Design and Construction of De-Totle Water Treatment Plant Using *Moringa oleifera* as Bio-Coagulant.

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ABSTRACT

This study has designed and constructed a De-Totle water treatment plant using *Moringa oleifera* as bio-coagulant. The treatment device is made up of four unit operations- coagulation, flocculation, sedimentation, and filtration (sand and charcoal filter media). Water parameters tested include turbidity, suspended solids, electrical conductivity, total dissolved solids, total coliform, *E. coli*, etc. Results obtained indicate an average turbidity and other water quality parameters removal of up to 99.5%. *Moringa oleifera* seed extract was found to have no significant effect on pH or alkalinity of the water. However, the residual turbidities recorded satisfied the Nigerian drinking water quality (NDWQ) recommended standard.

(Keywords**:** turbidity, *Moringa oleifera*, coagulation, treatment)

INTRODUCTION

Water covers 71% of the Earth's surface [4] and is vital for all known forms of life [5]. On earth, 96.5% of the planet's water is found in seas and oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapor, clouds (formed of solid and liquid water particles suspended in air), and precipitation [6]. Only 2.5% of the earth's water is fresh water, and 98.8% of that water is in ice and groundwater. Less than 0.3% of all freshwater is in rivers, lakes, and the atmosphere, and an even smaller amount of the earth's freshwater (0.003%) is contained within biological bodies and manufactured products [6].

Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack access to adequate sanitation [8]. There is a clear correlation between access to safe water and GDP per capita. However, some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability [9].

A report, issued in November 2009, suggests that by 2030, in some developing regions of the world, water demand will exceed supply by 50% [7,10]. Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. Approximately 70% of the fresh water used by humans goes to agriculture [11]. Water supply is a basic need of living creatures and human beings. Lack of portable water is the major cause of diseases and deaths especially in developing countries. Poorly treated water can lead to water borne diseases such as typhoid fever, dysentery, cholera, hepatitis, giardiasis, jaundice, etc. [1].

About 75% of the present world population lives in developing countries of the world. About 1.2 billion people still lack safe drinking water and more than 6 million children die from diarrhea in developing countries every year [3]. Safe drinking water is essential to the health and welfare of a community and nation at large. Water from different sources must be treated before consumption.

Various water treatment methods are used to make water safe and attractive to the consumer. The choice of methods depends largely on the level of turbidity as this varies across the seasons. In the conventional method of treating

water, coagulation, flocculation followed by sedimentation, filtration and disinfection (i.e. by chlorine), is used world-wide before distribution of treated water to the consumers. Many coagulants are also used such as inorganic, synthetic organic polymers and naturally occurring coagulants. The cost of importing these chemicals with scarce convertible foreign currency has forced many water treatment industries/agencies to resort to under-dosing so as to keep pace with increasing water demand. The result is the supply of poor quality water especially during the raining season, when suspended solids and other pollutants in surface water are very high.

Some water purification plants in the world use reverse osmosis water treatment process which can be very complex in design and requires additional treatments such as ultraviolet disinfection and advanced oxidation. This method can be cost effective and it takes time to produce the desired result. Further, it was testified that the use chemicals such as alum salt has been linked to Alzheimer's disease which causes brain impairment or memory loss and similar health related problems, besides production of large sludge volumes.

It is generally accepted that *Moringa oleifera* works as a coagulant due to positively charged (cationic e.g.NH_4^+), [12], water soluble proteins which bind with negatively charged particles (e.g. silt, clay, bacteria, toxins, etc.), allowing "flocs" to settle to the bottom or be removed by filtration. *Moringaoleifera* is locally available because it grows well in tropical region. The main objective of this study is to investigate the effectiveness of this water treatment device and to evaluate the efficiency of *Moringaoleifera* seed powder as a coagulant in the treatment of turbid surface water collected from rivers and dams.

MATERIALS AND METHOD

De-Totle Water Treatment Device and Fabrication

The water treatment device was designed and built. The device was built and constructed such that minimal external energy input is required as the water flow***s*** naturally by gravity from one treatment stage to the other and as a compact system that could be moved easily. The device consists of the sedimentation stage (i.e. raw water tank) with flow rate controller and sediment outlet tap. It has a sand filtration stage with clear water storage tank and flow level controller (i.e. control valve) connected. A charcoal filtration unit was also equipped with portable water storage tank for easy collection of clear water. The water samples used in this study was collected from two sources and at different seasons. Sample A was collected in March from river Landzu in Bida, while Sample B was collected in October from Tagwai Dam in Minna.

Preparation of *MoringaOleifera*Seed Suspension

Dry *Moringa oleifera* seeds were collected from Bosso Local Government Area of Niger State. The dried seeds were finely crushed using pestle and mortar. Water was added to temper and the mixture thoroughly worked into a paste. The paste was poured into a clean bottle and additional 200ml of clean water was added and stirred for about 5minutes. The resulting suspension was filtered through clean muslin cloth in a beaker and filtrate applied directly to the water samples to be treated.

The dosage of *Moringa oleifera* required to treat water sample depends on the turbidity of the water, though turbidity changes with season.

Experimental Procedure

The experimental method adopted in this work comprises of three stages as shown in Figure 1.

In stage one, the water sample was poured into water tank (sedimentation stage), and the required dosage of *Moringaoleifera* extract (filtrate) added, followed with fast and slow mixing for 2 and 10 minutes respectively. It was allowed to settle for 1-2 hours.

Stage two allows the settled water to be decanted and passed through the sand filter media to removed unsettled particles.

The final stage is where the water obtained from stage two is passed through charcoal filter media to remove taste, color and odor emanating from the nutrients (bio-coagulant) used.

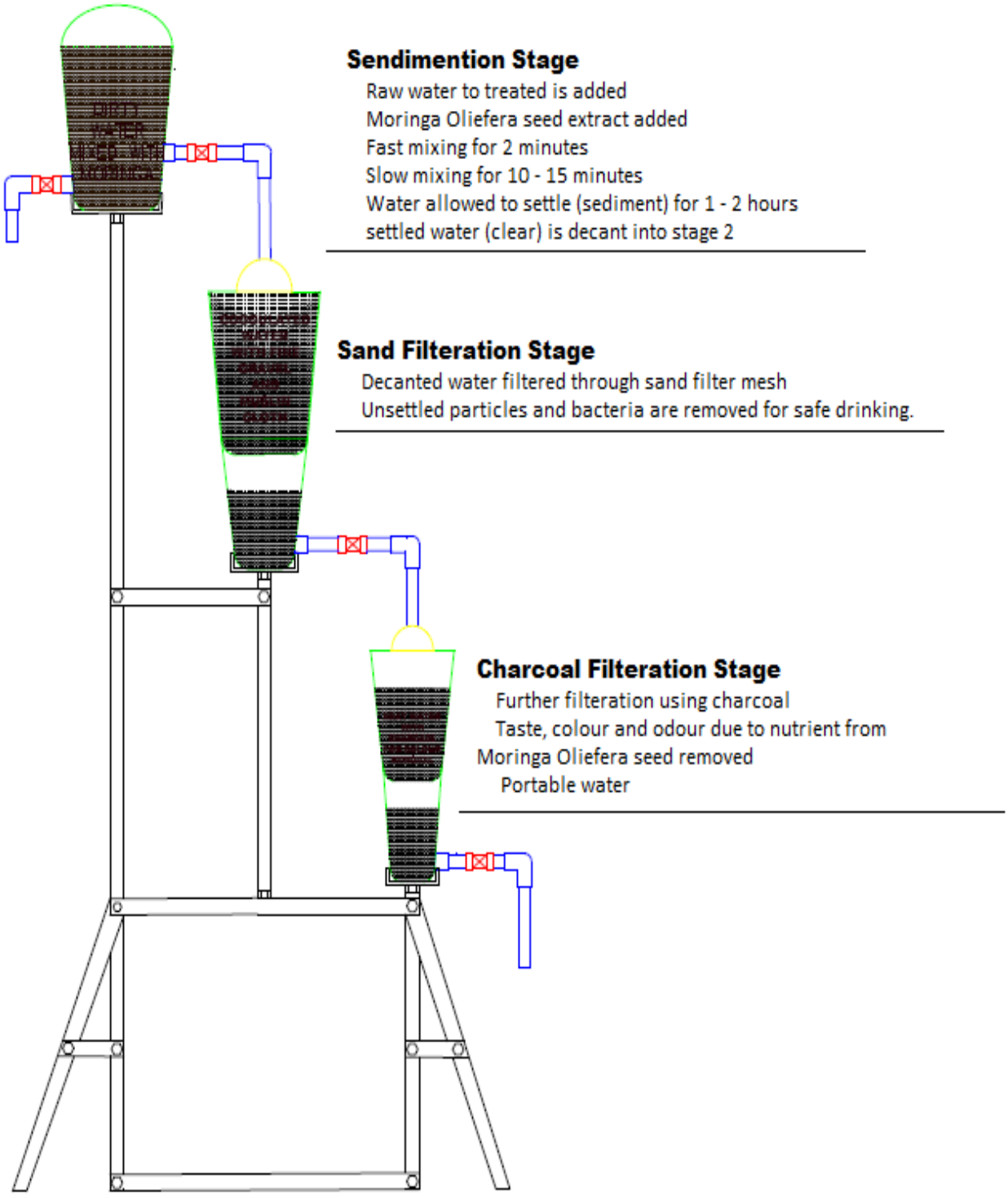

Figure 1: Diagrammatic Set-up of De-Totle Water Treatment Plant.

Figure 2: Pictorial View of De-Totle Water Treatment Plant.

RESULTS AND DISCUSSION

Table 1: Results from the Tested Water Sample (A) from Tagwai Dam.

S/n	Parameter	Raw Water	Treated Water	NSDWQ
1.	Turbidity (FTU)	>461.00	0.00	5.00
2.	Colour(PiCo)	>550.00	0.00	15.00
3.	Suspended Solids (mg/L)	756.00	0.00	NS
4.	Electrical Conductivity (uS/cm)	76.60	111.00	1000.00
5.	Total Dissolved Solids (mg/L)	37.80	55.00	500.00
6.	Nitrite (mg/L)	0.06	0.06	0.20
7.	Iron (mg/L)	0.07	0.05	0.30
8.	Manganese (mg/L)	0.30	0.20	0.20
9.	Chromium (mg/L)	0.00	0.00	0.05
10.	pH	7.20	7.20	6.5-8.5
11.	Odour	Objectionable	Unobjectionable	Unobjectionable
12.	Taste	Objectionable	Unobjectionable	Unobjectionable
13.	Total Hardness(mg/L)	38.00	32.00	150.00
14.	Total Alkalinity (mg/L)	27.00	32.00	NS
15.	Nitrate (mg/L)	15.75	15.93	50.00
16.	Iodine (mg/L)	1.54	1.53	NS
17.	Copper (mg/L)	0.00	0.00	1.00
18.	Phosphate (mg/L)	2.75	2.75	NS
19.	Total Coliform (cfu/100ml)	280.00	6.00	10.00
20.	E. Coli (cfu/100ml)	110.00	0.00	0.00

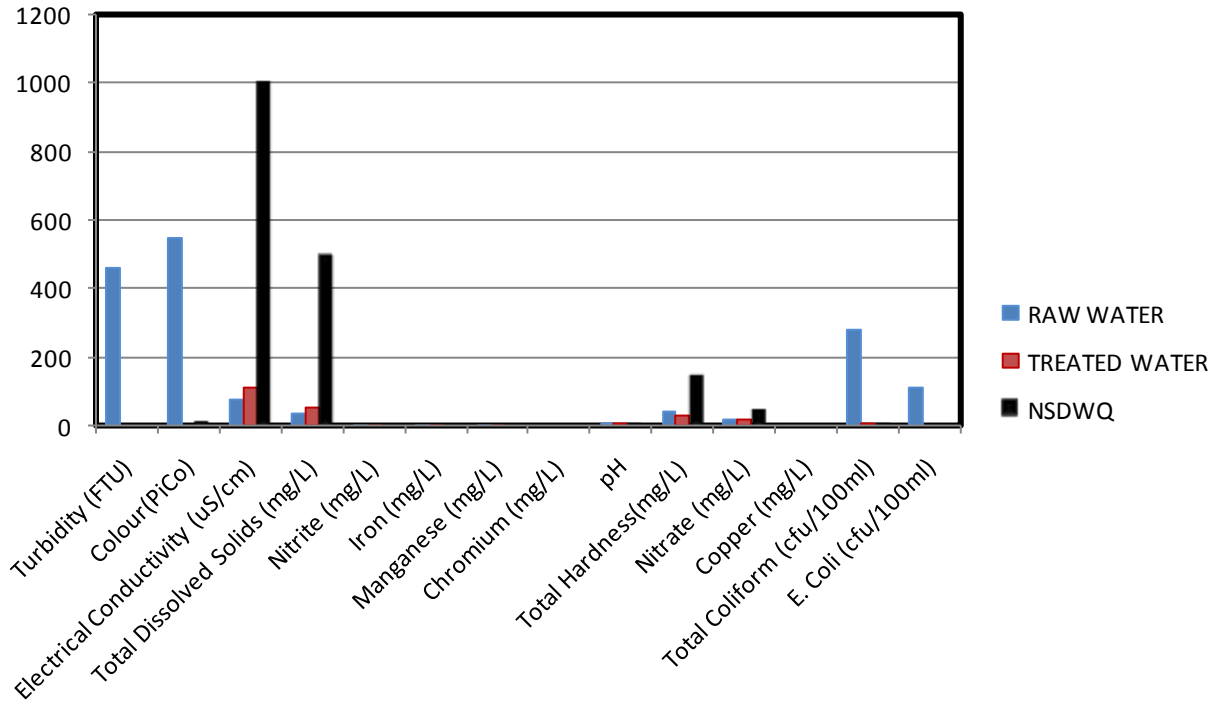

Figure 3: Graphical Representation of the Tested Parameters of Sample A (Tagwai Dam).

Table 2: Results from the Tested Water Sample (B) from River Landzu.

S/n	Parameter	Raw water	Treated water	NSDWQ
1.	Turbidity (FTU)	108.00	3.00	5.00
2.	Colour(PiCo)	282.00	9.00	15.00
3.	Suspended Solids (mg/L)	61.00	2.00	NS
4.	Electrical Conductivity (uS/cm)	150.00	130	1000.00
5.	Total Dissolved Solids (mg/L)	75	65.00	500.00
6.	Nitrite (mg/L)	0.08	0.08	0.20
7.	Iron (mg/L)	0.05	0.03	0.30
8.	Manganese (mg/L)	0.20	0.20	0.20
9.	Chromium (mg/L)	0.00	0.00	0.05
10.	pH	6.80	6.72	6.5-8.5
11.	Odour	Objectionable	Unobjectionable	Unobjectionable
12.	Taste	Objectionable	Unobjectionable	Unobjectionable
13.	Total Hardness(mg/L)	43.15	42.90	150.00
14.	Total Alkalinity(mg/L)	55.00	54.00	NS
15.	Nitrate (mg/L)	12.82	13.40	50.00
16.	Iodine (mg/L)	1.24	1.24	NS
17.	Copper (mg/L)	0.00	0.00	1.00
18.	Phosphate (mg/L)	2.27	2.27	NS
19.	Total Coliform (cfu/100ml)	120	8.00	10.00
20.	E. Coli (cfu/100ml)	78	0.00	0.00

NSDWQ- Nigerian standard for Drinking Water Quality; NS- Not Stated

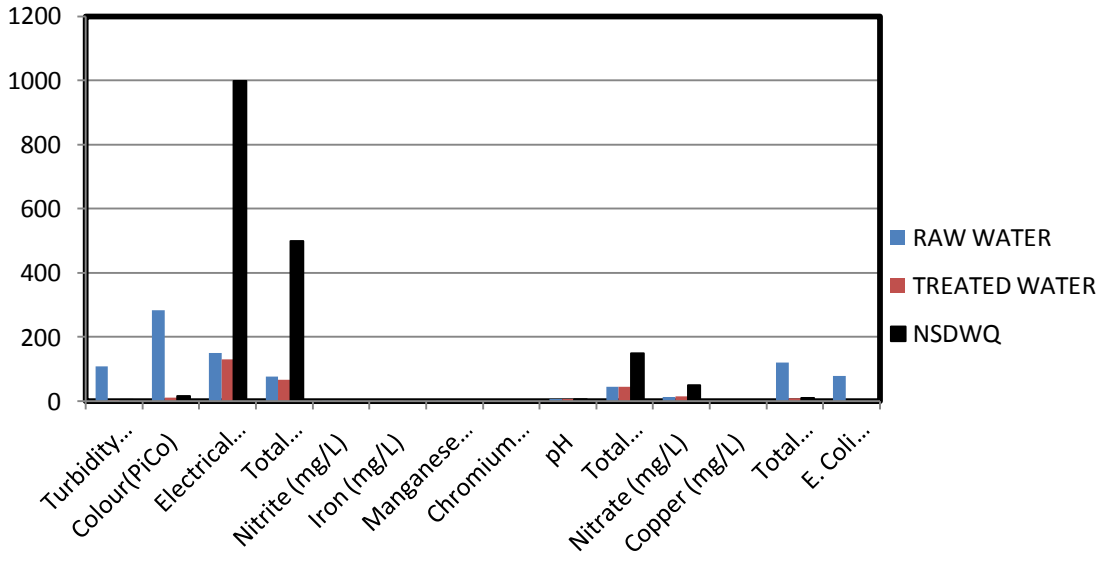

Figure 4: Graphical Representation of the Tested Parameters of Sample B (River Landzu).

DISSCUSSION

The results of all the tested parameters of both water samples are displayed in Tables 1 to 2 and Figures 3 to 4. Both samples recorded remarkable reduction in turbidity (>461.00FTU to 0.00FTU) and (108.00FTU to 3.00FTU), corresponding to 100% and 97% respectively, which indicated that *Moringa oleifera* performed very well as a coagulant, similar to an observation made by[2].

The results also showed that Moringa oleifera seed performed excellently well in the removal of suspended solid from Tagwai dam water with high initial value of 756.00mg/l of water sample to 0.00mg/l of treated water as compared to river Landzu with low level of 61.00mg/l of water sample to 2.00mg/l.

Charcoal filter media was very effective in adsorbing the color. Result from Tagwai dam water sample recorded 100% removal against 96.81% removal from River Landzu water sample. The results obtained were satisfactory as about 99.9% of total Coliform and *E. coli* were removed.

Design Parameters

The device was design in such a way that it allows minimal residual pressure, constant discharge at the first stage (low flow rate) and fewer disturbances at the second stage of the treatment. It requires no turbo machinery to supply the water to all the stages as the reasonable head was created to take care of this factor.

$$h = \frac{v^2}{2g} + \frac{p}{\rho g} + z \qquad (1)$$

Where h = total head
P = residual pressure = 1414.71N/m^2 (0.01396atm)
V = flow velocity = 2.00m/s
ρ = density = 1000kg/m^3
g = gravitational acceleration = 9.81m/s^2
Z = potential head = 2.56m
h = 2.908m ;
head loss = h – Z = 0.342m
Flow-Rate = Area × Velocity
Flow-Rate = $(\pi d^2/4) \times V$
Where d = diameter of the pipe = 50mm (0.05m)
Flow-Rate = 0.0125m^3/s

The maximum flow-rate as designed is 0.0125m^3/s. The flow-rate can further be reduced with the control valve when needed. The need for the reduction of the flow-rate may arise when the turbidity of the water becomes very high. However, this design is still on the prototype stage and has the potential of serving many residential buildings base on the basic parameters of- 0.30 to 0.46m^3/h/d (cubic meter per head per day), in any given residence. At that stage, the volume of the sedimentation tanks can be increased for maximum surface loading of 40m^3/m^2/d at peak flow with minimum retention time of 2 hours at peak flow and maximum weir loading of 250m^3m^2/d at peak flow. The neat water tank (taste, color and odor removal tank) can be designed for maximum surface loading of 35m^3/m^2/d at peak flow and minimum retention time of 2 hours at peak flow. A single pump shall be introduced only to transport the turbid water to the coagulation tank and more head created to serve high-raised buildings.

Table 4: Items/Materials Used.

S/n	Item description	Quantity
1	10L transparent plastic bucket	1
2	9L transparent plastic bucket	1
3	5L transparent plastic bucket	2
4	3L transparent plastic bucket	1
5	½ round metal pipe	1 length
6	Black paint (small tin)	1
7	½ inch valve	2
8	½ inch tap	2
9	Adhesive/accessories	
10	Charcoal	
11	Gravel	
12	Sandy soil	
13	Muslin filter cloth	1 yard

CONCLUSION

The effective dose of *Moringa oleifera* for low and high turbidity varies depending on the initial turbidity of raw water. Analysis of the treated water showed that *Moringa oleifera* did not significantly affect the pH or alkalinity after treatment. The residual turbidities and other water quality parameters measured satisfied the Nigerian Standard for Drinking Water Quality (NSDWQ). We therefore, recommend that further treatment be carried out so as to correct the pH of the treated water where necessary.

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