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Preliminary investigation of coagulation activity using *Moringa oleifera*, alum and activated carbon mixture in well water treatment

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Abstract
Investigation of coagulant of *Moringa oleifera*, alum and activated carbon mixture (matrices) in well water treatment were carried out on well water of Kofar Gabas of Jahun. In this work water quality assessment test, jar test were carried out. It was noted that there is general reduction in TDS values, and they are all within WHO recommended range i.e. (< 300mg/L). There is decrease in pH values for the whole matrices used below the WHO recommended of 6.5-8.5, since MO is in high percentage in all matrices. Low TDS values and average conductivity as well as closeness of pH values to recommended range given by WHO, made matrix B best of three matrices prepared.

Keywords: Activated carbon, alum, coagulant, *Moringa oleifera*, moringa seed, total dissolved solid

Introduction

Moringa oleifera is versed and important plant used in varied medicinal applications, production of biodiesel oil, essential oil as well as acting as bioactive coagulant in water treatment. The provision of potable water is an enormous undertaking, especially in developing countries. This is so because the chemicals required for treatment, namely: alum for coagulation, polyelectrolyte as coagulant aids, lime for softening and pH correction, and chlorine for disinfection; needs to be imported with scarce foreign exchange. In reaction to this, local materials are being considered as a substitute. *Moringa oleifera* seeds extract has been a subject of research by several scholars in this regard (Eman and Ali, 2009) [8].

Moringa oleifera seed (MO), (Zogale in Hausa) is applied as coagulant in place of Aluminium Sulphate (Alum) used in conventional treatment plants. (Aho and Lagasi, 2009) [3].

Water is essential for human life. Potable water should be free from contaminants. Children bear the greatest health burden associated with unsafe water supplies through preventable diseases like diarrhoea. In developing countries about 2 million people die every year due to diarrhoea disease; most are children of less than 5 years of age (WHO, 2007, Cheesbrough, 1984) [6, 31-33]. Other water related diseases reported in Nigeria are trachoma, schistosomiasis, ascariasis, trichuriasis, ancylostomiasis (hookworm), malaria and encephalitis (Sridhar and Olorutoba, 2008) [27, 28]. Unprotected water sources receive pollutants from runoff thus necessitating treatment at household level. The common methods for treatment requires coagulation/flocculation followed by sedimentation, filtration and disinfection. Common coagulants are Aluminium sulphate, ferric chloride, polyaluminium chlorides and synthetic polymers (Degremont and Kulack, 2004) [20].

One of the most important environmental issues today is ground water contamination (Vodela, 1997) [30] and between the wide diversity of contaminants affecting water resources, heavy metals receive particular concern considering their strong toxicity even at low concentrations (Marcovecchio *et al.*, 2007) [18]. Heavy metals are elements having atomic weights between 63.546 and 200.590 and a specific gravity greater than 4.0 i.e. at least 5 times that of water. They exist in water in colloidal, particulate and dissolved phases (Adepoju and Bello, 2009) [1, 2]. With their occurrence in water bodies being either of natural origin (e.g. eroded minerals within sediments, leaching of ore deposits and volcanism extruded products) or of anthropogenic origin (i.e. solid waste disposal, industrial or domestic effluents, harbor channel dredging) (Marcovecchio *et al*., 2007) [18].

Some of the metals are essential to sustain life e.g. calcium, magnesium, potassium and sodium must be present for normal body functions. Also, cobolt, copper, iron, manganese, molybdenon and zinc are needed at low levels as catalyst for enzyme activities (Adepoju and Bello, 2009) [1, 2], however, excess exposure to heavy metals can result in toxicity. Heavy metal can cause serious health effects with varied symptoms depending on the nature and quantity of the metal ingested (Adepoju-Bello and Alabi, 2005) [1, 2]. They produce their toxicity by forming complexes with proteins, in which carboxylic acid (–COOH), amine (–NH_2), and thiol (–SH) groups are involved. These modified biological molecules lose their ability to function properly and result in the malfunction or death of the cells. When metals bind to these groups, they inactivate important enzyme systems or affect protein structure, which is linked to the catalytic properties of enzymes. This type of toxin may also cause the formation of radicals which are dangerous chemicals that cause the oxidation of biological molecules. (Anyakora, 2010) [4].
Total Dissolved Solids (TDS) are the compounds in the water that cannot be removed by a traditional filter. TDS are made up of salts or compounds which dissociate in water to form ions. This means that a salt has two parts, one with a positive charge and one with a negative charge, which separate and mix with the water (H_2O) molecules. Table salt, for example, is sodium ion (Na^+) and Chloride ion (Cl) together to form sodium chloride (NaCl). Some common salts which make up TDS are sodium (Na^+), sulphate (SO_4^{2-}), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), and bicarbonate (HCO_3). For a reference, sea water has a TDS of around 35,000 ppm, and the Missouri River near Great Falls has TDS in the neighborhood of 250 ppm. These minerals can originate from a number of sources, both natural and as a result of human activities. Mineral springs contain water with high levels of dissolved solids, because the water has flowed through a region where the rocks have a high salt content. The water in the Prairie Provinces tends to have high levels of dissolved solids, because of high amounts of calcium and magnesium in the ground. These minerals can also come from human activities, agricultural and urban runoff can carry excess minerals into water sources, as waste water discharges. (Gottsch, 1992) [10].
The use of *Moringa* has an advantage over the alum in treatment of water because of its biological importance; it has been reported as edible. However not much has been done in Nigeria using moringa seed as a coagulant in water treatment system. The cost of this natural coagulant is less compared to the conventional alum for water treatment since it is available in most rural communities in Nigeria where treated water is a scarce resource. It is in this light that this research will carried out to confirm the effectiveness of extraction from mature dried *Moringa oleifera* seeds which is commonly available in most rural communities in Nigeria. It is in this also, that I will carried out investigation on biocoagulant properties of mixture *moringa* seed powder, alum and activated carbon.

2. Materials and Methods

2.1 Materials

Desiccator, beakers 250ml, 1000ml measuring cylinder, mortar and pestle, round bottom flask 600ml, heating mantle, oven, weigh balance, crucibles, thermometer, filter paper, flocculator, turbidity meter, pH Meter, beakers, conical flasks, washed bottles, pipette.

2.2 Methodology

2.2.1 Pre-treatment procedure

This is the initial stage of sample preparation and it includes the following:

2.2.2 Seed collection

This involves the collection of the fruits of *Moringa oleifera* and drying it. The drying process stimulates the opening of the fruits to release seeds embedded inside. The seeds were separated from the chaffs and other impurities.

2.2.3 Drying

After the seeds had been cleaned thoroughly; they were dried in an electric oven to reduce the moisture content of the seeds.

2.2.4 Weighing

This was done before and after the seeds was dried. The weight was taken and recorded using electronic weighing balance.

2.2.5 Preparation of biocoagulant

Dried *Moringa oleifera* seed were obtained from Hantsu village in Jahun. The *Moringa oleifera* seed coats and wings were removed. The kernel were crushed with a clean domestic mortar and pestle then grounded to a fine powder with a Moulinex domestic blender, the samples grinded were washed with distilled water. These were then air dried in the laboratory. 218.9g of this was weighed and placed on a filter paper which was folded carefully. The weight of the filter paper and sample was recorded, 500ml of the solvent (hexane) was measured using a measuring cylinder and then poured into a 600ml round bottom flask with the sample and heated at 60 °C for 2 hours after which the sample was removed and transferred into the air oven to dry at 105 °C for 30 minutes. This sample was then weighed and the difference was calculated as: weight of sample before extraction – weight of sample after extraction, divided by the initial weight of sample, and multiplied by 100 to give the percentage yield oil. (Malusare *et al.,* 2011) [17].

2.3 Matrices preparation

This was prepared by mixing various amounts of *Moringa oleifera,* activated carbon and alum.

1. Matrix A (0.25g alum + 0.25g AC + 4.5g MO)
2. Matrix B (0.5 g alum + 0.5gAC + 4.0g MO)
3. Matrix C (0.75Alum + 0.75gAC + 3.5g MO)

Key
AC – Activated Carbon
MO – *Moringa oleifera*

All the matrices composite were heated in oven at temperature of 40 °C for three hours, after which they were stored properly for use.

2.4 Collection of well water samples

The five samples were collected randomly at different location in Jahun town. Each sample container was properly labeled as 1, 2, 3, 4 and 5 respectively. The sample locations include Kofar Gabas, and Gadawa. Before sampling, the plastic containers and the glass apparatus were washed thoroughly with detergent and soaked in 5% nitric acid. They were rinsed thoroughly with distilled water and dried.

2.5 Composite samples used for analysis

- Dam water
- Well water (composite)
- Simulated water
- Distilled water (Control)

2.6 Water quality assessment

Using the known conventional alum as the standard, then the quality of the treatment using *Moringa oleifera* can be ascertained and proper justification can be made. With the following tests carried out.

2.6.1 Jar test

This test is for measuring coagulation activity of a given coagulant, using the raw water from different sources as well as turbidity, PH, conductivity, TDS and alkalinity and DO.

Coagulation: This is the gentle mixing of coagulant with raw water, in order for flocculation to take place so as to collect the settled sludge, when clean, clear and pure water is separated from its impure part. This is the process generally used by many treatment plants.

2.6.1.1 Apparatus

500ml beaker, measuring cylinder, spatula, analytical balance, pipette, filter paper, flocculator

2.6.1.2 Procedure

200ml of dam, well, simulated water and distilled water each were collected into 500ml beaker, after which they were arranged in flocculating machine. Coagulants were added 0.2mg each of control 1 (*Moringa* powder). After flocculator is set on, 120 revolution is observed for 1min and thereafter reduced to 30 revolution for the next 15 min. this is done in order to ensure gentle and perfect flocs formation, the flocs were therefore allowed to settle after ten minute. The clean water was then decanted into separate containers for further test such as pH, conductivity, turbidity, TDSe.t.c. The same procedure was repeated for; control 2 (activated carbon), control 3 (alum), matrix A (90% *Moringa*+ 5%AC+% Alum), matrix B (80% *Moringa* +10% AC +10% Alum), matrix C (70% *Moringa* + 15% AC + 15% Alum). (Muyibi and Alfugara, 2003) [21-23].

2.6.2 pH test

This is the test carried out to determine acidity or alkalinity of the raw water as well as treated water. This is done using the pH Meter. The standard pH by WHO standard for portable drinking water is 6.5-8.5 (WHO, 2006) [31-33].

2.6.2.1 Procedure

About 50ml of water (raw or treated) was poured into 250ml beaker and pH indicator was inserted and stabilized average value was taken. The pH is represented mathematically as pH = $-\log_{10} [H^+]$. Moreover, the pH is a prominent factor in the removal of colloids. The optimum pH is a compromise between the pH necessary for coagulation (according to the type of colloid) and the pH necessary for flocculation (relating to the build-up of iron or aluminum hydroxide floc). Usually it corresponds to the minimum solubility of the hydroxide in question (optimization of the flocculation stage). The pH and the minimal solubility are greatly influenced by the ionic strength and the presence of organic compounds; pH is largely corrected by liming the water (WHO, 1996) [31-33].

2.6.3 Turbidity

This is the test carried out to determine the clarity of both raw water and treated water. The WHO standard turbidity for drinking water is 1-5 Normal turbidity unit (NTU). Turbidity is caused by wide variety of suspended matter which range in size from colloidal to coarse dispersion depending upon degree of turbulence. Turbid waters are undesirable from aesthetic point of drinking water supplies and may also affect products in industries. Turbidity is measured to evaluate the performance of water treatment plant. (WHO, 1996) [31-33].

2.6.3.1 Apparatus

Turbidity meter, pipette, sample cell, beaker.

2.6.3.2 Procedure

About 50 ml of sample water was pipette into 50ml sample cell of turbidity meter, covered tightly and clean properly with white tissue, then insert in turbidity meter and the readings were taken and recorded.

2.6.4 Conductivity measurement

Conductivity which 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 may be objectionable to consumers (WHO, 2006) [31-33].

2.6.4.1 Apparatus: Conductivity meter, pipette, beaker

2.6.4.2 Procedure

The samples used for the pH measurements were used for conductivity test. The conductivity meter's electrode was then inserted, making sure it did not touch the beaker. The reading was recorded from the LCD display after it had stabilized.

2.6.5 Alkalinity

Water alkalinity is a measure of the concentration of bases in a solution or the ability to neutralize acids in water. It can also be referred to as the buffering capacity of water. Examples of bases are carbonates, bicarbonates, magnesium bicarbonate, ammonia, borates, phosphates, silicates, and organic bases. For all practical purposes, carbonates and bicarbonates are the main contributors to the alkalinity of water. (Lopez and Claudio, 1999) [16].

2.6.5.1 Procedure

Exactly 100ml of water sample was measured into conical flask (250ml), 3 drops of phenolphthalein indicator was added to water sample and pink color was observed, this was titrated against diluted 0.02N H_2SO_4, until the pink color just disappears and readings were recorded in ml of acid used.

2.6.6 Total hardness

When water passes through or over mineral deposits such as limestone, the levels of Ca^{2+}, Mg^{2+}, and HCO_3^- ions present in the water greatly increase and cause the water to be classified as *hard water*. This term results from the fact that calcium or magnesium ions in water combine with soap molecules, forming a sticky scum that interferes with soap action and makes it "hard" to get suds. One of the most obvious signs of water hardness is a layer of white film left on the surface of showers. Since most hard-water ions originate from calcium carbonate.

2.6.6.1 Procedure
Sample water was shaken thoroughly; 25ml was diluted to 50ml with distilled water. 2ml of buffer solution was added, and was titrated with EDTA within 5min. interval until blue coloration resulted as shown in appendix 9.

2.6.7 Dissolved oxygen (DO)
Although water is composed of oxygen and hydrogen atoms, biological life in water depends upon another form of oxygen-molecular oxygen. Oxygen is used by organisms in aerobic respiration, where energy is released by the combustion of sugar in the mitochondria. This form of oxygen can fit into the spaces between water molecules and is available to aquatic organisms.

2.6.7.1 Procedure
About 50ml of water sample was measured into rinsed beaker and electrode from dissolved oxygen meter was inserted and stabilized reading was taken for respective water samples.

2.6.8 Model of equipments used
- Equipment model No. crison micro PH 2000.
- Equipment model No. HACH sension 1 for PH.
- Equipment model No.: HACH sension5 conductivity and total dissolved solid.
- Equipment No.: HACH DR/890 colorimeter for turbidity.
- Model for weighing balance: PL303.

3. Result and Discussion
3.1 Results
1.5kg weight of *Moringa* seed were supplied from Jahun, the seed scale was peeled off and was grounded into fine particles. The final weight was then determined.
Weight of empty container = 200.1g
Total weight of the sample + container = 419g
Weight of *moringa* before extraction = 218.9g
Weight of the sample drying = 114g
Percentage weight extracted is therefore calculated,
% weight extracted = (weight of sample before extraction – weight of sample after extraction)/weight of sample before extraction
% weight extracted = [(218.9 – 144)/218.9] X100
= 34.21

3.1.1 Dissolved oxygen (DO)
After dissolved oxygen meter was inserted and stabilized reading was taken for respective water samples.
Raw water = 0.7
Treated raw water = 0.7
Well water = 0.treated well water = 0.8

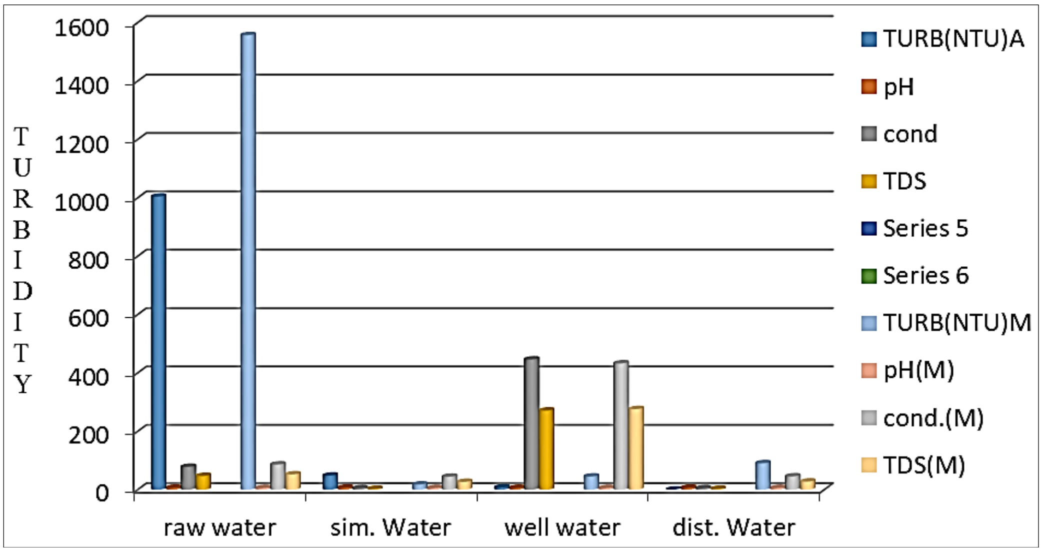


Fig 1: Physicochemical properties before and after treatment with control 1 (*Moringa oleifera* powder)

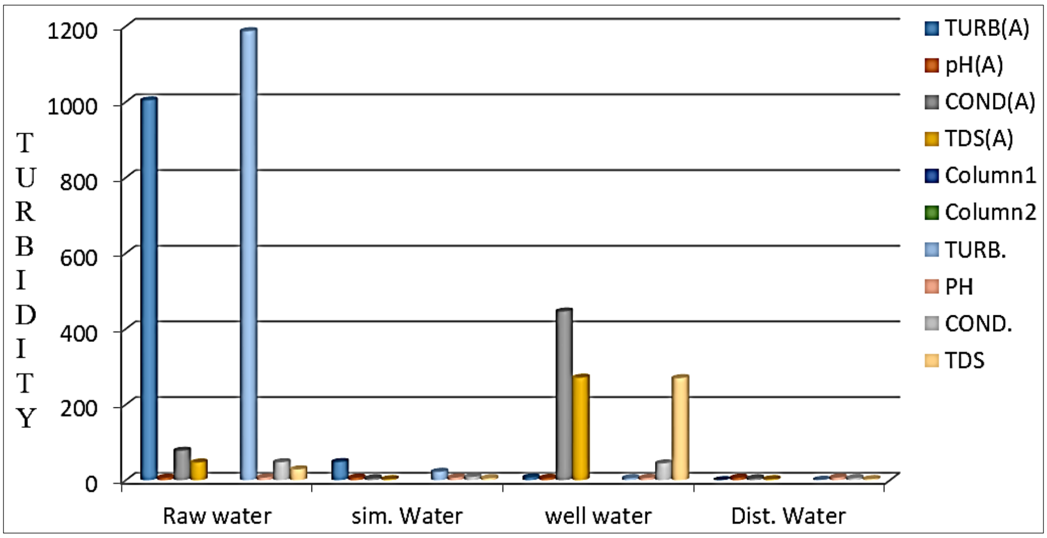
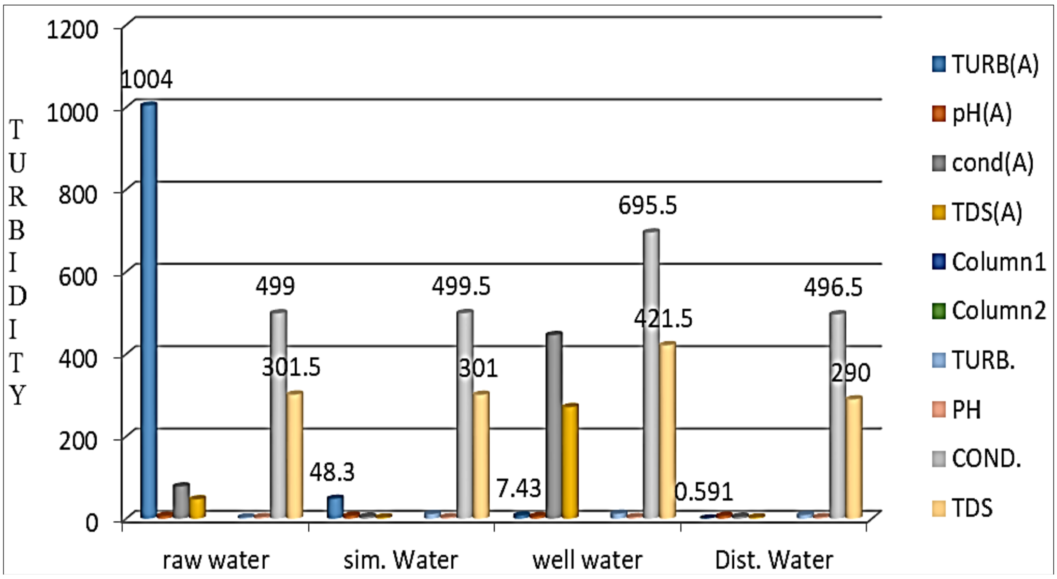


Fig 2: Physicochemical properties before and after treatment with control 2 (Activated carbon)



Key: TURB – Turbidity, COND – Conductivity, TDS – Total dissolved solid, Sim. – Simulated, Dist. – distilled

Fig 3: Physicochemical properties before and after treatment with control 3 (alum)

3.2 Discussion

The pH value of the raw water ranged between 6.0 and 6.6. When this raw water was treated with 100% *Moringa oleifera* the pH changed to the range of 5.5 to 5.8, this is in consonance with result of (Muyibi and Evison, 1995) [21-23] that showed that pH of the water softened with *Moringa oleifera* seed powder was within the recommended WHO (2006) [31-33] standards and. Also (Katayon *et al*., 2004) [15] indicated that *Moringa oleifera* seeds did not affect the pH value of water samples significantly although a slight decrease in pH was seen after the coagulation process of *Moringa oleifera*. (Katayon *et al*., 2004) [15] suggested that the decrease in pH when using *Moringa oleifera* seed powder may be due to hydrogen ions of the weak acidity of *Moringa oleifera* stock solution, which balances the hydroxide ions in the raw water.

The addition of alum to the water samples reduced the pH in the treated water below the WHO acceptable limit of 6.5 (WHO, 1996) [31-33]. When 100% alum was added to the water, the pH reduced from the range of 6.0 – 6.8 to 3.7-4.0. Alum caused a marked changes in the pH of the raw water from a value of 6 points to a treated water value of 4 points, so lime can be use to correct the pH of water sample.

The main concern in using *Moringa oleifera* for water treatment is the significant increase in organic load, as organic matters originating from the seeds can be released into the water during treatment. The presence of organic matter in treated water can cause problems of colour, taste, and odour and also facilitates the development of microorganisms upon storage, water treated with crude *Moringa oleifera* extract should not be stored for more than 24 hours. (Jahn, 1988) [12] The crude extract is therefore not generally not suitable for large water supply systems where the hydraulic residence time is very high (Eman and Ali, 2009.) [8].

3.3 Charts for matrices

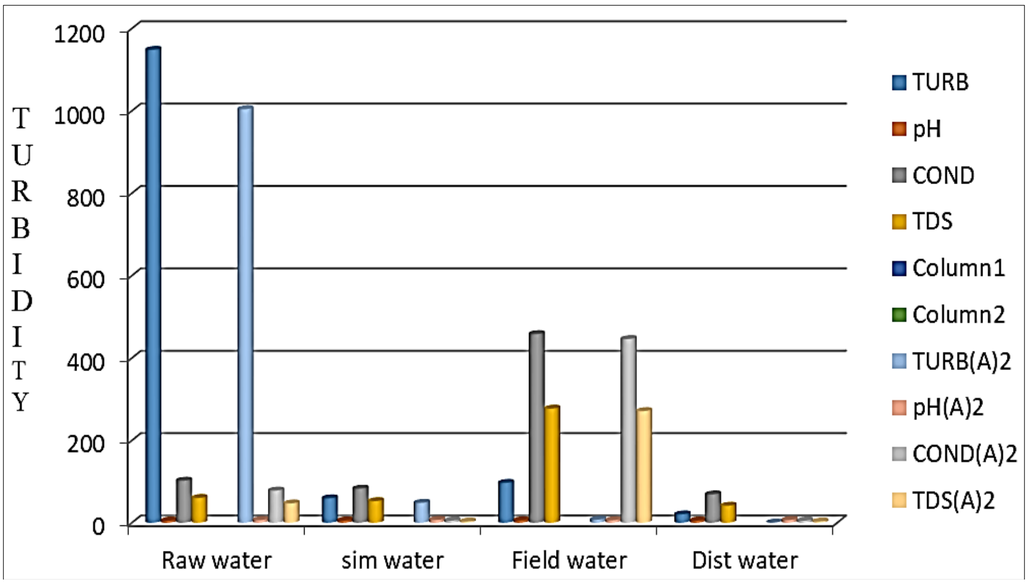


Fig 4: Physicochemical properties before and after the treatment with matrix A

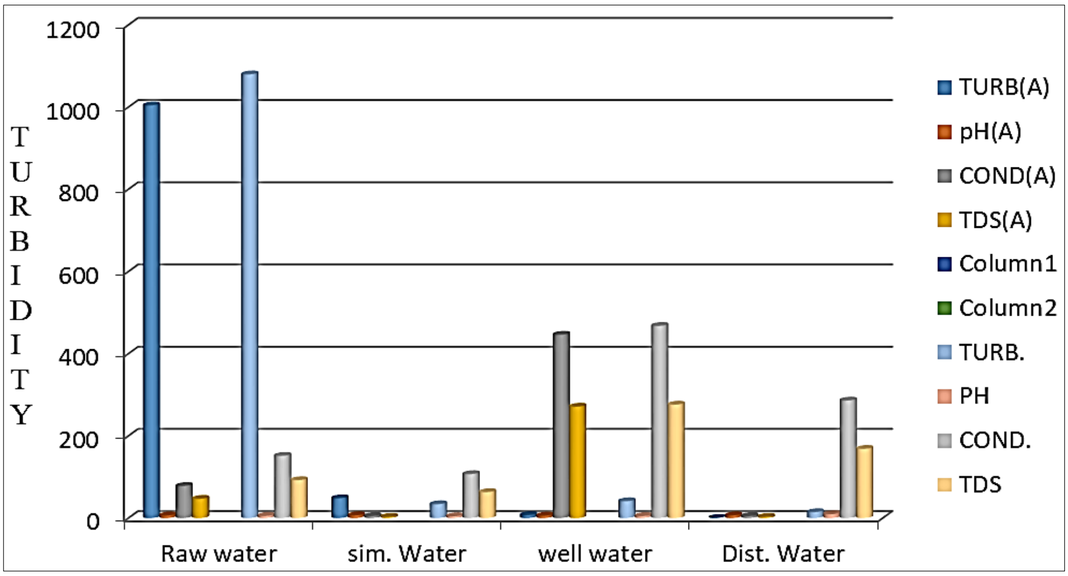
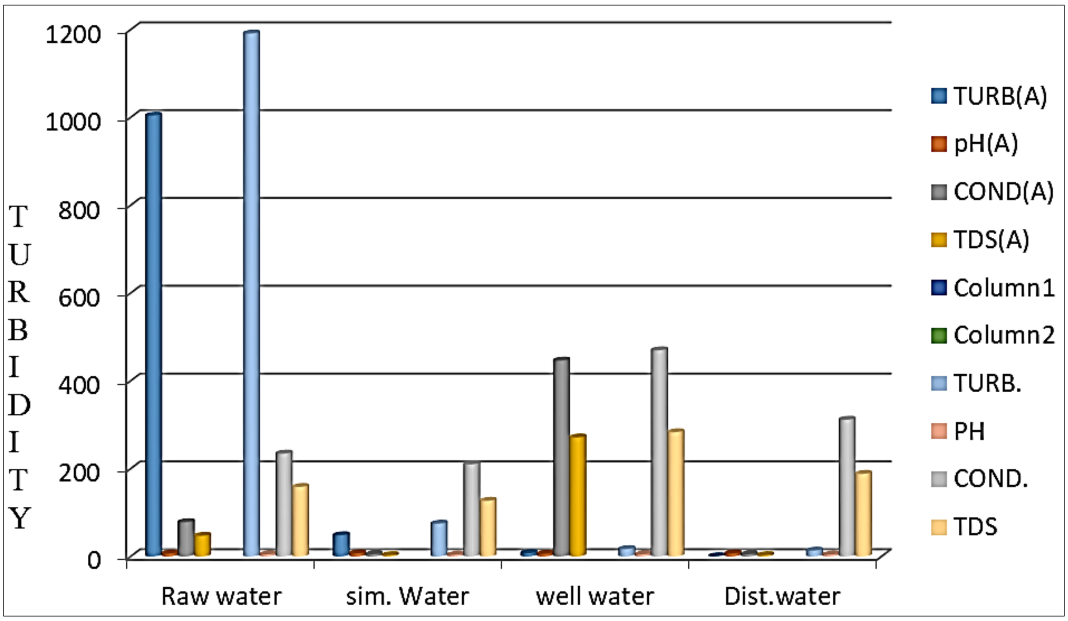


Fig 5: Physico-chemical properties before and after treatment with matrix B

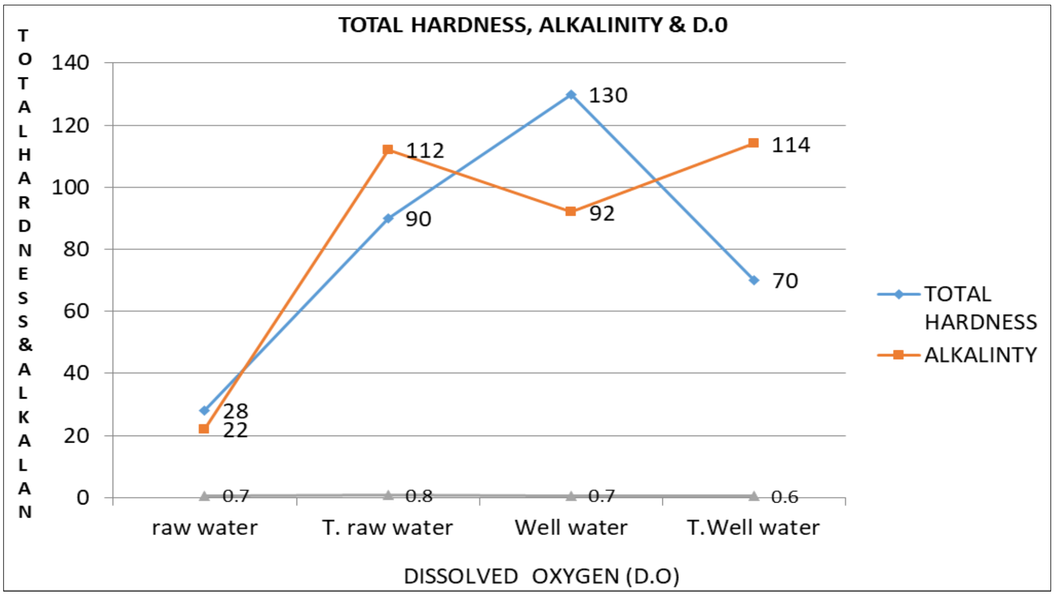


Key: TURB – Turbidity, COND – Conductivity, TDS – Total dissolved solid, Sim. – Simulated, Dist. - Distilled

Fig 6: Physico-chemical properties before and after treatment with matrix C

Various percentage combinations of *Moringa oleifera* seed powder, aluminiumsulphate and activated carbon (Figure. 3, 4 and 5) revealed drops in the pH value for the treated water to different degrees. The quantity *of Moringa oleifera* seed powder was more than the quantity of alum and activated carbon in any water sample treated, the pH reduction was not within the (WHO, 1996) [31-33] approved range of 6.5 to 8.5 but the reverse was the case when alum and activated carbon were either in equal quantity or greater amount than *moringa oleifera* seed powder in combination. Therefore there will not be need for pH correction using lime, but to increase the percentage of alum and activated carbon. Considering only pH as a determining factor for selection of optimum combination, matrix B was found to be closest to the WHO recommended range. All the reductions in pH values were corrected when using the well water. Generally there was increment in the values of total dissolved solids (TDS) in the treated water above the raw water values as can be seen in appendix 1 in comparison to tables of treated samples.

When organoleptic properties of treated water were considered as described by (WHO, 1971) [31-33]. "The presence of dissolved solids in water may affect its taste (Bruvold and, Ongerth. 1969) [15]. The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre; good, between 300 and 600 mg/litre; fair, between 600 and 900 mg/litre; poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre (Bruvold and, Ongerth. 1969) [15]. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste". In accordance with above palatability range all water treated with matrix A, Band C were found within the range.



Key: D.O – Dissolved Oxygen, T – Treated

Fig 7: Total Hardness, Alkalinity & D.0

4. Conclusion

From the results of this study, the turbidity of the treated water was not greatly influence by percentage of *moringa oleifera* present in the matrix, but effect on pH according to (Katayon *et al*., 2004) [15] was due to presence of H^+ from weak acid in *moringa oleifera*. It was noted that there were general reduction in TDS values and were all within the range specified by WHO standard which is of value less than three hundred milligram per liter (< 300mg/l) (Bruvoldand Ongerth, 1969) [15]. In line with the discussion above there were marked decrease in pH values for the whole matrices used, since *moringa oleifera* is in high percentage in all matrices. Low TDS values and average conductivity as well as closeness of pH values to recommended range given by WHO, made matrix B best of three matrices prepared. The composite well water can be treated effectively using matrix B with the aid of lime for pH correction.

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