Experimental Approach for Water Treatment Using Moringa Leaf Powder

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Abstract: The water samples under study was collected for physicochemical and microbial analysis, and treated with moringa leaf powder. The physicochemical and microbial parameters (pH, salinity, conductivity, turbidity, TDS, TSS, Nitrate, total Alkalinity, total hardness, Calcium, Chloride, Sulphate, Hydrogen carbonate, magnesium, sodium, Potassium, Iron, Manganese, Total coliform, TBC and *E.coli*) was examined. The values compared to WHO/SON limits. The results revealed that, turbidity and microbial load of the water samples tested were more than the standard values, however there was no microbial activity in the NDU borehole water sample. The raw water samples was passed through the packed bed reactor with packing of (50g, 100g and 150g) moringa leaf powder to reduce microbial load, turbidity and total hardness. Based the results obtained it was found that moringa oleifera had the tendency to change the turbidity, total hardness and reduce microbial load of the raw water samples.

Keywords: Experimental, approach, water, treatment, moringa, leaf powder.

1. Introduction

The quality and accessibility of water are of paramount importance to human health the provision of portable water is an enormous undertaking, especially in developing countries. This is so because the chemicals required for treatment needs to be imported with scarce foreign exchange.

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 [1-6]. 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, and 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 chemical are also associated with human health and environment problems [7],

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 constituent into forms that can be separated out physically. The ultimate goal of this work is to evaluate the effectiveness of Moringa leaf powder as a filtration septum using a low cost water treatment for semi-urban and rural dwellers in Bayelsa State. Moringa Oleifera Lam (synonym: Moringa Pterygosperma Gaertner) belongs to monogeneric family of shrubs and tree, moringaceae and it is considered to have its origin in Agara and Oudh, in the north west region of India, south of the Himalayon mountains. There is evidence that the cultivation of this tree in India dates back many thousands of years. The Indians knew that the seeds contain edible oil and they used them for medicinal purposes. It is probable that the common people also knew of its value as a fodder or vegetable. This tree can be found growing naturally at elevations of up to 1000m above sea level. It can grow well on hillsides but is more frequently found growing on pastureland or in river basins. It is a fast growing tree and has been found to grow to 6-7m in one year in areas receiving less than 400mm mean annual rainfall [8-10].

In English this tree is commonly known as Horseradish tree, Drumstick tree, Never Die tree, West Indian Ben tree, and Radish tree [11-15].

It is now cultivated throughout the Middle East, and in almost the whole tropical belt. It was introduced in Eastern Africa at the beginning of 20century. The plant can be used for as a live fence. The plant possesses many valuable properties which make it of great scientific interest. These include the high protein content of the leaves twigs and stems, the high protein and oil contents of the seeds, the large number of the unique polypeptides in seeds that can bind to many moieties, the presence of growth factors in the leaves, and the high sugar and starch content of the entire plant. Equally important is the fact that few parts of the tree contain any toxins that might decrease its potential as a source of food for animals or humans. For the sake of simplicity and clarity we will refer to the plant Moringa Oleifera Lam as moringa throughout this study.

The use of Moringa for water treatment and in the removal of water turbidity would be a viable replacement and/or supplement to the conventional chemicals. Previous studies focused mainly on the efficiency of Moringa seed extract as a coagulant. Some have focused on the physical factors affecting the use of Moringa seed in the coagulation of model turbid water. Other studies have focused on the quality of water treated by coagulation using two forms of seed (shelled and unshelled) using the extract with model turbid water as the source. Other study was focused on the effect of extracting the whole quantity of oil from moringa on the coagulation using turbid water from surface water source. There is a limitation, in the primary coagulations characteristic for the protein exists in the seed of the Moringa, as cationic polyelectrolytes, some studies were concentrated on the development and enhancement of these characteristics, to improve the capability of the Moringa as a coagulant in rendering the turbidity of the water.

To investigate the possibility of replacement of the conventional way of treating and removing water turbidity and reducing bacterial load by using Moringa with a new approach of processing including improvement and enhancement of the capability of

Moringa as a filtration septum in water treatment. It is however important to study water treatment, since the quality of water have direct effect on health. If locally available plant material like Moringa is found to be effective in treating water through research works like this, there will be no need to speed fortune for the importation of chemicals for water treatment.

In developing countries people living in extreme poverty are presently drinking highly turbid and microbiologically contaminated water as they lack knowledge of proper drinking water treatment and also not afford to use high cost chemical coagulants. To overcome the high cost of chemical for water treatment it is necessary to increase the use of natural coagulants for drinking water treatment. One of these alternatives is moringa.

Earlier studies have found moringa to be non-toxic and recommended it to be used for water treatment in developing countries. The use of moringa has an added advantage over the chemical treatment of water because it is biological and has been reported as edible [16]

The research work covers the following areas of studies such as: Fabrication of packed bed reactor, Water samples collection and analysis, Moringa sample collection, processing and analysis, Experimental setup, input flow of water through the packed bed reactor, and collection of output flow of water, input and output water samples collected for analysis, comparison of results of input and output water samples, microbial analysis, and drawing conclusion from the results

Materials and Methods

Water samples collection

The water samples used for this study was aseptically collected using the method [17-21] for river water sample collection from Amasooma river located in southern Ijaw L.G.A of Bayelsa State and from Tombia river located at Yenagoa L.G.A of Bayelsa state, the third water sample was collected from a borehole located at Niger Delta University main campus in Bayelsa State Nigeria. These Rivers are exposed to pollution from many industrial runoff, domestic waste and waste from markets and livestock also enter these rivers. People make use of these water sources in times of water scarcity. These rivers also supply many other human activities such as washing motor vehicles and cloths and even bathing. All these leave the water body contaminated.

Fig 1a: Amassoma River Source

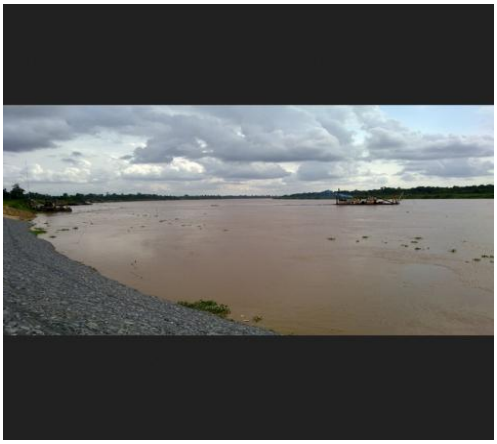

Fig 1b: Tombia River Source

The collected water samples were immediately taken to the department of chemistry, faculty of sciences Niger Delta University, Laboratory for analysis. The rivers sampled are presented in figure 1a and 1b.

Moringa leave samples collection processing and analysis

Moringa leaves samples collection

Moringa leaves used for the present study were collected from Agudama Community in Yenagoa L.G.A of Bayelsa State, Nigeria.

Processing of moringa leaves

(a) Sorting: fresh green undamaged non- insect infested leaves were selected while the brushed, discoloured, decayed and wilted leaves were discarded before washing the leaves.

(b)Washing: The stalks of the leaves were cut from the main branches and the leaves were washed thoroughly three times with plenty of water to

remove all the adhering dust, dirt and particles. The samples was then divided into two batches for the drying methods

(c) Drying methods: Two drying methods which are shade drying and sun drying were employed in this study

- **Air drying** (shade drying)
  The leaves were spread on board sheet and kept in a well ventilated room at a room temperature for three weeks.

- **Sun drying**

  The leaves were spread on board sheet and then covered with netted cloth to keep of insects and dust. The board sheet was now placed in direct sunlight away from animals and turned occasionally to ensure even drying. The leaves were sun dried for a week.

Fig 1c: Harvesting of fresh moinga leaves.

Fig 1d: Moringa leaf powder

Fig 1e: Blending of dried moringa leaves in the laboratory using blending machine.

Moringa Leaf Powder Preparation
The dried moringa leaves were milled into a fine powder with the aid of an electric blender. The powder was collected into a sterile bottle with cap and taken to the department of Chemistry faculty of Sciences Niger Delta University for analysis.

Chemical Analysis of Moringa Leaf Powder

The dried leaves were analyzed for proximate composition (protein, fat, fibre, carbohydrate and ash, vitamins (vitamin B1, vitamin A), minerals (iron, zinc, calcium) and anti- nutrients (phytate, oxalate, saponin, and tannin).

Protein was determined by micro Kjedahl procedure as modified [16]. Fat content was determined by extraction with petroleum ether as outlined [16]. Crude fibre was determined by modified Weeded method. Ash was obtained by dry ashing in the furnace at 600^0c for 2hrs. Total carbohydrate was determined by difference method. Moisture was determined by drying method. Vitamin A was determined using TCA (Trichloroacetic acid) method. Vitamin B1 was determined using the method [16]. Zinc and calcium was determined by the atomic absorption spectraphotometric method while iron were determined colorimetric procedure describe as presented [17]. Tannins and saponin were determined using spectrophatometric methods, while oxalate was determined by a method by Dye and modified [18].

Chemical analysis of water samples

Determination of pH

The pH meter was used for the determination of the pH of the water samples, before the measured butter solutions of different pH values, namely pH 4 and 9. The

electrode is thoroughly rinsed and then dipped into the water samples and a steady pH is recoded as the pH of the water sample.

Determination of Conductivity (µScm^{-1})
Electrical conductivity of the water samples was measured with the conductivity and salinity meter. The probe of the meter was inserted into the water sample and the central control switched to the conductivity position. A steady reading is recording as the conductivity of the water in (µScm^{-1}).

Determination of Salinity
The conductivity meter has a salinity position so that as the probe is dipped into the water body, the control switch is turned to the salinity position and when a steady reading is obtained, it is recoded as the salinity of the water sample.

Determination of Total Dissolved Solids
This is determined by measuring 100ml of water samples in an evaporating dish and evaporated to dryness on a steam bath. The evaporating dish was previously dried in an hot, air oven as the water is then evaporated to dryness. The dried evaporating dish and residues were placed in a drying oven to dry further.
The crucible and residue were then weighed and the difference in weight be recorded as the total dissolved solid expressed the parts per million (ppm) or mg/l.

Determination of Turbidity
A calibrated turbidity meter was used to measure the turbidity of the water samples. The equipment is zeroed with a blank and then the sample is placed in the bottle and in the meter and turbidity ready off directly from the read out as NTU units.

Total Suspended Solids
100ml of sample was filtered and the filter paper dried and weighed. The weight difference between filter paper before and after filtration was taken as the total suspended solid as ppm or mg/l.

Determination of Nitrate (NO_3-)
The wagetech water kit was used to determine the anxious namely NO_3, NO_2- SO_4 chlorides. The appropriate tablet is granted and dissolved in 10ml sample left to stand for ten minutes (10min) read at the appropriate wave length on the wagetech spectrophotometer 5000. The reading is read of from a table supplied by the company.

Determination of Total Hardness
100ml water sample was placed in 250ml conical flask, 5ml of Ammonia/Ammonium chloride butter was added followed by a 3 drops of Eriochrome black T indicator and is titrated against 0.01M EDTA, the addition of the Eriochrome indicator gives a red wine colour. The EDTA titration gives a marine blue end point. 1ml of EDTA = 1mg $CaCO_3$ as total hardness.

Determination of Total Alkalinity
100ml of sample was in a 250ml conical flask. 2-3 drops of methyl orange indicators was added. The orange colour was then titrated against a 0.01M, H_2SO_4 to a light pink end point.

Total alkalinity as mg/L $CaCO_3$

1ml = 1mg $CaCO_3$

Atomic Absorption Spectrometry
The metal ions Na, K, Ca, Mg, Fe and Mn were analyzed using the Atomic Absorption Spectrometer, samples were acid digested in the fume home, white, filtered. The samples were then filtered and sent for the diluted to 100ml into 100ml flasks. They were then sent for the AA spectrophotometric analysis.

Hydrogen Carbonate = HCO_3^-
2 drops of mixed indicator were added to the solution obtained from the hydroxide and titration. The solution was titrated with 0.02m standard HCl to the pink end point.

Determination of Sulfate (SO_4)
100ml sample was placed into a 250ml conical flask. 5ml of conditioning reagent was added and mixed properly. A spatula full of Barium chloride was added and stirred with a magnetic stirrer. The solution then poured in a meaning cell (curette). The spectrophotometer and read off from the calibration curve which has been previously done using standard sulphate solutions.

Determination of Chloride
100ml of water samples were placed in a 250ml conical flask 5ml of potassium chromate was added and mixes properly. The mixture was then titrated to brick-brown end point with a standard silver nitrate solution. 1ml of silver nitrate ($AgNO_3$) = 1mg of chloride Cl^{-}.

Microbial Analysis of the Water Samples
Total Coliform Count
Principle: Coliform group of bacteria is the main indicator of pollutions if are seen in any body of water it means that the water is unsuitable for domestic and other uses.

Procedures for Dilution: Four clean sterilized 100ml volumetric flasks were obtained and with the aid of sterilized 1ml graduated pipette, 1ml of sample was transferred in the 100m volumetric flasks and made up to the mark with distilled water. The dilution factor here is 10^2 1ml from this solution was transferred into the second flask and made up to the mark with distilled water. The dilution factor is 10^2 too plate preparation: adsorbent pads were placed in the various petri dish followed by the addition of 2ml of the media on the adsorbent pads. 1ml of the sample were withdrawn and filtered through the membrane filters with the aid of a vacuum pump.

The membrane is now placed or the absorbent pad in the petri dish containing the broth. The broth serves as nutrient for the coliform. The prepared petri dishes were then placed in an incubator pre-set at 35 ± 5^0c. Incubated for 24 hours, Greenish shinning colonies on the filter membrane indicates indicate the number of colonies to be counted. If no growth was observed, then incubate further for another 12 hours to give a total of 36 hours. The colonies were then counted.

Total Coliform/100 or 10^2ml =

$$\frac{colonies\ \ counted \times D \times 100}{Vol.\ of\ \ diluted\ \ \ sample\ \ \ filtered}$$

where D= dilution factor

Some bacteria grow within 18hrs but E.Coli appears from 24hrs to 36hrs.

Experimental procedure

Materials used: packed bed reactor, weighing balance, hose, whatman filter paper, plastic kegs, 10liters and 5liters capacities, moringa leaf powder.

Procedure

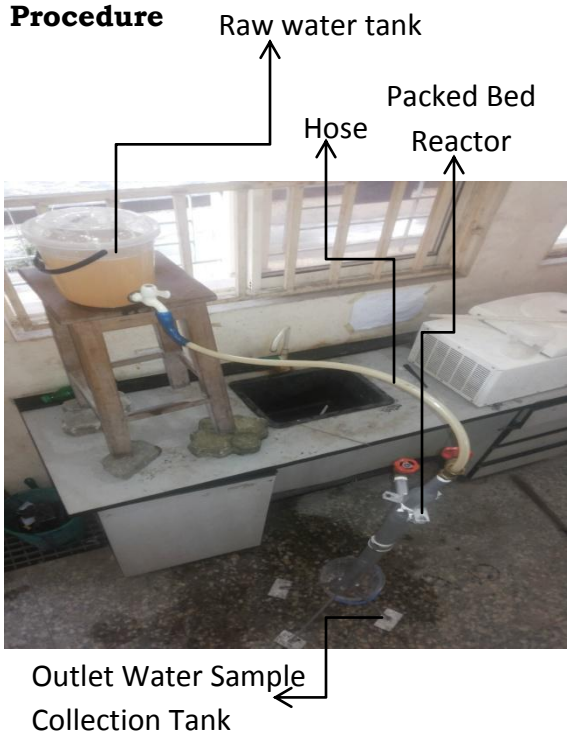

Fig 1f: Water Filtration Setup

- The apparatus was setup as shown in fig 1f
- Whatman filter paper was placed on the beds of the reactor.
- 50g of moringa leaf powder was weighed on a weighing balance.
- The reactor was loaded with 50g of moringa leaf powder.
- All system was locked.
- The inlet and outlet valves of the reactor was opened and water samples from the outlet valve was collected.
- Water samples collected from the outlet valve was taken to the department of chemistry, faculty of science laboratory for analysis.
- The reactor was unloaded and washed thoroughly with clean water.
- Repeat the above processes using 100grams and 150grams of moringa leaf powder for all raw water samples.

Results and Discussion

Table 1 presents the proximate composition of moringa leaves at different drying techniques. The moisture content of component A and B had comparable values of 6.55% and 6.75% respectively. The protein composition ranged from 24.43% - 32.66% the component B had the highest value. The fat composition varied 4.4%-6.69% the component B had the highest value.

The ash composition varied from 1.28-3.14 the component A had the highest value. The fibre composition ranged 1.47%-1.59% component A had the least value. The carbohydrate value ranged from 51.03%-60.00% the Component A had the highest value. Vitamin B1 composition ranged from 0,73-0.85 (mg/100g) the component B had the highest value. The vitamin A composition varied from 2.54-2.93 (mg/100g) the component B had the highest value. The iron composition had similar values of 0.39 Component A and 0.40 B 2.59 the component B had the highest from 1.27. The zinc composition had 0.78 and 0.80 the component B had the highest value.

Table 2 presents the anti-nutrients composition of moringa leaves at different drying techniques. Tannin composition varied from 1.60-1.84 component B had the least value. The phylate composition varied from 4.55-9.09 the SU had the highest value. The oxalate composition had similar values of 3.26 and 3.59 the SU had the highest value. The saponin composition ranged from 0.31-083 the SA had the highest value.

Table 1: The Proximate and Micro-nutrient composition of Moringa Oleifera leaves at different drying techniques.

Nutrient	Concen-tration of A parameters	Concen-tration of B parameters
Moisture %	6.55	6.75
Protein %	24.43	32.66
Fat %	4.41	6.69
Ash %	3.14	1.28
Fibre %	1.47	1.59
Carbohydrate %	60.00	51.03
Vitamin B1 (mg/100g)	0.73	0.85
Vitamin A (mg/100g)	2.54	2.93
Iron (mg/100g)	0.39	0.40
Calcium (mg/100g)	1.27	2.59
Zinc (mg/100g)	0.78	0.080

The proximate and micro-nutrient analysis result of moringa leaf powder obtained from component A (concentration of A parameters) and B (Concentration of B parameters) was illustrated in Table 1 for various parameters' comparison of the moringa leaf samples after drying shows that more of the useful nutrient with high concentration is obtained when the moringa leaf sample dried on room temperature as well in the absent of sunlight. The result presented in Table 1 shows the significant of sunlight on the concentration of useful component than can enhanced water remediation by the application of moringa leaf powder for water treatment.

Table 2: Anti-nutrient composition of moringa oleifera leaves at different drying techniques

Nutrient (mg/100g)	Concen-tration of A parameters	Concen-tration of B parameters
Tannin(mg/100g)	1.84	1.60
Phylate(mg/100g)	9.09	4.55
Oxalate(mg/100g)	3.59	3.26
Saponin(mg/100g)	0.31	0.83

where, A=the concentration of moringa leaves dried in the presence of sunlight.
B=concentration of moringa leaves dried at room environment (absent of sunlight)

The result presented in Table 2 illustrates the anti-nutrient composition of moringa leaf dried in the presence of sunlight as well in the absent of sunlight. The anti-nutrient values for moringa leaf dried in the presence of sunlight posses the maximum values in most case of the component investigated as shown in Table 2 .comparing the result reveals that the anti-nutrient of the moringa leaf dried in present of the sunlight inhibit the process as well reduce the effectiveness and performance of the system ina packed bed reactor operation.

Table 3presents the results of physic-chemical and microbial quality of the raw water samples used in the study. The source was prone to pollution from dumping domestic and market waste into the water bodies as well as pollution from surface runoff (except NDU bore hole). Most of the parameters were within the permissible limits specified by WHO and SON. Results of microbial analysis also show that the raw water samples were grossly contaminated. The total coliforms count and Eschericia coli (E. coli) indicative of faecal pollution.

Table 3: Physicochemical and microbial quality of raw water samples used in the study

Parameter	Amassoma River	Tombia River	NDU bore hole	WHO / SON Limits
PH	6.58	6.42	6.60	6.5-8.5
Salinity	0.02	0.02	0.11	-
Conductivity (µScm-1)	71.80	67.20	178	1000

Turbidity (NUT)	28.70	28.96	10.80	5
Total Dissolved Solid	36.50	33.60	89.02	500
Total Suspended Solid	3.87	4.20	2.40	-
Nitrate ($N0_3$)	0.172	0.168	0.126	10
Chlorine (Cl)	3.00	4.60	4.70	250
Sulphate ($S0_4$)	0.48	0.72	0.54	100
Hydrgen Carbonate ($HC0_3$)	1.00	1.00	1.40	-
Total Alkalinity	8.00	5.00	10.50	-
Total Hardness	2.00	15.00	25.00	150
Calcium (Ca)	2.85	3.50	3.76	-
Magnesium (Mg)	0.8	1.24	0.78	-
Sodium (Na)	1.600	1.85	1.54	-
Potassium (k)	0.72	0.85	1.20	-
Iron (Fe)	0.14	0.12	0.38	0.3
Manganese (Mn)	0.01	0.02	0.02	0.1
Colour (TUC)	Faint Brown	Faint Brown	Colourless	Colourless
Total Coliform (MPN/100ml)	$3.0x10^2$	$2.00x10^2$	0.00	10
Total Bacteria Count (MPN/100ml)	$5x10^2$	$4x10^2$	0.00	-
E. coli (MPN/100ml)	$2.00x10^2$	$2.00x10^2$	0.00	0

The parameters are measured in mg/l

Table 3 illustrates the characteristics and the physicochemical parameters of water samples investigated. Some of the results obtained are within the WHO standard while some are above the WHO standard. The various water samples are Amassoma river water, Tombia river water and Niger Delta University (NDU) borehole water. The characteristics and composition of the functional parameter necessary to quality water were examined as presented in Table 3.

Table 4: Amassoma river water sample before and after treatment.

S/N	Parameters	Before treatment	After treatment			WHO/SON LIMITS
			5Og Loading	100g Loading	150g Loading	
1.	P^H	6.58	6.37	6.48	6.49	6.5-8.5
2.	Salinity	0.02	0.03	0.02	0.02	-
3.	Conductivity (µScm-1)	71.80	168.8	165	1.68	1000
4.	Turbidity(NUT)	28.70	18.80	10.53	5.01	5
5.	Total Dissolved Solid	36.50	34.4	28.5	25.10	500
6.	Total Suspended Solid	3.87	1.89	1.46	1.35	-
7.	Nitrate ($N0_3$)	0.172	0.141	0.140	0.10	10
8.	Chloride (Cl)	3.00	2.65	2.22	1.85	250
9.	Sulphate ($S0_4$)	0.48	0.38	0.31	0.20	100
10.	Hydrogen Carbonate ($HC0_3$)	1	0.6	1.56	0.54	-
11.	Total Alkalinity	8	0.7	0.68	0.55	-
12.	Total Hardness	20	15	10.0	9.85	150
13.	Calcium (Ca)	2.85	1.42	1.40	1.38	-
14.	Magnesium (Mg)	0.8	0.68	0.62	0.53	-
15.	Sodium (Na)	1.6	1.20	0.74	0.7	-
16.	Potassium (k)	0.72	0.56	0.5	0.48	-
17.	Iron (Fe)	0.14	0.14	0.13	0.12	0.3
18.	Manganese (Mn)	0.01	0	0.00	0.00	0.1
19.	Colour (TUC)	Faint Brown	Green	Green	Green	Colorless
20.	Total Coliform (MPN/100ml)	$3.0x10^2$	0.00	0.00	0.00	10
21.	Total Bacteria Count (MPN/100ml)	$5x10^2$	$1.00x10^2$	$1x10^2$	0.00	-
22.	E. coli (MPN/100ml)	$2.00x10^2$	$1.00x10^2$	0.00	0.00	0

Table 4 illustrates the physicochemical parameters of Amassoma river water sample before and after treatment. The initial characteristics of the Amassoma river water was obtained before subjecting the river water into treatment using moringa leaf powder in a packed bed reactor. A packed bed reactor was obtained before subjecting the river water into treatment using moringa leaf powder in a packed bed reactor. A packed bed reactor was fabricated inlet and outlet flow, in which the packed bed chamber was filled with the moringa leaf powder.

Different degree of moringa leaf powder was introduced with the packed bed reactor (loading of 50g, 100g and 150g) and the water samples was allowed to pass through the packed bed reactor. The result obtained indicate reduction in the following

parameters. (conductivity, turbidity, total dissolved solid, total suspended solid, nitrate, chloride, sulphate, hydrogen carbonate, total alkalinity, total hardness, calcium, magnesium, sodium, potassium, manganese, total coliform, total bacteria count and E.coli). The parameters sampled for the investigation are illustrated in figures as shown in figure 1 to 63 which described the behaviuor of each component upon the influence of the dosing rate of moringa leaf powder in a packed bed reactor for the different water samples analyzed.

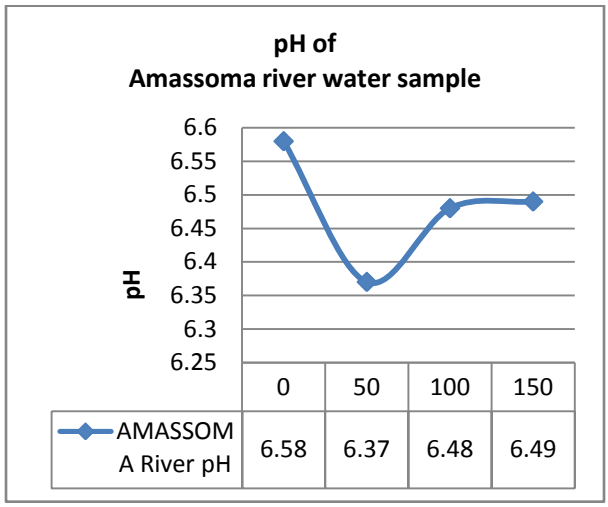

Fig 2: pH of Amassoma river water sample

From Figure 2 illustrates the relationship between pH and the loading mass of moringa leaf powder in a packed bed reactor. The result obtained shows decrease in pH value from 6.58 to 6.37 and suddenly increase from 6.37 to 6.49 for the various moringa lead powder loading in the packed bed reactor. The variation in the pH values can be attributed to the variation in the loading mass of moringa leaf powder.

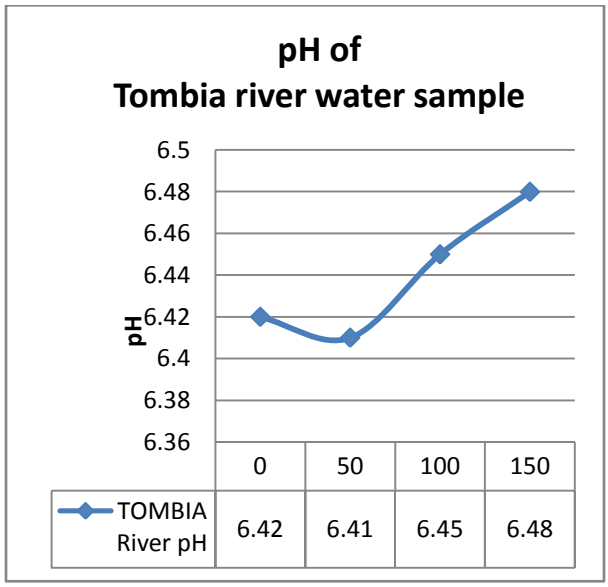

Fig 3: A graph of pH of Tombia river water sample against loading mass of moringa leaf powder in a packed bed reactor.

From Figure 3 illustrates the relationship between pH and the loading mass of moringa leaf powder in a packed bed reactor. The result obtained shows decrease in pH value from 6.42 to 6.41 and suddenly increase from 6.41to 6.48 for the various moringa lead powder loading in the packed bed reactor. The variation in the pH values can be attributed to the variation in the loading mass of moringa leaf powder.

Table 5: Tombia river water sample before and after treatment with moringa leaf powder

S/N	Parameters	Before treatment	After treatment			WHO/SON LIMITS
			5Og Loading	100g Loading	150g Loading	
1.	PH	6.42	6.41	6.45	6.48	6.5-8.5
2.	Salinity	0.02	0.03	0.02	0.02	-
3.	Conductivity (μScm^{-1})	67.20	95.3	94.50	96.45	1000
4.	Turbidity(NUT)	28.96	21.40	10.52	5.58	5
5.	Total Dissolved Solid	33.60	48.00	38.5	35.60	500
6.	Total Suspended Solid	4.20	2.41	2.21	1.28	-
7.	Nitrate ($N0_3$)	0.168	0.106	0.100	0.93	10
8.	Chloride (Cl)	4.60	3.80	3.16	2.46	250
9.	Sulphate ($S0_4$)	0.72	0.46	0.31	0.20	100
10.	Hydrogen Carbonate ($HC0_3$)	1	0.80	0.75	0.31	-
11.	Total Alkalinity	5.00	0.5	0.35	0.28	-
12.	Total Hardness	15.00	10	6.52	5.82	150
13.	Calcium (Ca)	3.50	2.50	2.35	2.00	-
14.	Magnesium (Mg)	1.24	0.72	0.60	0.43	-
15.	Sodium (Na)	1.85	1.80	1.65	1.39	-
16.	Potassium (k)	0.85	0.44	0.35	0.24	-
17.	Iron (Fe)	0.12	0.12	0.11	0.11	0.3
18.	Manganese (Mn)	0.02	0.01	0.00	0.00	0.1
19.	Colour (TUC)	Faint Brown	Green	Green	Green	Colorless
20.	Total Coliform (MPN/100ml)	$2.0x10^2$	0.00	0.00	0.00	10
21.	Total Bacteria Count (MPN/100ml)	$4x10^2$	$1.00x10^2$	0.00	0.00	-
22.	E. coli (MPN/100ml)	$2.00x10^2$	$1.00x10^2$	0.00	0.00	0

Table 6: NDU Borehole water sample before and after treatment.

S/N	Parameters	Before treatment	After treatment			WHO/SON LIMITS
			5Og Loading	100g Loading	150g Loading	
1.	PH	6.60	6.58	6.50	6.56	6.5-8.5
2.	Salinity	0.11	0.5	0.03	0.21	-
3.	Conductivity (μScm^{-1})	178	180	180	180	1000
4.	Turbidity(NUT)	10.80	5.80	4.50	2.25	5
5.	Total Dissolved Solid	89.02	92.00	90.00	85.00	500
6.	Total Suspended Solid	2.40	1.30	1.20	1.05	-
7.	Nitrate ($N0_3$)	0.126	0.095	0.070	0.04	10
8.	Chloride (Cl)	4.70	3.5	2.9	2.5	250
9.	Sulphate ($S0_4$)	0.54	0.40	0.34	0.25	100
10.	Hydrogen Carbonate ($HC0_3$)	1.40	1.05	0.95	0.85	-
11.	Total Alkalinity	10.40	1.00	0.83	0.75	-
12.	Total Hardness	25.00	20.00	10.80	14.50	150
13.	Calcium (Ca)	3.76	2.60	2.40	2.10	-
14.	Magnesium (Mg)	1.78	0.52	0.50	0.30	-
15.	Sodium (Na)	1.54	1.52	1.42	1.24	-
16.	Potassium (k)	1.20	0.95	0.80	0.65	-
17.	Iron (Fe)	0.38	0.38	0.38	0.36	0.3
18.	Manganese (Mn)	0.02	0.01	0.00	0.00	0.1
19.	Colour (TUC)	Colourless	Green	Green	Green	Colorless
20.	Total Coliform (MPN/100ml)	0.00	0.00	0.00	0.00	10
21.	Total Bacteria Count (MPN/100ml)	0.00	0.00	0.00	0.00	-
22.	E. coli (MPN/100ml)	0.00	0.00	0.00	0.00	0

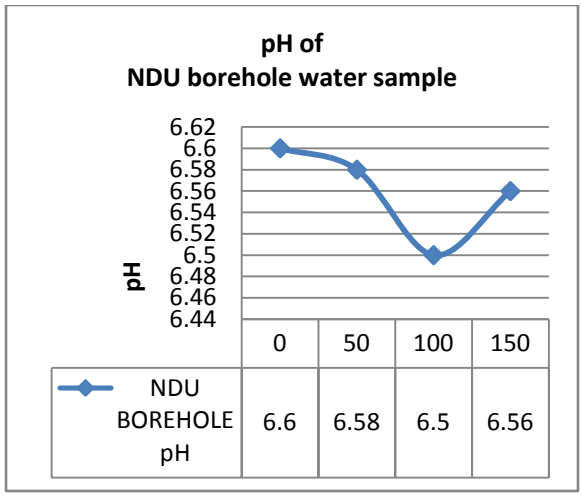

Fig 4: A graph of pH of NDU borehole water sample against loading mass of moringa leaf powder in a packed bed reactor.

From Figure 4 illustrates the relationship between pH and the loading mass of moringa leaf powder in a packed bed reactor. The result obtained shows decrease in pH value from 6.60 to 6.50 and suddenly increase from 6.50 to 6.56 for the various moringa lead powder loading in the packed bed reactor. The variation in the pH values can be attributed to the variation in the loading mass of moringa leaf powder.

Conclusion

The following conclusion can be drawn from the research work conducted in the experimental approach for water treatment using moringa leaf powder such as:

1. Moringa leaf powder is capable of reducing the following component in water such as(salinity, TSS, TDS, Turbidity, Chloride, Total Alkalinity, Total hardness, Nitrate, Hydrogen carbonate, potassium, sulphate, manganese and microbial load)
2. Morigna leaf dried in room temperature as well in absent of sunlight is more effective in remedying contaminated water than the moringa leaf dried in the presence of sunlight.
3. The characteristics of the moringa leaf indicate its useful to human health and when applied in water treatment helps to improve the nutrient of water which is good for human health.
4. Increase in loading mass of moringa leaf powder will help to reduce more of the parameters to the acceptable limit by the WHO standard
5. Zero microbial population was observed as the moringa leaf powder loading increases.
6. The green colour of water observed at outlet of the packed bed reactor can be removed by subjecting the outlet water into a slow sand bed filters.
7. Finally, when the green colour observed is removed the quality of water obtained is to World Health Organization Standard. Therefore the research work done in this area is found useful in improving water quality of the sampled rivers and borehole in Bayelsa State of Nigeria.

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NOMENCLATURE

WHO = World Health Organization

COD = Carbon Oxygen Demand

TOC = Total Organic Carbon

BOD = Biochemical Oxygen Demand

TDS = Total Dissolved Solid

MPN = Most Probable Number

TBC = Total Bacteria Count

NTU = Nepheleometric Turbidity Units

SON = Standards Organization of Nigeria

TSS = Total Suspended Solid

TCU = True Colour Units