A.V.V.S.Swamy, K. Syamala Devi / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 4, July-August 2012, pp.262-265

Biosorption Of Phenols

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ABSTRACT

Phenols are an important group of organic pollutants present in many industrial effluents such as petro-chemicals, textiles, tanneries; gasification units etc. The phenols should not exceed 0.01µg/l, 1mg/l in drinking & in industrial waters, respectively. But in most of the cities the situation is alarming where the phenol concentrations are more often crossed 8–10 ppm. For removal of the excessive phenols, adsorption became the most favored process because of its feasibility. An alternative to the conventional activated carbon for the reduction of phenols that would reduce the costs considerably has been attempted in the present study to remove the phenols. Biosorption was attempted using locally available and comparatively cheaper activated carbons viz., Rice Husk Carbon (RHC), Casuarina Wood Carbon (CWC) and Saw Dust Carbon (SDC). The removal of phenols showed an increase in all the three activated carbons with the increase of concentrations. It was observed that the SDC showed better performance compared to the RHC and CWC at lower concentrations of the phenols. The percentage removal of the phenols proved to be very good at higher concentration. On the whole the selected activated carbons have shown the efficiency of removal of phenols in the order: RHX<CWC<SDC.

***KEY WORDS** - Activated Carbon, Biosorption, Phenols, RHC, SDC.*

1. INTRODUCTION:

Phenols in water produce objectionable odours and bad taste even at lower concentrations particularly when phenol laden water is chlorinated. Phenols are harmful to human health and cause pain, renal irritation, severe shock and possibly death at higher concentrations. Phenols are used as raw material in the manufacture of many organic compounds. As the number of derivatives of phenols is increasing, their entry into the natural systems is also on the increase. The sewage waters in the metropolitan cities are showing phenol concentrations as high as 8 – 10 mg /l, giving us a caution that there is a need to improve the sewage treatment technology to remove the phenols. Locally available and economically feasible materials are to be developed in order to reduce the phenol concentrations in sewage. Hence it is felt that the removal of phenolic compounds using physical process i.e. the adsorption on the material of biological origin, is the most feasible and economic method when the quantities of the phenols are not economically feasible for recovery.

Now a days usage of phenols have crept into all facets of life. The concentrations of phenols are increasing in the industrial effluents and the situation has reached an alarming state in the sewage (Sharma, 1994). Lower phenolic concentrations cause disagreeable odour particularly when water containing phenols are chlorinated. Several authors have reported the omni presence of phenolics. Pande et al (2002) have reported the PCBs from the samples of a landfill site; while the occurrence of poly chlorinated Terphenyls in indoor air particulate matter was reported by Woodarz et al (1996).

(Deborah,1995) observed the neuro toxic effects of PCBs, CH_3 – Hg – Pb, CH_3– Hg which causes developmental disorders in both adult and developing organisms due to contamination of cooking oil. Both PCBs and PCDFs are present in cooking oils. Tryphons (1995) observed a high incidence of bacterial infections in the breast fed infants born to mothers who consumed large amounts of Great Lake Fish. The effects of the bis -phenols in the body weight, plasma LH Levels was studied by King et al (2001), and suggested a careful evaluation to the different levels of exposure to this compound.

The adsorption capacity of p – Chloro phenols from aqueous solutions was reported to be excellent. Krishnaiah (2002) studied the removal of phenol and its compounds through adsorption on amberlite XAD – 16 Resin. The activated carbon made from bituminous coal was used by Thakur et al (2002) for phenol removal. Singh and Singh (1999) have studied the phenol removal efficiency of granular activated carbon and different soils by addition of activated sludge. While Nobutada and Furukawa (1995) have been used the Gram +Ve and Gram –Ve bacteria strains Co – metabolically degrade variety of poly chlorinated biphenyls. Kavitha and Bebbi (2001) used a packed bed reactor for bio degradation of phenols. Singh and Srivasthava (2000) tried to remove phenols by using activated carbon developed from used tea leaves and reported that 77.2 to 97.7% phenols were taken up by the medium and the adsorption was maximum at pH 6.

The present study is an attempt to suggest an alternative which is cheaper and the material for the medium is locally available and economically feasible. The activated carbons used in the study were: Rice Husk Carbon, Casuarina Wood Carbon and Saw Dust Carbon. All these are easily available and cheaper.

2. MATERIALS & METHODS:

The adsorption technique is the most popular physical process of certain parameters in the waste water treatment. Activated carbons are the best – known adsorbents because they can be derived from many materials besides coal. In the present study the activated carbons derived from Rice Husk Carbon (RHC), Casuarina Wood Carbon (CWC) and Saw Dust Carbon (SDC) were used as adsorbants.

The process of manufacturing of Activated Carbon required by us H_3PO_4 impregnated powders of the above materials are carbonized at 300 – 500^0 C (Sharma, 1994). Phenol stock solution and estimations (4 – Amino Antipyrine method) were made as per the NEERI manual on Water & Wastewater Analysis, (1988).

3. RESULTS & DISCUSSION:

The Activate Carbon material selected for the present are Rich Husk, Casuarina Wood and Saw Dust. These three are selected on the availability of the resource and its cost. Primarily the present work aims at providing an alternative source for the conventional activated carbon to remove the phenols from the sewage waters. Each of the three activated carbons were used in the filter bed design for the Rapid Small Scale Column Test (RSSCT) for the efficiency of the activated carbon in the filter bed was maintained as suggested by Singh and Srivasthava (2000).

3.1 Removal of Phenols:

The phenolic concentrations used in the present study were 2,4,6,8,10,15 mg/l. A calibration curve was prepared with 5, 10, 15, 20 and 30 mg /l concentrations.

3.1.1. Rice Husk Activated Carbon:

The solutions containing the phenol concentrations from 2 to 20 mg/l were passed through the Rice Husk activated carbon bed. The final concentrations after the equilibration time were recorded for each concentration (Table 3.1.1). The percentage phenol removed was calculated and expressed in percentage. The removal of phenols was comparatively higher at higher input concentrations. But the higher removal did not bring down the concentrations nearer to the permissible limits. At lower input concentration, for eg. At 2mg/l input phenol concentration, 0.36 mg/l was removed which accounts for 18% removal.

Table 3.1.1. Percentage adsorption of the phenolic compounds by Rice Husk Carbon (RHC)

Initial Concentration of Phenols	Final Concentration of Phenols	% Phenolic Compounds Removed
2	1.64	18
4	2.7	32.5
6	3.6	40
8	4.16	48
10	4.7	53
15	6.3	58
20	7.2	64

3.1.2.Casuarina Wood Activated Carbon:

The quantity of phenols removed increased with increasing input phenol concentration. There was no consistency or any trend in the removal with the increasing concentration. The percentage removal was 20 for 2 mg/l input phenol concentrations while that increased to 40 percent in 4 mg/l solution (Table 3.1.2) after that from 6mg/l to 20 mg/l the percentage removal was marginal from one level to the other. However the removals did not differ significantly from those of the Rice Husk Carbon.

Table 3.1.2. Percentage adsorption of the phenolic compounds by Casuarina Wood Carbon (CWC)

Initial Concentration of Phenols	Final Concentration of Phenols	% Phenolic Compounds Removed
2	1.60	20
4	2.40	40
6	2.94	51
8	3.68	54
10	4.00	60
15	5.55	63
20	6.80	66

3.1.3.Saw Dust Activated Carbon:

The Saw Dust activated carbon had shown high efficiency for the removal of phenolics compounds and had significantly brought down the phenols in all concentrations. Thirty one percent of phenols were removed from 2 mg/l solutions. The percentage removal increased with increasing concentrations. The maximum percentage removal (78%) was recorded for 20 mg/l concentration. The increased percentage removal was marginal between 10 and 15mg/l (Table 3.1.3).

Table 3.1.3. Saw Dust Carbon (SDC):

Initial Concentration of Phenols	Final Concentration of Phenols	% Phenolic Compounds Removed
2	1.48	31
4	2.32	42
6	2.46	59
8	2.68	66.5
10	2.7	71.0
15	3.98	73.5
20	4.4	78

3.2.Comparison among the three activated carbons:

Among the three activated carbons of biological origin, the saw dust carbon has shown high efficiency of the removal of phenolics compounds. The highest percentage removals from lowest to highest concentrations were exhibited by the saw dust carbon without exception. The removal efficiencies of SDC was 31% (the lowest) for 2 mg/l concentration and the highest was 78% for 20 mg/l of phenol concentration. At all the concentrations of phenolic compounds, all the sorption agents used have shown increased removal efficiency with increasing concentrations. However, the increase of removal did not follow any systematic trend or consistency. For eg. The percentage removal was doubled from 2 to 4 mg/l in CWC and it was only 11% for SDC (Table 3.2). The increase of percentage removal gradually decreased with increasing concentrations starting from 6 mg/l to 20 mg/l for all the biosorbents.

Table 3.2. Comparison among the three Activated Carbons

Activated Carbon Type		Initial Concentrations of Phenols						
		2	4	6	8	10	15	20
RHC	Final Phenolic Concs	1.64	2.70	3.60	4.16	4.70	6.30	7.20
	% Phenols Removed	18.0	32.5	40.0	44.8	53.0	58.0	64.0
CWC	Final Phenolic Concs	1.6	2.40	2.94	3.68	4.00	5.55	6.80
	% Phenols Removed	20.0	40.0	51.0	54.0	60.0	63.0	66.0
SDC	Final Phenolic Concs	1.48	2.32	2.46	2.68	2.70	3.98	4.40
	% Phenols Removed	31.0	42.0	59.0	66.5	71.0	73.5	78.0

Many studies revealed that the concentration of phenolic compounds in the sewage ranged between 8 -10 mg/l. The use of granular activated carbon was not economically feasible for municipal corporations. Alternatives for conventional activated carbon have been on such for several decades. The present study assumes importance as the SDC has reduced the phenolic concentrations to 2.68 and 2.7 from 8 and 10 mg/l, respectively. Even the higher concentrations such as 15 and 20 mg/l were brought down to 3.98 and 4.4 mg/l, respectively. The SDC is easily available in all towns and cities. It is easy to regenerate the used SDC. It is highly effective at pH 6, and achieves highest percent removal in lowest equilibration time.

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