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REMOVAL OF TOXIC SUBSTANCES FROM CASSAVA EFFLUENT USING ALUM AND *Moringa oleifera* SEEDS AS COAGULANTS: A COMPARATIVE STUDY TOWARDS IMPROVED AGRICULTURAL PRACTICE

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ABSTRACT

Cassava as a food is widely eaten in nearly all tropical countries. This has led to the emergence of many cassava processing centres, which consequently results in extensive ecological pollution due to the release of cassava processing wastewater into the environment. Wastewater treatment is mostly carried out using chemical coagulants, which are not environmental friendly. This study aims at providing non-chemical based alternative treatment procedures for cassava wastewater. The treatment procedures involved the use of alum and *Moringa oleifera* seeds as coagulants. The coagulants were used in combination with sodium hypochlorite at 25 and 50 mg/L for coagulation periods of 24 h and 48 h. Physicochemical parameters including, pH, biological oxygen demand (BOD), cyanide, coliform count and heavy metals [Ni, Zn, and Cr] were evaluated for both raw and treated wastewaters using standard methods. The data obtained were subjected to descriptive and inferential statistics. At 50 mg/L dose and 48 h coagulation period, the removal efficiencies of cyanide were 98.91% and 99.63% for alum and *M. oleifera* seeds, respectively. *M. oleifera* seeds reduced coliform in the effluent by 96.73% and decontaminated heavy metals [Ni, Zn, and Cr]. However, none of the two treatments could reduce BOD to a permissible level. The study concluded that *M. oleifera* seed is a potential coagulant, and could therefore be used as a substitute to synthetic coagulants.

Keywords: Cassava wastewater, Coagulant, Coagulation period, Dosage, Treatment.

INTRODUCTION

The threat to ecosystem (biotic and abiotic components) caused by releasing of toxic substances through effluents discharge from either municipal or industrial sources (Okafor, 2011; Adamu *et al.,* 2021) has now become worrisome to environmentalists. Most industries are guilty of releasing contaminants into the environment from various anthropogenic sources. Soil is known as an essential natural resource. Its layers are polluted mainly with inorganic contaminants released from industries such as food processing and other related activities (Papazotas *et al.*, 2018).

Cassava (*Manihot esculenta*) belongs to the family Euporbaceae (Nwaugo *et al.,* 2008). It is generally known as one of the largest sources of carbohydrates foods, though poor in vitamins and protein (Otekunrin, *et al.*, 2019). The availability of this carbohydrate rich food makes it eaten often by the low-income earners in continents like Africa and Asia (Coker *et al.*, 2015; Otekunrin *et al.*, 2019). This reason has led to the establishment of many cassava processing centres, the fallout of which is an extensive ecological pollution due to the release of wastewater into the environment. The intervention by Nigerian government in the aspect of cassava mechanization has also resulted in proportional increase in production and processing activities, thus increasing the amount of cassava wastewater release into the environment.

Cassava roots consist of toxic substances such as; cyanogenic glucosides, mainly linamarin, and a small quantity of methyl linamarin (Ogunyemi *et al.*, 2018). Boadi *et al.* (2008) reported that cyanide range in raw cassava root and its peels is between 360.05 to 509.51 mg/kg. Ingestion of cyanide above 30 ppm can lead to respiratory problems and eventually death (Ogunyemi *et al.*, 2018). This is the reason why cassava root should be thoroughly prepared through peeling, slicing, crushing, draining and roasting before consumption.

Researchers have reported enormous negative impact of cassava effluent on the ecosystem (Eze and Onyilide, 2015; Eboibi *et al*., 2018). Cassava wastewater if allowed to drain untreated or ill-treated on agricultural soil would affect soil layers and contaminate bodies of water when it ends up in aquatic ecosystems. This could cause serious adverse effects on activities of humans, fauna and flora (Hazrat *et al*., 2019; Osadebe and Okounim, 2020). Adult catfish, *Clarias gariepinus,* showed signs of gills and liver damage due to exposure to cassava effluent (Wade *et al*., 2002; Olaoye *et al*., 2020). Akpokodje *et al*. (2018) also reported that cassava wastewater significantly retarded the development and growth performance of two cultivars of bean (*Phaseolus* spp.). Olorunfemi *et al*. (2019) and Olaoye (2018) reported that cassava wastewater contains heavy metals that are non-biodegradable in nature and the effect of heavy metals plant uptake are of great concern for agriculturists.

Despite various reports on the effects of cassava effluent on the environment, little attention has been paid to research on the treatment of cassava wastewater. Cassava wastewaters are carelessly released onto roads, agricultural soil and rivers. The current study aims at treating cassava wastewater using alum and *Moringa oleifera*, for the safety of agricultural soil and aquatic habitat by reducing BOD, cyanide and concentration of nickel, zinc and chromium in the cassava wastewater as well as decrease in the microbial load of the effluent.

MATERIALS AND METHODS

Study area

Idofian cassava mill processing is among the major processing centres of cassava into "garri"-cassava flakes located on the outskirts of Ilorin metropolis, Kwara State, North Central Nigeria. Idofian cassava processing centre Latitude 8 35′ 85″N and Longitude 4 79′ 15″E is located in Ifelodun local government area along Lokoja - Abuja (Figure 1) highway where travellers stop and buy items like cassava flakes and other cassava products at cheaper prices. The study area is not far from popular "Idofian market" where more than 60% items produced from this cassava processing center are being sold.

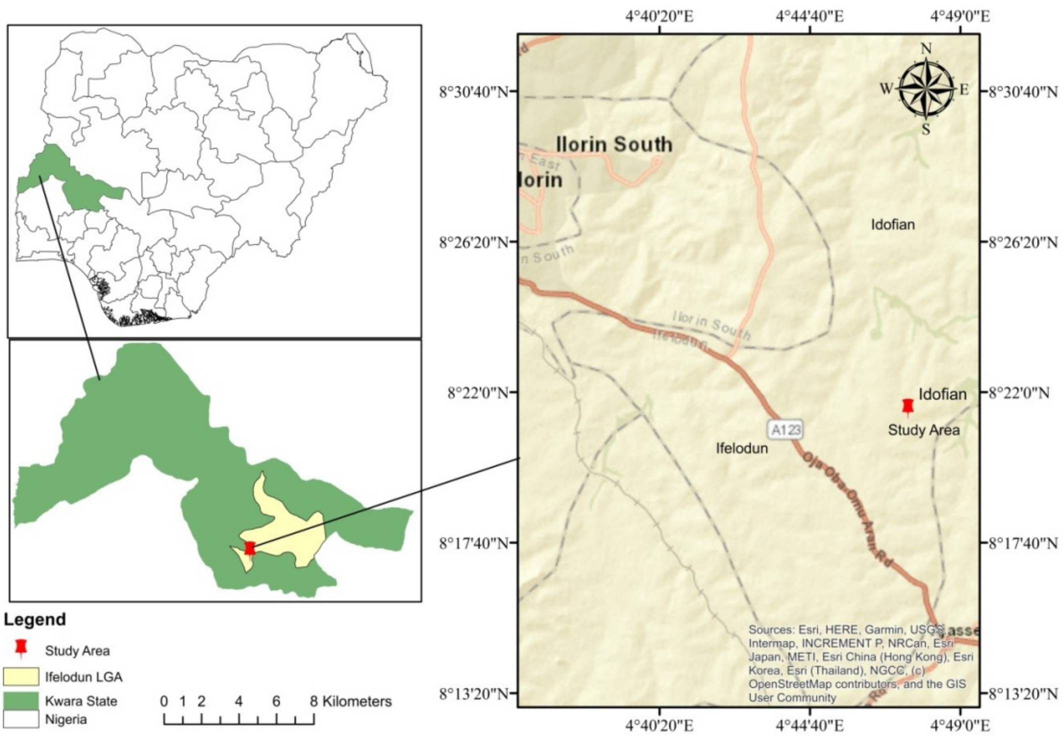

Figure 1: Map showing the study area.

Sample collection

Cassava effluent (300 L) was collected from cassava processing centre in (opaque) black kegs and stored in ice (about 4 °C) to guarantee the integrity of the sample is maintained before analyses were carried out. The sample was transported to the Processing and Storage Engineering laboratory at National Centre for Agricultural Mechanization for physicochemical analyses, part of the sample was also taken to University of Ilorin for the atomic Absorption Spectrophotometer analysis. The collection of sample was done in February, 2022 during harmattan season.

Moringa oleifera seeds were collected adjacent to the effluent sampling point. These seeds were obtained 5 days prior to the collection of effluent sample to ensure its readiness before effluent collection. Dried under sunlight for 48 h followed by sorting, dehulling and pulverization to fine powder with a mortar and passed through a 0.08 mm mesh size sieve and then stored in a polyethylene bag before the commencement of laboratory analyses.

Sample analysis

The APHA (1995) methodology was used for the determination of physicochemical properties such as BOD and total cyanide in the effluent. Heavy metals (nickel, zinc and chromium) concentrations in the cassava wastewater were also determined using atomic absorption spectrophotometer at specific wavelengths and pH as described earlier (APHA, 1995).

Biological examination

Faecal coliform count

The multiple-tube fermentation technique was used to obtain statistically valid most probable number (MPN) estimates of coliform density in the cassava effluent as described by (APHA and AWWA, 2012). In this procedure, 5 test tubes of 10 mL each of the effluent samples were used in the presumptive phase at an incubation temperature of 35 °C for 48 h. The inoculated tubes were observed for positive presumptive reaction (gas bubbles). The test tubes that showed positive presumptive reaction were then subjected to confirmatory test using lactose bile broth fermentation test tubes. The lactose bile was incubated at 35 °C for 24 h using a laboratory standard incubator (IncuMax 80l, Amerex Instruments, Inc). The MPN value was calculated by comparing the value to a standardized MPN table.

Treatment procedure for cassava effluent

The collected effluent sample was treated by two methods. The first method involved using alum $[KAl(SO_4)_2.12H_2O]$ as chemical coagulant combined with sodium hypochlorite at the same dose of 25 and 50 mg/L varied for coagulation times of 24 and 48 h. The second method was by the use of *Moringa oleifera* seeds also combined with the same volume of sodium hypochlorite and varied for the same coagulation time. The coagulant was added to 10 L each of cassava effluent for treatment procedure. Sodium hypochlorite was used as an antiseptic against microorganisms present in the effluent.

The experiment was fashioned in a completely randomized design (CRD) and replicated three times. The factorial experiment is shown in Table 1.

Table 1: Factorial experiment.

Alum (A) Method 1	Coagulation time for Treatment	
Hypochloride (H)	T_I	T_2
A_1H_1	$A_1H_1T_1$	$A_1H_1T_2$
A_2H_2	$A_2H_2T_1$	$A_2H_2T_2$
Moringa (M) Method 2		
Hypochloride (H)	T_I	T_2
M_1H_1	$M_1H_1T_1$	$M_1H_1T_2$
M_2H_2	$M_2H_2T_1$	$M_2H_2T_2$

A_1H_1=25 mg/L alum to 25 mg/L hypochlorite
A_2H_2=50 mg/L alum to 25 mg/L hypochlorite
M_1H_1=25 mg/L *Moringa* seeds to 25 mg/L hypochlorite
M_2H_2=50 mg/L *Moringa* seeds to 25 mg/L hypochlorite
T_1 and T_2 are coagulation times of 24 and 48 h

Removal efficiency

This is a parameter that represents the amount of analyte removed from the cassava wastewater relative to the amount of analyte present in the raw sample. This is calculated using the equation (Ademoroti, 1996):

$$\text{Removal efficiency} = \frac{C_a - C_b}{C_a} \times 100 \qquad (1)$$

where C_a is the influent (analyte present in the raw sample) C_b is the effluent (concentration of analyte removed from the cassava wastewater)

Statistical analysis

Data obtained were subjected to descriptive and inferential statistics. Data were tested for significant differences using one-way analysis of variance (ANOVA) and later means were separated using Duncan multiple range test.

RESULTS AND DISCUSSION

The cassava effluent collected from Idofian village was treated with alum as chemical coagulant and *Moringa oleifera* seeds as natural coagulant to study its effect on pH, BOD, cyanide, coliform count and heavy metals concentrations (nickel, zinc and chromium levels) in the effluent after treated.

Following addition of the coagulant, a continuing decline in the levels of contamination was observed in the parameters obtained. The starting amounts of 25 mg/L for 24 h, 25 mg/L for 48 h, 50 mg/L for 24 h and 50 mg/L for 48 h (dosage for treatment) showed progressive reduction in the concentration of contaminants as dosage increased with coagulation time as shown in Tables 2 and 3. This pattern indicates that a further addition of higher coagulant dose with coagulation time might have more effect on the physicochemical properties of cassava effluent because the higher the coagulant dose the more the negatively charged particles in the wastewater are neutralized. This causes the suspended solids in the wastewater to bind together into larger floc that can be removed subsequently by sedimentation and/or filtration.

In the cassava effluent treatment process using alum and *M. oleifera* seeds as coagulants, the result of each dose varied for different coagulant. This can be seen in Tables 2 and 3 below. A dose of 50 mg/L for 48 h coagulation time gave the best result as the treated wastewater gave the value of pH greater than 7, and the lowest value of coliform, BOD, cyanide, nickel, zinc and chromium for the two coagulants used separately.

The effect of coagulants treatment to cassava wastewater pH

The pH baseline of acidity or alkalinity is among the essential parameters influencing the coagulation efficiency in wastewater treatment. When the dose applied for the treatment does not yield the required pH range for the treated wastewater, it might end up producing poor quality of water.

As observed from the analyzed results, the pH of the control sample was acidic (4.61±0.02), the continuous release of effluent having this pH value would result in a progressive degradation and loss of biodiversity, which represents a real threat for the aquatic ecosystems (Naifar *et al.*, 2018; El Zrelli *et al.*, 2017).

Table 2: Physicochemical parameters of cassava wastewater as affected by alum coagulant.

Treatment dose	mg/L						(cfu/mL)
[*mg/L,T(h)*]	pH	BOD	Cyanide	Nickel	Zinc	Chromium	TCc
25, 24	5.58±0.25^{d}	144±3.01^{e}	0.14±0.02^{d}	0.12±0.02^{e}	2.14±0.01^{d}	1.45±0.06^{d}	86±6.25^{e}
25, 48	5.83±0.08^{d}	138±1.52^{d}	0.11±0.00^{d}	0.08±0.01^{d}	1.99±0.13^{c}	1.32±0.04^{c}	61±3.05^{d}
50, 24	6.55±0.03^{c}	126±2.08^{c}	0.08±0.01^{c}	0.03±0.01^{c}	1.37±0.10^{b}	0.75±0.21^{b}	33±2.51^{c}
50, 48	7.03±0.03^{b}	119±2.00^{b}	0.03±0.01^{b}	<0.01	0.71±0.03^{b}	0.42±0.03^{b}	24±2.08^{b}
Control	4.61±0.02^{a}	253±2.52^{a}	2.76±0.04^{a}	1.84±0.01^{a}	4.32±0.02^{a}	3.14±0.02^{a}	153±4.00^{a}
FEPA	6-9	50	0.10	1.00	1.00	1.00	10

Values are means ±S.D down the column with the same superscripts are not significantly different (p ⩽ 0.05).
FEPA: Federal Environmental Protection Agency.
FEPA (2003)
TCc : Total Coliform count (cfu/mL)
ND: Not Detected

Table 3: Physicochemical parameters of cassava wastewater as affected by *Moringa oleifera* seeds coagulant.

Treatment dose	mg/L						(cfu/mL)
[*mg/L,T(h)*]	pH	BOD	Cyanide	Nickel	Zinc	Chromium	TCc
25, 24	5.56±0.05^{b}	136±2.08^{b}	0.13±0.01^{b}	0.09±0.02^{b}	1.81±0.02^{b}	1.32±0.01^{b}	78±4.04^{b}
25, 48	6.02±0.10^{c}	131±2.00^{c}	0.09±0.01^{c}	0.04±0.02^{c}	1.67±0.05^{c}	1.07±0.03^{c}	50±3.00^{c}
50, 24	7.00±0.18^{d}	115±2.51^{d}	0.02±0.00^{d}	<0.01	0.91±0.03^{d}	0.41±0.00^{d}	19±5.03^{d}
50, 48	7.38±0.10^{e}	109±1.52^{e}	0.01±0.00^{d}	<0.01	0.44±0.02^{e}	0.34±0.03^{e}	5±1.52^{e}
Control	4.61±0.02^{a}	253±2.52^{a}	2.76±0.04^{a}	1.84±0.01^{a}	4.32±0.02^{a}	3.14±0.02^{a}	153±4.00^{a}

Values are means ±S.D down the column with the same superscripts are not significantly different (p ⩽ 0.05).

After treated with alum, the value of pH increased to 5.58±0.25, 5.83±0.08, 6.55±0.03 and 7.03±0.03 for the treatments using 25 mg/L for 24 h, 25 mg/L for 48 h, 50 mg/L for 24 h, 50 mg/L for 48 h dosages of alum, respectively, indicating that the treated wastewater samples were relatively neutral.

Using *M. oleifera* seeds as coagulant the value of pH increased to 5.56±0.05, 6.02±0.10, 7.00±0.18 and 7.38±0.10, for the following doses: 25 mg/L for 24 h, 25 mg/L for 48 h, 50 mg/L for 24 h, 50 mg/L for 48 h dosages, respectively. In both methods, the results showed significant ($p \leq 0.05$) variation for the treatment doses. Almost all the parameters were within the permissible limit pH range of 6.6-8.5 for water by WHO (2006) and 6-9 by FEPA, (1991) as reported by (Amagloh, 2009) except at treatment dose 25 mg/L for 24 h and 48 h with alum coagulant while only BOD, cyanide, zinc, chromium and coliform count parameters exceeded the standard range with natural coagulant at coagulant dose 25 mg/L for 24 h.

The pH value of the treated wastewater increased by increasing the coagulant dosage, the higher pH value was observed at treatment dose 50 mg/L for 48 h after treated with *M. oleifera* seeds than with chemical coagulant, which could suggest that the amino acids present in *M. Oleifera* (cationic coagulant) get ionized and produce carboxylate and H^{+} charge which attract colloidal particles in the medium and get neutralized and settle down as flocs. Since this produces carboxylate ions after ionization we could examine that the water becomes more alkaline (Muruganandam *et al.,* 2017). In another findings by Adeniyin *et al.* (2020), concluded that *M. oleifera* as a coagulant lies in the presence of water-soluble cationic proteins in the seeds. This suggests that in wastewater, the basic amino acids present in the protein of Moringa would accept a proton from wastewater resulting in the release of hydroxyl group making the solution basic.

The effect of coagulants usage on biochemical oxygen demand

The results of BOD is presented in Table 2 The initial BOD of cassava effluent was recorded to be 253±2.52 mg/L, far greater than permissible limit but after being subjected to treatment, the following BOD readings were obtained for alum coagulant: 144±3.01 mg/L, 138±1.52 mg/L, 126±2.08 mg/L and 119±2.00 mg/L with the following treatment dosages: 25 mg/L for 24 h, 25 mg/L for 48 h, 50 mg/L for 24 h, 50 mg/L for 48 h dosage, respectively. Meanwhile, the values obtained for natural coagulant were 136±2.08 mg/L, 131±2.00 mg/L, 115±2.51 mg/L and 109±1.52 mg/L with treatment dosages 25 mg/L for 24 h, 25 mg/L for 48 h, 50 mg/L for 24 h, 50 mg/L for 48 h dosage, respectively. Water is considered to be very contaminated when its BOD is above 50 mg/L recommended by FEPA and in this case, the parameters recorded for the two coagulants after treated were still above the FEPA standard it is unacceptable for releasing it into the environment (DPR, 2002 and FMoE, 1995).

The findings from this research established that the removal efficiency for BOD was not in conformity with other similar studies (Ashmawy *et al.,* 2012; Suhartini *et al.*, 2013). Adelodun *et al.* (2020) reported highest removal levels of 68.72% for BOD using *Moringa oleifera* seeds. This interprets that higher dosage of coagulant and coagulation time would be required to reduce the level of BOD of cassava effluent in order to conform to the standard set for the release of effluent into the environment.

The maximum removal efficiency is presented in Table 4, the maximum removal efficiency of 52.96% and 56.91% at treatment dose 50 mg/L for 48 h were observed with alum and *M. oleifera* seeds as coagulant, respectively. The BOD concentration reduced by approximately 53% (from 253±2.52 mg/L to 109±1.52 mg/L) with M. oleifera seeds at the optimum 50 mg/L dose for 48 h. The finding from this study revealed that the effectiveness of BOD removal was lower than the parameters reported in the previous studies (Suhartini *et al.*, 2013; Adelodun *et al.*, 2020; Abiye *et al.,* 2021).

The effect of coagulants application on cyanide

The cyanide in raw cassava wastewater was 2.76±0.04 mg/L. The amounts in the treated effluent values ranged from (0.03±0.01 to 0.14±0.02 mg/L) for the alum coagulant as shown in Table 2. The best cyanide reduction was achieved at treatment 50 mg/L for 48 h dosage with a cyanide level in the wastewater declined by 98.91% removal efficiency as shown in Table 4 while 99.63% was recorded with *M. oleifera* seeds coagulant (Table 5). This indicates that *M. oleifera* seed was more effective in removing cyanide from cassava wastewater than the chemical coagulant. The effectiveness of M. oleifera seeds in coagulation could be attributed to the sorbent quality and the presence of soluble cationic proteins embedded in M. oleifera seeds (Trevisan *et al.*, 2019; Magalhães *et al.*, 2021).

Comparison of cassava wastewater with 50 mg/L set by FEPA (Table 2), shows that the level of cyanide in raw wastewater was above the FEPA standard, this indicates that the wastewater is extremely toxic. After it was subjected to treatment with alum coagulant the values 0.14±0.02 mg/L and 0.11±0.00 mg/L were observed at treatment dose 25 mg/L for 24h and 25 mg/L for 48h, respectively, which were and above the recommended FEPA limit of 0.10 mg/L. The values recorded for other dosages were observed to be below the FEPA limit.

Meanwhile, with natural coagulant all the values were within the permissible limit of FEPA except only at first treatment dose of 25 mg/L for 24 h with value 0.13±0.01 mg/L (Table 3). The of value 0.03±0.01 mg/L observed at treatment dose 50 mg/L for 48 h was recorded as the highest removal efficiency of 99.63% among the treatment dose, the value 0.03±0.01 mg/L was lower than 0.09 mg/L reported by Olayinka and Anthony (2014) that used caustic hydrogen peroxide for the treatment of cassava effluent.

Table 4: Reduction efficiency (%) of physicochemical parameters of cassava wastewater as affected by alum treatment.

Treatment [*mg*/*L*,*T*(*h*)]	BOD	Cyanide	**Parameters** Nickel	Zinc	Chromium	TCc
25, 24	43.08	94.92	93.47	50.46	53.82	43.79
25, 48	45.45	96.01	95.65	53.93	57.96	60.13
50, 24	50.19	97.10	98.37	68.28	76.11	78.43
50, 48	52.96	98.91	ND	83.56	86.62	84.31

The effect of addition of coagulants on heavy metal

The results of effectiveness of using coagulants for the treatment of cassava effluent can be seen in Tables 2 and 3. The nickel content was observed to have almost completely decontaminated during the treatment with addition of alum and *M. oleifera* seeds coagulants. The nickel was reduced from 1.84±0.01 mg/L to undetectable at treatment 50 mg/L for 48 h with alum while with *M. oleifera* seeds the metal was decreased to undetectable level at treatment 50 mg/L for 24 h and 50 mg/L for 48 h. This result agreed with the earlier findings by Olayinka and Anthony (2014). The zinc concentration was decreased from 4.32±0.02 to 0.71±0.03 mg/L (83.56% removal efficiency) at treatment 50 mg/L for 48 h dosage with alum, meanwhile with *M. oleifera* seeds coagulant the raw value decreased from 4.32±0.02 to 0.44±0.02 mg/L with 89.81% removal efficiency. After the treatment with chemical coagulant, concentration of chromium decreased from 3.14±0.02 to 0.42±0.03 mg/L (86.62% reduction) at treatment 50 mg/L for 48 h dosage using alum whereas a decrease from 3.14±0.02 to 0.34±0.03 mg/L (89.17% reduction) was recorded with the natural coagulant.

Table 5: Reduction efficiency (%) of physicochemical parameters of cassava wastewater as affected by *Moringa oleifera* seeds treatment.

Treatment [*mg*/*L*,*T*(*h*)]	BOD	Cyanide	**Parameters** Nickel	Zinc	Chromium	TCc
25, 24	46.25	95.28	95.10	58.10	57.96	49.01
25, 48	49.40	96.73	97.82	61.34	65.92	67.32
50, 24	54.54	99.27	ND	78.93	86.94	87.58
50, 48	56.91	99.63	ND	89.81	89.17	96.73

The presence of high heavy metals (nickel, zinc, chromium) concentration of cassava wastewater could also be attributed to the wearing off of the cassava milling machine parts and emission from the cassava grating machine (Osakwe, 2010; Igiehon, 2015). It could also be from cassava source through bioaccumulation of heavy metals by the roots and foliage of cassava plant (Ayoola, 2008; Amusat *et al.*, 2018).

The effect of coagulants usage on total coliform count

The level of coliforms bacterial in the treated samples decreased significantly ($p \leq 0.05$) as the dosage and coagulation time increased.

The use of alum as coagulant for treating cassava effluent showed that the microbial content reduced by 84.31% (Table 4) at 50 mg/L for 48 h dosage, while with *M. oleifera* seeds recorded the higher reduction efficiency of 96.73% (Table 5) was observed at 50 mg/L for 48 h dosage. The result of total coliform count (cfu/mL) at 50 mg/L for 48 h dosage with *M. oleifera* seeds treatment was 5±1.52 cfu/mL which was below the FEPA permissible limit of wastewater discharge of 10 cfu/mL. This ascertains the efficiency of *M. oleifera* seeds as coagulant for decontamination of cassava effluent than alum and which means that the addition of *M. oleifera* seeds as coagulant led to the more degradation of the coliforms content of the cassava wastewater. The decrease in the coliforms level signified a reduction in the pollution of the cassava wastewater (Ugwu and Agunwamba, 2012). It was also reported that the M. oleifera seed powder act as an antimicrobial agent against, the active antimicrobial agent isolated was found to be 4-α-rhamnosyloxybenzylisothiocyanate (Adeniyin *et al*., 2020) and currently known as glucosidal mustard oil. This coagulates the solid matter in the wastewater so that it can be easily removed and thereby removing a good portion of the suspended microorganism (Egbuikwem and Sangodoyin, 2013).

CONCLUSION

The examined parameters of treated wastewater from cassava effluent using alum and *M. oleifera* seed as coagulants showed significant reduction in the level of toxicity. Usually, chemical coagulants have been widely used for the purification of wastewater and are known to increase the acidity of the treated water. This study has revealed that based on the results of this research, *M. oleifera* seed has multipurpose functions and has a potential to be used as a replacement for chemical coagulants used for the treatment of wastewater before discharging such water to the environment.

This study proved that the use of *M. oleifera* seed in the reduction of pH, cyanide, nickel, chromium and total coliform count is highly effective at 50 mg/L for 48 h dosage when compared with similar parameters obtained using chemical coagulant. Although, the performance of the natural coagulant was satisfactory at 50 mg/L for 48 h dosage, the BOD value after treated was still above FEPA standard for wastewater discharge. Since the natural coagulant at 50 mg/L for 48 h dosage is inefficient in treating cassava wastewater of very high BOD which necessitates special attention, the authors suggest that the further research can be carried out by increasing the dosage of *M. oleifera* seed with coagulation period.

In actual fact, the most favourable coagulant dose of alum and *M. oleifera* seed is determined by the natural condition of the cassava effluent to be treated. Hence, the heavier the load of pollutant, the higher the coagulant dose that is required.

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