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Preliminary Investigation of Water Treatment Using Moringa Oleifera Seeds Powder as Natural Coagulant: A Case Study of Belat River, Malaysia

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ABSTRACT
The increasing demand for potable drinking water has necessitated a need for an eco-friendly method of treatment. The Moringa oleifera is, therefore, an important commodity plant which has been traditionally used for the treatment of water in the tropical area. In this study the experimental procedure was conducted and operated at 200 rpm for 4 minutes, followed by 40 rpm for 30 minutes and 1 hour of sedimentation. The Jar tests carried out before and after treatment with Moringa Oleifera seed powder to evaluate the quality parameters such as pH, turbidity, conductivity, Total Dissolved Solid (TDS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Ammonia-Nitrogen (NH_3-N) and Nitrate-Nitrogen (NO_3-N). The result obtained showed that conductivity, TDS and COD increase as the Moringa seed powder dosage increased. Moreover, the turbidity of the treated water decreased by 98.80% and 96.71% for high and low turbid water, respectively. Also, the maximum BOD reduction was 66.67% 27.27% for high and low turbid water, respectively. Lastly, the NH_3-N and NO_3-N values were unstable. The results obtained showed that the cross-flow filtration using microfiltration is sufficient to produce the natural coagulant which is more efficient and cost-effective.

KEYWORDS; -*Bio-coagulant, Turbidity, Moringa oleifera seeds, Water treatment*

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I. INTRODUCTION

In recent times, the consumption of water for domestic and industrial use has been on an increasing trend with a rise in demand [1]. In many parts of the world river water, which can be highly turbid, is used for drinking purposes and for industrial use. This turbidity in this water is conventionally removed by treating the water with expensive chemicals, many of which are imported at great expense [2]. There is, therefore, a need for a plant-based alternative in treating this water at a lower cost using an environmentally friendly approach. Moringa oleifera is an example of these plant-based materials usually grown in developing countries with a natural coagulating property [3]. They are tropical plant found in Asia, India, Africa and Latin America with reported use in cleaning turbid river water. The coagulant in the seeds is believed to comprise of one or more proteins that act as a cationic polyelectrolyte. The soluble particles in the water attach to the active agent and bind them together to form large flocs in the water. It is worthy of note that aluminiumsulphate, has been used as a chemical coagulant for all levels of turbidity, but the chemical coagulant had an effect on pH and alkalinity [4]. However, previous studies indicated the Moringa plant as an efficient coagulant with no hazardous effect on the properties of the treated water [5]. The use of Moringa seed powder as a natural coagulant, therefore, has no effect on measured parameters and was found to be most efficient at high turbid water. In addition, a prolonged sedimentation time together with *Moringa oleifera* seeds improved the treatment.

In this study, the Jar test was conducted to evaluate the water quality parameters such as pH, turbidity, conductivity, Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Ammonia-Nitrogen (NH_3-N) and Nitrate-Nitrogen (NO_3-N) before and after treatment with MOSP. The performance of the natural coagulants was measured using River Belat,Kuantan, Malaysia as a case study.

II. MATERIALS AND METHOD

Experimental site

The river water sample was collected from Belat River, which is located atthe housing area in Gambang, Kuantan, Pahang, Malaysia. The water quality status of this river was tested with different doses of *Moringa oleifera seeds powder* (MOSP) and different powdered size using jar tests to evaluate the performance of MOSP on river water. The experiment was conducted at the Environmental Engineering Laboratory, Universiti Malaysia Pahang.

Preparation of Moringa Bio-coagulant

The *Moringa oleifera*seed was purchased from MitomasaSdn. Bhd., Kuala Lumpur. MO seeds' wings and coat from the mature and selected good quality of seeds were de-husked to get the kernels. The kernel of MO seeds was then dried at room temperature for 1 day and ground to a fine powder using a domestic grinder. Fine powders were then sieved through a 2 mm-mesh, 1mm-mesh, 500μm-mesh, and 250 μm-mesh. MO seeds powder strongly attracts moisture and the product can reabsorb humidity during or after grinding. Hence,MO seeds powder will be dried at 50℃ for 30 minutes to reduce moisture content. After drying, MO seeds powder was left to cool and packed into clean polythene bags and sealed. The bags were kept at chiller at 4℃ to maintain freshness and dryness for further use.

Experimental Jar Test Procedure

Each beaker filled with 500 mL of river water. These beakers were placed into the jar test machine. It was important to make sure that the turbidity was almost the same in each beaker before 0.05, 0.10, 0.50, 0.75, 1.0, 2.5, 5.0, 7.5 and 10.0g of 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 mins followed by 40 rpm for 30 mins [6]. Then, the mixtures were left 60 mins for settling. Finally, the water quality parameters were tested. The experiment was repeated with a different particle size of MOSP for 1mm, 500μm and 250 μm.

Testing the Water Quality Parameters

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 20NTU 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 0.0NTU 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℃. 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 3mg/L to 150mg/L while for high range reagent vials ranging from 20 mg// to 1500 mg/L. The samples were then inserted into COD reactor HACH DRB200 and heated for 2 hours at 150℃ with starong 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 [7]. The dissolved oxygen (DO) meter was used for BOD measurement. 1 liter 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 aluminum foil to prevent evaporation of the solution . All bottles will be put into the BOD incubator for 5 days at 20℃. The DO value will be measured after 5 days [7].

Twelve (12) samples including blank were tested each time for one powdered particle size for NH_3-N. 10ml each of de-ionized water that act as a blank and 11 samples after jar test will be added into different rounded sample cells respectively. Then, 12 sample cells were added with ammonia salicylate powder pillow before a 3 minutes reaction period with a spectrometer. Then, the 12 rounded cells were added with another ammonia cyanurate reagent powder pillow and a 15 min reaction period was started with spectrometer again. All rounded sample cells were cleaned before NH_3-N was measured using spectrophotometer DR2800. 22 samples cells were tested each time for one powdered particle size for NO_3-N. 10ml sample after jar test was added to 11 different sample cells respectively. Then, all the cells were added with NitraVer 5 nitrate reagent powder pillow before 1 minute reaction period with a spectrometer. The cells were taken out and shaken vigorously until the timer beeps before another 5 minutes reaction period was beginning. After that, another 11 different rounded sample cell was filled with 10 ml of the sample as a blank. Round sample cells were cleaned before each pair NO_3-N measured using spectrophotometer DR2800.

III. RESULT AND DISCUSSION

The Influence of Prepared Bio-Coagulant on Water Turbidity

River water treatment processes using MOSP have the ability to effectively remove turbidity. When MOSP was added to the sample and followed by rapid stirring, the resulting cationic protein from MOSP was distributed to all parts of the liquid and then interacted with the negatively charged particles that caused turbidity in water [6]. Such interactions disturb the forces that stabilize the particles so that it can bind to small particulates to form a precipitate. From Figure 1, it was shown that 98.80% of turbidity removal in with 0.05g of MOSP. This showed that the optimum dose of MO as coagulant was influenced by the level of the initial turbidity of the water to be processed.

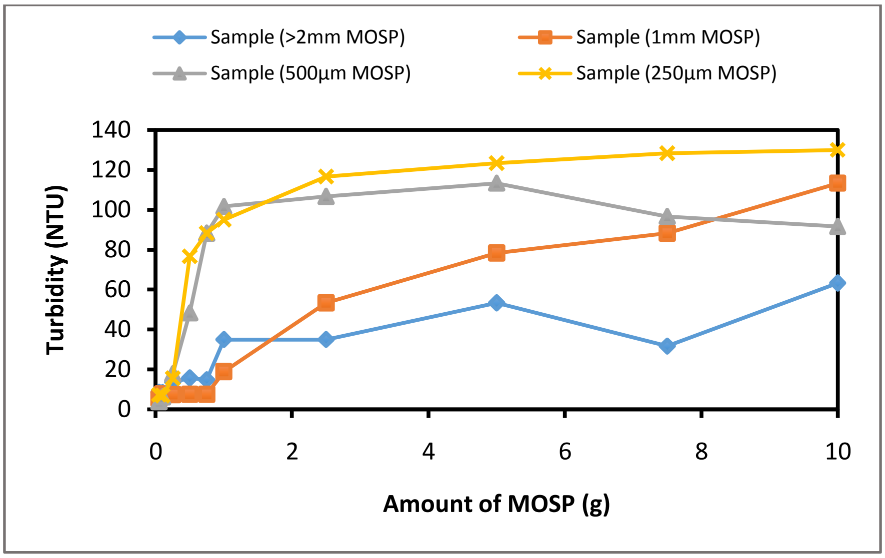

Figure 1: Turbidity removal of water treated with MOSP

The lowest turbidity value of river water after treatment with MOSP is 3.83NTU. When MOSP concentration exceeded the optimum dosage, turbidity was increased because all colloids have been neutralized and precipitated with an optimum dosage, so the excess coagulants will cause turbidity in water as they did not interact with oppositely charged colloidal particles [8]. The World Health Organization) establishes that the turbidity of drinking water shouldn't be more than 5 NTU, and should ideally be below 1 NTU [8]. Hence, for the high turbid river water treated with MOSP does not reach WHO standards.

The Influence of Prepared Bio-Coagulant on Water Conductivity

Conductivity in water is varying widely. The solubility of minerals in different geographic regions also varies. There is no standard value but a high level of conductivity is not allowed in drinking water for consumers. From the experimental results as shown in Figure 2, 1g and above MOSP will cause a high increase of conductivity. An increase in conductivity in a body of water can indicate pollution [9]. The uses of MOSP increase conductivity due to the presence of unbound ions [10]. According to a standard chemical report from Queensland Health Forensic and Scientific Services (QHFSS), levels up to 800 µS/cm are acceptable in drinking water. Hence, conductivity values for treated water with a different dose of MOSP are acceptable for drinking water standard.

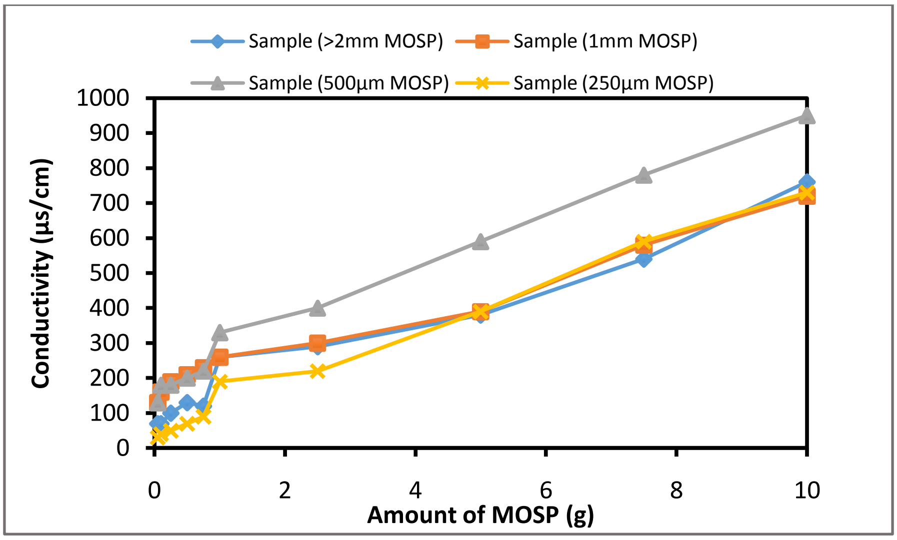

Figure 2: Water conductivity treated with MOSP

The Influence of Prepared Bio-Coagulant on Water pH

The pH result for raw river water before treatment with *Moringa oleifera* seeds powder (MOSP), the pH is within 6.67-7.60, which is in the ideal pH range for drinking water. From the result obtained as shown in Figure 3, MOSP with powdered size 2mm and 1mm with the dosage of 2.5g, 5.0g, 7.5g and 10.0g of MOSP will affect the pH value of the river water. River water becomes acidic after MOSP was added. Hence, MOSP with 2.5g and above are not recommended to treat water as it made the water become acidic.For MOSP with the powdered size of 500μm and 250 μm , treatment with MOSP does not have signaificant affect at the pH value of the river water. Hence, MOSP is suitable in treating river water for drinking purpose, as the pH is almost constant before and after treatment. In addition, no additional step has been required to adjust the pH value after the treatment. It is suggested that MOSP could be the best choice for river water treatment.

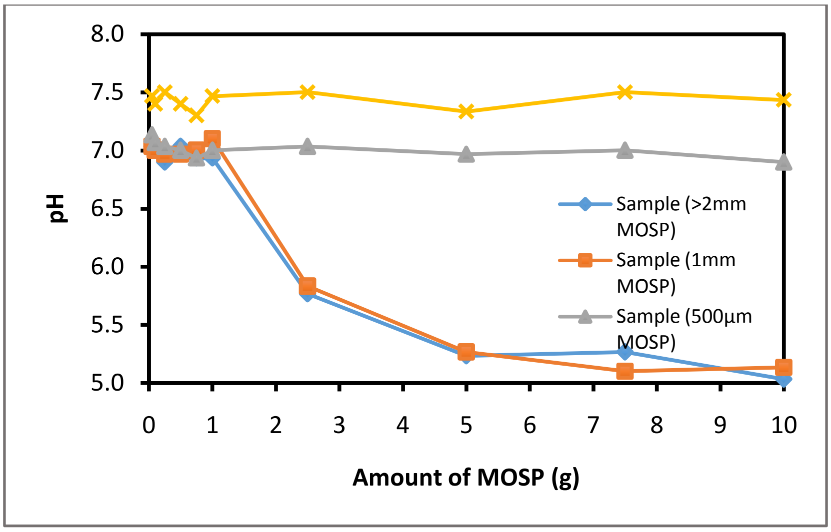

Figure 3: pH values for water treated with MOSP

The Influence of Prepared Bio-Coagulant on Water COD

The result of a COD test indicates the amount of water-dissolved oxygen consumed by the contaminants, during two hours of decomposition from a solution of boiling potassium dichromate [11]. The higher the chemical oxygen demand, the higher the amount of pollution in the test sample.From the COD result obtained as seen in Figure 4, COD of "Sungai Belat" river samples was 127.33mg/L for high turbidity before treatment and decreased to 40.33mg/L when 0.10g of MOSP with 2mm particle size of MOSP was used, which mean there is a 68.33% of COD removal. However, it showed that for overall treatment process with MOSP, COD increase when the concentration of MOSP increase. On the other words, COD is directly proportional to the amount of MOSP used. The COD value increased after the treatment as higher dosage was used because of the oil content of MO seeds which has not been removed [9]. The protein in the MO seeds leads to increase in the COD value. The COD value of drinking water standard set by Ministry of Health Malaysia of less than 250mg/L. Hence, 0.5g and above of MOSP is not recommended to use for river water treatment, as it will increase the COD value.

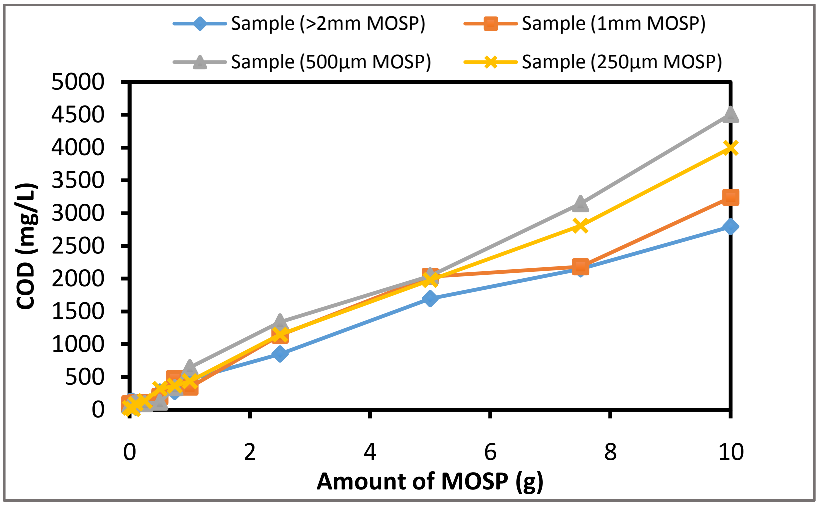

Figure 4: COD of water treated with MOSP

The Influence of Prepared Bio-Coagulant on Water BOD

The BOD for river water that collected from "Sungai Belat" was 16mg±1.00 mg/L. When the particle size of 2mm MOSP used for treatment, 0.05g, 0.10g and 0.50g of MOSP used showed a decrease in BOD value and others dosage show an increase in BOD value as shown in Figure 5. When the particle size of 1mm MOSP used for treatment, 0.05, 0.10 and 0.25g of MOSP used showed a decrease in BOD value and others dosage show an increase in BOD value. The higher the MOSP dosage used the higher the BOD value in river water. The optimum BOD removal was 66.67% when 0.05g of 2mm MOSP was used. When compare with COD, it was showed that BOD result has the same trend with COD result. The possible reason for the increase of the BOD value after treatment may due to the presence of an organic matter in MO seeds [12]. A BOD level of 1-2 ppm is considered very good. There will not be much organic waste present in the water supply. Water supply with a BOD level of 3-5 ppm is considered moderately clean. In water with a BOD level of 6-9 ppm, the water is considered somewhat polluted because there is usually organic matter present and bacteria are decomposing this waste. At BOD levels of 100 ppm or greater, the water supply is considered very polluted with organic waste. According to the Ministry of Health Malaysia, the standard of BOD of drinking water must less than 100ppm.By using more than 2.5g of MOSP for river water treatment, BOD parameters do not meet drinking water quality requirement set by Ministry of Health Malaysia [12].

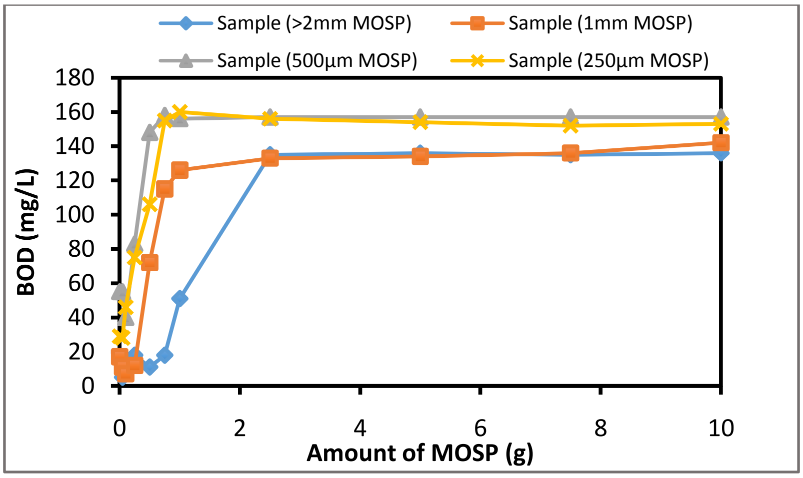

Figure 5: BOD of water treated with MOSP

The Influence of Prepared Bio-Coagulant on Water TDS

High TDS results in undesirable taste, which could be salty, bitter, or metallic. It could also indicate the presence of toxic minerals. For drinking water, the maximum concentration level set by EPA is 500 mg/L. TDS levels exceed 1000mg/L it is generally considered unfit for human consumption [13].From the result obtained as shown in Figure 6, the total dissolved solids in river water after treatment with MOSP is increasing for the different powdered size of MOSP used. However, the maximum TDS measured was 450mg/L when 10g of MOSP used for the 500μm particle size of MOSP, which is still in the TDS standard level set by EPA.

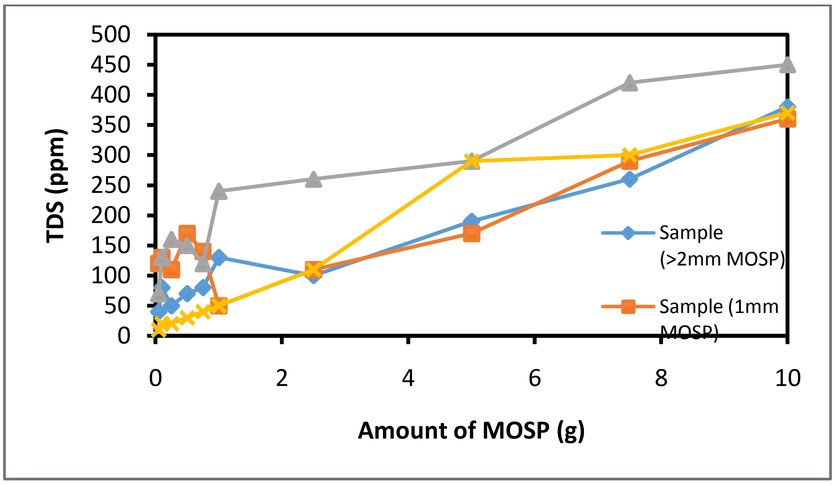

Figure 6: TDS of water treated with MOSP

The Influence of Prepared Bio-Coagulant on Water Ammonia-Nitrogen (NH_3-N)

Ammonia occurs naturally in water bodies arising from the microbiological decomposition of nitrogenous compounds in organic matter. Besides, fish and other aquatic organisms also excrete ammonia. Ammonia may also be discharged directly into water bodies by some industrial processes or as a component of domestic sewage or animal slurry. Ammonia can also arise in waters from the decay of discharged organic waste. From Figure 7, the result obtained fluctuated. Removal of ammonia using MOSP did not give a good result because MO is sources of cationic coagulants. Ammonia cannot be removed due to the positive charge of MO could not attract the positive charge of ammonium [14]. Besides, there might be some interference substances present that disturb the result such as calcium, iron, magnesium, monochloramine, nitrate, nitrite, pH, phosphate, sulfate, sulfide etc. The turbidity of water after treatment will give incorrect high values.

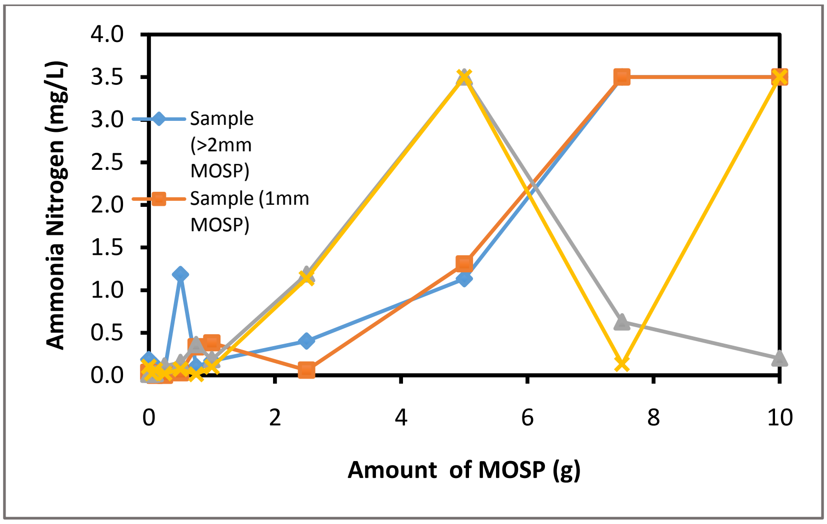

Figure 1: Ammonia-Nitrogen of water treated with MOSP

The Influence of Prepared Bio-Coagulant on Water Nitrate-Nitrogen (NO_3-N)

All aquatic organisms excrete wastes and aquatic plants and organisms eventually die [11]. These activities create ammonia. Some bacteria in the river water change this ammonia to produce nitrite that is then converted by other bacteria to nitrate. Nitrates (NO^{3-}) are an oxidized form of nitrogen and are formed by combining oxygen and nitrogen. Excess levels of nitrates can be considered to be a contaminant in waters. From Figure 8, the optimum dosage used to remove nitrate in high turbidity water was 0.05g of MOSP with 2mm particle size. On the other hand, the optimum dosage used to remove nitrate in low turbidity water was 0.10g of

MOSP with 50% to 55.56% of nitrate removal in water. The removal of nitrate is probably because the positive charge of MOSP could attract the negative charge of nitrate and increase the removal ability. However, if the dosage of MOSP used was too high which is more than 1g, it will causean increase of nitrate in river water [15].

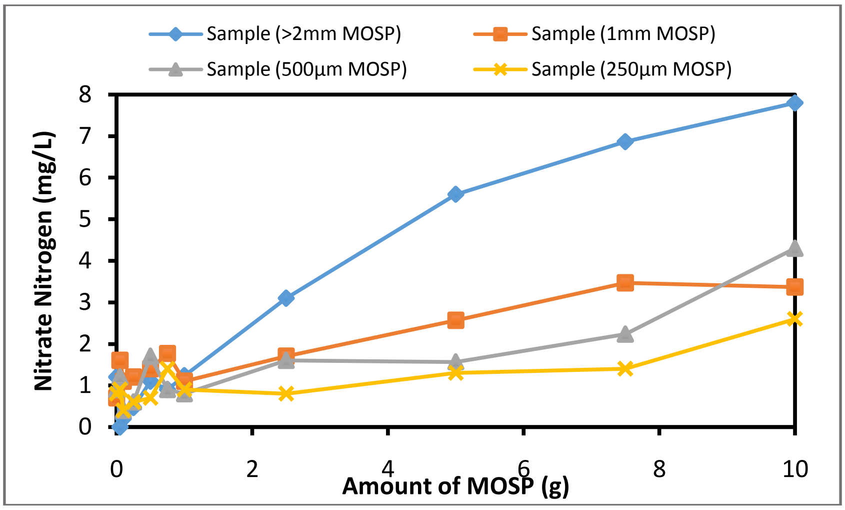

Figure 2: Nitrate-Nitrogen of water treated with MOSP

IV. CONCLUSION

In this study,a sustainable and cheap Moringa seeds coagulant was prepared for river water treatment for household usage. The turbidity was removed up to 98.80% after treatment. There was slightly changing of pH in high turbidity water but still within an acceptable range. Besides, conductivity and TDS increase as the dosage of MOSP used increase. COD and BOD were increasing after treatment due to the presence of organic matter in the MOSP. The unstable result was obtained for NH_3-N. Lastly, optimum dosage of 0.05g/500mL MOSP was able to remove NO_3-N.It was observed that the 1 mm microfiltration sizes performed better in terms of turbidity removal efficiency (98.80%) treated with 0.05 g (50 mg) of MOSP. In conclusion, 0.05g/500mL of MOSP used for river water treatment gave a significant improvement in the quality of water.

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