EVALUATION OF THE EFFECTIVENESS OF WATER MELON SEED AS COAGULANT FOR TREATMENT OF EKET AND ONNA RIVER WATER

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Abstract

The use of conventional metal-based coagulant for removal of suspended solid from drinking and waste water is known to have elongated effect on human health. This problem had hitherto lead to new grounds through use of alternative natural coagulant which does not generate chemical residue in its effluent. The use of natural coagulants of plant origin signifies a fundamental breakthrough in sustainable environmental water sanitation. Natural coagulant has helped improve the sequential processes of water and wastewater treatment for underdeveloped communities. Even though promising results have been recorded from some existing/discovered natural coagulant, the need to intensify effort in exploring and or discovering new plant based natural coagulant is necessary to sustain the environment through provision of good quality drinking water for sustaining livelihoods of human well-being and socioeconomic growth; as well as ensuring protection against pollution and water related diseases. This study examined the potential of water melon seed as coagulant in water and wastewater treatment. Water samples collected from Eket and Onna Rivers (EKR and ONR) were analyzed for the various parameters namely; conductivity, total dissolved solids, turbidity, colour and pH. The water was treated with up to 0.5g/L dosage of water melon seed coagulant in step variation of 0.05g/L. An optimum dosage of 0.2g/L and 0.15g/L gave minimum turbidity for EKR and ONR samples, respectively. The pH of 7 to 7.5 produced the minimum turbidity that satisfy the standard of quality drinking water. The stirring time of 8 minutes and 10 minutes produced a more effective colour removal in the water for EKR and ONR, respectively. Turbidity increased with mixing speed and thereafter decreased at 240 rpm for the two samples. EKR sample produced lowest turbidity 4.75 NTU and peak turbidity 5.92 NTU at mixing speed of160 rpm and 240 rpm, respectively, while ONR sample produced lowest turbidity 4.45 NTU and peak turbidity 5.43 NTU at mixing speed of 120 rpm and 240 rpm, respectively. The study has shown that water melon seed has the potential as coagulant in treatment of Eket and Onna river water.

Keywords: Water melon seed, Total dissolve solid, Water treatment, Coagulation flocculation, Turbidity, pH

Introduction

Availability of portable quality drinking water is a challenge faced by several localities in the under developed and developing countries especially with the rising cost of water treatment. This has become worst due to the instability of water bodies (streams, ponds, lakes and rivers) evidenced by the presence of dissolved colloidal particle and undissolved suspended solid caused by leachability of heavy metals from sewage sludge (Afangideh et al., 2015) and land development through human and construction activities. While a careful selection of treatment system for onsite treatment of domestic wastewater is pertinent in order to reduce the spread of diseases originating from groundwater contamination (Nnaji et al., 2014), the excessive storm runoff that emptied itself into several water bodies during the rainy seasons is one of many factors that consistently contribute to unpredictable variations of quality of water bodies. These occurrences has results in increased level of water turbidity as well as increased need and use of water treatment chemicals which are most often than not, expensive and unsustainable. Based on this and coupled with the poor treatment method adopted by some water distribution companies, a number of health cases which are related to poor quality drinking water distributed to consumers have been reported (Muyibi & Evison 1995; Luvhimbi et al., 2022)

Public water systems often used a series of water treatment steps that include coagulation, flocculation, sedimentation, filtration and disinfection which has been advanced into new technologies (Madaki and Seng 2013). However, coagulation and flocculation are two separate processes which are compulsory protocol used in consecutive succession, to overcome and or neutralize the electrostatic forces stabilizing the suspended particles (Duan and Gregory 2003). While coagulation deactivates/neutralizes the charges on the particles, flocculation assists/enables them to bind/cling jointly together, rendering them bigger; so that they can be separated effortlessly from the liquid (Edzwald, 1993; Ebeling et al., 2003; Hosseini et al., 2008). The process introduces small highly charged molecules into water to destabilize the charges on particles, colloids, or oily materials in suspension (Yin, 2010). A number of water treatment protocols have used various conventional coagulants namely: inorganic (e.g. aluminum sulphate, polyaluminum chloride, ferric chloride), synthetic organic polymers (e.g. polyacrylamide derivatives and polyethylene imine) or naturally occurring coagulants (e.g. chitosan, plant extracts). The various specific purpose for which some of these coagulants are used depends on their inherent chemical distinctiveness in line with their basic composition and functional group properties (Šćiban et al., 2005; Kurniawan et al., 2020). The most commonly used coagulant in water and wastewater treatment is aluminium salts (Šćiban et al., 2005). Apart from the fact that some developing countries could hardly bear the escalating cost of importing chemicals for water and wastewater treatment, a number of studies have enumerated several problems/disadvantages of the use of aluminium coagulants thus raising unbearable doubts and fear in terms of sustainable quality drinking water and cleaner environment (Mallevialle et al., 1984; Miller et al., 1984; Letterman et al., 1988). Also, aluminium salts as coagulant for water treatment have been reported to cause Alzheimers disease as well as generate unwarranted sludge and significant variation in water interaction as a result of hydroxyl OH and alkalinity reactions. Also, inadequate accomplishment was recorded on the use of ferric salts and synthetic polymers as coagulant because of their uncomplimentary effect on living organisms (Šćiban et al., 2005). More so, neurotoxicity and strong carcinogenic properties of monomers of some synthetic organic polymers such as acrylamide renders it inappropriate as coagulant (Mallevialle et al., 1984). Consequent upon the forgoing, researchers intensified effort to finding an alternative natural and unconventional coagulant that could effectively treat water and wastewater of high turbidity and at the same time cost effective, environmentally friendly, safe for human health and biodegradable (Ghebremichael 2005).

Some studies have reported the use of natural coagulants of plant origin to treat and clarify turbid water though this practice is not a new idea as natural coagulants have been utilized by domestic household for centuries in traditional water treatment in rural areas. But due to the global increasing lack of assessment of portable and quality drinking water (WHO, 2017), the resurgence of natural coagulant have become obvious especially in developing countries and regions. Some of the natural coagulants used in treatment of water and waste water are mesquite bean (*Prosopis juliflora*) and *Cactus latifaria* (Diaz et al., 1999), various bean (*Phaseolus*), peas (*Pisum*), peanuts (*Arachis*) and lupines (*Lupines*) (Gassenschmidt 1995), *Cassia angustifolia* seeds (Sanghi et al., 2002), seeds from *Moringa oleifera* (Gassenschmidt 1995; Okuda et al., 1999; Muyibi et al., 2009; Ndabigengesere et al., 1995). In contrast to the use of conventional chemical coagulant, natural coagulant could offer several benefits such as reduced cost of water treatment, reduced amount of sludge formation and readily available as such plant can be grown locally and commonly found. Limitations to this research is the increased chemical oxygen demand that may be induced by the organic nature of the plant based coagulant (Daniyan et al., 2011).

This study investigate the potential applicability of water melon seed as natural coagulant in the treatment of water of high level turbidity. The use of this coagulant is meant to substitute commercial coagulant and thus evade their negative effects. Water melon seed is considered in this study because it contains high protein which is similar to other seed that has been reported to have the active coagulating agents of cationic protein that exhibit isoelectric potentials (Golestanbagh et al., 2015). The objectives of this study include but limited to examining the characteristics effect of water melon seed powder extract dosage (coagulant) on the turbidity and other water parameters of two named selected river water.

Materials and methods

Water samples

The initial raw or untreated water samples used in this study was gotten from Eket and Onna rivers using clean plastic container. The collected sample was taken to the laboratory for evaluation and characterization and coagulation experiment.

Preparation of water melon seed coagulant

Water melon fruits were sourced from both Itam market and Akpanandem market, Uyo, Akwa Ibom state. Significant quantity of seeds from the fruits were collected after consumption of the edible part. Seeds were washed and sundry for about three weeks (Figure 1). The sun dried seeds was transferred to a laboratory rotatory electric blender that milled seeds to a smooth powdered structure. The powdered seeds was then transferred to an airtight container and kept for further process. The procedure of (Muhammad et al., 2015) was adopted for extraction or removal of oil from the powdered seed using n-Hexane. After 6-hour running of extraction apparatus to obtained complete extraction, the seed cake was washed using distilled water to remove residual n-Hexane. Thereafter the washed seeds was dried in an oven and then sieved to obtain the final powdered material known as water melon seed powdered (coagulant).

Figure 1: Dried water melon seed

Coagulation-flocculation tests

The coagulation tests were conducted following the jar test which is the method most commonly used for simulating the coagulation-flocculation process in a water treatment plant (Ndabigengesere et al., 1995; Ifeanyi et al., 2019). The tests were carried out based on standard bench-scale nephelometry (WST, 2003; AWWA, 2005). The jar test apparatus was used to carry out coagulation and flocculation on the water samples. A ten-place 1-litre (1000-ml) beakers were used to study the effect of coagulant dosage on coagulation, the effect of pH on coagulation and the effect of stirring time and speed on coagulation. The following parameters were then measured on the filtrate after the coagulation was completed; turbidity, colour, flocs weight, total dissolve solid (TDS) and conductivity. Ten different weights of the coagulant were placed in each beaker, the first having 0.05g, and the remaining nine varying from 0.05-0.5g at 0.05g interval in order to determine the optimum dosage. The raw water sample was then added to make up the 250ml mark and the jars were then placed in the jar test kit and the stirrers lowered into each. The stirring speed was set at 120rpm for rapid mixing for 2 minutes and 80rpm for slow mixing for 8minutes. After this was completed the samples were allowed to settle. An extended but constant settling time period of 60 minutes was adopted throughout this study. Thereafter, the settled flocs was filtered using a filter paper and the filtrate was tested for the parameters listed above. From the results obtained the dosage with the best results in terms of colour and turbidity removal was taken as the optimum for the respective water samples.

Results and Discussion

Physicochemical evaluation

Preliminary analysis that evaluate the physicochemical properties of initial source water from ONR and EKR are shown in Table 1. It was observed that the turbidity of the water sample was high; 170 NTU and 110 NTU with corresponding high colour 195 PCU and 180 PCU for EKR and ONR rivers, respectively. These water does not represent good quality drinking water since their turbidity and colour values are more than the WHO specified guidelines recommended for healthy/drinking water. It is therefore imperative that the need of treatment is required to make it safe. Similarly, all other constituents are within the conventional standard value and risk-free without treatment. Based on the study location, the author believes that these high level turbidity values may not be unconnected with the on-going massive construction activities within and around the area as at the time of sample collection. The turbidity level before construction activities may have been carried out but to the best of the author's knowledge, the turbidity levels from both sources were not found in any known documented report or research.

Table 1: Properties initial Preliminary analysis of initial fresh/raw source water results of samples of water

Parameters	EKR sample	ONR Sample	WHO guideline
Conductivity (µs/cm)	463	530	≤14000
Total dissolved solids (mg/l)	152	193	≤ 933
Temperature (ºC)	25.5	26.2	25 - 30
Turbidity (NTU)	170	110	≤ 5
Colour (TCU)	195	180	≤ 15
pH	6.73	6.92	6.5 - 8.5

Effect of dosage on coagulation

The effect of water melon seed powder (WSP) (coagulant) dosage on coagulation was measured by the turbidity value dissolved in 1L (1000 ml) initial raw water and filtrate solution obtained after an elapse settling time of 60 minutes is shown in Table 2. The dosage was varied in step 0.05g/L up to 0.5g/L was used. It was observed that there was no meaningful variations in conductivity, TDS, temperature and pH values of the treated water and that of the initial source water (untreated water). The results of coagulant dosage with conductivity values is consistent with the investigation of (Muhammad et al., 2015) that reported increased conductivity with increased in coagulant dosage. However, the results for EKR shows that turbidity and corresponding colour reduced from 170 NTU and 195 TCU of the original source water before treatment to a minimum optimal value of 8NTU and 25 TCU at 0.2g/L dosage, respectively. This result correspond to 95.3 % and 88.7 % efficiency of 0.2g/L turbidity and colour removal, respectively. Similarly, the results for ONR shows that the turbidity and corresponding colour reduced from 110 NTU and 180 TCU of the original source water before treatment to a minimum optimal value of 6 NTU and 20 TCU at 0.15g/L dosage, respectively. This result correspond to 94.5 % and 88.9 % efficiency of 0.15 g/L turbidity and colour removal, respectively. Figure 2 shows the clear representation that indicates the variation of turbidity and colour with coagulant dosage. Comparatively, lower optimal dosage are required to treat water with lower turbidity (Šćiban et al., 2005).

Table 2: Effect of coagulant dosage on physicochemical parameters for EKR and ONR

Source water	Dosage (g/L)	Conductivity (µs/cm)	TDS (mg/L)	Temperature (ºC)	Turbidity (NTU)	Colour (TCU)	pH
EKR	0	463	152	25.5	170	195	6.73
	0.05	465	150	25.5	50	140	6.56
	0.1	466	154	25.7	30	90	6.64
	0.15	467	160	25.6	18	50	6.42
	0.2	469	154	25.3	8	22	6.48
.	0.25	469	161	25.2	10	24	6.44
	0.3	470	169	25.8	15	27	6.43
	0.35	472	167	25.9	18	31	6.57
	0.4	471	170	25.1	16	28	6.52
	0.45	475	172	25.1	19	30	6.55
	0.5	474	175	25.8	22	31	6.48
ONR	0	530	193	26.2	110	180	6.92
	0.05	532	191	26.1	70	75	6.91
	0.1	533	192	26.2	25	80	6.94
	0.15	535	193	26.1	6	20	6.93
	0.2	536	192	26.3	8	21	6.96
.	0.25	538	194	26.2	11	25	6.95
	0.3	537	197	26.1	13	26	6.97
	0.35	539	194	26.4	11	26	6.91

0.4	538	195	26.0	14	28	6.98
0.45	539	198	26.2	15	30	6.96
0.5	540	200	26.2	17	33	6.94

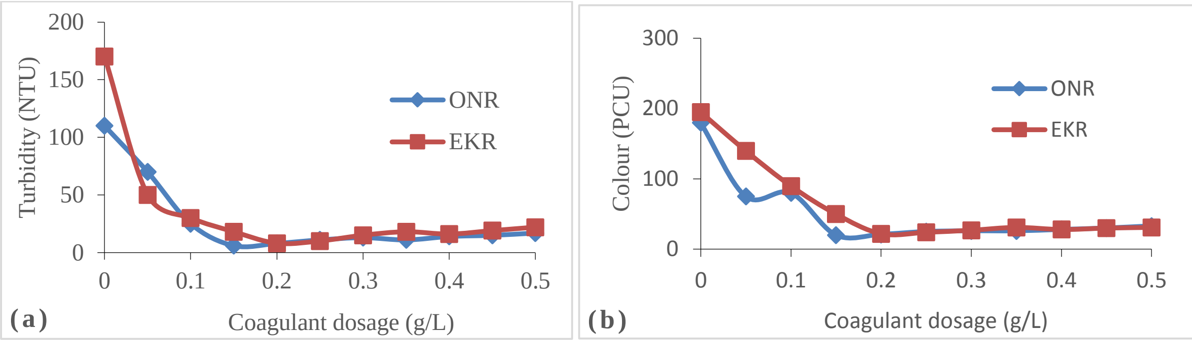

Figure 2: Variation of (a) turbidity and (b) colour with coagulant dosage

Effect of pH on turbidity

The jar coagulation test was repeated but this time for only the optimal dosages for the water treatment and the effect of pH was studied. The effect of pH on turbidity level of EKR and ONR water treated with 0.2 g/L and 0.15 g/L optimal coagulant is shown in Figure 3. Since pH offers a substantial part in the coagulation and flocculation process of water treatment plants before onward supply and or distribution for consumption (WHO 2017), it becomes imperative and of course necessary to study the effect of water melon seed cake as potential coagulant for treatment of high turbid river water. pH regulation may initiate a variation in the ionization of the colour particle with equivalent influence on attached or connected bond stretches, length and configurations and thus light absorption (Šćiban et al., 2005; Muhammad et al., 2015; Seyrig and Shan, 2007). The pH of the optimally treated water was adjusted or varied from 5.5 (slight acidic) up to 8.5 (slight alkaline). To make it alkaline, few controlled drops of 1M NaOH was added to each beakers and IM few controlled drops of H_2SO_4 was introduced to make it acidic. The results indicate that the turbidity decreased with increase pH value 7.5 after which which it increases. For EKR, the turbidity value of 4.52 NTU and 3.94 NTU was recorded at pH of 7 and 7.5, respectively. Similar trend was observed for ONR with turbidity value of 4.19 NTU and 3.73 NTU recorded at pH of 7 and 7.5, respectively. These values are less than maximum 5 NTU turbidity recommended by WHO for quality drinking water. The results in this study is consistent with the report of (Muhammad et al., 2015).

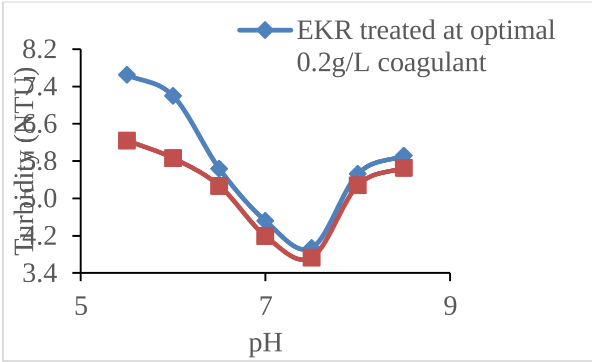

Figure 3: Effect of pH on turbidity for EKR and ONR treated with an optimal dosage of 0.2 g/L and 0.15 g/L waste melon seed coagulant, respectively.

Effect of stirring time on turbidity

The effect of various stirring time (2, 4, 6, 8. 10, 12, 14 and 16 minutes) on turbidity level of EKR and ONR water treated at the respective constant optimal coagulant dosage is shown in Figure 4. The coagulation-flocculation process was repeated the given time range of 2-16 minutes. The filtrate obtained from filtered samples were used for the turbidity test. The pH was maintained range of 7 to 7.5 while temperature was kept constant at 25.5 ^oC. The results for EKR indicate that the turbidity decreased to minimum or lowest 3.81 NTU at 8 minutes stirring time and afterward increased with further increasing stirring time. The corresponding colour removal of 19 TCU was observed For ONR, the minimum turbidity value of 3.73 NTU was recorded after stirring time of 10 minutes and corresponding colour removal of 16 TCU. These values are less than maximum 5 NTU turbidity recommended by WHO for quality drinking water. The results in this study is consistent with the report of (Muhammad *et al*., 2015).

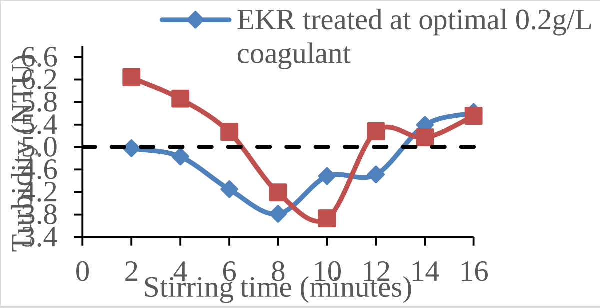

Figure 4: Effect of stirring time on turbidity

Effect of mixing speed on turbidity and colour

The effect of mixing speed on the turbidity of optimally coagulant dosage on EKR and ONR water treatment carried out by repeating the coagulation-flocculation protocol at several mixing speed of interval of 40 revolution per minute (rpm) is shown in Figure 5. The range from 40 rpm to 320 rpm was considered and on completing coagulation-flocculation, the filtrate was used for turbidity test (Daniyan et al., 2011; Adejumo et al., 2013). Generally, it was observed that turbidity increased with mixing speed and thereafter decreased at 240 rpm in the two samples. This trend is similar to the report of (Muhammad et al., 2015) who treated water samples from Gubi dam. The results for EKR sample shows that lowest turbidity of 4.75 NTU and peak turbidity of 5.92 NTU was observed at mixing speed 160 rpm and 240 rpm, respectively. Similarly, the results for ONR sample shows that lowest turbidity of 4.45 NTU and peak turbidity of 5.43 NTU was observed at mixing speed 120 rpm and 240 rpm, respectively. The effect of pH, temperature, TDS and conductivity is presented in Table 3. The pH and temperature had zero or no marked effect. The pH and temperature taken after the various mixing speed were mostly marginal and insignificant. What was more important was the neutrality evidenced in the pH values that was neither acidic nor alkaline. The total dissolve solid TDS and conductivity increased with mixing speed. The result obtained here is similar to that of (BinAhmed et al., 2015) who reported; rate of particle collision of coagulation-flocculation depends on specific mixing speed, intensity, and time period. The collision of flocs are important because its induce agglomeration of particles that have high settling rate thereby aiding coupling mechanisms of charge neutralization, sweep coagulation, bridging, and patch flocculation that favours the entire processes (Yunos *et al*., 2017).

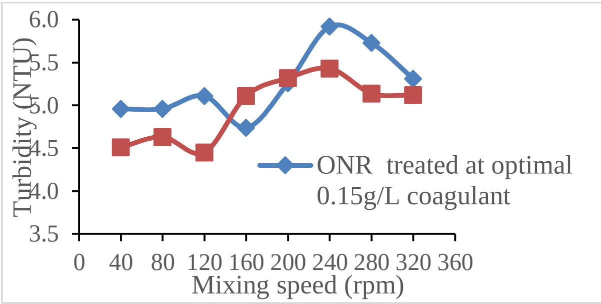

Figure 5: Effect of mixing speed on turbidity

Table 3: The effect of pH, temperature, TDS and conductivity

Specimen	Speed (rpm)	Turbidity (NTU)	Temperature (ºC)	pH	TDS (mg/l)	Conductivity (µs/cm)
EKR 0.2g/L	40	4.96	25.4	7.26	142	550
	80	4.96	25.6	7.19	148	562
	120	5.11	25.3	7.41	151	559
	160	4.74	25.5	7.39	163	588
	200	5.26	25.2	7.32	169	594
	240	5.92	25.4	7.25	184	603
	280	5.73	25.6	7.38	178	622
	320	5.31	25.3	7.16	167	626
ONR 0.15g/L	40	4.51	25.4	7.23	212	613
	80	4.63	25.6	7.36	221	624
	120	4.45	25.3	7.15	226	631
	160	5.11	25.6	7.13	229	647
	200	5.32	25.3	7.25	236	640
	240	5.43	25.6	7.41	238	649
	280	5.14	25.4	7.33	228	652
	320	5.12	25.2	7.17	218	658

Conclusion

Water samples collected from Eket and Onna Rivers were analyzed for the various parameters. Plant based sourced coagulant derived or processed from water melon seed was used as natural coagulant to treat the river water. An optimum dosage of 0.2g/L and 0.15g/L gave the minimum turbidity for EKR and ONR samples. The pH of 7 to 7.5 produced the minimum turbidity that satisfy the standard of quality drinking water. The stirring time of 8 minutes and 10 minutes produced a more effective colour removal in the water. Turbidity increased with mixing speed and thereafter decreased at 240 rpm for the two samples. EKR sample produced lowest turbidity of 4.75 NTU and peak turbidity of 5.92 NTU at mixing speed 160 rpm and 240 rpm, respectively. ONR sample produced lowest turbidity of 4.45 NTU and peak turbidity of 5.43 NTU at mixing speed 120 rpm and 240 rpm, respectively. The study has shown that water melon seed has the potential in treatment of Eket and Onna river water. This study does not guaranteed the direct consumption of the treated water after efficient coagulation-flocculation test using water melon seed coagulant but rather recommends further screening by way of checking the cations and trace metal composition, microbial activities as well as determining the total hazard quotient and health risk index for trace metals if found.

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Conflict of Interest: The author declare that they have no conflict of interest

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