AMERICAN JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ISSN: 2153-649X, doi:10.5251/ajsir.2012.3.6.487.492

A new water treatment system using *Moringa oleifera seed*

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ABSTRACT

Moringa seed (Zogale in Hausa) is applied as coagulant in place of Aluminium Sulphate (Alum) used in conventional treatment plants. Design and construction of a water treatment system based on average water demand for drinking of 25 litres per person per day is undertaken. Components of the system include a coagulant tank. Hand mixer, Sedimentation and Filtration tanks of diameters 0.690m, 0.230m, 0.391m and 0.44m respectively. Jar test analysis for Well, Borehole and surface water samples revealed that between 120,000 - 3000,000mg/L of Moringa seed powder is adequate enough to reduce the turbidity of Well and Borehole water samples to between 0 – 3 NTU, which satisfies WHO standards for portable water. The research is viewed as revolutionary for small household applications, particularly in rural areas, where water purification is absent and moringa widely consumed.

Key words: Water treatment, Seed, Moringa Oleifera

INTRODUCTION

Water is used for a variety of purposes like drinking, washing, bathing, recreation, as well as numerous other varied industrial applications. World Health Organization WHO (1971), reports that wholesomeness of water means absence of suspended solids, inorganic solids and pathogens. The report also specifies the minimum amount of 25litres (per capita per day) of potable drinking water. About one billion people lack safe drinking water and more than six million people (of which 2 million are children) die from diarrhea every year (Cheesbrough, 1984).

The situation persists and it will continue to cause substantial loss of human lives unless it is seriously dealt with at all levels. In developing countries such as Nigeria, water treatment plants are expensive. The ability to pay for services is minimal and skills as well as technology are scarce. In other to alleviate the prevailing difficulties, approaches should be focus on sustainable water treatment systems that are low cost, robust and requires minimal maintenance and operating skills. Locally available materials can be exploited towards achieving sustainable safe potable water supply. Drinking water treatment involves a number of unit processes depending on the quality of the water source, affordability and existing guidelines or standards. The cost involved in achieving the desired level of treatment depends among other things, on the cost and availability of chemicals. Commonly used chemicals for the various treatment units are synthetic organic and inorganic substances.

In many places, these are expensive and have to be imported in hard currency. Many of the chemicals are also associated with human health and environmental problems (Matawal and Kulack, 2004), and a number of them have been regulated for use in water treatment systems. Natural materials can minimize or avoid the concerns and significantly reduce cost available locally. Generally, coagulants are used for physical and chemical purification of turbid raw waters. They are applied to transform water constituents into forms that can be separated out physically. For instance, in Benue State of Nigeria, muddy water mixed with powdered moringa seeds results in purified water after one hour of storage, just as if it had been treated with the common Aluminum Sulphate (Alum). The ultimate goal of this work is to evaluate the effectiveness of Moringa seed powder as a coagulant using a low-cost water treatment for semi-urban and rural dwellers in Bauchi State.

Conceptual Framework: *Moringa Oleifera* is grown widelythroughout the tropics. It is also found in many states of Northern Nigeria and other Southern States. It is sometimes known as the DRUMSTICK or HORSERADISH tree. Ranging in height from 5 to 12m with an open, umbrella-shaped crown, straight trunk and corky, whitish bark, the tree produces a tuberous taproot. The evergreen or deciduous foliage (depending on climate) has leaflets 1 to 2cm in diameter; the flowers are white or cream coloured. The fruits (pods) are initially light green, slim and tender; eventually becoming dark green, firm and up to 120cm long, depending on the variety. The dried *Moringa* seeds are round or triangular, the kernel is surrounded by a lightly wooded shell with three papery winds.

Jahn (1986), reports that moringa leaves have outstanding nutritional qualities, among the best of all perennial vegetables. The protein content is 27 percent and there are also significant quantities of calcium, iron and phosphorous, as well as vitamins **A, B** and **C.** In Benue State for instance, fresh Moringa leaves are eaten as vegetables, while the roots are used in a variety of traditional medicines.Moringa plant and seeds which have no secondary effects on humans is shown in figures 1–3.

Coagulation with Moringa Seeds: According to Eilert (1978), the seeds of *Moringa Oleifera* contains significant quantities of low molecular-weight (water-soluble proteins) which carries positive charge when the crushed seeds are added to raw water, the proteins produce positive charges acting like magnets and attracting the predominantly negatively charged particles (such as clay, silt bacterias, and other toxic particles in water).The flocculation process occurs when the proteins bind the negative charges forming flocs through the aggregation of particles which are present in water. These flocs are then easily removed by settling or filtration: a situation that gave rise to this study on moringa seed application.

Research Methods: *Moringa Oleifera* is found in almost all states in Northern Nigeria especially Bauchi, Benue, Gombe, Taraba, Adamawa among other states. The seeds for this experimentation were obtained easily within Yelwa neighbourhood in Bauchi State. Matured seeds were removed from the pods and shelled. The resulting seed kernels were grounded into powder and used throughout the experiment. The design was based on average amount of water for drinking only by a person per day of 25litres (WHO, 1971). For a family of six (6) people, $0.15m^3$ capacity treatment system was designed and constructed. Certain assumptions were made for the first tank (coagulation) as follows:

Depth of tank	=	0.6m
Freeboard	=	0.04m
Sludge Cone	=	0.20m

Therefore, the diameter of the coagulation tank was calculated as 0.690m. For the Hand mixing tank of 0.52m height and a sludge cone of 0.02m, the diameter of the tank was obtained as 0.230m. A two hour detention time was adopted for the sedimentation (third) tank with the following assumptions.

Depth of tank	=	0.45m
Free board	=	0.05m
Sludge cone	=	0.15m

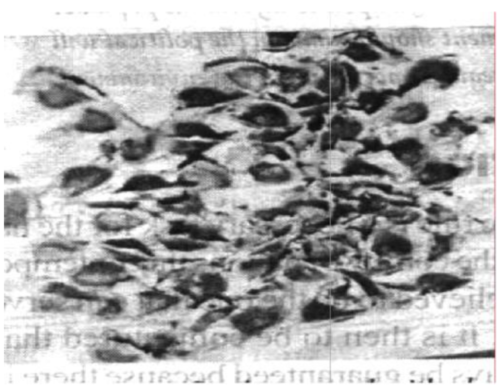
The diameter of the sedimentation tank was calculated as 0.391m. Finally, the diameter of the filtration (fourth) tank, 1m height was calculated as 0.44m. The constructed water treatment system is as shown in plate 1. The seed powder of between 120,000 and 300,000mg/L were mixed with $0.15m^3$ of different raw water samples in the coagulant tank for 30 seconds. The water in the hand mixer was agitated vigorously by manually stirring with a rod for 2 minutes before allowing same into the sedimentation tank at the rate of 500ml/sec. After 2 hours of detention time in the filtration tank. The filtered water was then collected through the suction outlet for laboratory analysis.

The results of the treated water samples were compared with the raw water samples along with World Heath Organization Standards. Total Dissolved Solids (TDS), Conductivity (µs/cm), Temperature and pH of the raw and treated water samples were determined using HACH model 44600 – 00 multiple kit. Turbidity (NTU) and suspended solids (mg/L) for the same samples were determined using Dr/2000 model 1990 spectrophotometer. Total bacteria counts (cfu/ml) were determined using pour plate methods as described by (Bissnette, et al. 1977).

RESULTS AND DISCUSSION

Table 1 shows the physical, chemical and biological analysis of Borehole water sample before and after treatment. The treatment increased the pH by average of 5.5%. The total dissolved solids (TDS) was reduced by 51% while the Total Bacteria count

Fig. 1: *Moringa Plant*



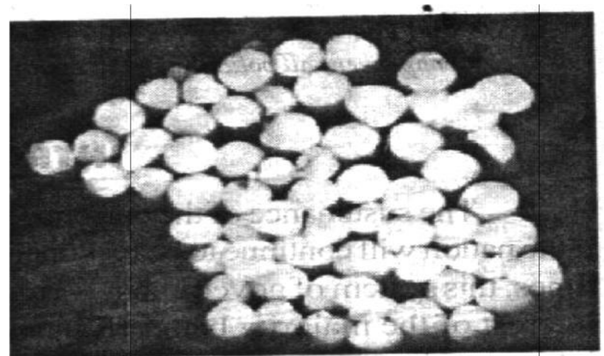


Fig. 3: Moringa Seed without shells

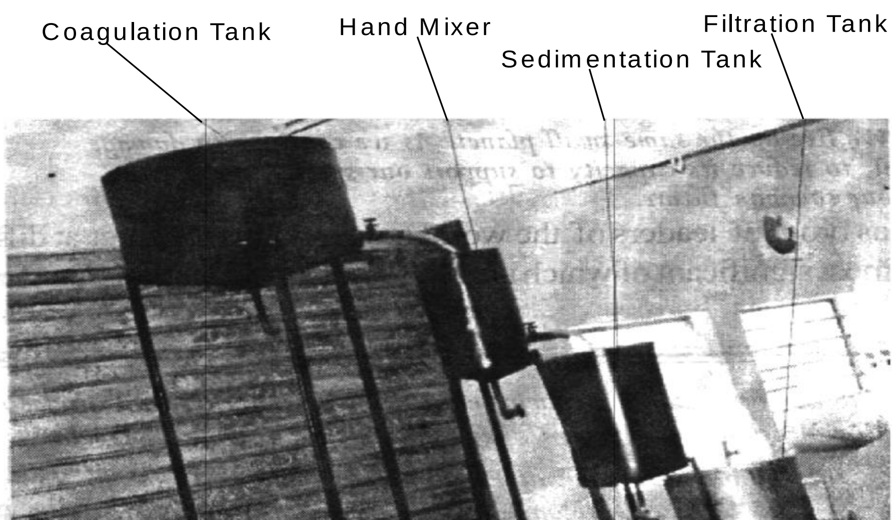


Plate 1: *Constructed Water Treatment*

(TBC) was reduced by 97%. The mean value of total dissolved solids after treatment was 115.4mg/L far below the limit of 1000mg/L specified by World Health Organization (WHO, 1971).

Table 1: Physical, Chemical and Biological Analysis of Borehole Water Samples Before and After Treatment

Sample	Temp ^0C	pH	TDS (mg/l)	Conduct (µs/cm)	TSS (mg/L)	Turb (NTU)	Total Solids (mg/L)	TBC (cfu/ml)
BH_1R_A	30.5	7.2	360	720	3	363	2	1300
BH_1R_B	30.4	7.2	320	635	3	323	2	1100
BH_1R_C	30.4	7.2	340	680	5	345	3	1200
BH_1T_A	30.1	7.6	145	290	0	145	2	34
BH_1T_B	30.1	7.6	145	290	1	146	2	39
BH_1T_C	30.0	7.6	145	290	1	146	2	35
BH_2R_A	30.9	6.8	142.7	285	0	142.7	2	1000
BH_2R_B	30.7	6.8	143.4	290	1	144.4	4	1100
BH_2R_C	30.5	6.8	142.4	280	2	144.4	2	1000
BH_2T_A	30.6	7.4	89.1	178.1	2	91.1	2	10
BH_2T_B	30.5	7.4	88.0	175.8	0	88.0	2	8
BH_2T_C	30.2	7.4	87.8	175.5	1	88.0	1	6
BH_3R_A	29.7	7.0	100.3	230	1	101.3	0	1500
BH_3R_B	29.9	7.0	99.8	230	0	99.8	0	1600
BH_3R_C	29.7	7.0	99.9	225	0	99.8	0	1400
BH_3T_A	28.4	7.4	113.7	200	0	113.7	0	46
BH_3T_B	28.2	7.4	113.6	199.5	0	113.6	0	49
BH_3T_C	28.1	7.4	112.8	199.6	1	113.8	1	52

Key: BHR = Borehole raw water
BHT = Borehole treated water
$BH_{1,2,3}$ = Three different boreholes
A, B, C = Three samples taken at each borehole

Table 2 shows the physical, chemical and biological analysis of well water sample before and after treatment. After treatment, the pH was increased by average of 8.8% while the total dissolved solids were reduced by 86.2%. Also affected was the Total bacteria count that reduced by 94.6%. The mean value of total dissolved solids was 371.7mg/L far below the limit specified by World Health Organization. The average Turbidity values ranged from 0 – 3 NTU after treatment.

Table 2: Physical, Chemical and Biological Analysis of Well Water Samples before and after Treatment.

Sample	Temp ^{0}C	pH	TDS (mg/l)	Conduct (μs/cm)	TSS (mg/L)	Turb (NTU)	Total Solids (mg/L)	TBC (cfu/ml)
W_1R_A	28.5	6.8	450	900	13	463	4	6500
W_1R_B	28.5	6.8	450	910	11	461	5	6300
W_1R_C	28.6	6.8	450	900	7	520	3	6700
W_1T_A	28.4	7.4	350	705	5	355	2	416
W_1T_B	28.4	7.4	350	700	3	353	2	410
W_1T_C	28.4	7.4	380	700	6	386	1	422
W_2R_A	30.4	6.6	440	880	7	447	7	4100
W_2R_B	31.1	6.6	430	870	3	433	9	4000
W_2R_C	30.4	6.8	430	860	2	432	9	3900
W_2T_A	28.7	7.6	380	760	1	381	3	340
W_2T_B	29.7	7.6	375	750	1	376	2	350
W_2T_C	28.5	7.6	370	750	2	372	2	345
W_3R_A	31.8	7.0	420	830	14	434	7	3280
W_3R_B	31.4	7.0	410	835	11	421	7	3200
W_3R_C	31.5	7.0	410	530	12	422	6	3000
W_3T_A	30.7	7.6	400	720	6	406	3	31
W_3T_B	30.5	7.6	380	700	4	384	1	35
W_3T_C	31.3	7.4	360	720	7	367	1	41

Key: WR = Raw well water
WT = Treated well water
$W_{1,2,3}$ = Three different wells
A,B,C = Three samples taken at each well

Table 3 shows the physical, chemical and biological analysis of surface water samples before and after treatment. The pH recorded an increase of 3.0% after treatment. Total dissolved solids were reduced by more than 40%. The total bacteria count that was too numerous to count before treatment was reduced to manageable levels after treatment. Similarly, the turbid surface water samples recorded a reduction by average of 42%.

Table 3: Physical, Chemical and Biological Analysis of Surface Water Samples before after treatment

Sample	Temp ^{0}C	pH	TDS (mg/l)	Conduct (μs/cm)	TSS (mg/L)	Turb (NTU)	Total Solids (mg/L)	TBC (cfu/ml)
SW_1A	27.1	7.6	330	650	138	468	127	TNTC
SW_1B	27.1	7.6	320	650	143	468	129	TNTC
SW_1C	27.1	7.6	320	650	148	468	135	TNTC
SW_1T_A	27.0	7.8	138	290	87	225	79	950
SW_1T_B	27.0	7.8	138	290	87	225	79	950
SW_1T_C	27.0	7.8	138	290	87	225	79	950
SW_2A	27.3	7.5	343	670	130	470	125	TNTC
SW_2B	27.3	7.5	342	670	131	473	127	TNTC
SW_2C	27.3	7.5	343	670	131	474	125	TNTC
SW_2T_A	27.1	7.7	129	290	80	209	69	810
SW_2T_B	27.1	7.7	130	300	85	215	70	790
SW_2T_C	27.1	7.7	130	298	85	215	70	800
SW_3A	27.6	7.6	360	700	145	505	132	TNTC
SW_3B	27.6	7.6	358	700	145	505	132	TNTC
SW_3C	27.6	7.6	360	700	145	505	132	TNTC
SW_3T_A	27.2	7.8	137	310	94	231	75	850
SW_3T_B	27.2	7.8	135	310	94	229	75	890
SW_3T_C	27.2	7.8	137	310	94	231	75	870

Key:
$SW_{1,2,3}$ = Three different surface water source
SWT = Surface treated water.
TNTC = Too numerous to count
A, B, C= Three samples taken at each surface source

CONCLUSION:

Application of plant coagulants such as Moringa oleifera is highly recommended for domestic water purification in Nigeria, where people are used to drinking contaminated turbid water. The low volume of sludge precipitation is biodegradable and hence environmentally sound technology. Furthermore, the flow of water from coagulation to filtration tank is achieved by gravity, thus eliminating the cost of pumping. However, secondary effect of bacteria using Moringa oleifera is recommended for further investigation.

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