EFFECT OF *MORINGA OLEIFERA* AS WATER CAOGULANT ON THE PHYSICO-CHEMICAL PROPERTIES OF GULBI-WATER

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ABSTRACT

Start with problem statement sentence (What led to this investigation?)This research investigated the suitability of *Moringa oleifera* seed extract as a natural coagulant in water treatment. Highly turbid water was collected from Gulbi River in Kaura-namoda, Zamfara State, ~~of~~ Nigeria. *Moringa oleifera* seed was processed into flour and de-fated with different organic solvent. (AOY = Normal borehole water, BOY = Raw water sample from the river, COY = Water treated with (de-fated *Moringa* flour with Chloroform~~.~~), DOY = Water sample with (de-fated *Moringa* flour with a~~A~~cetone), EOY = Water sample with (de-fated *Moringa* flour with d~~D~~iethyl ether~~.~~), FOY = Water sample with Alum, GOY = Water sample with undefated *Moringa* flour) and used as a coagulant in place of a~~A~~luminium s~~S~~ulphate (Alum). Collected water samples were treated with different *Moringa oleifera* flour coagulants samples. The water treated with different coagulants samples were analyzed based on physico-chemical properties. The pH values ranged from 5.6 to 6.7, value obtained for the treatments ~~were in the recommended range set by WHO~~[Do not present discussion]. The turbidity, conductivity, total solid, temperature and coliform ranged from 4.19 to 76.5 NTU, 94.0 to 188.4 µS/cm, 45.5 to 89.3 mg/l, [30.4 to 33.8~~–~~ ^{o}C – where is the temperature information in the results section?) and 9 × 40^{2}cfu, respectively. [There were 6 treatments + 1 control – you cannot just indicate ranges – rather indicate just most outstanding results overall] The ~~research~~ results are of value~~is viewed as revolutionary~~ to ~~for~~ small household applications, particularly in rural areas, where water purification is absent and *Moringa oleifera* trees are abundantly available~~is widely consumed~~.

Keywords: *Moringa oleifera*; borehole; physico-chemical properties; turbidity; Gulbi River

1.0 INTRODUCTION

Sustainable freshwater supply and effective treatment are critical needs of ~~many~~ all countries. In parts of many developing countries throughout Africa, Asia and Latin America, access to adequate, clean freshwater remains problematic. A ~~L~~lack of access to freshwater supply in many of these developing countries has been the main cause of disease and infant mortality [1]. It was recently (citing a 2010 source is not seen as recently, recently is last 5 years) documented that 884 million people lack access to good quality drinking water [2].

Over previous decades, chemical coagulants have been used in water treatment for the removal of suspended solids and to~~he~~ reduce~~tion of~~ the turbidity of water, as well as bacterial and viral load~~uses~~. C~~The c~~ommon types of these chemical coagulants ~~are~~ include aluminium sulphate, ferrous sulphate and ferric sulphate. The application of chemical coagulants in water and wastewater treatments has been ~~determined~~ found to cause the impurities, present in colloidal forms, to adhere upon contact, forming flocs ~~which~~ that can then be easily removed [3].

However, chemical coagulants are not readily available in developing countries, can be quite expensive for people living in remote rural areas ~~in developing countries~~, and can ~~pose~~ have adverse effects on public health if not applied at the correct dosage. Therefore, the use of natural coagulants of plant origin

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is a viable alternative to chemical coagulants. It has been widely documented [cannot state widely documented and then only cite 1 source {4} as an example of widely documented] that extracts from plants such as *Moringa oleifera* have proven more effective in the removal of suspended solids, in turbidity removal, in the softening of hard water, and also in the reduction of slurry produced as compared with that produced bythan chemical coagulants [4].

Water is used for several purposes by humans, however, but the level of purity of the water being consumed in very crucial since it has a direct effect on health [5]. The conventional method of water purification using aluminium sulphate and calcium hypochlorite these puts pressure on the nation's over-burdened financial resources since they are important thereby making treated water very expensive in most developing countries and behind beyond the reach of most rural folks. Hence, they resort to sources such as dams, streams, rivers, and lakes. Water from these sources is usually turbid and contaminated with microorganisms that cause many diseases. including guinea worm and dysentery Water borne diseases are one of the main problems in developing countries, a 2009 study [5] indicated that about 1.6 million people are use contaminated water and more than a million people (of which two million are children) die from diarrhea each year [5] – is this globally or only in Nigeria?.

This research was carried out to confirm the effectiveness of defatted and undeffated [see spelling in Abstract – inconsistently spelled throughout this paper – check and correct all] powder extracted from dried *Moringa oleifera* seeds which is available inform the Kaura-Namoda local government area of Zamfara State in Nigeria. The main objectives of the present research are to evaluate the effect of *Moringa oleifera* as coagulant on Gulbi-river water, which happens to be only source of drinking water to adjacentthe communitiesy.

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2.0 MATERIALS AND METHODS

2.1.1 [There cannot be a 2.1.1 without first a 2.1 – as 2.1.1 is a subsection of 2.1] Source of raw material

The Mmoringa oleifera mature seed and Aluminium Sulphate (*alum*) for this present research was obtained in (indicate year and season) from Kkaura-namoda main market, while the solvents and other used chemicals were gotten obtained from the Department of Food Technology, Federal Polytechnic, Kaura-namoda in Zamfara State.

2.1.2 Collection of water sample

Water samples were collected according to the method of Francis and Amos [5] with modification [indicate modification]. Plastic kegs of 2 litres (in other places it is written as liters – inconsistency – check and correct throughout paper) capacity were used to collect samples for physico-chemical parameters, while two kegs of 10 litres capacity were used to collect samples for laboratory-based filtration experiments. Thoroughly washed [indicate type of water used to wash – distilled or tap or de-ionised?] and sterilized glass bottles were used to collect samples for bacteriological analysis, while plastic sample bottles (PTFE) of 60 mlL capacity were used to collect samples for [heavy metal analysis – where is the heavy metals results presented?]. The samples were collected by submerging the containers into the water body – [indicate depth at which water was taken] – indicate water conditions (e.g. slow flowing or fast flowing water, near the river edge or at centre of river etc. etc.] [Indicate time of day water was taken, indicate if river was in flood or not etc.]. [Upstream or downstream of riverine human settlements] [how far from a human settlement – what do the settlement use the water for? Etc etc.] [a full description of the river conditions must be presented]

2.2 Preparation mMethods

2.2.1 Preparation of *Moringa* cCoagulant

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The seeds were harvested when they were fully matured. This is determined by observing if there are any cracked pods on the plants. The pods that were plucked were cracked to obtain the seeds which were air-dried at 40°C for two days. The shells surrounding the seed kernels were removed using knife and the kernels were pounded using laboratory mortar and pestle into powder and sieved using a strainer with a aperture size of 1.5 mm to obtain a fine powder, different portion of the powder were defatted with three different solvents (Chloroform, Acetone and Diethyl ether). This method is a slight modification [indicate modification]of the one proposed by Ghebremichael [6]. This was the coagulant prepared from *Moringa oleifera* seed. The chlorine and aluminium sulphate (alum) used in the study was obtained from the Kaura-Namoda water board. The 2 % solution of alum was made by adding 2 grams of alum in 100 mlmills distilled water and shaken for 60 seconds. The alum was totally soluble in the water.

2.3 Determination oOf pH

The Francis and Amos [5] method of pH was slightly modified. The pH of the sample was read using a calibrated Crison pH meter (Model Basic C20). A volume of 200 ml of the supernatants obtained from the beakers containing the treatments was measured into a beaker. The pH meter probe was then inserted making sure it did not touch the beaker. The pH reading was then taken from the LCD display after it had stabilized.

2.4 Determination of tTurbidity

The turbidity was determined using the method of Aho and Lagasi [7]. Turbidity was measured with a 2100P turbidimeter from Hach. The initial turbidity was measured 3 times on the raw water while stirring [indicate speed or stirring?], and the average value from the three measurements was used as starting value of raw water (RW – this abbreviation is not consistently applied). After the sedimentation phase, samples for turbidity measurement were collected from the supernatant using a standard pipette. The sample beaker was washed once with distilled water and twice with the supernatant before recording the turbidity. Each measurement took 1-2 minutes, washing included. In order to eliminate any differences in turbidity due to different sedimentation times, samples were taken from jars 1 to 6 into separate beakers before measurements were taken in [the the] water treated with different coagulant samples. [poor grammar]

2.5 Determination of Conductivity Determination

The Francis and Amos [5] method of pH was slightly modified [indicate modification applied]. The A 50 ml well-mixed sample was measured into a beaker. The WTW TDS/Conductivity meter probe was immersed in sample and its conductivity and TDS recorded. This was after calibration with 0.01N KC1.

2.6 Total bBacterial cCount.

The total bacterial count was determined using the method of Broin [8] with modification [indicate modification applied]. The different seeds extracts from the different samples at different coagulant samples (DOY, COY, DOY, EOY, FOY and GOY) was each made into a suspension and introduced into 1 liter each of raw water. A liter of raw water was kept aside as control. Another 1 liter of distilled water was also kept as control. The water samples were stirred [indicate speed of stirring] and allowed to settle and observed after 22 hours. The same procedure was repeated using alum. Total bacterial count of the raw water was recorded before and after application of coagulants. Total bacterial count was carried out by pour plate method, and oxoid agar was used as follows:
Water sample was diluted into three dilutions 10^{-1}, 10^{-2} and 10^{-3}; 1.0ml from 10^{-2} and 10^{-3} dilutions were transferred into sterile Petri-dish. Water and the agar were mixed thoroughly by gentle rotation (clockwise and counterclockwise, and rocking back and forth). The agar and the contents was allowed to solidify and incubated at 37°C for 24 hours. Average bacterial count from the triplicate plates was taken, and the bacterial content of the water was recorded from the known dilutions and multiplied by the dilution factor as shown by the formula [indicate source of this formula] below.
Equation = (C/V x M) where:
C = mean colony count
V = volume of plate

M = dilution e.g. (10^{-2} and 10^{-3}

3.0 RESULTS AND DISCUSSION

First write a paragraph on the results obtained, wherein the Table is mentioned, then place the Table. Thus paragraph-figure, paragraph-figure, paragraph-figure, paragraph-figure etc.

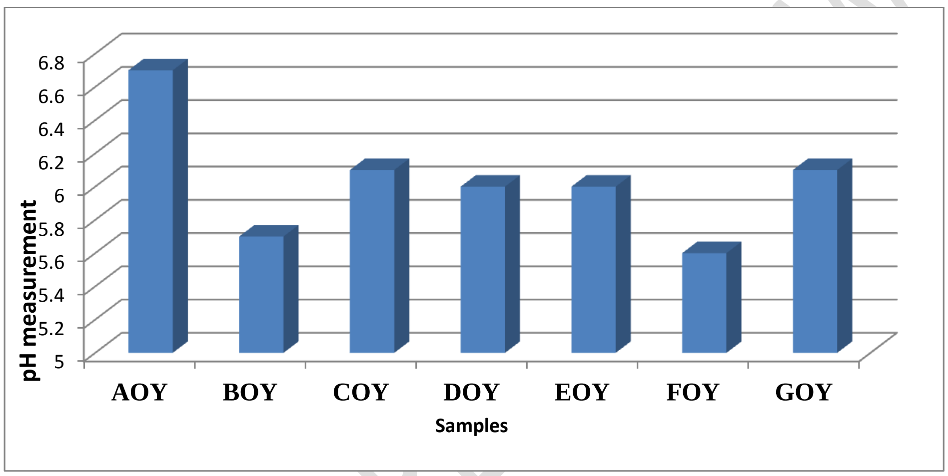

Fig 1: Results obtained for tThe pH analysis conducted onof collected Gulbi-water before and after treatment using different coagulants samples.

Key: AOY = Normal borehole water, BOY = Raw water sample from the river, COY = Water treated with (de-fated *Moringa* flour with Chloroform.), DOY = Water sample with (de-fated *Moringa* flour with Acetone), EOY = Water sample with (de-fated *Moringa* flour with Diethyl ether.), FOY = Water sample with Alum, GOY = Water sample with undefated *Moringa* flour.

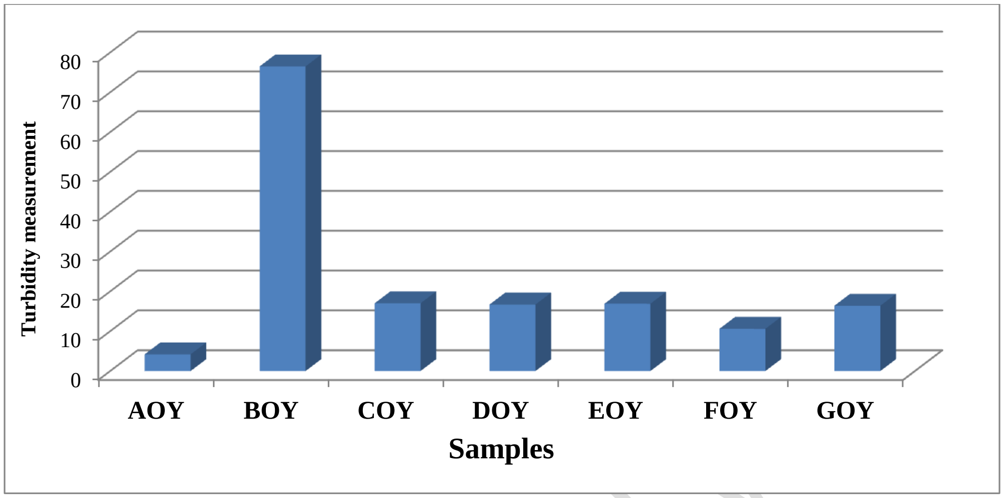

Fig 2: Results obtained for Turbidity measurement conducted on collected Gulbi-water before and after treatment using different coagulants samples.

Key: AOY = Normal borehole water, BOY = Raw water sample from the river, COY = Water treated with (de-fated *Moringa* flour with Chloroform.), DOY = Water sample with (de-fated *Moringa* flour with Acetone), EOY = Water sample with (de-fated *Moringa* flour with Diethyl ether.), FOY = Water sample with Alum, GOY = Water sample with undefated *Moringa* flour.

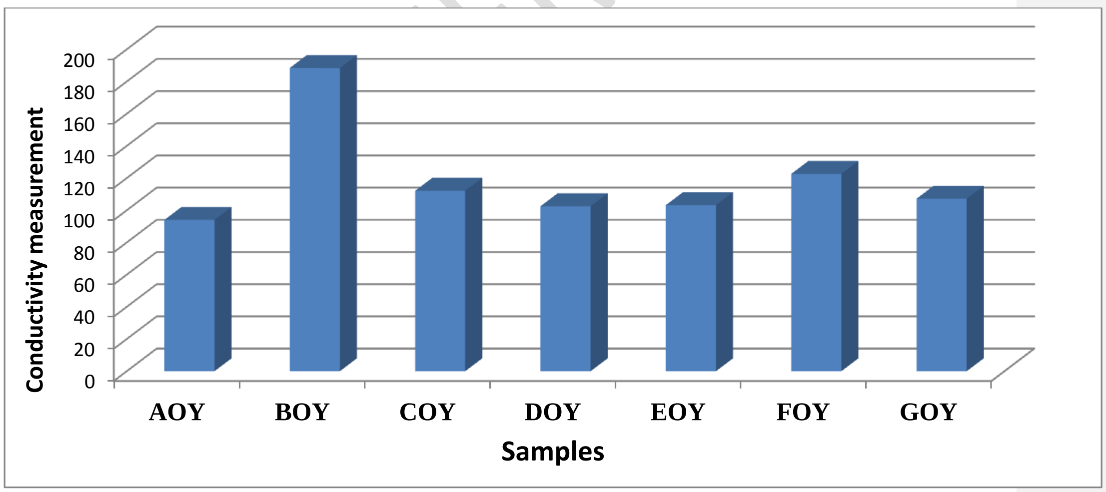

Fig 3: Results obtained for the cConductivity measurement conducted on collected Gulbi-water before and after treatment using different coagulants samples.

Key: AOY = Normal borehole water, BOY = Raw water sample from the river, COY = Water treated with (de-fated *Moringa* flour with Chloroform.), DOY = Water sample with (de-fated *Moringa* flour with Acetone), EOY = Water sample with (de-fated *Moringa* flour with Diethyl ether.), FOY = Water sample with Alum, GOY = Water sample with undefated *Moringa* flour.

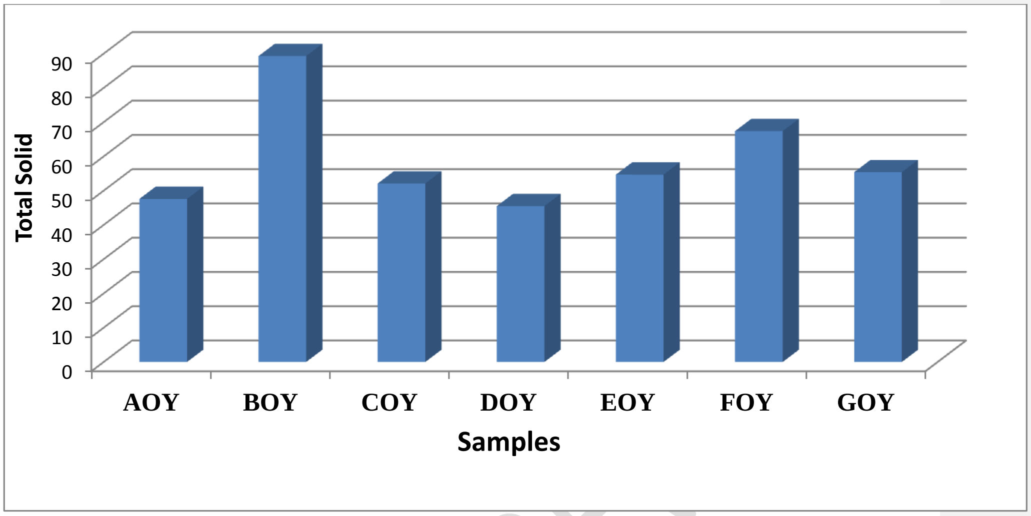

Fig 4: Results obtained for the tTotal solid (TS) [no abbreviation allowed in legend] conducted on collected Gulbi-water before and after treatment using different coagulants samples.

Key: AOY = Normal borehole water, BOY = Raw water sample from the river, COY = Water treated with (de-fated *Moringa* flour with Chloroform.), DOY = Water sample with (de-fated *Moringa* flour with Acetone), EOY = Water sample with (de-fated *Moringa* flour with Diethyl ether.), FOY = Water sample with Alum, GOY = Water sample with undefated *Moringa* flour.

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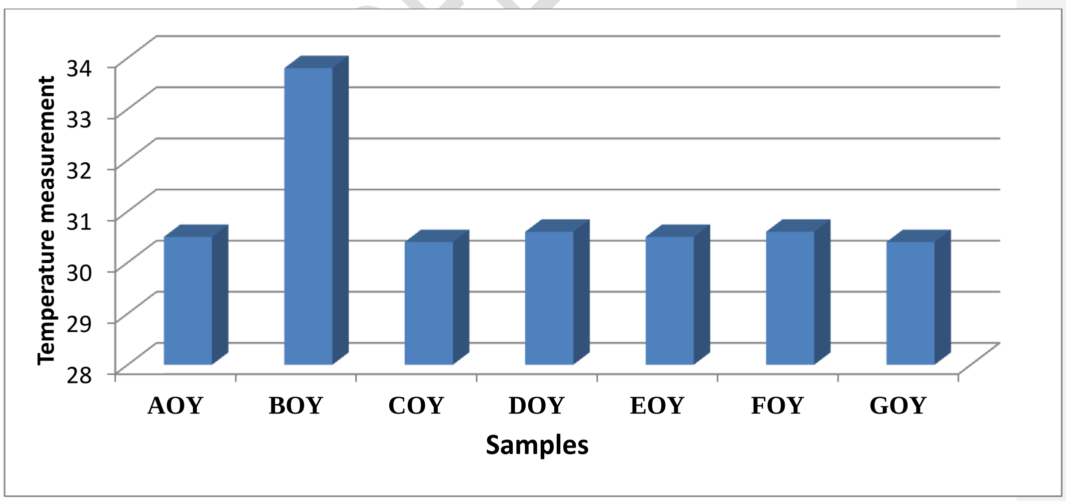

Fig 5: Results obtained for the Temperature measurement conducted on collected Gulbi-water before and after treatment using different coagulants samples. Where are these results reported on?

Key: AOY = Normal borehole water, BOY = Raw water sample from the river, COY = Water treated with (de-fated *Moringa* flour with Chloroform.), DOY = Water sample with (de-fated *Moringa* flour with Acetone), EOY = Water sample with (de-fated *Moringa* flour with Diethyl ether.), FOY = Water sample with Alum, GOY = Water sample with undefated *Moringa* flour.

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Table 1: Results obtained for the MPN [write out this abbreviation] (cfu/100ml)

Sample code	CFU/ ml
AOY	11×10^2
BOY	40×10^2
COY	10×10^2
DOY	9×10^2
EOY	10×10^2
FOY	12×10^2
GOY	10×10^2

3.1 pH ~~of the water sample before and after treatment~~

~~The result of the pH was presented in fig. 1, de-fated and undefeated *Moringa oleifera* flour coagulants, it was observed that A~~After treatment with samples (COY, DOY, EOY, FOY and GOY) coagulants, the pH ranged from 5.7 to 6.7, for the raw water (BOY) was 5.7, but when treated with *M.~~oringa~~ oleifera* samples coagulant (Fig. 1). The pH was increased from 5.7 to 6.1. The pH [increases with increase – bad grammar] in the turbidity removal efficiency of the *M.~~oringa~~ oleifera* coagulants. These results ~~of these studies confirmed to~~is, however, not in line with the finding of Oria-Usifo et al. [9] who~~ich~~ reported a pH range of 6.4 to 6.6 of water treated with *Moringa oleifera* flour and de-oil flour. A possible reason for this difference could be … It was reported that the action of *Moringa oleifera* as a coagulant lies in the presence of water soluble cationic proteins in the seeds [10, 11]. This suggests that in water, the basic amino acids present in the protein of *M.~~oringa~~ oleifera* flour would accept a proton from water resulting in the release of a hydroxyl group making the solution basic. [In essence the better the coagulating activity of the *M.~~oringa~~ o~~O~~leifera* coagulant used the treated water tends to be more basic – unclear – bad grammar.] ~~Ndabigengesere et al. [11] reported that the action of *Moringa oleifera* as a coagulant lies in the presence of water soluble cationic proteins in the seeds.~~ (Duplication of above section highlighted in red)

3.2 Turbidity ~~of the water sample before and after treatment~~

~~The result of the turbidity was presented in fig. 2; Turbidity may be caused when the light is blocked by large particles such as silt, microorganisms, plant fibers, sawdust, wood ashes, chemicals and coal dust. Any substance that makes water cloudy will cause turbidity.~~ (no introduction needed – immediately report on results obtained)~~The use of *Moringa oleifera* as a coagulant showed decreased turbidity after treatment with de-fated and undefated *Moringa oleifera* flour samples (COY, DOY, EOY and GOY).~~ (duplication of next sentence) D~~The d~~efated and undefated *M.~~oringa~~ oleifera* flour removed between 76.5 to 10.6 mg/l of turbidity in the treated water using coagulants (COY, DOY, EOY and GOY) (Fig. 2)~~was used in treating the raw water~~. The treated water samples using M.~~oringa~~ o~~O~~*leifer*a and alum used in treating the raw water sample all had a residual turbidity, which was found to be above the WHO limit (5NTU) for turbidity [indicate WHO source for this limit]. All the *M.~~oringa~~ oleifera* coagulant samples used ~~decreased~~ lowered the turbidity from 79.5 mg/l to 10.6 mg/l. ~~Residual turbidity did not meet the W.H.O standard of 5NTU~~. In all the de-fated *Moringa* coagulant used the treatment, the GOY s~~S~~ample ~~(GOY)~~ coagulant had the highest turbidity removall efficiency ~~interms of the *Moringa* flour used~~. These results are not in line with those found by ~~of these studies does not confirmed with finding of~~ Oria-Usifo et al. [9] whooich reported turbidity removal between

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69.6%-75.6% of turbidity in the treated water with *M.~~oringa~~ oleifera* flour and de-oil flour. A possible reason for this difference could be …

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The oil content in the seed will form an emulsion or film coating which may inhibit the contact with the surface of reaction and thus reduce floc formation. This is the reason for showing maximum percentage reduction observed when coagulation has no oil content. This therefore implies that additional treatment such as bio-sand filtration must be applied to the water sample before it is assumed safe for human consumption. *Moringa oleifera* seed poses no toxic effects on humans and the environment. It is an eco-friendly and cheaper method of purification of water and therefore can be used in the rural areas where no facilities are available for the treatment of drinking water. After the treatment of *Moringa oleifera* flour, sludge gets settled at the bottom of tank. Large scale treatment at village level produces large quantity of sludge which can be used as bio-fertilizers and it becomes an added advantage of this treatment. Considering the fact that *Moringa* coagulant can be locally produced, its use in water purification should be encouraged. This is likely to reduce the high cost of the current water treatment systems.

3.3 Conductivity ~~of the water sample before and after treatment~~

The results of the conductivity was presented in fig. 3, conductivity is a measure of total dissolved solids (TDS) in water varies considerable in different geographical regions owing to differences in the solubility of minerals; hence there is no standard value for it but high levels of it in drinking water maybe objectionable to consumers [12]. The conductivity ranged from 94.0 to 122.6 µS/cm for the different Moringa coagulant and alum used. The conductivity value of 94.0 µS/cm recorded for the control (AOY) was extremely high indicating the presence of dissolved impurities. This indicates that turbid water which is allowed to stand with no treatment is an inadequate procedure for removing dissolved and floating particles. It could be efficient if the turbid water is left to stand for a very long time. The conductivity measurements followed a similar pattern as the turbidity measurements. Increasing concentrations of both the *Moringa and alum* treatments led to decrease in conductivity values. However the result of these findings does not follow the same pattern with that of the Oria-Usifo et al. 2014. Treatment with *Moringa oleifera flour* values ranged from 102.5 to 112.1 µS/cm; and value of 122.6 µS/cm was recorded for the alum used.

3.4 Total solid ~~of the water sample before and after treatment~~s

The result of the total solid was presented in fig. 4. The Total Solids (TS) of the raw water sample was 89.30 mg/l which conforms to the standard limits of the W.H.O. After the treatment of the raw water sample with the undeffated and deffated (BOY, COY, DOY, EOY and GOY) *Moringa oleifera*, the TS were reduced to 45.50 to 55.40 mg/l in sample. When alum (FOY) used in treating the raw water sample, the TS of the water sample was reduced to 67.40 mg/l. The result of these studies does not confirmed with finding of Oria-Usifo et al. 2014 which reported TS range of 28.45 to 35.85 mg/l from water treated with *Moringa oleifera* powder. *Moringa oleifera* is known to be a natural cationic polyelectrolyte and flocculent with a chemical composition of basic polypeptides with molecular weights ranging from 6000 to 16,000 Daltons, containing up to six amino acids of mainly glutamic acid, methionine and arginine [13].

3.5 Total bacterial count ~~of the water sample before and after treatment~~

The results of the total bacterial count was presented on Table 1. presence of coliforms indicates that the water is feacally contaminated and not safe for drinking purpose. Due to coli forms various waterborne diseases occur and therefore, coliforms should be not exceed 10(cfu/100ml) for drinking water. In the present research, it was observed that the initial coliform of the untreated water sample was 40 (cfu/ml), which was beyond the recommended limits of WHO standards. After the treatment of the water sample with different de-fated and undefated *Moringa oleifera* coagulant powder, the coliforms decreased to 10 cfu per 100ml in sample COY, DOY, EOY and GOY which was within the WHO limit and the findings of Oria-Usifo et al. [9]. While sample FOY was 12 per 100ml which was above the WHO limit. The presence of coliform within the WHO limit gives an indication that the impurities present in the water after treatment with deffated and undefated *Moringa oleifera* powder are not harmful to humans. Therefore the treated water sample is safe for consumption. While the water sample treated with alum are safe for human consumption due to the high level of coliform unit present in the water sample which was above the WHO limit for drinking water.

4.0 Conclusion

The results of this research was able to show the ability of *Moringa oleifera* contains some coagulating properties have similar effect as the conventional coagulum, alum. The physic-chemical properties of the water after treated with *Moringa oleifera* coagulum were elucided. *Moringa oleifera* has an added advantage of having antimicrobial properties. Considering the fact that *Moringa* coagulum can be locally produced, its use in water purification should be encouraged. This is likely to reduce the high cost of the current water treatment systems. The use of moringa oleifera seed flour as a natural coagulant maintains the neutral state of water after treatment. Hence, the use of *Moringa oleifera* seed extract could be more suitable and have a distinct advantage over the use of chemical coagulants such as alum in water treatment for rural communities in developing countries.

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Many inconsistencies

Not in accordance with journal guidelines

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