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# Kinetic Parameters And Evaluation Performance for Decolorization Using Low Cost Adsorbent

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**Abstract.** In this investigation activated carbon has been employed as a low cost adsorbent for a basic dye adsorption in aqueous solution. Adsorption performance has been investigated using batch experiments. It is found that dye adsorption capacity (pollutant removal efficiency) of a steady system depends on adsorbent material, pH of solution, adsorbent dose, particle size, initial concentration, and type of activation. In the present study, coconut shell and corncob is used for removal of dyes by process of adsorption, which is abundantly available material. Adsorption Kinetics was studied using Lagergren and Helffrich Models. It was observed that coconut and cobcorn efficiently remove dyes from industrial waste at optimum condition.

**Keywords:** Dyes, Adsorption, Inexpensive adsorbent, Rate constant.

## 1. Introduction

Many dyes and pigments are hazardous and toxic at the concentration discharged to receiving water for human as well as aquatic life. Dyes used in the textile industry are difficult to remove by conventional waste water treatment methods. If an effort is not made to remove these visible pollutant from effluents, they are going to poor a public health problem in the nearby future. The color acquired by river water through discharge of colored industrial effluents inhibits the growth of desirable aquatic biota, reduce its recreation capacity and has a tendency to chelate metal ion.

Two things are mostly essential for the choice of bioadsorbent, they are cost and availability.

## 2. Adsorbent Characteristics And Preparation

### 2.1. Coconut Shell

Coconut shell is carbonized and washed with distilled water to remove the ash adhere over the surface of shells. There are two activation processes for increasing the active site on the surface of adsorbent.

- Acid treatment
- Steam treatment

#### 2.1.1. Acid treatment

Acid treatment is given by using $HNO_3$. The 50 gm of coconut shell powder sample is treated with 500 ml of 1 N acid and then mixture was gently heated on burner up to its boiling pt. for 15 min. Then washing is done to maintain the pH in between 6 to 6.5.

#### 2.1.2. Steam treatment

The effective activation occurs by supplying steam to the bio-adsorbent at a temp of 900-1100$^{O}$C . So the activation capacity of steam is much better than acid.

### 2.2. Cob corn

The waste material collected from farms was used as an adsorbent. Firstly dry it in sunlight for 2 days. Then raw material is heated at $150^0$C for 2 days.

Acid treatment or steam treatment methods are used. Same activation treatment is done for Cob corn as given to the Coconut shells.

## 3. Adsorption studies

The important physical and chemical characteristics of coconut shell and cob corn adsorbents were studied by adsorption process.

The adsorption process is carried out on the various major factors i.e.

- pH
- Contact time
- Amount of adsorbent
- Concentration of dye bath
- Particle size of adsorbent.

## 4. Experiments

Adsorption studies were performed using batch technique to obtained Particle Removal Efficiency and equilibrium data. Experiments were carried by shaking 5 gms of adsorbent dose with 50 ml of aqueous solution containing known concentration of dye. Sample-containing dyes were maintained at desired pH by adding HCl or NaOH. All the experiments were performed at room temperature 29 $^{O}$C

### 4.1. Preparation of aqueous solution of Indigo dye-liquor

The dye solution consists of following constituents.

(For 250 mg/lit.)

| Constituents | Amount (in gm) |
|---|---|
| Indigo powder | 0.250 |
| Caustic powder | 0.5 |
| Sodium Hydrosulphide | 1 |
| Setamol | 0.5 |
| EDTA | 0.5 |
| Primasol | 0.5 |
| H2O | Make up to 1000 ml |

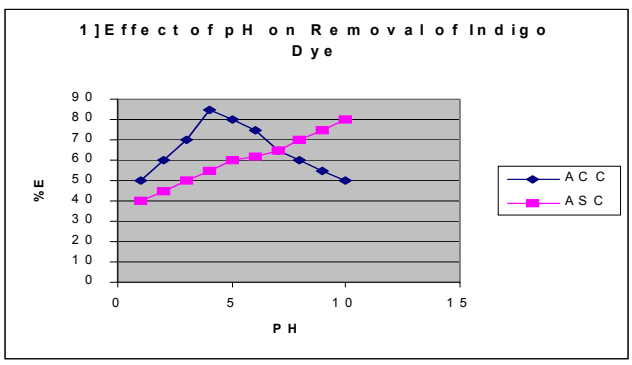
## 5. Result and Discussion

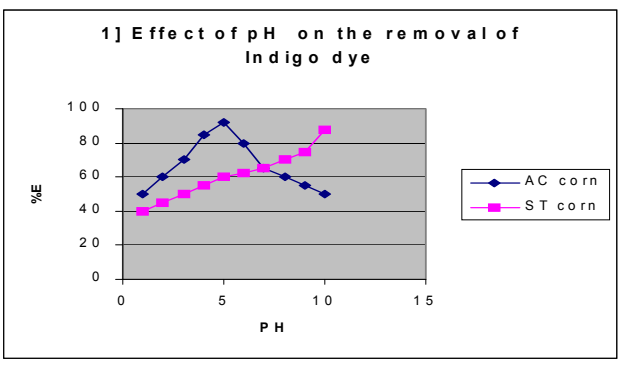
### 5.1 Removal Of Dyes: - Sorption studies

#### 5.1.1. Effect Of pH

The pH of the aqueous solution is an important controlling factor maintained by $HNO_3$ or $H_2SO_4$It was observed in the present investigation that with the increases in pH of solution, the extent of dyes removal increased in case of steam treated bioadsorbent, but it was reverse trend in case of acid treated bioadsorbent .The extent of dyes removal is graphically presented in plot (1 and 2).

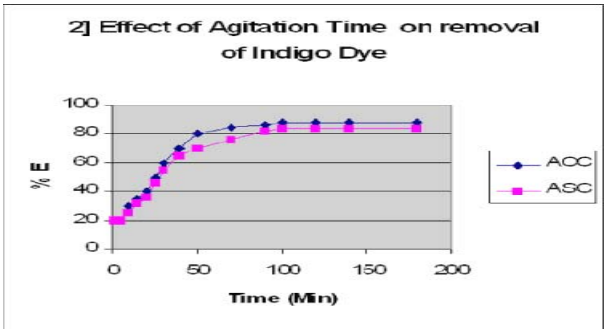
The adsorption is studied between pH 2-10 for acid activated coconut shell & acid activated cob corn.

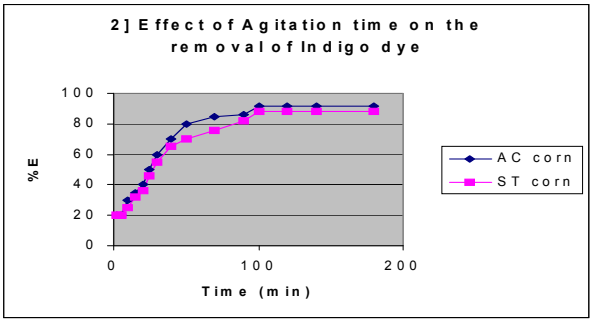


### 5.1.2. Effect of Agitation Ti*me*

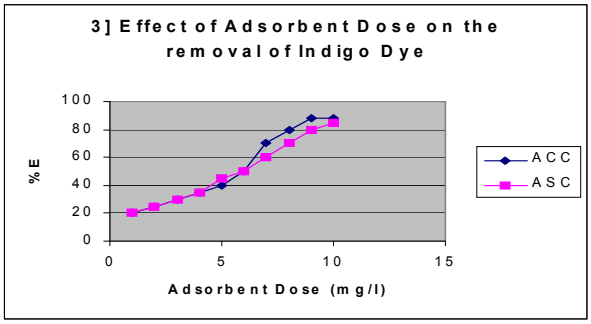
It was found that the rate of removal of dyes increases with increase in agitation time to some extent. Preliminary investigation on the rate of uptake of dyes on adsorbent material at their optimum pH values of 4 for acidic bioadsorbent and 10 for steam bioadsorbent indicated that the process are quite, rapid. This initial rapid adsorption subsequently gives equilibrium within a period of 100 min.

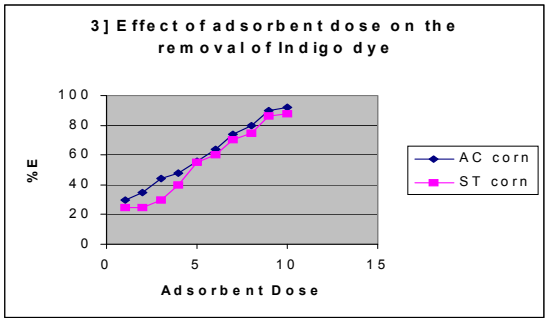



### 5.1.3. Effect of Adsorbent Dose

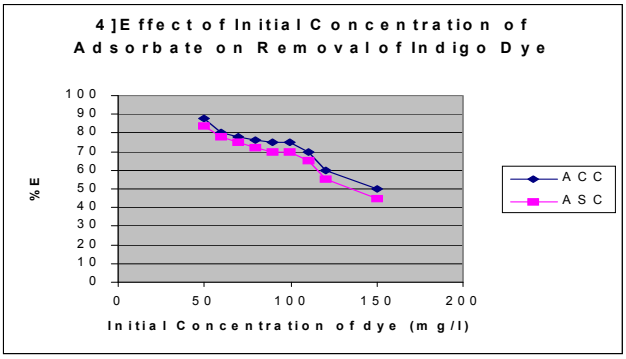
It can be seen that rate of removal of dyes increases with increase in amount of adsorbent. The amount of adsorbent dose was varied from.1 gm to 8 gm for removal of dyes. Result shows that among the adsorbent used, coconut acid activated, cobcorn acid activated was efficient for maximum removal of dyes at all the levels of adsorbent dose. Adsorption of dyes by acid activated cobcorn was found to be. 92%.

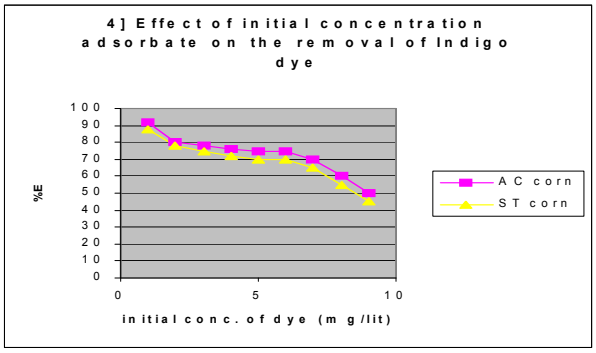



### 5.1.4 Effect of initial dyes concentration:-

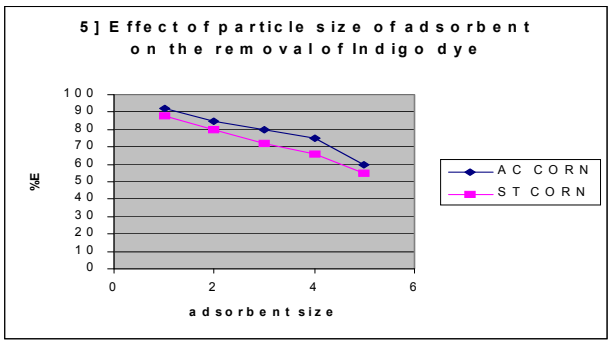
The activities of all the adsorbent material falls sharply with an increase in initial concentration of dyes as evident from plot .Coconut acid activated adsorbent may be seen fairly active in reducing dyes from 80-90%.It was also evident that dyes removal was found to be 88% at initial dyes concentration of 50 mg/lit and 84%. For ACC, ASC at pH 4 and at pH 10 respectively.

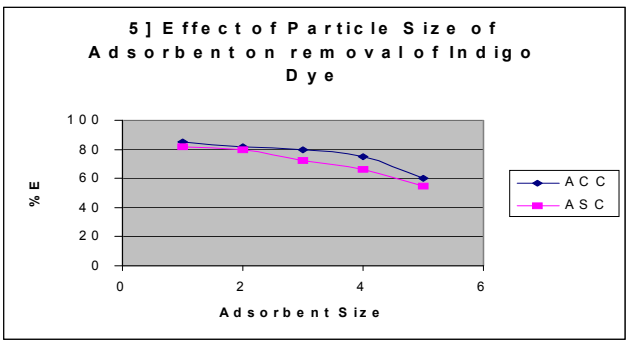



### 5.1.5 Effect of Adsorbent particles size:-

From Graph the removal of dyes has been studies at room temperature at 29+ $1^{O}C$ with the smallest particle size of 600 mic, maximum removal of dyes was found to be in decreasing order respective with increase in the particle size is varied from 600mic-1.4 mm.




# 6. Adsorption Kinetics

## 6.1. Helfferich model

The rate constant (k) can be determined using Helfferich equation

In [1-U (t)] = kt

Where U (t) = (Co-Ct) / (Co-Ce)

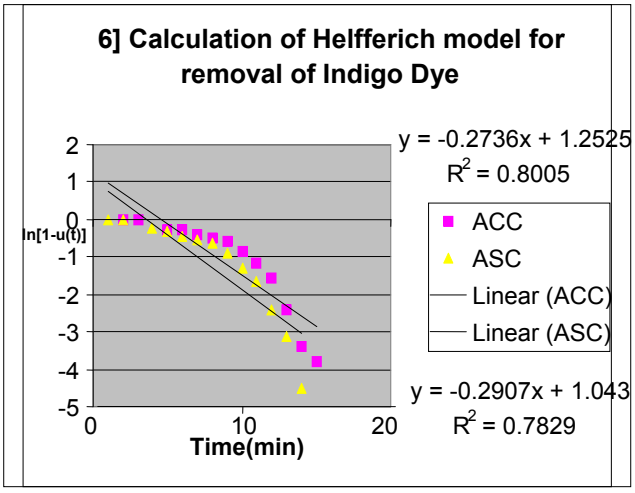
The straight line plot of [1-U (t)] Vs t indicates the applicability of Helfferich equation, and shows that the process follows first order kinetics.

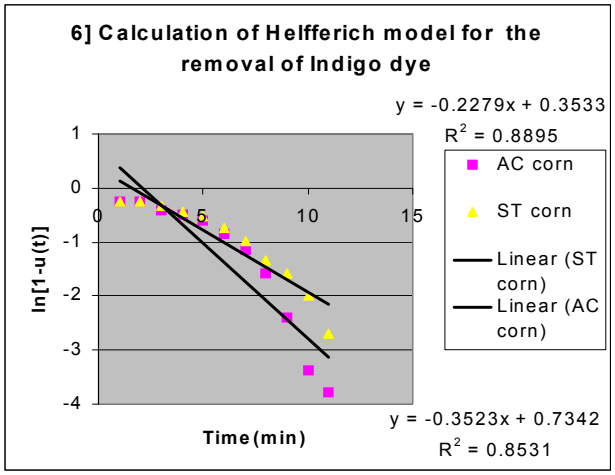
The two important physico-chemical aspects for parameter evaluation of the sorption process as a unit operation are kinetics and the equilibria of sorption.

### 6.1.1. Helfferich First Order Rates Model

Kinetics of sorption describing the solute uptake rate which in turn governs the residence time of sorption reaction (Ref. Rengaraj, et al, 1999).

The equilibrium constant K for Acid & Steam Activated Coconut Shell, Acid & Steam Activated Corn cob are 0.2736,0.2907,0.2279,.0.3523 respectively.




## 6.2. Lagergren Model

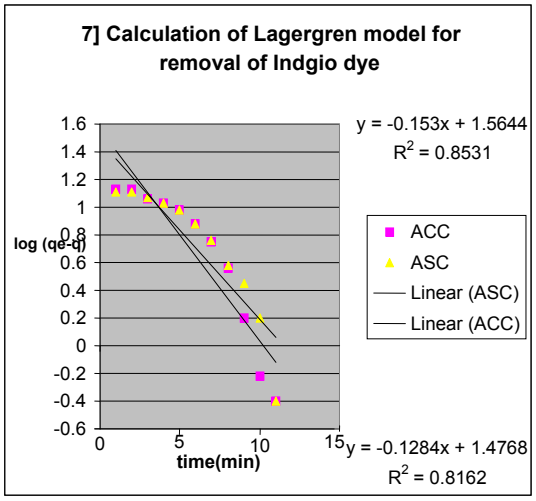
The specific rate constant R2 for the adsorption of dye on material was determined using the lagergren equation. The straight line plots of log (qe-q) vs. t using the data at different contact time for different adsorbent indicate there validity of the lagergren equation for the present system and shows that process follows the first order kinetics. The regression coefficient for Acid & Steam Activated Coconut Shell, Acid & Steam Activated Corn cob for the Lagergren Plots are 0.153,0.1284,0.1147,0.099 for respectively.

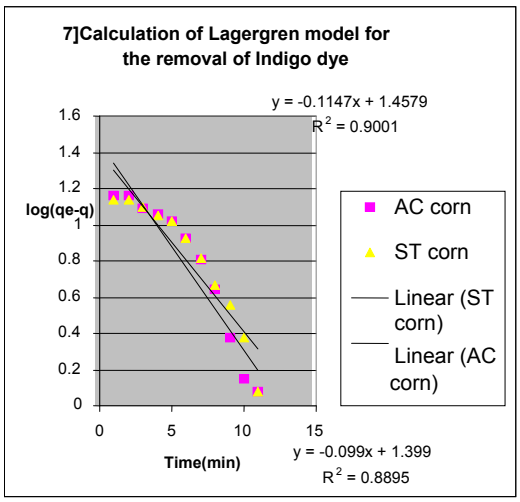
### 6.2.1. Lagergren model

Adsorption of solute on to adsorbent can describe by three consecutive steps. First by molecular diffusion, i.e. film diffusion. Secondly by pore diffusion and finally the adsorbate is adsorbed onto the active sites at the interior surface of the adsorbent particle. The overall rate of adsorption will be controlled either by film diffusion or by internal diffusion. The Lagergren first order rate expression that follows is

valid for both the systems and the same has been used for the determination of a specific rate constant. log $(q_e - q) = \log q - (k_{ad}.t) / 2.303$

Where q and $q_e$ (both in mg/g) are the amount of solute adsorbed at any time t (min) and at equilibrium time respectively.




## 7. Conclusion

The experimental result prove that the biodegradable waste used as adsorbent have considerable potential for the removal of textile dyes at laboratory scale at batch experiment, over wide range of concentration of dye and efficiently considered for waste water treatment at large scale in textile industry.

Results show that adsorption takes place faster on surface of acid activated cobcorn adsorbent than other adsorbent.

| | |
|---|---|
| Acid activated Cobcorn adsorbent | = 92% removal efficiency. |
| Steam activated cobcorn adsorbent | = 88% removal efficiency. |
| Acid activated coconut shell adsorbent | = 88% removal efficiency. |
| Steam activated coconut shell adsorbent | = 85% removal efficiency. |

Bio-adsorbent is readily available, cheap and thus more cost effective. The cost of preparation and activation of adsorbent is quite less and the market available charcoal and even for mass production of bio-adsorbent it would be reduced more. It is also observed that this unconventional adsorbent required less maintenance and super vision and also easily disposes off in the form of bricks manufacturing after use. So in this way by removing dyes from textile effluent at low cost, environment becomes free from hazardous effects of dyes and this treated water can be utilize even in boiler for steam generation after further treatment.

## 8. References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