# Removal of Toxic Phenol from Aqueous System by Rice Strew

Shreen, S. Ahmed[1], Howida, M. Bahgat[1,] Ashraf, H. Fahmy[2], Ibrahim, El-Tantawy El-Sayed[3]

[1] Soils, Water and Environment Research Institute, ARC, Giza, Egypt
[2]Plant Genetic Transformation Department Agricultural Genetic Engineering Research Institute
[3]Department of Chemistry, Faculty of Science, El-Menoufia University, Shebin El-Koom, Egypt
howida.magdy55@yahoo.com

**Abstract:** Phenolic compounds are common contaminants in wastewater and suspected as toxic and carcinogenic. The potential of employing rice strew for phenol adsorption from aqueous solution was studied. The adsorption of phenol in aqueous solution on rice strew was examined by optimizing various physicochemical parameters such as; pH, contact time, and the amount of adsorbent and ambient temperature. Data observed that, with an initial concentration of 100 mg/L phenol and pH 3.0, the maximum removal was found to be about 94.15% with 5.0 gm rice strew. The removal of phenol decreases with increasing the solution pH value. The Langmuir model was used for the mathematical description of adsorption equilibrium and it was found that the experimental data fitted very well to the Langmuir model. The studies showed that the rice strew can be used as an efficient adsorbent material for removal of phenols from water and wastewater.

[Shreen, S. Ahmed, Howida, M. Bahgat, Ashraf, H. Fahmy, Ibrahim, El-Tantawy El-Sayed. **Removal of Toxic Phenol from Aqueous System by Rice Strew.** *J Am Sci* 2016;12(8):21-28]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 4. doi:10.7537/marsjas120816.04.

**Keywords**: toxics; phenol; removal; wastewater treatment; rice strew.

## 1. Introduction

Over the past several decades there is growing concern about wide spread contamination of surface and ground water by various organic compounds which are emitted due to the rapid development of chemical and petrol chemical industries. Many industrial wastes include organics which are difficult, or impossible to remove by conventional biological treatment processes (Mahvi *et al*., 2004). Phenolic compounds which are common contaminants in wastewater and suspected as toxic and carcinogenic, are generated from petroleum and petrochemical, coal conversion and phenol-producing industries (Mustafa *et al*., 2008). Phenols being harmful to organisms at low concentrations are considered as priority pollutants by USEPA (Banat, et al., 2000) and European Union (Rodriguez *et al*., 2000) and many of them have been classified as hazardous pollutants because of their potential harm to human health. Stringent US Environmental Protection Agency (EPA) regulation call for lowering phenol content in the wastewater less than 1mg/L (Banat, et al., 2000). Whereas, the European Union (EU) lays down a maximum concentration of 0.5 μg $L^{-1}$ for total phenols in drinking water (Rodriguez *et al*., 2000). Apart from their toxicity and carcinogenity, phenols being extremely soluble in water can cause bad taste and odor, even at low concentration (Mostafa *et al*., 1989). The odor threshold for phenol is 0.04 ppm (U.S.EPA). In the presence of chlorine in drinking water, phenols form chlorophenol, which has a medicinal taste, which is quite pronounced and objectionable (Rengaraj *et al*., 2002). For these reasons it is essential to remove phenols from wastewater before it is discharged. Various treatment technologies such as adsorption, photo-degradation, flocculation, chemical oxidation, biological process, *etc*. are available for the removal of phenol from the wastewater. Biological process is particularly suited to wastewater containing small amount of phenol. Oxidation is used when phenol concentration in wastewater is very high. In coagulation and flocculation process, large amount of sludge is generated which may cause disposal problems. Among various physicochemical processes, adsorption is a well-established and powerful technique for treating domestic and industrial effluents used for the removal of phenol from wastewater. There is abundant literature available on removal of phenolic compounds by adsorption onto activated carbon (Mustafa *et al*., 2008). Activated carbons remove many of the impurities occurring in water and wastewater (Reynolds and Richards, 1996). In spite of these characteristics, due to the relatively high cost of activated carbons and variable performance of carbon regeneration, there have been attempts to utilize economic, practical, efficient and naturally occurring adsorbents like bottom ash, brick-kilm ash, fly ash, peat, soil, wood, bagasse, carbonized bark, straw, auto mobile tires, fertilizer waste and saw dust (Mustafa *et al*., 2008). However, the adsorption behavior of phenol on wheat husk has not been extensively studied. Since, the main component of wheat husk is carbon, it has the potential to be used as an adsorbent (Bledzki et al., 2010). In Egypt, Rice strew residuals per year is around 3.5 million tons, of which about 1.5 million tons is used in production of organic fertilizers, to be used with storage of some crops (onions - potatoes), plantation of non-traditional crops (mushrooms) and to feed farm animals instead of hay (Akmal, 2005). A wasted amount 2: 2.5 tons per year of rice strew are disposed of burning which has a big share in the formation of the black cloud specially in southern delta governorates and almost whole Greater Cairo specially in winter when humidity settles the suspended smog (Mansour *et al*., 2007) which causes a serious health problem. The utilization of this source of biomass would solve both a disposal problem and also access to cheaper material for adsorption in water pollutants control system. The present study is intended to use this locally available agricultural waste as a conventional cheap material for phenol adsorption.

## 2. Materials and Methods

### Sorbent and phenol properties

In this study the raw rice strew was selected as a natural organic sorbent. Raw rice strew was obtained from a roadside Nubareia Research Station (El-Behira Governorate). The test solutions were prepared by diluting stock solution of phenol to the desired concentrations.

### Rice strew preparation

The rice strew was carefully collected without any contamination. After collection, materials were treated to make them ready for use. The material were dried initially in an oven at about 70 °C and then ground to fine mesh and the particles size of 177.62 µm were separated by sieving through standard test sieves. Then these were boiled in distilled water continuously for 30 minutes. The suspension was then left to settle to allow the supernatant to be poured off. This process was repeated several times until the colored water-soluble components were removed completely. Finally the washed adsorbent was dried in an oven at 80 °C, allowed to cool and sieved into 177. 62 µm for subsequent use.

### Removal of phenol from aqueous solution by adsorption Studies

Batch adsorption: The batch experiments were conducted using three different weights (1.0, 3.0, and 5.0 g) of rice strew in 250 mL capacity stopper bottles with 100 mL of phenol solution. The test solutions were prepared by diluting stock solution of phenol to the desired concentrations. The stock solution was obtained by dissolving 1.0g of phenol, (obtained from Merck), in cooled distilled water and dilute to 1000 ml. The adsorbate concentration (phenols) was in the range of 100 ppm. The whole study was carried out at different pH as 3, 6, and 8. The effect of pH was studied by adjusting the pH of the solutions using 1 N HCl or 1 N NaOH solution. pH was measured using a pH meter. The bottles were then shaken at uniform speed at three different temperature degrees (25, 35, 45 °C) using an electric shaker for time intervals (1, 3, and 5 hours). However, experiments at different temperatures were carried out in beakers in a thermostatically controlled water bath using electrical stirrer. The amount of phenol adsorbed was determined from the difference between the amount of phenol initially added and that left after adsorption. The remaining concentrations of phenol in the supernatant were analyzed spectrophotometrically against respective reagent blank.

The percentage of phenol adsorption by the adsorbents was computed using the equation:

$$\text{Adsorption } \% = (C_0 - C_e / C_0) * 100$$

Where, C0 and Ce are the initial and equilibrium concentration of phenols (mg $l^{-1}$) in the solution.

Adsorption capacity was calculated by using the mass balance equation for the adsorbent:

$$q = (C0 - Ce)\ V) / W$$

Where, q is the adsorption capacity (mg $g^{-1}$), V is the volume of phenols solution (L) and W is the weight of the adsorbent (g).

### Determination of total phenols

Total phenolics were determined by the method of Singleton and Rossi (1965) 0.1 ml of ethanolic extract was mixed with 0.25 ml Folin reagent, 1.25 ml 20% sodium carbonate, and 0.4 ml deionized water. After standing for 40 min. at room temperature, the absorbance was measured at 725 nm. Total phenolics content was calculated as a catechin equivalent from the calibration curve of catechin standard solutions. All the assays were done in duplicate, from two separate extractions.

## 3. Results and discussion

### FTIR Spectra

The FTIR spectrum (Figure 1) of raw rice strew shows strong bands at 3352 $cm^{-1}$ due to -OH stretching presented in cellulose. The band at 2904 $cm^{-1}$ corresponds to C-H asymmetric stretching of -$CH_2$ - groups. The band at 1645 $cm^{-1}$ is attributed to H - O- H bending and the bands at 2372 $cm^{-1}$ are attributed to -OH stretching (Nakanishi and Solomon, 1977).

### Effect of Initial pH:

The removal of phenol from the wastewater is highly dependent on pH of the solution. Adsorbed amount decreased with increasing pH value. In any adsorbate-adsorbent system, pH of the system affects the nature of surface charge of the adsorbent, effects ionization, the extent of rate of adsorption and speciation of the adsorbate species. The adsorption of phenol on rice strew has been studied at different pH values (3, 6, and 8 pH). Measurement of initial and final phenol concentration gave the percent adsorption of phenol. The results are showed in Figures 2, 3 and 4. Adsorbed amount decreased with increasing pH value Jagwani and Pranita (2014), which can be attributed to the phenol ionization to form phenolate ions and at the same time the presence of hydroxyl ions on the adsorbent prevents the adsorption of phenoate ions (Halouli and Drawish,, 1995). Similar data has been reported through the adsorption of phenol onto tendu leaf refuse and modified carbon prepared from tendu leaf refuse by Nagda *et al.*, (2007). Also the removal of phenol by jute sticks in aqueous system. He found that the uptake with 40 ppm phenol was small at low pH ranges and gradually increased up to pH 10.0, where maximum removal 68% occured Mustafa *et al.* (2008).

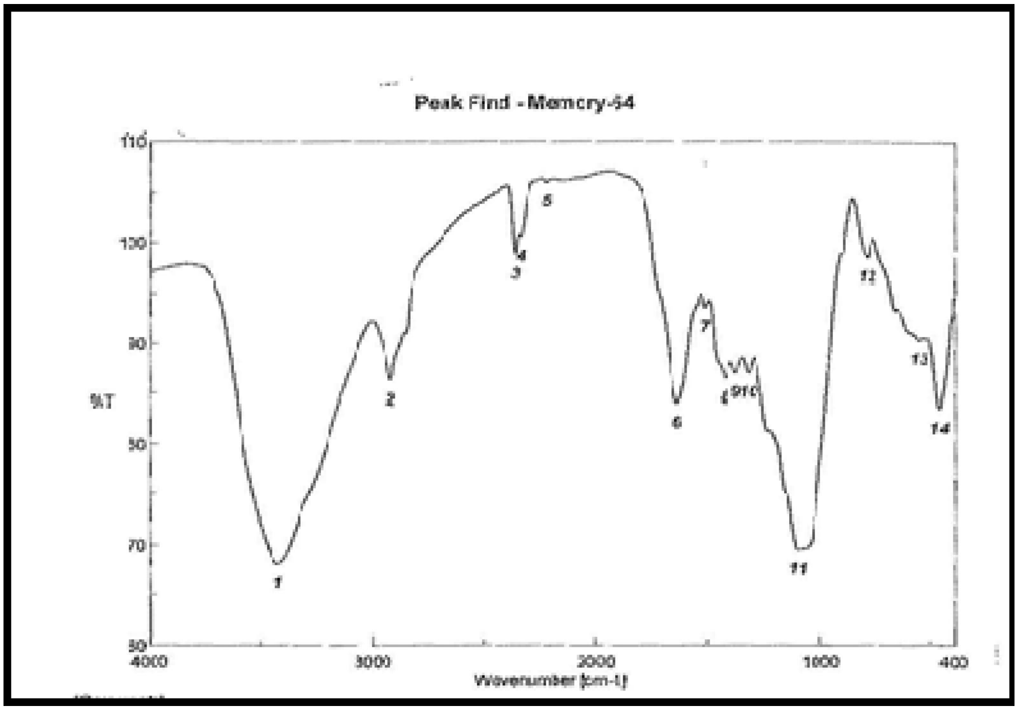


**Fig.1. FTIR spectrum of raw rice strew**

**Effect of contact time**

The effect of contact time on the removal of phenol by rice strew was observed in Figure 5. Removal ratio increases with the increase in time.The maximum percentage of phenol removal took place within 5 hours. The results also indicate that the sorption process can be considered very fast because of the largest amount of phenol attached to the sorbent within the first 5 hr of adsorption these data was agree by Mahvi *et al*., (2004), Mustafa *et al*., (2008) and Kermani *et al*., (2006).

**Effect of Rice strew Dose**

The effect of amount of rice strew on the efficiency of phenol removal was shown in Figure 6. Rice strew dosage was varied from 1g to 5g. The results show that, a minimum dosage of 1 gm of rice strew is required for 77.81% removal of phenol. But, Removal efficiency of phenol reached 88.81% by 3 gm rice strew. The maximum removal of phenol was observed by using 5.0 gm rice strew, removal % reached 94.15%. The data clearly shows that the rice strew is more effective adsorbent at higher dosage of rice strew than at lower dosage of rice strew. The increased in the amount of adsorbent, thus increasing the surface area of adsorbent material, hence increased the number of active sites in the adsorbent material surface i.e. increased the availability of binding sites for adsorption and consequently increase phenol removal capacity on rice strew. This lead to increase in the ability of adsorbent media to adsorb greater amount of phenol from water at different pH and temperature concentrations and ultimately the percent removal of phenol increased (Mohammed *et al*., 2013). Also, Increase in phenol removal efficiency with an increase in adsorbent dosage was also observed by Sarker, N. and Fakhruddin. (2015).

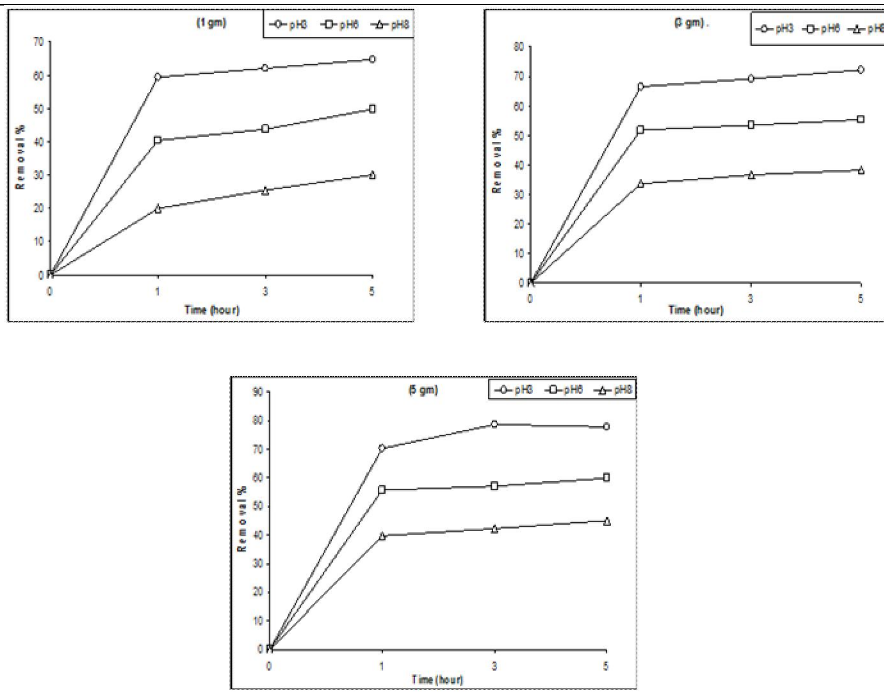


**Fig. 2. Effect of pH on phenol removal by rice strew with different weight at 25 °C.**

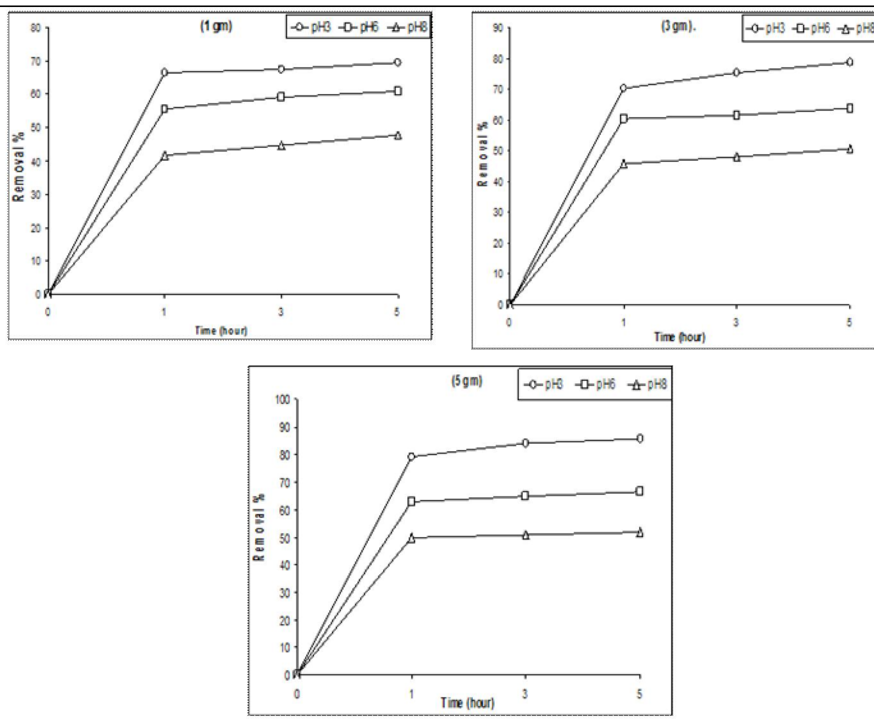


**Fig. 3. Effect of pH on phenol removal by rice strew with different weight at 35 °C.**

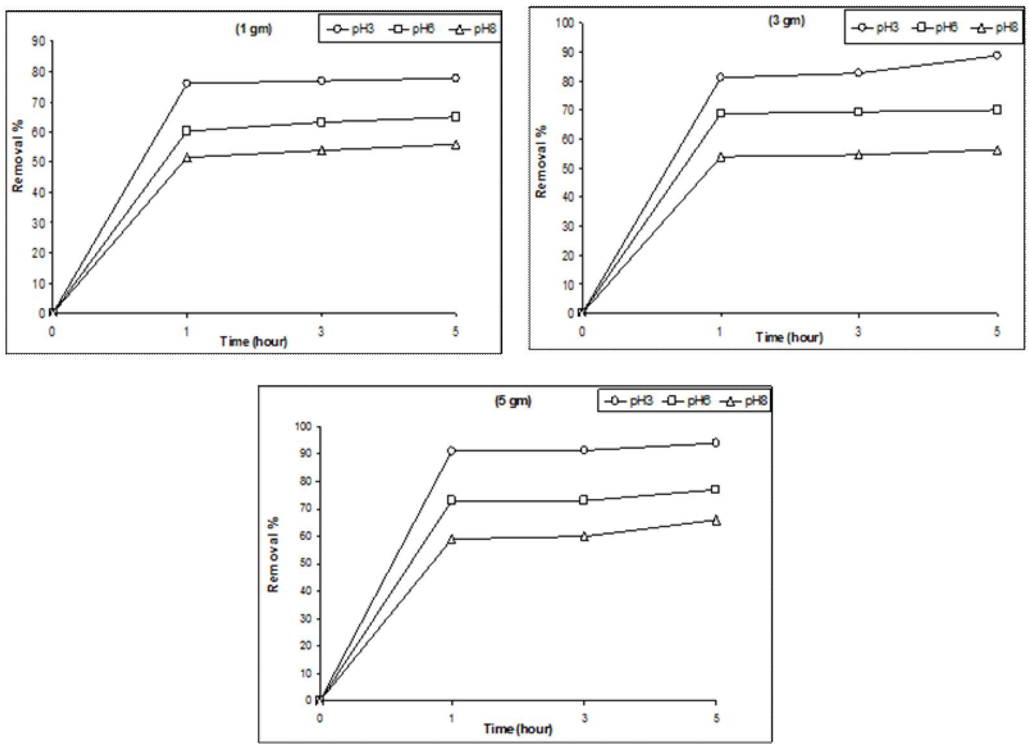


**Fig. 4. Effect of pH on phenol removal by rice strew with different weight at 45 °C.**

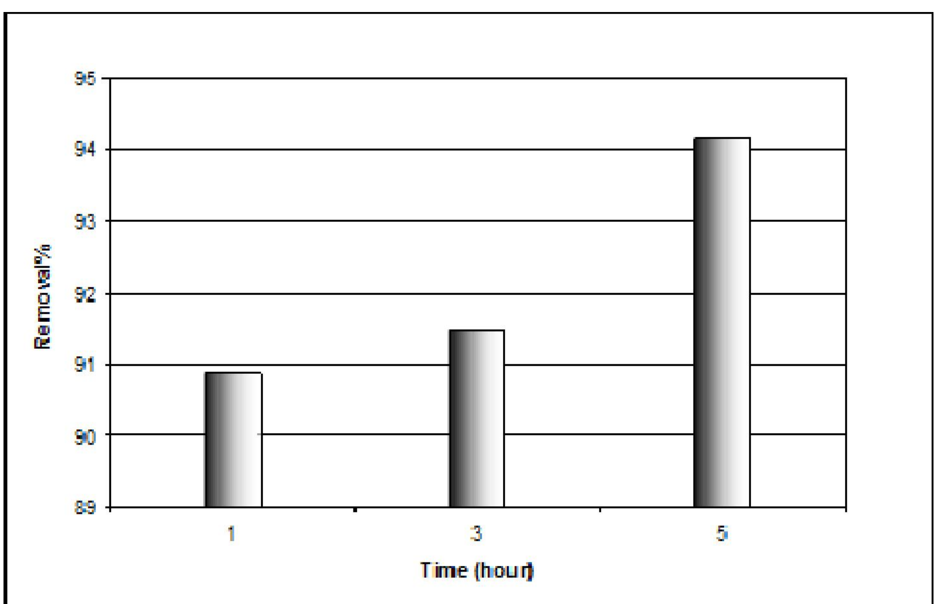


**Fig . 5. The effect of contact time on the removal of phenol by rice strew**

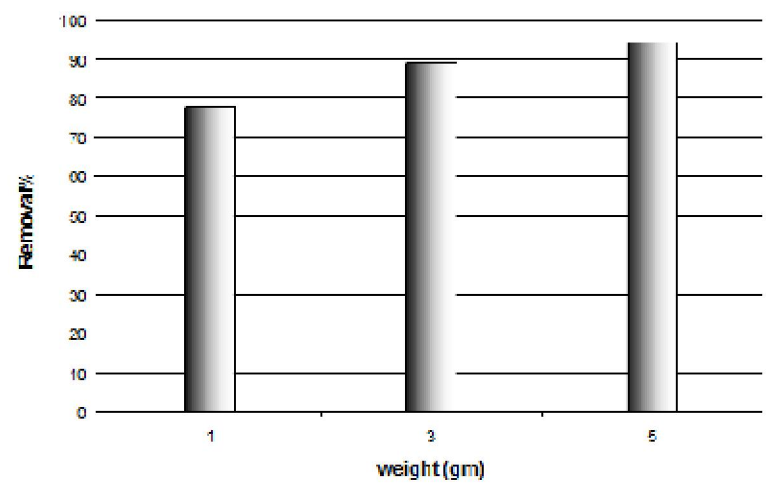


Fig. 6. The effect of rice strew dose on the removal of phenol by rice strew

**Effect of Temp**
Temperatu
separation proc
was studied at t
45 $^{0}$C (fig. 7.)
temperature ha
maximum remo
The effect of
increases the m

a swelling effect
adsorbent media
further. It was
pacity increased
om 25 to 45°C.
t that at higher
es occurs due to
).

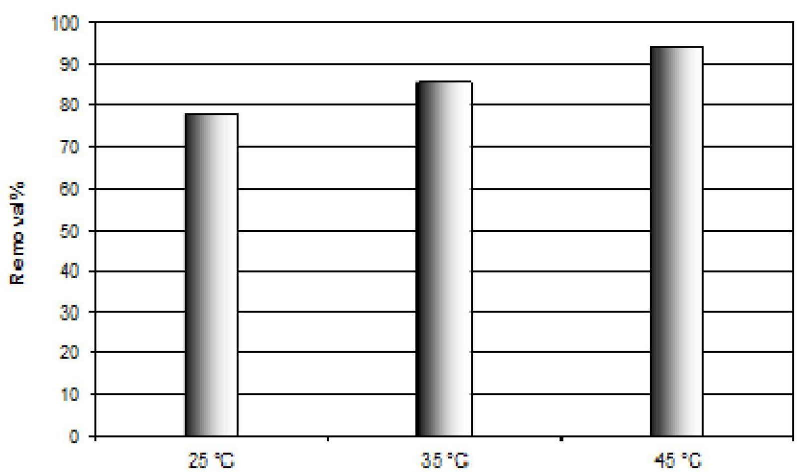


Fig. 7. The effect of temperature on the removal of phenol by rice strew

**Langmuir adsorption of phenol from aqueous solutions by rice strew**

The study of adsorption was carried out using model of Langmuir using standard procedures used various authors (Rengaraj et al., 2002; Aksu and Yener, 2001; Mahvi et al., 2004) which provide the basis for the design of adsorption systems. The most widely used equation for modeling of the adsorption data is the Langmuir model. Figure 8 show the Langmuir curves for phenol adsorption onto rice strew, at various condition (pH, adsorbent dose, Time and temperature). It was observed that the equilibrium data were very well represented by the Langmuir equation. The adsorption data fitted Langmuir equation with correlation coefficients value of 1.0 (the highest value) and 0.9797 (the lowest value). The maximum adsorption capacity of rice strew was found at acidic condition (pH 3), longest Time (5 hours), and high temperature (45 °C).

**Conclusion**

The present study shows that the rice strew is an effective adsorbent for the removal of phenol from aqueous solutions. Rice strew can be used as an adsorbent for phenol removal at a lower pH. Under batch conditions equilibrium was attained in 5 h. The data clearly exhibits that the rice strew is more effective adsorbent of phenol at lower pH than at higher pH.

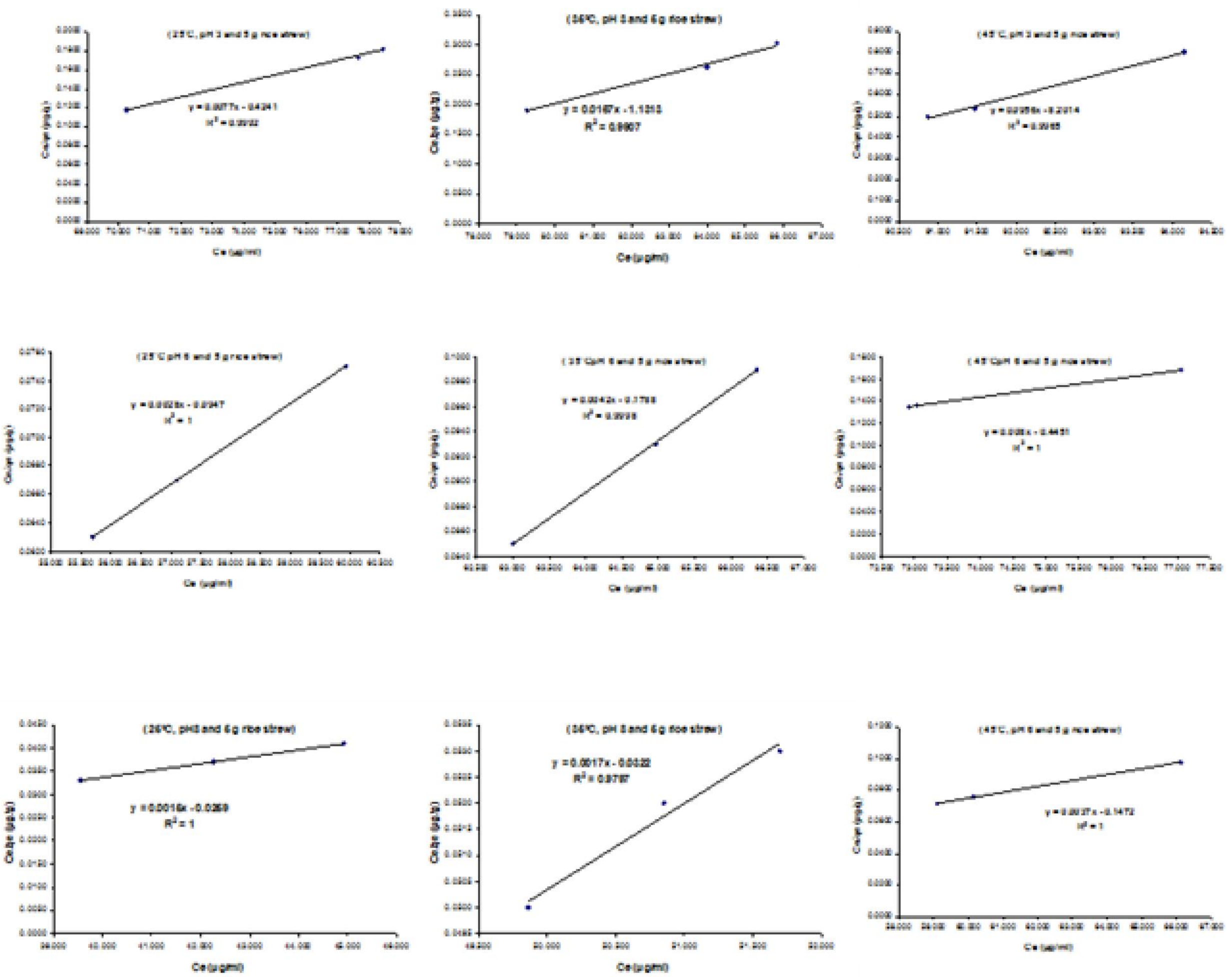

Fig. 8. Langmuir adsorption of phenol from aqueous solutions by rice strew at different times (1, 3, and 3 hr)

**Reference**


1. Akmal, T. (2005). Recycling Rice-Straw for the manufacture of construction brick, in Arabic.
2. Aksu Z. and Yener, J. (2001). A comparative adsorption/biosorption study of monochlorinated phenols onto various sorbent. Waste Manage. 21:695-702.
3. Banat, F. A.; Al-Bashir, B.; Al-Asheh, S. and Hayajneh, O. (2000). Adsorption of phenol by bentonite. Environ. Pollut, 107: 391-398.
4. Bledzki, A. K.; Mamuna, A. A. and Volk, J. (2010). Physical, chemical and surface properties of wheat husk, rye husk and soft wood and their polypropylene composites. Composites Part A, 41: 480–488.

5. Halouli, K. A. and Drawish, N. M. (1995). Effects of pH and inorganic salts on the adsorption of phenol from aqueous systems on activated decolourising charcoal. Sep. Sci. Technol., 30: 3313-24.
6. Jagwani, D. and Pranita, J. (2014). DEPORTATION OF TOXIC PHENOL FROM AQUEOUS SYSTEM BY WHEAT HUSK, International Journal of Plant, Animal and Environmental Sciences, 4(2):58-64.
7. Kermani, M.; Pourmoghaddas, H.; Bina, B. and Khazaei, Z. (2006). Removal of phenol from aqueous solutions by rice husk ash and activated carbon, *Pakistan Journal of biological sciences*, 9 (10): 1905-1010
8. Mahvi, A. H.; Maleki, A. and Eslami, A. (2004). Potential of Rice Husk and Rice Husk Ash for Phenol Removal in Aqueous Systems, American Journal of Applied Sciences, 1 (4): 321-326.
9. Mansour, A.; J. Srebric and B.J. Burley. (2007). Development of Straw-cement Composite Sustainable Building Material for Low-cost Housing in Egypt. Journal of Applied Sciences Research, 3(11): 1571-1580.
10. Mohammed, N. A.; Aseel, A. H. and Firas, S. A. (2013). PHENOL REMOVAL FROM WASTEWATER USING RICE HUSK, Diyala journal of pure science. 9 (4): 51-60.
11. Mostafa, M. R.; Sarma, S. E. and Yousef, A. M. (1989). Removal of organic pollutants from aqueous solution: part1, adsorption of phenol by activated carbon, Indian J. Chem., 28A: 94-98.
12. Mustafa, A. I.; Alam, Md. S.; Amin, Md. N.; Bahadur, N. Md. and Habib, Md. A. (2008). Phenol Removal from Aqueous System by Jute Stick, Pak. J. Anal. Environ. Chem., 9(2): 92-95.
13. Nagda, G. K.; Diwan, A. M. and Ghole, V. S. (2007). Potential of tendu leaf refuse for phenol removal in aqueous systems. Applied ecology and environmental research, 5(2): 1-9.
14. Nakanishi, K. and Solomon, P.H. (1977). Infrared Absorption Spectroscopy, 2nd ed ed.; Holden-Day Inc.: Oakland, CA, USA.
15. Rengaraj, S.; Seuny-Hyeon, M. and Sivabalan, R. (2002). Agricultural solid waste for the removal of organics: adsorption of phenol from water and wastewater by Palm seed coat activated carbon. Waste Management, 22: 543-548.
16. Reynolds, T. D. and Richards, P. A. (1996). Unit operations and processes in environmental engineering. 2nd ed. PWS Publishing Company: Boston, MA.
17. Rodriguez, I.; Llompart, M. P. and Cela, R. (2000). Solid phase extraction of phenols. J. Chromatogr. A, 885: 291-304
18. Sarker, N. and Fakhruddin, A. N. M. (2015). Removal of phenol from aqueous solution using rice straw as adsorbent. Appl Water Sci, 28: 1-7.
19. Singleton, V. L. and Rossi, J. A. (1965). Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents. American Journal of Enology and Viticulture, 16: 144-158.


6/29/2016