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COMPARATIVE ASSESSMENT OF *Moringa oleifera* SEED AND POD EXTRACTS FOR TURBIDITY REMOVAL FROM SURFACE WATER

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ABSTRACT
This paper presents a comparative study on the performance of Moringa oleifera seed and pod extracts in removing turbidity from high turbidity water. Turbidity removal efficiencies of M. oleifera seed and pod extracts were studied at 3, 6 and 9% w/v stock solution concentrations, using jar test. M. oleifera seed and pod extracts excellently removed turbidity from surface water with the seed extract exhibiting higher performance than the pod, with overall turbidity removal > 70%. Turbidity removal efficiencies of 98 and 84% at optimum dose of 100 and 200 mg/L were achieved by M. oleifera seed and pod extracts at 3 and 6% w/v, respectively. Turbidity was optimally removed at pH 6.5 and 8.0 using the M. oleifera seed and pod extracts, respectively. This study demonstrates the potentials of using M. oleifera pod extract for turbidity removal from surface water. Moringa pods can potentially replace its seeds in surface water treatment.
Keywords: Moringa oleifera; pod extract; seed extract; synthetic raw water; turbidity removal

INTRODUCTION

Access to clean water is fundamental to the wellbeing of human populations and an essential aspect in sustainable development. Lack of access to clean drinking-water is detrimental to public health. Therefore, understanding the extent to which people lack access to clean drinking-water is an important step towards tackling global water challenges (WHO and UNICEF, 2000).

About 30% of global population lack access to safely managed drinking-water services (UNICEF and WHO, 2017). The United Nations Sustainable Development Goal 6 targets provision of clean water and adequate sanitation for all (United Nations General Assembly, UNGA, 2015). The goal is partly tailored towards universally achieving equitable access to safe and affordable drinking water by all by 2030 through pollution prevention and control thereby improving water quality (UNGA, 2015). This can be achieved by sustainable use of appropriate wastewater and water treatment technologies.

Despite extensive recognition of the importance of improved water and sanitation and heavy investment by international donors and governments in developing countries in extending water supply systems, majority of the population of rural areas still lack access to safe drinking water (Rondinelli, 1991). Due to this situation, people living in rural communities abstract water from polluted sources (WHO and UNICEF, 2000). Poor water quality and inadequate supplies of clean water for personal hygiene coupled with poor sanitation are responsible for very high diarrhoeal cases leading to more than 2 million death annually, mostly among children below the age of five in low-income countries (WHO, 2006).

Water and sanitation improvements, coupled with improvement of personal hygiene can significantly affect the health of the population by reducing a variety of water-related diseases (Billig *et al*., 1999). Water quality may be hampered by physico-chemical parameters present in suspension and/or solution. Turbidity in water is caused by suspended and dissolved organic and inorganic matter, phytoplankton, and other microorganisms (APHA, 2005). It can provide food and serve as shelter to pathogens and if not removed, can promote their re-growth in water distribution network. Coagulation and sedimentation are used to remove turbidity from water.

However, costs of chemical coagulants such as alum and potential risks of chemical pollution resulting from sludge handling and disposal are key challenges associated with turbidity removal. Studies have pointed out drawbacks of using aluminium salts, such as Alzheimer's disease associated with residual aluminium in treated water (Ndbigengesere and Narasiah, 1998) and the problem of reaction of alum with natural alkalinity leading to decrease in pH and To tackle these challenges, attention should be paid to sustainable water treatment systems that are low-cost, robust and require minimal maintenance and basic skills. Locally available organic coagulants may provide viable alternatives and remarkably reduce treatment cost (Yung, 2003). Natural materials of plant origin have been used to clarify turbid water (Ndbigengesere *et al*., 1995). Among the materials that have been tested over the years, powder processed from the seeds of *Moringa oleifera* has been shown to be one of the most effective primary coagulants for water treatment (Amagloh and Benang, 2009). Attention has also been paid on the effectiveness of *M. oleifera* seeds in water and wastewater treatment.

Although many studies have been conducted on potential uses of *M. oleifera* seed in drinking water treatment, studies on the use of *M. oleifera* pods in drinking water treatment are very rare. Melesse and Berihun (2013) found that *M. oleifera* pods and seeds have similar chemical and mineral composition and this serve as the basis for comparing the efficiencies of *M. oleifera* seed and pod extracts as they possess similar chemical characteristics. *M. oleifera* pods may substitute or replace the use of its seeds in water treatment. This may help in resolving the conflicting interest of traditionally using *M. oleifera* seeds in agriculture and water treatment. This paper evaluated the suitability of using *M. oleifera* pod extract for turbidity removal from surface water and compared its performance with *M. oleifera* seed extract.

MATERIALS AND METHODS

Collection of *M. oleifera* seeds and pods

Good quality, matured and naturally dried *M. oleifera* pods containing seeds were collected from the Faculty of Agriculture Farm, Bayero University, Kano, Nigeria.

Sample Preparation

The seeds were removed manually from the pod while the husks were removed from the seeds to obtain the kernels. Both the kernels and pods were differently ground to powder using mortar and pestle. Each powder was then sieved with a 250 µm British Standard sieve and stored in a plastic container prior to oil de-fatting of the seed powder.

Extraction of Oil from the Seed Powder

Oil was extracted from *M. oleifera* seed powder using Soxhlet extraction technique (Ali *et al*., 2010). About 10 g of *M. oleifera* seed powder was carefully folded into a fat-free filter paper and a small fat-free cotton wool placed on top coagulant wastage.

and placed in the extraction thimble. The Soxhlet apparatus was then connected after the addition of 300 mL of petroleum ether. The extraction was then carried out using a heating mantle (Thermo Scientific, UK) evaporating the petroleum ether through three cycles until the extraction solvent became colourless (Muyibi *et al*., 2003). The sample was then removed and air-dried at room temperature for 24 h. This process was repeated until the required quantity was obtained for both the *M. oleifera* seed and pod powders.

Preparation of Coagulants

Two coagulants were prepared using the *M. oleifera* seed and pod powder crude extracts according to Jahn, (1988). Three, 6 or 9 g of the *M. oleifera* powder was dissolved in a beaker containing 100 mL of distilled water and mixed for 10 mins. The resulting suspension was then filtered through a muslin cloth and further filtered through a GF filter paper to give stock solutions at 3, 6 and 9% w/v. The stock solution was prepared daily to avoid deterioration (Muyibi and Evison, 1995a). This procedure was repeated using the *M. oleifera* pod powder to obtain the other coagulant.

Preparation of High Turbid Water

Five grammes of kaolin was weighed and mixed with 500 mL of tap water. It was allowed to soak for 24 h, forming a suspension. The suspension was stirred for 10 mins with a magnetic stirrer (Mettler Tolledo, England). The suspension was then used as a stock solution for preparation of turbid water samples. The stock solution of kaolin was diluted with tap water to get a high turbidity synthetic raw water of 495 NTU (Gidde *et al.,* 2012).

Jar Test

Jar test experiment was conducted using an SW6 Flocculator (Stuart, England). Six 1 L capacity beakers were filled with raw water of the same turbidity. A dose of the coagulant was applied to each beaker. The water samples were agitated concurrently. After about 5 mins of rapid mixing at 125 rpm, the stirring speed was reduced to about 40 rpm for 25 mins. The Flocculator was then stopped and the samples were allowed to settle for 1 h according to Muyibi *et al.* (2003). The supernatant was then collected from each beaker and analysed for residual turbidity. This procedure was applied to the other coagulant. Experiments were carried out in duplicates. The optimum coagulant dose was obtained from the sample of the raw water having the least residual turbidity.

Determination of Optimum pH

The above Jar test procedure was followed to determine the optimum pH of the two coagulants. The optimum coagulant dose obtained previously was kept constant for pH optimisation. HCl or NaOH was used to adjust pH of the water samples from 6.5 to 8.5 at an interval of 0.5 within the drinking-water range recommended by WHO (2011).The optimum pH is that of the water sample with the least residual turbidity. Experiments were carried out in duplicates.

Analytical Tests

Turbidity was measured in NTU using a portable turbidity meter (Mettler Toledo, England) and pH was measured using a pH meter (Jenway, England) according to standard procedures.

Turbidity Removal Efficiency

Turbidity removal efficiency was computed using Equation 1.

$$\text{Turbidity removal efficiency } (\%) = \left(\frac{C_i - C_f}{C_i}\right) \times 100 \quad (1)$$

Where C_i and C_f are the initial and final turbidity of the raw water in NTU

RESULTS AND DISCUSSION

Optimum Dose of *M. oleifera* Seed Powder Extract at 3% w/v

Figure 1 shows the turbidity removal efficiency of the *M. oleifera* seed and pod powder extracts.

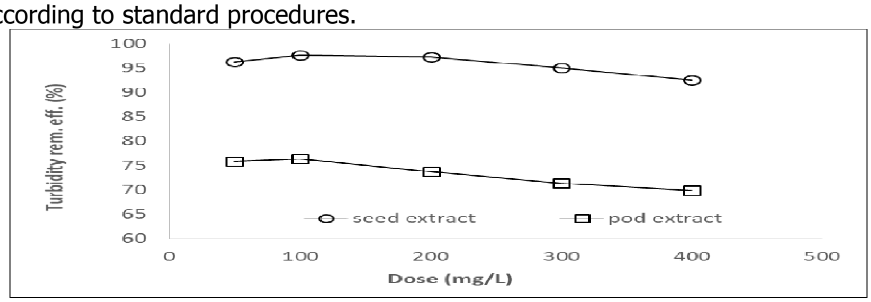

Figure 1: Turbidity removal efficiency of *M. oleifera* seed and pod extracts at 3% w/v

Turbidity removal efficiencies of 97.6 and 76.4% for the *M. oleifera* seed and pod extracts, respectively, were achieved at an optimum dose of 100 mg/L. This excellent turbidity removal corroborates the findings of Muyibi and Okuofu (1995) and Sani (1990) who reported >90% turbidity removal while treating high turbid water using *M. oleifera* seed extract at coagulant dose of up to 400mg/L. Interestingly, the pod extract in the current study exhibited very good turbidity removal efficiency though lower than the seeds. Its removal efficiency compares favourably with the performance of *M. oleifera* seed extract reported by Folkard *et al.*(1989) at coagulant dose of up to 200 mg/L. One-way analysis of variance revealed that the turbidity removal efficiencies of the *M. oleifera* seed and pod extracts were significantly different at α = 0.05 (p = 0.0000).

Dose of *M. oleifera* Seed Powder Extract at 6% w/v

The *M. oleifera* seed and pod extracts achieved turbidity removal efficiencies of 92 and 84.3% at optimum dose of 100 and 200 mg/L, respectively, at 6% w/v as shown in Figure 2. This follows similar trend with the extracts at 3% w/v.

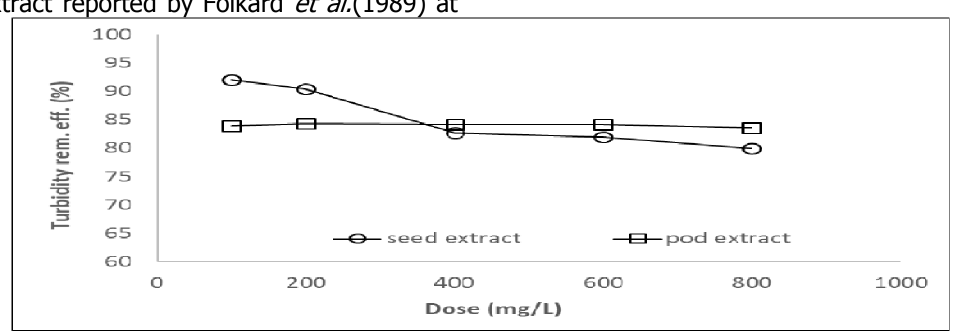

Figure 2: Turbidity removal efficiency of *M. oleifera* seed and pod extracts at 6% w/v

However, the seed extract exhibited a slightly lower turbidity removal efficiency at 6% w/v whereas the pod extract achieved a slightly higher turbidity removal at this concentration though at an optimum dose twice that of the 3% w/v. Unlike the 3% w/v, there was no significant difference between the turbidity removal efficiencies of the *M. oleifera* seed and pod extracts at 6% w/v, at 5% level (p = 0.5932).

This slightly higher performance in turbidity removal of the pod extract could be due to softer nature of the pods relative to the seeds which are harder while extracting the active ingredients, coupled with possible doubling effect of the 6% w/v stock solution concentration (compared to 3% w/v) leading to the active ingredients of the coagulant becoming more available in solution (Muyibi and Evison, 1995a).

Dose of *M. oleifera* Seed Powder Extract at 9% w/v

Figure 3 shows the turbidity removal efficiencies of the *M. oleifera* seed and pod extracts at 9% w/v.

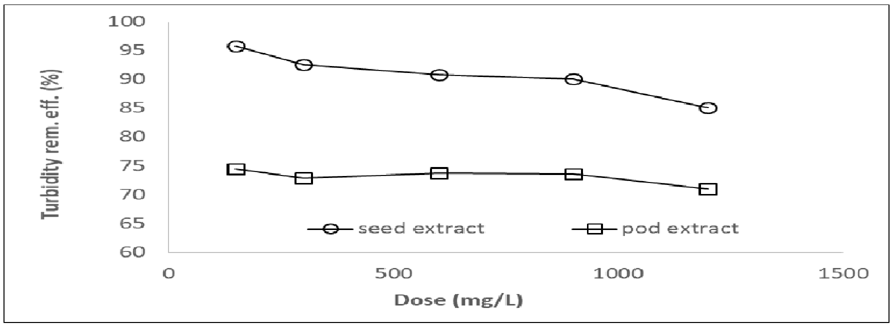

Figure 3: Turbidity removal efficiency of *M. oleifera* seed and pod extracts at 9% w/v

Turbidity removal of 95.8 and 74.5% were achieved at a dose of 150 mg/L for the *M. oleifera* seed and pod extracts, respectively. Expectedly, the *M. oleifera* seed extract performed wonderfully in removing turbidity from the raw water. Interestingly, the pod extract at 9% w/v exhibited very good turbidity removal efficiency higher than the 3 and 6% w/v.

At 9% w/v stock solution concentration, the *M. oleifera* pod extract achieved higher turbidity removal efficiency than at 6% w/v. However, the seed extract achieved slightly lower turbidity removal efficiency at 9% than at 6% w/v. The 6% w/v stock solution concentration appears to be the optimum for the *M. oleifera* pod extract. However, this was not the case with the *M. oleifera* seed extract as no regular trend was observed.

One-way ANOVA revealed significant difference between the turbidity removal efficiencies of the *M. oleifera* seed and pod extracts at 9% w/v ($\alpha = 0.05$ and $p = 0.0002$).

Optimum pH of the *M. oleifera* Seed and Pod Extracts

The optimum doses obtained previously were used to determine the optimum pH of the *M. oleifera* seed and pod extracts at 3, 6 and 9% w/v. Figure 4 shows the pH of the *M. oleifera* seed and pod extracts when used to treat high turbid water.

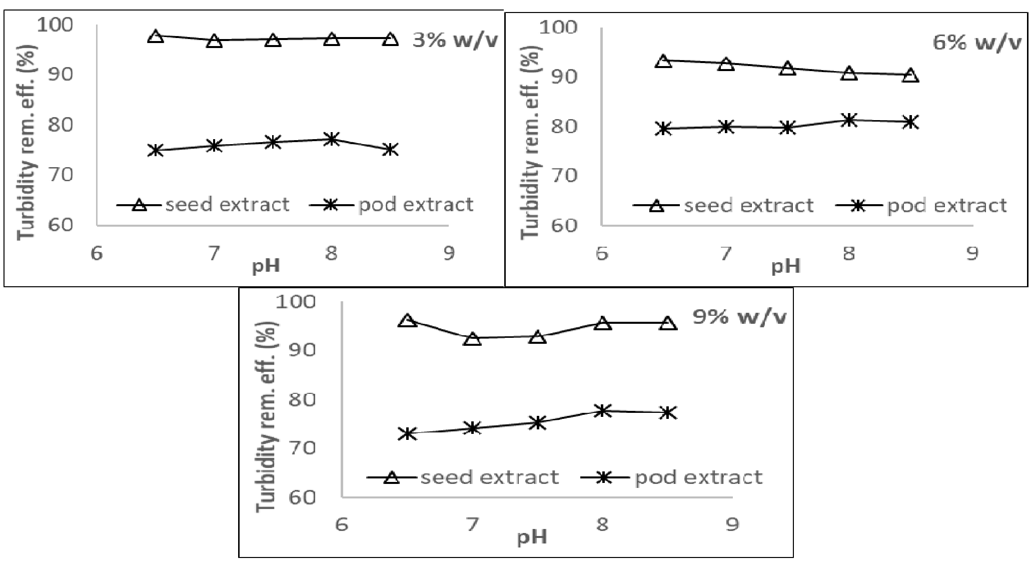

Figure 4: pH of the *M. oleifera* seed and pod extracts at 3, 6 and 9% w/v

When optimum coagulant dose was applied to the raw water, with the pH adjusted to within drinking-water range, the *M. oleifera* seed extract performed better than the pod in removing turbidity (Figure 4). Optimum pH values of 6.5 and 8.0 were recorded at 3 and 6% w/v with corresponding turbidity removal of 97.7 and 81.4% in the *M. oleifera* seed and pod extracts, respectively. Similar optimum pH values for turbidity removal from raw water using *M. oleifera* seed extract as coagulant were long reported by Cohen and Hannah (1971).

CONCLUSION

M. oleifera seed and pod extracts excellently removed turbidity from surface water with the seed extract exhibiting higher performance than the pod, with overall turbidity removal efficiency > 70%. Turbidity removal efficiencies of 98 and 84% at optimum dose of 100 and 200 mg/L were achieved by *M. oleifera* seed and pod extracts at 3 and 6% w/v, respectively. The 6% w/v stock solution concentration appeared to be the optimum for the *M. oleifera* pod extract. However, there was no apparent optimum concentration for the *M. oleifera* seed extract. The corresponding optimum coagulation pH values for the *M. oleifera* seed and pod extracts were 6.5 and 8.0, respectively. This study has demonstrated the potentials of Moringa pods in removing turbidity from surface water thereby indicating its potential use in drinking water treatment, especially at household level in low-income communities.

REFERENCES

Ali, E.N., Muyibi, S.A., Salleh, H.M., Md. Alam, Z. and Salleh, M.R.M., (2010); Production of Natural Coagulant from *Moringa oleifera* Seed for Application in Treatment of Low Turbidity Water. *Journal of Water Resources and Protection*, 2: 259-266.

Amagloh, F.K. and Benang, A. (2009); "Effectiveness of *M. oleifera* seeds as a coagulant for water purification", *African Journal of Agricultural Research*, 4(1): 119-123.

American Public Health Association (2005); *Standard Methods for the Examination of Water and Wastewater.* 17th Edition, APHA, Washington, DC

Billig, P., Bendahmane, D. and Swindale, A., (1999); Water and Sanitation Indicator Measurement Guide. http://www.fanta project.org

Cohen, J.M. and Hannah, S.A (1971); 'Coagulation and Flocculation' in *Water Quality Treatment: A Handbook of Public Water Supplies*, eds B Church and K Kesti, American Water Works Association, USA.

Folkard, G.K., Sutherland, J.P. and Grant, W.P. (1989): Optimization on the use of natural coagulants for water purification; *Technical report No. R4254*; Department of Engineering, University of Leicester.

Gidde, R.M, Anand, R.B and Chetan, N.M (2012); Comparative study of different form of *Moringa oleifera* extract for turbidity removal. *International Journal of Engineering and Development,* 2(1): 14-21.

Jahn, S. A. A., (1988); Using *Moringa* Seeds as Coagulants in Developing Countries. *Journal AWWA*, 80(6):43-50.

Melesse, A. and Berihun, K.(2013); Chemical and mineral compositions of pods of *Moringa stenopetala* and *M. oleifera* cultivated in the lowland of Gamog of a Zone, *Journal of Environmental and Occupational Science;* 2(1): 33-38.

Muyibi, S.A., Abbas, S.A., Noor, M.J.M.M., Ahmadon, F.R. (2003); Enhanced coagulation efficiency of *M. oleifera* seeds through selective oil extraction. *International Islamic University Malaysia Engineering Journal*, 4(1): 1-11.

Muyibi, S.A., and Evison, L.M. (1995a); *Moringa oleifera* seeds for softening hard water; *Wat. Res*., 29(4): 1099-1105.

Muyibi, S.A., and Evison, L.M. (1995b); "Optimizing physical parameters affecting coagulation of turbid water with *Moringa oleifera* seed"; *Wat. Res*., 29(12): 2689-2695.

Muyibi, SA, and Okuofu, CA (1995); Coagulation of low turbidity surface waters with *Moringa oleifera* seeds; Intern. *J. Environmental Studies*; 48: 263-273.

Ndbigengesere, A. and Narasiah, K.S. (1998) Quality of Water Treated by Coagulation Using *Moringa oleifera seeds. Wat. Resources,* 32(3): 781-91.

Ndbigengesere, A., Narasiah, K.S. and Talbot, B.G. (1995) "Active agents and mechanism of coagulant of turbid waters using *Moringa oleifera*," *Wat. Res.*, 29(2): 703–710.

Rondinelli, D.A. (1991); Decentralizing water supply services in developing countries: factors affecting the success of community management, *Public Administration and Development*, 11: 415-430.

Sani, M.A. (1990); The use of *Zogale (Moringa oleifera)* for water treatment; B. Eng. Final Year Project Bayero University, Kano, Nigeria, Unpublished.

UNICEF and WHO (2017) "Safely Managed Drinking Water - Thematic Report on Drinking Water 2017." World Health Organization, https://apps.who.int/iris/bitstream/handle/10665/325897/9789241565424-eng.pdf?ua=1.

UNGA, (2015); "Transforming Our World: The 2030 Agenda for Sustainable Development." United Nations General Assembly, https://www.unfpa.org/sites/default/files/resource-pdf/Resolution_A_RES_70_1_EN.pdf.

World Health Organization (2006); Guidelines for Drinking-water Quality, 1st Addendum to the 3rd edition, Volume 1: Recommendations, Geneva, Switzerland. Health Criteria and other Supporting Information: Second Edition, Volume 2, WHO, Geneva.

World Health Organisation (2011) Guidelines for Drinking-water Quality. 4th ed., WHO, Geneva.

World Health Organization and UNICEF (2000); Global water supply and sanitation assessment 2000 report. World Health Organisation/United Nations Children's Fund, Geneva.

Yung K. (2003); Biosand Filtration: Application in the Developing WorldCE401 Project prepared for Department of Civil Engineering, University of Waterloo, Canada.