JCEIB

Journal Chemical Engineering and Industrial Biotechnology
(JCEIB)
ISSN: 0126-8139 (Online); Open Access
Volume 5Issue 5 pp. 29-38; May 2019

DOI: https://doi.org/10.15282/JCEIB-V5-03.29/3/2019/5.5

ASSESSMENT OF MORINGA OLEIFERA CAKE RESIDUES (MOCR) AS ECO-FRIENDLY BIO-COAGULANT

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ABSTRACT
In recent times, the consumption of water for domestic and industrial use has been on an increasing trend with a rise in demand.Therefore, a need for a plant-based alternative of water treatment process at a lower cost using an environmentally friendly approach. *Moringa oleifera* is an example of the plant-based materials usually grown in developing countries with a natural coagulating property. In this study the Jar test was conducted to evaluate the performance of *Moringa oleifera* cake residue (MOCR) as biocoagulant for the treatment of water for safe drinking. The result obtained showed the lowest turbidity, pH, TDS, and water conductivity value as 4.7 NTU (0.75 mg/L), 5.2 (2.5 mg/L), 40 ppm (1.0 mg/L), and 50 $\mu s/cm$ (0.50 mg/L), respectively. Moreover, the standards COD and BOD values were less than the recommended Malaysian Standard of Water Quality of 250 mg/L and 100 mg/L, respectively. Hence, MOCR therefore is a potential source for plant-based coagulating agent for water treatment for domestic drinking water.

Keywords: *Moringa oleifera*; Biocoagulant; Water; Soxhlet extraction

1.0 INTRODUCTION
Water mustundergo multiple phases of treatment before it is safe for human consumption and for daily activities. Water resources such as rivers, lakes and groundwater might contain a lot of unwanted molecules which make it unfit for daily consumption. The purpose of water treatment is to purify and eliminate pollutants such as nitrates pesticides, heavy metals and organic materials, and to improve the taste (Matilainen and Sillanpaa, 2010). Waterborne diseases such as diarrheal disease, Hepatitis A, Cholera, Botulism, Typhoid, Dysentery, Cryptosporidiosis and Polio are the major causes of death in many developing countries (Idris *et al.,* 2016). Various synthetic water treatment methods are used to make water safe for the consumer. Infact, the use of synthetics water treatment methods is unhealthy and may causes some diseases (Paula *et al.,* 2014). For instance, excess concentration of aluminium sulphate (alum) which as a chemical coagulant in water treatment has been reported to cause Alzheimer's or other neuro-degenerative diseases (Olalere *et al.,* 2016). Hence the need arises for an effective and efficient eco-friendly plant-based method of treatment.

The conventional method of water treatment plants consists of a combination of coagulation, sedimentation, filtration and disinfection but the most applied water treatment technology since early 20th century is made up of coagulation, sedimentation and filtration (Abaliwano, 2008). In coagulation process the most common, the chemical coagulants used in this process are aluminium sulphate, ferric sulphate and ferric chloride (Matilainen and Sillanpaa, 2010). The coagulants' positive charge will neutralise the negative charge of the suspended and dissolved particles in the water. During this process, the particles will bind together to form larger particles. The larger particles which become heavy are able to settle quickly at the bottom of the reactor. This is followed by filtration which is the second step of conventional water treatment. This step consists of filters with different pore size and is often made up of gravel, charcoal and sand which play an important role in removing particulate matter from water by forcing the water to pass through the porous media (Cheremisinoff, 2001). There are a lot of invention related to water treatment process but most of the invention require higher expenditure because of the complexity of water treatment plants and it require many stages of water purification (Aziz and Ghazali, 2019). Therefore, Moringa oleifera seeds provide a lot of advantages compared to conventional coagulants towards the water treatment. The advantages of Moringa oleifera are cost effective, eco-friendly, no pH alteration required, no necessity for alkalinity addition and reduction of sludge volumes (Idris *et al*., 2016).

In this study, the Jar test was performed to assess the water quality parameters such as pH, turbidity, conductivity, Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), and Biochemical Oxygen Demand (BOD), before and after treatment with MOCR.

2.0 MATERIALS AND METHODS

2.1 Materials preparation

The *Moringa oleifera* (MO) seeds were purchased from Mitomasa Sdn. Bhd., Kuala Lumpur. The *Moringa oleifera*seeds were de-husked manually from its pod. The seeds obtained was then pulverised to produce *Moringa oleifera* seed powder and sieved through a 2mm, 1mm, 500 μm and 250 μm electronic siever. The analytical grade n-hexane was obtained from Sigma Adrich Co., Malaysia without further purification.

2.1.1 Soxhlet extraction and recovery of cake residue (MOCR)

20 g of seed powder was place in the extraction thimble with 250 mL of n-hexane solvent poured into the round bottom flask. Then, the Soxhlet extractor was then placed inside the heating mantle. Running cold tap water was supplied to the condenser and the water was allowed to continuously flow in and out of the condenser. The heating mantle was set to 80°C until the solvent starts to boil. Temperature of 80°C was chosen with the purpose to ensure n-hexane vaporises and able to pass through the siphon and react with the *Moringa oleifera* seeds powder in the thimble. Hence, the boiling temperature and critical temperature of n-hexane are set at 68.75°C and 234.45°C respectively. The temperature of the heating mantle was reduced to around 70°C (Eman *et al*., 2014). After the Soxhlet apparatus was set up, the hexane solvent was heated up for 45 minutes in order to extract the oil (Da Porto *et al*., 2016). The oil extracted, containing some portion of the solvent was then recycled back to the round bottom flask as it refluxes and the total process of reflux continues until total oil extraction was achieved when the

solvent become colourless. After the oil extraction process, the *Moringa oleifera*cake residue from the thimble was collected and dried overnight in an oven for 50°C for 1 h and as the drying process ended, the residue cake was weight using electronic weighing machine (Eman, 2016). The seed cake residue was then used for water treatment after the oil has been drained out of the *Moringa oleifera* seed. The presence of oil in the seed will affect the coagulation process and this confirmed the reason for the oil extraction process conducted. Moreover, the presence of the oil will increase the quantity of organic matter added to water as reported by Garcia-Fayos *et al*., (2016). Eman *et al.*(2014) also buttressed this and reported that the performance of the *Moringa oleifera* cake residue in water treatment process will decreases as the oil content in the *Moringa oleifera* cake residue increases (Eman *et al*., 2014).

2.1.2 Jar test experimentation

The river water sample was collected from Belat River (Figure 1), located at housing area in Kuantan, Malaysia. The water quality status of the river was tested with different dosage of Moringa oleifera cake residue using jar tests. Furthermore, each beaker was filled with 500 mL of river water. These beakers were placed into the jar test machine. It is important that the turbidity is almost the same in each beaker before 0.05, 0.10, 0.50, 0.75, 1.0, 2.5, 5.0, 7.5, and 10.0 g of *Moringa oleifera* seed powder (MOSP) with 2 mm particle size were added into different beakers filled with river water, respectively. The stirring speed was set at 200 rpm for 4 min followed by 40 rpm for 30 min. Then, the mixtures were left for 60 min to settle. Finally, the water quality parameters were tested. The experiment was repeated with a different particle size of MOSP for 1mm, 500µm and 250 µm.

2.1.3 Analysis of treated water

Digital turbidity meter (TB-500G) was used in this experiment to measure high turbidity before treatment with MOSP. The measurement range of this turbidity meter is from 20 NTU to 500 NTU with a 660 nm of wavelength. Digital turbidity meter (DTC-4DG) was used in this experiment to measure low turbidity after treatment with MOSP. The measurement range of this turbidity meter is from 0.0 NTU to 20.0NTU with an 860 nm of wavelength. The initial turbidity was measured 3 times on the raw water while stirring, and the average value from the three measurements was used as a starting value. After the sedimentation phase, samples for turbidity measurement were collected from the supernatant using a standard pipette. Moreover, the Spectrophotometer was used to measure the COD. COD reactor was preheated to 150 ºC. 2 mL each of de-ionized water (control) and samples after jar test was added into COD Digestion Reagent Vials. Digestion reagent vials used for measurement test were low range reagent vials ranging from 3 to 150mg/L while for high range reagent vials ranging from 20 to 1500 mg/L. The samples were then inserted into COD reactor HACH DRB200 and heated for 2 h at 150 ºC with strong oxidizing agent (potassium dichromate solution). Then the solutions were cooled down to room temperature. The vials were cleaned to remove any fingerprint before measuring COD with HACH spectrophotometer DR2800. The dissolved oxygen (DO) meter was used for BOD measurement. 1 L of diluted water sample was prepared by adding 1 mL each of phosphate buffer, magnesium sulfate, calcium chloride and ferric chloride solution into 1L of volumetric flask. Distilled water was added to 1L. About 10 mL of samples after jar test was transferred into each BOD bottle. Then, 300 mL of diluted water was added into the BOD bottle. Besides that, the control was prepared from 300 mL diluted water in BOD bottle. The DO was measured for all samples using DO meter. After that, the diluted water was added to the flared mouth of the bottle and covered with aluminium foil to prevent evaporation of the solution. All bottles were put into the BOD incubator for 5 days at 20 ºC. The DO value will be measured after 5 days.

3.0RESULTS AND DISCUSSION

3.1 Particle sizes study

Figure 1 shows the effects of changes in the amount of MOSP on the turbidity removal at different particle sizes. The result obtained showed that the highest removal efficiency (98.80%) at 4.8 NTU using 2 mm with 0.05 g of *Moringa oleifera* seeds powder (MOSP). This result indicated that at lower dose of the MOSP, the best turbidity was obtained below the established World Health Organization standard of 5.0 NTU (Haydar *et al.*, 2016). Guodeli *et al.*, (2015) reported that particle sizes in different sizes contributed differently to the water turbidity after the process of coagulation. However, at particle sizes below 2 mm, agglomeration tends to occur due to the sticking together of the particles. This explains why at particle sizes 1 mm, 500 µm and 250 µm, the turbidity removal was lower when compare with 2 mm as presented in Figure 3.1.

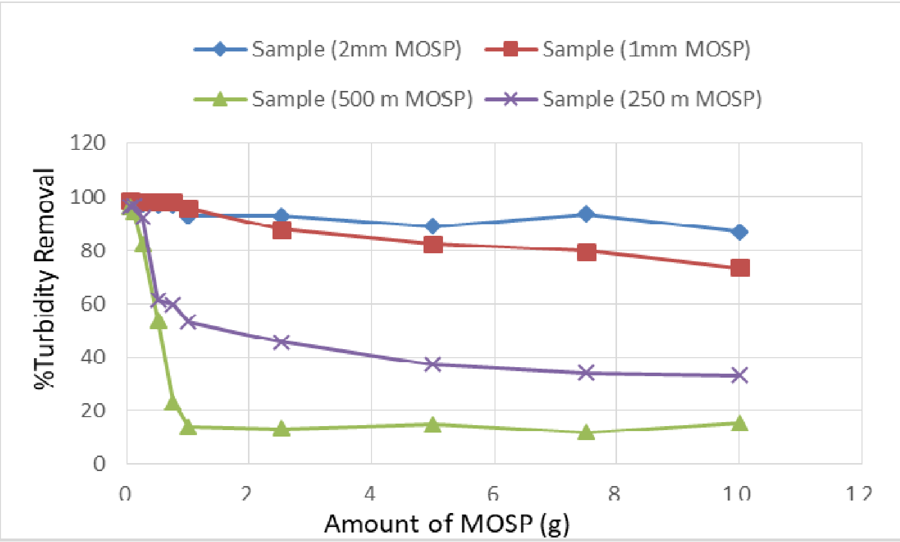

Figure 1: Turbidity removal of water treated with MOSP

3.2 Results of water analysis using *Moringa olieifera*cake residue after oil extraction

Oil was extracted from *Moringa oleifera* seeds powder using n-hexane as extracting solvent. The result obtained showed higher recovery for the *Moringa oleifera* cake (85.30%). The higher cake recovery confirmed the efficiency of n-hexane in the extraction of oil from Moringa seed powder (Ahmed, 2014).

$$Percentage\ cake\ recovery = \frac{W_0 - W_1}{W_0} \times 100\% = \frac{40 - 34.1}{40} \times 100\% = 85.30\%$$

(1)

where W_0 is the mass of *Moringa oleifera* seeds powder before extraction, W_1 is the mass of *Moringa oleifera* cake residue produced after extraction.

3.3 Turbidity measurement

Figure 2 shows the comparison between the dosage used for water treatment and the turbidity values obtained after water treatment. The lowest turbidity value is 4.7 NTU (0.75 mg/L). Therefore, 0.0015g/mL MOCR is the best dosage to be used because it gives the best turbidity value of 4.7. According to World Health organization, turbidity value lower than 10 NTU is considered as clear water while turbidity lower than 5 NTU is considered as drinkable water (Eman *et al*., 2014).

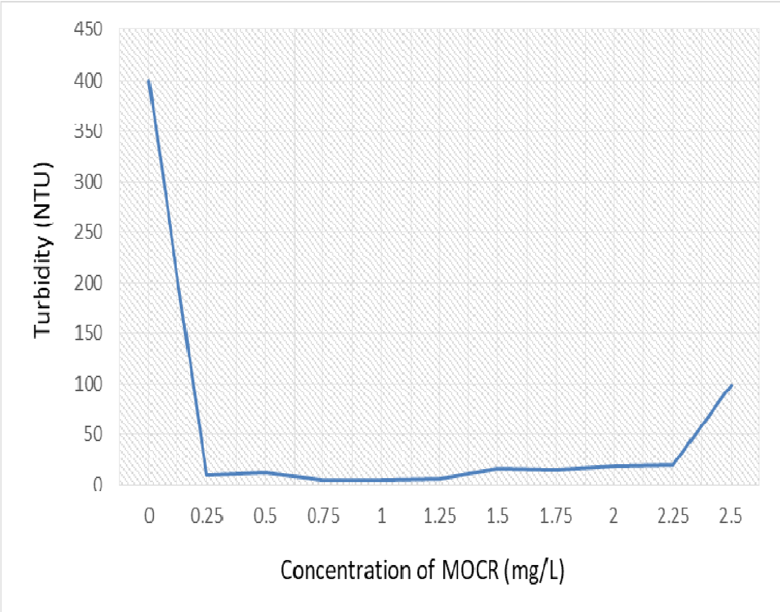

Figure 2: Turbidity values after treatment

3.4 pH Measurement

Figure 3 shows the comparison between the dosage used for water treatment and the pH values obtained after water treatment. The lowest pH value was 5.2 (2.5 mg/L). These results showed that MOCR dosage does not significantly impact the pH value which showed agreement with previously conducted research (Eman *et al*., 2014). Furthermore, the pH values were in range with the water standard for water quality. Therefore, 0.75 mg/L concentration is the best dosage to be used because it gives the best pH value of 6.5.

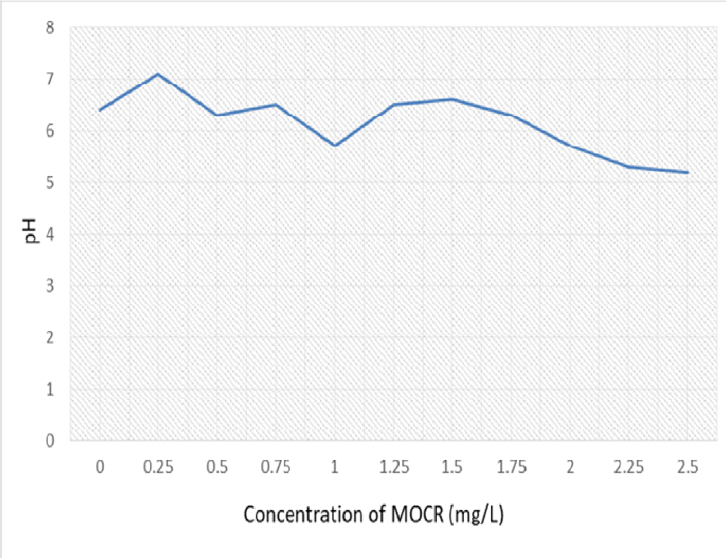

Figure 3: pH values after treatment

3.5 TDS measurement

Figure 4 shows the comparison between the dosages used for water treatment and the TDS values obtained after water treatment. The lowest value was 40 ppm (1.0 mg/L). However, the increase in TDS values does not agree with the research conducted by Mangale *et al.* (2012) because the TDS values were not reduced after the water was treated with MOCR (Mangale *et al*., 2012). The difference in result trend might be due to the pre-treatment steps used in the experiment on how was the river water sample collected whether it excludes fish, weeds, branches or large debris. Nevertheless, the results obtained are in agreement with the water standard for water quality as the majority of the values are less than 500 ppm. Therefore, the best TDS was obtained at 40 ppm since the lowest value at the concentration of 1.0 mg/L.

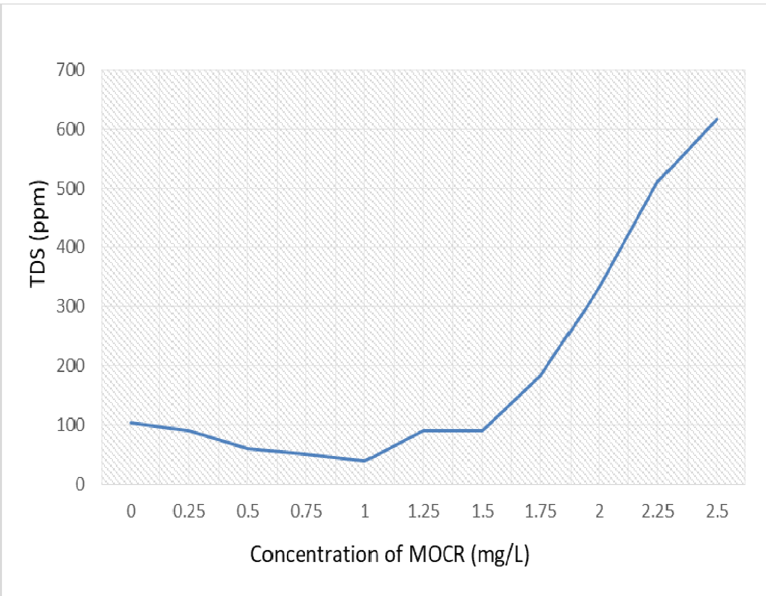

Figure 4: TDS values after treatment

3.6 Conductivity measurement

Figure 5 shows the comparison between the dosage used for water treatment and the conductivity values obtained after water treatment. The lowest is recorded water conductivity was 50 µs/cm (0.50 mg/L). However, the dosage obtained 0.75 mg/L was within the recommended range of standard water quality. The increase in conductivity indicates the increase in the number of free ions obtained after the dissolution of salt, ionic proteins and ionization of water (Miraji, 2014). This is still an acceptable value for drinking water, as the maximum value should be less than 1055 µs/cm according to World Health Organization, (2011).

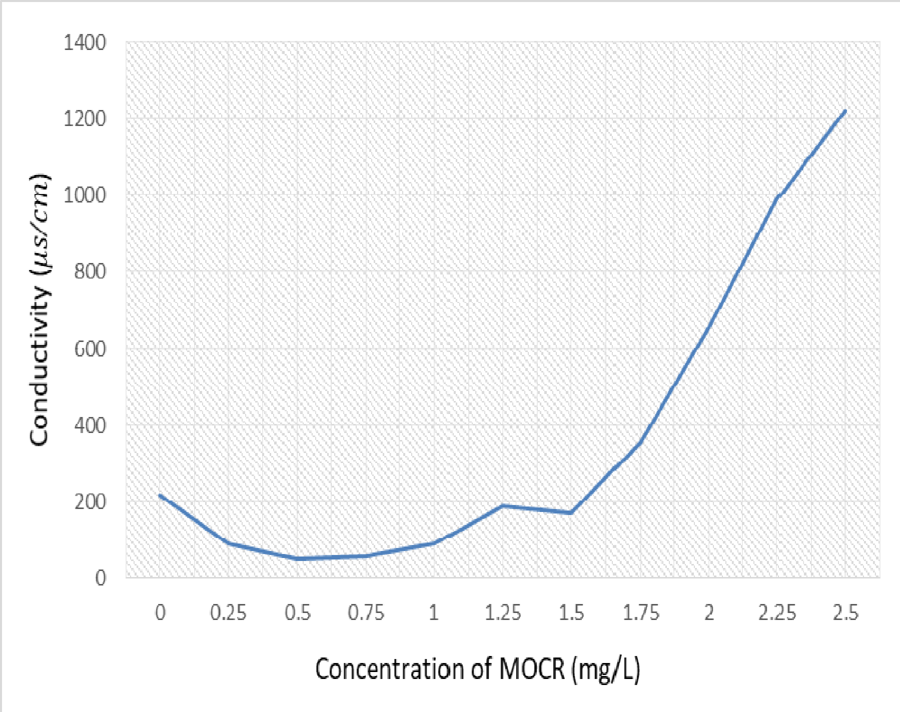

Figure 5: Conductivity values after treatment

3.7 COD measurement

Figure 6 shows the comparison between the dosages used for water treatment and the COD values obtained after water treatment. The COD value is directly proportional to the MOCR dosage (Eman *et al.*, 2014). According to Malaysian Water Standard Quality, the standards COD value to be released to the environment must be less than 250 mg/L. Hence, the best dosage is 0.75 mg/L because it showed the highest reduction of COD value.

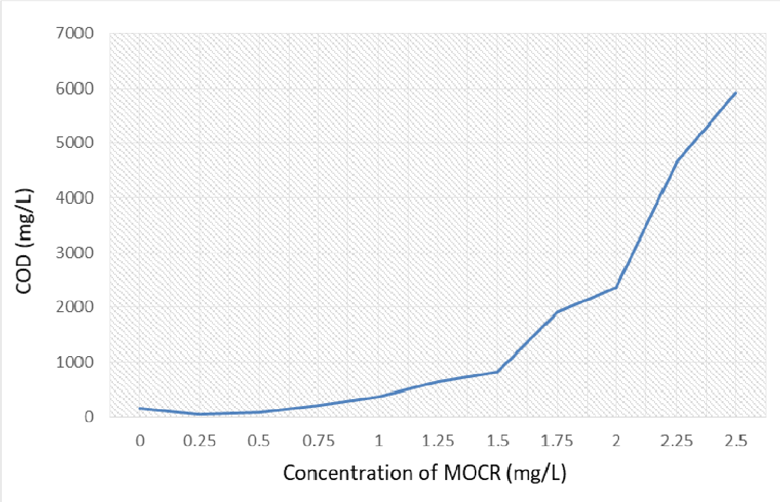

Figure 6: COD values after treatment

3.8 BOD measurement

Figure 7 shows the comparison between the dosages of MOCR used for water treatment and the BOD values obtained after water treatment. From the result obtained the lowest BOD value was 18 mg/L (0.25 g/mL). According to Malaysian Standard of Water Quality, the BOD value obtained must be less than 100 mg/L in order to categorise the water as clean water. The increase in BOD value after treatment may be due to the presence of the natural organic compound present in the MOCR (Shan *et al*., 2017). However, MOCR concentration of (0.75 mg/L) is the best dosage to be used.

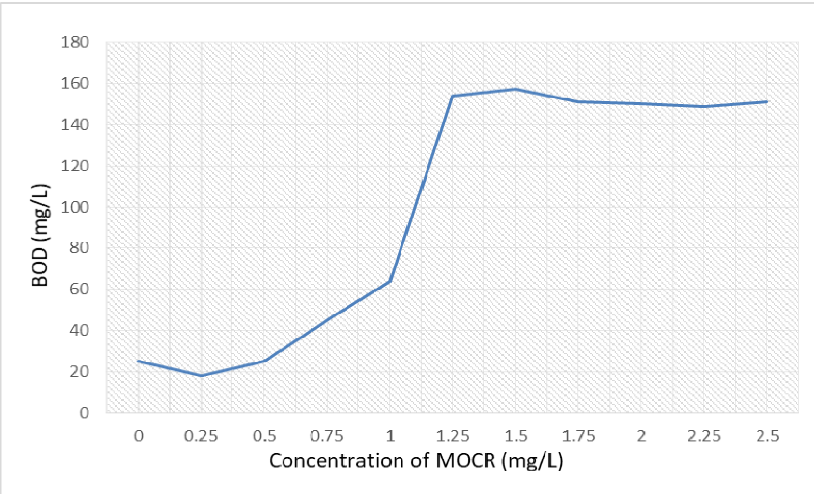

Figure 7: BOD values after treatment

3.9 Concluding remarks on the performance of MO residue as bio-coagulant

Table 1 summarizes the best results obtained from the experiment which is MOCR of 0.75 mg/L dosage. Moreover, 0.75 mg/L able to reduce 98.87% of the initial turbidity and has no significant impact on the water pH. 0.75 g/mL also have lower impact on the TDS, conductivity, COD and BOD values which are 50, 72.7, 24.76, and 44.4% respectively.

Table 1: Summary of best results

Parameters	Before	After	Percentage Difference (%)
Turbidity (NTU)	415	4.7	98.87
pH	6.4	6.5	1.5
TDS (ppm)	100	50	50
Conductivity ($\mu s/cm$)	220	60	72.7
COD (mg/L)	158	210	24.76
BOD (mg/L)	25	45	44.4

4.0 CONCLUSIONS

The experimental procedure was conducted in two batches, the first batch comprises of Moringa oleifera seeds powder as natural coagulant for water treatment, while in the second batch the seeds were placed inside the extraction thimble for the Moringa oleifera seeds oil extraction process and *Moringa oleifera* cake residue formed was used as bio-coagulant after the oil has been completely extracted. The first batch of the experimental procedure was employed to determine which of the particle sizes is appropriate and this was achieved by varying the amount of MOCR. The result obtained gave residual turbidity of the treated water less than 5.0 NTU. This is in accordance with the WHO standard, which established that the turbidity of drinking water shouldn't be more than 5 NTU. Also, the COD result indicated that there is no increase in the COD in the treated water sample. Moreover, the pH value obtained (6.5-7.5) implies that there is no need for any additives for pH adjustment as it is within the acceptable range for drinking water. The conductivity, on the other hand, was less than the accepted standard limit (1055 µs/cm) for drinking water. This obtained showed that the use of *Moringa oleifera* cake residue as a natural coagulant was found to be most efficient at high turbid water. In addition, a prolonged sedimentation time together with Moringa oleifera bio-coagulant improved the quality of the treated water.

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