



## Assessment of *Garcinia kola* seed as a natural material for water treatment

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### ARTICLE INFO

#### Article type:

Research article

#### Article history:

Received May 2017

Accepted October 2017

October 2017 Issue

#### Keywords:

*Garcinia kola*

Wastewater

Physicochemical

Microbes

### ABSTRACT

The coagulation and antimicrobial efficiency of *Garcinia kola* at different concentrations on turbid surface water samples collected from Ogbor Hill River in Aba was studied. Phytochemical analysis showed alkaloid content of  $2.11 \pm 0.04$  % while saponin, flavonoid and tannin contents were  $0.34 \pm 0.04$  %,  $2.16 \pm 0.03$  % and  $0.14 \pm 0.02$  % respectively. Phenol content was  $1.65 \pm 0.01$  %. The physicochemical and microbial analysis indicated that the water sample had temperature of  $30.5 \pm 0.10$  °C, pH of  $7.4 \pm 0.20$ , total dissolved solids of  $161.54 \pm 1.13$  mg/L, turbidity of  $31.64 \pm 0.08$  NTU, electrical conductivity of  $221.4 \pm 0.35$   $\mu$ S/cm, biochemical oxygen demand of  $5.87 \pm 0.03$  mg/L, chloride content of  $0.28 \pm 0.02$  mg/L, nitrate content of  $248.6 \pm 0.27$  mg/L, nitrite content of  $1.86 \pm 0.04$  mg/L,  $12.00 \pm 1.00$  MPN/ml of Total Coliform,  $(7.67 \pm 1.00) \times 10^2$  CFU/ml of *E. coli*,  $(10.33 \pm 1.15) \times 10^2$  CFU/ml of faecal *streptococcus*,  $(15.67 \pm 2.52) \times 10^2$  CFU/ml of *Staphylococcus aureus* and too numerous to count (TNTC) for Total Heterotrophic bacteria. However, microbial reduction after treatment with *Garcinia kola* seed extract at different concentrations ranged from 41.67 – 75.00 % for Total coliform, 34.81 – 73.92 % for *E.coli*, 12.87-70.96 % for *Faecal streptococcus*, 36.18 – 68.09 % for *Staphylococcus aureus* and 45.30 – 65.81 % for total heterotrophic bacteria. *Garcinia kola* seed is non-toxic and does not significantly affect the pH and conductivity of the treated water.

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**Capsule Summary:** The coagulation and antimicrobial efficiency of *Garcinia kola* at different concentrations on turbid surface water samples collected from Ogbor Hill River in Aba was studied. The water quality parameters improved significantly without compromising the pH and conductivity and also *Garcinia kola* seed showed non-toxic behavior for water treatment.

**Cite This Article As:** J. C. Nnaji, O. J. Kingsely and B. I. Ugwu. Assessment of *Garcinia kola* seed as a natural material for water treatment. Chemistry International 3(4) (2017) 353-358.

### INTRODUCTION

Bitter kola which is botanically known as "*Garcinia kola*", belongs to the family of plants called *Guttiferae*, the genus is known as *Garcinia* (Iwu, 1993). It is a herbaceous perennial

medicinal plant grown in tropical rain forest in Central and West Africa (Uko et al., 2001) and more predominantly in rainforest belt of Southern Nigeria (Agada and Braide, 2009). The tree is usually cultivated within villages in Southern Nigeria and grows to a height of about 12-14 m. It has been referred to as a "wonder plant" because almost every part of

it has been found to be of medicinal importance. It is commonly called "Akuilu" in Igbo land, "Namijingoro" in Hausa land and "Orogbo" in Yoruba land of Nigeria. It produces characteristic reddish, yellowish or orange coloured fruit with seeds covered with skimmor husk. It has a juicy substance which is assumed to contain the active ingredients. *Garcinia kola* seed could serve as raw material for pharmaceutical industries. The plant exhibits very potent pharmacological activities such as antioxidant, antibacterial, antiviral, antifungal and anti-inflammatory properties (Adegboye et al., 2008.)

In recent years the use of natural products has been widely investigated as an alternative for the currently expensive methods of water treatment. Some of the natural products can be effectively used as a low cost absorbent. The popular treatment system of water in Nigeria is the sedimentation, coagulation, disinfection (chlorination), filtration. Chlorine has been noted as a potential carcinogen and forms compounds such as tetrachloromethane (TCM) which also produces hormonal analogue that may interfere with male fertility. Aluminium sulphate (Alum), the widely used water coagulant generates acidic water, unsafe for pregnant women and causes pre-dementia in some people (loss of memory) (Yongabi et al., 2011). While all these defects exist, mankind has been blessed with indigenous knowledge and has been using it to survive, preceding the advent of these technologies. Exploring and exploiting the potentials of natural materials such as *Garcinia kola* to bring about cheap clean water in a more ecological friendly manner are the thrust of this work.

## MATERIALS AND METHODS

### Sample collection and preparation

The bitter kola (*Garcinia kola*) seed was botanically identified and confirmed at the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike. The seeds were dehusked, each seed was cut into small pellets with kitchen knife and the resulting pellets were subsequently dried in an electric oven for 12 h at 40 °C. The dried seed pellets were ground to fine powder using manual grinder and then sieved with 10 mm sieve. The powder was used in the extraction process while the remaining powder aliquots were used for phytochemical screening. All the chemicals used for analysis were of analytical grade.

### Qualitative and quantitative analysis of phytochemical constituents of *Garcinia kola*

Phytochemical tests were carried out to establish the presence of some specific phytochemicals (alkaloids, saponins, flavonoids, tannins and phenols). The chemical tests were carried out with standard specimens using standard procedures to identify the constituents as described by Sofowara (1993), Harborne (1998) and Trease and Evans (1989). In addition, alkaloids were determined using the alkaline precipitation gravimetric method (Harborne, 1998); flavonoids by the Ethyl acetate precipitation method (Bohm et al., 1994); saponins with the double solvent extraction

gravimetric method (Harborne, 1998); phenols with Follins method and tannins by the Follins-Dennis spectrophotometric method (Pearson, 1976).

### Preparation of stock solution

The powdered form of *Garcinia kola* was sieved to remove the large particles. 1 g of the powder was mixed with 100 ml distilled water to form 100 ml suspension. The suspension was then mixed thoroughly using a clean magnetic stirrer for 5 min to extract the active component, followed by filtration of the solution through a filter paper to remove solid materials. The stock solution was preserved in the refrigerator at 3 °C.

### Microbial Analysis

Bacterial load was determined by direct culture count as total viable count and expressed as the number of colony forming units per unit volume of the water sample. Serial dilution of the water sample was done before plating using the methods of Amadi and Ayogu (2005). Using a sterile syringe, 9 ml each of the diluents (sterile water) was placed into 10 different test-tubes arranged in a rack. The water sample was then shaken to mix and 1 ml was taken using sterile 5 ml syringe and then added into the first test tube in the rack and shaken properly to mix. 1 ml of the water was taken from the first test tube and delivered into the second test tube and mixed. This process was repeated for the 10-test tubes. 0.1 ml aliquot of each dilution 1 to 5 test tubes was then plated on an already solidified nutrient agar. The water sample was spread evenly on the surface of the agar using sterile swab stick, after which the inoculated media was allowed to dry and then incubated at 37 °C for 24 h. After the incubation period, number of colony growths on the agar were counted with colony counter Gallenkamp (model S 301-C) and recorded.

*Staphylococcus* species was determined by culturing on nutrient agar medium using pour plate method and was incubated at 37 °C for 24 h. Observed colonies were butyrous opaque and pigmented. The colonies were counted and recorded.

The isolating and counting of *streptococcus* spp were done on blood agar medium using pour plate method. Incubation was at 37 °C for 24 h. The colonies were transparent surrounded by an area of haemolysis. The colonies were counted and recorded.

*E. coli* was confirmed by sub culturing onto Eosin methylene blue agar (EMBA) and incubated at a temperature of 37 °C for 24 h. Growth of dark metallic sheen colonies confirmed the presence of *E. Coli*.

Total heterotrophic bacteria was cultured onto nutrient agar and incubated at a temperature of 37 °C for 24 h. The colonies were counted and recorded.

Total coliform was determined using most probable number (MPN) method. The water sample was thoroughly mixed by inverting the bottle several times. The cap was then removed and 50 ml of water was added to the bottle containing 50 ml of MarConkey broth (double strength),

using a 10 ml syringe. 10 ml of water was added to each of the five bottles containing 10 ml of MarConkey broth (double strength). Also, 1 ml of the water was added into each of the 5 bottles containing 5 ml of MarConkey broth (single strength). For the treated water sample, 50 ml of water was added to the bottle containing 50 ml of MarConkey broth (double strength) and 10 ml of water placed into each of the 5 bottles containing 10 ml of MarConkey broth (double strength). The inoculated broths were then incubated at 44 °C for 24 h with the bottles loosely capped. After the incubation period, the results were read and recorded using Cheesbrough (2000) standards.

### Physico-chemical Analysis of Water prior and after application of *G. kola*

Apparent colour of water samples was determined by visual comparison. 100 ml of the water sample was transferred into a pre-cleaned 100 ml beaker. Colour was determined by visual comparison of sample with a colour comparator (Custer Colour Strip). Taste and odour were determined by tasting and smelling the water sample using a panel of ten persons.

The turbidity of the water sample was determined using a multimeter analyzer (Hanna H19828). The meter was calibrated with 0.1M KCl solution for conductivity and buffer (4, 7 and 9) solutions for pH. The values for temperature, turbidity, pH and conductivity were read on the screen. BOD was determined according with the standard titrimetric method (APHA, 2005). The Nitrate ion content was determined using CHROMA colorimeter (model 257) calibrated with standard nitrate solution at 420 nm absorbance. Chloride was determined using the method of IS (2003); 50 ml of the water sample was measured into a conical flask with potassium chromate as indicator and was titrated with 0.02 M silver nitrate until the colour changes to brick red. Determination of Total dissolved solids (TDS) was carried out using a clean evaporating dish which was heated to 180 °C for 1 h in a drying oven and cooled in a desiccator. 100 ml of water sample was added. The water sample was stirred with magnetic stirrer and 50 ml was filtered using Whatman no.1 Filter paper. The total filtrate was transferred into the cooled evaporating dish and evaporated to dryness on a steam bath. The dish and sample were oven-dried at 180 °C for 1 h, cooled in a desiccator and weighed. The cycle of drying, cooling, desiccating and weighing was repeated until constant weight was attained.

### Experiments for Coagulation and Disinfection

The jar test was used. 10 ml of the various concentrations of *Garcinia kola* seed solution were measured into a beaker containing 1000 ml of the sample water. The solutions were mixed rapidly for 2 min; followed by 10 min of gentle mixing using glass rod to aid in coagulant formation. The suspensions were left to stand without disturbance for 1 h (Ndabigengesere et al., 1995). The supernatants formed were decanted and subjected to microbial and physicochemical analysis.

### Statistical analysis

Mean and standard deviation of triplicate values were calculated and the results were analyzed using single factor analysis of variance (ANOVA).

## RESULTS AND DISCUSSION

Table 1 shows the result of the quantitative phytochemical analysis of *Garcinia kola* seed. The alkaloid content of *Garcinia kola* was  $2.11 \pm 0.04$  %, Saponins, flavonoid and tannins contents were  $0.34 \pm 0.04$  %,  $2.16 \pm 0.03$  % and  $0.14 \pm 0.02$  % for *Garcinia kola* respectively and  $1.65 \pm 0.01$  % for Phenol contents of *Garcinia kola*.

Adesuyi et al. (2011) carried out phytochemical screening of *G. kola* seeds and concluded that they showed a high level of saponins (2.471%), flavonoids (2.041%) and cardiac glycosides (3.421%) and that alkaloids and tannins were present in considerable amounts of 0.647 and 0.34%, respectively. But that phenol was present in negligible amount (0.147%). Tannins are metal chelators and can form complexes with macro molecules. Through this process essential substrates co-factor and enzymes of micro-organism are depleted leading to cell death. This accounts for the antimicrobial activity against bacteria and fungi. Phenols and phenolic compounds have been extensively used in disinfections and it remains the standard with which other bactericides are compared (Oakenful, 1981)

Table 2 shows mean ( $\pm$ SD) physicochemical and microbial parameters of water sample before treatment with the seed solutions. The physicochemical analysis showed that the water sample had a mean temperature of  $30.5 \pm 0.10$  °C, mean pH of  $7.4 \pm 0.20$ , mean total dissolved solids (TDS) of  $161.54 \pm 1.13$  mg/L, mean turbidity of  $31.64 \pm 0.08$  NTU, mean electrical conductivity of  $221.4 \pm 0.35$   $\mu$ S/cm, mean Biochemical Oxygen Demand (BOD) of  $5.87 \pm 0.03$  mg/L, mean chloride content of  $0.28 \pm 0.02$  mg/L, mean phosphate content of  $275.19 \pm 9.33$  mg/L, mean nitrate content of  $248.6 \pm 0.27$  mg/L and nitrite of  $1.86 \pm 0.04$  mg/L. Also the microbial assessment of the water sample before treatment indicated that the water sample contains  $12.00 \pm 1.00$  MPN/ml of Total Coliform,  $(7.67 \pm 1.00) \times 10^2$  CFU/ml of *E. coli*,  $(10.33 \pm 1.15) \times 10^2$  CFU/ml of faecal *streptococcus*,  $(15.67 \pm 2.52) \times 10^2$  CFU/ml of *staphylococcus* and too numerous to count (TNTC) for Total Heterotrophic bacteria as showed in Table 2. The raw data obtained from the surface water at Ogor Hill River showed a very high total heterotrophic bacterial population and high faecal indicator bacteria, suggesting the presence of pathogens which is as a result of human activities like abattoir and pig breeding around the environs of the river.

The results presented in Table 3 show physicochemical parameters of water after treatment with *G. kola* seed extract. Temperature of the water sample was not significantly affected following coagulation with *Garcinia kola* seed extract. The mean temperature of water sample before coagulation was  $30.5 \pm 0.10$  °C, on addition of the *Garcinia*

**Table 1:** Quantitative phytochemical analysis of *Garcinia kola* and *Carica papaya* seed

Samples	% Alkaloid	% Flavonoid	% Tannin	% Saponins	% Phenols
<i>Garcinia kola</i>	2.11 ± 0.04	2.16 ± 0.03	0.14 ± 0.02	0.34 ± 0.04	1.65 ± 0.01

Data represent the mean ± standard deviation of triplicate samples.

**Table 2:** Mean (±SD) Physicochemical and microbial parameters of water sample before treatment with *Garcinia Kola* solution

Parameters	Value
Colour	Brownish
Odour	Objectionable
Taste	Objectionable
Temperature (°C)	30.50 ± 0.10
pH	7.40 ± 0.20
TDS (mg/L)	161.54 ± 1.13
Turbidity (NTU)	31.64 ± 0.08
Conductivity (µS/cm)	221.40 ± 0.35
BOD (mg/L)	5.87 ± 0.03
Chloride (mg/L)	0.28 ± 0.02
Nitrate (mg/L)	248.60 ± 10.27
Nitrite (mg/L)	1.86 ± 0.04
Total Coliform (MPN/ml)	12.00 ± 1.00
<i>E.coli</i> (CFU/ml)	767.00 ± 1.00
Fecal streptococcus (CFU/ml)	1033.00 ± 1.15
<i>Staphyl. Aureus</i> (CFU/ml)	1567.00 ± 2.52
Total Heterotrophic Bacteria (CFU/ml)	TNTC

TNTC = CFU/ml > 10,000, NTU = Nephelometric turbidity units

*kola* seed solution, mean temperature had a range of 30.00 ± 0.10 – 30.10 ± 0.20 °C. The *Garcinia kola* seed extract has no significant effect ( $P > 0.05$ ) on temperature of water sample.

The pH of the water sample was generally, slightly affected following coagulation with extract of *Garcinia kola* seed solutions. On addition of various concentration dosages of *Garcinia kola* seeds extract in water sample, pH of water sample decreased from 7.40 ± 0.20 to 6.84 ± 0.17. The slight decrease in pH following treatment with extract of *Garcinia kola* seed may be due to hydrogen ions from the extract, which balanced the hydroxide ion in the water sample. This is in line with previous study which has shown that the use of plant seed extract does not cause any significant change in the pH (Megersa *et al.*, 2014)

The amount of total dissolved solids decreased with increase in the concentration of the *Garcinia kola* solution. At 1 % concentration the TDS was reduced from 161.54 ± 1.13 to 133.42 ± 1.07 mg/L while at 2 %, 3 %, 4 % and 5 % the mean TDS was reduced to 122.53 ± 0.12 mg/L, 118.66 ± 0.20 mg/L, 106.42 ± 0.15 mg/L and 112.94 ± 0.13 mg/L respectively.

Results indicate that *Garcinia kola* seed extracts significantly reduced ( $P < 0.05$ ) TDS of water samples and it exhibited maximum TDS reduction at 4 % extract

concentration. At this optimum dose, *Garcinia kola* seed extract exhibited 34.12% TDS removal from the water sample. At 5% concentration dose, TDS tends to increase which could be as a result of organic particles from the coagulants.

The results indicate that the turbidity of raw water before treatment was 31.64 ± 0.08 NTU but after coagulation with *Garcinia kola* seed solution at different concentrations, turbidity was reduced. At 1 % concentration, the turbidity was reduced to 18.42 ± 0.02 NTU, whereas at 2 %, 3%, 4% and 5 %, turbidity was reduced to 15.82 ± 0.02 NTU, 10.42 ± 0.01 NTU, 11.96 ± 0.03 NTU and 14.33 ± 0.01 NTU respectively. *Garcinia kola* extracts significantly reduced ( $P < 0.05$ ) turbidity of water samples and exhibited maximum turbidity reduction at 3 % extract concentration. At this optimum dose, 67.07 % turbidity was removed by *Garcinia kola* seed extract.

The conductivity of the water samples had slight decreases with increase in the dosage of *Garcinia kola* seed extract. The mean conductivity of water sample before coagulation was 221.4 ± 0.35 µScm<sup>-1</sup>. On addition of the *Garcinia kola* seed solution, mean conductivity had a range of 213.00 ± 0.10 µScm<sup>-1</sup> - 219.40 ± 0.17 µScm<sup>-1</sup>. The *Garcinia kola* seed extract had no significant effect ( $P > 0.05$ ) on conductivity of water sample.

**Table 3:** Mean ( $\pm$ SD) Physicochemical Parameters of water sample after treatment with *Garcinia Kola*

Physiochemical Parameters	1%	2%	3%	4%	5%
Temperature	30.00 $\pm$ 0.20	30.10 $\pm$ 0.20	30.00 $\pm$ 0.10	30.10 $\pm$ 0.10	30.00 $\pm$ 0.20
pH	7.20 $\pm$ 0.10	7.10 $\pm$ 0.15	7.05 $\pm$ 0.22	6.84 $\pm$ 0.17	6.87 $\pm$ 0.29
Residue TDS (mg/L)	133.42 $\pm$ 1.07	122.53 $\pm$ 0.12	118.66 $\pm$ 0.20	106.47 $\pm$ 0.15	112.97 $\pm$ 0.13
Turbidity (NTU)	18.42 $\pm$ 0.02	15.80 $\pm$ 0.02	10.42 $\pm$ 0.01	11.96 $\pm$ 0.03	14.33 $\pm$ 0.01
Conductivity ( $\mu$ S/cm)	219.60 $\pm$ 0.17	218.80 $\pm$ 0.20	217.40 $\pm$ 0.20	215.00 $\pm$ 0.10	213.00 $\pm$ 0.10
BOD (mg/L)	3.68 $\pm$ 0.10	3.33 $\pm$ 0.06	2.50 $\pm$ 0.10	2.50 $\pm$ 0.20	2.67 $\pm$ 0.12
Nitrate (mg/L)	228.00 $\pm$ 0.10	215.41 $\pm$ 0.13	196.87 $\pm$ 0.15	149.30 $\pm$ 0.15	143.40 $\pm$ 0.10
Nitrite (mg/L)	0.24 $\pm$ 0.02	0.22 $\pm$ 0.05	0.21 $\pm$ 0.03	0.16 $\pm$ 0.05	0.12 $\pm$ 0.02
Chloride (mg/L)	0.28 $\pm$ 0.01	0.22 $\pm$ 0.05	0.22 $\pm$ 0.03	0.21 $\pm$ 0.01	0.20 $\pm$ 0.03

**Table 4:** Mean total bacterial count of water samples after treatment with *Garcinia kola* seed extract

Microbial count	Coagulant concentration				
	1 %	2 %	3 %	4 %	5 %
Total.coliform (MPN/ml)	7.00 $\pm$ 0.50	5.00 $\pm$ 1.00	5.00 $\pm$ 1.00	3.00 $\pm$ 1.00	3.00 $\pm$ 0.50
<i>E.coli</i> ( $10^2$ CFU/ml)	5.00 $\pm$ 0.50	4.00 $\pm$ 0.53	3.00 $\pm$ 0.10	2.00 $\pm$ 0.20	2.00 $\pm$ 0.10
<i>Fecal strept.</i> ( $10^2$ CFU/ml)	9.00 $\pm$ 0.10	8.00 $\pm$ 0.50	6.00 $\pm$ 0.20	5.00 $\pm$ 0.53	3.00 $\pm$ 1.00
<i>Staph..Aureus</i> ( $10^2$ CFU/ml)	10.00 $\pm$ 1.00	9.33 $\pm$ 0.15	8.00 $\pm$ 0.53	7.00 $\pm$ 0.20	5.00 $\pm$ 0.53
Total Heterotropic Bacteria ( $10^2$ CFU/ml)	64.00 $\pm$ 2.00	60.00 $\pm$ 1.00	2.00 $\pm$ 1.00	50.00 $\pm$ 0.50	40.00 $\pm$ 1.00

The mean BOD of water sample before coagulation was  $5.87 \pm 0.03$  mg/L and on adding various doses of *Garcinia kola* seed extract, the BOD had a range of  $2.50 \pm 0.10$  -  $3.63 \pm 0.10$  mg/L. The results indicated that *Garcinia kola* seed extracts significantly reduced ( $P < 0.05$ ) BOD of water samples and it exhibited maximum BOD reduction at 3% extract concentration. *Garcinia kola* extract removed 57.41 % of the BOD at this concentration. Above this optimum dosage, BOD increased. The nitrate ions present in the water sample were reduced on increase in the dosage of the *Garcinia kola* seed extract. Mean nitrate ion concentration of the water sample before coagulation was  $248.60 \pm 0.27$  mg/L and on addition of various doses of *Garcinia kola* seed extract the nitrate ion had a range of  $143.40 \pm 0.10$  -  $228.00 \pm 0.10$ . The result indicated that both *Garcinia kola* extracts significantly reduced ( $P < 0.05$ ) nitrate concentration of water samples and it exhibited maximum reduction at 5 %. *Garcinia kola* seed extract which removed 42.32% of nitrate.

The nitrite ion concentration of the water sample was reduced on increase in the dosage of the *Garcinia kola* seed extract. On addition of the different doses of *Garcinia kola* seed extract the nitrite concentration had a range of  $0.12 \pm 0.02$  -  $0.24 \pm 0.02$  mg/L. The result indicated that *Garcinia kola* extracts significantly reduced ( $P < 0.05$ ) nitrite

concentration of water samples and it exhibited maximum reduction at 5 %. *Garcinia kola* seed extract removed 93.54% of nitrite at this dosage.

Chloride ion in the water sample was not significantly affected ( $P > 0.05$ ) following coagulation with *Garcinia kola* seed extract. The mean chloride ion of water sample before coagulation was  $0.28 \pm 0.02$  mg/L but on addition of the *Garcinia kola* seed solution, mean chloride ion had a range of  $0.20 \pm 0.03$  -  $0.28 \pm 0.01$   $^{\circ}$ C.

Table 4 shows mean total bacterial count of water sample after treatment with *Garcinia kola* seed extract. *Garcinia kola* seed extract reduced microbial load at different concentrations. Before treatment with the seed solutions, Total Coliform count of water sample was  $12.00 \pm 1.00$  MPN/ml, *E.coli* was  $767.00 \pm 1.00$  CFU/ml, *Fecal streptococcus* was  $1033.00 \pm 1.15$  CFU/ml, *Staphylococcus aureus* was  $1567.00 \pm 2.52$  CFU/ml while Total Heterotropic Bacteria was above 10,000 CFU/ml i.e. too numerous to count (TNTC).

On treatment with 1% *G. kola* solution, total coliform, *E.coli*, *Fecal streptococcus*, *Staphylococcus aureus* and Total heterotropic bacteria were reduced to  $7.00 \pm 0.50$  MPN/ml,  $(5.00 \pm 0.05) \times 10^2$  CFU/ml,  $(9.00 \pm 0.10) \times 10^2$  CFU/ml,  $(10.00 \pm 1.00) \times 10^2$  CFU/ml and  $(64.00 \pm 2.00)$

$\times 10^2$  CFU/ml respectively. Total coliform, *E.coli*, *Fecal streptococcus*, *Staphylococcus aureus* and Total heterotrophic bacteria were reduced to  $5.00 \pm 1.00$  MPN/ml, ( $4.00 \pm 0.53$ )  $\times 10^2$  CFU/ml, ( $8.00 \pm 0.50$ )  $\times 10^2$  CFU/ml, ( $9.33 \pm 0.15$ )  $\times 10^2$  CFU/ml, and ( $60.00 \pm 1.00$ )  $\times 10^2$  CFU/ml for 2 % and  $5.00 \pm 1.00$  MPN/ml, ( $3.00 \pm 0.10$ )  $\times 10^2$  CFU/ml, ( $6.00 \pm 0.20$ )  $\times 10^2$  CFU/ml, ( $8.00 \pm 0.53$ )  $\times 10^2$  CFU/ml and ( $52.00 \pm 1.00$ )  $\times 10^2$  CFU/ml for 3 % solutions, respectively. The microbial load was also reduced at 4 % and 5 % concentration with the total coliform, *E.coli*, *Fecal streptococcus*, *Staphylococcus aureus* and Total heterotrophic bacteria being reduced to  $3 \pm 1.00$  MPN/ml, ( $2.00 \pm 0.20$ )  $\times 10^2$  CFU/ml, ( $5.00 \pm 0.53$ )  $\times 10^2$  CFU/ml, ( $7.00 \pm 0.20$ )  $\times 10^2$  CFU/ml and ( $50.00 \pm 0.50$ )  $\times 10^2$  CFU/ml for 4 % and  $3 \pm 0.50$  MPN/ml, ( $2.00 \pm 0.10$ )  $\times 10^2$  CFU/ml, ( $3.00 \pm 1.00$ )  $\times 10^2$  CFU/ml, ( $5.00 \pm 0.53$ )  $\times 10^2$  CFU/ml and ( $40.00 \pm 1.00$ )  $\times 10^2$  CFU/ml for 5 %, respectively. Gamba *et al.* (2011) studied the antibacterial activity of ether and aqueous extracts *Garcinia Kola* seeds against clinical bacterial isolates of *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* at 50, 100, 150 mg/ml. They observed significant anti-microbial activity and concluded that it may be due to phytochemical compounds (flavonoids, tannins, saponins, sterols, and terpenes) present in the seeds.

The result from this work also indicated that on treatment of water sample with the seed solutions, *Garcinia kola* showed antimicrobial efficiency of 41.67 – 75.00 % for Total coliform, 34.81 – 73.92 % for *E.coli*, 12.87-70.96 % for *Fecal streptococcus*, 36.18 – 68.09 % for *staphylococcus Aureus* and 45.30 – 65.81 % for Total heterotrophic bacteria. As the concentration of the *Garcinia kola* solution increased from 1- 5 %, the inhibition of the microbial growth by the solutions increased i.e. the extracts worked in a dose dependent manner.

## CONCLUSIONS

This study has successfully revealed that the seed extracts of *Garcinia kola* seed solution significantly reduced TDS, turbidity, BOD, nitrate, nitrite concentrations of water samples. It also possesses antimicrobial properties against total coliform, *E.coli*, *streptococcus spp.*, *staphylococcus Aureus* and total heterotrophic bacteria. These extracts are natural antimicrobial agents and coagulants with potentials in controlling bacteria which causes water borne diseases and reduces suspended particles in raw water. It can be concluded that *Garcinia kola* seed can be used in treating water.

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