Aqueous Ferriferous Scavenging with Waste Plastic-Cellulose Composite for Remediation

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Abstract: This work was conducted to investigate the adsorptive removal of iron (III) ions from simulated and ferriferous water using unmodified and modified waste PET-bottle/coconut husk composites. The waste PET-bottle/coconut husk composites were prepared by melt mixing and modified using ferric and ferrous chloride. The composites were characterized using the Fourier Transform Infrared (FTIR) spectroscopy. The adsorption process was carried out using batch method while residual adsorbate concentration in solution was determined using Atomic Absorption Spectroscopy (AAS) analysis. The residual equilibrium concentrations results were applied to the kinetics, equilibrium and intraparticle diffusion analyses. The kinetics results of the adsorption showed that the most fit model based on the R^2 values for the unmodified is the second order with a value of 0.79, while that of the modified composite correlated with the pseudo first order with an R^2 value of 0.95. The highest rate constant was 2.29 g/mg min for PFO for the unmodified implying the shortest exposure and contact time per unit mass of adsorbent. The Freundlich and Sips isotherm models both correlated at 97% with the unmodified composite, while the Freundlich model was the most fit model for the modified composite with an R^2 value of 0.87. Q_{max} calculated from Langmuir isotherm was 6657.91 and 7939.32 mg/g for unmodified and modified composites respectively, indicating a higher sorption potential for the modified composite. The modified composite gave a far higher and near unity R^2 value of 0.96 for intraparticle diffusion than the unmodified composite with 0.46.

Keywords: Plastic, waste, composites, modified, unmodified, isotherms, kinetics,

I. Introduction

Groundwater contamination with iron is a widespread issue; the World Health Organization recommends a level of less than 0.3 mg/L, although the concentrations typically vary from 0 to 50 mg/L (WHO, 2022). Iron is found in two forms; iron (II) which is soluble and does not cause any issues on its own, and iron (III) which is insoluble and formed by the oxidation of iron (II) when it comes in contact with oxygen in the air or through action of iron related bacteria. Iron (III) forms insoluble hydroxides in water. Water that contains iron (III) creates visual and practical problems such as colour, odour, brown staining, and deposition in water distribution systems, resulting in excessive turbidity. Groundwater that contains iron is frequently visibly reddish-brown or orange in colour, discolouring clothing and imparting an unpleasant taste.

Most groundwater samples from the Niger Delta region include a significant amount of iron, which is a major undesirable contaminant. Iron concentration levels above the WHO permissible limits for groundwater quality have been observed in boreholes in some parts of the South East (Aralu, Okoye, Abugu et al., 2023; Osuagwu, Uwaga and Inemeawaji, 2023). Electrical resistivity assessment of boreholes also showed high concentration levels of iron above WHO permissible limits in parts of Niger Delta of Nigeria (Oghale & ThakGod , 2023)

Scientists have a keen interest in removing iron from groundwater, and there are a number of techniques for doing so, including ion exchange (Gahlot et al., 2022), oxidation (Thinojah & Ketheesan, 2022), chemical precipitation (Morosini *et al.*, 2014), supercritical fluid extraction (Kiselev & Iacovelli, 2022), and accumulation by aquatic macrophytes (Coimbra and Borges, 2023). This study provides elucidation on the scavenging potential of composites prepared from waste materials for the uptake of iron (III) ions from aqueous solution and ferriferous groundwater in real time, which is a menace in some places in the Niger Delta area.

Problem Statement

It is no longer a news from a faraway land that plastics are a threat to human life and the environment. Due to the abundance and the common use of plastic products and materials, virtually all countries in one form or the other are victims of plastic pollution. The theme of the World environment day in 2023 was “Beat plastic pollution”. The caption was to raise awareness of the critical issues of the useful, yet dangerous product all over the world. Polyethylene terephthalate (PET-RIC 1) bottles is one major plastic product commonly found wasted after use. Though, there is a growing campaign and drive for reducing, reusing and recycling to cut down on the surge of plastic pollution, there is need to diversify the recycling method. One of the ways is the production of composite materials of waste plastics. This work assessed the adsorption capacity of unmodified and modified waste PET bottles/coconut husk composite used for the uptake of iron (III) in aqueous solutions.

II. Materials and Methods

Materials and Apparatus

Coconut Husk, Waste Polyethylene terephthalate (PET) bottles, Ferric Nitrate (Fe $(NO_3)_3$), Ferrous Chloride ($FeCl_2$), Ferric Chloride ($FeCl_3$), Sodium Hydroxide (NaOH), (Reagents produced by Loba Chemie PVT LTD, India) Distilled water, Hot plate, Weighing balance, Pipettes, Beakers, Volumetric flasks, Thermometer, Filter papers, Speed shaker, pH meter, Spatula, Kegs, Oven, Non-stick pot, Sample containers, Storage containers, Grinding machine, 150, 300, 600 µm sieves.

Preparation of Coconut Husk

Coconut husk was obtained from a coconut vendor from Amarata in Yenagoa city in Nigeria. The husks were collected, washed, dried and pulverized. It was sieved into 150 µm, 300 µm and 600 µm mesh sizes and stored in various containers and labeled accordingly for further use. The 300 µm mesh size coconut husk was used to prepare the composite.

Preparation of Waste Polyethylene Terephthalate (PET) Bottles Matrix

Used and discarded Polyethylene terephthalate (PET) bottles were collected and shredded to smaller sizes. They were washed, dried and stored for use to form the composite.

Preparation of Unmodified Composite

75 g of shredded waste Polyethylene terephthalate (PET) bottles was weighed into a non-stick pot and placed on the hotplate for 40 minutes for it to melt at a temperature of 100°C. When it was molten,15g of sieved coconut husk was added to it and stirred until a homogeneous solid was formed. It was then removed from the pot and placed on a white tile to cool before it was pulverized by a grinding machine and sieved to 150, 300 and 600µm mesh sizes .The various weighed composites were washed with distilled water, oven-dried for 40 minutes and stored in their separate containers and labeled accordingly. The 300 µm composite was later used to prepare the modified composite.

Preparation of Modified Composite

0.75 M ferric chloride ($FeCl_3$) and 0.25 M ferrous chloride ($FeCl_2$) solution was prepared which is a modified method adopted from Yamamura *et al.*, (2009) in which 50 mL of the solution was measured to a beaker; 28 g of the composite was weighed into the solution. 5 M sodium hydroxide was also prepared and the mixture was precipitated by droplet addition of sodium hydroxide (NaOH) to the beaker containing the iron solution and the composite. The mixture was stirred intermittently as the sodium hydroxide was added until it got to pH 10.9. The mixture was stirred for one hour, after which it was rinsed with distilled water till it got to a 7.3 pH. The process was repeated and the modified composite was placed in an oven to dry for 45 minutes.

Fourier Transform Infrared Spectrometer (FTIR) Analysis

Functional groups determination and analysis of the prepared composites were carried out using the Fourier Transform Infrared (FTIR) Spectrometer in both the modified and unmodified PET/Coconut husk composite.

Preparation of Stock and working Solutions

A 1000 ppm stock solution was prepared by dissolving 4.3189 g of iron (III) nitrate in 1000 mL volumetric flask. From the stock solution, 20 mL was measured into a 500 mL volumetric flask and filled to obtain 40 ppm working solution to carry out the measurements for effect of time. Also 20, 40, 80, 160 and 320 ppm working solutions were prepared to carry out the measurements for effect of concentration.

Experimental Procedure for Adsorption Kinetics

1000 ppm of iron(III) solution was prepared, labeled and stored, after which 40 ppm of the solution was prepared and stored in a bottle. 0.1 g of the unmodified and modified composites each, were respectively weighed into sample bottles, then 10 mL of the 40 ppm iron solution was measured into each sample bottle and they were shaken using the speed shaker at a constant speed of 250 rpm for 5, 10, 20, 40, 80, 160 and 220 minutes. After the shaking, they were decanted and the residual solution was taken for Atomic Absorption Spectroscopy (AAS) analysis.

Experimental Procedure for Adsorption Isotherm

Working solutions of iron of 20, 40, 80, 160 and 320ppm were prepared and was stored in bottles. 0.1 g of the unmodified composite and 0.1 g of the modified composite were weighed into various sample bottle and the various concentrations of the iron solutions were added to the bottles. The unmodified composite solution was shaken at a constant speed of 250 rpm for 80 minutes, while the modified composite was shaken for 160 minutes. After the shaking, they were decanted and the supernatants were taken for Atomic Absorption Spectroscopy (AAS) analysis.

Experimental Procedure for Groundwater adsorption

Water sourced from the ground was collected from a point around the university campus and the iron (III) content was found to be 16.740 ppm by AAS. 0.1g of the unmodified composite was weighed into sample bottles and 10 mL of the iron water was measured into bottles and shaken for 80 minutes after which it was taken for Atomic Absorption Spectroscopy (AAS) analysis. Also, 0.1g of the modified composite was weighed into sample bottles, 10 mL of the water was added and they were shaken at a constant speed of 250 rpm for 160 minutes then it was taken for Atomic Absorption Spectroscopy (AAS) analysis.

Data Analysis for Ion Scavenging Capacity of Composites

The amount of ferric ions adsorbed on the unmodified (PCH) and modified (MPCH) composites were calculated thus:

$$Q_e = \frac{C_o - C_e}{M} \times \mathrm{V} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where,

Q_e = quantity adsorbed at equilibrium (mg/g)

C_e = final concentration of the metal ion at equilibrium (mg/L)

C_o = initial metal ion concentration (mg/L)

V = Volume of the adsorbate (L)

M = mass of the adsorbent (g)

The percentage of ferric ions adsorption from aqueous solution was calculated thus:

$$A\% = \frac{C_o - C_e}{C_o} X\, 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where,

A% = percent of metal ion adsorbed

C_e = final concentration of the metal ion at equilibrium (mg/L)

C_o = initial metal ion concentration (mg/L)

Adsorption Kinetics

The kinetics was studied using first-order, second-order, pseudo first-order, pseudo second-order and Elovich using the following non-linear equations respectively.

$$q_t = q_o e^{-k_1 t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where,

k_1 = rate constant per minute

q_e= equilibrium adsorption capacity (mg/g)

q_t = adsorbate adsorbed onto adsorbent at time t (mg/g)

t = time (minutes)

$$q_t = \frac{q_o}{1 + q_o k_2 t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Where,

k_2 = rate constant per minute

q_o = equilibrium adsorption capacity (mg/g)

q_t = adsorbate adsorbed onto adsorbent at time t (mg/g)

t = time (minutes)

$$q_t = q_e(1 - e^{-k_1 t}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

Where,

q_e = equilibrium adsorption capacity (mg/g)

q_t = adsorbate adsorbed onto adsorbent at time t (mg/g)

k_1 = rate constant per minute

t = time (minutes)

$q_t = \frac{{q_e}^2 k_2 t}{1 + q_e k_2 t}$……………………………….. (6)

Where,

k_2 = rate constant per minute

q_t = adsorbate adsorbed onto adsorbent at time t (mg/g)

q_e = equilibrium adsorption capacity (mg/g)

t = time (minutes)

$q_t = \frac{1}{\beta}\ln(\alpha\beta) + \frac{1}{\beta}\ln t(\frac{1}{\beta})$ ………………..(7)

Where,

q_t = adsorbate adsorbed onto adsorbent at time t (mg/g)

β = desorption constant

α = initial adsorption rate (mg/g.min)

Adsorption Isotherms

Equations 8 through 12 show the isotherm models applied for adsorption of iron(III) ions by the unmodified and modified composite, namely: Langmuir, Freundlich, Temkin, Redlich-Peterson (R-P), and Sips isotherms, respectively.

$q_e = \frac{q_m k_l C_e}{1 + k_l C_e}$………………………. (8)

Where,

k_l= Langmuir sorption equilibrium constant (L/mg)

C_e = concentration of sorbate in the solution at equilibrium (mg/L)

q_m = maximum amount of metal ion adsorbed by unit mass adsorbent (mg/g)

q_e = amount of metal ion adsorbed per unit mass at equilibrium (mg/g)

$q_e = k_f {C_e}^{\frac{1}{n}}$……………………. (9)

Where,

n = Freundlich exponent (dimensionless)

C_e = concentration of sorbate in the solution at equilibrium (mg/L)

q_e = amount of metal ion adsorbed per unit mass at equilibrium (mg/g)

k_f = Freundlich equilibrium constant (mg/g)

$q_e = \frac{RT}{b_T}\ln k_T C_e$…………………….. (10)

Where,

k_T = Temkin equilibrium constant (mg/g)

C_e = concentration of sorbate in the solution at equilibrium (mg/L)

q_e = amount of metal ion adsorbed per unit mass at equilibrium (mg/g)

$q_e = \frac{k_{RP}\, C_e}{1 + a_{RP} {C_e}^g}$………………………. (11)

Where,

C_e = concentration of sorbate in the solution at equilibrium (mg/L)

q_e = amount of metal ion adsorbed per unit mass at equilibrium (mg/g)

a_{RP} = Redlich-Peterson constant (mg/L)

k_{RP} = Redlich-Peterson constant (L/g)

$$q_e = \frac{q_s k_s C_e^{n_s}}{1 + k_s C_e^{n_s}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (12)$$

n_s = Sips exponent (dimensionless)

k_s = Sips equilibrium constant (mg/L)

C_e = concentration of sorbate in the solution at equilibrium (mg/L)

q_s= amount of metal ion adsorbed per unit mass at equilibrium (mg/g)

Intraparticle Diffusion

The diffusion behaviour of the composites were assessed by Webber-Morris Intraparticle diffusion equation which takes the form in (13)

$$Q_t = K_{ID} t^{\frac{1}{2}} + C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(13)$$

Where,

C = Constant related to the thickness of boundary layer (mg/g)

K_{ID} = Intraparticle diffusion rate constant ($mg/g/min^{-1/2}$)

Q_t = Quantity of ions adsorbed at time t (mg/g)

III. Results and Discussion

Results

The FTIR results of unmodified PET/Coconut Husk Composite (PCH) and modified PET/Coconut Husk Composite (MPCH) are shown in figures 1 and 2, while the inference and deductions from the spectra bands are given in table 1.

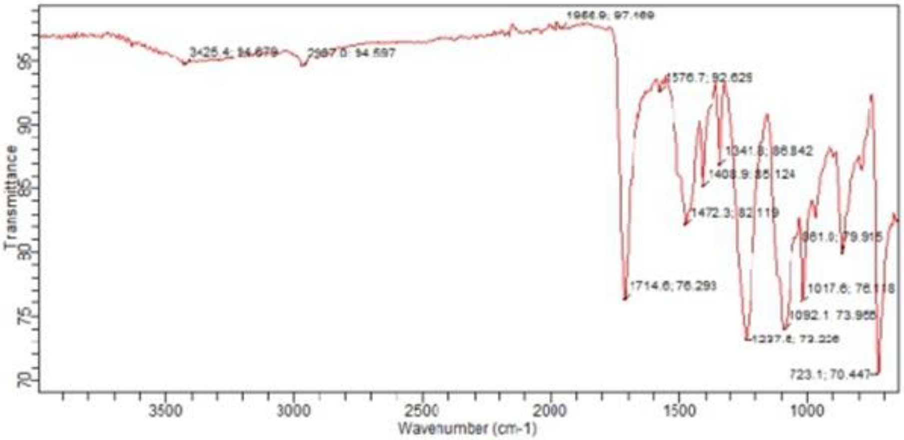

Figure 1: FTIR chart for Unmodified PET/Coconut Husk Composite (PCH)

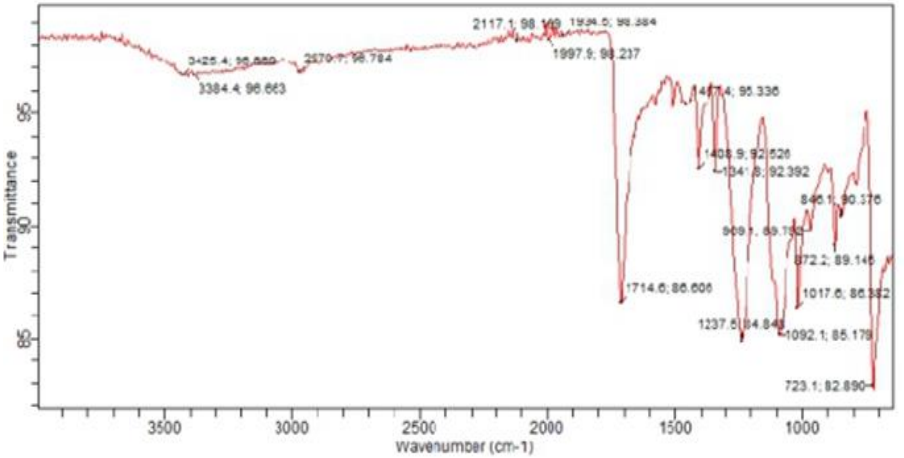

Figure 2: FTIR chart for Modified PET/Coconut Husk Composite (MPCH)

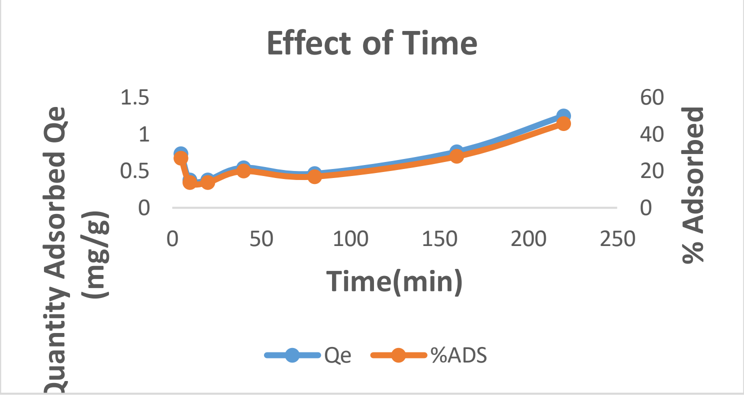

Figure 3: Variation of contact time on adsorption of ferric ions using unmodified PET/Coconut Husk composite (PCH)

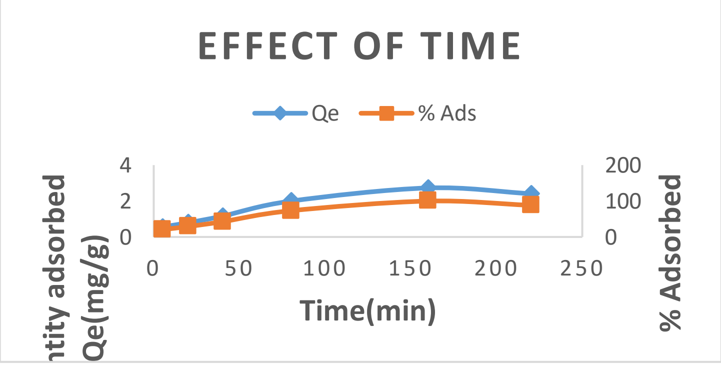

Figure 4: Variation of contact time with adsorption of ferric ions using modified PET/Coconut Husk Composite (MPCH)

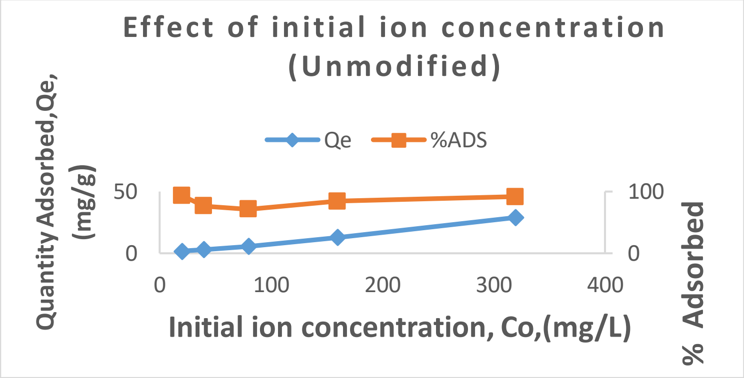

Figure 5: Influence of initial ion concentration on the adsorption of ferric ions using unmodified PET/Coconut Husk Composite (PCH)

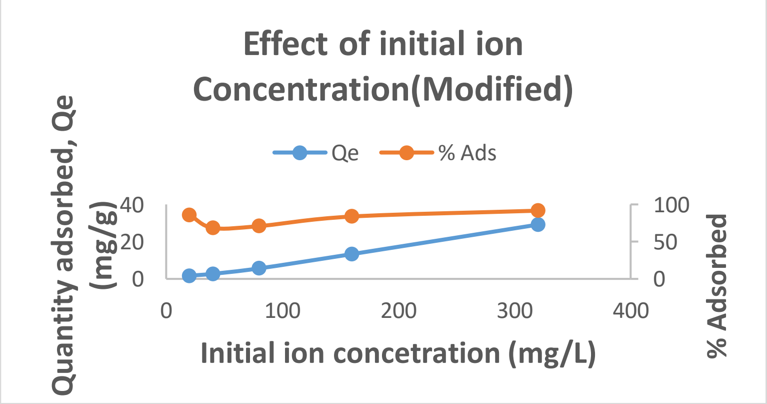

Figure 6: Influence of initial ion concentration on the adsorption of ferric ions using modified PET/Coconut Husk Composite (MPCH)

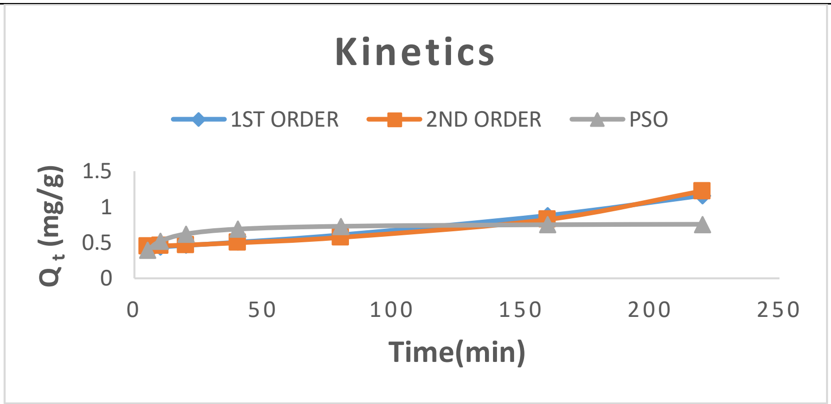

Figure 7: Kinetic plots for the adsorption of ferric ions using unmodified PET/Coconut Husk Composite (PCH)

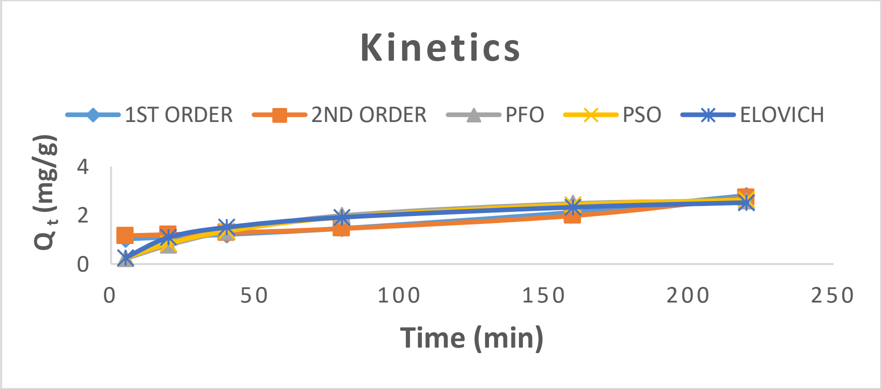

Figure 8: Non-linear Kinetic plots of the adsorption of ferric ions using modified PET/Coconut Husk Composite (MPCH)

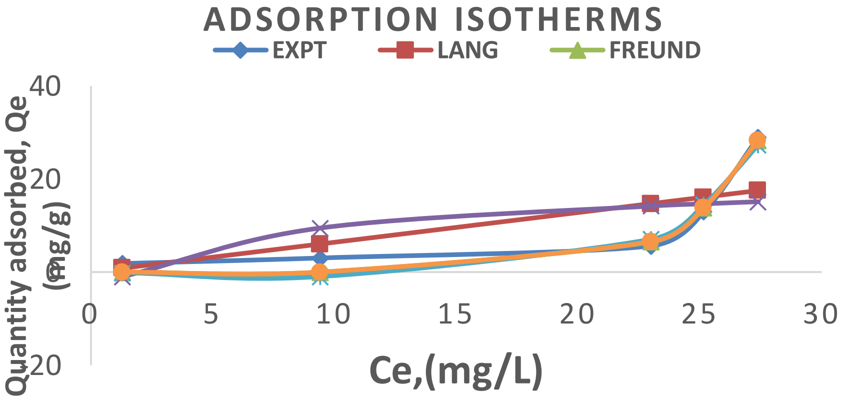

Figure 9: Adsorption isotherms for the adsorption of ferric ions using unmodified PET/Coconut Husk Composite (PCH)

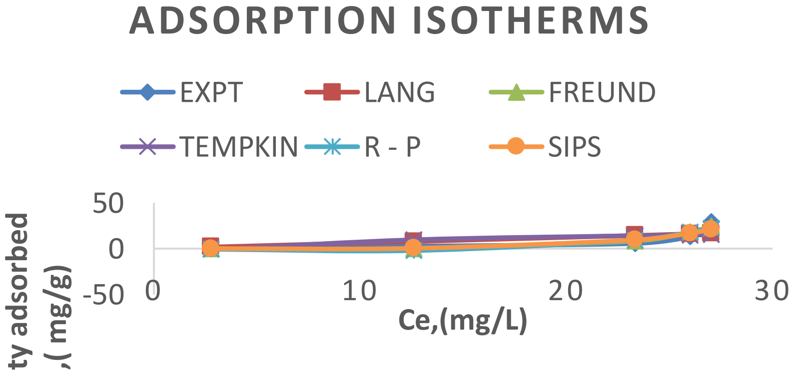

Figure 10: Adsorption isotherms for the adsorption of ferric ions using modified PET/Coconut Husk Composite (MPCH)

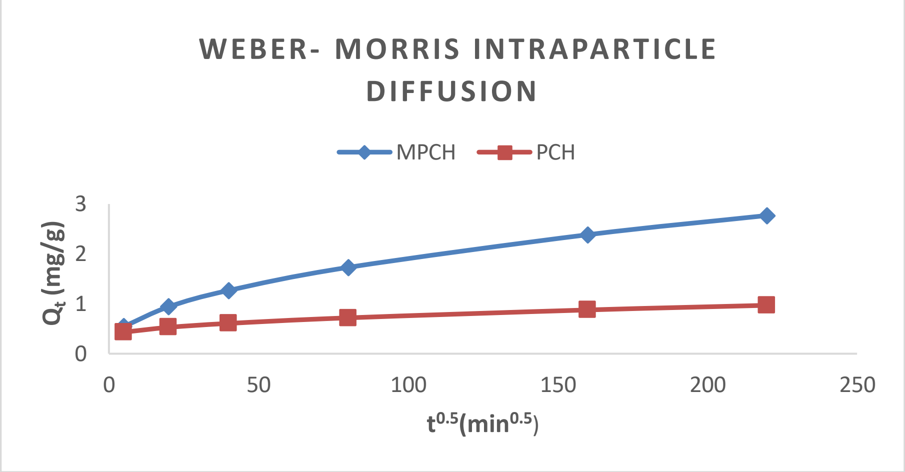

Figure 11: Intraparticle Diffusion Plots for the adsorption of ferric ions using unmodified and modified PET/Coconut Husk Composite.

IV. Discussion

Table 1: Fourier Transform Infrared Spectroscopy Characterization results of composites

S/N	Absorption Bands (cm^{-1})		Inference	Deduction
	Unmodified	**Modified**		
1	3425.4	3384.4 3425.4	Presence of OH group both composites.	Second peak for the OH group in the modified is due to the modification.
2	2967.0	2970.7	Presence of carboxyl (COOH) group.	Difference in bands is due to modification of composite.

Effect of Contact Time

The results of the effect of contact time on the adsorption of ferric ions by unmodified

and modified PET/Coconut Husk composites are shown in figures 3 and 4. PCH had a high adsorption at 5 minutes but reduced at 40 minutes after which it rose and had its highest adsorption at 220 minutes, where the highest adsorption was at 45.72%. This finding was similar to that observed by Khattak *et al*, (2017) who used magnetic carbon nanostructures made from biomass in heavy metals elimination in drinking water and they observed that the uptake of the contaminants was very fast in the first few minutes and this was interpreted to mean that there were more available sites for adsorption of the metals on the adsorbents.

Modified PET/Coconut Husk Composite (MPCH) was used in the adsorption Fe^{3+} from solution. Its lowest adsorption was at 5 minutes and it increased steadily and got to its peak at 160 minutes, then dropped a little at 220 minutes. The highest percentage of adsorption was 99.85% at 160 minutes. This behaviour correlated with Gunorubon and Chukwunonso (2018) who studied ferric ions adsorption using activated carbon obtained from periwinkle shell where the percentage of ferric ions adsorption increased as the contact time increases.

Influence of Initial Ion Concentration

The adsorption of Fe^{3+} using unmodified PET/Coconut Husk Composite (PCH) was studied over varying concentrations: 20, 40, 80, 160 and 320 ppm. The plot in figure 5 shows it follows a steady rise, while its highest adsorption percentage was at 20 ppm with 93.44%.

Similarly, the adsorption of Fe^{3+} using modified PET/Coconut Husk Composite (MPCH) was also studied in varying concentration: 20, 40, 80, 160, 320 ppm. The plot in figure 6 shows a steady progression that was close to a straight line. Modified PET/Coconut Husk Composite (MPCH) has its highest adsorption percentage at 320 ppm with 91.56%.

Both adsorptions using the unmodified and modified PET/coconut husk composite showed that as amount of iron (III) adsorbed increased, so the initial metal ion concentration increases. This can be credited to the fact that the adsorbents had available sites to contain higher levels of metal ion concentrations. This finding was similar to what was observed by Abasi *et al*., (2011) where the unaltered fruit endocarp of the raphia palm (*Raphia hookeri*) fruit was used to study the uptake of Pb^{2+}, Fe^{3+}, and Cd^{2+}.

Water sample was obtained from the water facilities in real time to test for the adsorbent capacities; the Fe (III) concentration in the real water sample was measured to be 16.74ppm. On using unmodified PET/Coconut Husk Composite (PCH) to carry out the adsorption, its adsorption percentage was 72.08%, while modified PET/Coconut Husk Composite (MPCH), had an adsorption percentage of 76.25%. This result also indicates that the modified composite is of a better performance than the unmodified in real time.

Based on the information provided in Table 2, the non-linear adsorption kinetics of unmodified PET/coconut husk (PCH) exhibited coefficient of determination (R^2) of nil, nil, 0.07, 0.73, and 0.79 for the PFO, Elovich, PSO, first-order, second-order models, respectively. The obtained nil values for the PFO and Elovich models indicate that the adsorption process does not conform to those specific models. Pseudo second-order had a low R^2 value of 0.07; first-order had a value of 0.73 while the second-order had a value of 0.79 thereby making the adsorption to have a greater control by second-order kinetics by comparison.

Table 2: Kinetic Parameters of Adsorption for Unmodified (PCH) and Modified(MPCH) PET/Coconut Husk

		PCH	**MPCH**
KINETICS	**PARAMETERS**	**VALUES**	**VALUES**
First order	q_o (mg/g)	0.42	1.00
	K_1	-0.005	-0.005
	R^2	0.73	0.72
Second order	q_o (mg/g)	0.44	1.15
	K_2	-0.007	0.002
	R^2	0.79	0.62
PFO	q_e (mg/g)	0.64	2.65
	K_1	2.29	0.02
	R^2	Nil	0.95
PSO	q_e (mg/g)	0.77	3.34
	K_2	0.26	0.005
	R^2	0.07	0.93
Elovich	α (mg/g.min)	-0.64	0.19
	β	2.00	1.68
	R^2	Nil	0.88

Column 2 of Table 2 shows the results for the non-linear adsorption kinetic parameters using modified PET/coconut husk (MPCH) with coefficient of determination (R^2) of 0.62, 0.72, 0.88, 0.93, and 0.95 for second order, first-order, Elovich, PSO and PFO models respectively. The kinetic models used, proved that PFO and PSO had values that were close to unity (0.95 and 0.93), but pseudo first-order had a higher value of 0.95 thereby making the adsorption a pseudo first-order prevalent adsorption, which implies physisorption was more prevalent than chemisorption with the adsorbent.

Unmodified PET/coconut husk composite (PCH) had a lesser coefficient of determination when compared to modified PET/coconut husk composite (MPCH), this may be due to the modification.

Table 4: Table showing the values of Adsorption Isotherm Parameters for unmodified PET/Coconut Husk composite (PCH)

		PCH	**MPCH**
ISOTHERM	**PARAMETERS**	**VALUES**	**VALUES**
Langmuir	q_m(mg/g)	6657.91	7939.32
	K_L (L/g)	9.62×10^{-5}	7.76×10^{-5}
	R^2	0.53	0.49
Freundlich	k_F (mg/g)	2.26×10^{-11}	8.22×10^{-10}
	n	0.12	0.14
	R^2	0.97	0.87

Temkin	k_T (mg/g)	5.29	7.16
	b_T	0.63	0.31
	R^2	0.37	0.37
Redlich-Peterson	k_{RP} (L/g)	-0.11	-0.25
	a_{RP} (mg/L)	9.43×10^{-9}	1.4×10^{-5}
	g	6.61	4.42
	R^2	0.95	0.78
Sips	q_S (mg/g)	1.00	-0.89
	k_S (mg/L)	1.01×10^{-6}	4.67×10^{-6}
	n_S	8.40	5.32
	R^2	0.97	0.79

From the data presented in Table 4, the coefficients of determination (R^2) for the Temkin, Langmuir, Redlich-Peterson, Freundlich, and Sips models were computed to be 0.37, 0.53, 0.95, 0.97, and 0.97 respectively, for the unmodified PET/coconut husk composite (PCH). For the modified PET/coconut husk composite (MPCH), the coefficients of determination obtained for the Temkin, Langmuir, Redlich-Petersen, Sips and Freundlich models were 0.37, 0.49, 0.78, 0.79 and 0.87 respectively.

For the unmodified PET/coconut husk composite (PCH), Redlich-Peterson, Freundlich, and Sips models respectively have coefficient of determination values R^2 close to unity (0.95, 0.97 and 0.97). The investigation of the adsorption isotherm models indicated that the unmodified composite exhibited the best correlation with Sips and Freundlich models. Notably, the Sips model merges elements from both Langmuir and Freundlich models, highlighting the significant influence of the Freundlich model on the adsorption process. The adsorption on the modified PET/Coconut husk composite demonstrates a close correlation to the Freundlich model, as proven from the coefficient of determination (R^2) of 0.87.

The modified PET/coconut husk composite (MPCH) had a lesser correlation when compared to the unmodified PET/coconut husk composite (PCH) which was close to unity.

Also, the fact that both the unmodified and modified PET/coconut husk composites fitted closely to the Freundlich model shows that they both possess heterogeneous adsorbent surfaces for multi-layer adsorption.

The nonlinear maximum adsorption capacities for unmodified PET/coconut husk composite (PCH) and modified PET/coconut husk composite (MPCH) were 6657.91 and 7939.32 mg/g respectively.

Intraparticle Diffusion

The coefficient of determination (R^2) obtained from the adsorption using the unmodified PET/coconut husk composite (PCH) and the modified PET/coconut husk composite (MPCH) were both 0.9613.

Figure 11 shows that multi-linearity for modified and unmodified PET/coconut husk composites (MPCH and PCH) was observed to be low with R^2 value of 0.9613. This value is close to unity for a linear function and thus it can be said that the adsorption with both adsorbents was controlled by the intraparticle diffusion.

V. Conclusion

Waste polyethylene terephthalate (PET-RIC 1) matrix was successfully composited with waste coconut husk biomass. The unmodified and modified composites were characterized and applied in the adsorptive scavenging of ferric ions in simulated and real-time water through batch equilibrium, kinetic and intraparticle diffusion analyses. The results indicated that pseudo first-order kinetics was the most favourable rate model for both the unmodified and modified composites in terms of the highest rate constant (k_1) of 2.29 g/mg min and the coefficient of determination (R^2) of 0.95. This result corroborated with the multi-layer Freundlich model with a coefficient of determination (R^2) of 0.97 and 0.87 respectively for the unmodified and modified composites, which is indicative of physisorption as the prevalent equilibrium. Thus the composite may also be reused after desorption. Kinetic data puts the quantity of iron removed by modified composite to be 2.65 mg/g from PFO and 3.34 mg/g from PSO, all of which far exceeded the quantity removed by the unmodified composite. The R^2 value of the intraparticle diffusion at 0.96 shows that the composites had significant internal pores that could take in metal ion particles and so remove them from solution.

Conflict of interest

The authors do not have any form of conflict of interest in this work.

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