



## **ASSESSMENT OF THE EFFICACY OF SHRIMP POWDER AS A COAGULANT IN WASTEWATER TREATMENT**

**David<sup>1\*</sup>, Adekunle Olorunlowo, Ndambuki<sup>2</sup>, Julius Musyoka, Snyman<sup>3</sup>, Jacques, Kupolati<sup>4</sup>, Williams Kehinde, Muloiwa<sup>5</sup>, Mpho, Opafola<sup>6</sup>, Omobolaji Taofeek, Senuga<sup>7</sup>, Damilola Wahab and Okeke<sup>8</sup>, Ifechi Mary**

**<sup>1,2,3,4,5</sup> Department of Civil Engineering, Tshwane University of Technology, Pretoria, South Africa.**

**<sup>1,6,7</sup> Department of Civil Engineering, Olabisi Onabanjo University, Ibojun Campus, Ogun State, Nigeria.**

**<sup>8</sup> Ove Arup and Partners Nigeria Limited**

**\* Corresponding author: [Davidao@tut.ac.za](mailto:Davidao@tut.ac.za)**

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### **ABSTRACT**

This study evaluates the efficacy of shrimp shell powder as a coagulant in wastewater treatment, specifically targeting batik effluent. The primary aim is to compare the performance of shrimp shell powder to traditional alum in reducing key parameters such as Turbidity, Total Suspended Solids (TSS) and color (pt-co) levels. The shrimp shells were rinsed, air dried, grounded. Jar tests were performed, and the effectiveness of coagulation tests was compared to the use of alum. In comparison to using shrimp shells powder at the prescribed dose of 25g of shrimp shell powder in milliliters of the effluent provided outstanding results (the mixture gives a slightly clear water) and alum at 20g. The effectiveness of shrimp powder and alum reduced turbidity by 37.22% and 44.49%, TSS by 25.35% and 37.98%, color 14.14% and 36.13% respectively. In contrast to alum, the shrimp shell powder increases the pH due to the presence of alkaline elements (Calcium 45.0 wt%, Magnesium 15.3 wt%, and sodium 2.0wt%) and also increased the electrical conductivity which reduced the removal efficiency by -1.30% because of the presence of high Calcium content (45.0 wt%) Calcium ions have a high charge density, making them effective at carrying electrical charge. The experimental results indicate that shrimp shell powder substantially diminishes these parameters, underscoring its potential as an environmentally friendly and sustainable substitute for conventional coagulants. The results show that shrimp shell powder works like alum and could be a good way to make water



treatment technologies less harmful to the environment. Using shrimp shell powder could also help turn waste into something useful by turning a byproduct of the seafood business into something valuable. This study paves the way for more research aimed at optimizing the utilization of shrimp shell powder in extensive water treatment applications, highlighting its potential for sustainable and efficient wastewater management.

**KEYWORDS**

Shrimp Powder, Wastewater Treatment, Coagulant.

## 1. INTRODUCTION

Water is essential for human growth because water may be used for a multitude of functions, including food production, energy generation, and sanitation. Providing people with access to clean water and sanitation is a global challenge, especially in underdeveloped countries. Improved sanitation reduced open defecation, wastewater treatment, and worldwide recycling are among the targets of the United Nations Sustainable Development targets ([UN Water, 2017](#)). These days, the depletion of non-renewable resources and access to drinking water are regarded as significant issues. Future water treatment technologies must encourage the use of environmentally friendly, renewable materials that don't produce harmful consequences. Coagulation/flocculation is the most popular procedure among the numerous water treatment methods ([Tuanny, et al., 2020](#)).

A vital need for life's sustenance and communities' general well-being is accessed to clean, safe drinking water. It is well known that individuals are capable of surviving on water. In developing countries, water pollution from home and commercial operations, as well as farming methods, has become a major issue affecting economic stability and, consequently, posing serious health risks to the populace. However, many regions around the world struggle to ensure the availability of potable water due to a number of concerns, including pollution, industry, and the increase in population.

Contamination of water is a major global issue. Around the world, human-hazardous materials and microorganisms represent a threat to societies. Many places now have restricted access to clean drinking water as a result of pollution. For development and health, access to clean drinking water is essential at all levels—local, regional, and national. Recently, several compounds have been identified that may help filter contaminated water ([Hassan, et al., 2022](#)). For wastewater treatment, flocculation/coagulation is one of the favored methods. According to [Sugita et al. \(2009\)](#), Chitosan has the chemical formula  $C_6H_{11}NO_4$  and is known as poly-(2-amino-2-deoxy- $\beta$ -(1-4)-D-glucopyranose). Chitin involves deacetylation to generate it. Reactive, renewable, biodegradable, non-toxic, and environmentally benign, chitosan is a naturally occurring biocoagulant ([Wardhani et al., 2014](#); [Widyastuti et al., 2014](#)). Since it works well for purifying water and wastewater, chitosan is beneficial in several areas and helps to lessen environmental pollution. The optimal concentration of chitosan solution for usage as a biocoagulant varies with the kind of wastewater or treated water ([Faridah et al., 2021](#)). You require coagulants to filter water. Because of specific chemical features, they work well for treating water. Because they usually contain positive charges, they can pull in and neutralize water particles that have negative charges. This neutralizing process helps get rid of

contaminants by letting particles come together to make bigger flocs. Filtration and sedimentation techniques can then easily remove these flocs and any pollutants that are mixed in with them. The solubility and pH levels of coagulants can also change which can change how well they work in different types of water. Chitosan is a natural substance that helps water treatment work better. It comes from the shells of shrimp and crabs. Chitosan's positive charge helps particles stick together in water. It gets rid of organic waste, suspended particles, and some heavy metals quite well. It is a better choice for the environment and lasts longer than regular coagulants. Shrimp are a lot of natural resources. It was found that shrimp shells were thrown out in several traditional marketplaces and left to rot, which could have hurt the area's beauty. Potential solutions to these problems include using seafood waste in this case shrimp powder as a chitosan source. Several data indicate that chitosan showed good activity in the adsorption of Hg (II) and Pb (II) ions. (Lukum, et al., 2020).

The study's objective is to determine if shrimp powder can be used as an effective and sustainable coagulant in wastewater treatment in this case batik effluent, and if it offers any advantages over traditional coagulants.

The novelty of the aim lies in exploring shrimp powder as a unprecedented, unconventional, and sustainable coagulant in wastewater treatment, paving the way for potentially groundbreaking innovations in the field.

## **2. MATERIALS AND METHODS**

### **2.1. Materials**

Shrimp shells were collected from Eti Osa Market, Lagos State. Wastewater which in this case is batik effluent was collected at a discharge point at Adire Mall in Itoku, Abeokuta, Ogun State. Conventional coagulant i.e alum will be collected in Ibogun market, Ifo, Ogun state.

### **2.2. Methods**

#### **2.2.1. Determination of Coagulant Composition through EDX & XRF and the surface morphology through SEM Analyses**

The determination of coagulant composition through Energy-Dispersive X-ray (EDX) and XRF (X-Ray Fluorescence) and SEM (Scanning Electron Microscopy) analyses is a crucial step in understanding the surface morphology, properties and behavior of coagulants used in water treatment processes.

##### **2.2.1.1. X-Ray Fluorescence (XRF) analysis:**

This technique is based on quantum chemistry and atomic physics. All of the photons, or primary radiations, that a conventional X-ray tube could generate were used on the samples. These radiation-damaged materials emitted X-ray line spectra in secondary fluorescence that

related to their individual parts. The energy and intensity of the emission lines were determined by the detection method. This system consists of two components: a primary channel simultaneous wavelength disperses spectrometer and a computer for control and data processing. The quick detection technique employs individually positioned (analyzing) crystals surrounding the item. As a result, secondary radiation's wavelength increases. A mass gas flow detector detects the intensity of each wavelength independently. The element in the material was quantitatively analyzed using the spectral line energy of the emitted lines as an analysis. X-Ray Fluorescence (XRF) laboratory analysis.

- Indicates the elemental composition of the coagulant.
- Detects metals, oxides, and other inorganic substances.
- Provides quick and non-destructive analysis.

#### **2.2.1.2. Scanning Electron Microscopy (SEM) analysis:**

With applications in materials science, biology, forensic science, and failure analysis, scanning electron microscopy (SEM) analysis is a potent and adaptable technique used to study the surface morphology and composition of materials. It offers advantages such as nondestructive testing, high-resolution imaging, and surface and compositional information, but it also requires vacuum conditions and may involve sample preparation, making it an essential tool for researchers and scientists seeking to understand the properties and behavior of materials at the micro and nano scale. Scanning Electron Microscopy (SEM) analysis have the following capabilities:

- examines the shape and surface structure of coagulant particles.
- reveals the particle size, shape, and dispersion.
- Improves comprehension of surface chemistry and reactivity.

#### **2.2.1.3. Energy-Dispersive X-Ray (EDX) Analysis**

Energy Dispersive X-ray Spectroscopy (EDX) is a powerful way to analyze materials and figure out what chemicals they are made of. When a high-energy electron beam hits the sample, it makes X-rays that this device can pick up. These X-rays contain energies that correspond to the elements in the sample, allowing for their identification and quantification. This method is often employed with scanning electron microscopy (SEM) to give accurate information about the sample's structure and composition.

#### **2.2.1.4. Combining XRF and SEM analyses:**

- Gives a full understanding of the makeup and properties of the coagulant
- Enhances coagulant efficacy and dosage.

- Facilitates the creation of innovative coagulant formulations.

### 2.2.2. Determination of Physiochemical Properties of the Wastewater

Several steps are taken to fully describe the chemical and physical properties of wastewater. These steps include collecting the water, measuring the pH, temperature, conductivity, TDS, turbidity, color, odor, BOD, COD, and heavy metals.

## 3. RESULTS AND DISCUSSIONS

### 3.1. Jar Test

The jar test is a way to show how natural water coagulates and flocculates in a lab setting. This experiment can tell you the best pH, coagulant dosage, and coagulant aid. Consequently, coagulation and flocculation were devised to remove detrimental compounds absorbed by particles, alongside microorganisms and colloids that induce turbidity (Jasim et al., 2022).

This test uses a multi-position agitator to mimic mixing and settling conditions, giving you precise control. The jar test is very important for figuring out the right amount of chemicals to use to treat wastewater because it utilizes small amounts and settles well. This test finds the best chemical and amount to add to the water at a wastewater treatment plant to get rid of impurities and particles that are floating about. We used a TT-TB centrifuge and five 500ml beakers, each holding 200ml of batik effluent, to do the coagulation technique in this experiment. The five 500 ml beakers, each holding 200 ml of the tested substance, were given 5g, 10g, 15g, 20g, and 25g of coagulant (shrimp shell powder) per liter. Five 500 ml beakers holding 200 ml of the tested sample each had 5, 10, 15, 20, and 25 g/l of alum added to them. The test was run in two stages under the same conditions; the first stage utilized only alum, and the second stage used powdered shrimp shell. The procedure was repeated after blending the mixture vigorously for two minutes at 180 rpm, gradually for twenty minutes at 40 rpm, and allowing it to settle for thirty minutes. samples of the top layers of the treated supernatant.

**Table 3.1 Comparison of removal efficiency of physiochemical properties**

Physiochemical Properties Parameters	Ci	Cf		100%	
	Batik effluent Wastewater	After Adding Coagulants to the Batik Effluent.		Removal Efficiency% (Ci-Cf/Ci) *100	
		Shrimp Shell Powder	Alum	Shrimp powder	Alum
pH	11.5	12.0	7.5		
Temperature °C	26	27.5	27		
E.C (us/cm)	26,852	27,200	23,134	-1.30	13.84
TSS (mg/l)	6,430	4,800	3,988	25.35	37.98
Color (Pt-Co)	2,970	2,550	1,897	14.14	36.13
Turbidity (NTU)	385.5	242	214	37.22	44.49

The removal efficiency was calculated with the formula  $(Ci-Cf/Ci) \times 100$ , Ci being the original values of the untreated batik effluent and Cf being the values for the treated batik effluent.

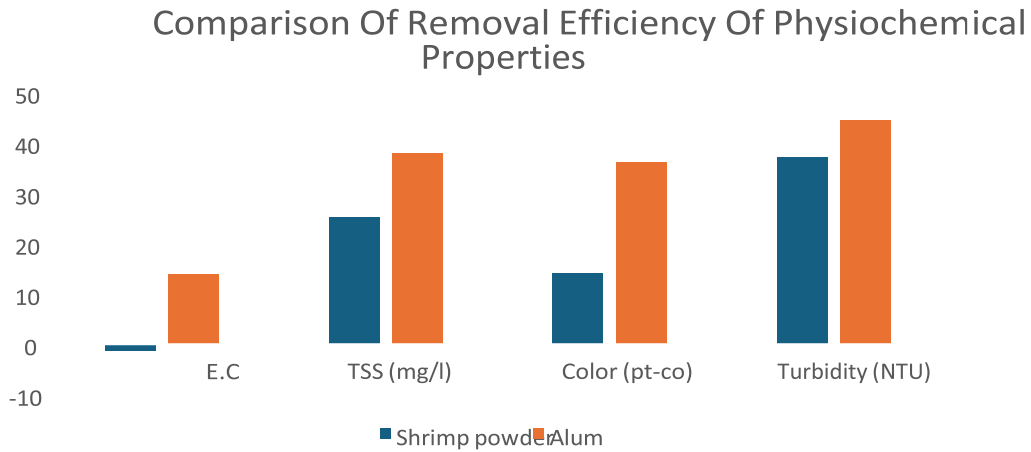


Fig 3.1 Chart for Comparison of Removal Efficiency of Physiochemical Properties

Table 3.2 Jar Test Optimal Dosage

Coagulant Dosage		Rapid mixture of 180 rpm	Slow mixture of 40 rpm	Detention time	Observation	
Shrimp powder	Alum	Time (mins)	Time (mins)		Shrimp powder	Alum
5	5	2	20	30	Not Clear	Not Clear
10	10	2	20	30	Not Clear	Not Clear
15	15	2	20	30	Not Clear	Not Clear
20	20	2	20	30	Not Clear	Slightly clear
25	25	2	20	30	Slightly Clear	Slightly Clear

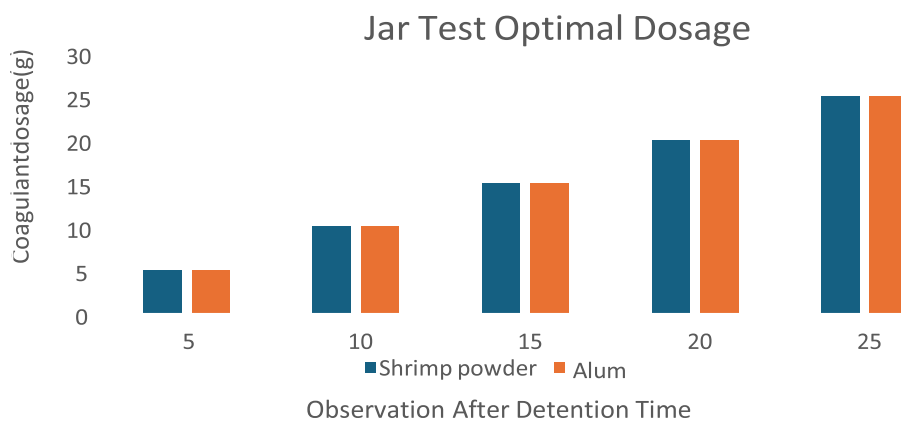


Fig 3.2 Chart for Jar Test Optimal Dosage

The section above compares the efficiency of the two coagulants in removing TSS, turbidity, electrical conductivity, and color from batik effluent. Shrimp shell powder and alum were used as a coagulant with batik effluents that had an initial TSS of 6,430mg/l, Turbidity of 385.5 NTU, 26,852 (us/cm) electrical conductivity, and 2,970 color. Alum exhibited a slightly higher removal efficiency for turbidity, TSS, electrical conductivity, and color than shrimp shell

powder at 44.49%, 37.98%, 13.84% and 36.13% respectively. The electrical conductivity of the batik effluent increases when shrimp shell powder was used as a coagulant because of the presence of high Calcium content (45.0 wt%) Calcium ions have a high charge density, making them effective at carrying electrical charge.

### 3.2. X-RAY FLUORESCENCE (XRF ANALYSIS) ON SHRIMP SHELL POWDER

To identify the chemical components of Shrimp shell powder, Rolab Research and Diagnostics Laboratory, Ibadan performed the XRF spectrophotometric analysis, SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, CaO,

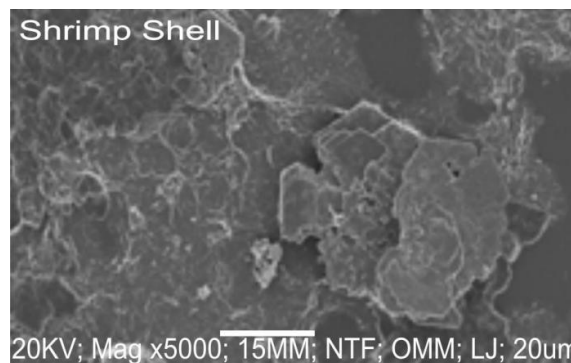
P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, MnO, MgO, Na<sub>2</sub>O, and LOI values are shown in [Table 3.3](#) below to be 10.20, 20.50, 2.25, 0.12, 55.90, 4.31, 0.60, 0.05, 4.10, 1.70 and 0.04 respectively. When all constituent elements are added together, the efficiency of removing pollutants from wastewater is 100%.

**Table 3.3 Chemical Constituents of Shrimp shells powder using XRF Analysis**

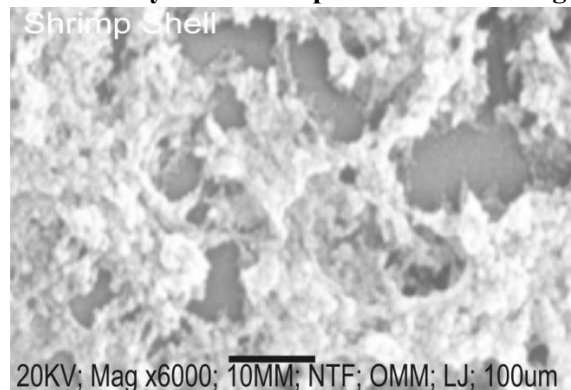
SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	CaO	P2O5	K <sub>2</sub> O	MnO	MgO	Na <sub>2</sub> O	LOI
10.20	20.50	2.25	0.12	55.90	4.31	0.60	0.05	4.10	1.70	0.04

### 3.3. SCANNING ELECTRON MICROSCOPE (SEM) ANALYSIS OF SHRIMP SHELL POWDER

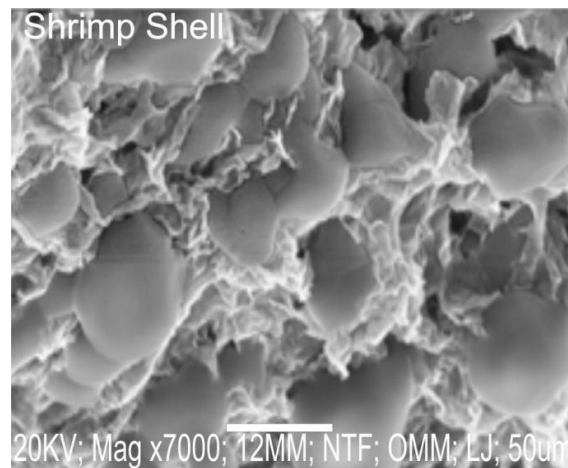
The surface morphologies of the sampled shrimp powder was determined using SEM ([David, et al. 2024](#)). You can see the Shrimp shell powder, which was the only coagulant used in this study, in the SEM images of Plates 4.3, 4.4 and 4.5 (at 5000, 6000 and 7000 magnification).



**Plate 3.1 SEM Analysis of Shrimp shell at 5000x magnification**

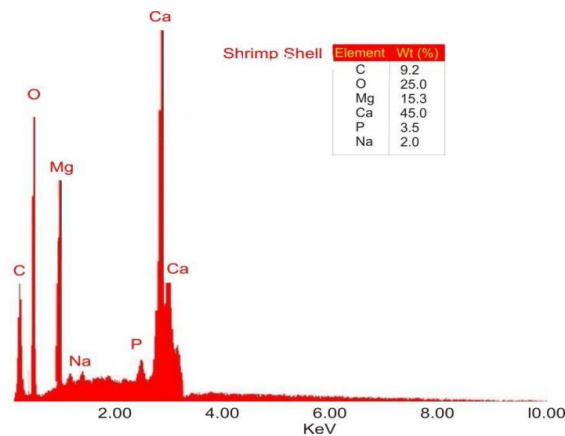


**Plate 3.2 SEM Analysis of Shrimp Shell at 6000x magnification**



**Plate 3.3 SEM Analysis of Shrimp shell at 7000x magnification**

### 3.4. ENERGY-DISPERSIVE X-RAY (EDX) ANALYSIS ON SHRIMP SHELL POWDER



**Plate 3.4 EDX Analysis on Shrimp Shell Powder**

The Energy-Dispersive X-ray (EDX) analysis was conducted to determine the elemental composition of the shrimp powder used as a coagulant in wastewater treatment (batik effluent). The EDX spectrum revealed the presence of various elements, including Carbon (9.2 wt%), Oxygen (25.0 wt%), Magnesium (15.3 wt%), Calcium (45.0 wt%), Phosphorus (3.5 wt%) and Sodium (2.0 wt%). The results indicate that the shrimp powder is primarily composed of organic compounds, with a significant presence of magnesium and oxygen. These results compare favourably with that of alum. Despite extensive research to the contrary, data reveal that traditional coagulants are more effective at coagulating than shrimp shell powder. Using shrimp powder as a coagulant helps you to avoid many of the negative repercussions of traditional coagulants like alum because it is a readily available, environmentally friendly, non-toxic, and biodegradable natural resource. Fibrous or thread-like coagulants can hold together and trap small particles in the sample. This makes it possible to remove them by bridging coagulation. The study found that shrimp shell powder works like alum and could be a good way to cut down on the environmental impact of water treatment procedures. Using shrimp

shell powder could also help turn waste into something useful by turning a byproduct of the seafood business into something valuable. This study paves the way for more research aimed at optimizing the utilization of shrimp shell powder in extensive water treatment applications, highlighting its potential for sustainable and efficient wastewater management.

#### 4. CONCLUSION

This study effectively investigated the feasibility of shrimp shell powder as a natural coagulant in wastewater treatment. The powder made the water less cloudy almost as well as chemical coagulants. This eco-friendly and long-lasting way of treating water could be useful in the future, especially in places where traditional coagulants are hard to get. Still, it's important to remember that shrimp shell powder might not work as well for treating water in all situations. This could be due to the type of treatment method used, the chemical composition and dosage, or the quality of the water supply. More research into how to best use shrimp shell powder as a coagulant could make it easier to use it in a lot of wastewater treatment. Consequently, it is imperative to conduct additional study and provide greater financial resources and consideration to the utilization of shrimp shell powder as a coagulant in water treatment.

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