



OPTIMISATION OF *Moringa oleifera* POD EXTRACT CONCENTRATION FOR SURFACE WATER CLARIFICATION

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ABSTRACT

Natural coagulants can potentially compliment or replace synthetic chemicals used for turbidity removal from surface water. This paper evaluated the turbidity removal efficiency of *Moringa oleifera* pod extracts on synthetic high and medium turbidity raw water. The turbidity removal efficiency was evaluated at 3, 6 and 9% w/v stock solutions of *M. oleifera* pod extract, using jar test. Results obtained revealed that 6% w/v *M. oleifera* pod extract optimally removed turbidity from the synthetic raw water at about 200 mg/L coagulant dose, corresponding to a turbidity removal efficiency of about 80% in both high and medium turbid synthetic raw waters. This study demonstrated the potentials in using *M. oleifera* pod extract for turbidity removal from surface water. The pod extract can be used to clarify raw water at household level in rural communities.

Keywords: Clarification; extract concentration; *Moringa oleifera* pod; synthetic raw water; turbidity removal.

INTRODUCTION

Safe water and adequate sanitation are essential to the wellbeing of every individual but many people lack access to this primary need, particularly in rural communities in developing countries (Bartram *et al.*, 2005). Turbidity in water is caused by suspended particles such as clay, silt, finely divided organic and inorganic materials and soluble coloured organic compounds (APHA, 2005). The consumption of high turbid water may cause severe health risk such as Alzheimer's disease (Perl and Good, 1991). Coagulation-flocculation and sedimentation are the conventional methods for surface water clarification but are expensive due to high cost of chemical coagulants. The cost of procuring chemical coagulants for water treatment is escalating and becoming unaffordable to low-income communities with associated problems in handling synthetic coagulants such as aluminium sulphate. It is imperative to find alternative coagulants that can replace the conventional ones.

Naturally occurring coagulants are usually presumed safe for human health. *Moringa oleifera* seed powder has been found to be an environmentally-friendly, cheap and viable alternative to expensive conventional chemicals. *M. oleifera* seed powder has traditionally been used for household water treatment in Sudan, Indonesia and other places (Delelegn *et al.*, 2018; Keogh *et al.*, 2017; Jahn

and Hamid, 1979; Folkand and Sutherland, 1996).

Compared to the commonly used chemical coagulants, *M. oleifera* has a number of advantages including lower sludge volume and low cost of handling biodegradable sludge, and minimal effect on pH of the treated water. These make *M. oleifera* a consumer-friendly and sustainable alternative, with high potentials for use in both high and low income communities (Ghebremichael, 2004). The water soluble *M. oleifera* seed (and pod) proteins possess coagulating properties similar to those of alum and other synthetic cationic polymers (Mataka *et al.*, 2006). The active agents of *M. oleifera* extract responsible for coagulation are dimeric cationic proteins with molecular weight of 13 kDa and isoelectric points between 10 and 11 (Jahn, 1981; Ndabigengesere *et al.*, 1995). Although many studies have been conducted on the use of *M. oleifera* seeds in water clarification, little or no attention has, however, been paid to the use of *M. oleifera* pod in water treatment. This material is traditionally considered as solid waste but serve as a good candidate for surface water clarification.

Melesse and Berihun (2013) reported that *M. oleifera* pods and seeds have similar chemical and mineral compositions. In view of this, there is need to evaluate the performance of this material in turbidity removal from surface water.

This may be achieved by determining the optimum dose of the material that can suitably be used in water clarification. As such, this study aimed at evaluating the potentials of *M. oleifera* crude pod extract for turbidity removal from medium and high turbid synthetic raw water with a view to determining optimum dose and pH suitable for coagulation. This may help in realizing a cheaper and a more sustainable coagulant in water treatment and minimising a conflicting interest of using the *M. oleifera* seeds in agriculture, since the pods are usually disposed of as solid waste.

MATERIALS AND METHODS

M. oleifera Pod Extract

Matured and dried *M. oleifera* seed-containing pods were obtained from Faculty of Agriculture Farm, Bayero University, Kano, Nigeria. The seeds were removed by hand-picking them from the pod. The pods were then ground using a clean pestle and mortar and sieved with a 250 µm British Standard sieve to obtain a fine powder. The powder was stored in a plastic container at room temperature prior to extraction. The extraction was done using petroleum ether as a solvent, according to AOAC (1995).

Synthetic Raw Water and Turbidity Measurement

Synthetic high turbidity raw water of about 495 NTU and medium turbidity water of about 100 NTU (Doerr, 2005) were prepared using kaolin according to Gidde *et al.* (2012) and used in the study. Kaolin stock solution was prepared once and used to prepare the synthetic raw water for all of the experiments. Turbidity values of the raw and clarified water were measured with a potable turbidity meter (Model: SGZ-200BS, England) based on Nephelometric method (APHA, 2005). Turbidity measurements

were carried out in duplicates but simple arithmetic means were used to compute the turbidity removal efficiencies and corresponding values of standard errors were computed and plotted as shown in Figures 1 to 3.

Stock Solutions preparation and Jar Test

Three stock solutions of the *M. oleifera* pod extract with concentrations of 3, 6 and 9% (weight per volume; w/v) were prepared according to Muyibi and Evison (1995). Varying dosage of the coagulants ranging from 0 to about 800 mg/L were applied to the raw water and jar test was carried out according to APHA (2005) and Muyibi *et al.* (2003) using a PEF003/11 Flocculator (Edibon International, Spain).

RESULTS AND DISCUSSION

It was envisaged that high stock solutions concentration may result in having more solids than liquid in solution. Optimisation of stock solution was, therefore, imperative in order to determine the extent to which the *M. oleifera* pod powder can dissolve and release the essential active ingredients in the extract. At stock solution concentration higher than 9% w/v, a paste, rather than a solution, was obtained. This informed the decision to test three different stock solution concentrations (i.e. 3, 6 and 9% w/v).

Turbidity Removal Efficiency of 3% w/v of *M. oleifera* Pod Extract

The optimum dose of a coagulant is here considered to be that dosage which yields the highest turbidity removal efficiency (in %) or least residual turbidity (in NTU) in the range of turbidity values obtained after applying varying dose of *M. oleifera* pod extract to turbid water samples and subjecting the prepared samples to jar test.

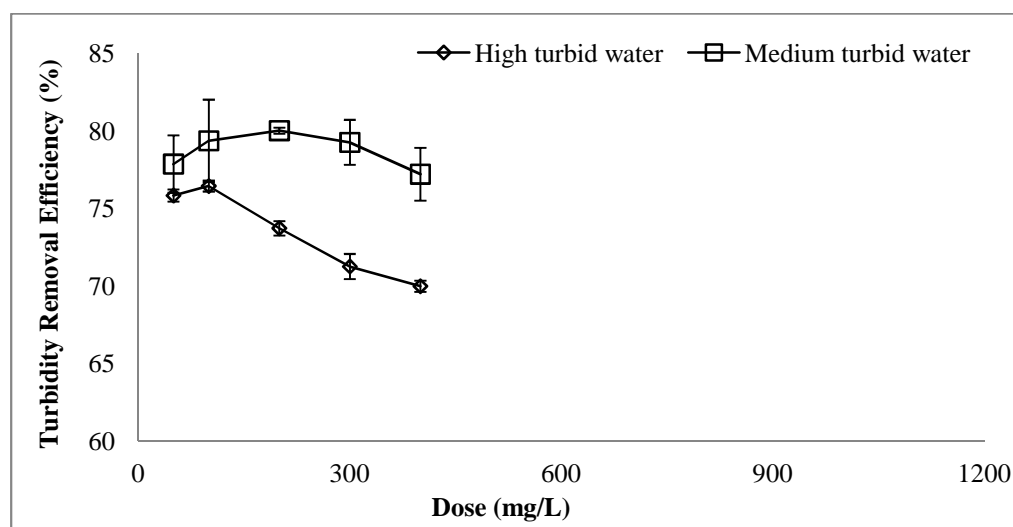


Figure 1: Turbidity removal efficiency of 3% w/v of *M. oleifera* pod extract for high and medium turbid waters

The optimum dose for 3% w/v of *M. oleifera* pod extract appeared to be 100 mg/L with about 76% turbidity removal efficiency (Figure 1) for high turbid water. In contrast with medium turbid water, the optimum dose was found to be 200 mg/L with 80% turbidity removal efficiency. From the results obtained it can be deduced that 3% concentration of *M. oleifera* pod extract is more effective in turbidity removal from medium turbid water than high turbid water. The result obtained falls within the optimum dosage range of 75 -

200 mg/L earlier reported by Folkard *et al.* (2005).

Turbidity Removal Efficiency of 6% w/v of *M. oleifera* Pod Extract

Figure 2 shows the results obtained when 6% w/v of *M. oleifera* pod extract was used to treat high turbid water (495 NTU) and medium turbid water (100 NTU). About 84 and 81% turbidity removal efficiencies were, respectively, achieved at an optimum dose of about 200 mg/L (Figure 2).

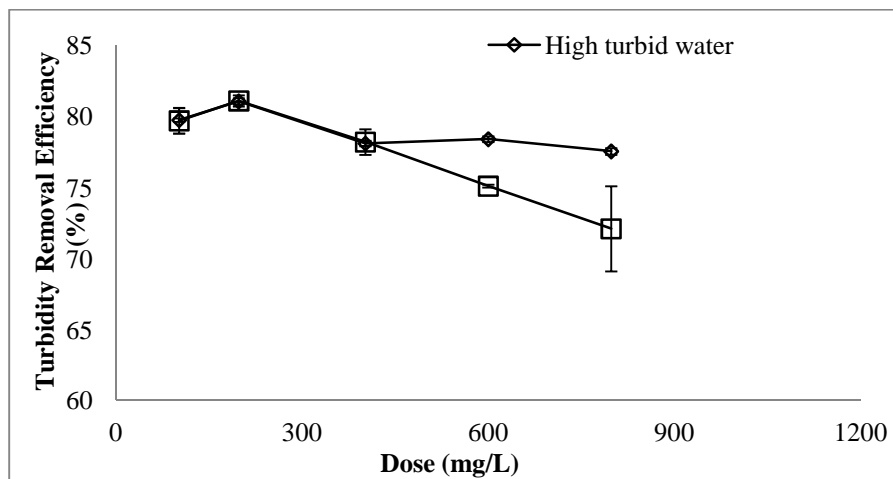


Figure 2: Turbidity removal efficiency of 6% w/v of *M. oleifera* pod extract for high and medium turbid waters

Achieving the same value of optimum dose for both the high and the medium turbid waters could be due to the fact that, medium turbidity water contains less colloidal particles than high turbid water with lower rate of inter-particle contact which as a result exerts higher dose of the coagulants for effective coagulation process (Muyibi and Evison, 1995).

81% turbidity removal efficiencies were obtained at an optimum dose of about 150 mg/L for the high and medium turbid waters, respectively. This, in contrast, achieved lower turbidity removal efficiencies than the earlier presented values in the current study. This could possibly be due to low concentration of active ingredients of *M. Oleifera* pod extract at 9% w/v compared to the lower stock solution concentrations of 3 and 6% w/v.

Turbidity Removal Efficiency of 9% w/v *M. oleifera* Pod Extract

Figure 3 shows the result of coagulation with 9% w/v of *M. oleifera* pod extract. About 75 and

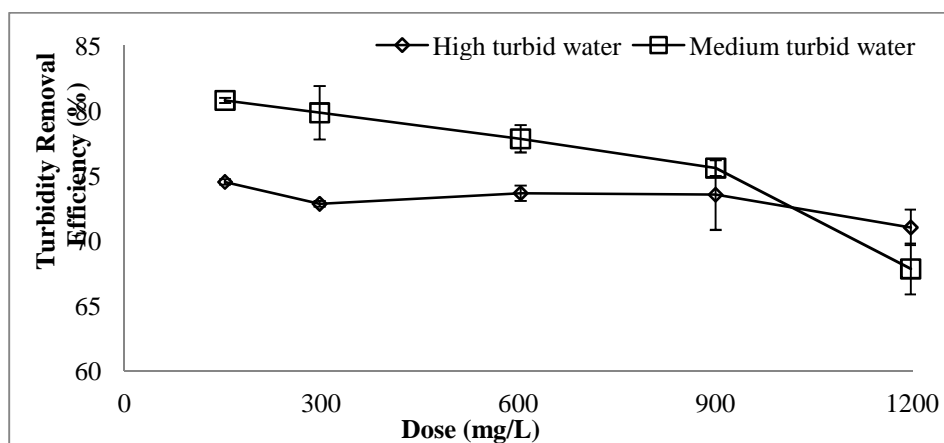


Figure 3: Turbidity Removal Efficiency of 9% w/v of *M. oleifera* pod extract for high and medium turbid waters

CONCLUSION

M. oleifera pod extract efficiently removed turbidity from high and medium turbid waters. However, the pod extract seemed to be more efficient in removing high turbidity than the medium one. This study has, therefore, demonstrated the potential of using *Moringa oleifera* pod extract in removing high turbidity

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