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Adsorption of Phenol on Carbon Based on Cactus and Banana Peel

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Abstract

Water pollution from industrial discharges can have harmful effects on the environment and health. To reduce these effects, several wastewater treatment processes, particularly physicochemical processes, are used, in particular the adsorption technique. This study uses cactus coals (ERC, AUC) and banana peels (PBC) to remove phenol in aqueous solution. Experimental results of the influence of different parameters showed that adsorption increases with time and reaches equilibrium at 90 minutes. The adsorption is maximal at acidic pH and decreases from 2.93 to 1 mg / g for ERC, then from 2.27 to 1.19 mg / g for AUC and finally from 2.19 to 1 mg / g for PBC in the range of pH 2-12. These results indicate that ERC adsorbs phenol more.

Key words: Heavy metals, Road deposited sediments, Geo-statistical analysis, Nigeria, Atomic Absorption Spectroscopy.

INTRODUCTION

Water pollution has been a serious problem for environmental and water users. These hazardous pollutants have a remarkable ecological effect on ecosystem and posed major threat to the aquatic lives (Pan and Kurumada, 2008). Phenol, a colourless-to-white solid with a characteristic odour, is the simplest monatomic phenol, soluble in water and organic solvents (Duan et *al*., 2018). Pollutants containing phenol are released from many different anthropogenic sources such as petroleum refinery, pesticide manufacturing plants, petrochemicals, organic chemical manufacture (Acosta et *al*., 2018). This pollutant penetrates ecosystems as the result of drainage off the municipal or industrial sewage to surface water. By Natural Sources; Phenol is a constituent of coal tar, and is formed during decomposition of organic materials (Chandana and Sridevi, 2009). Increased environmental levels may result from forest fires. Phenol is toxic and some is known or suspected carcinogens (Ry and Murugesan, 2002). The presence of phenol in drinking water and irrigation water represents a serious health hazards to humans, animals, plants and microorganisms (ATSDR, 2007). Ingestion of phenol for a prolonged period of time causes mouth sore, diarrhea, excretion of dark urine and impaired vision at concentrations levels ranging between 10 and 240 mg/L (Álvarez-Torrellas et al 2017). The treatment of thise pollutants in multi-component system is complex and required effective purification processes (Han and *al*., 2006, Achak and *al*., 2009). To protect our environment from pollutants, it can be achieved either by minimizing the introduction of pollutants into the environment or by their removal from contaminated media. Several methods have been used for the removal of these polluant including chemical oxidation with ozone (Matta and *al*., 2008), photo degradation (Lv *et al*., 2011), Fenton degradation (Pourata and *al*., 2009), biological degradation (Moussavi and *al*., 2009), ozonation (Maldonado and *al*., 2006), membrane filtration (Banasiak and *al*., 2011) and adsorption (Al-Muhtase and *al*., 2011). Adsorption remains the most used and easy to implement techniques. Lignocellulosic biomass obtained from wastes and by-products ofcrops and fruit production are considered as attractive precursors for the preparation of activated carbons (Mohamed and *al*., 2010). Transformation of biomass obtained from these materials may show high performance in adsorption processes and surface reactivity. This adsorbent offers goodversatility and flexibility to modify its physical and chemical properties. Banana, a tropical fruit, is widely cultivated over 130 countries worldwide.

As part of this work three adsorbents have retained our attention; banana skin and two different kinds of cactus. In Ivory Cost, banana is massively cultivated and can be consumed in the fresh form and 80% of ripe banana is processed and is ingredient in many types of food such as baby food, banana streamed pastry, deep fried banana, sun-dried banana, sweet banana crisp, and banana stirs. In general banana peel was abandoned as a solid waste.

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The cactus is a tree native to the arid and semi-arid regions of Mexico. It belongs to the genus Opuntia; it is a succulent xerophytic plant capable of storing a large quantity of water and presenting no danger to human health (Habibi Y, 2004). It also has considerable values in the fields of cosmetics, medicine and food (Arba and *al*., 2000, Boujghagh. and Chajia, 2001). Cactus has great water retention capacity; this is due to mucilage water retention by implying coagulation properties (de Souza et *al*., 2014). In recent years a lot of research is invested in the field of wastewater decontamination, in particular the biosorption of heavy metals and the elemination of turbidity.

In this work, we report the preparation of banana peel and cactus support for the removal of phenol in order to develop new materials capable of reducing these environmental problems. The effects of various operating parameters on biosorption, such as contact time, initial pH, sorbent dose, and initial solution temperature were monitored and optimal experimental conditions were determined.

2. MATERIALS AND METHODS

2.1. Preparation of carbon support

In order to valorize abundant agricultural waste, three coals from two different species of cactus and banana peels are proposed for the retention of phenol. These are carbon from Agave Utahensis (AUC), Euphorbia Resinifira (ERC) and local banana peel (PBC).

The banana peels and cactus used as raw material in this work were manually selected, exhaustively washed with distilled water until the pH is constant to remove soluble impurities and finally dried at room temperature 105 ° C. Charring was done in a muffle furnace at 550 ° C, with a ramp rate of 10 ° C / min; for 1 hour. The resulting carbons were stored in a desiccator for use in adsorption experiments.

2.2. Preparation of solutions

The commercial phenol used (99%, MERCK) did not undergo any prior treatment. All solutions for each procedure were prepared by diluting with ultra pure water. The pH of the solutions is adjusted with nitric acid (HNO_3) and sodium hydroxide (NaOH), while measuring these values using a HANNA brand pH-meter.

2.3 Experimental procedure

The samples were analyzed using a UV/Vis spectrophotometer (WFJ-752) at its maximum wavelength of 510 nm.

2.3.1 Effect of contact time

In order to study the effect of the contact time, an amount of 1 g of calcined carbons was added to 100 ml of phenol solution C = 14 mg / L. The samples were taken at 20-180 min. The flasks were stirred at room temperature. After equilibrium, the adsorbent was separated from the solution by filtration. The samples were analyzed by spectrophotometer.

2.3.2. Effect of adsorbent dosage

The effect of adsorbent dosing on phenol adsorption was studied. several quantities of adsorbents were tested in which masses between 0.5 and 3 g were placed in a solution of 100 mL of phenol (14 mg / L at pH = 6.8 and the suspensions were stirred at room temperature 25 °C for 120 min).

2.3.3 Effect of pH of the solution

The degree of ionization of the phenolic ions in aqueous solution and the surface charge of the absorbents are strongly influenced by the pH solution. The effect of the pH of the phenol adsorption solution by calcined carbons was studied by varying the initial pH of the pH solutions from 2 to 12. This end was adjusted using HCl or NaOH before the adsorbent was added and measured with a HANNA HI 99301 pH meter.

The initial phenol concentration was set at 14 mg / L. An amount of calcined carbon (1 g) was incubated by stirring for 90 min in 100 ml phenol solution. After equilibrium, the suspension was filtered to separate the liquid and solid phases. The residual phenol concentration was measured spectrophotometrically at 510 nm using the 4-amino-antipyrine method.

2.3.4 Effect of concentration

Batch experiments were carried out to study the adsorption of phenol on banana and cactus carriers. Adsorption experiments were performed in Erlenmyer flasks (250 mL) containing 100 mL of phenol solution at a concentration of 1 to 12 mg / L. 1 g of calcined carbon was added and the mixture stirred for 90 minutes. After filtration, the solutions were filtered and analyzed.

2.3.5 Effect of temperature

The effect of temperature on phenol absorption was studied at different temperatures (20-60 ° C) by maintaining a constant initial concentration of phenol (14 mg / L). For this purpose, 1 g of activated carbons was added to the phenol solution. The samples were shaken for 120 minutes.

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3. RESULT AND DISCUSSION

3.1. Effect of Contact Time

Effect of contact time on adsorption of phenolic compounds by banana peel cactus are presented in Fig 1. The result showed that the removel efficiency increased with increasing soaking time. Initially, adsorption increased sharply and slowed gradually until equilibrium was attained in approximately 3h. Almost, no remarkable improvement was observed after longer contact time. This observation was attributed to the availability of readily accessible sites during the initial stage, and the remaining vacant surface sites were difficult to be occupied due to the repulsive forces between the solute molecules on the solid and bulk phases, as the equilibrium approached. The time required to attain this state of equilibrium is termed as equilibrium time.

The contact time required for the phenol to reach to the equilibrium was relatively short. This finding indicated the economical availability for the real practical applications.

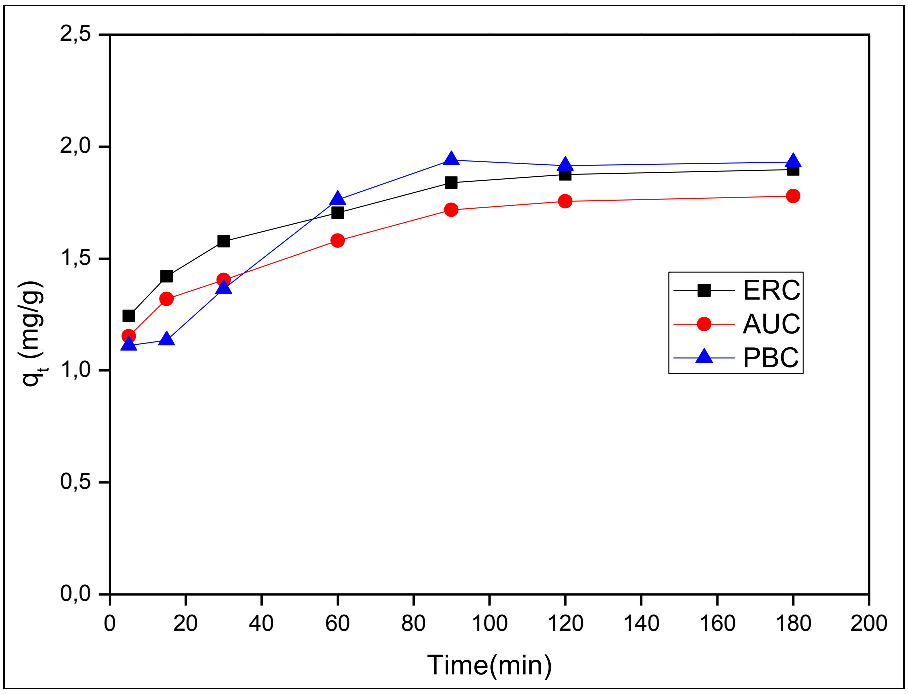

Figure 1: Effect of contact time.
C_0= 14 mg/L, m = 1g, V = 100mL, pH = 6.8, T = 25°C

Adsorption rate of phenol on cactus and banana charbons was found to be relatively much faster than those reported for some other normal adsorbents. Xiaolo and Youcai, (2006) investigated the adsorption of phenolic pollutants in the aqueous solution by aged-refuse, and reported that the remaining concentration of the phenolic pollutants in the liquid phase becomes asymptotic to the time axis after 4h of shaking. Usarat and Pakulanon (2007) determined that the sorption equilibrium of phenol on dried sewage sludge was reached within 20h. Adsorption of bromophenols onto carbonaceous adsorbents derived from fertilizer solid waste was performed by Bhatnagar (2007) and reported an equilibrium time of about 8h. However, El Gaidoumi et *al*. (2015) in their study on Phenol Adsorption by a Moroccan Pyrophyllite, indicated a 25 min equilibrium time. The comparison of the three characters makes it easy to conclude that PBC has an adsorbent capacity greater than the AUC but normative at the ERC.

3.2. Effect of adsorbent dosage

Figure 2 shows that the adsorption capacity was found to be high at low doses. This decrease in adsorption capacity with the increase in the adsorbent dosage is mainly attributed to the unsaturation of the adsorption site during the adsorption process (Han and *al*., 2006).The same results were obtained by achak et *al*. (2009) in the study of the adsorption of banana peel for the removal of phenolic compound from olive mill wastewater.

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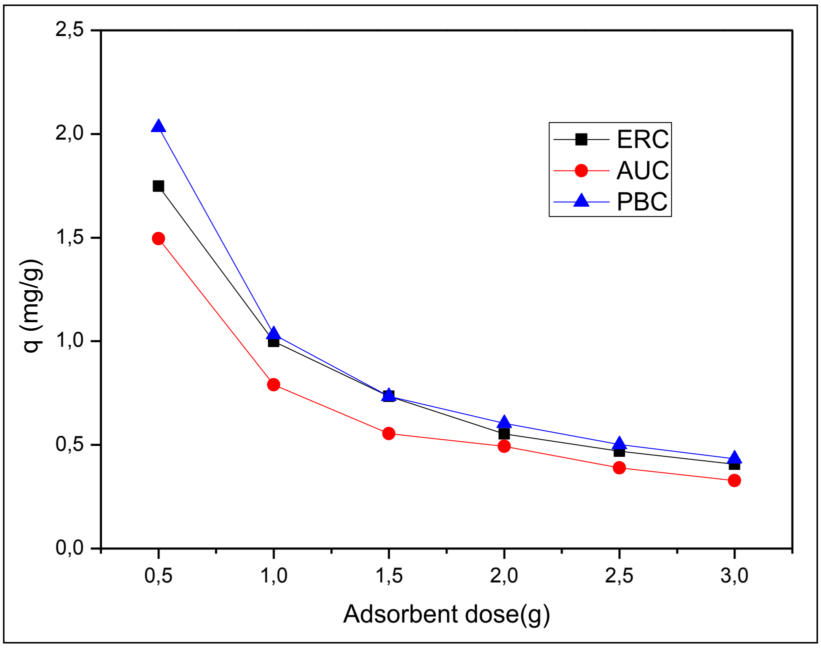

Figure 2: Effect of adsorbent dosage
C_0= 14 mg/L, V = 100mL, pH = 6.8, t = 120min, T = 25°C

3.3. Effect of pH on phenol biosorption

The most important parameter influencing the adsorption capacity is the pH of adsorption medium (Goyal and *al*., 2003). The pH affects the adsorption mechanisms on the adsorbent surface and influences the nature of the physic-chemical interactions of the species in solution and the adsorptive sites of adsorbents (Zumrize and Yener, 2001). The effect of pH on the adsorption of phenol by charbons (cactus, banana peel) at pH ranging between 2 and 12 is shown in Fig 3. There is a considerable decrease in the adsorption capacity of phenol in the pH range studied. Similar results have been obtained by Usarat and Pakulanon, (2007), which studies the adsorption of phenols on dried sludge. They reported a decrease in phenol adsorption at higher pH. Many other authors with similar behavior indicated a change in the surface charge of the adsorbent. Indeed, as the pH of the medium increases, the number of negatively charged sites increases, this should be less favorable to the adsorption of negatively charged phenolate ions and the surface of the positively charged adsorbent due to electrostatic repulsion. (Namasivayam and Kavitha, 2002, Fu and Viraraghavan, 2002).

On the other hand, in other studies, we can find appreciable adsorption rates at alkaline pH. The work of Achak and *al*. (2009) on the removal of phenolic compounds from banana peel has shown that an increase in pH to (pH 7-11) results in an increase in adsorption capacity.

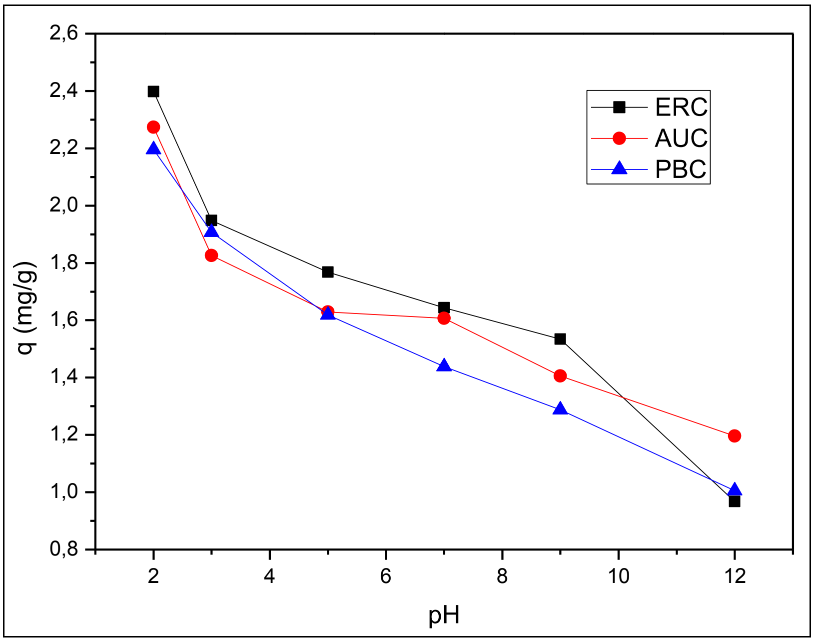

Figure 3: Effect of Solution pH.
C_0= 14 mg/L, m = 1g, V = 100mL, t = 90min, T = 25°C

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3.4. Effect of initial phenol concentrations

The concentration effect was evaluated as one of the most important factors affecting adsorption.

Figure 4 shows the effect of the concentration on phenol adsorption of cactus and banana peels. These results show that the adsorption is considerably improved by increasing the phenol concentration. This is related to an increase in the driving force of the concentration gradient to overcome the mass transfer resistance between the aqueous phase and the solid phase.

The maximum adsorption was determined, in addition these results shows ERC is a better absorption of phenol than other coals.

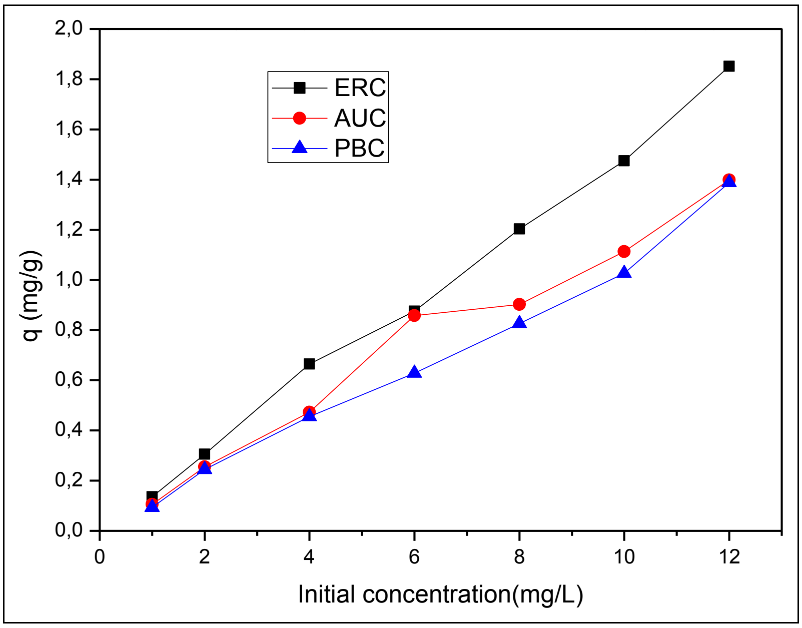

Figure 4: Effect of initial phenol concentrations.
m = 1g, V = 100mL, pH = 6.8, t = 90min, T = 25°C

3.5. Effect of temperature

The performance of sorbents under different reaction temperature was studied. Fig 5 shows the removal of phenol as a function of solution temperature in an aqueous solution of pH =6.8. The initial phenol concentration is 14 mg/L and adsorbent dosage is 1 g. With varying the temperature of phenol solution from 20 to 60 °C. The sorption efficiency is enhaced by increasing the temperature from 20 to 50°C. The observed enhanced in sorption capacity might be explained in the base the of chemical adsorbate-adsorbent interaction leading to creation of new adsorption sites. These interactions can produce an increase in the rate of intra-particule diffusion of phenol ions into the charbon at higher temperature.

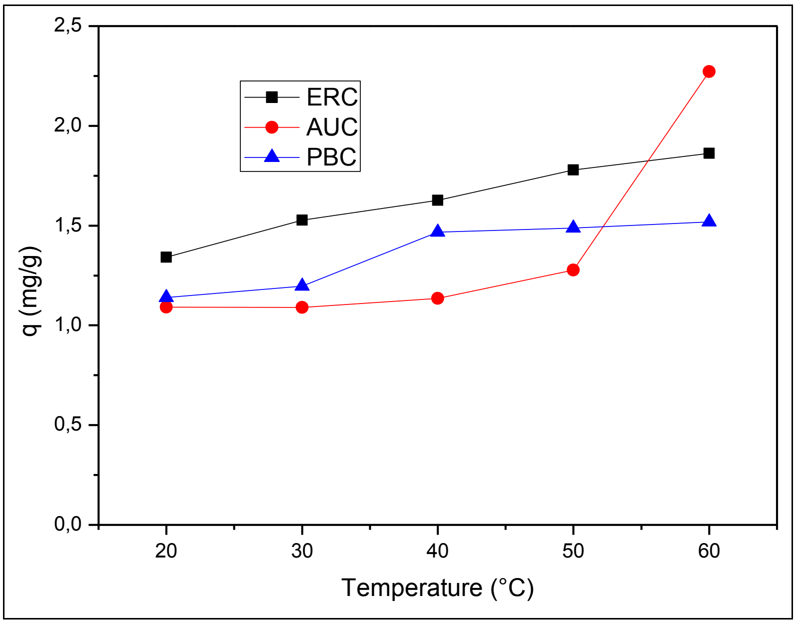

Figure 51: Effect of Temperature.
C_0= 14 mg/L, m = 1g, V = 100mL, pH = 6.8, t = 90min

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4. CONCLUSION

The results obtained in batch adsorption of phenol on cactus-based coals (ERC, AUC) and banana peels (PBC) have shown that the adsorption of phenol is possible by these materials. The best adsorption has been found to be preferential for ERC. The study shows that the physicochemical parameters have a considerable effect on the adsorption of phenol on coals from biomass; in fact, adsorption increases with increasing pH, concentration, and temperature. In addition, this study showed that the adsorption increases with time until the adsorption equilibrium is reached after 90 minutes. On the other hand, the study of the effect of the adsorbent dose shows that the adsorption of phenol decreases as the amount of adsorbent increases.

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