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A Review of the potentials of Moringa Oleifera Seed for Waste Water Treatment

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Abstract

The provision of potable water is an enormous undertaking, especially in developing countries. This is so because the chemicals required for treatment, namely: alum for coagulation, polyelectrolyte as coagulant aids, lime for softening and pH correction, and chlorine for disinfection needs to be imported with scarce foreign exchange. In reaction to this, Research has shown that communities in the developing countries are still using plant-based materials as one of the strategies for purifying drinking water. This research emphasis on the practice of using natural plant-base materials as coagulants for water purification as has been observed in Africa's countries for a few decades and it is aimed to reduce water turbidity. They include Moringa oleifera seeds powdered. Apart from Moringa oleifera, other species such as Cactus latifera and Prosopis juliflora have shown that coagulation effects. The plant organs, seed, root or leaf is normally used. Water purification by these species is essential because they contain acrylamide monomers that are harmless to humans and their existing environment. This paper discuss a review of these various applications of moringa oleifera seeds extract in water treatment and highlights the areas requiring further investigations.

Introduction

Large world populists are living in rural areas, have an income below the one-dollar-per-day poverty line and lack access to quality water for their livelihoods [Aldom, J.E. (1995)]. However, this problem of lacking access to quality water has major negative impacts on people's well-being such as; poverty, massive health effects, a shortage of safe drinking water, poor personal hygiene and a problem of sanitation. According to [Aldom, J.E. (1995)]. it is estimated that a minimum of 7.5 litres of water is required for individual consumption, personal hygiene and preparing food. Hence; a safe, affordable, reliable and easily accessible, quality water supply is crucial for household activities, good health and agriculture. This will equally improve the individuals' life in terms of poverty reduction and other live comfortably matters. But insufficiencies in water supply affect health adversely both directly and indirectly. Consequently, improvement in the aspects of water supply signify the important opportunities toward enhancing public well-being, provide proper and affordable treatment system [Atabay, H.I (1997)]. Techniques that will improve water supply for humans' need should further be developed such as water and soil conservation (WSC) technique, rainwater harvesting and conservation (RWHC) techniques, Rainwater harvesting system for both water and agriculture improvement as well as suitable, sustainable and environmentally safe wastewater treatment strategy.

Wastewater treatment methods include precipitation, coagulation/flotation, sedimentation, filtration, membrane process, electrochemical techniques, ion exchange, biological process, and chemical reactions. Each method has its own merits and limitations in applications because of their cost. Presently, there is an increasing trend to evaluate some indigenous cheaper materials for the removal of these pollutants and pesticides from aqueous solutions. A large number of cheaper materials including industrial and agricultural wastes have been used to remove different

pollutants from the industrial effluents for their safe disposal into the biosphere (Moringa oleifera (MO) is a tropical plant belonging to the family Moringaceae, a single family of shrubs with 14 known species. MO is native to India but is now found throughout the tropics. It is a non-toxic natural organic polymer. The tree is generally known in the developing world as a vegetable, a medicinal plant, and a source of vegetable oil. It is drought tolerant and has nutritional, medicinal, and water-cleaning attributes. Its leaves, flowers, fruits, and roots are used locally as food articles. The medicinal and therapeutic properties of this plant have led to its application as a cure for different ailments and diseases, physiological disorders, and in eastern allopathic medicine (Akhtar et al. 2007). Sludge produced by coagulation with MO is not only innocuous but also four to five times less in volume than the chemical sludge produced by alum coagulation (Ndabigengesere et al. 1995). An additional benefit of using coagulants derived from MO is that a number of useful products may be extracted from the seed. In particular, edible and other useful oils may be extracted before the coagulant is fractionated. Residual solids may be used as animal feed and fertilizer, while the shell of the seed may be activated and used as an adsorbent. The coagulant is thus obtained at extremely low or zero net cost (Ghebremichael et al. 2005).

REVIEW OF RELATED LITERATURE

Investigations were carried out on the use of *M. oleifera* in conjunction with alum. Felkard *et al* (1989) reported dramatic improvements in floc characteristics and significant savings in imported alum usage of the order of 50 to 80%. Muyibi and Okuofu (1995) also observed that the floes formed in conjunctive use were bigger, denser and settled faster after slow mixing, than when alum *or M. oleifera* alone were used. Furthermore, rates of floc formation and settling were reported to be comparable to alum in the range of raw water turbidities (26-40 NTU) considered. Saving in alum use in the range of 40-80% was similarly reported, depending on the raw water and the quality of the product water desired.

In the same study, it was noted that as optimum dose of alum was reduced by 80%, 60%, and 40% and the *M. oleifera* seed dose increased by 10mgll from *20mg/l* to *50mg/l,* respectively the residual turbidity of the water decreased. In another study, Muyibi and Evison (1996) reported a saving of up to 40% in alum use when *M. oleifera* was used as a co-coagulant. The lowest residual turbidity was recorded at a combination of *30mg/l* alum + *40mg/l M. oleifera.*

M. oleifera as a Coagulant Aid

Since *M. oleifera* seed extract is a polyelectrolyte, it may be able to function as a coagulant aid, using alum as the primary coagulant (Jahn, 1982). This possibility was a subject of study in recent times. Muyibi and Okuofu (1995) reported that in one investigation, the optimum dose of alum without *M. oleifera* was *40mg/l.* When

M. oleifera was used as a coagulant aid, the optimum dose of *M. oleifera* was found to be *10mg/l* while alum was 20mgll. The optimum time of application of *M. oleifera* was found to be 50 seconds' after slow mixing. It was further noted that the floes formed were dense and settled faster than with alum alone. The residual turbidity was also found to be much lower than that of alum alone.

Use of Moringa oleifera 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. *M*. o*leifera* seed extract has been identified as a potential softening agent (Muyibi and 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 *M. oleifera.* Sani (1990), using water samples from Watari and Challawa rivers, and from Yarimawa and Kofar Kabuga wells, reported total hardness reduction from 54mg/l to 25mg/l CaCo3 for river Watari water while using 40-200mg/l *M. oleifera* dosage. This reduction was from 95 to 30mg/l CaCo3 for Challawa water using *50-250mg/l* M. o*leifera* dosage. For Yarimawa well water, the reduction was from *11.2mg/l* at *100mg/l M. oleifera* to9.8mg/l at *400* mg/l *M. oleifera* dose; whereas for Kabuga well water sample, the hardness reduced from 21 mg/l to 17mg/l CaCo3 as M. o*leifera* dosage increased from 0 - 250mg/l, but at 150mg/I, the hardness went up to 20mg/l and leveled off to 15mg/l CaCo3 at 250mg/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 *M. oleifera.* It was also observed that for the same initial hardness, water samples containing both calcium and magnesium hardness required higher doses *of* M. o*leifera* than those containing only calcium hardness. Muyibi and Evison (1995a) using water samples from 4 sources of varying hardness in England also observed that hardness reduction increased with increasing dosage of *M. oeifera.* This was later corroborated in another study by Muyibi and Evison

(1996). In this work, it was further reported that for water samples with hardness values of 50 to 600mg/l CaCo3, softening with *M. oleifera* was found to be dependent on the initial hardness of the water and the seed extract dosage. Muyibi and Okuofu (1995) also found that the absorption isotherm for softening with *M. oleifera* was linear and of approximately the Langmuir type. This was later corroborated in another study by Muyibi and Evison (1996). Softening of water with *M. 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), Muyibi and Evison (1995a); Muyibi and Evison (1996).

Use of Moringa oleifera in Water Disinfection

The gravest of all dangers to which water supplies can be exposed is contamination by pathogenic organisms. Disinfection is a chemical process for eliminating pathogenic microbes from an environment. Chemical agents that have been used as disinfectants include halogens, phenols, alcohols, heavy metals, dyes, soap and detergents, ammonia compounds, hydrogen peroxide, and various alkalis and acids (Metcalf and Eddy, 1991). The most common of these are the oxidizing chemicals, and chlorine is the most universally used. However, chlorine has problem of decay and reduced concentration as the water flows through the distribution network (Devarakonda et al, 2010). It also has the potential for forming carcinogenic and mutagenic disinfection by-products (DBPs) (Goveas, et al, 2010). Disinfectants and their by-products may also be associated with increased risks of cardiovascular diseases, cancers, and birth defects. Although such risks are low, Arbuckle et al., (2002); Bove et al., (2002); and Woo, et al., (2002) noted that associations with such diseases could not be ruled out. These, and the high cost of chlorine, especially in developing countries where it needs to be imported, makes it imperative to look for cheaper alternatives that are also environmentally friendly. Studies by Eilert, et al (1981); Suarez, et al (2003), Suarez, et al (2005), Fisch, et al (2004), Thilza, et al (2010), and Bukar, et al (2010) identified the presence of an active antimicrobial agent in *Moringa oleifera* seeds.

Eilert *et al* (1981) identified *4-rhamnousyloxy-benzyf-isothiocynate* as an active antimicrobial agent in *M. Oleifera.* This is readily soluble to water at 1.3umol/l and is non-volatile. In a study using pure *4- rhamnotyloxy-benzylsothiocynate* isolated from defatted *M. Oleifera* seeds, the antimicrobial action of *M.*

Oleifera was investigated on three bacteria species - *Bacillus Subtilis* (gram -ve) , *Serratia Marcescens* (gram -ve) and *Mycobacterium Pheli.* The result showed that B. *Subtlis* was completely inhibited by 56mol/l and *M. Pheli* by 40mol/l. Only partial inhibition was observed for S. *Macesscens* in the range of concentration considered. The effect of residual turbidity on the antimicrobial action of *M. oleifera* was also reported. Folkard (1989), using extract of *M. Stenopetala,* was able to achieve 90% reduction of *Herpes simplex* virus and *Orf* virus. Whereas re-growth of *Serratia Marinatubra* occurred at high dosage (800rng/l), no re-growth w*as* observed at lower seed dosage. In each case, the initial sample turbidity was between 20 to 25 NTU with residual turbidities in the range of 3-8NTU. However, Jahn (1986) reported that residual turbidities greater than 100NTU was companied by bacterial removal of only 0-36%. Hegarty *et al* (1999) in their study observed no correlation between the presence of *Helicobacter pylori* and the traditional indicator organisms in water supplies. Epidemiological association between water sources and the prevalence of *H pylori* infection has also reported by several researchers (Klein et al 1991; Remirez-Ramos et al 1994; Mendal et al
1992; Mitchell et al 1996; Goodwin 1993. Hopkins et al, 1993).

Water and sanitation facilities in sub-Saharan Africa and Africa in general are appauling and for the most part absent. Poor waste disposal facilities, open field defecation, untreated cum poorly treated wastewater from factories constantly contaminate ground water resource. An average of 125 litres of clean water is needed per person yet, in Africa in general most people can not boost of 25 litres of clean free water. Hulten et al (1996); and Forrest et al, (1998) used *H.pylori* specific nucleic acid sequence to detect *H. pylori* in water in Columbia, Peru, Sweden and as well as in Sewage in the United States. Other techniques such as PCR and combined fluorescent antibody cyanoditoyl tetrazolium chloride (CTC) staining had been used in addition to enumerate *H.pylori* in attempt to overcome the phenomenon of viable but non culturable (VBNC *H.pylori)*. The studies of hegarty et al (1999) strongly indicated that *E Coli* was not detected in 50% of the samples in which *H.pylori* was detected, this lack of significant association between the presences of *E.Coli* for the determination of the potability of water may fail to protect people from *H.pylori* and other specific infection. Such a lack of association may possibly indicate that *H.pylori* may survive longer in freshwater habitat than E coli or possibility that *H.pylori* is part of a normal flora of many fresh water bodies and can survive in limited nutrients. While total coliforms were found in 85% of the samples containing *H.pylori*, however, there should be a careful interpretation of their association.

A somehow conclusive report on the limitations of Indicator organisms as a reflection of the ultimate pollution picture of water has been done by Efstratiou et al (1998). In their studies on the Correlation of bacterial indicator organisms with salmonella spp., Staphylococcus aureus and Candida albicans in sea water, total coliforms correlated better with Salmonellas and staphylococcus aureus than did faecal coliforms and faecal streptococci, faecal coliforms correlated better with the presence of Candida albicans.

Thilza, et al (2010) reported that Moringa leaf stalk extract had mild activities against *E. coli* and *Entrobacter aerogenes*. Bukar, et al (2010) also studied the antimicrobial activities of Moringa Seed Chloroform extract and Moringa Seed Ethanol extract. They found both to have inhibitory effects on the growth of *E. coli* and determined the Minimum Inhibitory Concentration (MIC) to be >4mg/ml. Thilza, et al (2010) using extract from Moringa leaf stalk, found that at dilutions of 1000mg/ml, 700mg/ml, 400mg/ml, and 200mg/ml, only mild activity against *E. coli* and *Entrobacter Aerogenes* was noticed. They also found that the highest activity was produced by *E.Coli* at 1000mg/ml which comparatively was less than that of the standard drug tetracycline (250mg/ml).

Suarez *et al* (2003) had reported that Moringa seeds protein may be a viable alternative to chemicals commonly used as food preservatives or for water disinfection. Bichi, et al (2012a) has shown that its highest disinfection action was achieved with the use of de-fatted seed cake and extracting the active ingredients by aqueous extraction. Bichi, et al (2012b) also found that the optimal conditions for the extraction of the bioactive compounds to be 31 minutes mixing time, 85 rpm mixing speed and 3.25 mg/mL Moringa dosage. In another study, Bichi, et al (2012c) developed a kinetic model for the application of *Moringa oleifera* seeds extract in water disinfection and determined the coefficient of specific lethality (Λcw) for *E. coli* inactivation to be 3.76 L mg-1 min-1. The mode of attack of the Moringa seeds extract on the *E.coli* cell was explained as by rupturing the cell and damaging the intercellular components, when water dips in to the cell which causes it to swell more and burst leading to death.

Moringa Oleifera seeds as alternative natural coagulant for water treatment

The practice of using natural material from plant as coagulants for water purification has been reported [Berger, M.R., Bichi, M. H., Agunwamba, J. C., and Muyibi, S. A. (2012c); Bina, B. (1991) Broin, M., Santaella, C., Cuine, S., Kokou, K., Peltier, G., and Joët, T.(2002);Bukar, A., Uba, A. and Oyeyi, T.I.(2010)Buthelezi, S.P., Olaniran, A.O., and Pillay, B. (2009); Devarakonda, V., Moussa, N.A., VanBlaricum, V., Ginsberge, M., and Hock, V.(2010);Eilert, U.(1978)]

]. Asia and Africa's countries have been using such products for a few decades to reduce water turbidity. They include Moringa oleifera seeds powdered. Apart from Moringa oleifera, other species such as Cactus latifera and Prosopis juliflora have shown that coagulation effect. The plant organs viz. seed, root or leaf is normally used. Water purification by these species is essential because they contain acrylamide monomers that are harmless to humans and their existing environment. The use of such conventional chemicals attracts extra cost and are rarely found. Whereas, natural seeds coagulant are mostly availability in most rural communities, these make it less expensive compared to ones. Hence, these natural products have potential for commercialization in near future due to their abundance and other valuable properties that are health and environmentally sound [Burkill, H.M (1985a].

M. oleifera seed was found to be an effective purifier towards removing suspended materials such as suspended solids, turbidity and other waste products. As earlier stated, due to the nonexistence of enough knowledge on how such natural material works, the use of chemical coagulants in water treatment become more common. The mostly used chemicals are; alum (Aluminum sulphate), synthetic organic polymer, synthetic polymeric derivatives and inorganic coagulant which are all a threat to humans' health and environment. [30] Matilainen, Anu, (2010) [31] Vieira, Angelica (2010)] as well as WHO (2004). Also, the use of such substances for water cleanness has developed a strong pressure on the economy of some developing and under-developing nations as the products are imported. This makes the process of wastewater treatment costly in those nations [Amagloh, Francis (2009)]

Alternatively, the use of natural plant materials as coagulant become interestingly significant than the traditional ferric salts commonly used nowadays [Beltrán-Heredia (2009)] Water treatment using natural coagulant from M. oleifera seeds is safe, because it contains a natural organic polymer and biodegradable materials [Eilert, U.(1978)] High contaminations are removed and non-hazardous sludge is generated [Bhuptawat, (2007)]

The sludge volume generated by coagulation activity from the seeds extract is lower as compared with that of alum or other ferric salts. It softens the hard water due to seed proteins that are essential for water purification [Amagloh, F.et al (2009)] [Mangale Sapana, (2012)] [Ndabigengesere, (1998)] and also contains antioxidant compounds that may be essential towards waste treatment. [Deming, M.S et al (1987]. Its effectively acts as an absorber of cadmium and disinfect the water from microorganisms. Therefore, the entire disinfection may be accomplished with the traditional approach by boiling and local filtration of the water. Vieira et al [2010]. After the coagulation processes, the seed residue can be used as fertilizer or animal fodder, Likewise, the dried pods and husks can be pyrolysed for activated carbon using one-step steam pyrolysis.

Materials and Methods

Coagulants used

The seeds were harvested when they were fully matured. This is determined by observing if there are any cracked pods on the plants. The pods that were plucked were cracked to obtain the seeds which were air-dried at 40°C for two days. The shells surrounding the seed kernels were removed using knife and the kernels were pounded using laboratory mortar and pestle into powder and sieved using a strainer with a pore size of 2.5 mm2 to obtain a fine powder. This method is a slight modification of the one proposed by Ghebremichael (2004). This was the coagulant prepared from *Moringa* it was observed that the *Moringa* coagulant treatment had an added advantage of reducing microbial load. It gave a lower count of 2 for the Most Probable Number (MPN) of total coliform per 100 ml with both the 10.0 and 12.0 g *Moringa* treatment while the conventional recorded a count of 8 coliforms per 100 ml. This supports findings of Schwarz (2000) that the process of flocculation removes about 90 -99% of bacteria which are normally attached to the solid particles. The control treatment had the highest counts of coliform (17/100 ml). This affirms earlier stated recommendation above that raw water without treatment is not safe for drinking.

The seed kernels of *M. oleifera* according to Schwarz (2000) contain lower molecular weight water-soluble proteins which carry a positive charge. When the seeds are crashed and added to water, the protein produces positive charges acting like magnets and attracting predominately negatively charged particles such as clay, silk, and other toxic particles. Under proper agitation, these bound particles then grow in size to form the flocculates which are left to settle by gravity. This accounted for the effectiveness of *Moringa* as a coagulant for raw water purification. The 10.0, 12.0 g of alum, and 12.0 g of *Moringa* treatments recorded values that were acceptable according to the WHO (2006) guideline for drinking water. As expected, the control treatment gave the highest turbidity value of log101.32NTU. It is clearly seen that higher concentrations of *Moringa* powder of 12.0 g/1000 ml loading dose as coagulant gives similar effect on turbidity compared with alum of loading doses of 10.0 g/1000 ml and 12.0 g/1000 ml. This shows that *Moringa* can be adopted for water purification.

Others include

2.1 Preparation of Synthetic Wastewater Dairy industry wastewater (DIW) for adsorption tests was prepared by adding milk powder into tap water.

2.2 Preparation of Moringa oleifera Biomass

2.3 Batch Biosorption Studies

DISCUSSION

M. Oleifera seeds extract is a potential source for water treatment due to its efficacy. When used for the treatment of wastewater, excellent results were obtained. The seeds are environmentally friendly because they do not further deteriorate the environment. Also, due to its availability and maximum effluent removal from both domestic and synthetic wastewater, the application of the seeds in wastewater treatment is undeniable. Intrinsically, the following suggestions may improve the efficacy of the seeds. It applicatios in water coagulation and softening has received a lot of attention. Currently, *M. Oleifera* coagulant is being used in many countries including Malawi, Sudan, Egypt and Malaysia. Moringa coagulants are also being patented by many researchers. The mechanism of the action of *Moringa oleifera* seeds extract in water disinfection as well as the kinetics of this action is yet to be fully understood. The effect of the method of seed processing on the disinfection action of Moringa is also a researchable area. These understandings would also pave way for its practical application in the field.

CONCLUSION

The conclusion is drawn that biocoagulants have been used in many African indigenous communities from antiquity with great benefits. In an era of increasing environmental concerns, water scarcity admist the draw backs of chemical coagulants and poor sanitary facilities in most low income earning countries, the need to further develop natural coagulants as alternative environmentally favourable water purifying chemicals is exigent. therefore *Moringa oleifera* seeds can be used as a coagulant to replace conventional coagulants, flocculant, hard water softener, disinfectant, and for removing of heavy metal in drinking water treatment. Thus improved application of this should be encouraged, especially in rural water supplies where the water requirement is relatively small and the production of Moringa is likely to be high and constant.

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