Journal of Scientific and Innovative Research 2016; 5(1): 19-25
Available online at: www.jsirjournal.com

Research Article

ISSN 2320-4818
JSIR 2016; 5(1): 19-25
© 2016, All rights reserved
Received: 20-01-2016
Accepted: 01-03-2016

Keno David Kowanga
Unit of Science, Jordan University College, Morogoro, Tanzania

Godfrey Omare Mauti
Health Sciences Department, Kampala International University College, Dar es Salaam, Tanzania

Eliakim Mbaka
School of Pure and Applied sciences, Biochemistry and Biotechnology Department, Kenyatta University, Nairobi, Kenya

Correspondence:
Keno David Kowanga
Unit of Science, Jordan University College, Morogoro, Tanzania

Effect of crude and defatted *Moringa oliefera* seeds as natural coagulants in the removal of physical, chemical and bacteriological parameters from turbid river water

Keno David Kowanga, Godfrey Omare Mauti, Eliakim Mbaka*

Abstract

There is a great concern about commercial coagulants and their residues in treated water which leads to Alzheimer disease in old people. For this reason, a lot of research is focused on plants with coagulating properties. A lot of interest is on *Moringa oliefera* as a plant with clarifying properties, this study was aimed at investigating efficiency of crude and defatted *Moringa oliefera* seed in aiding removal of turbidity, chemical and bacteriological parameters from turbid Ndarugo river water in comparison with alum. Conventional jar test apparatus was used in coagulation process. The optimum dosages was obtained at 50 mg/L, 175 mg/L and 150 mg/L which gave represented residual turbidity of 3.73±0.09, 4.93±0.31 and 3.27±0.45 for alum, crude *Moringa oliefera* seed powder and defatted *Moringa oliefera* seed powder respectively. Total coliforms were reduced to between 93.48% to 96.96% by all the coagulants; however E. coli was not detected in raw turbid water and clarified sample. In the study, it was observed that *Moringa oliefera* seed showed a good alternative as coagulants reducing water parameters to values below maximum permissible limits as stipulated by WHO.

Keywords: Alzheimer disease, Coagulants, *Moringa oliefera*, Total coliforms.

INTRODUCTION

Low supply of treated water in developing countries has caused large number of people to take water from unprotected sources which is polluted with microorganisms. For this reason, 88% of global water borne diseases are caused by drinking unsafe and unhygienic water [1]. During treatment of water for domestic and industrial use, large amount of chemical coagulants which change the composition of treated water is used [2]. These chemical coagulants are mostly aluminum based coagulants which are expensive and their concentration in treated water lead causes Alzheimer disease that mostly affect old people and prevents brains from functioning normally leading to memory loss thus preventing affected people from speaking clearly [3]. For these reason it is desirable to find cost effective and environmentally friendly coagulants to replace or supplement aluminum based coagulants. *Moringa oliefera* seed has proven to be the best natural coagulant and much research is focused on what form it should be used to clarify water [4]. This study compare the effectiveness of alum, crude and defatted *Moringa oliefera* seed powder in removal of physical, chemical and bacteriological parameters from turbid Ndarugo River water which is normally treated and used at Jomo Kenyatta University of Agriculture and Technology.

MATERIALS AND METHODS

Sampling

Samples of *Moringa oleifera* seeds were collected from a single tree grown by a farmer in Meru, Industrial alum (aluminum sulphate) was purchased from Kobian (Kenya) Limited Nairobi. The samples were then transported to J.K.U.A.T laboratory in Juja for extraction of bioactive materials responsible for coagulation.

Turbid River Water Samples

Turbid water samples were collected from Ndarugo River, near Jomo Kenyatta University of Agriculture

and Technology after a heavy downpour the previous night. After the particulates have settled, the turbid water containing colloidal particles were carefully collected, downstream, midstream and upstream (six, 20 litres containers at each point) using pond sampler (grab sampler) in high density polythene (HDPE) 20 litres containers. The location of sampling was mid-depth in moving water at the main flow line; main flow line was identified by observing the flow patterns across the channel. The samples were then transported to Civil Engineering Department, Environmental laboratory at Jomo Kenyatta University of Agriculture and Technology for coagulation/flocculation process using jar test apparatus.

Preparation of *Moringa oleifera* Seeds

Crude *Moringa oleifera* seed powder: The seeds were de-shelled to remove the kernels. Seed kernels were further dried at ambient temperatures for a period of five days. The white kernels were milled into a fine powder using a mill (Model; SK-M10R Grinding Mill) at 8000 rpm, and sieved with a sieve with an aperture of 0.5mm before used to purify turbid river water.

Defatted *Moringa oleifera* seed powder*:* Extraction of oil from *Moringa oleifera* seed powder was carried out by adding hexane to the seed powder using soxhlet apparatus (Muyibi *et al.,* 2003). The oil content from the *Moringa oleifera* seeds was found to be 33.35±0.08%. The *Moringa oleifera* seed cake residue stock after oil extraction was sieved with a sieve with an aperture of 0.5mm before used to clarify water.

Evaluation of Optimum Dosages of the Coagulants (Jar Test)

The jar test was carried out to purify turbid Ndarugo river water which had initial turbidity of 86.77±0.52 NTU with different dosages of aluminum sulphate (alum), crude *Moringa oleifera* seed powder and defatted *Moringa oleifera* seed powder. Jar test was done in triplicates using jar test apparatus (Model; SC.D 41-11359 ZTC) located in Civil Engineering Department, Environmental Laboratory. It was set under the following conditions: coagulation time of 60 s (1 minute) ; rapid mixing speed at 160 rpm and slow mixing speed for 1200 s (20 minutes) at 25 rpm; the flocculation process, and settling time of 3600 s (1 hour) [2]. Initial, residual turbidity and all there parameters were determined for raw water and supernatant solutions of purified water in each beaker after the jar test.

Analysis of Physical Parameters

Turbidity

Turbidity was determined using portable turbidity meter (Model, KRK TR-3Z) in triplicates. It was calibrated using control and setting it to zero before measuring raw and purified/clarified water samples.

pH

The pH was determined using pH electrode (Model; pHs-3S) in triplicates. The instrument was calibrated using buffer solutions with pH values of 4.00 and 7.00, before measuring the samples.

Total Dissolved Solid and Conductivity

These parameters were determined by Jenway a portable TDS meter/Conductivity meter (Model, 4076) in triplicates. The instrument was set to measure TDS then it was rinsed with distilled water, and then used to measure conductivity.

Analysis of Chemical Parameters

Determination of sulphates, chloride, phosphates were done as per spectroscopic procedure by Bassett *et. al.,* 1983 and determination of nitrates was done using copperized cadmium granules reduction column [5].

Determinations of Metals

Samples Preparation:
Unfiltered (but decanted/supernatant) raw and clarified water samples were digested with 8 mL of 3:1:1 (HNO_3:H_2SO_4:$HClO_4$) acid mixture (vol./vol.); for cadmium (Cd) and Lead (Pb) determinations, H_2SO_4 was not included. The mixture was heated in a water bath for one hour at 50°C for mercury (Hg) and on a hot plate for three hours at 130°C – 140°C for other metals. In the determination of mercury, the digestion was completed by cooling the mixture in an ice bath and adding 6% wt./vol. $KMnO_4$ slowly until effervescence was complete. Further digestion was allowed for two more hours, followed by cooling and addition of 15 mL of 20% wt./vol. NH_2OH/HCl solution. The final volume before analysis was diluted to 50 mL for other metals and 100 mL (for Hg) with distilled water.

Preparation of Stock Solution and working standards: Stock solutions were prepared by dissolving appropriate amounts of analytical grade salts in 250 mL distilled water. 5 mL of concentrated nitric acid was added and the solution finally made to the mark using distilled water and kept refrigerated in plastic bottles at 4˚C. The stock solutions were then diluted to make working standards.

Analytical techniques:
The concentration of metals in the samples were analyzed using a FAAS (Flame Atomic Absorption Spectrophotometer) (Model, 210 VGP Buck Scientific), equipped with an air-acetylene flame while the concentration of mercury was analyzed using Cold-Vapour Atomic Absorption Spectrophotometer (CVAAS). As a quality assurance procedure, a 6-point calibration through zero was applied. The resulting linear calibration line ($r^2 \geq 0.996$) was the requirement for any sample measurement. Furthermore, after every 10 measurements, the 1.0 mg L^{-1} working solution was checked for accuracy. The calibration was repeated in cases where incorrect values were obtained. Finally, the standard solution for the required absorbance was checked as part of the quality assurance process.

Bacteriological Analysis

The tests were done using Multiple Tube Technique arranged in three parts: - presumptive, confirmed and completed tests in Food Microbiology Laboratory in Jomo Kenyatta University of Agriculture and Technology.

The Presumptive Test
12 tubes (4 groups of 3 tubes were set up for each sample, each tube was labeled according to the amount of dilution that the sample water was subjected to: 10^0, 10^1, 10^2, 10^3 respectively. Samples of raw and purified water samples were shaken and 9 mL of sterile MacConkey broth was placed to each of the tubes, with a 10 mL pipette, 1 mL of water sample was transferred to each of the three 10^0 tubes. The other tubes were filled after serial dilution of the samples; the inoculated test tubes were then incubated at 35°C for 48 hours. The test tubes were then examined and the number of the tubes in each set that had 10% gas or more was recorded using most probable number (MPN).

The Confirmed Test

The positive lactose broth tubes from presumptive tests were tested using brilliant green broth by inoculated with a loop-full of the culture from the positive presumptive tubes. The tubes were the incubated for 48 hours at 35°C these tubes were checked for gas production this was an indication of a positive test.

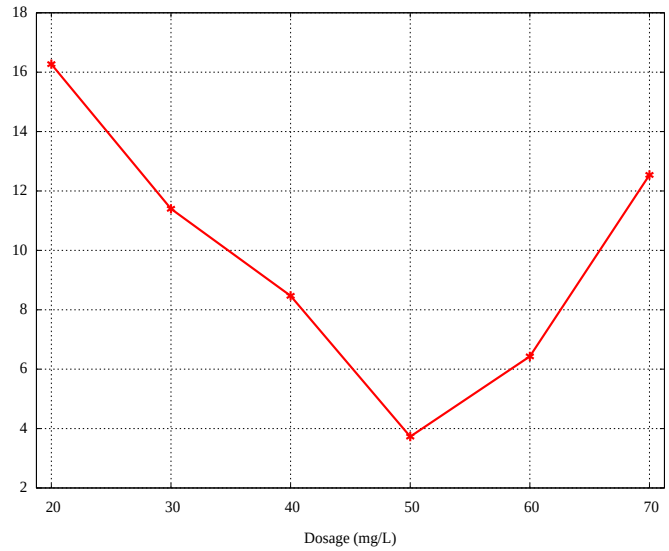
The Completed Test

EMB agar plates were prepared and a loop-full of the positive samples from confirmed test tubes were inoculated by streaking. These plates were incubated for 24 hours at 35°C; the presence of *E. coli* was indicated by colonies having dark centers with or without a greenish metallic sheen.

RESULTS AND DISCUSSIONS

Alum

Jar tests were conducted to determine optimum dosage of Alum on turbid Ndarugo River water having initial turbidity of 86.77±0.52 NTU. After coagulation and flocculation, the effective dosage was established at 50 mg/L which gave residual turbidity of 3.73±0.09 NTU this represented 95.70% reduction in initial turbidity after one hour settling. The results showed that above optimum dosage, the colloidal particles in water showed a tendency to restabilize; this occurred when dosage was increased to 60 mg/L, the residual turbidity increased to 6.43±0.37 NTU this represented 92.59% reduction in initial turbidity as shown in table 2. This finding is in agreement with other studies at optimum dosage [6].



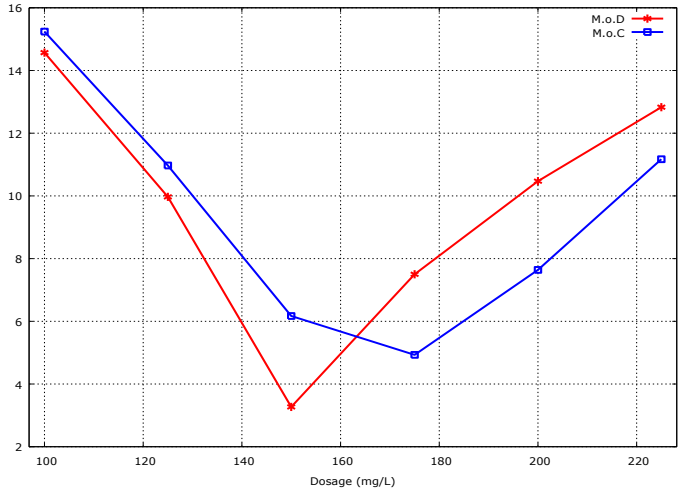
(Jar Test Conditions: Coagulation time; rapid mixing speed, 160 rpm, 60 s; slow mixing speed, 25 rpm, 20 min.; flocculation process, 1 hr)

Figure 1: Performance of Alum on Turbid Ndarugo River water

According to figure 8, alum resulted in producing treated water with turbidity less than 5 NTU and the flocs produced were white, large, rigid and settled well in less than 10 minutes; the supernatant was clear after 20 minutes settling. Since of effective dosage gave residual turbidity of less than 5 NTU, no further tests were made as WHO recommend that treated water should have turbidity of less than 5 NTU before the water can be effectively disinfected with chlorine [7].

Moringa oleifera seed

Jar test was then conducted on defatted *Moringa oleifera* seed powder and crude *Moringa oleifera* seed powder using the turbid Ndarugo River water. The optimum dosage was established at 150 mg/L and 175 mg/L giving residual turbidity of 3.27±0.45 NTU and 4.93±0.31 NTU; this represented 96.23% and 94.32% reduction in initial turbidity for defatted *Moringa oleifera* seed powder and crude *Moringa oleifera* seed powder respectively, after one hour settling. Optimum dosages gave residual turbidities below WHO guideline and no further jar tests were made. It was also observed for defatted *Moringa oleifera* seed powder optimum dosage occurred at 150 mg/L a value lower than 175 mg/L for crude *Moringa oleifera* seed powder; this shows that defatted *Moringa oleifera* seed powder was more effective compared to crude *Moringa oleifera* seed powder. More polyelectrolytes in defatted *Moringa oleifera* seed powder dissolved in turbid Ndarugo River water aiding in coagulation unlike in crude *Moringa oleifera* seed powder which had oil; this prevented more polyelectrolytes from dissolving in water to aid in coagulation.



*M.o.D = *Moringa oleifera* Defatted, M.o.C = *Moringa oleifera* Crude
(Jar Test Conditions: Coagulation time; rapid mixing speed, 160 rpm, 60 s; slow mixing speed, 25 rpm, 20 min.; flocculation process, 1 hr)

Figure 2: Performance of *M. oleifera* (Crude and Defatted) seeds on Turbid Ndarugo River water

Crude and Defatted *Moringa oleifera* seed powder as Coagulant Aid

The best ratio for optimum dosage of alum and defatted *Moringa oleifera* seed powder and crude *Moringa oleifera* seed powder when used in conjunction, were 40 mg/L to 20 mg/L for alum to defatted *Moringa oleifera* seed powder which gave residual turbidity of 2.38±0.07 and reduced dosage of alum by 20% and 50 mg/L to 25 mg/L for alum to crude *Moringa oleifera* seed powder which gave residual turbidity of 3.91±0.42 and reduced dosage of alum by 0%.

The best turbidity removal efficiency obtained were about 97.26% and 95.49% for alum to defatted *Moringa oleifera* seed powder and alum to crude *Moringa oleifera* seed powder. The results obtained indicated that coagulation aid should be added one minute after addition of alum. Poor performance was obtained when coagulant aid and alum were added simultaneously. This finding was in agreement with studies done on other natural polyelectrolytes as coagulant aid [8]. The use of defatted *Moringa oleifera* seed powder and crude *Moringa oleifera* seed as coagulant aid in flocculation process decreased alum dosage significantly up to 70% for 1:2 alum to defatted *Moringa oleifera* seed powder and 60% for 1:2 alum to crude *Moringa oleifera* seed; the results were in agreement with WHO set guidelines of below 5 NTU. There was an improvement in the floc size when defatted *Moringa oleifera* seed powder and crude *Moringa oleifera* seed powder were used as a coagulant aid in conjunction with alum as compared to either

defatted *Moringa oleifera* seed powder or crude *Moringa oleifera* seed powder alone. In addition, defatted *Moringa oleifera* seed powder and crude *Moringa oleifera* seed powder significantly reduced the required dosage of alum, thereby reducing costs of treatment.

Table 1: Effect of Natural Coagulants Aids on Alum

(Jar Test Conditions: Coagulation time; rapid mixing speed, 160 rpm, 60 s; slow mixing speed, 25 rpm, 20 min.; flocculation process, 1 hr)

Coagulants	Optimum Ratio and Dosage (mg/L) Alum : N.C	Residual Turbidity (NTU)	% Reduction in Turbidity	% Reduction in mass of Alum
Alum : M.o.D	1 : 1 20 : 20	4.57±0.32	94.73	60
	1 : 2 15 : 30	4.89±0.24	94.36	70
	2 : 1 40 : 20	2.38±0.07	97.26	20
Alum : M.o.C	1 : 1 25 : 25	5.11±0.04	94.11	50
	1 : 2 20 : 40	4.73±0.03	94.55	60
	2 : 1 50 : 25	3.91±0.42	95.49	0

*M.o.D = *Moringa oleifera* Defatted, M.o.C = *Moringa oleifera* Crude, N.C = Natural coagulant, Standard deviations were calculated from 3 replicate jar tests, optimum dosage of alum was 50 mg/L, initial turbidity was 86.86±0.28 NTU

Analysis of Physical and Chemical Parameters

The best turbidity, pH, conductivity, TDS and total hardness removal were obtained for water samples treated with defatted *Moringa oleifera* seed powder but even though there coagulants reduced these physical parameters to values within the W.H.O and N.E.M.A guidelines, table 2. The removal of these parameters may have occurred during coagulation and flocculation process, as colloidal particles in water are destabilized by the coagulants to form flocs some of these ions are trapped in the flocs hence are deposited as sludge in the beakers hence reducing their concentration in supernatant solution [9].

Table 2: Chemical and Physical Parameters of Raw and Clarified water

Coagulants **Optimum dosage** **Parameters**	**Units**	**Raw water** **-**	**Alum at** **50 mg/L**	**M.o.D at** **150 mg/L**	**M.o.C at** **175 mg/L**
Turbidity	NTU	86.77±0.52	3.73±0.09 (95.70%)	3.27±0.45 (96.23%)	4.93±0.31 (94.32%)
pH	-log[H^+]	7.1±0.2 -	6.8±0.1 (4.22%)	6.6±0.2 (7.04%)	6.7±0.1 (5.63%)
Alkalinity	mg/L (as $CaCO_3$)	245.94 ±0.31 -	176.45±0.97 (28.25%)	168.44±0.86 (31.51%)	169.48±47 (31.09%)
Conductivity	µS/cm	0.083 ±0.005	0.083±0.005 (0%)	0.073±0.005 (12.05%)	0.073±0.005 (12.05%)
TDS	mg/L	58.00±0.00	59.00±0.82	55.33±0.47	56.67±0.47
Ca^{+2}	mg/L (as $CaCO_3$)	248.63 ±0.51 -	111.45±0.59 (55.18%)	102.98±0.36 (58.63%)	117.21±1.79 (52.88%)
Mg^{+2}	mg/L (as $CaCO_3$)	235.37 ±1.64 -	212.07±0.94 (10.07%)	207.22±0.01 (12.08%)	206.52±0.22 (12.40%)
Total Hardness	mg/L (as $CaCO_3$)	484.00 -	323.52 (33.22%)	310.20 (35.97%)	323.73 (33.18%)
Nitrates ($NO_3^{2-}N$)	mg/L	12.68±0.77 -	5.46±0.33 (56.94%)	4.37±0.79 (65.64%)	5.12±0.36 (59.62%)
Sulphates (SO_4^{2-})	mg/L	1.899 ±0.023 -	1.232±0.031 (35.13%)	1.188±0.042 (37.42%)	1.203±0.051 (36.67%)
Phosphates (PO_4^{2-})	mg/L	20.01±0.25 -	13.24±0.05 (33.79%)	13.39±0.49 (33.03%)	13.24±1.23 (33.79%)
Chloride (Cl^-)	mg/L	98.71±0.57 -	61.38±0.12 (37.82%)	57.93±74 (41.31%)	54.43±0.37 (44.86%)
Chromium (Cr^{+2})	mg/L	0.400 ±0.016	0.075±0.043 (81.25%)	0.025±0.076 (93.75%)	0.100±0.002 (75.00%)

Cadmium) (Cd^{+2})	mg/L	-0.025 ±0.058	0.008±0.000 (66.67%)	ND	ND
Lead (Pb^{+2})	mg/L	-0.70±0.31	0.28±0.25 (60.00%)	0.30±0.07 (57.14%)	0.32±0.02 (54.29%)
Nickel (Ni^{+2})	mg/L	0.367 ±0.121	0.167±0.027 (54.58%)	0.100±0.041 (72.75%)	0.133±0.008 (63.67%)
Copper (Cu^{+2})	mg/L	0.089 ±0.010	0.021±0.006 (76.36%)	0.016±0.002 (82.26%)	0.011±0.008 (88.17%)
Zinc (Zn^{+2})	mg/L	-0.088 ±0.049	0.054±0.002 (36.64%)	0.056±0.000 (36.36%)	0.058±0.017 (34.09%)
Manganese (Mn^{+2})	mg/L	-2.55±0.06	1.05±0.13 (56.82%)	0.80±0.22 (68.63%)	0.90±0.02 (64.71%)
Mercury (Hg^{+2})	mg/L	0.023 ±0.007	0.017±0.002 (26.09%)	0.008±0.000 (65.22%)	0.011±0.001 (52.17%)
Iron (Fe^{+2})	mg/L	-1.133 ±0.011	0.467±0.013 (58.81%)	0.333±0.044 (70.58%)	0.400±0.072 (64.70%)

*Standard deviations were calculated from 3 replicate measurements using three solutions, M.o.D = *Moringa oleifera* Defatted, M.o.C = *Moringa oleifera* Crude, ND= Not Detected, (x %) = % Removal, detection limits: 0.0013 mg/L NO_4^{-2}, 0.003 mg/L PO_4^{-2}, 0.0043 mg/L SO_4^{-2}, 0.0075 mg/L Cr^{+2}, 0.0001 mg/L Cd^{+2}, 0.006 mg/L Pb^{+2}, 0.1 mg/L Ni^{+2}, 0.0158 mg/L Cu^{+2}, 0.0066 mg/L Zn^{+2}, 0.0063 mg/L Cl^{-}, 0.003 mg?L Hg^{+2}, 0.0248 mg/L Fe^{+2}, 0.15 mg/L Mn^{+2}

Chemical Parameters: Anions: Nitrates removal by the coagulants ranged from 56.94% by alum to 65.64% by defatted *Moringa oleifera* seed powder, phosphates removal ranged from 33.03% by defatted *Moringa oleifera* seed powder to 33.79% by both alum and crude *Moringa oleifera* seed powder, sulphates removal varied by 35.13% by alum to 37.42% by defatted *Moringa oleifera* seed powder and chloride removal varied by 37.82 % by alum to 44.86% by crude *Moringa oleifera* seed powder, figure 2. All these chemical parameters were reduced to values within the W.H.O and N.E.M.A guidelines, table 5. These parameters were removed by adsorption and charge neutralization mechanism during coagulation and flocculation process, as coagulants are normally positively charged the negative charge in these anions are thus attracted by the positive charge on the coagulants during the formation of flocs hence they are deposited as sludge at the bottom of the beaker reducing their concentration in supernatant solution [10].

Cations (Heavy metals): The highest heavy metals removal were as follows:- 93.75% for Cr (II) by defatted *Moringa oliefera* seed powder, 100% for Cd (II) by crude and defatted *Moringa oliefera* seed powder, 60% for Pb (II) by alum, 72.75% for Ni (II) by *Maerua subcordata* powder, 88.17% for Cu (II) by defatted *Moringa oliefera* seed powder, 88.17% Cu(II) by crude *Moringa oliefera* seed powder, 36.64% Zn (II) by alum, 68.63% for Mn (II) by defatted *Moringa oliefera* seed powder, 65.22% for Hg (II) by defatted *Moringa oliefera* seed powder and 70.58% for Fe (II) by defatted *Moringa oliefera* seed powder, table 2. Most of these parameters were as well reduced to values within the W.H.O and N.E.M.A guidelines. The cations were trapped in the colloidal particles and they were removed as flocs were formed; then deposited as sludge at the bottom of the beaker reducing their concentration in supernatant solution. Natural coagulants could also have been removed these cations by surface complexation, chemical precipitation, physical adsorption and ion exchange during coagulation and flocculation process, as explained in our publications on biosorption[11].

Bacteriological Parameters: Tables 3, 4, 5 and represent results from bacteriological analysis.

Table 3: Presumptive Test: Total Coliforms

Water Samples at Optimum Dosage	Test Tubes with Positive Reaction per Dilution				MPN /100 mL	% Removal
	10^0	10^1	10^2	10^3		
Raw Water Sample	3	3	0	0	230	-
Water purified with Alum (50 mg/L)	2	1	0	0	15	93.48
Water purified with M.o.D (150 mg/L)	1	1	0	0	7	96.96
Water purified with M.o.C (175 mg/L)	2	0	0	0	9	96.09

*M.o.D = *Moringa oleifera* Defatted, M.o.C = *Moringa oleifera* Crude

Table 4: Confirmed Test: Feacal Coliforms

Water Samples at Optimum Dosage	Test Tubes with Positive Reaction per Dilution				MPN /100 mL	% Removal
	10^0	10^1	10^2	10^3		
Raw Water Sample	2	2	1	0	28	-
Water purified with Alum (50 mg/L)	1	0	0	0	4	85.71
Water purified with M.o.D (150 mg/L)	0	0	0	0	0	100
Water purified with M.o.C (175 mg/L)	0	0	1	0	3	89.29

*M.o.D = Moringa oleifera Defatted, M.o.C = Moringa oleifera Crude

Table 5: Completed Test: *E. coli* Test

Water Samples at Optimum Dosage	*E. coli* Test
Raw Water Sample	Negative
Water purified with Alum (50 mg/L)	Negative
Water purified with M.o.D (150 mg/L)	Negative
Water purified with M.o.C (175 mg/L)	Negative

*M.o.D = *Moringa oleifera* Defatted, M.o.C = *Moringa oleifera* Crude

Table 6: W.H.O and N.E.M.A Guidelines for Water Quality

PARAMETERS	UNIT	W.H.O GUIDELINES	N.E.M.A GUIDELINES
pH	-log[H^+]	6.5 – 8.5	6.5 – 8.5
Turbidity	NTU	< 5.0	< 5.0
Conductivity @ 25°C	µS/cm	NS	NS
Total Hardness	mgCaCO3/L	<500	<500
Total Alkalinity	mgCaCO3/L	<500	NS
TDS @ 25°C	mg/L	<1500	<1500
Chloride	mg/L	<250	250
Zinc	mg/L	<5	NS
Sulphates	mg/L	<400	400
Iron	mg/L	<0.3	0.3
Manganese	mg/L	<0.1	0.1
Nitrate	mg/L	<10	10
Lead	mg/L	<0.05	NS
Cadmium	mg/L	<0.01	0.01
Mercury	mg/L	<0.01	NS
Total Coliforms	No./100 mL	<10	< 10
Feacal Coliforms	No./100 mL	Nil	Nil

The results from presumptive test showed that total coliforms from raw water was 230 MPN, this was reduced to 15 MPN, 7 MPN and 9 MPN this represented 93.48%, 96.96% and 96.09% for alum, defatted *Moringa oleifera* seed powder and crude *Moringa oleifera* seed powder as indicated in table 3. The results from confirmed test also showed that feacal coliforms from raw water was 28 MPN this was reduced to 4 MPN, 0 MPN and 3 MPN this represented 85.71%, 100% and 89.29% for alum, defatted *Moringa oleifera* adnd crude *Moringa oleifera* crude powder, table 4. However, completed test tested negative for all samples indicating that there was no *E. coli* in both raw and purified water samples, table 5. The removal of coliforms may have occurred during coagulation and flocculation process, as colloidal particles in water were destabilized by the coagulants to form flocs coliforms were trapped in the flocs and deposited as sludge at the bottom of beakers reducing their concentration in supernatant solutions. Natural coagulants-*Moringa oleifera* has also showed antibacterial effects. Therefore its antimicrobial effects were attributed to bactericidal activities as well as flocculation. Roussy reported a bridging mechanism in bacterial reduction during coagulation by natural coagulants; the coagulants get stack on the microbial cell surface, thereby forming an impervious layer around the cell that blocks the channels, which are crucial for living cells [12]. This indicates that flocculation was not the only mechanism by which microbial reduction occurred. It has also been reported that *Moringa oleifera* contains antibiotics called glucosinolate-4-alpha-L-rhamnosyloxy benzyl isothiocyanate this could have accounted for its better performance in removal of coliforms [13].

Acknowledgement

The principal author would like to acknowledge supervisors of the project, National Council of Science and Technology for providing funds to carry out this study. This manuscript was extracted from the author's M.Sc. Thesis "Purification of Turbid River Water and Biosorption of Cu(II) and Pb(II) using Natural Coagulants: *Maerua subcordata, Prosopis juliflora* and *Moringa oliefera"*

REFERENCES

1. Singh SM. Trace metal levels in drinking water on Viti Levu, Fiji Islands. South. Pacific Journal of National Science 2003;21:31-34.
2. Kastalsky A, Nikoladze G, Mints D. Water treatment for public and industrial supply. 2nd Ed., Mir. Publishers. 2009, 782-798.
3. Miller R., Kopfter F, Kelty K, Strober L. The occurrence of aluminum in drinking water. Journal of American Water Works Assiation 2004;76:84-91.
4. McConnachie GL. Water treatment for developing countries using baffled-channel hydraulic flocculation proccess. Journal of Institute of Civil Engineering Marit Energy 2003;101:55-61.
5. Bassett J, Denney RC, Mendham J. Vogel's textbook of quantitative inorganic analysis 1st Ed., Longhorn. 1983, 510-756.
6. Ebeling J M, Sibrell P, Ogden S, Summerfelt S. Evaluation of chemical coagulation/flocculation aids for the removal of suspended solids and phosphorus from intensive recalculating aquaculture effluent discharge. Journal of Aquaculture Engineering 2003;12:19–20.
7. WHO, Guidelines for Drinking Water Quality, Switzerland, Geneva, 2002.
8. WHO, Guidelines for Drinking Water Quality, Switzerland, Geneva, 2002.
9. Schulz C. Surface water treatment for communities in developing countries. John Wiley and Sons, UK, 2002, 432-442.
10. Muyibi SA, Evison LM. Flocs settling characteristics of turbid water coagulated with *Moringa oleifera* seeds. International Journal of Environmental Studies 1999;6:483-495.
11. Sutherland JP, Folkard GK, Mtawali MA. Grant WD. *Moringa oleifera* as a Natural Coagulant. In: Proceedings of the 20th WEDC Conference, Colombo, Sri Lanka. 2000, 297-299.

12. Roussy J, Van Vooren M, Dempsey B, Guibal E. Influence of Chitosan characteristics on the coagulation and the flocculation of Bentonite suspensions. Jounal of Water.Resources 2005;39:3247-3258.
13. Qin C, Li H, Xiao Q, Liu Y, Zhu J, Du Y. Water-Solubility of Chitosan and its antimicrobial activity. Journal of Carbohydrate Polymers. 2006;63:367–374.