Adsorption Efficiency of Sawdust Activated Carbon on Congo red and Tartrazine Dye Removal from Textile and Food Industrial Wastewaters

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Abstract

Conventional methods for the removal of dyes are either expensive or inadequate because of their stability towards light, oxidizing agents and resistance towards aerobic digestion, besides generating sludge with disposal problem. However, Adsorption of dyes is a relatively new technology and efficient method for treatment to remove contaminant from effluent. The study investigated the adsorption mechanisms and removal of Congo red and tartrazine dyes from textile and food industrial wastewaters onto naturally based activated carbon prepared from sawdust. It further characterized the physical and chemical properties with dye concentrations of the wastewaters before and after treatments with the adsorbent using standard methods and Ultraviolet-visible Spectrophotometer respectively. The composition of the sawdust activated carbon was determined based on the dry combustion method using Brunauer, Emmett and Teller (BET) (VARIO EL III, Elemental Germany), Scanning Electron Microscope elemental (SEM) (High resolution SEM -Carl Zeiss) was used to study the surface morphological characteristics and structural chemical functional groups in the activated carbon was determined using the Fourier Transform Infrared technique (SHIMADZU-FTIR-8400S). Batch adsorption experiment were conducted and initial concentration (20, 30, 40 and 50 mg/L), adsorbent dosage (0.5, 1.0, 1.5 and 2.0 g), pH (2, 4, 6 and 8) and contact time (20, 40, 60 and 80 minutes) were optimized for Congo red and tartrazine dye using SDAC as adsorbent. Data from the initial concentration was used to test conformity with Langmuir and Freundlich adsorption models. Adsorption efficiencies for simulation ranged from 11.11±0.00 to 85.00±0.70 and 31.57±0.00 to 66.67±1.40 for Congo red and tartrazine dyes respectively. Optimized adsorption conditions for Congo red and tartrazine dye were pH 8, 2.0 g adsorbent dosage, 80 minutes contact time and 50 mg/L dye concentration; and pH 2 for food industrial wastewater, gave removal efficiencies of 72.41% and 78.57% for textile and food industrial wastewaters respectively. Physicochemical characteristics of the wastewaters were observed to decrease after treatment with SDAC. Data best fit Langmuir than Freundlich adsorption model. Results concluded that SDAC was found beneficial for adsorption of Congo red and tartrazine dyes in Textile and Food Industrial Wastewaters.

Index Term: Adsorption, dyes, food, Industry, Sawdust, Textile, UV-Visible Spectrophotometer, Wastewater, Nigeria.

1. Introduction

Industrial developments in recent years have left their mark on the different environmental matrixes. Many industries like the textile and food industry used dyes to colour their products and thus produce wastewater containing organics with a strong colour while in dying and production processes, and the percentage of dye lost wastewater is 50% due to the low levels of dye-fiber fixation [1,2]. Discharge of these dyes into water bodies affects the people who may use the water for domestic purposes such as washing, bathing and drinking [3,5].

More than 0.7 million tons of synthetic dyes are produced annually worldwide. In addition, over 10,000 different dyes and pigments have been applied in those industries [4] Studies indicate that approximately 15% of produced synthetic dyes per year have been lost during processing operations that involve the production and handling with many organic compounds hazardous to human health [6,7,8]. Wastewaters of dye production and application industries present an environmental problem because of the aesthetic nature due to the fact that the colour is visible even in a low dye concentration. Inclusively, dyes can affect aquatic plants because they reduce sunlight transmission through water. It may impart toxicity to aquatic life and may be mutagenic, carcinogenic and may cause severe damage to human beings, such as dysfunction of the kidneys, reproductive system, liver, brain and central nervous system [6,9].

The textile and food industry consumes large quantities of water at its different stages of production among other processes. The non-biodegradable nature of dyes and their stability toward light and oxidizing agents complicate the selection of a suitable method for their removal [10]. In addition, toxicity bioassays have demonstrated that most of them are toxic.

Several methods such as membrane, electrochemical, coagulation/flocculation, biological, etc. have been used for dye removal from wastewater [11,12]. Among

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the treatment methods, adsorption is considered to be relatively superior to other techniques because of low cost, simplicity of design, availability and ability to treat dyes in more concentrated form [13,2]. Adsorption of dyes is a new technology for treatment of wastewater containing different types of dyes [14,15]. The adsorption process is one of the efficient methods to remove contaminant from water and wastewater [2]. The process of adsorption has an edge over conventional methods such as coagulation, flocculation, reverse osmosis, activated sludge, bacterial action, chemical oxidation, ozonation etc. due to its sludge free clean operation and complete removal of dye even from dilute solutions [11]. The conventional methods for the removal of dyes are either expensive or inadequate because of their stability towards light, oxidizing agents and resistance towards aerobic digestion, besides generating sludge with disposal problem [16].

Adsorption by activated carbon is an important way to clean up effluents and wastewater [17], where it used to polish the influent before it is discharged into the environment. However adsorption by activated carbon has some restrictions such as the cost of the activated carbon, the need for regeneration after exhausting and the loss of adsorption efficiency after regeneration. Therefore adsorption by agricultural by-products used recently as an economical and realistic method for removal of different pollutants has proved to be an efficient at removing many types of pollutants such as heavy metals [18], COD [19], phenol [20], gasses and dyes [21,2].

2. Methods

2.1 Collection, Preparation and Carbonization of Sample

The sawdust were collected from a local mill in Ile-Ife, Osun State, Nigeria. The sawdust was rinsed with water to remove particles, and sun-dried to constant weight. A known weight (100 g) of the dried sawdust was prepared by placing the material in a weighed ceramic crucible and carbonized in a muffle furnace (HERAEUS D-6450) at 700 ^oC for 1 hour under closed conditions, and sieved to <150 μm particle size [14,16,22,2].

2.2 Chemical Activation of the Carbon

The method is as outlined in [14,23]. One hundred grams (100 g) of the charred sawdust was soaked in 2% phosphoric acid (H_3PO_4) (v/v) for 24 hours and continuously heated on a magnetic stirrer hotplate (Stuart Scientific)

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at 85 °C till complete dryness. The heated sample were washed with distilled water until neutral pH (pH 7) is achieved. It was filtered and finally dried in an oven at 110 °C for 4 hours, cooled at room temperature and used as an adsorbent.

2.3 Determination of Ash Content

The ash content of the sawdust activated carbon was determined according to the method of [24,25]. Twenty grams (20 g) of the char sawdust sample was placed into a dried weighed crucible. It was then transferred into a furnace (HERAEUS D-6450) set at temperature of 550 °C and was held for 3 hours. It was removed and allowed to cool in a desiccator and was reweighed. The ash content of the sample was determined using the equation below:

$$\%\ \text{Ash content} = \frac{weight\ of\ ash}{weight\ of\ original\ sample\ used} \times 100$$

2.4 Determination of Volatile matter

Volatile matter of the sawdust activated carbon was determined by heating 10 g air dried sample in a muffle furnace (HERAEUS D-6450) at 900 °C for 7 minutes and calculated using the equation below: [14,24,26]

$$(\%) Volatile\ matter = \frac{Initial\ weight - Final\ weight}{Final\ weight} \times 100$$

2.5 Surface Area and Pore Size Determination

The surface area and pore size distribution of the sawdust activated carbon were determined using computer-controlled nitrogen gas adsorption analyzer at −196 °C (Quantachrome, Boynton Beach, USA) [23,24].

2.6 Characterization of the Activated Carbon

The elemental composition and the surface morphological characteristics of the sawdust activated carbon were determined based on the dry combustion method using Brunauer, Emmett and Teller (BET) (VARIO EL III, Elemental, Germany) and Scanning Electron Microscope (SEM) (high-resolution SEM Carl Zeiss) [23,24]. Structural chemical functional groups in the activated carbon were determined using the Fourier transform infrared technique (FTIR, SHIMADZU-FTIR-8400S) [14,22,2].

2.7 Preparation of Samples for SEM Analysis

The sawdust activated carbon sample was prepare according to the method of [2]. The SDAC sample was placed on the aluminum holder stub using a double sticky carbon tape. Insulating sample was located with carbon and electrically grounded. Also, silver paint was used to electrically ground the sample. Then, the sample were completely dried in the drying oven at 60 °C for about 3 hours and was left overnight in the drying oven. The sample was loaded in the SEM holder, and the SEM machine was switched on. The SEM instrument then placed the sample in a relative high-pressure chamber where the working distance is short, and the electron optical column is differentially pumped to keep vacuum adequately low at the electron gun. Imaging was then acquired.

2.8 Preparation of Sample for FTIR Analysis

The SDAC samples were analyzed using the FTIR KBr method. A drop of the liquid was placed on the face of a highly polished KBr plate. A second plate was placed on top of the first plate so as to spread the liquid in a thin layer between the plates and clamped together. Liquid on the edge of the plate was wiped after which the sample plate was mounted onto a sample holder connected to a recording device and analyzed.

2.9 Batch Adsorption Experiment on Simulated Congo red and Tartrazine dyes Wastewaters

The batch adsorption experiment were carried out according to the method of [16,27,2]. Dyes (Congo red and Tartrazine) polluted wastewater were simulated by preparing standard solutions of the dye (10, 20, 30, 40 and 50 mg/L) concentrations in the laboratory. Batch adsorption experiment were performed using of 0.5, 1.0, 1.5, and 2.0 g of the adsorbent made from sawdust activated carbon and 50 ml each of the simulated dyes solution in different conical flask separately with constant shaking using rotary shaker (Stuart Scientific) operated at a speed of 500 rpm. Contact time and pH were also optimized for successful adsorption. Congo red and tartrazine dyes contents were filtered using (Whatman No. 45) filter paper. The filtrates containing the residual concentrations of dyes were centrifuged at 300 rpm after adsorption and were determined using UV-visible spectrophotometer (UV-160A, Shimadzu, Japan). The data obtained were subjected to one-way analysis of variance (ANOVA).

2.10 Characterization of the Textile and Food Industrial Wastewaters

The textile wastewater used in this study was collected from a local dyeing industry, while the Food Industrial wastewater was collected from 7up Company in Ilorin respectively.

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The physicochemical properties of the Textile and Food Industrial Wastewaters samples were determined using standard methods and its dyes concentrations were determined using Ultraviolet-visible Spectrophotometer (Shimadzu UV-160A, Japan Model).

2.11 Adsorption Efficiency

The percentage of the dyes (Congo red and Tartrazine dyes) adsorbed (adsorption efficiency %) were determined for each of adsorption process carried out using the following formula [14,24,25]. The adsorption behaviours of the samples were studied by evaluating the percentage removal efficiency of the dyes as expressed below:

$$Adsorption\ Efficeincy = \frac{(C_0 - C_1)}{C_0} \times 100\%$$

Where:

C_0 is the initial concentration of dye solution (mg/L) in the filtrate before adsorption

C_1 is the final concentration of dye solution (mg/L) in the filtrate after adsorption.

2.12 Adsorption Isotherm

Equilibrium models and sorption isotherms were used to explore how an adsorbate interacts with an adsorbent. The adsorption isotherms relate the interaction between the adsorption molecules, the liquid and solid phases at equilibrium state in adsorption process. Common equilibrium models used to describe isotherms of dye sorption on sawdust activated carbon includes Langmuir and Freundlich which are applied in this study [27,25,2].

3.0 Result and Discussion

3.1 Carbonization of Sawdust

In the result of carbonization, 100 g of sawdust gave a percentage yield of 82.43±0.91 % carbon with 5.29±0.12 % of volatile organic matter and 6.51±0.04 % of ash content. These results described that the sawdust is a rich source of carbon that can be trapped for different uses due to its lignocellulosic properties. Also, it is a potential material which is amenable for value addition [28,29].

3.2 Characterization of Activated Carbon

3.2.1 Physicochemical Properties of the Sawdust Activated Carbon (SDAC)

The results of the physicochemical properties (carbon yield, volatile organic matter, ash

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content, bulk density, solid density, BET surface area, total pore volume and pH were presented in Table 1. The high percentage carbon yield obtained from sawdust activated carbon (SDAC) makes it an asset compared to other agricultural wastes [16,28,29] with low ash yield (6.51±0.04). High carbon yield and low ash content give better characteristics of pore structures and this led to the established fact that high carbon yield of agricultural waste is an indicative of good adsorption [15,28,29]. In addition from Table 1, the pH (6.2±0.14) is almost neutral which describe an indicative of an acidic substrate.

3.2.2 Elemental Composition of Sawdust Activated Carbon before and after Adsorption Experiment

The sawdust activated carbon (SDAC) was analyzed using Brunauer, Emmett and Teller (BET) (VARIO EL III, Elemental, Germany) to determine its elemental composition before and after the adsorption experiment. The result shows that carbon has the highest percentage (61.58%) compared to other elements (oxygen (33.04%), Hydrogen (5.32%), Nitrogen (3.89%) and Sulphur (0.61%) before and Carbon 65.30%, Oxygen 20.10% and Sulphur 14.30% after adsorption experiment. This confirms the credibility of SDAC for adsorption [14,24]. The high percentage of carbons obtained were due to pyrolytic effects hence, most of the organic substances have been degraded into gaseous and liquid tars leaving a material with high carbon purity. The presence of other elements in the adsorbent enhances adsorption through adsorption mechanism such as ion exchange [14,24,2]

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Table 1: Physicochemical Characteristics of Sawdust Activated Carbon (SDAC)

Characteristics	Units	Sawdust Activated Carbon (SDAC)
Bulk density	g/ml	0.41±0.028
Moisture Content	%	0.53±0.014
Solid density	g/ml	3.8±0.45
BET Surface area	m^2/g	521.7
Ash content	%	6.51±0.04

pH	-	6.2±0.14
Volatile matter	%	5.29±0.12
Fixed carbon	%	82.43±0.91
Total Pore Volume	m^2/g	0.073

3.2.3 Surface Morphology of Sawdust Activated Carbon before and after Adsorption Experiment.

The surface morphological characteristics of sawdust activated carbon (SDAC) was characterized using scanning electron microscopy technique (SEM). SEM is described as a type of electron microscope that produces images of a sample by scanning the surface with a focused bean of electrons [29,30,2]. Figure 1(a) shows the surface morphology of the SDAC (adsorbent) before and Figure 1(b) after adsorption process.

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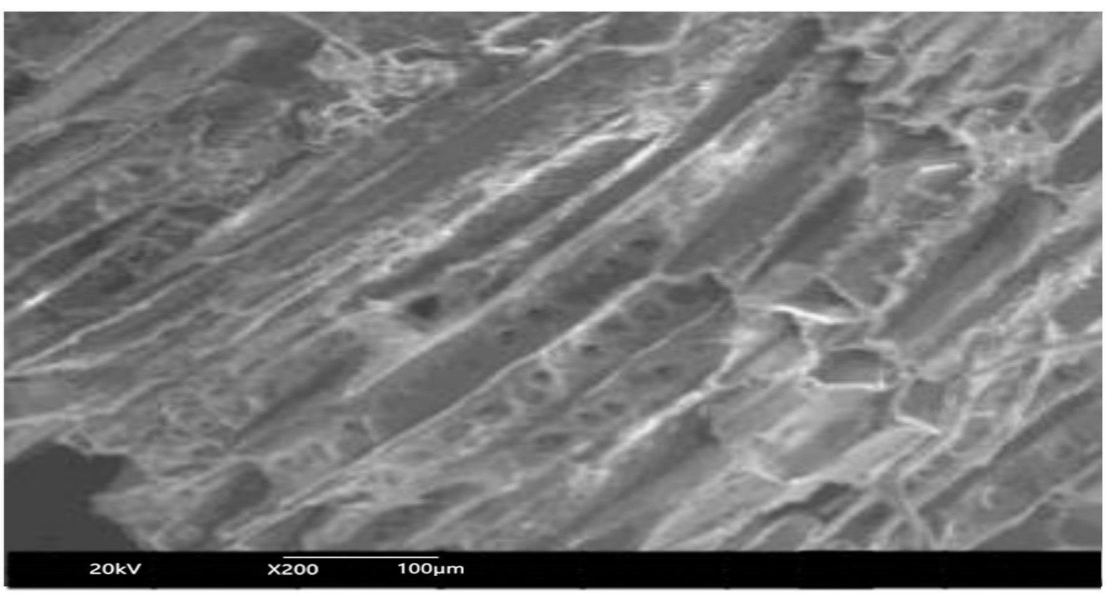
(a)



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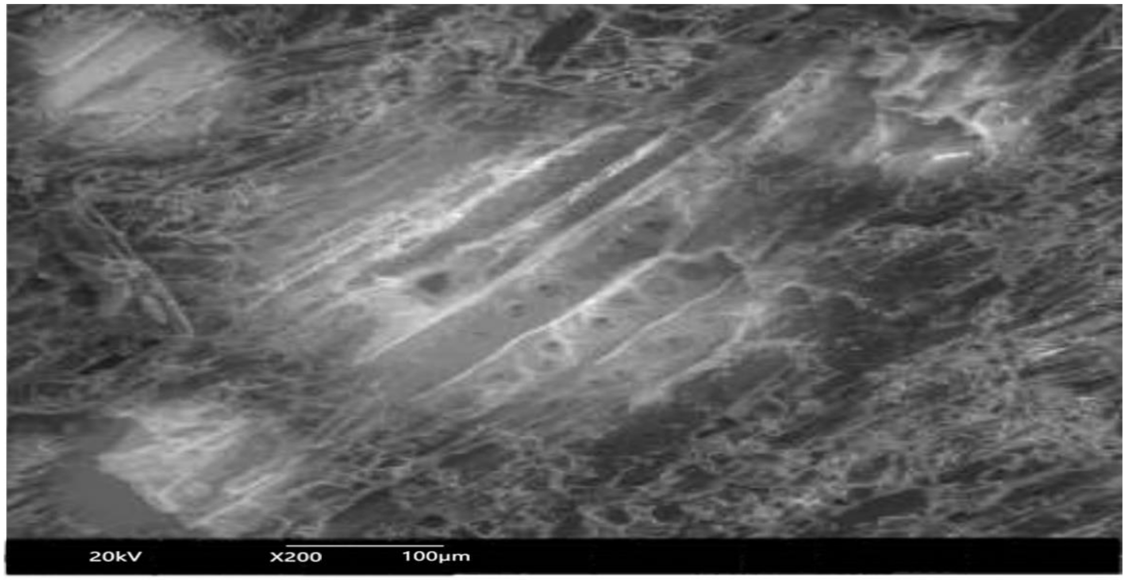

Figure 1: Scanning electron micrograph of Sawdust Activated Carbon (a) before and (b) after adsorption of dyes (Congo red and Tartrazine dyes).

This explains the mass of particle and the surface morphology of the adsorbent. The surface of the SDAC shows a small cavities and rough surfaces that indicates the presence of interconnected porous network [28,29]. However, the surface of SDAC were already clogged after adsorption, an indication that adsorption had occurred.

3.2.4 Functional Groups of Sawdust Activated Carbon (SDAC)

Fourier transform infrared spectroscopy (FTIR) was used to examine the functional groups of the sawdust activated carbon (SDAC) to ascertain the presence of some characteristic functional groups [2]. The functional groups of the SDAC were determined using Fourier transform-infrared spectroscopy (SHIMADZU-FTIR-8400S). Figure 2 shows the functional groups present in the SDAC. Each of the bands on the FTIR represents a particular functional group which enables adsorption. The functional groups present are the Hydroxyl (3398.69 - 3049.58 cm^{-1}) indicates the presence of cellulose and hemicellulose components of the sawdust, Carbonyl (2505.62 – 1871.01 cm^{-1}) [27], Aldehydes (1697.41- 1188.19 cm^{-1}), Ester (875.71 – 713.69 cm^{-1}), and Methoxy groups (584.45 – 484.15 cm^{-1}) [24,2].

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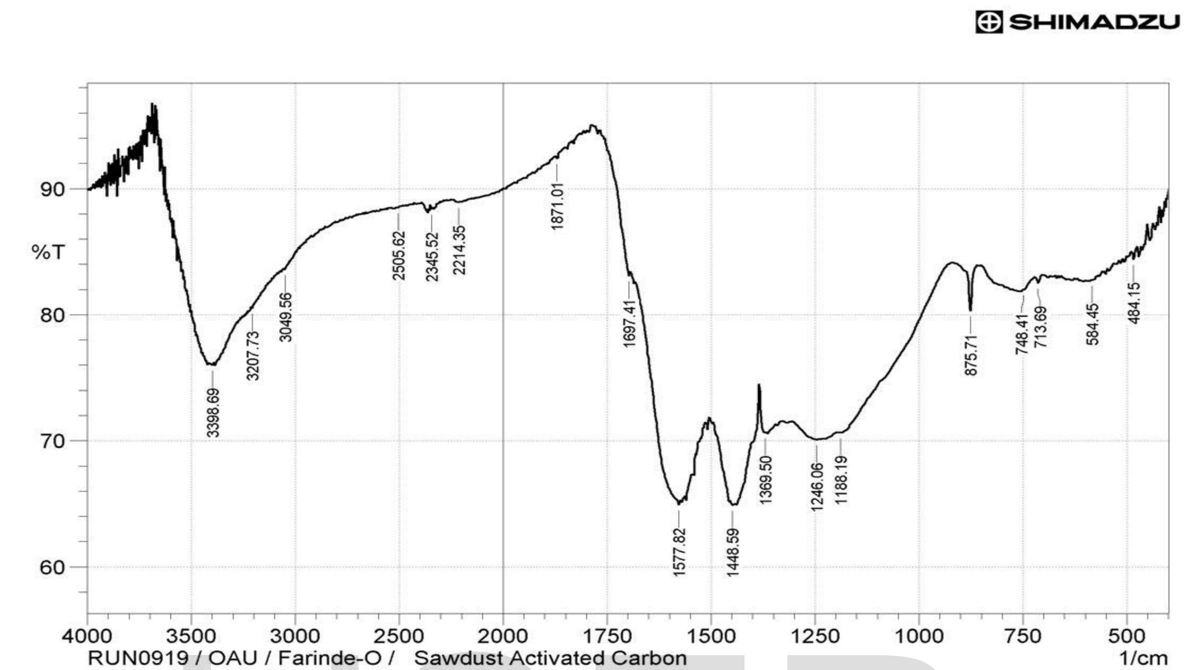

Figure 2: FTIR of Sawdust Activated Carbon

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3.2.5 Physicochemical Parameters of Wastewater Sample before and after Adsorption

The results of physicochemical parameters of textile and food industrial wastewater samples before and after adsorption are presented in Table 2. This is essential to know the effect of the adsorption of dyes (Congo red and tartrazine dyes) on the physicochemical properties of the wastewater samples. The physicochemical parameters of textile and food industrial wastewater samples before and after adsorption experiment were examined to determine the range of contaminants. All the physicochemical properties examined were observed to decreased for both textile and food industrial wastewater after adsorption.

Table 2: Physicochemical Parameters of Textile and Food Industrial Wastewater Samples before and after Adsorption Experiment

S/N	Parameters	Unit	Textile Wastewater before Adsorption	Food Industrial Wastewater before Adsorption	Textile Wastewater after Adsorption	Food Industrial Wastewater after Adsorption
1	pH	-	6.57±0.25	6.03±0.03	6.93±0.16	6.67±0.11
2	Conductivity	µS/cm	434.68±7.72	14.60±0.42	382.24±4.24	11.94±0.22
3	COD	mg/l	1680±12.62	321±9.89	1659±25.46	291±5.65
4	BOD	mg/l	440±5.56	16.18±0.60	398.72±15.99	13.28±0.09
5	TDS	mg/l	24220±140	2230±1.41	20149±24.04	2187±9.25
6	Total Hardness	mg/l	96.83±0.75	5.61±0.57	86.41±1.711	5.36±0.07
7	Turbidity	NTU	14.02±0.01	13.22±0.04	10.93±0.62	9.08±0.13
8	Sulphate	mg/l	318.36±3.74	123.01±0.26	297.06±11.24	108.66±0.67
9	TSS	mg/l	716±7.07	640±4.24	611.33±14.02	611.07±1.35
10	Chloride	mg/l	1052±9.79	21.89±1.28	933.78±6.70	13.93±0.21
11	Nitrate	mg/l	8.46±0.21	0.39±0.03	7.06±0.04	0.31±0.01
12	Calcium	mg/l	17.64±0.24	1.32±0.01	10.12±0.06	1.07±0.01
13	Dyes Concentration	mg/l	50±1.41	50±1.41	29.00±2.83	28.00±1.41

The absorbance of the textile and food industrial wastewater were determined using the UV spectrophotometer and the concentrations were then determined using the regression equation from the calibration curve of the standards of the dye solutions.

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The concentration obtained was then used to vary the concentrations of the dye in the textile and food industrial wastewater (20, 30, 40 and 50 mg/L) used.

3.3 Batch Adsorption studies on Simulated Wastewater of Congo red and Tartrazine Dye using Sawdust Activated Carbon as Adsorbent.

The effect of sawdust activated carbon for the adsorption of Congo red and tartrazine dye were investigated. Such factors influencing adsorption which includes pH, adsorbent dosage, contact time and initial dye concentration were examined using the sawdust activated carbon as adsorbent.

3.3.1 Effect of pH on Adsorption of Congo red and Tartrazine Dyes in Simulated Experiment

The results of investigation on the adsorption of Congo red and tartrazine dyes using sawdust activated carbon as adsorbent with varied pH (2, 4, 6 and 8) are presented in Figure 3 while all other conditions (adsorbent dosage, contact time and concentration) were kept constant. The pH is one of the factor that affects the adsorption process; it governs both, the surface chemistry of the adsorbent and of the adsorbate [31]. It is a measure of acidity ($pH < 7$) or basicity ($pH > 7$) of an aqueous solution [2]. The adsorption efficiency of Congo red dye was 85.19% at pH 2, 78.57% at pH 4 and 6, with the highest adsorption efficiency of 92.30% at pH 8, while the highest adsorption efficiency for Tartrazine dye was obtained at pH of 2 and 4 with 78.57% at pH of 6 and 8 using sawdust activated carbon respectively. This trend is in correspondence with the work of [24,26]. However, the adsorption efficiency increases with increase in pH for Congo red dye but decreases with increase in pH for Tartrazine dye.

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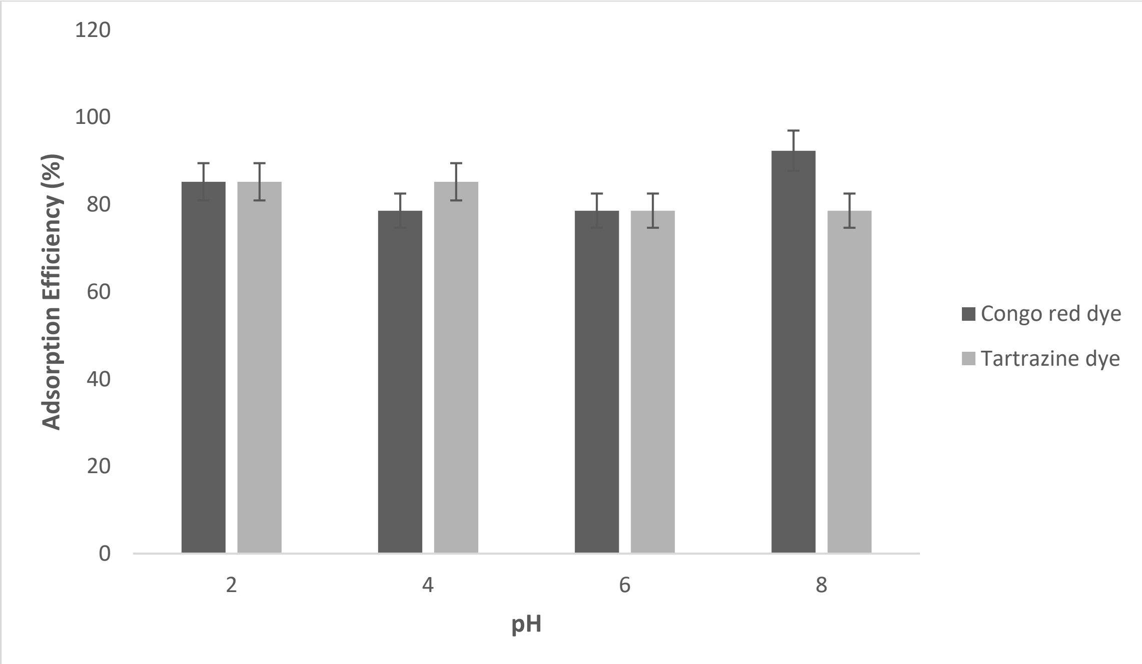

Figure 3: Effect of pH on adsorption of Congo red and Tartrazine dyes in simulated experiment.

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3.3.2 Effect of Adsorbent Dosage on Adsorption of Congo red and Tartrazine Dyes in Simulated Experiment.

The result of varied adsorbent dosages for the adsorption of Congo red and tartrazine dyes by sawdust activated carbon is presented in Figure 4 while other conditions (Contact time, concentration and pH) were kept constant. Adsorbent dosage is used to determine the adsorbent's capacity to adsorb an adsorbates at the operating conditions [2,25,28]. The adsorption efficiency of Congo red were 72.41% at 0.5 g, 78.57% at 1.0 g, with the highest adsorption efficiency of 92.30% observed at 1.5 and 2.0 g. For tartrazine dye, the adsorption efficiency were 38.89% at 0.5 g, 42.86% at 1.0 g, 56.25% at 1.5 g and 72.41% at 2.0 g with the highest adsorption efficiency. The results explains that by increasing the adsorbent dosages from 0.5 to 2.0 g, the dye removal efficiency also increases. The increase in adsorption of the dyes by increase in adsorbents dose can be attributed to the fact that at higher absorbent dosages, the surface area and the binding sites available for the attachments of dye molecules increase, which result in the more efficient adsorption process [2,3].

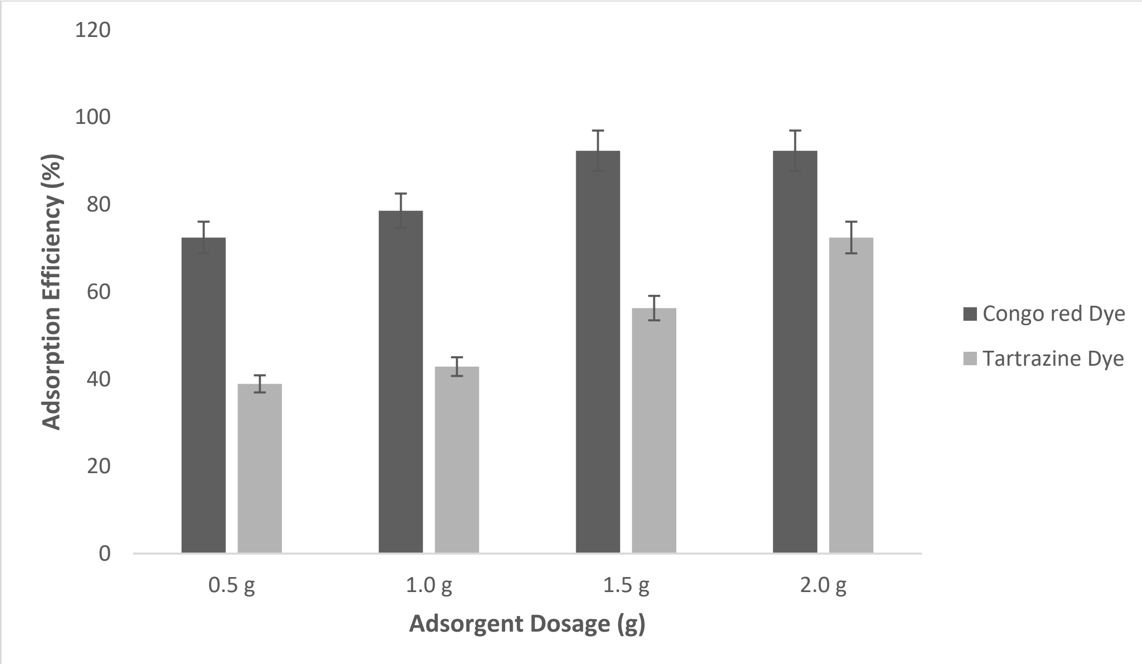

Figure 4: Effect of Adsorbent Dosage on adsorption of Congo red and Tartrazine dyes in simulated experiment.

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3.3.3 Effect of Contact Time on Adsorption of Congo red and Tartrazine Dyes in Simulated Experiment

The effect of contact time on the adsorption of Congo red and Tartrazine dyes using sawdust activated carbon as adsorbent by varied contact time (20, 40, 60 and 80 minutes) while other conditions (concentration, adsorbent dosage and pH) were kept constant are presented in Figure 5. The removal efficiency of Congo red and Tartrazine dyes were 66.67% and 85.18% at 20 minutes, 66.67% and 92.30% at 40 minutes, 72.41% and 66.67% at 60 minutes and 72.41% and 85.18% at 80 minutes respectively as the contact time increases from 20 to 80 minutes. A well percentage of dye removal was obtained at 60 minutes for Congo red and 40 minutes equilibrium time for tartrazine dye. This is due to the fact that as the dye solution-adsorbent system is being agitated at longer time, more of the molecules or atoms of the dye tend to accumulate on the surface of the adsorbent until equilibrium is reached. Similar trends have been observed by some other researchers [2,12,31,32].

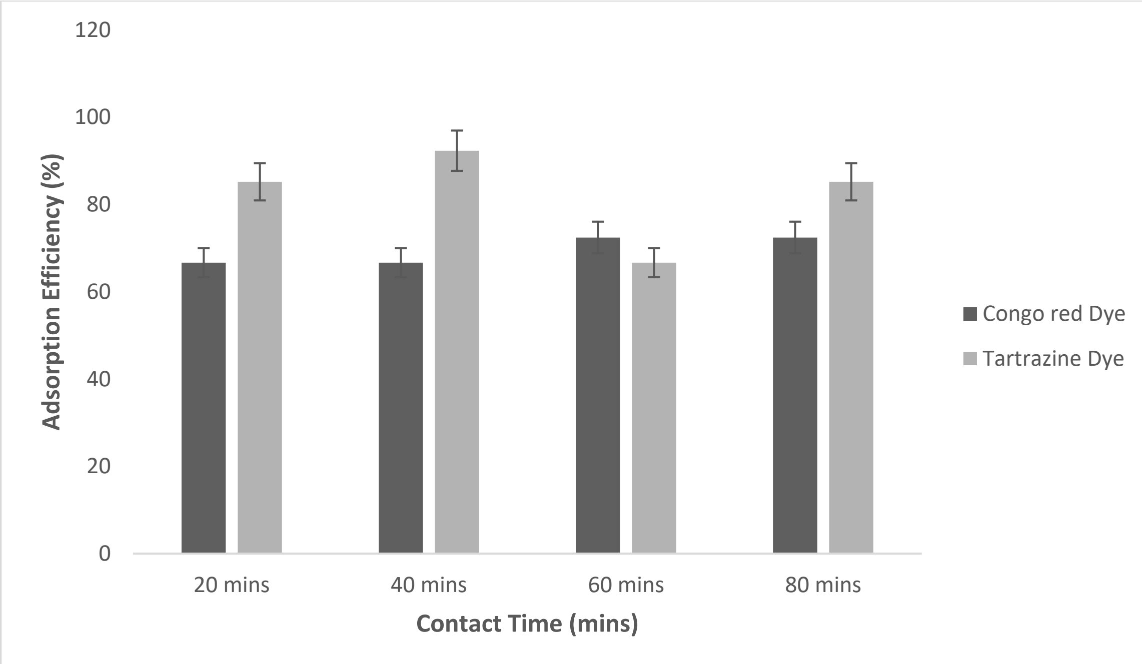

Figure 5: Effect of Contact Time on adsorption of Congo red and Tartrazine dyes in simulated experiment.

3.3.4 Effect of initial concentration on Adsorption of Congo red and Tartrazine Dyes in Simulated Experiment

The effect of the varied initial dye concentration (20, 30, 40 and 50 mg/L) of Congo red and Tartrazine dye on the adsorption experiment using sawdust activated carbon as adsorbent is presented in Figure 6 while other conditions (Contact time, adsorbent dosage and pH) were kept constant. The removal efficiency were 11.11% and 42.86% at 20 mg/L, 36.00% and 66.67% at 30 mg/L, 81.00% and 42.87% at 40 mg/L and 85.00% and 31.57% at 50 mg/L for Congo red and tartrazine dye respectively. However, it was observed that adsorption increases with increase in concentration for Congo red with highest adsorption efficiency of 66.67% at 30 mg/L for tartrazine dye. This results is due to increasing of initial dye concentration which result to high mass transfer driving force, so the dye adsorption becoming higher [23,25].

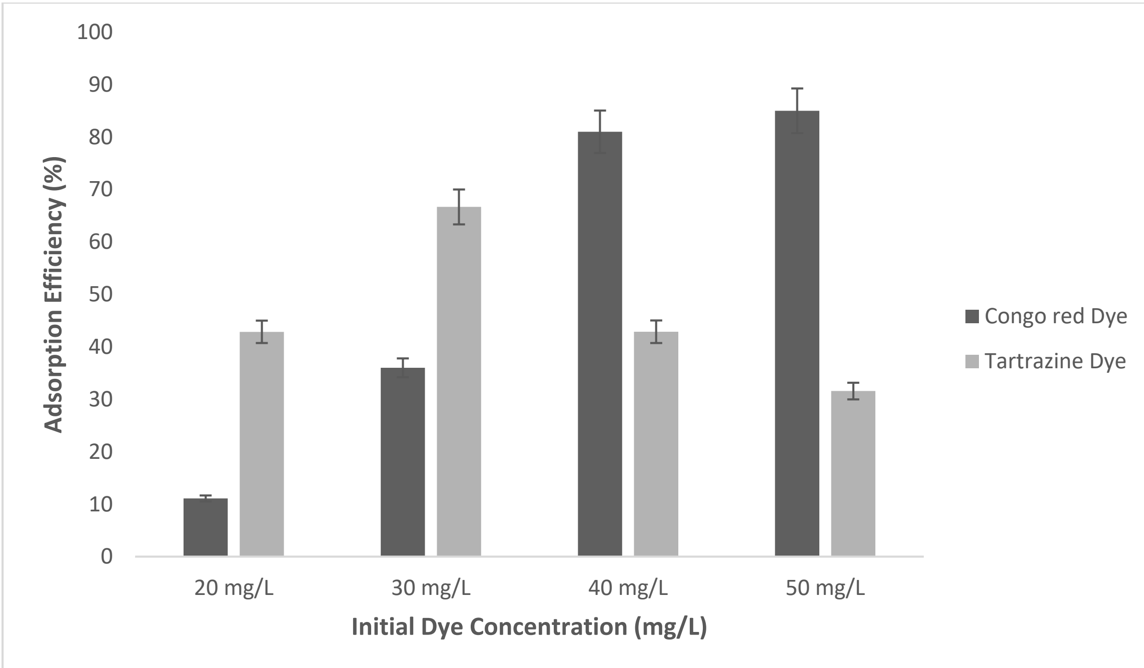

Figure 6: Effect of Initial Dye Concentration on adsorption of Congo red and Tartrazine dyes in simulated experiment.

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3.3.5 Adsorption of Congo red and Tartrazine Dyes from Textile and Food Industrial Wastewater using Sawdust Activated Carbon as Adsorbent

Adsorption experiment was conducted on the wastewater from textile and Food Industrial industries using sawdust activated carbon as adsorbent with the optimized conditions (pH – 8.0 for textile and pH – 2.0 for food industrial wastewater, adsorbent dosage -2.0 g and 80 minutes contact time) obtained from simulated experiments. The dye concentration of the textile and food industrial wastewaters sample were determined using Ultraviolet-visible Spectrophotometer (Shimadzu UV-160A, Japan Model). The results of investigation on the adsorption process for textile and food industrial wastewater is shown in Figure 7. The result showed the removal efficiency of sawdust activated carbon for the adsorption of Congo red and Tartrazine dyes in textile and food industrial wastewater were 72.41% and 78.57% respectively as presented in Figure 7. The increase in the amount of dye adsorbed per unit mass of the adsorbents with increase in dye concentration is subjected to higher initial concentration which enhances the driving force between the aqueous and solid phases and increased the number of collisions between dye molecules and the adsorbent [25,28,33].

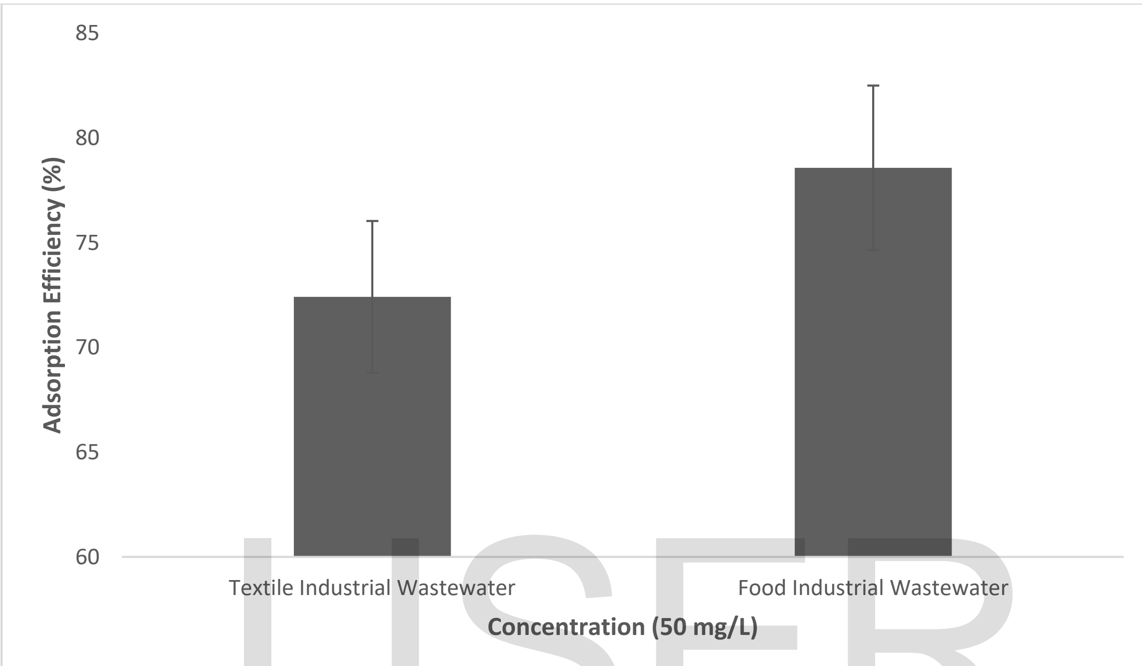

Figure 7: Adsorption of Dyes from Textile and Food Industrial Wastewater using Sawdust Activated Carbon as Adsorbent

3.4 Adsorption Isotherm

Adsorption studies were conducted on the textile and food industrial wastewater using sawdust activated carbon as adsorbent with the optimized conditions (pH – 8.0 for textile and pH – 2.0 for food industrial wastewater, adsorbent dosage -2.0 g and 80 minutes contact time) from simulated experiment. The results of the sorption ability of the sawdust adsorbent was evaluated through determination of adsorption isotherm of dye (Congo red and Tartrazine dye) sorption system and were presented in Figures 8a and b (Langmuir isotherm) and Figures 9a and b (Freundlich isotherm), while Tables 3 show the coefficients of these isotherms (Langmuir and Freundlich) respectively. The results deduced that the adsorption process is feasible for Langmuir than Freundlich isotherms model for the adsorption of dye from the simulated wastewater. The adsorption capacity is usually predicted from equilibrium sorption isotherm [2,24,34].

(a)

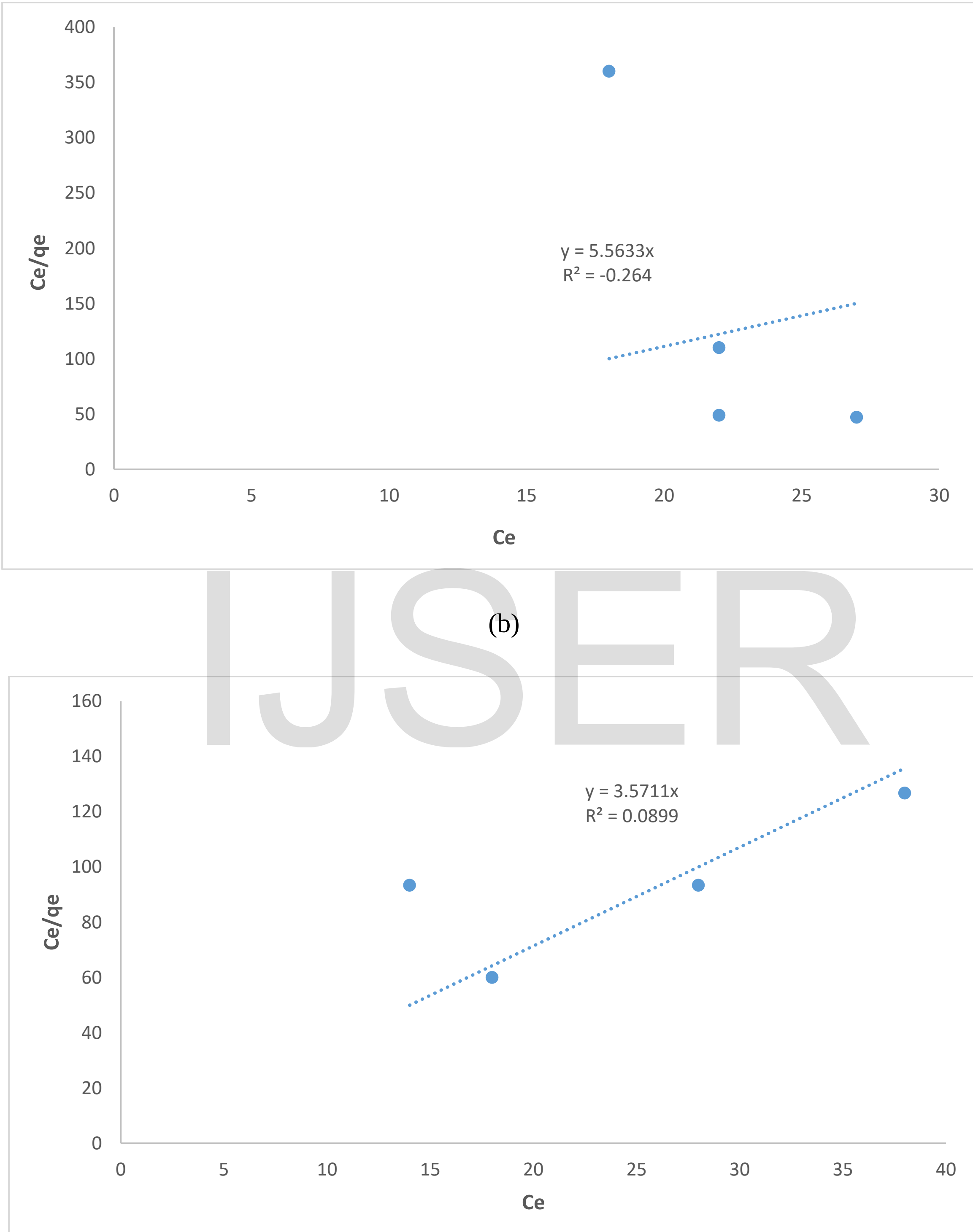

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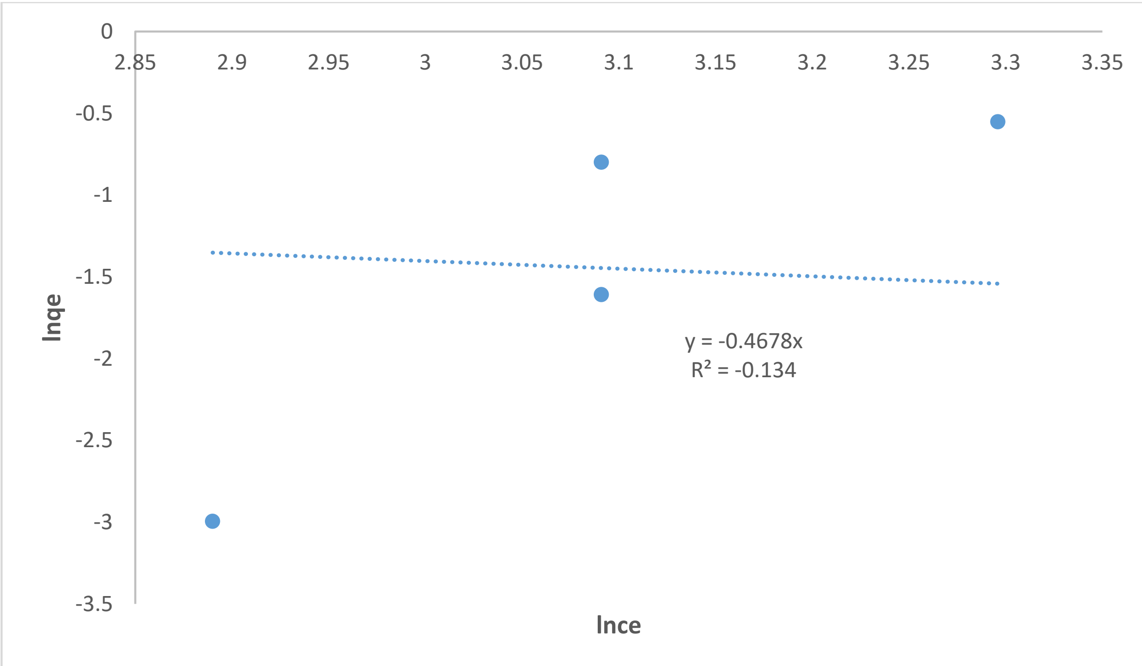
Figure 8: Langmuir adsorption isotherms for the adsorption of (a) Congo red and (b) Tartrazine dye using Sawdust activated carbon.

(a)



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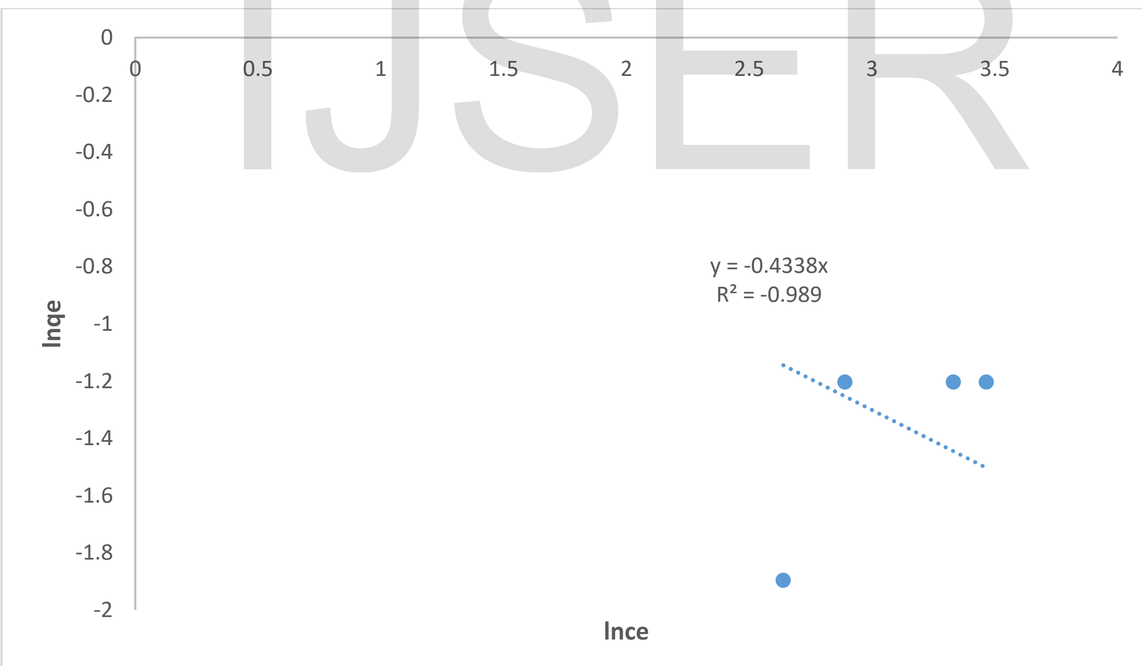

Figure 9: Freundlich adsorption isotherms for the adsorption of (a) Congo red and (b) Tartrazine dye using Sawdust activated carbon

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Table 3. Langmuir and Freundlich adsorption isotherm constants for the adsorption of Congo red and Tartrazine dye using Sawdust Activated Carbon (SDAC) as adsorbent

Adsorbent	Contaminants	**Langmuir constants**			**Freundlich constants**		
Sawdust Activated Carbon		q_m (mg/g)	k_a(L/mg)	R^2	I/n	k_f(mg/g(l/mg)$^{1/n}$)	R^2
	Congo dye	0.1798	0.00	-0.264	-0.4678	1.000	-0.134
	Tartrazine Dye	0.2800	0.00	0.0899	-0.4338	1.000	-0.989

R^2= correlation coefficient

3.6 Conclusion

In this study, removal of Congo red and tartrazine dye has been studied. High quality activated carbon was prepared using sawdust. Best adsorption condition for sawdust activated carbon (SDAC) in this study were adsorbent dosage -2.0 g, 80 minutes contact time, 50 mg/L and pH – 8.0 for textile and pH – 2.0 for food industrial wastewater. The high adsorption efficiency of SDAC was attributed to high surface area of the adsorbent. SDAC demonstrates a quantifiable adsorption for both Congo red and Tartrazine dyes. The adsorption data was feasible to Langmuir than Freundlich isotherms. The study concluded that the development of economic, efficient and high quality adsorbent from SDAC was found beneficial for adsorption of Congo red and tartrazine dyes and may be easily incorporated to water and wastewater systems to treat other toxicants.

3.7 Recommendation

The study recommends more in depth study on the use of sawdust activated carbon for toxicants removal from wastewater and efficient use in the field of adsorption.

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Competing Interests

The authors declared no competing financial interests.

Data Availability

The data used to support the findings of this study are included within the article.

Ethical Issues

Authors have declared no ethical issues in the manuscript.

Conflicts of Interest

Authors have declared no conflict of interest in the manuscript.

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