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Study on Costus Afer Juice and its Dried Peels as Coagulants for Treatment of Amassoma River Water in Niger Delta

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***Abstract**: Drinking water is an inevitable necessity for the existence of the human race on planet earth, but contamination of this water has made it difficult for people to get clean water source for drinking. This has made local dweller or villagers to use alum as coagulant to treat their river water before consumption in communities such as Amassoma in Bayelsa State Nigeria. Alum is known for its high potential health risk even in minute amount in water. This research work looks at the coagulation of Amassoma river water using costus afer juice and its dried peels which are bio-product with no potential health risk in treating Amassoma river water before consumption. The parameters analyzed in the water treatment are Total Dissolved Solids (TDS) Turbidity, Electrical conductivity and pH. The experimental was run for four days and the result showed that both the peels and juice of costus afer effectively coagulated the river water. The juice and peels treated water had pH 6.8 and 7.4 on the third and fourth day within World Health Organization (W.H.O) limits. Their turbidity values are also lower than the untreated Amassoma river water. They also had TDS values of 118.47 and 148.16 ppm respectively within W.H.O standard. The turbidity value of the juice treated water is within W.H.O limits while that of the dried peels was slightly above W.H.O standard. Comparing these result with alum treated river water showed that despite the alum treated water having a lower turbidity of 3.02 FTU within W.H.O standard, it had a higher TDS (1528 ppm) and EC (3856 µS) values far above W.H.O limits and pH more acidic and far below W.H.O acceptable standards. This makes costus afer juice and peels better coagulating agent for treating Amassoma river water compared to the alum compounded with its health hazards. Between the costus afer juice and its dried peels, the juice performed better as a coagulating agent for the treatment of Amassoma river water.*

Keywords—Costus afer; Coagulant; Test jar; Water treatment; Turbidity; Total dissolved solid

1. INTRODUCTION

Water plays an important role for the survival of living things on earth specifically human beings, plant and animals. The access to clean drinking water mostly in rural areas and villages in developing countries has been of great concern. Drinking of unclean water exposes people especially children to diseases such as diarrhea, cholera, allergies and other water borne diseases caused by bacteria's and viruses. This diseases if not properly handle can lead to death. The World Health Organization [WHO] estimates that 1.8 billion people worldwide do not have access to clean drinking water [1]. This has made water treatment and purification important before consumption.

The process of treating and purifying water for consumption is expensive and arduous because of the chemicals, micro-organism, toxic metals, suspended solids and dissolved organic and inorganic materials in the water. This in turn has made rural dwellers to look for alternative method for purifying their water before drinking.

The use of aluminum sulphate (alum) has become an easy way out for purifying and killing microorganisms in water because it is readily available and cheap. Rural dwellers in Amassoma (Ama) Village in Bayelsa State, southern part of Nigeria depends on their river as source of drinking water. The river water is often polluted by the activities of boat drivers, waste disposals, timber business activities and pollutants from companies. In order to purify the water before consumption, the villagers use Alum to coagulate particles in the water and clear the colour of the river water before consumption. The use of alum in water above certain limit is known to be hazardous to human health. This is because excess aluminum sulphate in the human body can cause brain damage which might result to Alzheimer's disease [2-4].

Alum is a hydrated double sulphate salt often referred to as potassium alum with chemical formula $KAl(SO_4)_2{\cdot}12H_2O$. Potassium alum is commonly used in water coagulation. Other monovalent cations forms of alum like potassium exist such as ammonia aluminum sulphate and sodium aluminum sulphate. Other forms of alum that exist are the trivalent metal ions alums such as chromium (III) sulphate with formula $KCr(SO_4)_2{\cdot}12H_2O$ used in clearing turbid water in cosmetics and chemical industries.

Table 1 shows the initial comparism of parameters of Amassoma river water against W.H.O (World Health Organization) standard [5]. From the table it can be seen that the untreated Amassoma river water is high in turbidity which is a measure of its cloudiness due to suspended solids compared World Health Organization standards therefore requiring treatment before consumption. The turbidity is one way of determining the quality of drinking water.

Table 1 Parameters of Amassoma river against W.H.O standards

Water parameters	pH	Turbidity (FTU)	TDS (ppm)	EC (µS/cm)
Amassoma river water	6.8	78.0	33.33	27.00
W.H.O standard	6.5-8.5	0-5.0	1000	250

The most common unit for measuring turbidity is the Formazine turbidity unit (FTU) also known as Formazine Nephelometric unit (FNU) or Nephelometric turbidity unit (NTU) which indicates that turbidity measurement is carried out in a turbidimeter by measuring the scattered light from the sample at 90^o angle from the incident light

Total dissolved solids (TDS) in water are mostly inorganic compounds such as heavy metals and salts which might be essential for life. TDS sometimes contains some trace of organic materials which are dissolved in the water. It is one of the major causes of turbidity in water and sediment in drinking water and if the water is not properly treated before drinking, it could cause diseases and sickness. TDS is responsible for the taste in drinking water and its hardness. It is measured using a TDS meter and the measuring unit is in part per millions (ppm) or milligram per liter.

The pH of water depends on acid–base equilibrium in the water and for drinking-water it lies within the range 6.5–8.5 [5] and is usually measured electrometrically with a glass electrode pH meter. The effect of change in pH on humans after drinking water is difficult to analyze because the human stomach is acidic. Drinking acidic water introduces heavy metals and minerals in the water to our body which can reduce calcium intake in our body, cause gastrointestinal sickness and exposes our children to contaminants. These parameters need to be properly regulated through the process of water treatment to make the water clean and safe foe drinking.

The process of treating water to reduce these problems may be different based on the locations and available technology as well as the type of water that needs to be treated. Nevertheless, the basic principles are the same which involves Coagulation / flocculation process; sedimentation; filtration; disinfection and fluoridation processes.

Coagulation involves treating the water with substances such as alum, lime or polymer which are added to the water to bring particles in the water together due to electrostatic interaction forming larger particles which can be filtered off. Coagulation process uses adsorption principles in bringing particles together in the water. Adsorption is a process where molecules, ions and atoms adhere to a surface called adsorbents. In water purification, chemicals such as alum, polymers and plant based materials acts as adsorbents to remove dirt's and other insoluble materials from the liquid. They have very high internal surface area that permits adsorption. Some of the natural or synthetic adsorbents are activated carbon, zeolites (alumina-silicate-polymers), natural clay minerals and Silicic acid.

These chemicals are not readily available to the rural dweller that's why they turn to alum that is cheap and readily available to treat their water before consumption. This necessitates the need for an alternative ways of coagulating local river waters for consumption. One effective way is through the use of bio friendly plant based materials

Research has shown that bio purification of water is friendly and easy to carry out [6]. In bio purification, biomasses are used to bind and concentrate pollutants from even more diluted aqueous solution. Bio-purification process has advantages such as low operational cost, minimization of the volume of chemical and biological waste sludge as well as a high efficiency in decontamination of much diluted effluents.

Research has shown that different plant based coagulants such as moringa oleifera [7], orange peel, banana pith, neem leaf powder [8-10], drumstick seeds, tamarind seeds, banana peel and sweet potato [6] have been used in bio purification of water.

This research work looks at the treatment of Amassoma river water using Costus afer peels and its juice as coagulants. This study is important because it informs the rural dwellers in Amassoma town and other villages around that costus afer is a possible bio product available in abundances in their locality to treat their river water before consumption and minimize the harmful effects of using alum.

Costus afer also known as bush cane or spiral ginger **is** Perennial, rhizomatous herb that grows up to 4 m tall. Its leaves are arranged spirally. It is found in tropical Africa, tropical America and south-East Asia and is commonly called monkey sugar cane in Nigeria. It can be propagated by seed, by stem cuttings or rhizome cuttings. Its mashed or chewed stem or pounded fruit sometimes mixed with sugar cane juice are used to treat cough, respiratory problems and sore throat also its dried stem [11-12]. Cold water extract of the stem is used to treat small epileptic attacks and its rhizome pulp is applied to abscesses and ulcers to mature them, applied to teeth to cure toothache, and when mixed with water to treat diarrhea and amoebic dysentery [13]. Costus afer are known to contain steroidal sapogenins, saponinsaferosides and dioscin, which are important biopharmaceuticals and the phytochemical analysis of its leaf and stem crude extracts shows the presence of flavonoids, saponins, alkaloids, tannins, phenols, and glycosides [14].

2. EXPERIMENTATION

2.1 Equipment

Whatman filter paper no. 42, 500ml beakers, 400 ml Niger Delta University potable drinking water, 400 ml Amassoma river water, freshly plugged costus afer cane, potassium alum, stirrer, furnace, pH meter (Hanna instrument), Turbidity meter (H1 93703, Hanna instruments), Total Dissolved Solid reader (H1 98192 Hanna instruments), Electronic Conductivity meter (H1 98192 Hanna instruments), Resistivity meter (H1 98192 Hanna instruments), and stop watch.

2.2 Methods

The freshly plugged costus afer was washed properly with water and rinsed with distilled water to remove sand particle and dirt. Its peels were removed from the cane as shown in Fig. 1. The peeled bush cane was mashed and squeezed to extract its juice which was stored in a refrigerator for further use. The peels of the bush cane were then dried in an Oven at 100°C for 24 hours

Fig. 1 peeled costus afer stems

The test jar technique was applied in the analysis of the water samples. In the technique as shown in Fig. 2, sample A contains 50ml of juice extract of costus afer + 350 ml of Amassoma River water) , sample B (dissolved 50 grams of Alum + 350 ml Amassoma River water), sample C (400 ml untreated Amassoma River water only), sample D (50grams dried peels of costus afer + 350 ml Amassoma River water) and sample E contains 400 ml of Niger Delta University potable drinking water as control. The experiment was run for four days and sample results recorded daily.

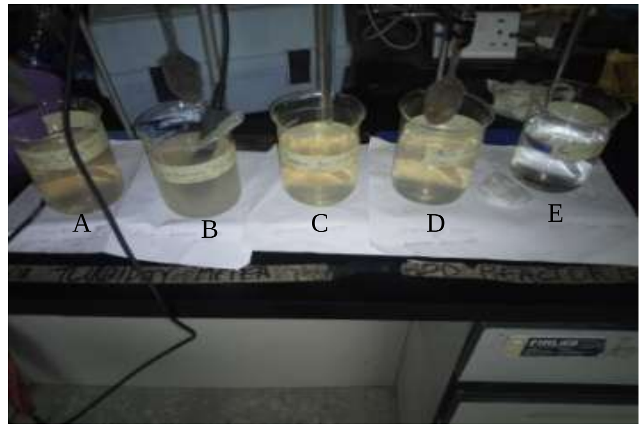

Fig. 2 Test jar technique for samples A, B, C, D and E

3. RESULTS AND DISCUSSION

Table 2 shows the recorded data obtained in day 1, for the pH, turbidity, total dissolved solids and electrical conductivity for portable drinking water, Amassoma river water, Amassoma river water treated with alum, Amassoma river water treated with costus afer dried peels and Amassoma river water treated with costus afer juice. Results for the subsequent days were also recorded as shown in Tables 3, 4 and 5 respectively.

Table 2 recorded pH, turbidity, TDS and EC for day 1

Water parameters	Drinking Water (E)	Ama Water (C)	Ama Water + Alum (B)	Ama Water + Charred Costus Afer peels (D)	Ama Water + Costus Afer Juice (A)
pH	7.1	6.8	5.8	6.0	5.5
Turbidity (FTU)	0.0	78.0	96.0	52.0	59
TDS (ppm)	272.7	33.33	539.3	30.23	91.91
EC (µS)	812.4	27.7	63.0	88.10	69.71

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Table 3 recorded pH, turbidity, TDS and EC for day 2

Water parameters	Drinking Water (E)	Ama water (C)	Ama Water + Alum (B)	Ama Water + Charred Costus Afer peels (D)	Ama Water + Costus Afer Juice (A)
pH	7.4	6.9	3.8	6.4	5.6
Turbidity (FTU)	0.0	56.0	4.51	40.62	57
TDS (ppm)	416.7	33.90	1288	58.49	99.45
EC (µS)	832.8	67.84	286	116.8	78.73

Table 4 recorded pH, turbidity, TDS and EC for day 3

Water parameters	Drinking Water (E)	Ama Water (C)	Ama Water + Alum (B)	Ama Water + Charred Costus Afer peel (D)	Ama Water + Costus Afer Juice (A)
pH	7.4	7.2	3.8	7.3	6.8
Turbidity (FTU)	0.0	55.0	3.27	39.57	44
TDS (ppm)	433.0	33.93	1471	89.57	108.78
EC (µS)	8661.2	67,84	2946	179.14	99.40

Table 5 recorded pH, turbidity, TDS and EC for day 4

Water parameters	Drinking Water (E)	Ama Water (C)	Ama Water + Alum (B)	Ama Water + Charred Costus Afer peels (D)	Ama Water + Costus Afer Juice (A)
pH	7.4	7.2	3.80	7.4	6.80
Turbidity (FTU)	0.0	53	3.02	15.57	33-0
TDS (ppm)	463.5	39.18	1528	148.16	118.47
EC (µS)	927.5	78.38	3856	299.20	106.94

Comparing the results in tables 2, 3, 4 and 5 for day 1, day 2, day 3 and day 4 respectively for the coagulation of Amassoma river water showed that the pH of the untreated river water relatively increased from pH 6.8 to neutral pH of 7.2 which falls within W.H.O standards. This might be due to the sedimentation of particles in the water. The alum treated Amassoma water had an acidic pH which decreases as the treatment days increases from pH 5.8 to 3.8. The costus afer dried peels treated water pH increased from slightly acidic to neutral pH (6.0 to 7.4). While the Amassoma river water treated using costus afer juice initially had acidic pH of 5.5 and increased to pH 6.8 at the fourth day of treatment. This analysis showed that as the coagulation process for the Amassoma river progresses particles in the water settles down which in turn affects the initial pH of the mixture. The pH of the coagulants was found to increase with time and days except for alum which decreases. And based on W.H.O standard for pH of drinking water the water treated with alum is not fit for human consumption.

The turbidity of the untreated Amassoma river water, Amassoma river water treated with alum, Amassoma river water treated with costus afer dried peels and Amassoma river water treated with costus afer juice all decreases as the number of day's increases. Among the coagulants used in treating the river water, alum had the lowest turbidity of 3.02 FTU on the fourth day close to portable drinking water with 0.0 FTU. The turbidity of the costus afer peels followed next with 15.57 FTU compared to the costus afer juice of 33 FTU. The turbidity of the costus afer peels and juice are lower than the untreated Amassoma river water of 53 FTU. This result is corroborated in Fig. 3 which shows sharp drop polynomially in turbidity of the Amassoma water treated with alum and then parallel to the drinking water. The turbidity of the river water treated with costus afer peels showed a gradual almost mix linear/polynomial drop while the juice treated water dropped polynomially with days but faster than the untreated Amassoma river water. This shows that costus afer peels and juice are good coagulants for treating and settling suspended and dissolved particles in the river water.

Tables 2, 3, 4 and 5 also showed that the TDS and electrical conductivity of the drinking water, untreated Amassoma river water, Amassoma river water treated with alum, Amassoma river water treated with costus afer dried peels and Amassoma river water treated with costus afer juice all increases as the number of days increases. The increase in TDS of the drinking water (control) might be as a result of the purification process it has undergone before use and also the time it was exposed to the atmosphere where particles might have falling into the water and dissolve in it. The TDS values of the untreated Amassoma river water is relatively small which showed that there are less dissolved substance in it. The TDS value of the alum treated river water had the highest value of 1528 ppm on the fourth day which is above W.H.O limits making it unfit for consumption. Its lowest TDS value (539.3ppm) was obtain on the first day of of coagulation which was within W.H.O limits but increased as days passes by. This increased value is as a result of the dissolve potassium alum salt in the river water. While the TDS values for the costus afer peels and juice treated water on the fourth day are 148.16 ppm and 118.47 ppm respectively which are within W.H.O recommended standard. Comparing these values to the untreated Amassoma water, showed the costus afer peels and juice constituents (phytochemicals) dissolved gradually with time in the water and coagulates particles in the river water through the process. These results is corroborated in Fig. 4 which shows the sharp increase polynomially in TDS value for the alum treated water which gradually flattens as the number of days increases. Next to it is the drinking water which increased gradually almost in a polynomial form far above the untreated river water, treated river water with juice and dried peels before flattening off. The Amassoma untreated water almost had a polynomial TDS plot indicating the minute changes recorded in its TDS value. In the diagram it looks as if it's parallel to the horizontal axis. While juice treated water increased exponentially above the untreated water. The dried peels treated water also had an exponential increase in TDS value near the starting point of the untreated water and above the juice treated water.

Among the coagulants used in treating Amassoma river water, Potash alum treated Amassoma river water had the highest electrical conductivity of 3855µS on the fourth day which is attributed to the dissolve potash alum in the water and is known to conduct electricity. The costus afer peel had EC value of 299.20 µS slightly above W.H.O standard and the juice had 106.14 µS which falls within W.H.O standard. Although the EC of the drinking water increased to 927.5 µS above W.H.O standard on the fourth day, this might be attributed to particles that dissolved in it as it is exposed to atmosphere in the laboratory during the experimental period.

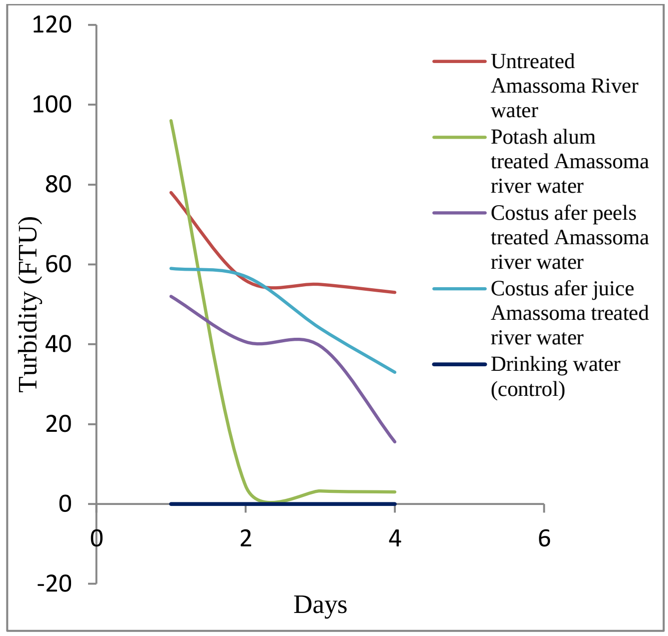

Fig. 3 turbidity of the treated and untreated water

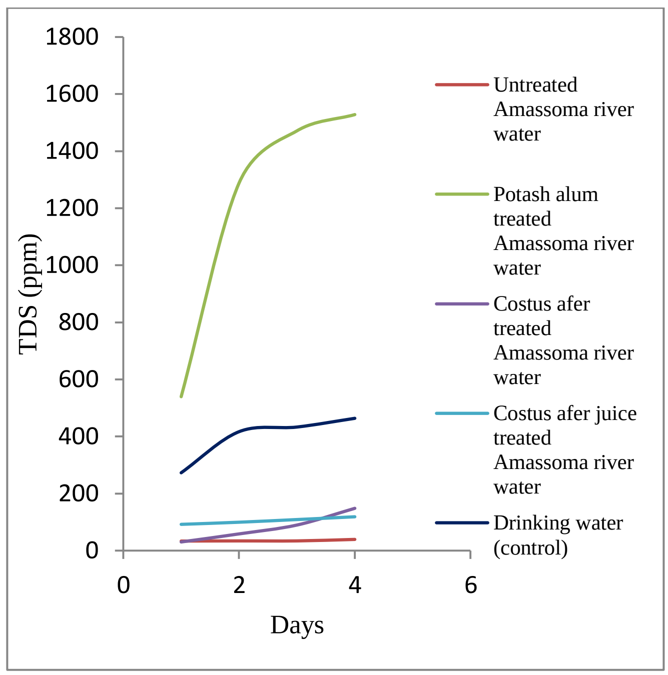

Fig. 4 TDS of the treated and untreated water

4. CONCLUSION

The experimental results showed that Amassoma river water was coagulated effectively for consumption using costus afer dried peels and juice. The costus afer juice performs better in than the dried peels in reducing TDS with turbidity, electric conductivity and pH within W.H.O standards during the experimentation period. Comparing these result to the alum treated river water showed that despite the alum reducing the river water turbidity to 3.02 FTU within W.H.O standard, it had higher TDS and EC values far above W.H.O limits and its pH is more acidic far below W.H.O acceptable standards. This makes it unfit for consumption with its health hazards.

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