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Removal of Phenolic Compounds from Industrial Wastewater Through Adsorption Techniques

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Abstract: Phenol is a high-risk environmental pollutant even at small concentrations. This study was conducted to remove phenol from industrial wastewater by adsorption using sawdust and activated carbon manufactured from coconut and comparing phenol removal efficiency using 2 types of adsorbents. The phenol removal efficiency of each of the two different types of adsorbents was studied at different factors in terms of the initial concentrations of phenol in wastewater (200, 240 and 290) mg/l at contact times (30, 60, 90 and 120) minutes and pH (3.9, 3.5 and 2.4) with different doses of activated carbon (0.5, 0.9 and 1.2) g and other doses of sawdust (20, 30 and 40) g. The results showed an increase in removal efficiency while increasing the dose of the adsorbent and increasing contact time. The highest efficiency using activated carbon is 85.6% when using 0.9 g of activated carbon at contact time of 120 minutes, while the removal efficiency is 40.4% if using 40 g of sawdust at the time of contact of 120 minutes

Keywords: Adsorption. Phenol. Sawdust. Activated carbon.

1. INTRODUCTION

Phenol pollution is a significant environmental problem. Phenolic compounds are a typical wastewater pollutant. Phenol is one of the most important hazardous pollutants, according to the U.S. Environmental Protection Agency (USEPA) [1].

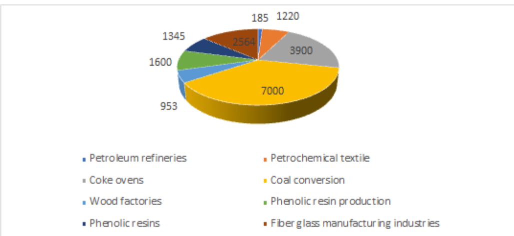

Fig 1. Approximately how much phenolic waste (in mg/l) can be found in various industrial effluents [2]

According to Fig. 1, phenol is widely employed in a variety of sectors, including the paper, plastic, pesticide, petroleum and petrochemical, and medicinal ones. Additionally, these industries produce a lot of effluents, some of which have millions of milligrams per liter more contaminants than natural water [3]. Phenol is very soluble in water and is detectable as a badly taste and odor in water supplies [4].

Due to their toxicity, phenols and their derivatives are highly dangerous environmental contaminants. The quantity of phenol and the time of exposure essentially determine the effects on health. Because phenol is very hazardous even at low concentrations, exposure to it by humans is one of the risks in any refinery's effluent [5]. Additionally, phenols have a number of harmful impacts on the environment, including negative effects on soil owing to decreased porosity and flocculation, negative effects on plants due to decreased seed germination, and negative effects on groundwater due to toxic phenol seeping through the soil [6]. The World Health Organization (WHO) has established a maximum permissible concentration in drinking water of 0.001 mg/L. Therefore, it is necessary to remove phenol from domestic, industrial, and agricultural wastewaters in order to reduce the phenol concentration to below the acceptable level [7].

The literature has details about a number of removal techniques, including flocculation, membrane separation, solvent extraction, oxidation, photodegradation, and electro-Fenton oxidation [8]. The adsorption method has been found to be extremely popular in the treatment of wastewater. Adsorption strategies used to remove phenol are often divided into three groups: chemical, physical, and biological adsorption [9]. Although useful, chemical methods are not accepted since they frequently release additional hazardous substances. The biological degradation processes are also not investigated, despite the fact that temperature has a significant impact on them [10]. Since physical adsorption techniques are so effective, they are frequently employed in industry [11]. Adsorption using various natural adsorbents is likely the most cost-effective and efficient treatment method for phenol removal [12]. Several researchers are looking for naturally occurring adsorbents that are affordable and accessible [13]. However, some crucial factors to consider when selecting the finest adsorbents include surface area, pore sizes, structural features, adsorption performance, straightforward regeneration, and a wide range of applications [14].

Because they are typically inexpensive, natural materials derived from agricultural wastes are frequently chosen as effective adsorbents [15].

The current study aims to investigate the efficiency of industrial sawdust and coconut activated carbon used as adsorbents for phenol removal from wastewater, as well as to investigate the effects of initial phenol concentration, adsorbent dosage, pH value, and contact time on the adsorption process, in order to identify the most effective conditions.

2.MATERIALS AND METHODS

Sample collection

Samples of refinery wastewater were taken from a local petrochemical factory and stored at room temperature in dark-colored plastic containers. Three samples were collected and each sample was 5 liters. Samples were collected at different times through day. The weight used in each trial in experimental work was 5 gm (40 ml). The main characteristics of the refinery wastewater are given in Table 1.

TABLE 1. Characteristics of the refinery wastewater

	Concentration of Phenol (mg/l)	**pH**
1st Sample	200	3.9
2nd Sample	240	3.5
3rd Sample	290	2.4

Adsorbent preparation

Two types of adsorbents were used sawdust and activated carbon. Sawdust was collected from the local resource. It was boiled with distillate water and, then, filtrated and dried in an oven at 80^{o} C for 24 hrs. Finally, it was sieved to particle size range of 4-6 mm. Activated carbon used in experimental work was from coconut.

Adsorption procedure

The studies were performed for assessing the adsorption efficiency of the phenol from wastewater using sawdust and activated carbon. The experiments were carried out with the variation of process variable like initial phenol concentration, pH, contact time, type of adsorbent and adsorbent dose.

Batch adsorption experiments were carried out by adding an amount of adsorbent varied between (20-40) g in case of sawdust and between (0.5-1.2) g in case of activated carbon with 40 ml of wastewater of different phenol initial concentration and pH as mentioned in Table 1 in 250 ml stopper conical flasks. These flasks were placed on a rotating shaker with constant shaking at 150 rpm to maintain the equilibrium condition. For the kinetics study, samples were withdrawn at regular intervals and filtered. The phenol concentration was then measured using UV spectrophotometer equipment (Shimadzu UV/Vis 1601 Spectrophotometer, Japan). The percentage of phenol removal is derived from Eq. (1).

$$\%\, removal\ of\ phenol = \frac{Co-Ct}{Co} * 100 \quad (1)$$

where C_o and C_t are phenol concentrations initially and at any given time respectively.

3.RESULTS AND DISCUSSION

Effect of initial concentration of phenol

In experimental work, the initial concentration of phenol was studied at different doses of activated carbon and sawdust. Phenol removal efficiency was tested at various concentrations of phenol in wastewater 200, 240 and 290 mg/l at 120 minutes contact time. Figure 2 shows that the phenol removal efficiency increases as the adsorption dose of activated carbon increases, but efficiency decreased at the initial concentration of 200 mg/l due to the shift from acid (pH value 3.9) to base (pH value 7.6).

Figure 3 shows that phenol removal efficiency using sawdust decreases with the increase in the initial concentration of phenol. This decrease of efficiency at high concentrations is due to the accumulation of phenol particles on adsorption surface [16].

Figure 4 shows the effect of initial concentration of phenol on removal efficiency of phenol at different contact times for adsorbent dose 1.2 g activated carbon and Fig. 5 for adsorbent dose 40 g of sawdust. The results indicate that phenol removal efficiency decreases with increasing of initial concentration of phenol.

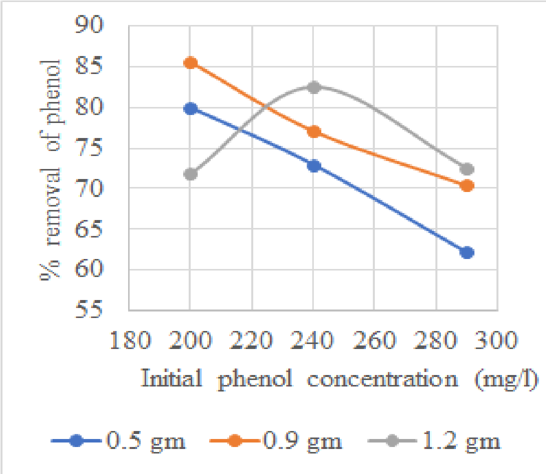

Fig 2. Effect of initial phenol concentration on phenol removal efficiency at different doses of activated carbon

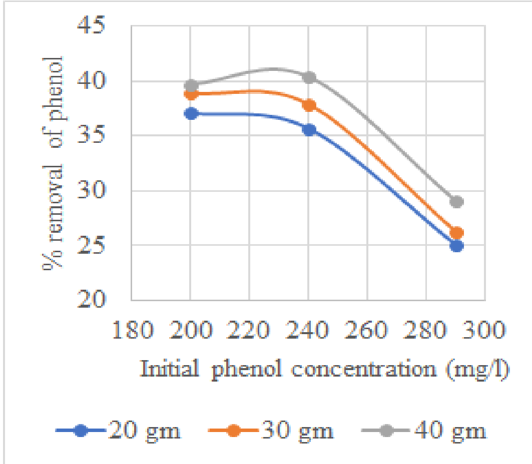

Fig 3. Effect of initial phenol concentration on phenol removal efficiency at different doses of sawdust

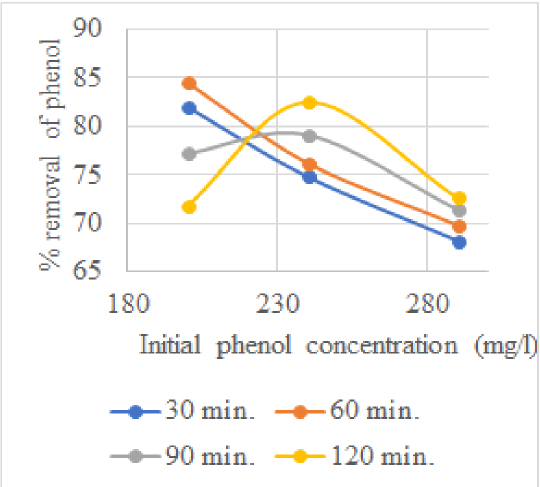

Fig 4. Effect of initial phenol concentration on phenol removal efficiency at different contact times for activated carbon

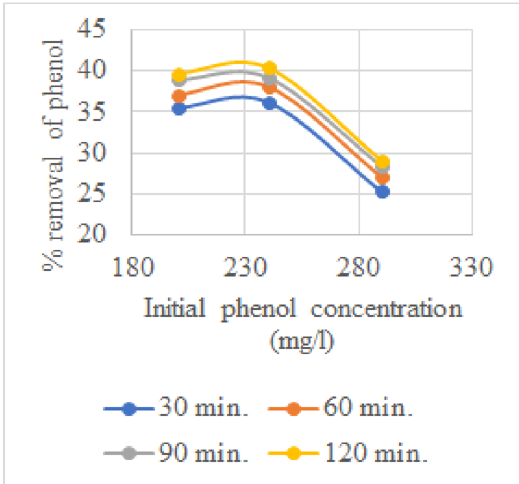

Fig 5. Effect of initial phenol concentration on phenol removal efficiency at different contact times for sawdust

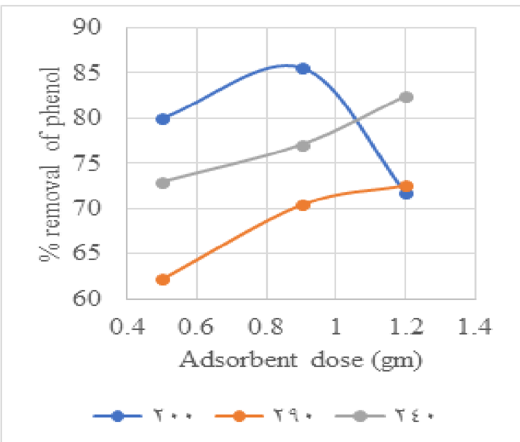

Fig 6. Effect of adsorbent dose of activated carbon on phenol removal efficiency at different initial phenol concentration

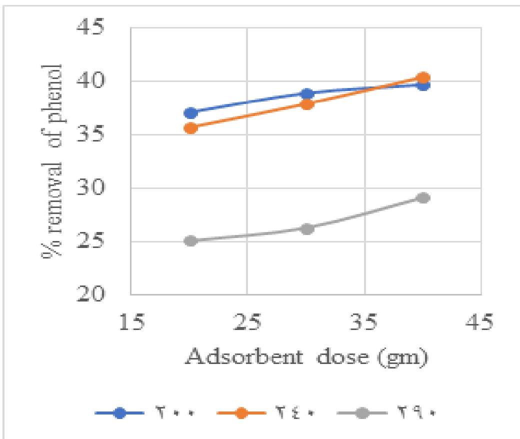

Fig 7. Effect of adsorbent dose of sawdust on phenol removal efficiency at different initial phenol concentration

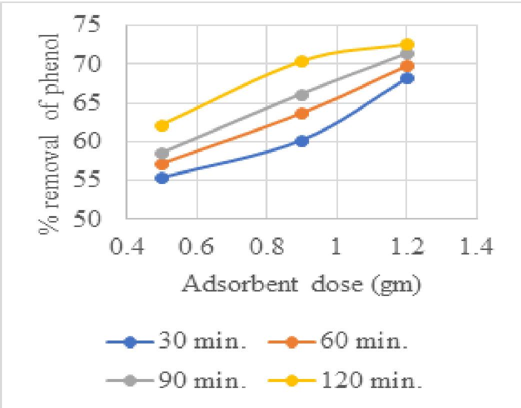

Fig 8. Effect of adsorbent dose of activated carbon on phenol removal efficiency at different contact times

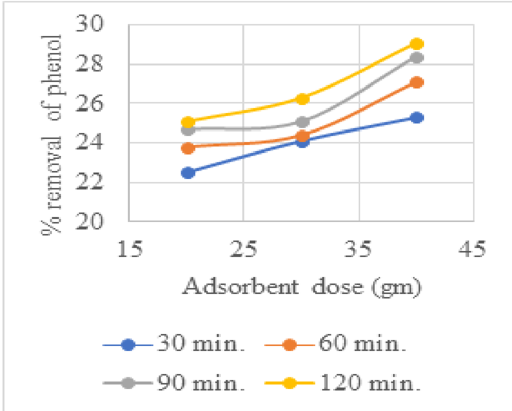

Fig 9. Effect of adsorbent dose of sawdust on phenol removal efficiency at different contact times

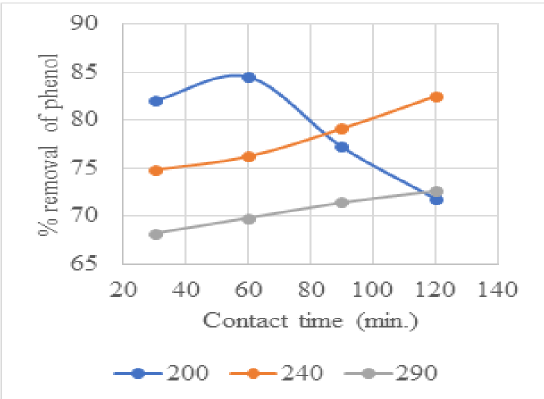

Fig 10. Effect of contact time with activated carbon on phenol removal efficiency at different initial phenol concentration

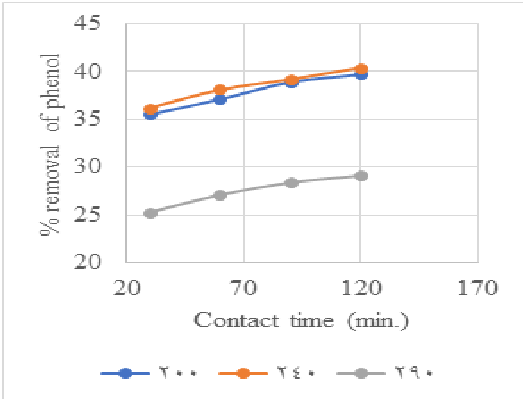

Fig 11. Effect of contact time with sawdust on phenol removal efficiency at different initial phenol concentration

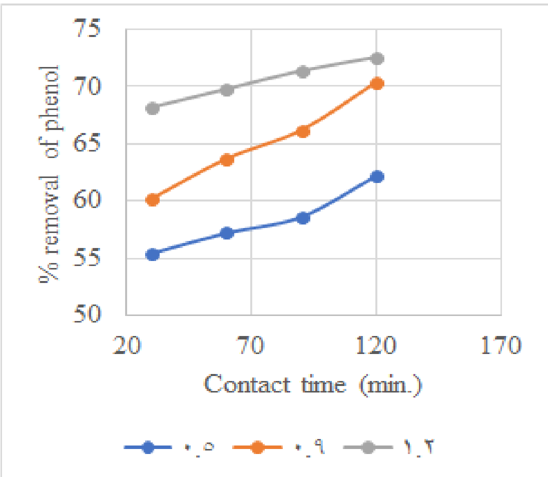

Fig 12. Effect of contact time on phenol removal efficiency at different adsorbent dose of activated carbon

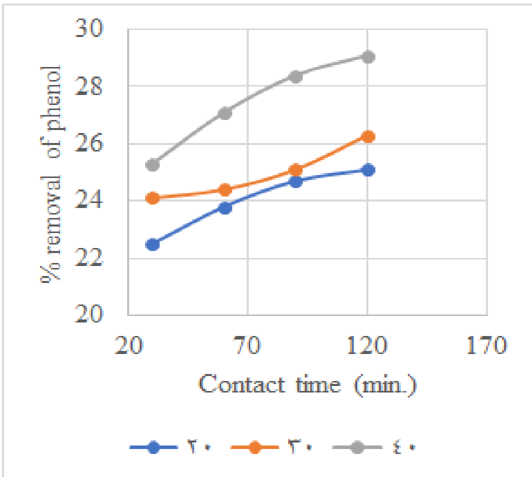

Fig 13. Effect of contact time on phenol removal efficiency at different adsorbent dose of sawdust

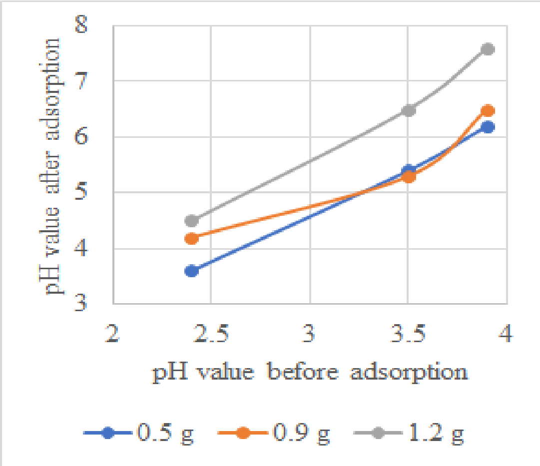

Fig 14. Values of pH after adsorption at different adsorbent dose of activated carbon

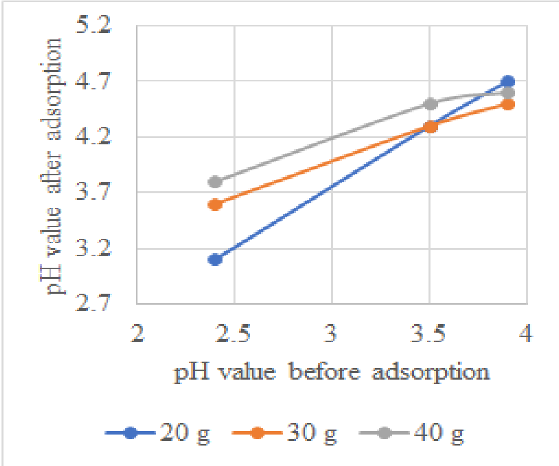

Fig 15. Values of pH after adsorption at different adsorbent dose of sawdust

Effect of adsorbent dose

Experiments were conducted at different adsorbent doses of activated carbon (0.5, 0.9 and 1.2) g as shown in Fig. 6 and doses (20, 30 and 40) g of sawdust in Fig. 7 to study the effect of adsorbent dose on phenol removal efficiency at different initial concentrations of phenol in wastewater (200, 240 and 290) mg/l at 120 minutes contact time. The results indicated an increase in phenol removal efficiency with an increase in adsorbent dose due to an increase in surface area of adsorbent. The results of removal efficiency through activated carbon are almost double the values resulting from the use of sawdust as adsorbent.

Figures 8 and 9 show the same results as above but with different contact times and with the initial concentration of phenol 290 mg/L where the results show increased phenol removal efficiency with increasing of adsorbent dose and increasing of contact time.

Effect of contact time

The results illustrated the effect of contact time on the removal of phenol. Figure 10 shows an increase in phenol removal efficiency while increasing contact time when using an adsorbent dose of 1.2 g of activated carbon with varying initial concentrations of phenol. The same effect is shown when using an adsorbent dose of 40 g of sawdust instead of activated carbon as evident in Fig. 11.

Both Fig. 12 and Fig. 13 show the same effect with the use of different doses of activated carbon and sawdust at the initial concentration of phenol 290 mg/l. The increase in phenol removal efficiency with increasing of contact time is due to the presence of many empty places in the adsorbent material that increase the removal efficiency[17].

Effect of pH value

Both Fig. 14 and Fig. 15 show pH values of water after adsorption in cases of adsorption by activated carbon and sawdust, respectively, with the pH of water varying before adsorption and the dose of the adsorbent.

The results show that the pH of water has shifted from acid to base in the case of activated carbon at 1.2 g and a value of pH 3.9. The effect of the pH change on the efficiency of phenol removal from wastewater is shown as the higher the pH value the more efficient the removal until the shift to the base occurs and a lack of removal efficiency begins as previously indicated. This is due to the competition between phenol ions and OH^- ions.

4.CONCLUSION

The efficiency of both activated carbon from coconut and sawdust was studied on the removal of phenol from industrial wastewater and the various factors affecting the removal efficiency such as initial phenol concentration in wastewater, the dose used from each adsorbent, contact time and the effect of pH of wastewater. The results showed that the removal efficiency decreases with the increase in the initial concentration of phenol and increases with the increase of the adsorbent dose as well as the contact time until the equilibrium time of 120 minutes. The removal efficiency decreases with increasing of pH value than 7 and the shift to a base. The results also show the high efficiency of activated carbon compared to sawdust in the removal of phenol from industrial wastewater.

REFERENCES

[1]. Jalili Naghan, D., et al., Parameters effecting on photocatalytic degradation of the phenol from aqueous solutions in the presence of ZnO nanocatalyst under irradiation of UV-C light. Bulgarian Chemical Communications, Volume 47, Special Edition D (pp. 14–18) 2015, 2015.

[2]. Girish, C. and V. Ramachandra Murty, Adsorption of phenol from aqueous solution using Lantana camara, forest waste: kinetics, isotherm, and thermodynamic studies. International scholarly research notices, 2014. 2014.

[3]. Ahmadi, E., et al., The performance of mesoporous magnetite zeolite nanocomposite in removing dimethyl phthalate from aquatic environments. Desalination and Water Treatment, 2016. 57(57): p. 27768-27782.

[4]. Sarker, N. and A. Fakhruddin, Removal of phenol from aqueous solution using rice straw as adsorbent. Applied Water Science, 2017. 7(3): p. 1459-1465.

[5]. El-Naas, M.H., S. Al-Zuhair, and M.A. Alhaija, Removal of phenol from petroleum refinery wastewater through adsorption on date-pit activated carbon. Chemical engineering journal, 2010. 162(3): p. 997-1005.

[6]. Lakshmi, S., et al., Studies on different methods for removal of phenol in waste water-Review. International Journal of Science, Engineering and Technology Research, 2016. 5(7): p. 2488-2496.

[7]. Almasi, A., et al., Effect of molasses addition as biodegradable material on phenol removal under anaerobic conditions. Environmental Engineering & Management Journal (EEMJ), 2018. 17(6).

[8]. Shokoohi, R., et al., Investigation of the efficiency of heterogeneous Fenton-like process using modified magnetic nanoparticles with sodium alginate in removing Bisphenol A from aquatic environments: kinetic studies. Desalination and Water Treatment, 2018. 101: p. 185-192.

[9]. Hao, O.J., H. Kim, and P.-C. Chiang, Decolorization of wastewater. Critical reviews in environmental science and technology, 2000. 30(4): p. 449-505.

[10]. Shokoohi, R., et al., Study of the efficiency of bio-filter and activated sludge (BF/AS) combined process in phenol removal from aqueous solution: determination of removing model according to response surface methodology (RSM). Desalination and water treatment, 2017. 77: p. 256-263.

[11]. Shokoohi, R., et al., Survey on efficiency of BF/AS integrated biological system in phenol removal of wastewater. Desalination and Water Treatment, 2017. 82: p. 315-321.

[12]. 1Darwish, N.A., K.A. Halhouli, and N.M. Al-Dhoon, Adsorption of phenol from aqueous systems onto spent oil shale. Separation science and technology, 1996. 31(5): p. 705-714.

[13]. Roostaei, N. and F.H. Tezel, Removal of phenol from aqueous solutions by adsorption. Journal of Environmental Management, 2004. 70(2): p. 157-164.

[14]. Banat, F., et al., Adsorption of phenol by bentonite. Environmental pollution, 2000. 107(3): p. 391-398.

[15]. Mandal, A., P. Mukhopadhyay, and S. Das, Removal of phenol from aqueous solution using activated carbon from coconut coir. IOSR J Eng, 2018. 8(12): p. 41-55.

[16]. Ekpete, O., M. Horsfall, and T. Tarawou, Potential of fluted pumpkin and commercial activated carbons for phenol removal in aqueous systems. ARPN J Eng Appl Sci, 2010. 5(9): p. 1-9.

[17]. Uddin, M., M. Islam, and M. Abedin, Adsorption of phenol from aqueous solution by water hyacinth ash. ARPN Journal of engineering and applied sciences, 2007. 2(2): p. 11-17.