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Microbial Load of Domestic Water Sources Treated with *Moringa oleifera* and *Jatropha curcas* Seed Powder

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Authors' contributions

This work was carried out in collaboration among all authors. Author UGE conceptualized the problem, designed the study and handled the experiment. Author ARA supplied materials with which the manuscript was drafted and also managed correspondences. Author NAO proof read the manuscript and effected corrections where necessary. Author KMR performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Microbial load of domestic water sources treated with *Moringa oleifera* and *Jatropha curcas* seed powder**.**
Study Design: The container test method was used for the treatments. One gram (1.0 g) each of the plant seed (*Moringa oleifera* and *Jatropha curcas* seeds) powder was weighed and added separately into 1000 ml of water sample. The mixture was stirred rapidly for 3 minutes and allowed to stand undisturbed for 1 hour and 3 hours, after which the top water was decanted.
Place and Duration of Study: Advanced Research Laboratory, Department of Microbiology, Gregory University Uturu, from May to September 2017.
Methodology: Tenfold serial dilutions were used for processing of the domestic water samples, after which 0.5 ml of the water sample was cultured on the media using the spread plate method.

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This was incubated appropriately and other standard microbiological methods were employed to determine microbial loads and characterize the isolates.
Results: The microbial counts were generally high, $0.6\times10^1 - 2.5\times10^2$ cfu/ml (borehole), $0.8\times10^1 - 6.3\times10^3$ cfu/ml (well), $2.0\times10^1 - 1.4\times10^4$ cfu/ml (stream), while the total potential pathogenic bacteria counts (TPPBC) were the least in occurrence. Treatment with *Moringa oleifera* and *Jatropha curcas* seed powders showed a significant decrease in the microbial load. After treatment with 1.0g of the seed powder for one hour, an apparent decrease in the microbial load was noticed. When allowed for three hours (3 hrs), the counts further reduced to no growth for potential pathogenic bacteria (TPPBC) especially for water samples that had low counts.
Conclusion: *Moringa* and *Jatropha* seeds powder showed efficiency as a biocoagulant and thus can be used for water treatment. *Moringa* seed powder had a greater potential to serve as an alternative coagulant for water treatment. The intervention improved the quality of water and will provide significant benefits to the health of the consumer rural populace.

Keywords: Jatropha curcas; Moringa oleifera; microbial load; domestic water sources; Uturu.

1. INTRODUCTION

Water has since been proved to occupy about two-thirds of the earth but in spite of its abundance, the availability of potable water is an enormous problem in both developing and developed countries [1]. The consumption of unsafe water has resulted in the contraction of various diseases and to the death of many people of all ages. The quality of domestic water is dependent on its source and type [1]. However, the quality of water is of vital concern for mankind since it is directly linked with human welfare [2].

Anthropogenic activities in any given area may influence the water quality in that particular area [3]. Domestic water supplies are one of the fundamental requirements for human life, which without it; life cannot be sustained beyond a few days. Poor water, sanitation and lack of access to adequate water supplies lead to the spread of disease which children bear the greatest health burden [4]. Domestic water supply in most developing countries is sourced from groundwater, surface water and atmospheric water with the former two being available all season [5].

Good health is therefore basic to human welfare and a fundamental objective of social and economic development, yet most Nigerians lag far behind other developing countries in the vital task of improving health [6].

Nigeria is one of such developing countries where about half of its over 170 million citizens lack access to potable water. While many of the residents of the urban areas provide water for themselves from private or commercial boreholes; millions who live in the villages still get their domestic water from streams and rivers [7].

Statistics from To Water Aid Nigeria shows that over 63 million Nigerians have no choice but to get water from wherever they can. About 45,000 children under five years old die every year from diarrhea caused by unsafe water and poor sanitation [7].

The use of natural materials of plant origin to clarify turbid surface waters is believed to have started from Biblical book of Exodus (15:23-27), "*And the people murmured against Moses, saying, "What shall we drink?" And he cried unto the Lord; and the Lord showed him a tree, which when he had cast into the waters, the waters were made sweet...."* [8]

Moringa oleifera belongs to the family *Moringaceae* of shrubs and is cultivated in the tropical belt. Bichi [9] has described *Moringa oleifera* as a multi-purpose tree for life. The seeds are eaten green, roasted, powdered and steeped for tea or used in curries. It has found applications in medicinal uses, in cosmetics, in food supplements, and water treatment [9]. Polyelectrolyte has been identified as one of the active ingredients in the *M. oleifera* seed. The subject of investigation of *M. oleifera* is, as a result, its use for coagulation, co-coagulation, or coagulant aid in many parts of the world, which has enabled the softening of water and have potential advantage since it is accompanied by very low reduction in alkalinity, which is required to provide the necessary buffering capacity to achieve required treatment objectives [9]. Many researchers have also identified the presence of an active antimicrobial agent in *Moringa oleifera* seeds [9].

Jatropha curcas L. (physic nut) is a species of flowering plant in the spurge family *Euphorbiaceae*. It is called *olulu-idu/uru* by the Igbos [10]. It is now widely cultivated in both tropical and sub-tropical regions around the world [10].

Jatropha species are very toxic and should not be used in herbal medicine as advised by Lioglier [11]. The various parts of *Jatropha* plants are pounded and applied on skin infected with eczema, itches, carbuncles, mouth blisters, wounds and swelling [12]. Venereal diseases and urinary discharge are also believed to be cured with this plant [13]. Phorbol esters from *Jatropha* species have been reported to possess tumour-promoting activity where their actions stimulate protein kinase C involved in signal transduction and development of most cells and tissues. However, its role in producing tumours was found to be non-significant in mice [14]. *J. curcas* is one of the species that is used for cancer treatments in Mexico [15]. Phorbol esters extracted from the seed of *J. curcas* inhibited *S. pyrogenes*, *Proteus mirabilis*, *Pseudomonas putida*, *Fusarium* sp., *A. niger* and *Curvularia lunata* [16].

Access to safe drinkable water is a major concern throughout Achara-Uturu Community in Isuikwuato Local Government Area, Abia State, Nigeria. The unavailability of potable water has been a critical challenge requiring attention in this community and has resulted in dependence on untreated water from surface run-off for consumption and other domestic functions which has caused water-borne diseases. Onwuchekwa et al. [6] reported the prevalence of typhoid fever in referral hospitals in Umuahia and Aba, Abia State, Nigeria as 41.6% and 50.0% respectively. Ogwuegbu et al. [17] reported 15.3% of typhoid in Uturu-Okigwe. The primary essence of water treatment is to improve its quality to acceptable standards [18]. The treatment processes are usually aimed at reducing the spread of waterborne diseases. Difficulties associated with the adoption of certain water treatment approaches in rural communities of Nigeria is as a result of the high cost and scarcity of chemical coagulants and disinfectants which even when available could raise a lot of safety issues among the patronizing populace. For instance, aluminium sulphate (alum) generates acidic water which is unsafe for pregnant women and has been known to cause predementia in some people [19]. The absence of electricity supply in Uturu community makes it impossible to have a water treatment plant, which normally relies for its functionality on electricity. This research work derived its objective from the foregoing limitations. These limitations make it mandatory that we must develop simple, affordable and environmentally friendly water purification alternatives, such as the use of *Moringa oleifera and Jatropha curcas* seed powder for use in local water purification in communities where the majority of the rural poor dwell.

2. MATERIALS AND METHODS

2.1 Study area

Uturu is a rural community in Isuikwuato L.G.A of Abia State, Nigeria, where farming is the main source of living of the people.

The main surface water supply in Uturu is the Ihiku stream, with very few seasonal privately owned hand-dug wells. The rainy season months are April to September, while the dry season lasts from October to February.

2.2 Collection of Water Samples

The water samples were borehole, well water and stream collected using the same method as inhabitant normally use. Seasonal variations were considered during the sample collections (Dry and Rainy seasons). For bacteriological water analysis, contamination of the water samples was avoided before and after sampling by collecting the samples in clean, sterile 1000 ml screw-cap bottles. The samples were labelled to indicate the source from which they were collected. They were transported in an ice-pack container to the Advance Microbiology laboratory of Gregory University, Uturu.

2.3 Collection of *Moringa oleifera* and *Jatropha curcas* Seeds

The seeds were collected from Uturu and were authenticated by Mr. Tony at the Department of Biology, College of Natural and Applied Sciences of Gregory University, Uturu.

2.4 Preparation of *Moringa oleifera* and *Jatropha curcas* Seeds Powder

The collected *M. oleifera and Jatropha curcas* seeds were de-shelled and the endocarps air-dried at room temperature. Direct sunlight was avoided to prevent degradation of some of the plant phytochemicals or antimicrobial

constituents. The dried kernels were pulverized using an electric blender to obtain a powder. The powder was sieved with a plastic strainer of small pore size to obtain a fine powder. The fine powder obtained was stored in a sterile air-tight container in a dark place to prevent oxidation [20].

2.5 Water Treatment using *M. oleifera* and *Jatropha curcas* Seed Powder

One litre (1000 ml) each of the water samples were transferred into each of four chemically free sterile clean plastic white containers pre-sterilized with alcohol. The concentrations of plant seed (1 g) were added to the water samples contained in the plastic containers. The mixture (water and plant seed-1000/g) was stirred rapidly with electric stirrer for 60 seconds and then slowly for 2 minutes. The treated water samples were allowed to stand undisturbed for 1 hour and 3 hours after which the top was decanted and 100 ml collected for subsequent microbial and physicochemical analysis [21].

2.6 Enumeration of Microbial Counts

Tenfold serial dilutions were used for processing of all the water samples. After the dilutions, exactly 0.5 ml of the water samples were planted on the media (Eosin methylene blue agar, McConkey agar, Mueller-Hinton agar, blood agar and nutrient agar) using the spread plate method and incubated. On the establishment of growth, each culture plate was examined closely for distinct colonies [22;23]. The colonies formed on the surfaces of the agar were counted with colony counter and was expressed as colony-forming unit per ml (cfu/ml) for each of the total viable microorganisms, total coliform, faecal coliform, fungi and possibly pathogenic bacteria.

2.7 Bacterial Isolation and Identification

The bacterial isolates were characterized and identified based on their motility, microscopic and colonial morphologies, Gram staining reaction, biochemical tests which include; catalase, methyl red, Voges Proskauer (MR-VP), nitrate reduction test, starch hydrolysis, gelatin liquefaction test, indole, oxidase, urease, triple sugar iron agar (TSI) and sugar fermentation as described in medical laboratory manual for tropical countries concerning the Bergey's manual of systemic bacteriology [24]. The fungi were identified based on their cultural and microscopic characteristics and concerning the methods described by Barnett et al. [25].

3. RESULTS

In the dry season, the microbial load of the borehole water samples was 1.2×10^2 cfu/ml for TVC, 1.0×10^1 cfu/ml (TCC), 0.5×10^1 cfu/ml (TFC), TFC and TPPB were absent before treatment. After 1hr and 3hrs of treatment, TVC was reduced to 1.0×10^2 cfu/ml and 1.9×10^1 cfu/ml for *M. oleifera, J. curcas* was 0.9×10^2 cfu/ml and 1.6×10^1cfu/ml. TCC was reduced to 0.1×10^1 cfu/ml for *M. oleifera.* and No bacterial growth (NBG) was recorded for *J. curcas* after 3 hrs of treatment. Total fungal count followed the same trend until no growth was noticed after 3hrs of treatment with the plant's seeds powder. However, *J. curcas* seed powder reduced the microbial load better than the *M. oleifera* (Table 1).

The well water had higher microbial growth counts which range from 0.5×10^1 - 5.7×10^3 cfu/ml before treatment. It was reduced to NBG - 5.0×10^2 cfu/ml for *M. oleifera,* and NBG - 3.5×10^2 cfu/l for *J. curcas* (Table 2).

The stream water had the highest microbial range of 1.1×10^1 - 1.3×10^4 cfu/ml before treatment. After treatment with 1.0 g of the seed powder for 1hr, an apparent decrease was pragmatic. When allowed for 3hrs, the counts further reduced; TVC was 4.2×10^3 - 2.0×10^3 cfu/ml, TCC 1.1×10^2 – 1.0×10^2 cfu/ml and TFCC 1.3×10^1 - 1.0×10^1 cfu/ml, no bacterial growth was recorded for potential pathogenic bacteria (TPPBC). The TFC was 1.0×10^1 - 0.9×10^1 cfu/ml (Table 3).

Considering the rainy season, the microbial counts were generally high, 0.6×10^1 – 2.5×10^2 cfu/ml (borehole), 0.8×10^1 – 6.3×10^3 cfu/ml (well), 2.0×10^1 – 1.4×10^4 cfu/ml (stream). After the treatment, it was also reduced (Tables 4 - 6).

Based on the conventional methods using colonial features on media, microscopic cell arrangements, biochemical reactions and carbohydrate utilization; the following fungi and bacteria were identified: *Aspergillus fumigatus, Aspergillus niger* and *Candida albicans. Erwinia tasmaniensis*, *Serratia* marcescens, *Staphylococcus saprophyticus*, *Enterococcus faecalis, Staphylococcus aureus*, *Escherichia coli*, *Salmonella* species, *Pseudomonas aeruginosa*, *Proteus mirabilis, Klebsiella pneumoniae, Bacillus cereus* and *Enterobacter aerogenes* (Table 7 and 8).

Table 1. Microbial load (cfu/ml) of borehole water samples treated with 1.0g of the plant's seed (dry season)

Microbial group	Before treatment	1hr after treatment		3hrs after treatment		Standard
		M. oleifera	*J. curcas*	*M. oleifera*	*J. curcas*	WHO
TVC	1.2×10^{2}	1.0×10^{2}	0.9×10^{2}	1.9×10^{1}	1.6×10^{1}	1.0×10^{2}
TCC	1.0×10^{1}	0.6×10^{1}	0.4×10^{1}	0.1×10^{1}	NBG	10
TFCC	NBG	NBG	NBG	NBG	NBG	0
TPPBC	NBG	NBG	NBG	NBG	NBG	0
TFC	0.5×10^{1}	0.3×10^{1}	0.2×10^{1}	NFG	NFG	0

Key: TVC = Total viable count, TCC = Total coliform count, TFCC = Total faecal coliform count, TPPBC = Total potential pathogenic bacteria count, TFC = Total fungal count, NBG = No bacteria growth, NFG = No fungal growth

Table 2. Microbial load (cfu/ml) of well water samples treated with 1.0 g of the plant's seed (dry season)

Microbial group	Before treatment	1hr after treatment		3hrs after treatment		Standard
		M. oleifera	J. curcas	M. oleifera	J. curcas	WHO
TVC	5.7×10^{3}	3.8×10^{3}	3.2×10^{3}	5.0×10^{2}	3.5×10^{2}	1.0×10^{2}
TCC	3.8×10^{2}	2.7×10^{2}	2.0×10^{2}	4.0×10^{1}	3.5×10^{1}	10
TFCC	2.1×10^{1}	1.6×10^{1}	1.4×10^{1}	0.5×10^{1}	0.2×10^{1}	0
TPPBC	0.5×10^{1}	0.3×10^{1}	0.2×10^{1}	NBG	NBG	0
TFC	2.8×10^{1}	2.0×10^{1}	1.4×10^{1}	0.7×10^{1}	0.5×10^{1}	0

Key: TVC = Total viable count, TCC = Total coliform count, TFCC = Total faecal coliform count, TPPBC = Total potential pathogenic bacteria count, TFC = Total fungal count, NBG = No bacteria growth, NFG = No fungal growth

Table 3. Microbial load (cfu/ml) of stream water samples treated with 1.0g of the plant's seed (dry season)

Microbial group	Before treatment	1hr after treatment		3hrs after treatment		Standard
		M. oleifera	J. curcas	M. oleifera	J. curcas	WHO
TVC	1.3×10^{4}	1.0×10^{4}	0.9×10^{4}	4.2×10^{3}	2.0×10^{3}	1.0×10^{2}
TCC	4.9×10^{2}	3.7×10^{2}	3.4×10^{2}	1.1×10^{2}	1.0×10^{2}	10
TFCC	3.4×10^{1}	2.6×10^{1}	2.4×10^{1}	1.3×10^{1}	1.0×10^{1}	0
TPPBC	1.1×10^{1}	0.7×10^{1}	0.2×10^{1}	0.1×10^{1}	NBG	0
TFC	3.8×10^{1}	2.9×10^{1}	2.0×10^{1}	1.0×10^{1}	0.9×10^{1}	0

Key: TVC = Total viable count, TCC = Total coliform count, TFCC = Total faecal coliform count, TPPBC = Total potential pathogenic bacteria count, TFC = Total fungal count, NBG = No bacteria growth, NFG = No fungal growth

Table 4. Microbial load (cfu/ml) of borehole water samples treated with 1.0g of the plant's seed (rainy season)

Microbial group	Before treatment	1hr after treatment		3hrs after treatment		Standard
		M. oleifera	J. curcas	M. oleifera	J. curcas	WHO
TVC	2.0×10^{2}	1.5×10^{2}	1.3×10^{2}	4.7×10^{1}	3.9×10^{1}	1.0×10^{2}
TCC	2.0×10^{1}	1.5×10^{1}	1.3×10^{1}	0.6×10^{1}	0.4×10^{1}	10
TFCC	0.3×10^{1}	NBG	NBG	NBG	NBG	0
TPPBC	0.1×10^{1}	NBG	NBG	NBG	NBG	0
TFC	0.6×10^{1}	0.4×10^{1}	0.2×10^{1}	0.2×10^{1}	NFG	0

Key: TVC = Total viable count, TCC = Total coliform count, TFCC = Total faecal coliform count, TPPBC = Total potential pathogenic bacteria count, TFC = Total fungal count, NBG = No bacteria growth, NFG = No fungal growth

Table 5. Microbial load (cfu/ml) of well water samples treated with 1.0g of the plant's seed (rainy season)

Microbial group	Before treatment	1hr after treatment		3hrs after treatment		Standard
		M. oleifera	J. curcas	M. oleifera	J. curcas	WHO
TVC	6.3×10^3	4.2×10^3	3.9×10^3	7.6×10^2	5.0×10^2	1.0×10^2
TCC	4.9×10^2	3.9×10^2	1.8×10^2	19.0×10^1	15.0×10^1	10
TFCC	2.4×10^1	1.3×10^1	1.0×10^1	0.9×10^1	0.6×10^1	0
TPPBC	0.8×10^1	0.5×10^1	0.4×10^1	0.1×10^1	NBG	0
TFC	3.2×10^1	2.6×10^1	1.9×10^1	0.7×10^1	0.8×10^1	0

Key: TVC = Total viable count, TCC = Total coliform count, TFCC = Total faecal coliform count, TPPBC = Total potential pathogenic bacteria count, TFC = Total fungal count, NBG = No bacteria growth, NFG = No fungal growth

Table 6. Microbial load (cfu/ml) of stream water samples treated with 1.0g of the plant's seed (rainy season)

Microbial group	Before treatment	1hr after treatment		3hrs after treatment		Standard
		M. oleifera	J. curcas	M. oleifera	J. curcas	WHO
TVC	1.4×10^4	1.1×10^4	1.0×10^4	4.5×10^3	3.8×10^3	1.0×10^2
TCC	0.6×10^3	0.5×10^3	0.4×10^3	2.8×10^2	1.9×10^2	10
TFCC	3.2×10^2	2.4×10^2	2.2×10^2	4.9×10^1	4.0×10^1	0
TPPBC	2.0×10^1	1.1×10^1	0.5×10^1	0.2×10^1	NBG	0
TFC	0.5×10^2	4.0×10^1	3.3×10^1	1.8×10^1	1.1×10^1	0

Key: TVC = Total viable count, TCC = Total coliform count, TFCC = Total faecal coliform count, TPPBC = Total potential pathogenic bacteria count, TFC = Total fungal count, NBG = No bacteria growth

4. DISCUSSION

The microbial load of the borehole water samples were higher than 0.3-0.5 cfu/100L reported by Nwaugo et al. [1] and total potential pathogenic bacteria (TPPB) were absent before treatment. After 1hr and 3hrs of treatment, total viable count (TVC) was reduced to 1.0×10^2 cfu/ml and 1.9×10^1cfu/ml for *M. oleifera, J. curcas* was 0.9×10^2 cfu/ml and 1.6×10^1cfu/ml, while the total coliform count (TCC) was reduced to 0.1×10^1cfu/ml for *M. oleifera* and to no bacteria growth (NBG) for *J. curcas* after 3 hrs of treatment. Total fungal count followed the same trend until no growth was noticed after 3hrs of treatment with the plant's seeds powder. Rural communities which rely mainly on river, stream, well and pond water sources lack access to potable water supplies as a result of similar microbial load reported by Edessa et al. [26]. WHO [27] described waters from these sources as faecally contaminated, devoid of treatment and are used directly by the inhabitants. However, *J. curcas* seed powder reduced the microbial load better than the *M. oleifera.* The microbial growth counts of the well water were reduced to 5.0×10^2 cfu/ml and NBG for *M. oleifera,* and 3.5×10^2 cfu/l and NBG for *J. curcas.* The stream water had the highest microbial growth among the water sources and was also reduced after the treatment concerning time. Broin et al. [28] reported the flocculating properties of *M. oleifera* protein extract towards bacteria. The bacteriostatic effect has also been observed against several human pathogens. However, Suarez et al. [29] reported the inhibition of *Escherichia coli* growth to be transitory, with the resumption of growth after 6 hours. The growth of bacterial species on the blood agar suggested that consumers of this water are endangered, especially by drinking it. This may cause serious water-borne health-related illnesses. The culture on blood agar produced hemolytic zones of various diameters. This indicated potentially pathogenicity and the likelihood of causing diseases when they gain entrance into the human body. After treatment with 1.0 g of the seed powder for 1hr, an apparent decrease was pragmatic. When allowed for 3hrs, the counts further reduced. Devappa et al. [16] proved that the seed of *J. curcas* inhibited *S. pyrogenes*, *Proteus mirabilis*, *Pseudomonas putida*, *Fusarium* sp., *A. niger* and *Curvularia lunata* respectively. The purification is due to the functional groups in the amino acids of plant seed proteins. Considering the rainy season of the domestic water sources, the microbial counts were generally high and after the treatment, it was also reduced. This supports the findings of Daniyan et al., who reported

Table 7. Identification of fungi isolated from the various water samples

Macroscopy/Colony Morphology				Microscopy	
Nature of Colony	**Reverse side**	**Texture**	**Nature of growth**	**Characteristics**	**Organism**
Woolly, whitish-yellow edge with a covering of brown which later turned dark brown to black	White to yellow	Woolly	Rapid	Septate hyphae with unbranched conidiophores arising from specialized foot cell. The conidiophore is enlarged at the tip forming a rounded vesicle which is covered with flask-shaped that has chains of smooth dark brown conidia	*Aspergillus niger*
Powdery, whitish edge with a covering of blue-green which later turns dark green.	White to tan	Powdery	Rapid	Septate hyphae with unbranched conidiophores arising from specialized foot cell. The conidiophore is enlarged at the tip forming a rounded vesicle which is covered with flask-shaped that has chains of round blue conidia	*Aspergillus fumigatus*
Whitish cream-coloured, pasty and smooth SDA.	white	creamy	Rapid	Septate pseudohyphae with clusters of round blastospore at the septa and large thick-walled terminal chlamydospores, positive to Germ-tube test.	*Candida albicans*

Table 8. Identification of bacteria isolated from the various water samples

Colony features	Microscopy	Biochemical reactions												Carbohydrate utilization							
	Cell Arrangement	spore	Motility	Capsule	Catalase	Oxidase	Coagulase	Indole	Nitrate	MethylRed	V.P	Urease	H_2S	citrate	Glucose	Sucrose	Lactose	maltose	mannitol	xylose	Organism
Large smooth colonies with orange pigments on nutrient agar (NA).	Gram-negative short rods in singles and chains	-	+	-	-	-	-	-	-	-	+	-	-	+	+	+	+	-	-	-	*Erwinia* species
Large smooth colonies with red pigments on Nutrient Agar (NA).	Gram-negative short rods in single	-	+	-	-	-	-	-	-	-	+	±	-	+	+	+	-	-	+	-	*Serratia marcescens*
Smooth circular colonies creamy and butyrous and translucent on Nutrient Agar (NA)	A gram-positive group of oval cells	-	-	-	+	-	-	+	+	+	+	+	+	-	+	+	+	+	+	+	*Staphylococcus saprophyticus*
Small dark red colonies that ferment lactose on MacConkey Agar (MA)	Gram-positive cocci in pairs and some in short chains	-	-	-	-	-	-	-	-	+	+	-	-	-	+	+	+	+	+	+	*Enterococcus faecalis*
Circular smooth colonies with light-yellow pigments on Mannitol Salt Agar (MSA).	Gram-positive group of oval cells, some clustered	-	-	-	+	-	+	+	+	+	+	+	+	-	+	+	+	+	+	+	*Staphylococcus aureus*
Small pink shiny smooth colonies on MacConkey Agar (MA).	Gram-negative short rods in singles	-	+	-	+	-	-	+	-	+	-	-	-	-	+	±	+	+	+	+	*Escherichia coli* and *fergusonii*

Colony features	Microscopy	Biochemical reactions													Carbohydrate utilization						Organism
	Cell Arrangement	spore	Motility	Capsule	Catalase	Oxidase	Coagulase	Indole	Nitrate	MethylRed	V.P	Urease	H_2S	citrate	Glucose	Sucrose	Lactose	maltose	mannitol	xylose	
Non-lactose fermenting, pale coloured colonies with black centres on SSA.	Gram-negative short rod in singles	-	+	+	+	-	-	-	-	-	-	-	+	-	+	-	-	+	+	+	*Salmonella* enterica
Flat large spreading colonies with dark-blue colouration on nutrient agar (NA).	Gram-negative short rods in single and some appeared in chains	-	+	+	-	+	-	-	-	-	-	-	-	-	+	-	-	-	+	-	*Pseudomonas aeruginosa*
Large swarmy creamy and translucent colonies on NA	Gram-negative short rods in singles	-	+	-	+	+	-	-	+	+	-	+	+	+	+	+	+	-	-	-	*Proteus mirabilis*
Large mucoid pink colonies on MA	Gram-negative short rod in singles	-	-	+	-	-	-	-	+	-	+	+	-	+	+	-	+	-	-	-	*Klebsiella pneumoniae*
Cream raised dull colonies, waxy with projection margins on NA	Gram-positive rods in pairs and some appeared in singles	+	-	+	+	-	-	-	-	-	-	-	-	+	+	+	+	+	-	-	*Bacillus cereus*
Slight mucoid pink colonies on MA	Gram-negative short rod in singles	-	+	+	-	-	-	-	+	-	+	+	-	-	+	+	-	-	+	-	*Enterobacter aerogenes.*

KEY: + = Positive, - = Negative, V.P = Voges-Proskauer, NA = Nutrient Agar, MA = MacConkey Agar, BA = Blood Agar

that the process of flocculation removes about 90-99% of bacteria which are normally attached to the solid particles. Most plants seed proteins are positively charged, they bind to the contrarily charged particles in the water through the mechanism of adsorption and neutralization especially when the pH is below 10 Kekuda [30] observed a considerable reduction in the growth of test bacteria by distillate of *M. oleifera,* suggesting antibacterial effect. Among the bacteria tested, more inhibition was observed in the case of *E. coli* followed by *S. aureus, K. pneumoniae, P. aeruginosa and B. subtilis* as reported by Kekuda [30]. Inhibition of fungi was also observed as reduced colony diameter in plates poisoned with distillate as compared to control plates. More inhibition of *A. niger* was found followed by *A. oryzae, A. terreus and A. nidulans* [30]. The antimicrobial activity of the steam distillate of *M. oleifera* might be possibly due to the essential oil fraction of the plant material present in the distillate fraction [30]. The genera *Escherichia*, *Klebsiella*, *Enterobacter* and *Serratia* (collectively called the coliform bacilli) and *Proteus* include overt and opportunistic pathogens responsible for a wide range of infections. *Bacillus cereus* has been implicated in food-borne intoxication. *Escherichia fergusonii* which is closely related to the well-known species *Escherichia coli* cause bacteraemia or urinary tract infections. *Escherichia fergusonii* was reported by Olowe et al. [31] as the new emerging enteropathogen from drinking water sources in Ado-Ekiti, Ekiti State, Nigeria. *Staphylococcus aureus* and *Pseudomonas aeruginosa* cause diseases like mastitis, abortions and upper respiratory complications. Aside *Escherichia* species and some *Bacillus sp.,* most microorganisms have been implicated as a causative agent of one waterborne disease or the other. For instance, *Salmonella sp., Shigella sp.,* and *Proteus sp.* are the causative agents of typhoid fever, dysentery and urinary tract infection respectively. *Aspergillus niger* has been reported to cause lung diseases, aspergillosis and otomycosis. Similarly, most *Aspergillus* species are human and livestock pathogens associated with aspergillosis of the lungs and sometimes causing corneal, otomycotic and nasoorbital infections. They produce a significant quantity of aflatoxin. *Candida albicans* is reported to cause vaginitis and yeast mastitis.

5. CONCLUSION

The results obtained showed that seed powders of *M. oleifera* and *Jatropha curcas* had coagulating properties at a loading dose of 1.0 g/L. This serves as a greater potential for alternative coagulant for water treatment. Thus, the intervention improved the quality of water and provided significant benefits to the health of people in the rural area. The use of local *Moringa* and *Jatropha* seeds as primary coagulants for reduction of microbial load of domestic waters was helpful in the production of water within acceptable permissive standards in this rural area where the purchase of chemical coagulants is not even an option. This research succeeded in putting the reasons for the high microbial load in water supply sources in Achara-Uturu community and has shown how inexpensive natural coagulants can be used for water purification.

This calls for immediate actions of UNICEF, UNAIDS, governmental and non-governmental bodies to liberate this community from water-borne related diseases by citing regional water treatment plant that is environmentally friendly and safe, such as the use of *Moringa* and *Jatropha* seeds as the coagulant.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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