

# Exploring the Characterization of Cactus Opuntia as a Coagulant for Turbidity and Chromium removal from Simulated Paint Wastewater

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**Abstract**— The coagulation–flocculation potential of Cactus Opuntia Extract (COE), an environmental-friendly coagulant was exploited. The bio-extract was analyzed for functional groups, crystalline structure, surface morphology and phytoconstituents. The FTIR spectrum of COE depicts strong stretch at peaks  $3406.36\text{ cm}^{-1}$ ,  $3000\text{ cm}^{-1}$  etc. which confirms the presence of amine group and aromatic ring. The SEM micrographs reveal that the COE is characterized by a rough surface morphology where particles could be adsorbed. The COE was confirmed to have phytoconstituents like flavonoids and tannin which confirmed its coagulability. The effects of coagulant dosage, effluent pH and settling time on the process were studied. At the experimental parameters, the optimum removal efficiencies were recorded at 3 g/l dosage of COE coagulants at pH 6. The obtained maximum efficiencies were 99.6% and 98.14% for turbidity and chromium ion concentration removal using COE respectively. From the results, it is evident that COE is a better low cost and environmental-friendly natural coagulant effective for the removal of turbidity and chromium ion concentration from paint waste water. Therefore, being biodegradable, environmental-friendly, abundant, inexpensive and leaving little or no traces of harmful substances on environment which makes it safe to human health, COE is a promising alternative to the conventional coagulants used in the treatment of paint industry wastewater.

**Keywords**— Coagulation-Flocculation, Cactus opuntia, Simulated Paint wastewater, XRD, SEM and FTIR.

## I. INTRODUCTION

Paint waste water (PWW) is normally generated from paint production. Production of paint generally is predominantly one of the major feasible small and medium scale enterprises (SMEs) in Anambra State and Nigeria at large. However, the wastewater generated from the paint producing plant has become a considerable concern in the scientific community (da Silva et al., 2016) and poses great threatening alarm to the environment if not properly treated prior to its discharge. This is due to the high quantity of different harmful chemical compounds used in production of paint. These chemicals comprise mainly inorganic substances with high polar and hydrophilic functional groups (Madukasi et al., 2009). Also, da Silva et al., (2016) maintained that the wastewater presents high coloration, turbidity, strong odor and contain high loads of organic and toxic chemical substances, such as surfactants, bactericides, oils, solvents and preservative agents. There are also traces of some elements such as mercury, copper, chromium, zinc, iron, lead and coloring agents (Madukasi et

al., 2009; Aboulhassan et al., 2014). The release of the wastewater directly into water bodies can constitute to ecological instability, since the presence of color blocks the passage of sunlight, thereby preventing the photosynthesis of aquatic plants, which in turn leads to the depletion of dissolved oxygen (da Silva et al., 2016). Therefore, there is need to reduce their concentrations (specifically, the particles in this study) to acceptable standards before discharging into the environment (Simate et al., 2012). However, several researchers have employed different technologies like adsorption, ion exchange, electrochemical, filtration, ultrafiltration, sedimentation, reverse osmosis and coagulation–flocculation in the treatment of this wastewater (Santos et al., 2012; Muruganandam et al., 2017). Nevertheless, coagulation–flocculation technique has remained the best initial treatment method for the removal of colloidal, suspended materials and organic and inorganic matter that dispersed in the solution (da Silva et al., 2016; Suidan, 1998; Diterlizzi, 1994).

Investigation on the wastewater treatment strategies recently has been focusing attention on the utilization of biomaterials to combat a variety of pollutants including heavy metal ions, dyes, colors, phosphates, nitrates, chlorides, phenolic compounds, pesticides, detergents and particulates among others. This led to the discovery of natural flocculants that purify water through coagulation– flocculation processes (Li et al., 2009). Armenante (2004) defines coagulation as the process through which very fine solid suspensions are destabilized so that they can begin to agglomerate into small aggregates if conditions allow, while flocculation is defined as the process by which destabilized particles actually conglomerate into larger aggregates that can be separated from wastewater using standard techniques. The inorganic, organic and biomaterials that promote aggregation and sedimentation of suspended particles in solution are called coagulants and flocculants. Natural flocculants are viable alternative for developing countries like Nigeria. Some of the bioflocculants that have been tested include okra, gaur and mesquite seed gum (Carpinteyro-Urban and Torres, 2013), bacteria isolates (Buthelezi et al., 2012), Moringa oleifera and Opuntia spp, kenaf, Conicia indica (Varsha and Jay, 2012), and Plantago psyllium. The advantages of natural flocculants over conventional coagulants–flocculants include their

harmlessness, biodegradability, low commercial cost, relative abundance, renewability and high efficiency and therefore of smaller environmental impact compared to inorganic and synthetic polymers (Sharma et al., 2006). It is therefore, desirable to explore for these cost-effective and more environmentally acceptable bio coagulants to meet legislative requirements for a clean environment.

Coagulation could be described as an action that involves neutralization of charge whereas activity could be a physical process and does not involve neutralization of charge. The coagulation-flocculation process can be used as a preliminary or intermediary step between other water or wastewater treatment processes like filtration and sedimentation. One of the factors that affect coagulation is the type of coagulant used; its dose and mass, pH and initial turbidity of the water that is been treated; and properties of the pollutants present. In a sol, particles can settle terribly slowly or not in any respect as a result of the mixture particles carry surface electrical charges that reciprocally repel one another. A typical metallic salt used as coagulant with the opposite charge is added to the water to overcome the repulsive charge and “destabilize” the suspension. For example, the mixture particles square measure charged and alum is value-added as a coagulator to form charged ions. Once the repulsive charges are neutral (since opposite charges attract), the Van der Waals force can cause the particles to cling along (agglomerate) and for small or larger aggregates.

This present research is focused on Exploring the Characterization of Cactus opuntia (*ficus-indica*) as a Coagulant in the Treatment of Paint Wastewater on the basis of turbidity and chromium removal using one factor at a time approach.

## II. MATERIALS AND METHODS

### 2.1 Simulation of Paint Waste Water (PWW)

All the chemicals used in the experiments were of analytical grade. In order to prevent photo-catalysed changes in the effluent composition, Simulated water-based paint effluent was prepared by adding 1700 mg (1.7 g) aqueous water-based emulsion pal blue paint and made up to 1,000 ml, using distilled water. Thereafter, the solution was characterized to get the physical-chemical properties of the simulated sample, which were used as the real effluent from paint industry.

### 2.2 Collection and Preparation of COE Coagulants

Cactus opuntia (*ficus-indica*) pods were collected from Egbuna Street Off Ezenei Quarter, Oshimili South LGA Asaba, Delta State, Nigeria. The samples were washed, sliced, sun dried for two (2) weeks and oven dried at 60°C for 24 h. The resultant materials were milled and sieved using a 0.2-mm sieve.

### 2.3. Extraction of Active Component

The procedure for the extraction of active ingredient from COE are as outlined. A specific amount (1 g) of Cactus Opuntia Extract was suspended in 100 ml of solvent named eluent (3N of NaCl). The mixture was stirred for 15 min. And the solution was allowed to settle for 15 min. Filtered the

solution using a filter cloth. Then the filtrate (supernatant liquid) known as eluate was obtained and kept in the refrigerator to prevent deterioration which served as the coagulant. The procedures enumerated were repeated for 2 g, 3 g, 4 g and 5 g of Cactus Opuntia Extract.

### 2.4. Characterization of Samples

#### 2.4.1 Simulated Paint Waste Water (PWW) Characterization

Simulated Paint wastewater quality parameters (TDS, turbidity, pH and conductivity and Heavy metals) were Characterized as listed in Table 3.1 and table 3.2 according to American Public Health Association (APHA) standard for the examination of water and wastewater (Wennie et al. 2014; CCME 2008; Freese et al. 2003 and APHA 2012).

#### 2.4.2 Coagulant Characterization

Cactus opuntia Extract was characterized under proximate analysis such as Moisture content, ash content, crude fibre, protein content, fat content, carbohydrate was determined by standard methods of analysis as enumerated in sections 2.4.2.1 – 2.4.2.6 and summarized in table 3.3.

##### 2.4.2.1 Determination of Moisture Content

A petri-dish was washed and dried in the oven. Exactly 2 g of the sample was weighed into the petri-dish. The weight of the petri-dish and sample was noted before drying. The petri-dish and sample were put in the oven and heated at 100°C for 1 hr, the result was noted and heated for another one hour until a steady result was obtained and the weight noted. The drying procedure was continued until a constant weight was obtained

$$\% \text{ moisture content} = \frac{W_1 - W_2}{\text{Weight of Sample}} \times 100 \quad (2.1)$$

##### 2.4.2.2 Determination of Ash Content

According to AOAC, 1984

Empty platinum crucible was washed, dried and the weight was noted. Exactly 2 g of wet sample was weighed into the platinum crucible and placed in a muffle furnace at 500°C for 3 hr. The sample was cooled in a desiccator after burning and weighed. The ash content was calculated by the residue left after combustion.

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad (2.2)$$

Weight of ash = (Weight of crucible + weight of ash) - (weight of crucible)

##### 2.4.2.3 Determination of Crude Fiber

About 2 g of material was defatted with petroleum ether. Thereafter Boiled under reflux for 30 min with 200 ml of a solution containing 1.25 g of H<sub>2</sub>SO<sub>4</sub> per 100 ml of solution. Filtered the solution through linen on a fluted funnel. Washed with boiling water until the washings are no longer acid. Transferred the residue to a beaker and boil for 30 min with 200 ml of a solution containing 1.25 g of carbonate free NaOH per 100 ml. Filter the final residue through a thin but close pad of washed and ignited asbestos in a Gooch crucible. Dry in an electric oven and weigh. Incinerate, cool and weigh. The loss in weight after incineration x 100 is the percentage of crude fibre

$$\% \text{ crude fiber} = \frac{\text{Weight of Fibre}}{\text{Weight of Sample}} \times 100 \quad (2.3)$$

##### 2.4.2.4 Determination of Crude Proteins

According to AOAC, 1990

**Principle:** The method is the digestion of sample with hot concentrated sulphuric acid in the presence of a metallic catalyst. Organic nitrogen in the sample is reduced to ammonia. This is retained in the solution as ammonium sulphate. The solution is made alkaline, and then distilled to release the ammonia. The ammonia is trapped in dilute acid and then titrated.

**Procedures:** Exactly 0.5 g of sample was weighed into 30 ml Kjehdal flask (gently to prevent sample from touching the walls of the side of each and then the flasks were stoppered and shaken. Then 0.5 g of the Kjehdal catalyst mixture was added. The mixture was heated cautiously in a digestion rack under fire until a clear solution appeared. The clear solution was then allowed to stand for 30 min and allowed to cool. After cooling about 100 ml of distilled water was added to avoid caking and then 50 ml was transferred to the Kjehdal distillation apparatus.

A 100 ml receiver flask containing five ml of twenty-two element acid and indicator mixture containing 5 drops of Bromocresol blue and one drop of stain was placed underneath a condenser of the distillation equipment so the faucet was regarding 20 cm within the answer. The 5 ml of 40% sodium hydroxide was added to the digested sample in the apparatus and distillation commenced immediately until 50 drops gets into the receiver flask, after which it was titrated to pink colour using 0.01 N hydrochloric acid.

It is calculated as % Nitrogen = Titre value x 0.01 x 14 x 4  
 % Protein = % Nitrogen x 6.25 (2.4)

2.4.2.5 Determination of Crude Fat

Soxhlet fat extraction method

This method was carried out by continuously extracting a food with non-polar organic solvent such as petroleum ether for about 1 hr or more.

**Procedure:** Dry 250 ml clean boiling flasks in oven at 105-110°C for about 30 mi. Transfer into a desiccator and allow to cool. Weigh correspondingly labelled, cooled boiling flasks. Fill the boiling flasks with about 300 ml of petroleum ether (boiling point 40-60°C). Plug the extraction thimble lightly with cotton wool. Assemble the Soxhlet apparatus and allow refluxing for about 6 hr. Remove thimble with care and collect petroleum ether in the top container of the set-up and drain into a container for re-use. When flasks are almost free of petroleum ether, remove and dry at 105°C -110°C for 1 hr. Transfer from the oven into a desiccator and allow to cool; the weigh.

2.4.2.6 Carbohydrate Determination

(Differential method)

100- (% Protein + % Moisture + % Ash + % Fat + %Fiber) (2.5)

2.4.3 Instrumental Analysis of COE

The following instrumental analyses: scanning electron microscopy (SEM) and Fourier transform infrared (FTIR) were carried out using ASTM E1185-88 and ASTM E2809, for SEM and FTIR respectively.

The scanning electron microscope model JSM-6400 was used. A very thin layer of the coagulant was dispersed on sample holder with double-sided tape and coated with a thin layer of carbon by using BIO-RAS Sputter. The images were captured at different magnifications. FTIR-8400S Fourier Transform Infrared Spectrophotometer was used to determine

the functional groups present in sample. The spectrum was measured within the range of 3406.36 – 754 cm<sup>-1</sup> waves

2.5 Coagulation-Flocculation Studies

The coagulation studies were carried out using Jar test apparatus, and explained in procedural steps as enumerated below.

Five (5) different beakers containing 1l of the simulated PWW were set-up. The pH of the simulated PWW was adjusted to pH (2, 4, 6, 8, 10) with the aid of 0.1 M NaOH and/or 0.1 M H<sub>2</sub>SO<sub>4</sub>.

A 100 ml volume of the coagulant at 1 g/l dosage in 1l was added into simulated PWW. Jar test for coagulation study was set-up on a magnetic stirrer and was agitated at a rapid mixing rate of 200 rpm for 3 min and followed by slow mixing at 80 rpm for 15min. The mixture was allowed to settle at 5, 10, 20, 30,40, 60, 90, 120, 150, 180 mins. After each settling period, 50 ml of clarified top layer of the sample was collected using syringe and was analysed for Turbidity and Chromium ion concentration removal. The processes as enumerated were repeated for 2 g/l, 3 g/l, 4 g/l and 5 g/l dosages.

2.6 Analytical Method

The supernatant samples were withdrawn with the aid of syringe at specified time range (5–180 min) to determine residual turbidity and chromium ion concentration. The turbidity and chromium ion concentration removal efficiency (%) were calculated by applying equation 2.6 and its analogous respectively.

$$\text{Removal Efficiency (\%)} = \left[ \frac{T_0 - T_t}{T_0} \right] \times 100 \quad (2.6)$$

where T<sub>0</sub> and T<sub>t</sub> are initial turbidity of effluent and effluent turbidity at any time.

III. RESULTS AND DISCUSSION

3.1 Simulated Paint Waste Water Characterization Results

The simulated paint waste water was carried out for physico-chemical properties and heavy metals as shown in table 3.1 and 3.2 respectively.

TABLE 3.1: Physiochemical Properties of simulated PWW

Parameter	Content
pH	7.11
Total Dissolved Solid, TDS, mg/l	54
Turbidity, NTU	1700
Conductivity, us/cm	136

3.2 Proximate Analysis Results

The proximate analysis of Cactus Opuntia Extract was carried out for moisture content, ash content, fat content, crude fiber content, protein content and carbohydrate as presented in table 3.3.

3.3 Instrumental Analysis Results (SEM and FTIR)

3.3.1 SEM Result

The SEM technique is used to analyse the surface morphology of the polymeric coagulant. The plate 3.1 shows the SEM micrographs of the sample at different magnifications.

TABLE 3.2: Heavy Metal Analysis of simulated PWW

Parameters	Concentration	Tolerance Value	Reference Test Method
Cobalt mg/l	0.017	0.01	APHA 3120-B 22 <sup>nd</sup> Edition 2012 by AAS or AOAC 974.27, AOAC 993.14
Magnesium mg/l	10.688	2	APHA 3120-B 22 <sup>nd</sup> Edition 2012 by AAS or AOAC 974.27, AOAC 993.14
Chromium mg/l	0.966	0.01	APHA 3125B 22 <sup>nd</sup> Edition 2012 by ICP-MS or AOAC 993.14, AOAC 974.27
Iron mg/l	0.25	0.3	by ICP – APHA 3500-Fe B 22 <sup>nd</sup> 2012 & APHA 3120 – B 22 <sup>nd</sup> Edition 2012 OES or AOAC 974.27
Manganese mg/l	0.112	0.1	APHA 3120-B 22 <sup>nd</sup> Editon 2012 by ICP-OES or AOAC 993.14, AOAC 974.27
Lead mg/l	0	0.01	APHA 3125B 22 <sup>nd</sup> Edition 2012 by ICP – MS or AOAC 993.14, AOAC 974.27
Zinc mg/l	0.433	5	APHA 3111B 22 <sup>nd</sup> Edition 2012 by AAS or AOAC 974.27
Copper mg/l	0.6	1	APHA 3500-Cu C 22 <sup>nd</sup> Edition 2012 & APHA 3120-B 22 <sup>nd</sup> Edition 2012 by ICP-OES or AOAC 993.14 AOAC 974.27
Calcium mg/l	14.926	20	APHA 3120 – B 22 <sup>nd</sup> Edition 2012 by ICP – OES or AOAC 993.14, AOAC 920.205
Arsenic mg/l	0.127	0.01	APHA 3120 – B 22 <sup>nd</sup> Edition 2012 by ICP – OES or AOAC 993.14, AOAC 920.205
Sodium mg/l	18.414	100	APHA 3120B by ICP-OES 22 <sup>nd</sup> Edition 2012, or AOAC 973.54
Silver mg/l	0.317	0.1	APHA 3120-B 22 <sup>nd</sup> Edition 2012 by AAS or AOAC 974.27, AOAC 993.14
Aluminium mg/l	0	0.02	APHA 3120B 22 <sup>nd</sup> Edition 2012 by ICP – OES or AOAC 993.14
Nickel mg/l	0	0.01	APHA 3125B 22 <sup>nd</sup> Edition 2012 by ICP- MS or AOAC 993.14

TABLE 3.3: Proximate composition of dried Cactus Opuntia Extract at 60°C drying temperature.

Constituents	Cactus Opuntia Powder (%)
Moisture content	1.63
Ash content	20.46
Fat content	2.3
Crude Fiber content	6.15
Protein content	7.52
Carbohydrate	61.94

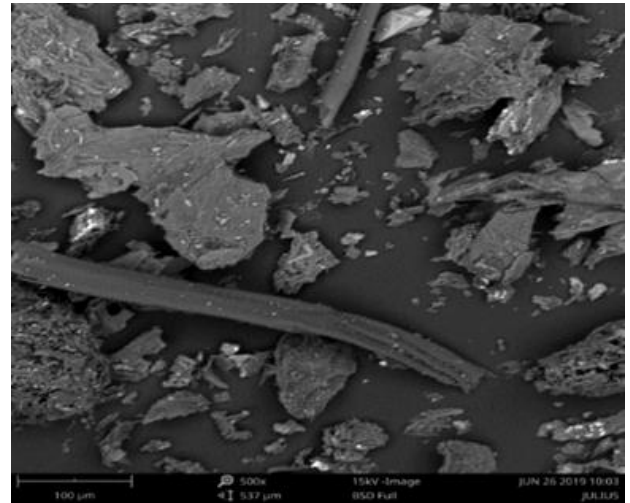


Plate 3.1: SEM 500 X Cactus Opuntia

The SEM micrographs reveal that the COE is characterized by a rough surface morphology. Particles could be adsorbed or attached to the rough surfaces of the polymer chains by electrostatic force to form bridges. The pores and rough surfaces shown on the SEM images confirm that adsorption would play an important role in the treatment processes which agrees with (Obiora-Okafo et al., 2014) findings. The morphologies of the coagulant also possess the compact-net structures. The compact-net structure is more favourable in particle removal due to bridge aggregation formation among flocs and clogging of the particles on the adsorption sites as shown in Plate 3.1.

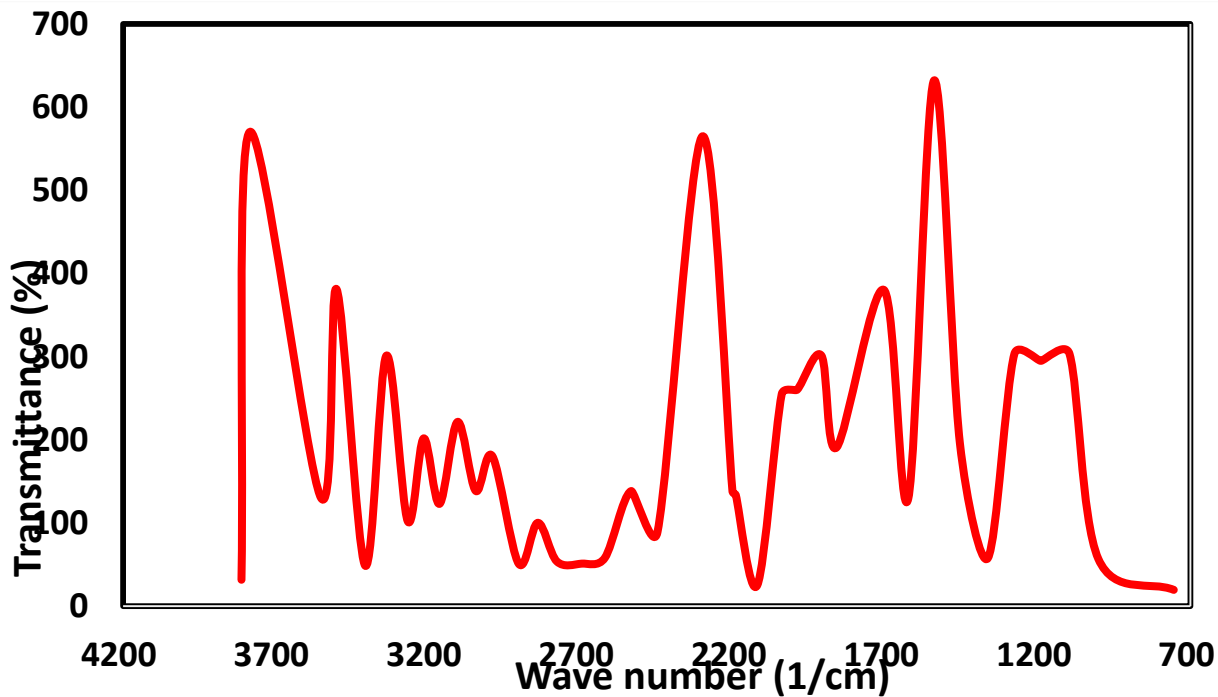


Fig. 3.1: FT-IR spectrum of Cactus opuntia (ficus-indica).

3.3.2 FTIR Result

The FTIR technique is an important tool to identify the characteristic functional groups, which are instrumental in determination of functional groups and organic compounds inherent in any tested sample. This study is thus aimed at showcasing the functional groups and compounds present in the Cactus Opuntia.

The FTIR spectrum of Cactus opuntia is shown in Figure 3.4. The strong stretch at  $3406.36\text{cm}^{-1}$  was due to polymeric OH stretching vibration of water and stretching vibration of amine group. Peaks at  $3000\text{cm}^{-1}$  shows the presence of C=C-H group, which indicates aromatic ring. Sharp peak at  $1500\text{cm}^{-1}$  confirmed the presence of benzene group. The peak at  $1456.11\text{cm}^{-1}$  confirms the presence of carboxylic acid salt. Presence of aromatic primary amine stretch (C – N stretch), was depicted by the peak at  $1364.22\text{cm}^{-1}$ . Vibrational peak at  $1190.74\text{cm}^{-1}$  shows the C=C stretch. Several peaks were formed from  $1002$  to  $754\text{cm}^{-1}$ , which further confirms the presence of aromatic group. Hence, the FTIR spectra reveal that the Cactus Opuntia mainly carries aromatic groups and this result agrees with the findings of Vishali and Karthikeyan (2014).

3.3.4 Phytochemical Analysis

Qualitative phytochemical analysis was carried out on COE to check for the presence of various phytoconstituents like flavonoids, alkaloids, carotenoids, tannin, antioxidants and phenolic compounds etc. that confirm its coagulability as shown in table 3.4.

3.4. Effects of process variables on the removal of turbidity and chromium ion concentration from PWW using COE

3.4.1. Effect of effluent pH on turbidity and chromium ion concentration on PWW using COE.

pH is defined as the negative log of the hydrogen ion concentration. It plays an important role in the coagulation-

flocculation process. An optimum pH must be established for an efficient operation. An Interpretations were drawn from the graphical trend and the optimum pH was recorded at pH 6 using one factor at a time approach. The region of increase in removal efficiency could be attributed to progressive protonation as positive species progressively conjugated with available negative species toward equilibrium. The decreasing region was as a result of net negative species-induced charge reversal, which entails re-stabilization and coagulation recession which agrees with that reported by (Menkiti et al., 2011). The highest turbidity removal efficiency was recorded as 99.69%, while that of Chromium removal efficiency was recorded as 99.70% at pH of 6 using Cactus Opuntia as shown in Figure 3.2 and 3.3 respectively.

TABLE 3.4: Phytoconstituents table

Component	Retention	Peak Area	Height
Proanthocyanin	0.08	232.8066	139.94
Rebalinidine	2.39	12252.8106	301.042
Naringin	4.12	6344.5478	157.568
Quinine	6.016	18154.0688	442.689
Flavan-3-ol	7.47	8442.9838	206.428
Anthocyanin	10.366	19598.0668	476.646
Lunamarin	12.97	6238.3258	152.341
Sapogenin	15.46	4967.5639	121.273
Sparteine	17.966	11339.2568	276.424
Phenol	20.313	12756.484	307.63
Flavonones	22.73	9573.1408	233.186
Steroids	25.65	10008.8176	245.115
Epicatechin	27.536	11458.0104	280.295
Kaempferol	29.86	5478.4406	133.723
Phytate	33	14337.0482	348.877
Flavone	34.6	6059.794	147.836
Oxalate	36.876	6988.5601	170.31
Naringenin	39.2	10234.6024	249.263
Resveratol	42.276	3473.1416	85.31
Tannin	44.17	10509.6768	256.782

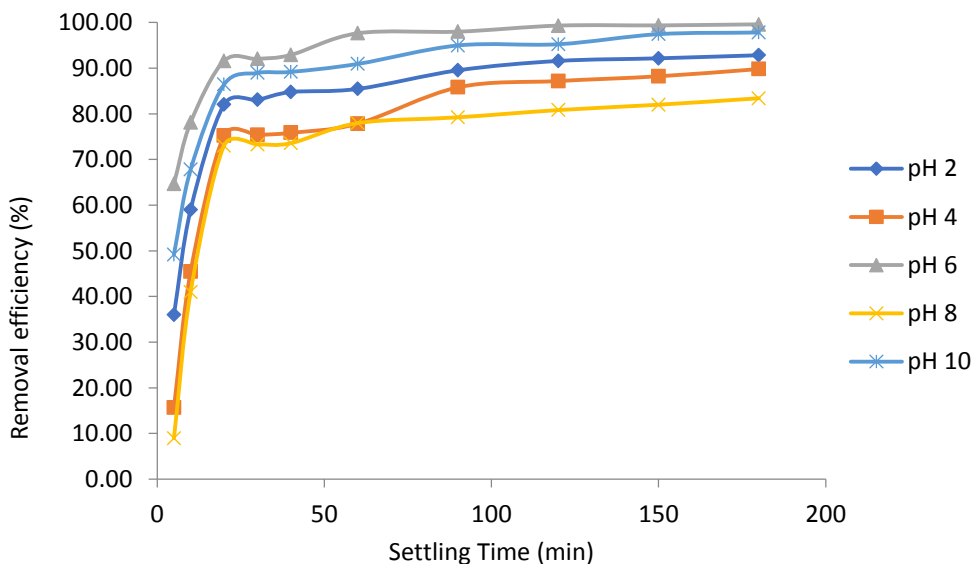


Fig. 3.2: Effect of pH on Turbidity removal using COE

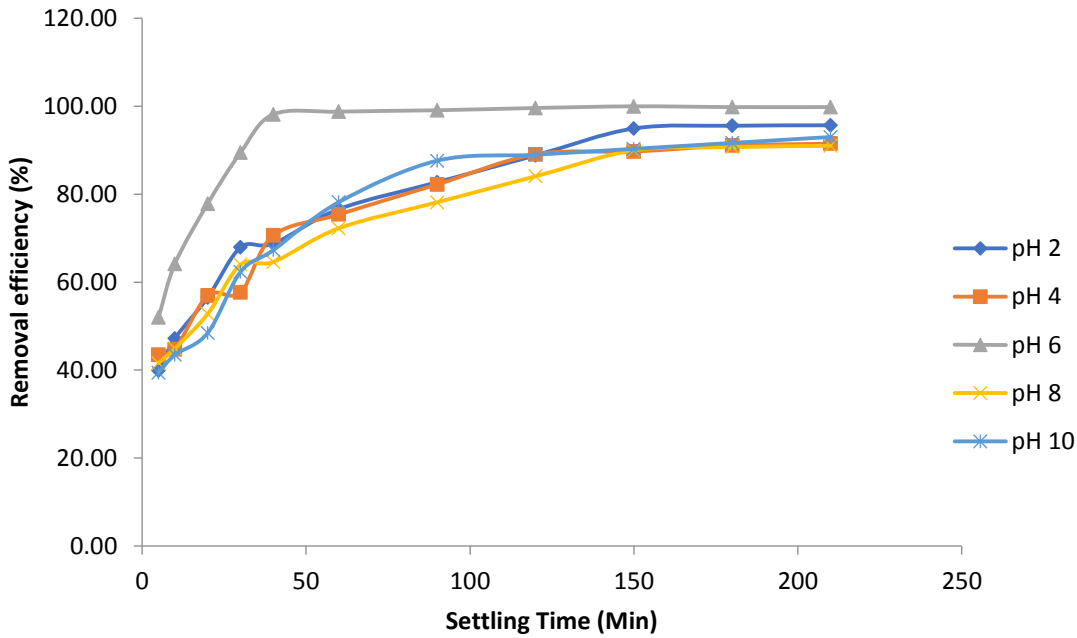


Fig. 3.3: Effect of pH on Chromium ion removal using COE

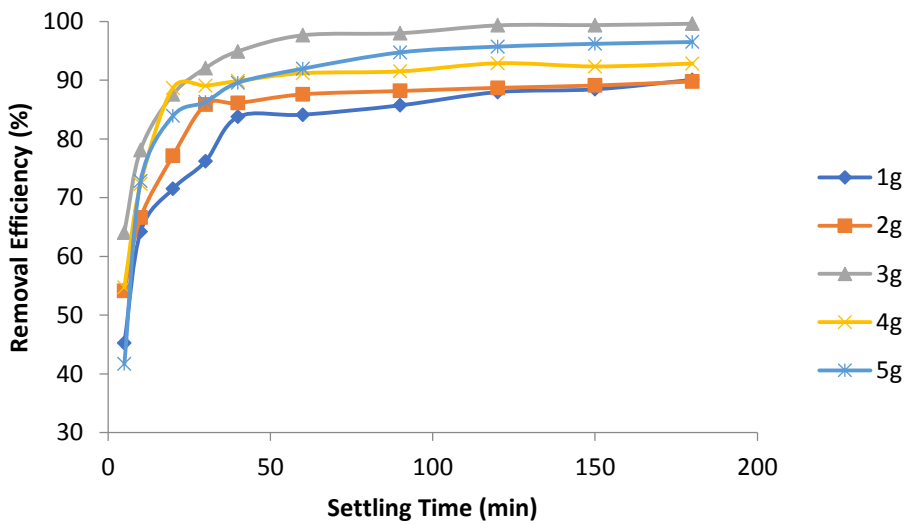


Fig. 3.4: Effect of Coagulant Dosage on Turbidity removal using COE

3.4.2. Effect of coagulant dosage on the removal of turbidity and chromium ion concentration from PWW using COE

The effect of coagulant dosage on the removal of turbidity and chromium ion concentration were shown in the figure 3.4 and 3.5.

These figures indicate that the removal efficiency is enhanced by increasing the coagulant dosage. The optimum removal efficiency was recorded at 3g/l for both COE and Alum coagulants. The obtained maximum efficiency was 99.6% for turbidity using COE While 98.14% was the obtained maximum efficiency for chromium ion concentration removal using COE. Increasing the dosage beyond 3g/l reduced the efficiency of the process.

The coagulants apparently served as condensation nuclei and paint effluent particles were enmeshed as the precipitate was settled. The high dosages of the COE could also give rise to chain bridging and adsorption mechanism. Furthermore, sudden decrease found in the removal efficiency at furtherance of dosage was as a result of re-stabilization which might have occurred due to particle overdosing. Overdosing deteriorates supernatant quality which makes particle not to coagulate effectively (Obiora-Okafo et al., 2015).

3.4.3. Effects of initial concentration

Initial concentrations of simulated PWW samples 1500, 1700, 1900, 2100 and 2300 mg/l, were prepared and named as sample numbers 1–5, respectively. The pollutant removal is

augmented with the decrease in the initial concentration of effluent from 2300 to 1500 mg/l and the best removal efficiency was achieved at 1500mg/L. This is due to more

efficient utilization of the coagulant resulting to a greater driving force by a lower concentration gradient as depicted in figure 3.6.

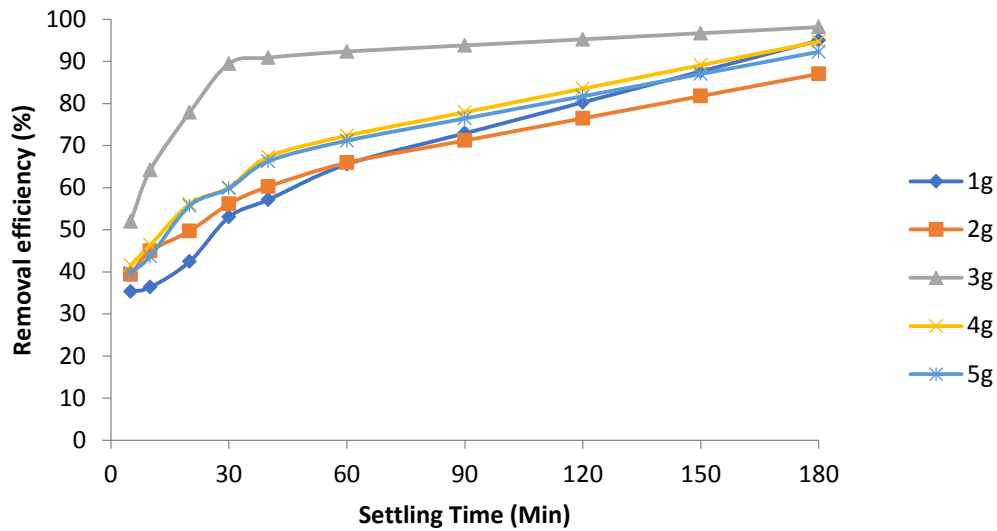


Fig. 3.5: Effect of Coagulant Dosage on Chromium ion concentration removal using COE

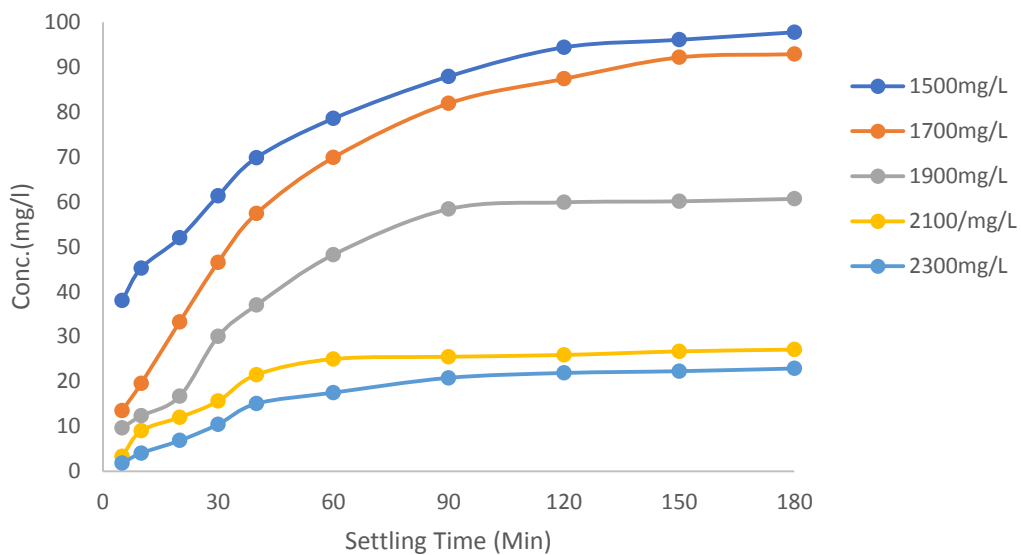


Fig. 3.6: Effect of initial concentration on the removal of Turbidity COE

#### IV. CONCLUSION

The environmental-friendly approach for PWW coagulation–flocculation was successfully conducted using COE under stated experimental conditions. The present study showed that the organic polymer coagulant used was effective for the removal of turbidity and chromium ion concentration from paint wastewater. The efficacy of COE was due to its coagulation characteristics as analysed in the characterization results. Proximate analysis showed that COE has the features of a coagulant. FTIR analysis indicated that some chemical bonds such as -OH, N-H, C=H present aids the coagulation-

flocculation process. SEM image revealed rough surfaces, different pores sizes, and compact-net structure. These instrumental analyses results reveal the functionality of the coagulant sample while the jar test operation showed that the removal efficiency of Turbidity and Chromium ion concentration was greatly influenced by the effects of process parameters such as coagulant dosage, effluent pH, effluent initial concentration and settling time. The optimum removal efficiency was recorded at 3 g/l dosage for COE coagulants at pH 6. The obtained maximum efficiencies were 99.6% and 98.14% for turbidity and chromium ion concentration removal using COE respectively. Being biodegradable, environmental-

friendly, abundant, inexpensive and leaving little or no traces of harmful substances on environment which makes it safe to human health, COE is a promising alternative to the conventional coagulants used in the treatment of paint industry wastewater.

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*Equipment used:* the following equipment were used Beakers, Stop watch, Weighing balance (JA-SARIES, Model: JA203H), Magnetic stirrer (Searchtech Instrument, Model-78HW-1), Local Sieve Cloth, Mesh sieve (Acrylic frame sieve, Model-GAA-41), Hi-tech digital Thermometer (hanna, HI98501), pH meter (HANNA instrument, HI 8314), Petri dish, Crucible, Pipette, Measuring cylinder, Electric oven (Saisho, Model: S-940)

#### List of symbols

AAS - Atomic absorption spectroscopy  
 APHA- American Public Health Association  
 AOAC- Association of Analytical Chemists  
 COE -Cactus Opuntia Extract  
 FTIR- Fourier transform infrared  
 NTU - Nephelometric turbidity units  
 PWW -Paint Waste Water  
 SEM -Scanning electron spectroscopy  
 Ti - Initial turbidity of solution, NTU  
 To - Final turbidity of solution, NTU

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