a clear supernatant was obtained.

iv. Determination of Biochemical Oxygen Demand (BOD: A three hundred millimeter BOD bottles were used for the samples and blank. Ten millimeter of the sample was measured and put into BOD bottle and allowed to dilute (30 times dilution of the sample). Ten millimeter of distilled water was also measured as blank sample. Initial Dissolve Oxygen (DO) in samples was recorded. The bottles (containing the samples) were immediately covered and preserved in BOD incubator for five days at 20ºC. After the five days period, two millimeter of manganese sulfate was taken and mixed in the pipette just below the surface of the liquid to avoid introduction of air bubbles. Two millimeter of alkali-iodide-azide reagent was also later added to the contents and was shaken and allowed to settle. Two millimeter of concentrated sulfuric acid was then introduced into the samples through a pipette that was held just above the surface of the sample. The glass stopper was gently placed the bottles were inverted several times to dissolve the flocs. Two hundred and three millimeter of the content in each of the bottles was transferred into separate conical flasks and titrated with standard solution of sodium thiosulphate until the yellow colour of released iodine almost faded off. One millimeter of starch solution was then added and the colour changed to blue. The solution was continuously titrated until the blue colour disappears to colourless.

The BOD was calculated using the expression:

$$BOD = \frac{DO_i - DO_5 - BC \times V_d}{V_S},$$

where;

DO_i = Initial DO of diluted sample

DO_5 = DO for diluted sample after 5-days

BC = Blank correction ($C_0 - C_5$)

C_0 = Initial DO of blank

C_5 = DO of blank after 5-days

V_S = Volume of sample taken

v. Determination of Chemical Oxygen Demand (COD): The COD was assessed using the titrimetric method. COD vials with stopper were used for the sample and blank test. Two and half millimeter of the sample and distilled water were measured and transferred into the COD vials. One and half millimeter of potassium dichromate solution and three and half millimeter of sulphuric acid solution were then introduced into each of the two COD vials containing the sample and distilled water. The vials were caped tightly; placed into a block digester at a high temperature (150°C) and heated for 2 hours. The vials were removed and kept to cool at room temperature. A burette was filled with Ferrous Ammonium Sulphate solution, adjusted to zero and fixed to a burette stand. The samples were moved into a flask and some drops of ferroin indicator were added to it. The colour of the solution then turns bluish green and was subsequently titrated with ferrous ammonium sulphate ($FeAlSO_3$), till an end point was reached when the colour changed to reddish brown. The down volume of $FeAlSO_3$ solution was taken.

The Chemical Oxygen Demand was determined as

$$COD = \frac{B - A \times N \times 8}{V} \times 1000 \text{ (mg/l)};$$

where;

B = Volume of $FeAlSO_3$ for blank sample (ml)

A = Volume of $FeAlSO_3$ for wastewater sample (ml)

V = Volume of the Sample (ml)

N = Normality of ferrous Ammonium sulphate (N)

After determination of the various physicochemical parameters in the waste water sample descriptive statistics using graphs was employed in the analysis of the results.

RESULTS AND DISCUSSION

The purification efficiency of the *Moringa oleifera* seed powder was tested by analyzing some physicochemical parameters of the treated wastewater. The values of the selected physicochemical parameters corresponding to the wastewater before and after treatment are shown on Tables 1 and 2.

Table 1: Some Physicochemical Characteristics of Raw water

Parameters	Values
Colour	*Brownish black*
Ph	*4.17*
Turbidity (NTU)	*29.0*
BOD_5 (mg/l)	*2177.85*
COD (mg/l)	*7137.67*

Source: Fieldwork, 2016

Table 2: Some Physicochemical Characteristics of treated water

Parameter	Dosage					
	20	40	60	80	100	120
Colour	Brownish Black	Brownish Black	Fairly Clear	Colourless	Colourless	Colourless
pH	4.19	4.85	5.28	6.95	6.29	6.85
Turbidity (NTU)	28	31	16	14	12	9
BOD_5 (mg/l)	542	422	264	87	28	20
COD (mgl)	7171	7162	3540	2110	1009	890

Source: Fieldwork, 2016

The pH of wastewater was found to be 4.19 and after treatment with 20 g, 40 g, 60 g, 80 g, 100 g and 120 g dose of *Moringa oleifera*, the pH was recorded 4.19, 4.85, 5.28, 6.95, 6.29 and 6.85 respectively as shown on Table 2. There is indication that the pH of the wastewater increases as the dosage of *Moringa oleifera* seeds powder increases. At a dosage of 40 g the pH of the wastewater decreases drastically and the acidity continues to decrease as the dosage increases. Figure 1 shows the variation in pH of the wastewater with increasing dose of the *Moringa oleifera* seeds powder. *Moringa oleifera* seeds are known to consists low molecular weight proteins that are water soluble which accepts protons in the wastewater and releases hydroxyl ions which make the water more alkaline and therefore, reduces the acidity of the wastewater as also pointed out by Babu and Chaudhuri (2005).

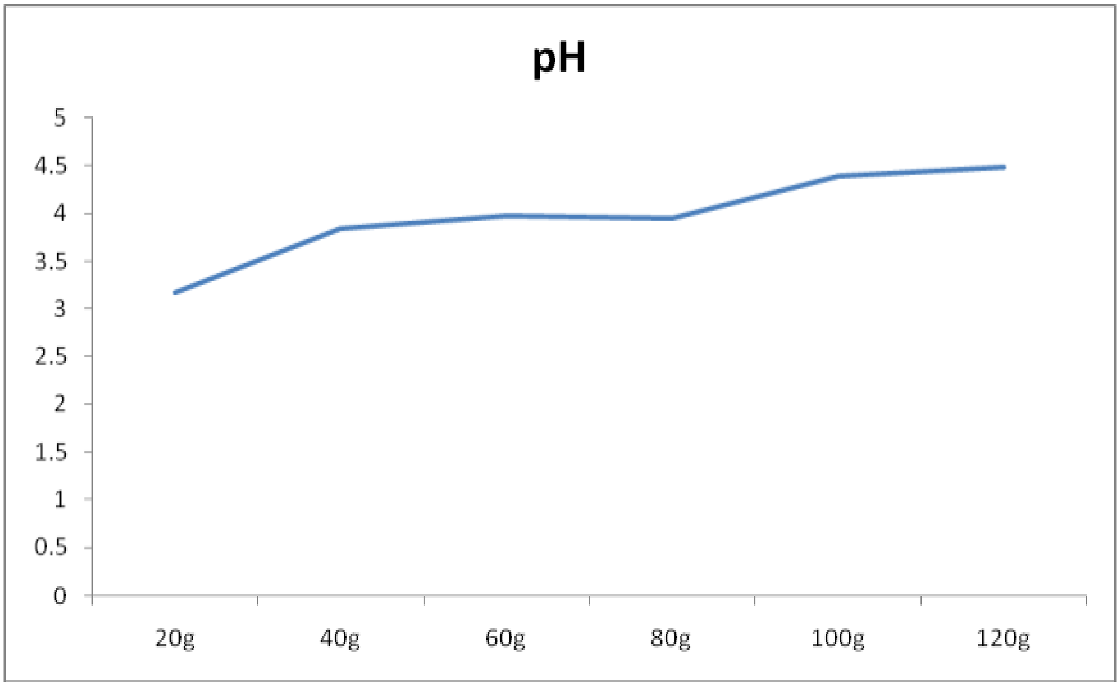

Figure 1. Variation of pH with dose of *Moringa oleifera* seeds powder
Source: Fieldwork, 2016

The turbidity of the wastewater decreases from 29.0 NTU as the coagulant dose increases. After the wastewater was treated with 20 g, 40 g, 60 g, 80 g, 100 g and 120 g of *Moringa oleifera* seeds powder, the turbidity was recorded at 26 NTU, 31 NTU, 16 NTU, 14 NTU,12 NTU and 9 NTU respectively as shown on Table 1. The turbidity variation with increasing doses of *Moringa oleifera* seeds powder is shown on Figure 2. Muyibi and Evison (1995) also observe that *Moringa oleifera* is capable of removing turbidity in water between 92 and 99%. Several studies observe that 80 – 99% turbidity removal by effects of *Moringa oleifera* as a main coagulant both for raw and synthetic turbid waters have been documented by Muyibi and Okufu, (1995), Ndabigengesere *et al.*, (1995), Muyibi and Evison, (1996). Boateng (2001) also reported the use of alum and *Moringa oleifera* in treatment of surface water with success rate between 68.8 - 98.9% reduction in turbidity.

The *abinitio* colour of the wastewater was brownish black, however with increased dosage of *Moringa oleifera* seed powder, the colour changes gradually. At 60 g dosage, the colour of the treated wastewater begins to be clear and 80 g, 100 g and 120 g dosages, the water was completely colourless. It is therefore obvious that the colour of the wastewater improves with increasing dose of *Moringa oleifera* seeds powder. The maximum reduction in turbidity was found at 120 g dosage, when the levels of particulate matter or sediments in the wastewater reduce appreciably. Figure 2 shows the variation in turbidity with increasing organic coagulant dose.

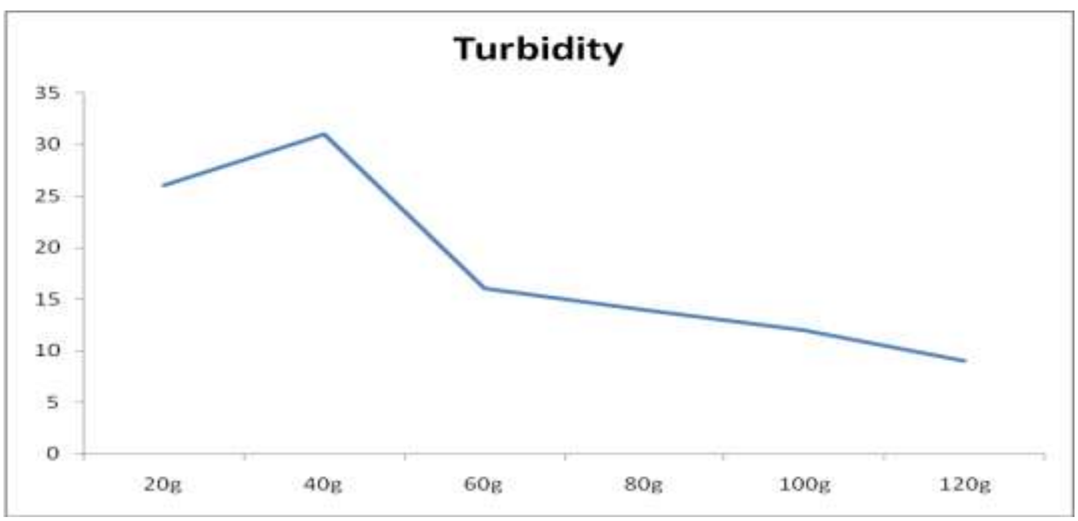

Fig 2. Variation of Turbidity with doses of *Moringa oleifera* seeds powder (Source: Fieldwork, 2016)

The Chemical Oxygen Demand (COD) of the wastewater reduces with increase in dosage of *Moringa oleifera* seeds powder. Between 20 g and 40 g dose, there was no significant improvement in the COD reduction. But at 60 g dosage, the COD reduces drastically to 2540 mg/l and 2110 mg/l, 1009 mg/l and 890 mg/l at 80 g, 100 g, and 120 g respectively. Fifty percent reduction in COD was achieved at 60 g dosage and continues to increase with 100 g and120 g dosages. The results on Table 2. depicts different COD values obtained at the different doses of *Moringa oleifera* seeds powder, as 7171 mg/l, 7162 mg/l, 3540 mg/l, 2110 mg/l, 1009 mg/l and 890 mg/l for 20 g, 40 g, 60 g, 80 g, 100 g and 120 g after 30 minutes agitation and 30 minutes settling respectively. The COD removal occurred mostly during the processes of filtration. The reduction in COD may also be as a result of the relatively high *Moringa oleifera* flocs that are formed that are mobile or excited as also observed by Afilab *et al.,* (2012) filterable.

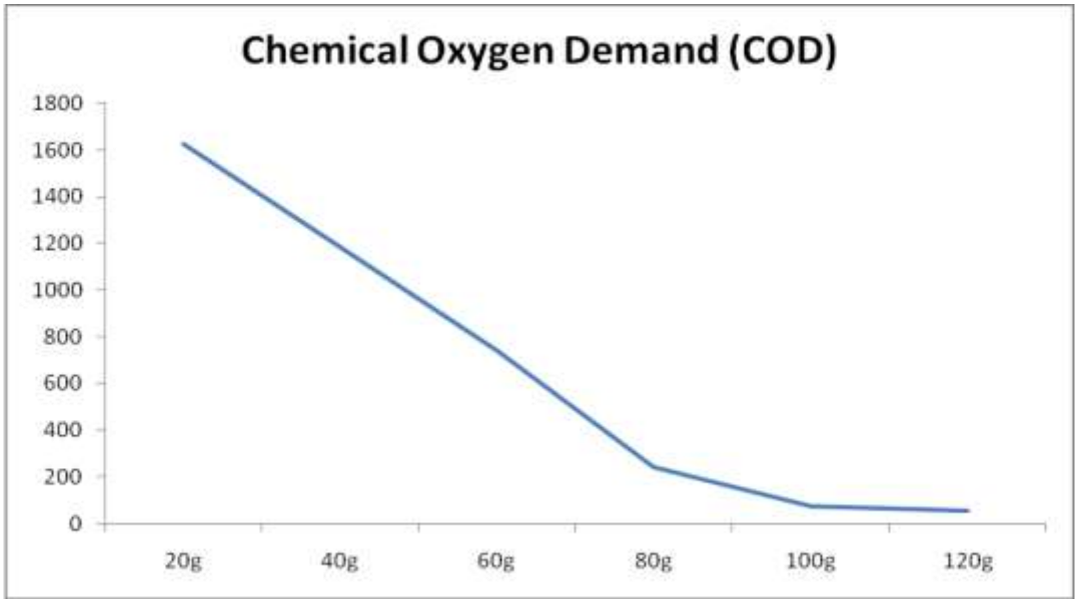

Figure 3. Variation of COD with doses *Moringa oleifera* seeds powder
Source: Fieldwork, 2016

The initial biological oxygen demand of the wastewater was found at 2177.5 mg/l as shown on Table 1. After application of the *Moringa oleifera* seeds powder and incubation of the wastewater for 5 days, the BOD values were recorded as 542 mg/l, 522 mg/l, 264 mg/l, 87 mg/l, 28 mg/l and 20 mg/l at 20 g, 40 g, 60 g, 80 g, 100 g and 120 g respectively. The graphical presentation of the BOD values with increasing dosages of *Moringa Oleifera* seeds powder is shown on Figure 4.
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Generally, water treated with *Moringa Oleifera* is said to be more pure and best for human consumption than water treated with synthetic coagulants such as aluminum sulphate that is linked to neurodegenerative diseases as observed by Egbuikwem and Sangodoyin (2013). The reduction in biological oxygen demand has high relationship with water quality

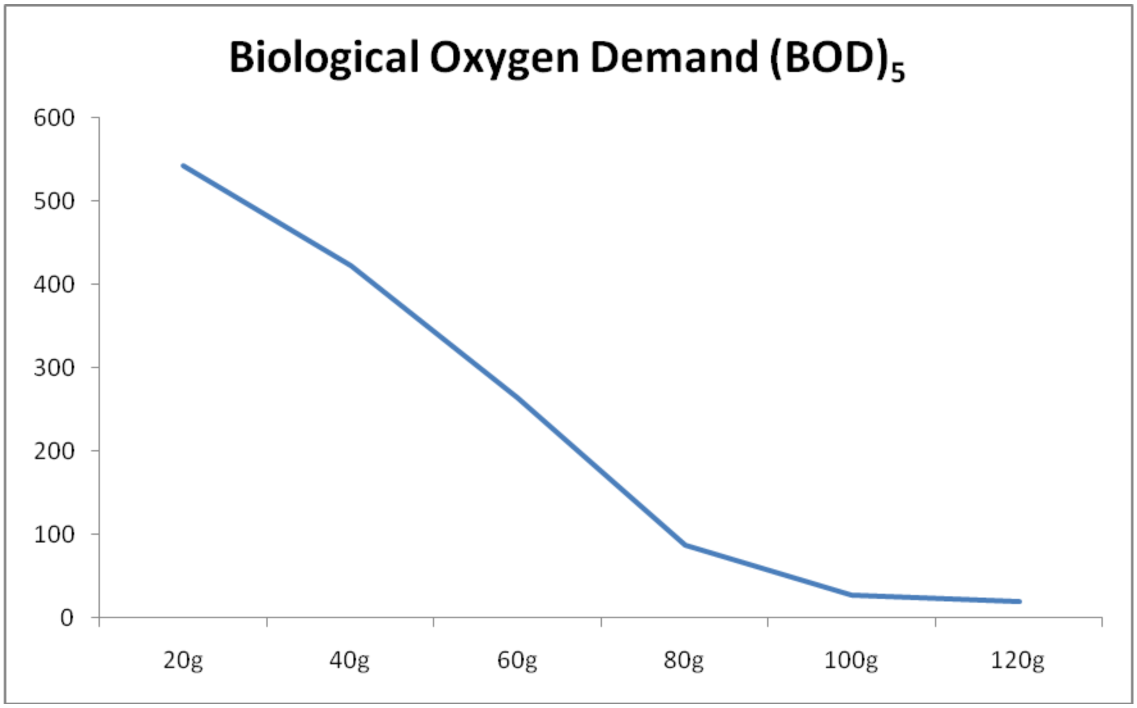

Figure 4. Variation of BOD with doses of *Moringa oleifera* seeds powder
Source: Fieldwork, 2016

CONCLUSION

The paper examines the role of *Moringa oleifera* seeds powder in the purification of some physicochemical parameters in wastewater from the Nigerian Breweries Kaduna. The paper concludes that *Moringa oleifera* seeds powder has good coagulation properties for treatment of wastewater. Its coagulation efficiency can reduce the pH, turbidity, BOD, COD and change the colour of Breweries wastewater to colourless. The paper postulates that the use *Moringa oleifera* seeds powder in purifying Breweries wastewater is a good alternative to conventional methods of using inorganic substances that are rather costly with other side effects, provided there are plantations of the tree. The paper therefore asserts that *Moringa oleifera* coagulant is capable and effective in reducing acidity, turbidity, BOD, COD and improve the colour of wastewater, the coagulant is good, organic natural, cheap and reliable alternative for purification of wastewater provided the supply of the seeds are available.

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