EFFICACY AND EFFECT OF SELECTED BIO-COGULANT ON TREATMENT OF APONMU RIVER

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ABSTRACT

In the wastewater treatment process of coagulation-flocculation-sedimentation, natural coagulants may be used to reduce turbidity. Manihot Esculenta (cassava peel) and Citrus Aurantium Dulcis (orange peel) were employed as natural coagulants for the treatment of Aponmu river. The best overall results were obtained when alum was partially replaced with cassava peel (70% AL30% CA), with all parameters (BOD; 6.1mg/L, COD; 9.9mg/L, hardness; 85.6mg/L, and Cu; 0.07mg/L, at pH of 6.3) meeting WHO drinking water standards and accepted practices for water and wastewater examination. However, alum's negative environmental effects on the production of non-biodegradable sludge and lingering effects on treated water are greatly reduced by partial substitution.

Keywords: *Wastewater, Coagulant, Orange Peel, Cassava Peel,*

INTRODUCTION

Wastewater treatment with metallic salts such as aluminum sulfate (commonly known as alum), ferric sulfate, and ferric chloride is still a common method for both large and small-scale systems (Britannica, 2020; Fakorede and Adewunmi, 2020). Coagulant and flocculant are key components for reducing turbidity and eliminating suspended colloidal particles in a water body. The procedure is typically carried out in a chemical reactor, in which influent water or wastewater enters the basin and is mixed with coagulant agents using a mechanical mixer, followed by sedimentation to remove particles by gravity settling (Amir *et al.* 2018; Ahmed *et al*., 2019)

Coagulants come in a variety of forms. Chemical-based coagulants, such as alum and ferric salts, are the most used (Asrafuzzaman *et al*. 2011). However, the employment of these chemical coagulants has several drawbacks, including the production of hazardous voluminous sludge (Daverey *et al.* 2019). When coagulant is used to treat water, there is a possibility of coagulant residue remaining in the water after treatment. Alum, a chemical coagulant residue, is hazardous since it can induce Alzheimer's disease if swallowed (Choubey and Neogi, 2017).

Natural coagulants are coagulants that are generated from plant-based components. Natural coagulants are both safe and environmentally friendly (Ahmed *et al.* 2019). Plants, microbes, and animals can all be used to extract it (Choubey *et al*. 2012). Some plants can act as coagulants because they can carry out some of the coagulation processes, such as neutralizing the charge in colloidal particles and performing polymer bridging (Chee and Ta, 2014).

Furthermore, if a natural coagulant was employed, the leftover coagulant would be harmless. Similarly, natural coagulant is substantially less expensive than artificial coagulant. Chemical coagulants, such as alum, can successfully treat high turbidity water, but the process is expensive and harder to employ in developing nations. Natural coagulants, on the other hand, are substantially cheaper and may be derived from diverse plant wastes, significantly lowering treatment costs (Camacho *et al*., 2017). However, this research discusses the use of cassava and orange peels as natural coagulants for Aponmu surface water treatment.

Materials and method

Materials

Fresh cassava (*Manihot esculenta*) and orange peels were obtained from a cassava farm and local orange sellers respectively in Ilara-Mokin Ondo-State, Nigeria.

The surface water samples for analysis were collected from Aponmu river.

Method

1. Preparation of coagulants (stock solution)

The orange peels were cut into small pieces and washed in distil water to remove soil and suspended impurities before being used. The peels were then dried in an oven at $100^{o}C$ for 48 hours to eliminate the moisture content. Following the drying process, the peels were taken out of the oven and placed in desiccators for 30 minutes, The desiccators contain calcium chloride ($CaCl_2$), which is used to cool and maintain a dry atmosphere. The peels are then grounded to fine powder and sieved through 600 µm following the method used by (Thuraiya *et al*., 2015).

Fresh cassava peels were soaked for 5 days in an open container exposed to the atmosphere, with the water being replaced every 24 hours to release the cyanogen glycoside present in the peels prior to carbonation. After a five-day fermentation period, the fermented cassava peels were thoroughly washed three times with distilled water before being dried for seven days in the scorching sun.

Figure 1: Grinded orange peels

The dried sample were then crushed with a mortar and pestle and filtered through a 500µm sieve filter. To remove any unnecessary matter added during the crushing process, the filtrates were thoroughly washed with distilled water. The washed sample was then put in an oven of temperature $105^{o}C$ oven for 12 hours to remove moisture. A total of 500 g of the dried sample was measured and placed in the muffle furnace's hot zone for 120 minutes at $380^{o}C$. At room temperature, the carbon produced was allowed to cool for 5 hours. 100 g of the carbonized sample was triggered with 150 g of 1.0 M Zinc chloride following the method used by (Chua *et al*., 2016).

Figure 2: Grinded cassava peels

The alum solution is made by dissolving one gram of $Al_2(SO_4)_3.18H_2O$ in one liter of water that has been subjected to distillation. It is then moved and mixed properly to generate 1 percent solution concentration. As a result, 1ml of this solution contains 1 mg of alum.

Figure 3: Raw Alum $(Al_2(SO_4)_3.18H_2O)$

2. Procedure of the experiment

Raw waster sample from the Aponmu river was collected in a 10-liter container (contaminant-free) and kept at 6°C until use. The basic ingredients (Cassava and Orange peels) were pulverized after being sourced locally. Minutes before dosing, stock solutions of orange, cassava, and alum were prepared (Kigho *et al*., 2016; Adamu *et al*., 2014). The raw water sample was then placed into eleven 1000 mL beakers for jar testing. Different doses of coagulants were used in the jar test to identify appropriate/optimal coagulant dosage.

Ten beakers of 1000 mL capacity were filled with 500 mL of raw sample and labeled according to the dosage of the coagulant added to it, while one raw sample beaker was left without any coagulant addition and labeled as control. Table 1 shows the doses used in the jar test. These doses (describe in Table 1) were added to the raw water and stirred vigorously for 3 minutes, then slowly for another 5 minutes with a magnetic stirrer. After allowing it to settle for about an hour, the clearer of each dosage was taken as the best for that coagulant. The optimum dose of coagulant was determined from these jar test using designed % optimum dosages as shown in Table 1.

These tests were carried out in triplicate at the water laboratory at Elizade University. All analytical methods, including those used to characterize raw water, are based on standard methods (APHA, 2012).

Table 1

Samples	% Optimum Dosage
OR 100	100% Orange Peel
OR50CA50	50% Orange Peel And 50% Cassava Peel
OR70CA30	70% Orange Peel And 30% Cassava Peel
CA 100	100% Cassava Peel
CA70OR30	70% Cassava Peel And 30% Orange Peel
AL 100	100% Alum
AL50CA50	50% Alum And 50% Cassava Peel
AL70CA30	70% Alum And 30% Cassava Peel
AL50OR50	50% Alum And 50% Orange Peel
AL70OR30	70% Alum And 30% Orange Peel
CONTROL	No Coagulants

Figure 4: Jar test set-up

3. percentage removal determination

Then, the percentage removal efficiency was calculated using equation 1 below.

Percentage Reduction Efficiency (%)

$$= \frac{T_0 - T_1}{T_0} \ x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

where, T_0 = initial Concentration

T_1 = final Concentration

RESULTS AND DISCUSSION

In the present experimental study, the effect of partial replacement of alum with bio-coagulant concentrations on physio-chemical and bacteriological parameters (BOD, COD, pH, total suspended solid, total dissolved solid, total solid, and total hardness), coliform, and heavy metals were investigated.

Excel version 16 statistical software was used to analyze the data. The outcome of the treatment of the basic characteristics of wastewater is presented in Table 2.

1. Effect of bio-coagulants

The effect of different partial replacements of alum stock solution with bio-coagulants of orange and cassava stock solution on parameter removal is shown in Table 2, 3, and 4. 70%AL30%CA dosage per 500ml of wastewater gives the best percentage removal of 50.4% BOD, 90.8%, COD, and 91.7% Cu. However, singularly (100% OR, %100 CA) and combination (50%OR50%CA 70%OR30%CA and 70CA30%OR) of cassava and orange stock solutions in wastewater treatment are disadvantageous because poor calcination method and organic matter from them is released into the wastewater treatment system, which often leads to a higher demand for chemical oxygen (COD) and bio-chemical (BOD), as shown in Table 2 and reported in the research conducted by (Baptista *et al.,* 2017; Jorg *et al.,* 2020).

2. Analysis of Variance (ANOVA)

Natural (bio-coagulants (orange and cassava peel) were examined and compared to other surface water treatment techniques in this study. The table 5 below displays the findings of the analysis of variance for the various sources of variation identified in the research.

The data in the Table 5 are used to analyses the source of variations to get the greatest accuracy. Several criteria, such as the sum of square, mean value, P-value, and F-value, shows the experimental result of the output of variations considered in this study. The ANOVA test was specifically conducted to check if the variables used in this study are statistically significant. It is well known that the mean parameters in Table 5 range from 0.035833 for total suspended solids (TSS) to 340.2583 for hardness, indicating varying differences in that the sample mean values. The disparities in the samples, are due to random sampling errors and differences in the measurements indices of the parameters used. The one-way ANOVA null hypothesis was rejected since the p-value (2.89E-09) was less than or equal to 0.05 and the overall F value was more than the F critical value, indicating some flaws in the data generation and analysis. However, the ANOVA test indicated that a significant change was observed between the influent and the effluent samples. Many recent studies on the use of natural coagulants for water treatment found that plant-based coagulants such as Moringa Oleifera seeds, soya bean and banana peels are also very effective for removing impurities, turbidity, and colour from wastewater.

One of such is reported by Aina *et al.* 2020 and they concluded that using 40 – 120mg/L of the natural coagulants such as soyabean and banana peel can effectively remove turbidity and colour from surface of water. Desta *et al*,(2021) also concluded that the use of Moringa seed powder with a 7 – 9 pH range aid effective removal of impurities and using 0.1g of Moringa oleifera seed powder, best adsorption equilibrium was observed.

Application of natural based coagulant have shown their efficiency in water treatment specially in developing countries. Moringa Oleifera, banana and orange peels should be used without any transformation so that it usage will can be accepted widely. Other researchers also opined that going by profitability index, there are economic importance from these natural coagulants that needs to be explored. Future research must expound on others plant-based coagulant, the cost benefit analysis and the level of acceptances and applications.

Table 2: Showing the result of phyysiochemical parameters

S/N	*Samples*		*BOD mg/L*	*% Removal*	*pH*	*% Removal*	*COD mg/L*	*% Removal*	*TSS mg/L*	*% Removal*	*TDS mg/L*	*% Removal*	*TS mg/L*	*% Removal*	*TH mg/L*	*% Removal*
1	Raw		*12.3*	-	7.3	-	108	-	162.3		162.3		162.3	-	1260	-
2	SP1	OR 100	*18.9*	-54	6.5	11	145	-34	22.1	87	43.4	73	65.5	60	121	90
3	SP2	OR50CA50	*23.4*	-90	6.6	10	135	-25	12.4	92	46.3	71	58.7	64	576.2	54
4	SP3	OR70CA30	*7.4*	40	6.4	12	137	-27	22.9	86	38.4	76	61.3	62	729.7	42
5	SP4	CA 100	*7.5*	39	6.7	8	130	-20	15.9	90	40.1	75	56.0	65	92.4	93
6	SP5	CA70OR30	*7.3*	41	6.5	11	118	-9	22.5	86	43.3	73	65.8	59	359.8	71
7	SP6	AL 100	*5.5*	55	6.1	16	18.5	83	23.3	86	22.5	86	45.8	72	84	93
8	SP7	AL50CA50	*6.4*	48	6.5	11	35	68	13.8	92	49.9	69	63.7	61	86.4	93
9	SP8	AL70CA30	*6.1*	50	6.3	14	9.9	91	21.8	87	48.8	70	70.6	57	85.6	93
10	SP9	AL50OR50	*6.6*	46	6.4	12	48	56	25.1	85	39.9	75	65.0	60	398	68
11	SP10	AL70OR30	*6.2*	50	6.2	15	11	90	24.8	85	78.0	52	102.8	37	230	82

Table 3: showing the result heavy metals of the treated water samples

S/N	*samples*		***Cd mg/L***	*Cu mg/L*
1	Raw			0.12
2	SP1	OR 100	ND	0.04
3	SP2	OR50CA50	ND	0.02
4	SP3	OR70CA30	ND	0.03
5	SP4	CA 100	ND	0.03
6	SP5	CA70OR30	ND	0.02
7	SP6	AL 100	ND	0.09
8	SP7	AL50CA50	ND	0.06
9	SP8	AL70CA30	ND	0.01
10	SP9	AL50OR50	ND	0.07
11	SP10	AL70OR30	ND	0.08

Table 4: showing the result of coliform of the treated water samples

1	*Raw*		***Positive***
2	SP1	OR 100	**Positive**
3	SP2	OR50CA50	**Negative**
4	SP3	OR70CA30	**Negative**
5	SP4	CA 100	**Positive**
6	SP5	CA70OR30	**Positive**
7	SP6	AL 100	**Positive**
8	SP7	AL50CA50	**Negative**
9	SP8	AL70CA30	**Negative**
10	SP9	AL50OR50	**Negative**
11	SP10	AL70OR30	**Negative**

Table 5 showing the ANOVA analysis result of the experiment

Groups	*Count*	*Sum*	*Average*	*Variance*
COD	12	807.4	67.28333	3485.154
TDS	12	975.7	81.30833	1537.195
TSS	12	0.43	0.035833	0.000408
BOD	12	80.3	6.691667	7.386288
Hardness	12	4083.1	340.2583	132013.3
Cu	12	0.61	0.050833	0.001336
TS	12	976.06	81.33833	1537.487
pH	12	78.06	6.505	0.092882
Temp	12	312.85	26.07083	0.215663

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1116169.014	8	139521.1	9.061063	2.89E-09	2.033295
Within Groups	1524389.712	99	15397.88			
Total	2640558.726	107				

Conclusion

Cassava and orange peels are examples of agricultural waste from the food processing sector that are present in all developing nations and have substantial economic and societal value. It is thought to be a suitable, efficient, and sustainable water treatment technique. The study demonstrated the excellent efficacy of using orange and cassava peels to reduce (BOD, COD, hardness, and Cu). The best overall results were obtained with all parameters of (BOD; 6.1mg/L; COD; 9.9mg/L; hardness; 85.6mg/L; and Cu; 0.07mg/L, at pH of 6.3), when alum was partially replaced with cassava peel (70% AL30% CA). The use of these coagulants in treatment of surface water represents an important advancement in a stable environment for a better eco-system, particularly in less urbanized areas.

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