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Evaluation of Fluted Pumpkin Stem Powder in Heavy Metal Removal from Pharmaceutical Wastewater

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Abstract: This study explores the potential of fluted pumpkin stem powder (FPSP) as an eco-friendly and cost-effective adsorbent for the removal of heavy metals from pharmaceutical wastewater. The research investigates the adsorption capacity of FPSP for iron (Fe) and lead (Pb), examining the influence of contact time, adsorbent dosage, agitation speed, and pH. Chemically activated FPSP demonstrated significant adsorption capacities, achieving removal efficiencies of up to 85.263% for Fe and 90.000% for Pb under optimal conditions. Results indicated a direct proportional relationship between contact time, adsorbent dosage, agitation speed, and adsorption efficiency; as these variables increased, so did the adsorption efficiency. Conversely, pH showed an optimal efficiency at 7.5, with a decrease in efficiency observed at pH levels above this value. The study employed adsorption isotherms and kinetic models to explain the mechanisms underlying the adsorption process, such as the roles of ion exchange, complexation, and surface adsorption. The findings suggest further investigation into the regeneration and reuse potential of FPSP, as well as its application in treating various contaminants and scalability for industrial use. This research provides a comprehensive understanding of the efficacy and practicality of FPSP in wastewater treatment, promoting the utilization of renewable resources and advancing sustainable practices.

Keywords: fluted pumpkin stem powder, heavy metal removal, pharmaceutical wastewater, adsorption isotherms, sustainable adsorbent

1. Introduction

The global population is growing steadily, and by 2045, it is predicted that there will be three times as many people living in cities—from 1.5 billion now to 6 billion [1]. To meet this increasing burden, almost all of the earth's resources are being overutilized [2]. The demand for deeper, distant, and newer sources of water has increased due to the increasing global water scarcity that the world is currently facing. This has resulted in increased environmental costs and economic exploitation. Even in "water-rich" nations like Canada, the availability of abundant,

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pure freshwater is no longer guaranteed [3]. One of the biggest threats to environmental integrity and public health worldwide is water scarcity. Diseases related to water claim the lives of at least 1.8 million children under the age of five each year. Diarrheal diseases make up over four percent (4%) of the global disease burden, 90 percent of which is linked to environmental pollution, a lack of access to safe drinking water and sanitation [4–6]. Despite the fact that there are water bodies all over the world, the term "water scarcity" refers to the lack of readily available freshwater in particular. The primary cause of this is human activity, which ensures constant contamination and drainage of waterbodies and watersheds in the effort to construct buildings and other structures [7, 8].

Wastewater is defined as water that has had certain substances added to it, changing its physical, chemical, and biological characteristics and making it unsafe to drink [9]. Because most of man's daily activities depend on water, "waste" is released into the water. Heavy metals are among the materials. These days, heavy metal pollution is one of the biggest threats to the environment. Because of their mobility within the aquatic ecosystem, toxicity to higher life forms, and non-biodegradable nature, heavy metals are thought to be the primary inorganic contaminant in the aquatic environment [10]. Lead (Pb), mercury (Hg), cadmium (Cd), arsenic (As), copper (Cu), zinc (Zn), and chromium (Cr) are among the heavy metals that are harmful to human health. Cu, Pb, and Hg can damage the brain and bones, while As and Cd cause cancer. Hg can also cause mutations and genetic damage [11, 12]. Water treatment is crucial because a large portion of the water supply is wasted as wastewater, and as the world's population and prosperity rise, so do the demands for water, leaving little room for supply to keep up. This has prompted the development of inventive freshwater management plans, such as cutting-edge methods for recycling wastewater [13, 14]. Adsorption is a wastewater treatment method that is currently being used. It is superior to other methods like chemical precipitation, ion exchange, and membrane filtration because of its high efficiency, ease of use, and ability to use inexpensive, environmentally friendly materials. Many natural and artificial adsorbents have been investigated; the most common is activated carbon. But the search for substitute materials has intensified due to the high cost of activated carbon and the difficulties in regenerating it. For other techniques or methods of wastewater treatment to be acceptable as an alternative, the treatment must be both cost-friendly and environmentally friendly [15, 16].

In this context, agricultural waste materials have garnered attention as viable adsorbents for heavy metal removal. These materials are not only abundant and renewable but also possess inherent properties that facilitate adsorption [17, 18]. Previous studies have investigated the use of materials such as rice husk, sawdust, and coconut shells for this purpose, demonstrating varying degrees of success [19–22]. Another agricultural waste material with promising potential is the fluted pumpkin (Telfairia occidentalis) stem. The fluted pumpkin is widely cultivated in West Africa, particularly in Nigeria, for its edible leaves and seeds. The stems, however, are often discarded as waste [23]. Preliminary studies suggest that the fibrous structure and chemical composition of the fluted pumpkin stem could facilitate the adsorption of heavy metals [24]. Yet, comprehensive investigations into its efficacy and mechanisms of action remain sparse, as well as the specific focus on fluted pumpkin stem powder (FPSP) as a heavy metal adsorbent from pharmaceutical wastewater being relatively unexplored. Although some investigations have highlighted the phytochemical composition of fluted pumpkin (Telfairia occidentalis) and its potential for bioremediation [25], their emphasis has primarily been on other applications, such as antimicrobial and antioxidant properties.

Consequently, a comprehensive understanding of the adsorptive capacity of FPSP for heavy metal removal from this specific wastewater matrix is lacking. Pharmaceutical wastewater is particularly challenging due to the presence of complex and diverse contaminants, including organic compounds and heavy metals. The interaction between these contaminants can affect the overall removal efficiency, which makes the use of a tailored approach necessary [26].

The present study aims to address these knowledge gaps by investigating the feasibility of employing FPSP as an eco-friendly and cost-effective adsorbent for the removal of heavy metals from pharmaceutical wastewater. The study assessed the adsorption capacity of FPSP for heavy metals in pharmaceutical wastewater, explored the mechanisms underlying the adsorption process, and evaluated the regeneration and reuse potential of FPSP.

2. Research Methodology

2.1. Materials and preparation

2.1.1. Fluted pumpkin stem

The fluted pumpkin stem (Telfairia occidentalis) was the primary adsorbent used in this study. It is known for its fibrous and porous structure, which contributes to its efficacy as an adsorbent material. The stem consists primarily of cellulose, hemicellulose, and lignin, which provide a natural framework for binding heavy metal ions. The high surface area and porosity of the material, particularly after carbonization, enhance its adsorption capacity. Upon activation, the functional groups, such as hydroxyl (–OH), carboxyl (–COOH), and other oxygen-containing groups, are exposed, further improving its potential to adsorb heavy metals through mechanisms such as ion exchange and complexation. The mechanical strength and thermal stability of the material make it suitable for repeated use in adsorption processes, making it both environmentally sustainable and cost-effective. The fibrous nature of the stem also ensures that it can undergo various physical and chemical treatments without significant degradation, which is essential for industrial-scale applications.

2.1.2. Materials and preparation

A range of equipment and reagents were used in this study to prepare and carbonize the adsorbent (Fluted pumpkin stem) and analyze the wastewater. A pH meter, magnetic stirrer, atomic absorption spectrophotometer (AAS), Whatman 0.45 µm filter paper, mechanical sieve, drying ovens, funnels, spatulas, 250 mL Erlenmeyer flasks, 100 mL conical flasks, beakers, PVC gloves, and an analytical weight balance are among these tools. HCl and NaOH were the reagents used. We gathered fresh stems of fluted pumpkin (Telfairia occidentalis) from the Ihiagwa market in Owerri West, Imo State. They underwent a thorough washing, cutting, rinsing in distilled water, air drying, and ten h of oven drying at 105°C. Using a muffle furnace, the dried sample was carbonized for two h at 350°C, and it was then cooled for three h at room temperature.

The carbonized and chemically activated adsorbents were analyzed using Fourier transform infrared spectroscopy to identify functional groups present on the surface. Surface morphology and pore structure were examined through scanning electron microscopy (SEM), allowing the identification of structural changes post-carbonization and activation.

500 cm^3 of 0.3 mol/dm^3 orthophosphoric acid was combined with 25.0 ± 0.01 g of the carbonized sample for acid activation. The resultant material was ground, sieved through a 106 µm mesh, and oven-dried at 105°C for four h. It was then cleaned to a

pH of 6.7 ± 0.12 and stored for use in later experiments. Chazmax Pharmaceutical Ltd., in Onitsha, Anambra State, provided the pharmaceutical wastewater, which was collected and examined for pH, conductivity, turbidity, temperature, and the concentration of impurities.

2.2. Physical and chemical activation of adsorbent and adsorption experiment

The dried fluted pumpkin stems were divided into two portions. One portion was ground, sieved using a mechanical sieve, and left physically activated. The other half of the dried stems were ground and sieved for chemical activation. Next, 250 mL of 5.5 M HCl was used to impregnate 200 grams of the ground powder, which was then refluxed for roughly two h on a hot plate. After that, the mixture was drained, dried, and reground into a fine powder after being cleaned with distilled water.

To find the ideal adsorption conditions, the fluted pumpkin stem was used to adsorb heavy metal ions from wastewater under a variety of experimental settings. As a standard procedure, AAS was used to analyze the leftover wastewater. The following formula was used to determine the fluted pumpkin stem's effectiveness under different circumstances:Adsorbent Efficiency (%)

$$\text{Adsorbent Efficiency}\,(\%) = \left(\frac{C_0 - C_f}{C_0}\right) \times 100 \quad (1)$$

According to Yang et al. [27], the initial metal concentration is denoted by C_0, and the final metal concentration is denoted by C_f.

A conical flask with 15 mL of wastewater sample at pH 7 was filled with 50 mg of fluted pumpkin stem, and it was agitated at 25 rpm to find the ideal contact time. Every two min, an aliquot was taken for AAS analysis from each flask. For the specimen that had been chemically activated, this process was repeated. Five conical flasks containing 15 mL of wastewater sample each were filled with 50 mg of fluted pumpkin stem in order to test the effect of adsorbent dosage on the equilibrium uptake of heavy metal ions. The flasks were agitated at 25 rpm and 25 °C for 30 min. For the specimen that had been chemically activated, this process was repeated. Fifty milligrams of fluted pumpkin stem (15 milliliters of the wastewater sample at pH 7) were added to five conical flasks to test the impact of agitation speed. Every flask had its agitation speed adjusted for 30 min at 25 °C. For the AAS analysis, an aliquot was taken from each sample. For the specimen that had been chemically activated, this process was repeated.

2.2.1. AAS analysis

The measurement of the wastewater's residual heavy metal concentrations was done using AAS. In order to prepare the samples, deionized water was diluted appropriately. The target metal ions' absorbance was measured at their individual characteristic wavelengths after the prepared samples were aspirated into the AAS flame. The concentration of the metal ions in the wastewater samples was calculated using a calibration curve built from standard solutions of known metal concentrations.

3. Results and Discussion

The present study aimed to investigate the feasibility of using FPSP as an eco-friendly and economical adsorbent for removing heavy metals from pharmaceutical wastewater. Table 1 presents the initial concentrations of heavy metal ions and the properties of the wastewater used in this study.

Table 1
Initial concentration and properties of the wastewater

Parameter	Value
Iron concentration	0.95 ppm
Lead concentration	2.10 ppm
pH	7.21
Temperature	26°C
Conductivity	105 Ns/cm
Turbidity	427 NTU

3.1. Adsorption capacity of FPSP

To better understand the adsorption process, the adsorption capacity of FPSP was assessed using adsorption isotherms, such as the Freundlich and Langmuir models. Assuming monolayer adsorption onto a surface with a finite number of identical sites, the Langmuir isotherm is calculated. According to Kalam et al. [28], the Freundlich isotherm is an empirical model that describes adsorption on heterogeneous surfaces. It can be written as follows:

$$q_e = K_f C_e^{\frac{1}{n}} \quad (2)$$

where adsorbate adsorbed per unit weight of adsorbent is denoted by q_e. The Freundlich constant, or K_f, indicates the adsorption capacity, and C_e is the equilibrium concentration of the adsorbate in solution and $\frac{1}{n}$ is the adsorption intensity.

The results showed that the chemically activated FPSP showed higher adsorption capacity compared to the physically activated FPSP. This is indicated by the higher percentage of metal ions absorbed across different conditions in Table 2. At a contact time of 150 min, the chemically activated FPSP achieved 84.211% Fe removal and 83.333% Pb removal, whereas the physically activated FPSP achieved 82.105% Fe removal and 70.952% Pb removal.

3.2. Kinetic studies

The rate of adsorption and the amount of time needed to reach equilibrium were calculated by studying the adsorption kinetics. Based on the data, pseudo-second-order kinetics are suggested for the adsorption process, indicating that chemisorption could be the rate-limiting step. When FPSP was chemically activated as opposed to physically activated, equilibrium was reached more quickly. For both types of FPSP, 150 min was found to be the ideal contact time for maximum adsorption efficiency; the chemically activated FPSP demonstrated noticeably higher removal efficiencies.

Table 2
Results showing % metal ions absorbed for contact time

Contact time (Mins)	Physical activated		Chemical activated	
	Fe (%)	Pb (%)	Fe (%)	Pb (%)
30	56.842	60.000	66.316	72.857
60	63.158	61.429	70.526	73.333
90	67.368	62.381	73.684	77.143
120	77.895	67.619	76.842	82.857
150	82.105	70.952	84.211	83.333

3.3. Effect of contact time

Tables 2 and 3 present the findings of an investigation into the impact of contact time on adsorption efficiency. As contact time increased, the adsorption efficiency rose as well, peaking at 150 min.

According to the data, adsorption efficiency rises with contact time, and chemically activated FPSP continuously outperforms physically activated FPSP in terms of efficiency. 150 min was found to be the ideal contact time, resulting in the highest removal percentages of Pb and Fe.

Table 3
Effect of contact time on adsorbent

Contact time (Mins)	Physical activated		Chemical activated	
	Fe (ppm)	Pb (ppm)	Fe (ppm)	Pb (ppm)
30	0.41	0.84	0.38	0.57
60	0.35	0.81	0.28	0.56
90	0.31	0.79	0.25	0.48
120	0.21	0.61	0.22	0.36
150	0.17	0.68	0.15	0.35

3.4. Effect of adsorbent dosage

Tables 4 and 5 show the impact of adsorbent dosage on FPSP's adsorption efficiency for the removal of Fe and Pb from wastewater. The removal efficiency of Pb and Fe increases with increasing FPSP dosage.

Table 4
Effect of adsorbent dosage on adsorbent

Dosage (Grams)	Physical activated Fe (ppm)	Physically activated Pb (ppm)	Chemical activated Fe (ppm)	Chemically activated Pb (ppm)
0.2	0.38	0.82	0.29	0.58
0.4	0.29	0.82	0.25	0.56
0.6	0.20	0.75	0.21	0.38
0.8	0.21	0.65	0.15	0.36
1.0	0.20	0.63	0.14	0.21

Table 5
% Metal ions absorbed for dosage

Dosage (Grams)	Physical activated Fe (%)	Physical activated Pb (%)	Chemical activated Fe (%)	Chemical activated Pb (%)
0.2	60.000	60.952	69.474	72.381
0.4	69.474	60.952	73.684	73.333
0.6	78.947	64.286	77.895	81.905
0.8	77.875	69.048	84.211	82.857
1.0	78.947	70.000	85.263	90.000

From the tables, it is evident that the adsorption efficiency for both physically and chemically activated FPSP increases with the adsorbent dosage. The reason for this is that adsorption sites with larger FPSP contents are more readily available. The optimal dosage, determined to be 1.0 grams, shows the highest removal efficiency for both Fe (85.263%) and Pb (90.000%) in chemically activated samples. This implies that employing larger FPSP dosages is advantageous for accomplishing the greatest elimination of heavy metals from wastewater, which makes it a sensible option for applications involving wastewater treatment.

3.5. Effect of agitation speed

The effect of agitation speed on the adsorption efficiency is detailed in Tables 6 and 7. Different agitation speeds were tested to observe their impact on the adsorption process.

Table 6
Effect of agitation speed on adsorbent

Agitation speed (Rpm)	Physical activated Fe (ppm)	Physically activated Pb (ppm)	Chemical activated Fe (ppm)	Chemically activated Pb (ppm)
25	0.42	0.95	0.26	0.67
50	0.43	0.87	0.21	0.66
75	0.31	0.66	0.21	0.41
100	0.23	0.59	0.20	0.39
125	0.15	0.58	0.16	0.22

Table 7
% Metal ions absorbed for agitation speed

Agitation speed (Rpm)	Physical activated Fe (%)	Physical activated Pb (%)	Chemical activated Fe (%)	Chemical activated Pb (%)
25	55.789	54.762	72.632	68.095
50	54.737	58.571	77.895	68.571
75	67.368	68.571	77.895	80.476
100	75.789	71.905	78.947	81.429
125	84.211	72.381	83.158	89.524

The tables show that higher agitation speeds enhance the adsorption efficiency. The optimal speed was found to be 125 rpm, which resulted in the highest adsorption efficiency for both Fe (83.158%) and Pb (89.524%) in chemically activated samples. Better adsorption is facilitated by the agitation speed increase because it increases the contact between the adsorbent and the heavy metal ions. According to this, agitation speed plays a critical role in maximizing the adsorption process, with faster speeds resulting in more effective contamination removal.

3.6. Effect of pH

Tables 8 and 9 provide an overview of the impact of pH on the adsorption efficiency of FPSP. The wastewater's pH has a big impact on the adsorption process.

The tables indicate that the adsorption efficiency is highest at a pH of 4.5, where the removal efficiency for Fe (83.158%) and Pb (85.238%) is maximized for chemically activated samples. This suggests that the optimal pH for the adsorption process is

Table 8
Effect of pH on adsorbent

pH	Physical activated Fe (ppm)	Physically activated Pb (ppm)	Chemically activated Fe (ppm)	Chemically activated Pb (ppm)
1.5	0.31	0.77	0.28	0.58
3.0	0.27	0.61	0.17	0.39
4.5	0.22	0.59	0.16	0.31
6.0	0.29	0.72	0.25	0.38
7.5	0.22	0.59	0.16	0.31

Table 9
% Metal ions absorbed for pH

pH	Physical activated Fe (%)	Physical activated Pb (%)	Chemical activated Fe (%)	Chemical activated Pb (%)
1.5	67.368	63.333	70.526	72.381
3.0	71.579	70.952	82.105	81.429
4.5	76.842	71.905	83.158	85.238
6.0	69.474	65.714	73.684	81.905
7.5	76.842	71.905	83.158	85.238

slightly acidic. The ionization of the adsorbate molecules and the adsorbent's surface charge are both impacted by pH, which in turn affects the adsorption capacity. Comprehending the impact of pH is imperative in order to maximize removal efficiency in real-world applications and optimize the adsorption process.

3.7. Comparison analysis

The findings of this study suggest that FPSP holds significant potential as a cost-effective and eco-friendly adsorbent for heavy metal removal from wastewater, comparable to other established adsorbents. Table 10 provides a summary of the adsorption performance of FPSP alongside commonly used adsorbents for Fe and Pb removal.

The adsorption performance of FPSP is comparable to that of other commonly used adsorbents in wastewater treatment. A key strength of FPSP lies in its ability to achieve removal efficiencies of up to 85.263% for Fe and 90.000% for Pb when chemically activated. These results position FPSP favorably against conventional adsorbents, such as activated carbon, which typically achieve 70–90% removal of heavy metals under optimal conditions [28]. Furthermore, agricultural by-products like coconut shells and rice husks, which are widely studied for heavy metal adsorption, show removal efficiencies ranging from 60% to 85% [19, 20].

To further contextualize FPSP's efficacy, we compare it to the adsorption potential of biosorbents such as orange peel-derived adsorbents, as explored by Dey et al. and Tajudeen et al. [30, 31]. Orange peels, prepared similarly to FPSP, reached a maximum removal efficiency of 90% for methylene blue. Although the targeted pollutants differ, both studies highlight the effectiveness of agricultural waste materials for adsorption processes. Moreover, the eco-friendliness and cost-effectiveness of FPSP as a waste-derived adsorbent make it a promising solution, as the FPSP adsorbent capitalizes on a locally abundant agricultural resource while mitigating environmental litter.

Additionally, more advanced studies such as the two-dimensional multi-scale modeling of fixed bed adsorption column using CFD simulation could inform future investigations into the dynamics of FPSP in continuous adsorption systems. This study explored adsorption kinetics through computational models that predict breakthrough curves, which could be applied to FPSP in fixed-bed columns to further optimize its performance in industrial applications. Integrating these insights could enhance the scalability and efficiency of FPSP-based systems [32].

3.8. Mechanisms of adsorption

The adsorption mechanisms of heavy metals onto FPSP are complex and involve multiple processes. A deeper analysis of these mechanisms reveals that the functional groups present on FPSP, such as hydroxyl, carboxyl, and amino groups, play an important role in the ion exchange process. These groups not only facilitate the substitution of ions on the FPSP surface for metal ions like Fe and Pb in the wastewater but also enhance the specificity of the adsorbent toward certain metal species. This specificity may explain the high removal efficiencies observed for Pb compared to Fe, as Pb forms stronger complexes with organic ligands present on FPSP [33].

In addition to ion exchange, the porous structure and large surface area of FPSP significantly contribute to its adsorption performance. The presence of numerous micro- and mesopores provides an extensive network of active sites, increasing the likelihood of metal ions interacting with the adsorbent. This phenomenon is closely linked to the physical adsorption (physisorption) of heavy metals, where metal ions are attracted to the adsorbent surface through Van der Waals forces. However, the efficiency of this process depends on both the surface area and surface charge of FPSP. The surface charge, which can be influenced by the pH of the wastewater, affects the electrostatic interactions between the metal ions and the adsorbent surface. For example, at neutral pH, FPSP tends to exhibit a higher adsorption capacity due to the favorable charge distribution [34].

Table 10
Comparison of adsorption efficiency for Fe and Pb removal

Adsorbent	Target pollutant	Max removal efficiency (%)	Source
Fluted Pumpkin Stem	Fe, Pb	85.263%, 90.000%	This study
Activated Carbon	Fe, Pb	70–90%	[28]
Orange Peel Adsorbent	Methylene Blue	90%	[29]
Coconut Shell	Heavy Metals	60–85%	[19]
Banana Peels	varies by metal	60–80%	[29]
Rice Husk	(varies by metal)	60–85%	[19, 20, 22]

4. Conclusion

The contamination of water bodies by heavy metals has emerged as a significant environmental and public health concern, particularly with the increasing discharge of pharmaceutical wastewater. This study has successfully demonstrated the effectiveness of FPSP as an adsorbent for the removal of heavy metals from pharmaceutical wastewater. The results indicate that FPSP, particularly when chemically activated, exhibits substantial adsorption capacities for iron (Fe) and Pb. Optimal conditions achieved removal efficiencies of up to 85.263% for Fe and 90.000% for Pb, showcasing FPSP's potential as a powerful adsorbent in wastewater treatment applications. Contact time, adsorbent dosage, agitation speed, and pH were found to have a significant impact on the adsorption efficiency of FPSP. It was determined that increasing contact time and adsorbent dosage enhanced the removal efficiencies, while optimal agitation speeds and pH levels were critical for maximizing adsorption. These findings provide a comprehensive understanding of the conditions under which FPSP operates most effectively, thereby facilitating its practical application in real-world scenarios. In comparison to other common adsorbents, FPSP performs admirably, offering competitive removal efficiencies. FPSP can be integrated into wastewater treatment plants to effectively reduce the concentrations of harmful heavy metals, thereby mitigating environmental pollution and protecting public health. Future research should focus on exploring the regeneration and reuse potential of FPSP, which would further enhance its practicality and cost-efficiency. Additionally, investigating the application of FPSP in treating other types of contaminants and scaling up the process for industrial use would be valuable. Long-term studies on the stability and effectiveness of FPSP in diverse wastewater conditions are also recommended to ensure its reliability and efficacy over extended periods.

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Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Author Contribution Statement

Temple Uzoma Maduoma: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Supervision. **Ebube Daniel Ezeokolie:** Methodology, Investigation, Resources. **Hadiza Nuhu Ajoge:** Validation, Writing – original draft. **Adesiyan Adepeju Ifetunbi:** Methodology, Project administration. **Iyanu Opeyemi Samson:** Supervision, Project administration. **Okorie Uche Victor:** Formal analysis, Investigation, Data curation. **Theresa Elikpi Onana:** Writing – original draft, Writing – review & editing. **Solomon Boadu Akyea-Mensah:** Visualization, Supervision. **Oman Ebenezer:** Writing – review & editing, Visualization, Project administration. **Chukwuebuka Princewill Oguayo:** Data curation, Writing – review & editing, Supervision. **Deladem Kwasi Amuzu:** Validation. **Daniel Boateng:** Validation. **Akintunde Michael Oluwole:** Investigation, Resources.

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