Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2017, 4(8):187-192**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Optimum Residence Time for Moringa Coagulated Water Maximum Turbidity and *E. coli* Abstraction

P. N. Egbuikwem[1], A. A. Amori[2]*

[1]Department of Agricultural and Bio–Environmental Engineering, School of Engineering Technology Imo State Polytechnic, Umuagwo, Owerri, Nigeria
[2]Department of Agricultural and Bio-Environmental Engineering, Federal Polytechnic, Ilaro, Ogun State, Nigeria

Abstract Coagulation is a vital water treatment process required when handling water laden with colloidal particles and pollutants. It is usually achieved by the application of inorganic coagulants like Aluminum Sulphate in the water. The use of Alum in water treatment is considered unsuitable owing to its health implications as well as economic considerations. In an effort to addressing these shortcomings and improving the quality of lives of the people, researches on the use of natural technology in water treatment are welcoming and needful. This study assesses the coagulating efficacy of Moringa seed extract and evaluates the optimum residence time for moringa coagulated water for maximum turbidity removal and *E. coli* reduction. Moringa seeds got from IITA, Ibadan, were processed and the oil content was extracted using hexane in an electro thermal soxhlet apparatus in line with International Standards. Sampled waters sourced from; stream, pond, and well were subjected to coagulation – flocculation – sedimentation treatment processes using the plant coagulant in a jar test apparatus. Following the international tests methods, the physio-chemical and micro biological parameters were determined. At varying quiescent conditions of 1 hr, 2 hrs, 3 hrs and 24 hrs and optimum dosages of 2.5, 4.5 and 6.0 ml, turbidity removal efficiencies for the well, stream and pond water samples were 90.4, 95.8, 97.9 and 100 %; 95.6, 98.9, 99.9 and 100 %; 96.7, 97.6, 99 and 100 % respectively. However, maximum *E. Coli* reduction was obtained at 3 hrs residence time with an overall efficiency of 95%. The study has proven mo seed to contain coagulating substance capable of reducing turbidity and *E. coli* present in water significantly. Conclusively, this study has proven that 3 hrs quiescent time is the best for maximum turbidity removal and microbial reduction for water treated with *Moringa Oleifera* seed extract in order to make available quality water for economy growth any nation.

Keywords *Moringa Oleifera*, Coagulant Efficiency, Residence Time, Turbidity, *E. Coli*, Optimum dosage

1. Introduction

Access to safe drinking water is essential for quality of human life [1]. A research conducted by [2] showed that about 1.2 billion people in the world do not have access to potable water. Presently about 40 percent of world population lives in countries where water demands now exceed supplies and reference [3] reported that in certain parts of Africa especially in rural communities, waterborne and water related diseases like typhoid, cholera, diarrhea and draneunculiasis are fast becoming endemic. Experts predicted that by 2025, two-thirds of the world's population will live in countries suffering from serious water shortage [4]. Most water bodies contain some level of impurities and as such absolutely pure water is rarely, if ever, found in nature. These impurities must be substantially removed for the water to be suitable for human consumption. Reference [5]

reported that impurities in water like colloidal matter cause some problems in obtaining drinking water and their removal is aided by Coagulation – Floculation water treatment process.

In conventional water treatment, coagulation is achieved using chemical coagulants such as aluminum sulphate, ferric chloride, polyaluminum chloride, etc. While the effectiveness of these coagulants is well-recognized, nonetheless, their application in water treatment is becoming unsuitable owing to ineffectiveness in low-temperature water, relatively high procurement costs, detrimental effects on human health, production of large sludge volumes and the fact that they significantly affect pH of treated water. There is also strong evidence linking aluminium-based coagulants to the development of Alzheimer's disease in human beings [1, 6-7]. In an effort to curb the aforementioned shortcomings and adverse effects, researches on the employment of natural, simple and low costs technologies like the M.O seed in water treatment have been extensively reported. However, the ultimate goal of the present study was to explore the coagulating activity of the seed substance of M.O. and to evaluate the optimum residence time for M.O. coagulated water for maximum turbidity removal and *E. coli* reduction.

2. Materials and Methods

A. Preparation of *Moringa Oleifera* seeds

Samples of quality seeds of *Moringa Oleifera* was obtained from International Institute of Tropical Agriculture (IITA) Ibadan. The seeds were then deshelled and the kennels subjected to oven drying at 50 ^{o}C (25 ^{o}C) for 24 hours. Thereafter, the dried seeds were placed in a desiccator to cool (Plate x) and then crushed into powder form (Plate xx) using a IKA analytical mill (model A11BS$_2$). Due to the negative effect of the oil content on the coagulating properties of the M.O seeds, n-hexane was used to extract the oil content from the seed using an electro thermal soxhlet apparatus. The cake residue after oil extraction was dried at room temperature and weighed. The oil content after extraction was 33.4% of the seed weight which is close to the 35% recorded in previous studies as reported by [8-10]. Each experiment in the study uses stock solution prepared from samples of the press cake of M.O seeds by dissolving 5g of the residue after oil extraction in 100ml of distilled water. The mixture was then blended with a stirrer for 2mins to extract the active ingredients. Thereafter, the resulting suspension was filtered through a clean muslin cloth and the filtrate yielded a stock solution of 5000mg/l.

B. Collection and Preparation of Water Samples

Water samples for initial physic-chemical and microbial analyses were collected in 2 opaque plastics containers of 10l capacity from three different sources namely; stream, pond and well all located in Epe Eti-Osa Local Government Councils of Lagos State. The water samples collected were collected on different days and the stored in ice (about 4 °C) to ensure the integrity of the water at the point of collection is maintained. Within 3 to 5 hours of collections, the water samples were analyzed for physic-chemical and microbial parameters (Table x) using ASTM standard.

C. Experimental Procedure

An experimental set up consisting of a four – paddle variable speed flocculator was used to perform the Jar - Test. Eight beakers containing 1 litre of each water sample were used, with beaker no 1 as the control (without dosage). Depending on the quality of the water samples, dosing with the plant extract was set at 1.5 ml – 4.5 ml, 3.0 ml – 6.0 ml and 1.0 ml – 4 ml ranges from beaker no 2 through 7, with increment of 0.5 ml for the stream, pond and well water samples respectively. Following coagulation, solutions were given a flash mix for 3 min at 120 rpm, followed by 30 min of gentle agitation at 40 rpm. The suspensions were left under quiescent condition for 1 hr, 2hrs 3hrs and 24 hrs to stimulate flocs settling. After each residence time, water samples were gently collected and tested for residual turbidity and pH using turbidimeter (Model: HI 93703) and pH meter respectively. While *E. Coli* contents were analyzed by membrane filtration method, procedure described as Standard Method for Examination of Water and Wastewater [11].

3. Results and Discussion

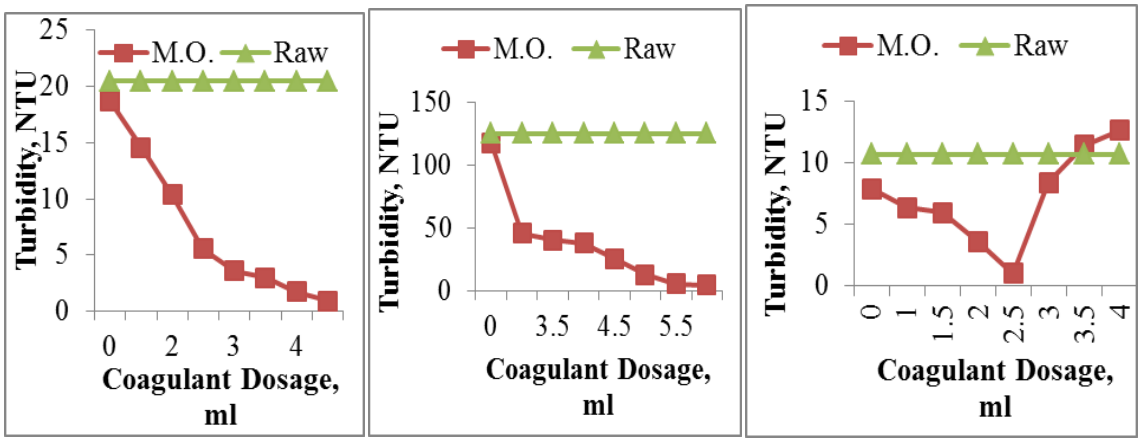
The results of the physic-chemical and biological analysis of the raw water samples are presented in Table 1. Samples from stream and well had turbidity values of 20.5NTU and 10.7NTU respectively, classifying them as low turbidity water, while sample from pond was classified as medium turbidity water with turbidity value of

125NTU. It was observed that none of the water samples is safe for drinking owing to the presence of *E. coli* bacteria. The pH of the stream and well water samples were 6.8 and 7.0 respectively, which fell within WHO guideline of 6.5-8.5. The level of Electrical Conductivity was more pronounced in the well than other sources. This could be due to waste systems interference with the groundwater [12] and also s result of the geology of the site and water table level as observed by [13].

Table 1: Properties of the raw water samples

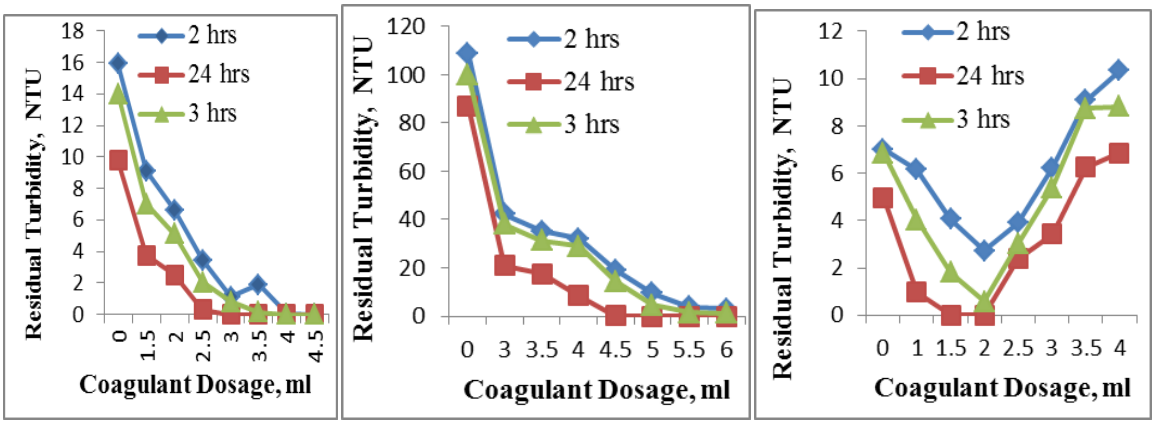
Parameters	Water Sources		
	Stream	Pond	Well
Turbidity (NTU)	20.5	125	10.7
pH	6.8	5.3	7.0
E.C. (µs/cm)	45	18	189
TDS (mg/l)	23	10	98
Temperature (°C)	27	28	27
E. coli (CFU/100ml)	TNTC	57	21

The turbidity of the water samples sourced from stream, pond and well were 20.5, 125 and 10.7 NTU respectively. The results of the jar test performed indicated that at optimum dosages of 4.5 ml, 6.0 ml and 2.5 ml, as shown in Figure 1 and at 1 hr residence time, turbidity removal efficiencies of 95.6 %, 96.7 % and 90.4 % were recorded for the stream, pond and well water respectively. At residence times of 2 and 3 hrs, removal efficiencies were 95.8 and 97.9 %; 98.9 and 99.9 %; 97.6 and 99.0 % for the well, stream and pond waters respectively. At extended residence time of 24 hrs, 100 % turbidity removal efficiency was obtained in all the cases monitored even at lower dosages. This signifies less residual M.O. in water and which however implies cost saving and low cost technology in water treatment.



(Stream) *(Pond)* *(Well)*

Figure 1: Turbidity removal of the water samples using moringa seed extract at 1 hr residence time



(Stream) *(Pond)* *(Well)*

Figure 2: Settling behaviors of flocs formed by moringa seed extract.

For the control study, removal efficiencies recorded were 8.9 %, 6.4 % and 26.0 % for stream, pond and well respectively. Nonetheless, at extended settling of 24 hrs, the residual turbidities were 9.8, 75.0, and 5.0 NTUs and which correspond to 52.3 %, 40.0 % and 53.5 % removal efficiencies respectively. These results are higher than the WHO guideline for drinking water. It is therefore implies that the traditional/simple method of allowing turbid water to settle without any form of treatment (coagulation) is not efficient in addressing the challenges facing potable water supply especially in rural communities.

The results of the *E. coli* contents of the sourced waters as presented in table 1 show that the waters are laden with pathogenic and enteric organisms, which makes the water unsafe for human consumption and other domestic uses. However, the application of *Moringa* seed extract to the water samples reduced the *E. coli* contents from TNTC, 57 CFU/100ml and 21 CFU/100ml to 33 CFU/100ml, 8 CFU/100ml and 2 CFU/100ml for the stream, pond and well water samples respectively. Better reductions in the *E. coli* content were achieved at extended residence time of 3 hrs, thereby giving an overall efficiency of 95 %. It therefore implies that the antimicrobial activity of the plant extract is more effective and active at a reasonable residence time of 3 hrs. The results obtained were in agreement with the findings of [14] which stated that the process of flocculation removes about 90 - 99% of bacteria which are normally attached to the solid particles. Meanwhile, after 24 hrs settling and at different concentrations of moringa extract, an increase in the number of *E. coli* was observed. The results which suggest microbial re-growth is in disagreement with the results of [15], who recorded no microbial re-growth at 24 hrs observation. The re-growth could be tied to the nutrient content of moringa seeds upon which survived organisms feed on and multiply

Table 2: Effect of Moringa on *E. coli* and pH at various detention times for the stream water

Parameters	Time (hr)	Coagulant dosage ml							
		0	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**
pH	1	6.8	6.6	6.6	6.4	6.5	6.6	6.7	6.6
E.C.(µs/cm)	1	45	47	47	47	48	48	48	49
TDS (mg/l)	1	23	24	24	25	25	25	26	26
Temperature (^oC)	1	27	27	27	27	28	28	27	27
E.Coli (CFU/100ml)	1	TNTC	NU	91	79	50	42	49	33
	3	NU	85	62	53	41	33	37	15
	24	NU	92	69	61	45	40	45	21

Table 3: Effect of Moringa on *E. coli* and pH at various detention times for the pond water

Parameters	**Time (hr)**	**Coagulant dosage ml**							
		0	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**
pH	1	5.4	5.3	5.4	5.3	5.4	5.4	5.3	5.3
E.C.(µs/cm)	1	18	19	19	21	20	22	22	23
TDS (mg/l)	1	09	10	11	11	11	13	14	12
Temperature (^oC)	1	29	29	29	29	29	29	29	29
***E. coli* (CFU/100ml)**	1	53	41	27	22	15	17	08	09
	3	50	32	19	15	09	08	03	05
	24	54	37	27	20	15	13	09	08

Table 4: Effect of Moringa on *E. coli* and pH at various detention times for well water

Parameters	**Time (hr)**	**Coagulant dosage ml**							
		0	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**
pH	1	7.0	7.0	7.0	7.1	7.1	7.1	7.1	7.0
E.C.(µs/cm)	1	189	191	191	190	189	189	191	191
TDS (mg/l)	1	99	99	99	97	97	99	100	100
Temperature (^oC)	1	29	29	29	29	29	29	29	29
***E. coli* (CFU/100ml)**	1	19	16	11	07	03	03	04	03
	3	16	12	07	05	03	01	02	01
	24	18	15	06	07	06	03	04	05

Table 2 to 4 present the results of the pH of water treated with moringa seed extracts. The results show that the extract has no significant effect on the pH of the treated water and which is in disagreement with the findings of [7].

4. Conclusion

The present study has shown that the seed extract of *Moringa* contains some active ingredients capable of stabilizing colloidal matter present in water. Maximum (100 %) flocs removal was achieved at 24 hrs quiescent condition and at lower dosages, which therefore implies that at extended residence times, improved quality water can be obtained with little concentration of the seed extract, which on the other hand means cost saving and less residual *Moringa* in treated water. Meanwhile, there seem to be conflict of interests at the 24 hrs settling owing to the microbial re-growth. At 1 hr settling, turbidity removal efficiencies were 95.6 %, 96.7 % and 90.4 % for the stream, pond and well water respectively, but with less microbial reduction. While at 3 hrs sedimentation time, maximum *E. coli* reduction was recorded with 100 % turbidity removal. The results indicate that turbidity of the treated waters met the World Health Organization guideline for drinking water. Considering the results of the controls (without treatments), it is concluded that the local, simple and traditional method of allowing turbid water to settle without any form of coagulation is not efficient in addressing the challenges facing potable water supply especially in rural communities.

The result also showed that the plant extract of *Moringa seed* does not affect the pH, E. C., TDS and Temperature of water significantly. This study has conclusively indicated that turbid and polluted water can be treated considerably with the application of seed extract of *Moringa Oleifera*, and therefore, presents 3 hrs as the optimum residence time for maximum flocs removal and microbial reduction.

Recommendations

Reduction in *E. coli* content does not certify the water safe for consumption. Thus, there is need to disinfect the water before use. For zero chemical introduction to drinking water, It is therefore recommended that "Boil-Before Use" policy be implemented for water treated with *Moringa* seed extract.

There is the need to carry out further detailed tests, which include toxicity to guarantee the safety of using plant extracts as a coagulant in the purification of drinking water for human consumption.

Moreso, studies on the cost effective ways of defatting the oil content of *Moringa Oleifera* seed using local technology need to be conducted so as to make it obtainable in rural and peri – urban communities. Commercialization of the product is also an important area that needs to be researched into for its full scale application and implementation in water treatment industry.

Acknowledgement

The authors are grateful to the HOD, Civil and Environmental Engineering, University of Lagos, Prof. O. M. Sadiq, for approving the usage of the Departmental laboratory for my analysis, and also to all the staff of the Department of the Department for their assistance, especially the Lab. Technicians, Mr. Orebiyi Kazeem and Mrs. Ogunbodede Adenike.

References

[1]. Egbuikwem, P. N. and Sangodoyin, A. Y. (2013). Coagulation Efficacy of *Moringa Oleifera* Seed Extract Compared to Alum for Removal of Turbidity and *E. Coli* in three Different Water Sources. *European International Journal of Science and Technology*, Vol. 4, No. 7 Pp 13 – 20

[2]. Emam, N. Ali, Suleyman A. Muyibi, Hamzah M. Salleh, Mohd Ramlah M. Salleh and Md Zahangir Alam. *Moringa Oleifera* Seeds as Natural Coagulant for Water Treatment. Thirteenth International Water Technology Conference, IWTC 13 2009, Hurghada, Egypt 163-168

[3]. Nwaiwu, N.E. and Bello, A.A. (2011). Effect of *Moringa oleifera*-alum Ratios on Surface Water Treatment in North East Nigeria. Research Journal of Applied Sciences, Engineering and Technology 3(6): 505-512

[4]. Cunningham, W. P., Cunningham, M., and Saigo, B. W. (2005). Environmental Science: A Global Concern, 8th Edition, McGraw Hill New YorK, pp. 353

[5]. S.C Ng., S. Katayon, M.J Megat Mohd. Noor and A.G.L. Abdullah (2006). The Effectiveness of Moringa Oleifera as Primary Coagulant in High-Rate Settling Pilot Scale Water Treatment Plant. International Journal of Engineering and Technology, Vol. 3, No. 2, pp. 191-200

[6]. Vijayaraghavan, G., Sivakumar,T. and Vimal Kumar, A. (2011). Application of Plant Based Coagulants for Waste Water Treatment. International Journal of Advanced Engineering Research and Studies. Vol.1, No. 1, pp.88-92

[7]. Amagloh, F. K., and Benang A. (2009). Effectiveness of *Moringa Oleifera* Seed as Coagulant for Water Purification. *African Journal of Agricultural Research,* 4 (1): 119-123.

[8]. Muyibi, S. A., Birima, A. H., Mahammed T. A., Noor, M. J. (2004). Conventional Treatment of Surface Water using *Moringa Oleifera* Seed Extract as Primary Coagulant. *IIUM Engineering Journal,* 5: 1

[9]. Othmam, Z., Bhatia, S., and Ahmad, A. L. (2008). Influence of the Settleability Parameters for Palm Oil Mill Effluent (POME) Pretreatment by using *Moringa Oleifera* Seeds as an Environmental Friendly Coagulant. International Conference on Environment

[10]. Garcia-Fayos, B., Arnal, J. M., Verdu, G. and Sancho, M. (2010). Aquapot Project: Potential of *Moringa Oleifera* Seeds and its Application in Drinking Water Treatment. Institute for Industrial, Radiophysical and Environmental Safety (ISIRYM). Universidad.

[11]. APHA (1998). Standard Methods for the Examination of Water and Wastewater, 20th ed. American Public Health and American Water Works Association and Water Environment Association.

[12]. Sangodoyin, A. Y., (1993). Considerations of Contamination of Groundwater by Waste Disposal Systems in Nigeria. *Environmental Technology*, 14(10): 957-964

[13]. Sangodoyin, A. Y., (1991). Ground and Surface Water Pollution by Open Refuse Dump in Ibadan, Nigeria. *Discovery and Innovation*, 3(1): 37-43.

[14]. Schwarz, D. (2000). Water Classification using Moringa Oleifera. Technical Information W1e, Gate Information Services, Eschborn, Germany. Internet: http://www.gtz.de/gate/gateid.afp. Accessed on 31st October 2011.

[15]. Bina, B., Mehdinejad, M. H., Dalhammer, G., Rajarao, G., Nikaeen, M., and Attar, M. (2010) Effectiveness of *Moringa Oleifera* Coagulant Protein as Natural Coagulant aid in Removal of Turbidity and Bacteria from Turbid Waters. *World Academy of Science, Engineering and Technology. 67* Pp. 618 – 620