International Journal of Science Academic Research
Vol. 04, Issue 03, pp.5341-5346, March, 2023
Available online at http://www.scienceijsar.com
ISSN: 2582-6425

Research Article

EVALUATION THE EFFICACY OF MORINGA OLEIFERA SEED POWDER ON PHYSICO-CHEMICAL PARAMETERS OF WHITE NILE RIVER WATER

[1,*]**Bashir. Ali Awad ElGeed**, [1]**Suhaila Merghani Hassan Abdalsalam**, [1]**Eman Elsadig ELJak** and [2]**Wafaa Mohammed Zaid**

[1]Department of Chemistry, Faculty of Science, University of Bakht Alruda, Sudan
[2]Department of Chemistry, Faculty of Education, University of Bakht Alruda, Sudan

Received 14th January 2023; **Accepted** 19th February 2023; **Published online** 30th March 2023

Abstract

This study aimed to evaluate the efficacy of *Moringa oleifera* seeds powder on purification White Nile river water, during the dry season (March-April 2014), water samples were collected from twelve different locations from the River at El duwaim city, on dimension 3.0 meters in front of the bank and 20 centimeters below the water surface. The physico-chemical parameters concentrations of water samples (pH, turbidity, electrical conductivity, total dissolved salts, total hardness, alkalinity, iron and chloride) were detected before treatment by *Moringa oleifera* seeds powder., various doses of *Moringa* seed powder (50, 100 and 150 mg / L) were added to water samples, and then left it for an hour to two hours, and analyzed to detect the effects on that parameters. The results showed that there was a decrease in the concentration of these parameters is directly proportional with increasing dose and time respectively (except pH).

Keywords: *Moringa oleifera*, physico-chemical, coagulants, health risk, household water, turbidity, disinfectant, White Nile River

INTRODUCTION

Water is a major need for life survival on the earth. Good quality of drinking water is one of the most human necessities, and the lack of access to adequate safe water supplies leads to the spread of diseases (Howard and Bartram, 2003; and Bartram and Helmer, 1996). Surface water was polluted by sewage, industrial water discharge and run off from the land clearing. It is unfortunate in many developing countries water-related diseases are due to contaminated and polluted drinking water, resulting in high risk to human health, (WHO, 2006). About 1 billion people are without safe drinking water worldwide. The vast majority of these people are located in sub-Saharan Africa, South Asia and East Asia. Countless lives are lost annually due to drinking and using contaminated water (WHO, 2006). The people at greatest risk are children, people living under unsanitary conditions and the elderly (WHO, 2006). Globally, 4 billion cases of diarrhea are reported every year causing 1.8 million deaths, out of which about 90 % are children under five (UNESCO, 2007). For many developing countries water treatment process involved coagulation, flocculation and sedimentation (which are the processes involved for removing turbidity from water) and disinfection are expensive processes because of the high costs involved and the difficulty in assessing the chemical coagulants including alum. This is the reason why these countries need low cost methods requiring low maintenance and skill. Poly aluminium chloride and alum added impurities such as epichlodine are carcinogenic (Ghebremichael *et al*., 2005; and Muyibi *et al*., 2003). Aluminium is regarded as an important poisoning factor in dialysis encephalopathy. Aluminium is one of the factors which might contribute to Alzimer disease (Okuda *et al*., 1999; Sharma *et al*., 2006).

Corresponding Author:** ***Bashir. Ali Awad ElGeed,
Department of Chemistry, Faculty of Science, University of Bakht Alruda, Sudan

Aluminium reaction with water reduces water pH and its efficiency in cold water (Katayon *et al*., 2005; Santos *et al*., 2005). Many plants have been used to clarify water. Naturally occurring coagulants are usually presumed safe for human health. These include *Moringa oleifera*, *Moringa stenopetala, Vicia faba* (Jahn 1986; and Jahn,1988), Many researchers reported that the *Moringa oleifera* seed is non-toxic and good coagulant in water treatment. It is recommended to be used as a coagulant in developing countries. The major problem of drinking water in Sudan and other developing countries is not just a lack of water availability, but in fact, that the people are not concerned with the water quality which, causes health risk. In Sudan for many years drinking water pollution problems were not payed attention, but today the population is aware of the importance of good water quality and its relationship to health.

Applications of *Moringa oleifera* in Water Treatment

The knowledge that seeds from the *Moringa oleifera* tree can purify water is not new; the seeds have been used for generations in countries like India and Sudan (Lilliehöök, 2005). The traditional use of the *Moringa oleifera* seeds for domestic household water treatment has been well known to certain rural areas in the Sudan (NRC, 2006). In the West Asia, one of the best known uses for *Moringa oleifera* is the use of powdered seeds to flocculate contaminants and purify drinking water (Berger *et al.,* 1984; Gassenchmidt *et al.,* 1995; Olesen, 1987). Detailed studies have been carried out on the use of *Moringa oleifera* seeds extract in water treatment (Okuda *et al.,* 2001a, b; and Muyibi *et al.,* 2003).

Characteristics of the active agents

The coagulant in the seeds was first confirmed by the German scientist Samia Alazharia Jahn (Schwartz, 2000). The active agent is believed to be a protein, but the exact form of the protein is not yet known. Recent researchers have identified proteins of sizes ranging from 3 to 60 kDa, all possessing coagulating ability, which means that the *Moringa oleifera* seeds probably contain several different proteins that may act as coagulants. The protein(s) act as cationic polyelectrolytes (Sutherland *et al.,* 1994), which attach themselves to the soluble particles and create bindings between them, leading to large flocs in the water. Stirring and mixing accelerates the electrostatic flocculation, and the flocs condense (Göttsch, 1992).

Active Ingredients in *Moringa oleifera* Seeds

Folkard *et al.,* (1989) identified the active ingredient in the *Moringa oleifera* seed to be a Polyelectrolyte. According to Jahn (1988), the *Moringa oleifera* flocculants are basic polypeptides with molecular weights ranging *from* 6,000 to 16,000 daltons. Six polypeptides were identified with their amino acids being mainly glutamic acid, proline, methionine, and arginine. Bina (1991) identified the active ingredient as a polypeptide acting as cationic polymers; and Ndabigengesere *et al.,* (1995; 1998) reported that the active ingredients in an aqueous *Moringa* extract are dimeric cationic proteins with molecular weights of about 13 000 daltons and iso-electric point of between 10 and 11.

Use of *Moringa oleifera* as Coagulant

Coagulation is by far the most widely used process to remove the substances producing turbidity in water. These substances normally consists largely of clay minerals and microscopic organisms and occur in widely varying sizes ranging from those large enough to settle readily to those small enough to remain in suspension for a very long time. Colloidal and fine impurities in water possess a certain anticoagulation stability which is due to the presence of hydrate shells or a double electric field around particles.

This anti-coagulation stability of impurities can be disturbed by heating, freezing, addition of electrolytes to water or by the application of a magnetic field. This problem is most often solved by coagulating hydrophilic and hydrophobic impurities. (Nikoladze *et al*, 1989). The active ingredient in the *Moringa oleifera* seed has also been identified as a polyelectrolyte (Folkard *et al.,* 1989). Its use for coagulation, co-coagulation, or coagulant aid has been a subject of investigation in many parts of the world. Most of these works have been documented by, Ndabigengesere *et al.,* (1995), Muyibi and Okuofu (1995), Muyibi and Evison (1996), and Buthalezi *et al.,* (2009).

Use of *Moringa oleifera* seeds in Removal of water Turbidity

Raw water drawn for human consumption becomes highly turbid due to the addition of solid particles (clay and silt), organic and inorganic compounds, and many other micro- and macroscopic organisms. (Clesceri *et al.,* 1989). The increased turbidity levels of water reduce the process of photosynthesis, thereby affecting the aquatic ecosystems and food chain adversely. The consumption of highly turbid water may constitute a health risk. This can lead to waterborne disease outbreaks. The removal of turbidity in water would be extremely beneficial as it would alleviate the majority of problems associated with turbidity. Coagulation has been identified as one of the most effective techniques for removal of turbidity from water. In developing countries, water treatment companies utilize alum and other chemicals for coagulation, but as these chemicals are not locally available in all places, they have to be imported, which requires high foreign exchange. Hence, the use of locally available plant materials such as *Moringa oleifera* either alone or in combination with other coagulant materials may prove highly beneficial. Turbid water-clarifying properties of *Moringa oleifera* were first reported by Jahn after observing the use of its seeds by Sudan women for clarifying turbid Nile water. Since then, *Moringa oleifera* has gained the sudden interest of researchers and has been significantly studied as a coagulant and disinfectant. (Sutherland *et al.,* 1994; Okuda *et al.,* 1999**;** Katayon, *e tal* 2004; Farooq *et al.,* 2007**)** On average, 92−99% turbidity reductions have been reported using *Moringa oleifera* seeds as coagulant (Muyibi *et al.,* 1995).

Use of *Moringa oleifera* seeds in water softening

Softening is the removal of ions which cause hardness in water. Hardness is caused mainly by calcium and magnesium ions, or at times, by iron, manganese, strontium, and aluminum ions. Hardness causes excessive soap consumption and scale formation in hot water pumps, boilers and pipes. Public water supplies should not exceed 300 to *500mg/l* of hardness; although, aesthetically, a hardness greater than 150mgll is unacceptable (Corbitt, 1990). Because the cost *of* chemicals for softening is high, local materials are being considered as substitutes. *Moringa oleifera* seed extract has been identified as a potential softening agent (Evison, 1995a; Muyibi and Evison, 1996; Muyibi and Okuofu, 1996). Barth *et al.,* (1982) reported that initial hardness *of* water varying from 80300mg/l CaCO3 was found to have been reduced to between 50-70% after coagulation and softening with *Moringa oleifera.* Sani (1990), reported total hardness reduction from 54mg/l to 25mg/l CaC03 for river water while using 40-200mg/l *M. oleifera* dosage. Muyibi and Okuofu (1995) studied the softening of water samples from 17 hand-dug wells in Kano Nigeria, and found that the residual hardness decreased with increased dosage of *Moringa oleifera.*

It was also observed that for the same initial hardness, water samples containing both calcium and magnesium hardness required higher doses *of Moringa oleifera* than those containing only calcium hardness. Evison (1995a) using water samples from 4 sources of varying hardness in England also observed that hardness reduction increased with increasing dosage of *Moringa oleifera.* This was later corroborated in another study by Muyibi and Evison (1996). Softening of water with *Moringa oleifera* has a potential advantage since it is accompanied by very low reduction in alkalinity, which is required to provide the necessary buffering capacity to achieve required treatment objectives (Muyibi and Okuofu (1996), Evison (1995a); Muyibi and Evison (1996).

MATERIALS AND METHODS

Physicochemical analysis of water samples

Total dissolved solids (T.D.S), electrical conductivity (E.C), and pH were determined in the laboratory by bench meter (Martini -instrument, model Mi 180: Romania). 100 ml of water sample were put in a beaker then a glass electrode was put in the sample, and the results were recorded directly.

Determination of water Alkalinity

100 ml of the water sample were poured into a 250ml Erlenmeyer flask. 3-5 drops of methyl orange were added. Burette was rinsed with three 10ml portions of 0.1M HCl (this only needs to be done before the first titration). The burette was filled with the acid and the initial volume was recorded. The sample was titrated with the 0.1M HCl to the endpoint (orange to red), and the final volume was recorded. The alkalinity of the samples was found in (mg/L).

Determination of Chloride residues

Sample (10 ml) was taken in conical flask and 2-3 drops of potassium chromate solution (5% K_2CrO_4 in water) was added. Then was titrated with 0.1N $AgNO_3$ (1.6987g of Ag NO_3 in 100 ml of double distill water) till the color was changed from yellow to brick red.

Determination of water Hardness

10ml of a filtered water sample was poured into a 250ml Erlenmeyer flask. About 150 ml of distilled water were added, followed by 15ml of pH 10 buffer. The mixture was mixed thoroughly. Then 4 drops of Eriochrome Black T indicator (EBT) were added (and titrated with standard 0.01M EDTA solution until a pure blue color was obtained.

Determination of water turbidity

Turbidity measurement was conducted using turbidity meter (HACH, 2100P) according to the procedure described by the Standard Methods (APHA, 1995). This method depends on comparison of the intensity of light scattered by the sample under defined condition with the light scattered by the standard reference suspension under the same conditions.

Determination of Iron

Iron determined according to APHA, 1992.Heavy or trace metals were determined after digestion of the solution of the samples. Water samples digestion was carried out by taking 10ml of the sample and adding 4ml Perchloric acid, 20ml concentrated nitric acid and 2ml concentrated tetraoxosulphate VI acid. The mixture was heated until white fumes evolved and clear solution obtained. After digestion, the samples for were allowed to cool and then transferred to 100ml volumetric flask. This was made up to mark with distilled water and thoroughly mixed. The sample was allowed to stand overnight (in place of centrifuge) to separate insoluble materials. It was then filtered. Iron (Fe), was determined using (Atomic Absorption Spectrometry).

RESULTS AND DISCUSSION

The purification potential of *M. oleifera* seed powder was tested by analyzing the physicochemical characteristics of White Nile River water samples. The mean values of various physicochemical parameters corresponding to twelve different water sources before and after treatment with 50, 100 and 150 mg/L concentrations of *M. oleifera* seed powder according to 1 and 2 hour(s) time intervals were represented in (Table) the mean values of physicochemical parameters before treatment of water samples were as follows:

The addition of powdered moringa seed (*M. oleifera*) as a coagulant in River water treatment processes did not significantly affect the temperature. Temperature of each sample was still in the normal temperature range for water.
The scale of pH in river water samples before and after treatment were shown in (table) water samples were treated with different doses of *Moringa oleifera*. Results showed that after treatment with *Moringa oleifera* seed powder; pH was increased through 50,100 and 150 doses, after treatment the range of pH was 7.22± 0.29 – 7.50±0.13 which was within the recommended acceptable range of pH for drinking water specified by WHO,(1971). The pH increases with increasing concentrations of the *Moringa* as coagulant. It was reported that the action of *Moringa oleifera* as a coagulant lies in the presence of water soluble cationic proteins in the seeds. This suggests that in water, the basic amino acids present in the protein of *Moringa oleifera* would accept a proton from water resulting in the release of a hydroxyl group making the solution basic (Olayemi, *etal*.,1994; Dalen, *et al.,* 2009). Turbidity level in river water samples before and after treatment was given in (table). The observed initial turbidity was 337.11 NTU in River water which was above the standard limits of WHO (1993). It was observed that the turbidity of River water were significantly decreased at (P≤ 0.05) with increasing of *Moringa oleifera* seed powder dose at 50, 100 and 150 mg/l respectively. Residual turbidity was reduced to 23.07 NTU. This result is in agreement with range of optimum dosage research work by (Folkard, *et al*., 2005). Due to this there was an improvement in the flock size and flock settled rapidly. The overdosing resulted in the saturation of the polymer bridge sites and caused restabilization of the destabilized particles due to insufficient number of particles to form more inter-particle bridges. The high positive charge and small size suggest that the main destabilization mechanism may be adsorbed and charge neutralization. This was also reported by(Madsen, *et al*. 1987) who reporting that 90-99% of turbidity was removed by using *Moringa oleifera* seed powder.

Table 1. Physicochemical Parameters studied before and after treatment of River water with various doses of M. *oleifera* seed powder at different settling time

Parameters	Control	50mg/L		100mg/L		150mg/L	
		0ne hour	Two hours	0ne hour	Two hours	0ne hour	Two hours
PH	7.49 ± 0.10^{a}	7.22 ± 0.29^{b}	7.30 ± 0.18^{ac}	7.40 ± 0.20^{ad}	7.42 ± 0.21^{e}	7.43 ± 0.13^{af}	7.50 ± 0.13^{ag}
Turbidity(mg/L)	337.09 ± 21.53^{a}	109.48 ± 6.26^{b}	88.23 ± 6.67^{bc}	67.05 ± 4.27^{dc}	42.03 ± 2.61^{e}	23.07 ± 1.43^{ef}	13.19 ± 1.27^{gf}
Conductivity	182.10 ± 4.75^{a}	139.48 ± 3.75^{b}	123.94 ± 3.14^{c}	113.85 ± 3.09^{de}	109.41 ± 3.01^{e}	78.52 ± 2.31^{f}	68.53 ± 1.83^{g}
T.D. S (mg/L)	77.38 ± 1.99^{a}	49.57 ± 1.36^{b}	45.95 ± 1.34^{c}	37.57 ± 1.04^{d}	32.82 ± 0.98^{e}	24.32 ± 0.71^{f}	21.96 ± 0.78^{gf}
T.hardness(mg/L)	8.46 ± 0.17^{a}	5.75 ± 0.13^{b}	5.24 ± 0.12^{c}	4.22 ± 0.15^{de}	3.96 ± 0.09^{e}	2.79 ± 0.07^{f}	2.55 ± 0.07^{gf}
Alkalinity (mg/L)	46.70 ± 1.54^{a}	17.63 ± 0.60^{b}	16.26 ± 0.47^{bc}	15.44 ± 0.58^{dbc}	15.14 ± 0.59^{ebd}	14.26 ± 0.68^{fcd}	14.52 ± 0.66^{gcd}
Iron (mg/L)	0.34 ± 0.02^{a}	0.23 ± 0.01^{b}	0.22 ± 0.01^{cb}	0.15 ± 0.01^{d}	0.13 ± 0.00^{ed}	0.13 ± 0.00^{fd}	0.10 ± 0.00^{g}
Chloride (mg/L)	21.37 ± 1.31^{a}	15.42 ± 1.03^{b}	14.69 ± 0.94^{bc}	12.46 ± 0.81^{cd}	11.11 ± 0.66^{ed}	8.88 ± 0.57^{fg}	8.00 ± 0.50^{g}

Data are presented as means ±SE.

[a, b, c , d,e,f, and g] value with different superscripts in the same row and column are significantly different at (P≤ 0.05).

Electrical conductivity in River water samples before and after treatment was shown in (table). Before the treatment with *Moringa oleifera* seeds electrical conductivity was 182.10 µS/cm. After the treatment, the electrical conductivity of River water was reduced with increasing dose of Moringa *oleifera* seed powder 50,100and 150mg/L respectively. The range of decreased electrical conductivity was 131-73 µS/cm. This result is in agreement with (Ndabigengesere, *et al*., 1995), the decrease in EC of water with *Moringa oleifera* seeds was due to the presence of lower molecular weight water soluble proteins which carry positive charge (Eman *et al.,* 2010; Agarwal *et al.,* 2007). There is no standard value, but high level of conductivity is not allowed in drinking water for consumers (WHO, 2006). TDS levels in River water samples before and after treatment were given in (table). The initial TDS was 77.38 mg/l. After the treatment with *Moringa oleifera* seed powder, the total dissolved solids was reduced from river water in the range 49.58-24.33 mg/l. These were present within the limit according to WHO standards (2004). *Moringa oleifera* is known to be a natural cationic polyelectrolyte and flocculent with a chemical composition of basic polypeptides with molecular weights ranging from 6000 to 16,000 Daltons, containing up to six amino acids of mainly glutamic acid, methionine and arginine (Jahn,1986). The presences of hardness in River water samples before and after treatment were shown in (table). Mean hardness was 8.47 mg/l for river water sample. It was observed that hardness of water was decreased with increased dose of *Moringa* seed powder at 50, 100 and 150 mg/l of river water. Hardness range was 5.75 – 2.79 mg/l which within the limits of WHO standards. As a polyelectrolyte, it may therefore be postulated that *Moringa oleifera* removes hardness in water through adsorption and inter-particle bridging (Lamer and Healy, 1963). According to (Suleyman *et al.,* 1995) as a polyelectrolyte it may therefore be postulated that *Moringa oleifera* removes hardness in water through adsorption and inter-particle bridging. Secondly, with the observation that light, slow-settling solids/ flocks were formed and precipitation reaction lead to the conversion of soluble hardness-causing ions to insoluble compounds would also be a good prediction of the reaction mechanism. (Muyibi and Evison,1994). Alkalinity levels in river water samples, before and after treatment were shown in (table). Alkalinity during the present research work was observed to be 46.71mg/l for River water. At various doses of *Moringa oleifera* seed powder, it was observed that the alkalinity was reduced after the treatment with 50,100 and 150 mg/l dose. The alkalinity ranges were 46.71 -14.27 mg/l which were within the standards limits of (WHO, 2004).

The precipitates (solids / flocks) were light and did not settle easily. The chemical constituent of the precipitate is however not known. It was also confirmed that alkalinity reduction in the coagulation of water sources using *Moringa oleifera* seeds (Amagloh and Benang, 2009). Iron metal concentration was reduced significantly after treatment with different dosage of *Moringa oleifera* seeds shown in (table). The removal of metal ions increased with increased of *Moringa oleifera* seed powder. More decrease in metals load was observed for *Moringa* was due to heterogeneous properties, the aqueous solution of *Moringa oleifera* seeds contains low molecular weight amino acids. These amino acids contain physiologically active group of binding agents which at low concentration interact with metals to increase the sorption of metal ions (Brostlap and Schuurmans, 1988). In addition, these proteinous amino acids have pH dependent properties which generate negative charged environment playing important role in binding of metals (Costa, 1997; Muyibi *et al.,* 2002). Chloride ion concentration in River water samples before and after treatment were shown in (table). The chlorides were at 21.37 mg/l in the River water samples. It was observed that *Moringa* seed treatment with chloride ions reduces the chloride level, because cations from the seed attract negatively charged chloride ions present in water and neutralize the chlorides, resulting in adjusting River water chloride concentration within standard limits of 15.43 - 8.88 mg/L (WHO, 2008).

REFERENCES

Agarwal, M, Rajani, S and Mishra, A. (2007). Study on flocculating efficiency of Okro mucilage in sewage wastewater. *Macromol. Mat. Eng,* 286(9), 560-563.

Ali, E.N. (2010). Application of *Moringa* Seeds Extract in Water Treatment; *PhD Thesis;* Department of Biotechnology Engineering, International Islamic University, Kuala Lumpur, Malaysia.

Amagloh, F. K., and Benang, A. (2009). Effectiveness of *Moringa oleifera* seeds as a coagulant for water purification, University for Development Studies, Faculty of Applied Sciences, Department of Applied Chemistry and Biochemistry, Navrongo, Ghana.

APHA. (1992). *Standard methods for the examination of water and wastewater.* 18th ed. American Public Health Association, Washington, DC.

APHA.(1995). Standard methods for the examination of water and wastewater, 19th edu. American Public Health Association.

Barth, H., Habs, M., Klute, R., Muller, S., and Bernard, T., (1982); Anwendung Von naturlichen Wirkstoffen aus *Moringa oleifera* Lam Samen zur Trinkwasseruabereitung; *Chem.*3. No.106, pp75-78

Bartram, J, Helmer, R.(1996). Introduction in Water Quality and Monitoring- A practical guide to the design and implementation of freshwater quality studies and monitoring programmes. UNEP/WHO publishing.

Berger, M.R., Habs, M., John, S.A.A., and Schmahi, D. (1984); Toxicological assessment of seeds from *Moringa oleifera /jeters* and *Moringa*. *Stenopetala* two efficient primary coagulants for domestic water treatment of tropical waters; *East African Med. Jr.*; Sept., pp712-716.

Bichi, M. H., Agunwamba, J. C., Muyibi, S. A., and Abdulkarim, M.I. (2012). Effect of Extraction Method on the Antimicrobial Activity of *Moringa oleifera* Seeds Extract; *Journal of American Science*; 8(9).

Bina, B. (1991); Investigations into the use of natural plant coagulants in the removal of bacteria and bacteriophage from turbid waters; *Ph.D thesis*, University of Newcastle Upon Tyne.

Brostlap.A.C., and . Schuurmans.J.(1988)."Kinetics of valine uptake in tobacco leaf disc. Comparison of wild types the digenic mutant and its monogenic derivatives". *Planta*. vol. 176, pp. 42-50.

Buthelezi, S.P., Olaniran, A.O., and Pillay, B. (2009); Turbidity and antimicrobial Load removal from river water using bioflocculants from indigenous bacteria isolated from wastewater in South Africa; *African Journal of Biotechnology,* Vol. 8(14), pp. 3261-3266.

Clesceri, L. S., Geenberg, A. E., Eaton, A. D., Eds.(1989). Standard Methods for the Examination of Water and Wastewater, 20th ed.; American Public Health Association: Washington, DC,; pp 2−8.

Costa. G. (1997). “Amino acids exuded form cadmium concentrations”. *Journal of Plant Nutrition.* vol. 20, pp. 883–900.

Eilert, U.(1978); Antibiotic principles of seeds of *Moringa oleifera*. *Indian Medical Journal* 38(235): 1013-1016.

Eman N. Ali., Suleyman A. Muyib.i, Hamzah M. Salleh., Md Zahangir Alam, Mohd Ramlan M,and Salleh, (2010). Production of Natural Coagulant from *Moringa oleifera* Seed for Application in Treatment of Low Turbidity Water. *J. Water Resource and Protection*, 259-266.

Fahey, J. W; Haristoy, X; Dolan, P. M; Kensler, T. W; Scholtus, I; Stephenson, L. K; Talalay, P. and Lozniewski, A. (2002). Sulforaphane inhibits extracellular, intracellular, and antibiotic-resistant strains of *Helicobacter pylori* and prevents benzo[*a*]pyrene-induced stomach tumors; *Proceedings of the National Academy of Sciences USA* 99: 7610-7615.

Fahey, J. W; Zalcmann, A. T. and Talalay, P. (2001). The chemical diversity and distribution of glucosinolates and isothiocyanates among plants; *Phytochemistry* 56(1):5-51.

Farooq, A.; Sajid, L.; Muhammad, A.; Anwarul, H. G.(2007). *Phytother. Res.,* 21, 17.

Folkard, G.K., Sutherland, J.P. and Grant, W.P. (2005).Optimization on the use of natural coagulants for water purification; *Technical report No.R4254*; Department of Engineering, University of Leicester.

Gassenschmidt, U., Jany, K.D., Tauscher,B. and Niebergall, H. (1995). Isolation and charaterization of a flocculating protein from *Moringa oleifera* Lam. *Biochimica et Biophysica Acta*, 1243, pp477-481

Ghebremichael. K. A., Gunaratna. K. R., Henriksson. H., Brumer and Dalhammar. G.(2005). *J. Water Research,* 39 (11): 2338-2344.

Göttsch E. (1992). Purification of turbid surface water by plants in Ethiopia, Walia 14 (1992), pp. 23-28 http://www.deutsch-aethiopischer-verein.de/Walia-1992 Purification

Howard G, and Bartram J. (2003). Domestic water quality service level and health. WHO/SDE/WSH/032.

Jahn, S.A.A (1986).Proper use of African natural coagulants for rural water supplies-Research in the Sudan and a guide to new projects;*GTZ Manual No.191*.

Jahn, S.A.A. (1988). Using *Moringa* seeds as coagulants in developing countries. *J. Am. Water Works Assoc.,* 80: 43-50.

Kaser, F., Werner, C., and Nahayo, D. (1990). Rural Water treatment, using *Moringa oleifera* seeds as coagulants; *Natural Resources Development*; No.33, 33-47.

Katayon S., Megat Mohd Noor M.J., Asma M., Thamer A.M., Liew Abdullah A.G., Idris A., Suleyman A.M,, Aminuddin M.B, Khor B.C., (2004). Effects of storage duration and temperature of Moringa oleifera stock solution on its perfomance in coagulation, *International Journal of Engineering and Technology,* 1(2), pp. 146- 151, ISSN: 1823-1039.

Katayon. S., Megat. M. N., Asma. M., Ghani. L. A. A. and Suleyman, A. M., (2005) *J. Bio resource Technology.* 97(13):1455-1460.

Lamer V.K. and Healy T.W.,(1963) The adoption flocculation reactions of macromolecules at the solid-liquid interface. *Revised pure and Applied Chemistry*, Vol. 13, pp. 112-122.

Lilliehöök, Henrik, (2005). *Use of Sand Filtration on River Water Flocculated with Moringa oleifera*, Division of Sanitary Engineering, Department of Civil and Environmental Engineering, Luleå University of Technology, ISRN: LTU-EX- - 05/177- - SE.

Madsen, M., Schlundt, J. and Omer, El-F. E., (1987). Effect of water coagulation by seeds of *Moringa oleifera* on bacterial concentration. *Journal of tropical Medicine and Hygiene,* 90: pp. 101-109.

Muyibi, S.A. and Okuofu, C.A. (1996); Softening hard well waters with *Moringa Oleifera* seed extracts; *Intern. J. Environmental Studies*; Vol.50, pp247-257.

Muyibi, S.A., and Evision, L.M. (1996). Coagulation of turbid water and softening of hard water with *Moringa oleifera* seeds; *Intern. J. Environmental Studies*; VOl.49, pp247-259.

Muyibi, S.A., and Evison, L.M. (1995). Optimizing physical parameters affecting coagulation of turbid water with *Moringa oleifera* seed; *Wat. Res*., Vo1.29, No.12, PP 2689-2695.

Muyibi, S.A., Saad A. Abbas, Megat Johari Noor, M.M., Fakrul Razi Ahmadon (2003). Enhanced coagulation efficiency of *Moringa oleifera* seeds through selective oil extraction. *IIUM Engineering Journal, 4* (1), 1-11.

Muyibi, SA, and Okuofu, CA (1995). Coagulation of low turbiditv surface waters with *Moringa oleifera* seeds; Intern. *J. Environmental Studies*; Vo1.48, PP 263-273.

Muyibi, S.A., and Evison, L.M. (1994). *Moringa oleifera* seeds for softening hard water; *Wat. Res*., Vol.29, No.4, pp 1099-1105.

Ndabigengesere, A. and Narasiah, K. S.(1998); Quality of water treated by coagulation using *Moringa oleifera* seeds; *Wat. Res., 32* (3), 781-791.

Ndabigengesere, A., Narasia, K.B., and Tolbot, B.G. (1995). Active agents and Mechanisms of coagulation of turbid waters using *Moringa oleifera*; *Wat. Res*. Vol.29, No.2, pp703-710..

Nikoladze, G.; Mints, D., and Kastalsky, A. (1989). Water treatment for public and industrial supply; Mir Publishers, Moscow.

Okuda, T., Baes, A.U., Nishijima, W., and Okada, M. (1999). Improvement of extraction method of coagulation active components from *Moringa oleifera* seed. *Water Res*., 33, 3373-3378.

Okuda, T., Baes, A.U., Nishijima, W., and Okada, M. (2001a). Isolation and Charactrization of Coagulant Extracted from *Moringa oleifera* seed by Salt Solution. *Wat. Res., 35* (2), 405-410.

Olayemi, A. B., and Alabi, R. O. (1994). Studies on traditional water purification using M. oleifera seed, African study monographs, 15, 101-109.

Olsen, A.(1987). Low technology water purification by bentonite clay and *Moringa oleifera* seed flocculation as performed in Sudanese villages. Effects on *Schistosoma mansoni* cercariae; *Water Research* 21(5): 517-522.

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

Santos, A. F. S.; Argolo, A. C.; Coelho, L.C.B.; Paiva, P. M. G. (2005).Detection of water soluble lectin and antioxidant component from *Moringa oleifera* seeds.Water R.39(6):975- 980.

Schwarz Discha, (2000). Water clarification using *Moringa olefiera*, Gate information Service, Germany. http://www. deutsch-aethiopischer-verein.de/Gate_Moringa.pdf

Sharma. P., Kumari, P., Srivastava. M. M. and Srivastava S., (2006). Bio resource Technol. 97 (2): 299-305.

Suleyman A. Muyibi and Lilian M. Evison.(1995). “*Moringa oleifera* seeds for softening hard water”, Department of

Civil Engineering, University of Newcastle upon Tyne, Newcastle upon Tyne NEI 7RU, England, *Wat. Res.* 29(4), 1099-1105 .

Sutherland, J. P.; Folkard, G. K.; Mtawali, M. A.; Grant, W. D.(1994) Moringa oleifera as a natural coagulant. Proceedings of the 20th WEDC Conference, Colombo, Sri Lanka; pp 297−299.

UNESCO (2007). UNESCO water portal newsletter No. 161: Water related Diseases. http://www.unesco.org/water/ news/newsletter/ 161.shtml

World Health Organization. (2004). Guidelines for Drinking Water Quality. 3rd. Edn. Vol. 1 Recommendation, Geneva, pp515.

World Health Organization (WHO) (2006). Guidelines for drinking water quality, First Addendum to Third Edition, vol 1 Recommendations. Available from http://www.who.int/water_sanitation_health/dwq/gdwq0506.pdf

World Health Organization.(2008). “Guidelines for Drinking Water Quality,” 3rd Edition, World Health Organization, Geneva.

Zaika, L. L. (1988). Spices and Herbs: Their antimicrobial activity and its determination. J. *Food Safety* 9: 97-118.

****