Abstract—The adsorption of phenol was examined in aqueous solution into plant based absorbents charcoals viz. Sugarcane bagasse (Saccharum officinarum) and Kekar saw dust (Acacia nelotica) and their Tween-20 modified forms. Effects of various process parameters such as contact time, adsorbent dosage, pH and phenol concentration were investigated. The adsorption capacities of the charcoals were found dependent on the pH of phenol solution with pH 2.0 being optimal. Surfactant modified charcoals were found better adsorbent compared to raw form in case of Acacia nelotica (Kekar saw dust) but no effect has been seen in case of Sugar cane bagasse charcoal due to blockage of binding sites. The adsorption capacities were found to be 70.4 mg/g, 47.39 mg/g for raw charcoals of Sugarcane bagasse and Kekar saw dust charcoal. While, the modified charcoals shown 41.32 mg/g and 67.56 mg/g for sugarcane bagasse and kekar saw dust respectively. The equilibrium data were fitted to Freundlich isotherms. The desorption studies showed to recover the absorbed phenol from charcoal were performed with NaOH, HCl solution, distilled water.

Index Terms—Phenol, adsorbent charcoals, Tween-20, Isotherms.

I. INTRODUCTION

The pollution of water with phenol from petrochemical industries is a highly important environmental problem, first of all because of the propagation of the pollution, and second because of its unfavorable consequences on the aquatic life, on the organoleptic properties and uses of water. So, many industrial wastes contain phenolic compounds which are difficult, or impossible to be removed by conventional methods. Different methods are available for the removal of phenol from aqueous wastes, out of which adsorption remains the most efficient and economical. Adsorption of phenol from aqueous environment is a relatively new technology for the treatment of wastewater. Adsorbents charcoals derived from suitable biomass and surfactant modified biomass charcoals can be used for the effective removal and recovery of phenol from wastewater.

II. MATERIAL AND METHODS

A. Preparation of Adsorbents

The plant based materials used for the study were SB, KSD. Both the biomass were obtained from the local area. Biomass were heated at 250°C in hot air oven for 2.3h. Both the biomass charred into black coal. It was ground in a mortal with pestle. The particle size was maintained in the range of below 180 MICS.

B. Modification of Adsorbents

The charcoals of both the biomass dip overnight in a solution of non-ionic biodegradable surfactant (Tween-20) then shaking for 5h over shaker then washed with double distilled water, dry at 80°C for 24h. Now the coated biomass charcoals9-11 is ready for experimental study.

C. Preparation of Phenol solution

All the reagents were of analytical grade and prepared in triply distilled water. An aqueous stock solution was obtained by dissolving 1.0g of phenol in 1000 ml triple distilled water. This was used as the source of phenol in synthetic waste water. The pH of solution was adjusted using 0.2N HSO4 or 0.2N NaOH. Fresh dilution was used for each study.

D. Preparation of 2% of 4-Aminoantipyrine solution

Dissolved 2.0g of 4-AAP in distilled water and dilute up to 100ml.

E. Preparation of 8% Potassium ferricyanide solution

Dissolved 8.0g of Potassium ferricyanide in distilled water and dilute up to 100ml.

F. Buffer solution preparation

Dissolve 16.9g Ammonium chloride in 143 ml conc. Ammonium hydroxide and dilute to 250 ml with distilled water.

To study the comparative screening effects of plant waste biomass charcoals type sorbents for Phenol, removal capacity, the experiments were conducted in 250ml Erlenmeyer flasks at 20 °C on vortex shaker at 160 rpm. Experiments were conducted at pH 2 to 7 and initial phenol conc. of 10 mg/L was maintained. After 80 minutes of mixing the biomass charcoals,
the filtrate were pass through whatman No. 1 filter paper. The change in phenol conc. due to adsorption was determined calorimetrically (Double beam UV-VIS Spectrophotometer model 5704 SS ECI). A reddish-yellow color complex was developed in the reaction between phenol and 4-aminoantipyrine in basic medium, absorbance was measured at wavelength 500nm. (standard methods,1999). The percentage sorption efficiency (%) and the amount of phenol adsorbed per gram of biomass charcoals were calculated.

III. RESULT AND DISCUSSION

A. Graphs

Fig. 1. Effect of pH on Adsorption of Phenol. Initial Phenol conc. = 10mg/L adsorbents dosage = 500mg/ 100ml, Contact time =80 minutes

Fig. 2. Effect of biomass charcoals dosage on Adsorption of Phenol. Initial phenol conc. = 10 mg/L, pH =7.0, Contact time = 80 minutes

Fig. 3. Effect of biomass charcoals dosage on Adsorption of Phenol. Initial phenol conc. = 10 mg/L, pH =7.0, Contact time = 80 minutes

Fig. 4. Effect of Phenol concentration. Contact time = 80 minutes, Adsorbents dosage = 500mg/100ml, pH = 7.0

Fig. 5 Desorption of Phenol

B. Tables

<table>
<thead>
<tr>
<th>Adsorbent</th>
<th>SBC ($q_e$) (mg/g)</th>
<th>MSBC($q_e$) (mg/g)</th>
<th>KSDC($q_e$) (mg/g)</th>
<th>MKSDC ($q_e$) (mg/g)</th>
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<td>1.0</td>
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<tr>
<th>Initial concentration (mg/L)</th>
<th>SBC ($q_e$) (mg/g)</th>
<th>MSBC($q_e$) (mg/g)</th>
<th>KSDC($q_e$) (mg/g)</th>
<th>MKSDC ($q_e$) (mg/g)</th>
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<td>6.24</td>
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### TABLE III
Adsorption Constants for Adsorption of Phenol on Different Adsorbents and Modified Adsorbents

<table>
<thead>
<tr>
<th>Biomass Charcoal</th>
<th>Langmuir Isotherm</th>
<th>Freundlich Isotherm</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>( b ) (L mg(^{-1}))</td>
<td>( q_{m} ) (mg g(^{-1}))</td>
</tr>
<tr>
<td>SBC</td>
<td>0.062</td>
<td>70.4</td>
</tr>
<tr>
<td>MSBC</td>
<td>0.082</td>
<td>41.32</td>
</tr>
<tr>
<td>KSCDC</td>
<td>0.017</td>
<td>47.39</td>
</tr>
<tr>
<td>MKSDC</td>
<td>0.089</td>
<td>67.56</td>
</tr>
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</table>

![Fig. 6. (a-d) Langmuir isotherms for phenol adsorption on adsorbent and modified adsorbent charcoals](image-url)

(a) $y = 0.0142x + 0.2291$ $R^{2} = 0.9282$

(b) $y = 0.0242x + 0.3955$ $R^{2} = 0.9205$

(c) $y = 0.0111x + 1.2174$ $R^{2} = 0.9524$

(d) $y = 0.7048x + 0.7019$ $R^{2} = 0.9845$

(a) $y = 0.5559x + 0.6791$ $R^{2} = 0.927$

(b) $y = 0.7778x + 0.0582$ $R^{2} = 0.9896$

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In addition to Langmuir adsorption isotherm, the fitting of data to Freundlich sorption isotherm reveals that the sorption process is not restricted to one specific class of sites and assumes surface heterogeneity. The Freundlich model gave the best fitting of the experimental results.

The adsorption data obtained for phenol adsorption on to the plant based biomasses charcoal used as adsorbents in the present investigation were modeled. The values of the Langmuir constants ($q_m$, $b$) and Freundlich constants ($K_F$, $n$) are presented for adsorption of Phenol by SBC, MSBC, KSDC, MKSDC, (Table-3).

Sugarcane bagasse charcoal had maximum phenol uptake capacity of 70.4 mg/g when compared to all biomass charcoals. It shows that the $R^2$ value more in Freundlich isotherm for raw charcoals and in modified form. Freundlich isotherm model gave best fitting for all biomass charcoals. Figure-6 and Figure -7 show that Langmuir and Freundlich isotherm model of Phenol. On the basis of the data of table-3 It is clear that Sugarcane bagasse charcoal is the best adsorbent.

IV. CONCLUSION

Sugarcane bagasse charcoal and Kekar SD charcoal as raw and Tween-20 modified charcoals have been studied as possible adsorbents for removal of phenol from aqueous solutions. This study showed that Sugarcane bagasse charcoal has higher adsorption efficiency (79.0%) than other charcoals. Although, modified Kekar SD charcoal (76.0%), Modified sugarcane bagasse charcoal (73.0%) are also good adsorbents. as compared to raw Kekar SD charcoal (42.0%) under experimental conditions. The Phenol removal was highly dependent on pH, initial phenol concentration adsorbent mass and contact time. The pH 2.0 was found for maximum adsorption of Phenol by all the adsorbents. The Freundlich and Langmuir adsorption models were used for the mathematical description of the adsorption equilibrium of phenol to adsorbents. The adsorption equilibrium data fitted well to Freundlich isotherm. The adsorption capacity were 70.4, 67.56, 47.39, 41.32mg/g for SBC, MKSDC, KSDC, MSBC respectively. Sugarcane bagasse charcoal shown the highest adsorption capacities for phenol. Sugarcane bagasse is easily available plant waste and can, therefore, be used in batched reactors in small scale industries having phenol in waste water.

Desorption studies shows that the recycling of adsorbent and adsorbate may be possible.

IV. ACKNOWLEDGMENT

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