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Analytical Assessment on The Removal of Phenol From Aqueous Solution Using orange Peel Based Activated – Carbon

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ABSTRACT: *This study examines the effectiveness of activated carbon from orange peel in the removal of phenol from aqueous solutions. The effect of many parameters such as concentration, time, adsorbent dose and pH in the adsorption were studied. The values obtained showed that as the concentration of phenol increased in the solution from 10 to 50mg/l the concentration of phenol adsorbed by a constant mass of the adsorbent decreased. Increased in contact time from 25 to 145 minutes, increased the concentration of phenol adsorbed from 1.12±0.004 to 2.52 ±0.026mg/l. Varying the adsorbent dosage from 0.5 to 2.5g, the quantity of phenol increased from 1.51±0.034 to 2.11±0.004mg/l and decreased to 1.81±0.003mg/l at an adsorbent dose of 2.5g. Increase in the pH range from 1.26 to 8.79 increased the concentration of phenol adsorbed from 1.38±0.05 to 2.41 ±0.004mg/l in pH 1.26 to 3.22. However, this study proves that orange peel activated carbon is a good material for purification of our drinking water from phenol.*
Keywords: Activated, adsorbent, adsorption orange, peels, phenol

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I.   INTRODUCTION

In recent times, adsorption phenomenon has become a useful tool for purification and separation. Adsorption process by solid adsorbent has great potential as one of the most efficient methods for the treatment and removal of organic contaminants in waste water. The search for the removal of organic pollutant using alternative low cost adsorbent is now on the increase by many researchers [1] due to various reasons such as:

- Agricultural wastes have low ash content and high density [2].
- Commercial activated carbon are expensive but agricultural bye-products are low in cost.
- Activated carbon with a developed micro-porosity and wide micro spore size distribution which are characteristic of activated carbon produced from agricultural origin can improve the adsorption of organic pollutants especially PAHs [3].

Use of agricultural bye-product for the production of activated carbon is primarily for economic and ecological advantages. The use of orange peel as a biosorbent material presents strong potential due to its high content of pectin (galacturonic acid), hemicelluloses and lignin. The use of this orange waste has been reported as precursor materials for the preparation of an adsorbent by common chemical modifications such as alkaline, acid, ethanol and acetone treatment.

Meanwhile, activated carbon are common adsorbent used for the removal of undesirable odour, colour, taste and other organic and inorganic impurities from domestic and industrial waste water. The major constituent of activated carbon is the carbon account for up to 95% of the mass weight. In addition, activated carbons contain other hetero-atoms such as hydrogen, nitrogen, sulphur and oxygen. These are derived from the source raw material or become associated with the carbon during activation and other preparation procedures [4]. The activated compound particles has three main types of pores existing in it by which adsorption takes place, such as; macro, meso and micro pores.

The passage way to the particle interior and surface area is provided by the macro pores. The surface areas of the activated carbon particles are largely due to the micro pore and are created during the activated process. Therefore, the performance of the activated carbon depends on the surface area and the pores structure. The surface area determines the amount of material which can be adsorbed and pore structure determines the size of the molecule that can be adsorbed [5].

This study investigates the potential of activated carbon from orange peel in removing phenol from aqueous solution. This was achieved through specific objective, assessing the adsorption of phenol in aqueous medium by using parameters such as effect of time, adsorbent dose, and phenol concentration.

II. MATERIALS AND METHODS

2.1 Sample Collection and preparation

About eighty (80) orange were sourced from various fruits stands at Itu Local Government Area of Akwa Ibom State. The oranges were peeled using stainless knife and separated from the fruits and other materials. The peels were thoroughly washed with distilled water and later dried in an oven at $105^{o}C$ for three hours.

The dried orange peels were carbonized in a close muffle furnace at $300^{o}C$ for one hour thirty minutes. The carbonized orange peel was crushed using porcelain motar and pestle. It was later soak in 20% phosphoric acid for sixteen hours to become activated. The activated carbon was washed with deionized water carefully to pH 7, dried in an oven at $105^{o}C$ for three hours, later sieve with a mesh size of 1.18 mm and stored in a transparent container for further analysis [6] .

2.2 Preparation of Phenol Concentration by Serial Dilution

Phenol was purchased from Mike-Ene chemical shop at No. 16 Udi Street, Uyo, Akwa Ibom State. 250ml of 0.4M of phenol solution was prepared. 5 samples bottles were taken and labeled. 1.5g of oranged peel activated carbon was accurately weighed and transferred into each of the bottles.

Using a measuring cylinder, 50ml, 40ml, 30ml, 20ml, and 10ml of the phenol solution were added followed by addition of 10ml of deionized water to 40ml of phenol solution, 20ml of deionized water of the phenol solution, 40ml of deionized water to 10ml of phenol solution to each of the sample bottles, so that the total volume 50ml remains constant in each bottle. These sample bottles were shaken thoroughly using orbital magnetic shaker for four hours. The solution in each of the sample was filtered using a dry filter paper and the filtrates were collected in a well labeled 100ml conical flask. The initial 5ml of the filtrate was discarded. 5ml of the filtrate was measured out into a clean conical flask and titrated against standard potassium permanganate solution [7]. The titration was repeated to minimize the error in values. From the values the concentration of phenol remaining and hence the amount of phenol adsorbed was calculated.

2.3 Effect of Contact Time

1.5g of the activated carbon was weighed and transferred into each of the five sample bottles. Using measuring cylinder, 50ml of the phenol solution was added into each of the bottles. The time for shaking was varied; 25 minutes, 55 minutes, 85 minutes 115 minutes, and 145 minutes, respectively. The phenol solution in each of the bottles was allowed to settle and ten filtered using a filter paper. The filtrates were collected in properly labeled conical flasks [8]. The initial 5ml of the filtrate was discarded. Another 5ml of the filtrate was measured out into a clean conical flask and titrated against standard potassium permanganate. The titration was repeated three more times for each filtrate.

2.4 Effect of Adsorbent Dose

To five sample bottles, 0.50g, 1.00g, 1.50g, 2.00g and 2.50g of the activated carbon was measured and transferred into each of the bottles respectively. 50ml of 0.5M phenol solution was added into each of the bottles. At a constant time of two hours, shaking was carried out; the solutions in each of the bottles were allowed to settle and then filtered using a filter paper. The filtrates were collected in a cream labeled conical flask.

The initial 5ml of the filtrate was discarded. Another 5ml of the filtrate was measured out and titrated against standard potassium permanganate solution. The titration was repeated for each filtrate for three times.

2.5 Effect of pH

This was determined by varying the pH of the 0.5M phenol solution. 2.0g of the activated carbon was measured and transferred into each of the sample bottles. 50ml of the phenol solution was added into each of the bottles. The pH was varied using 1.0M HCl and 1.0M NaOH. The effect of pH on the amount of phenol removal was analyzed for pH 1.26, 2.06, 3.22, 5.95 and 8.79 with the aid of standardized pH meter. The phenol solution was shaken with orbital shaker for two hours, allowed to settle and then filtered using a filter paper. The filtrates were collected in clean well labeled conical flasks. The initial 5ml of the filtrate was discarded. Another 5ml of the filtrate was measured out into a clean conical flask and titrated against potassium permanganate. The titration was repeated for each filtrate, three times to minimize error in values.

III. RESULTS AND DISCUSSION

Table 1: Values of Phenol Concentration against concentration of phenol adsorbed

Phenol concentration (mg/l)	50.0	40.00	30.00	20.00	10.00
Concentration of phenol adsorbed (mg/l)	1.20±0.003	1.71±0.004	2.47±0.004	3.01±0.001	3.71±0.003

The results in Table 1 are plotted in figure 1 below as phenol concentration against concentration of phenol adsorbed.The concentration of adsorbate is very vital, as a given mass of the adsorbent can only adsorbed a fixed amount of the solute, the smaller the concentration of solution that a given mass of adsorbent can purify. The adsorption of phenol increased from 1.20 ml ± 0.003 to 3.71 ± 0.003 ml in a constant time of five hours at an adsorbent dose of 2.0g. Hence, as the concentration of phenol present in the solution decreases, the amount of phenol adsorbed increases. This might be attributed to sufficient adsorption site available for the adsorption of the phenol [9]. Also reportd by Ebiekpe and Okafor [10]   that plausible reason might be attributed to the fact that at lower initial metal ion concentrations sufficient adsorption sites are available for the adsorption of the heavy metals ions.

3.1 Effect of Contact Time

Table 2: Values for Contact time against concentration of Phenol Adsorbed

Contact Time (minutes)	25	55	85	115	145
Amount Adsorbed (mg/l)	1.12±0.004	1.59±0.001	1.99±0.036	2.10±0.034	2.52±0.026

The effect of contact time on the removal of phenol was conducted at different intervals ranging from 25 minutes to 145 minutes. The adsorption of phenol increased from 1.12 ml to 2.52ml at an adsorbent dose of 2g and constant volume 50ml of 0.5M phenol solution. Hence, as contact time increases, adsorption of phenol also increases.

3.2 Effect of Adsorbent Dose

Table 3: Values of Adsorbent Dose against Amount of Phenol Adsorbed

Adsorbent Dose (g)	0.5	1.0	1.5	2.0	2.5
Amount Adsorbed (mg/l)	1.5±0.034	1.65±0.002	1.85±0.020	2.11±0.004	1.81±0.003

The adsorption of phenol was conducted using different adsorbent dose with time and phenol concentration constant (0.5M). The adsorption increases from 1.51 to 2.11mg/l then decreases at an adsorbent dose of 2.5g. However, the rate of phenolics compounds binding with adsorbent increases more rapidly in the initial stages and after a certain point adsorption is marginal. Therefore, the optimum dosage was taken as 2.0g in 50mg/l of 0.5M phenol. The initial faster rate may be due to availability of the sites on the adsorbents. As these were progressively filled, the more difficult the sorption becomes [10] .

3.3 Effect of pH

Table 4: Values of pH against concentration of Phenol Adsorbed

pH	1.26	2.06	3.22	5.95	8.79
Amount Adsorbed (mg/l)	1.38±0.005	2.28±0.001	2.41±0.004	1.88±0.002	1.44±0.001

pH (log of Hydrogen ion concentration) is one of the vital parameters controlling adsorption. In order to optimize the pH for maximum efficiency, experiments were performed in the pH range of 1.26 – 8.79. In the alkaline range, the pH was varied using aqueous 1.0M NaOH, whereas in the acidic range pH was varied using 1.0M HCl. The maximum adsorption capacity increases with increase in pH from 1.26 to 3.22 in the acidic range. Dropped in the separation efficiency was noticed for further increase in pH due to the formation of phenolate ions. However pH is one of the vital parameters controlling adsorption, because it affects the surface charge of the adsorbent and the degree of ionization.
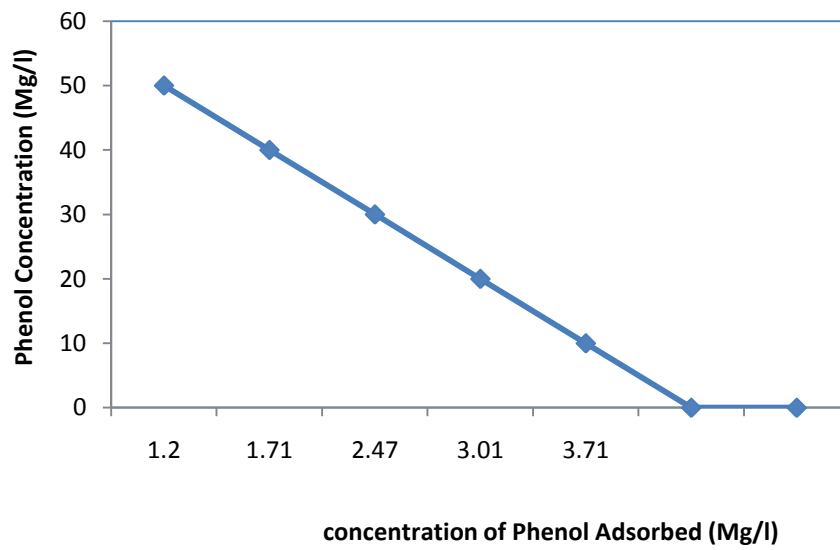
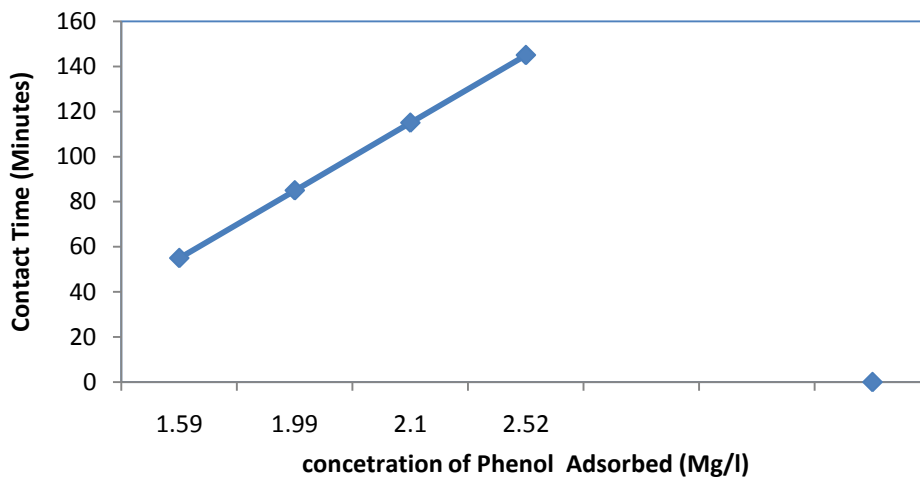**Fig I:** Phenol Concentration against amount of phenol adsorbed

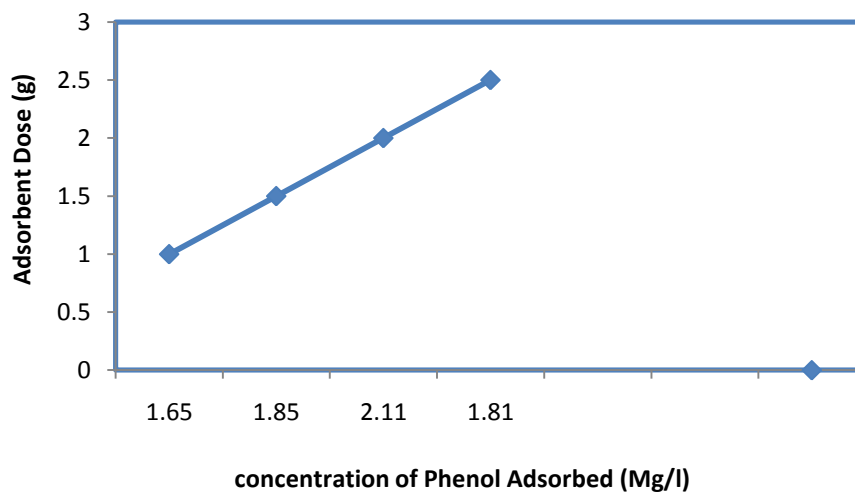**Fig 2**: Contact Time against concentration of Phenol Adsorbed

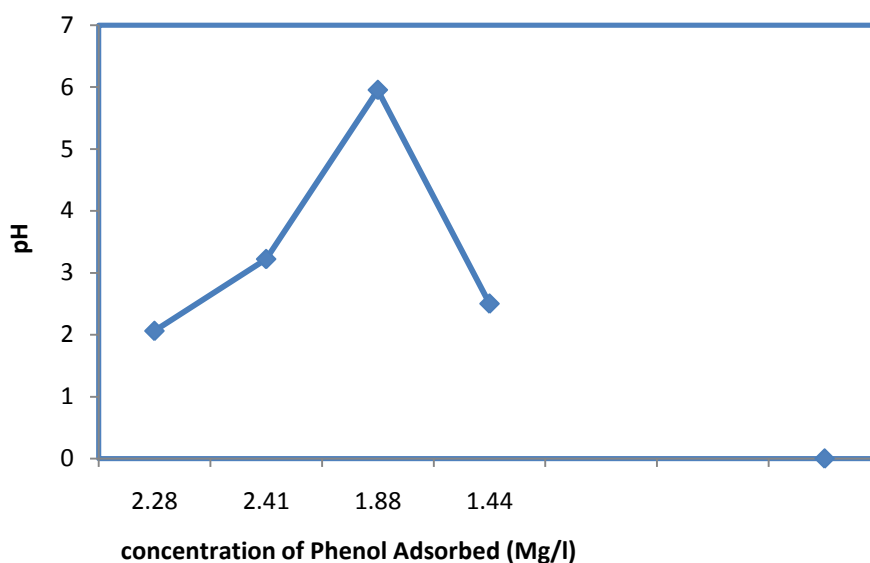**Fig 3:** Adsorbent Dose against concentration of Phenol Adsorbed

Fig 4: pH against concentration of Phenol Adsorbed

IV. CONCLUSION

The effectiveness of the activated carbon from orange peel was investigated by performing experiments based on various parameters, concentration, contact time, adsorbent dose and pH. From the result it was observed as the concentration of phenol in solution was decreased; the concentration of phenol adsorbed from the solution by the adsorbent was increased. As the contact time increases, adsorption of phenol increased. Also the rate of phenol binding with adsorbent increased in the initial stages and after some point adsorption is marginal. Thus, the optimum dosage was taken. Finally the adsorption capacities increased in the acidic range and dropped in efficiency was observed for further increase in pH. On the whole orange peels should not be regarded as waste rather be converted to activated carbon for purification of our water for a cleaner and healthier environment. It will also serves as source of income.

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