Removal of COD using leaves, stem and root of Mangifera Indica as Biosorbent

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Abstract— Modern environmental legislation focuses more on prevention of pollution through control of hazardous materials and processes as well as on protection of eco-systems. A number of technologies have been developed over the years for the treatment of industrial wastewater esp. COD. Potential of biosorbent prepared of leaves, stem and root of two species of Mangifera indica as a commercial grade activated carbon was determined to remove COD from the wastewater. For this purpose a system of standardised batch absorbers under steady state conditions is used to study the effect of these media. The influence of contact time, adsorbent dosage, pH of the solution, initial COD concentration, temperature and adsorbent particle size on the rate of per cent COD reduction is evaluated. Biosorbents has shown quite effective adsorbent capacity for COD reduction from the textile wastewater. The results revealed 96-98% of COD reduction which makes it an attractive option for the treatment of textile wastewater.

Key words: Mangifera indica, COD, biosorbent, bagasse pith.

I. INTRODUCTION

Wastewaters from various industries exert a pull on attention of environmental protection agencies all over the world. They not only deface the look of natural waters, but are also highly toxic. Pollution of water by organic and inorganic chemicals is of severe environmental concern [1]. Domestic wastewater differs in characteristics from the industrial wastewater. In domestic wastewater the organic load is mainly due to the processes like food processing, washing, bathing and sewage. The main components of domestic wastewater are proteins, carbohydrates, detergents, tannins, lignin, humic acid, fulvic acid, melanic acid and many other dissolved organic compounds [2]. The organic content of wastewater is traditionally measured using lumped parameters such as BOD, COD and TOC. These parameters as such do not show any chemical identity of organic matter. The organic content of wastewater is traditionally measured using lumped parameters such as BOD, COD and TOC.

The conventional wastewater treatment technologies being adopted in industrialized nations are quite expensive to build, operate and maintain. Moreover, to comply with strict environmental regulations and for restoration of safe environment, it has become vital to find less costly and easily adaptable treatment technologies for the wastewater [3]. Numerous conventional treatment technologies have been considered for treatment of wastewater contaminated with organic substances. Among them, adsorption process is found to be the most effective method. Commercial activated carbon is regarded as the most efficient material for controlling the organic load. However due to its high cost and about 10-15 % loss during regeneration, unconventional adsorbents like fly ash, peat, lignite, bagasse pith, wood, saw dust etc. have attracted the attention of several investigations and adsorption characteristics have been widely investigated for the removal of refractory materials [4] for varying degree of success.

Researchers are keen to come-up with the innovative technology for the removal of such organic pollutant load to the permissible limits. The review of literature reveals that adsorption has proved to be cost-effective and user-friendly method above all other technical methods. In recent years, there has been awareness of the limited resources naturally available to mankind. Thus, use of waste as a treating material has found a grip in research. In consequence, adsorption based innovative technology has emerged with the use of agricultural waste and industrial waste for the treatment purposes. Such adsorption approach can offer an easy and economic solution to these environmental challenges. Moreover, activated carbon is considered very effective in reduction of color, absorbable organic halides (AOX) and non-biodegradable pollutants of such wastewater [5].

The aim of this study was to assess the potential of biosorbents prepared from various parts (i.e. Leaves, Stem and Roots) of two species (Subja and Kesar) of *Mangifera indica in* reduction of COD concentration from textile wastewater.

II. METHODOLOGY

A. *Preparation of biosorbent:*

Mature and fresh leaves (KL: Kesar Leaves, SL: Subja Leaves), stems (KS: Kesar Stems, SS: Subja Stems) and roots (KR: Kesar Roots, SR: Subja Roots) were collected from local orchards and washed thoroughly by using distilled water to clean them from dirt and impurities.

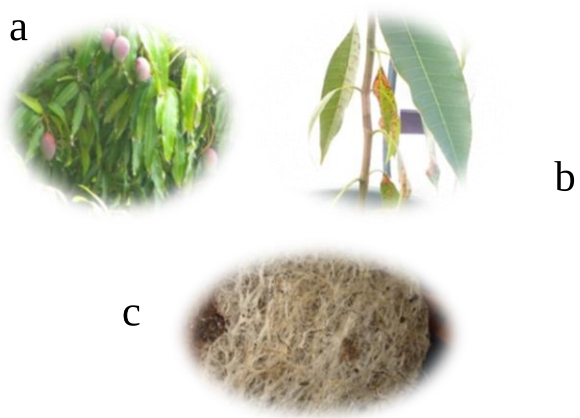

Fig. 1: (a) Leaves, (b) stem and (c) roots of *Mangifera indica*.

After that, the leaves were sun dried for a day on a perforated tray. Further, the materials were dried in an oven for 24 hours until the material appeared to be free from moisture. After drying, the material were ground by a mechanical grinder and sieved to constant size of 80µm and the resulting powders from leaves, stems and roots were activated at 700°C in muffle furnace for 30, 45 and 60 minutes respectively. After attaining the temperature, the carbonised material was taken out and immediately covered with a petri dish to avoid contact with atmospheric air.

Fig. 2: (a) Dried and grinded biosorbent (b) Activated biosorbent

Later, it was kept in various glass bottles ready for further experiments.

B. Adsorbate (Textile Wastewater):

Wastewater samples were collected from the textile industry. The pH and EC of the samples were measured on the site and the other parameters were analysed in the lab according to the APHA (1989).

Samples were stored at temperature below 3°C to avoid any change in the physic-chemical characteristics. The COD of the samples were estimated before and after adsorption giving different treatment.

C. Adsorption studies:

All the experiments were carried out at ambient temperature (25°C) in batch mode. The batch experiments were conducted in different flasks of 250 ml capacity using an average speed shaker. Adsorption experiments were conducted in different batches for all the experimental conditions like contact time, adsorbent dosage, pH of the solution, initial COD, temperature and adsorbent particle size. The influence of various operating parameters were studied by varying one parameter and keeping others constant. Stirring speed of the shaker was kept constant for each run throughout the experiment thus ensuring equal mixing. The analysis of wastewater was carried out using standard methods (APHA, 1980). Experiments were carried out in duplicate and the maximum deviation was 3%.

The effect of pH was studied with constant initial concentration, adsorbent dose, and contact time but varying the pH values from 2 to 12 using dilute NaOH or HCl solution. The samples were agitated for specific time, filtered and then analyzed for residual COD concentration.

Effect of contact time of the biosorbents (KL, SL, KS, SS, KR, SR) with wastewater sample was investigated by agitating 250 ml sample and adding 0.5 g adsorbent for different time-periods varying from 5 to 60 min. Initial COD concentration of the sample was 1200 mg/l. pH of 3-6 for each respective biosorbents, agitation speed 600 rpm and adsorbent particle size: 1.5 mm. The treated samples were withdrawn from shaker at predetermined time intervals, filtered and the residual COD concentration was measured.

To determine contribution of the biosorbents dose on COD, 250 ml of sample was treated with different doses of adsorbent ranging from 0.1 to 1 g/250 ml, the other conditions were; treatment time of 30 min, pH 3-6 for each respective biosorbents, initial COD concentration of the sample was 1200 mg/l, agitation speed 600 rpm and adsorbent particle size: 1.5 mm. The samples were agitated for specific time intervals, filtered and then analyzed for the residual COD concentration.

The effect of initial COD was studied by keeping all other conditions constant except changing the initial COD concentration ranging from 500 mg/l to 1500 mg/l.

The treated samples were withdrawn from shaker at predetermined time intervals, filtered and the residual COD concentration was measured.

The effect of temperature and adsorbent particle size on the COD reduction was also studied. As usual, one parameter is varied for one set of experiments. Discrete values of the temperature kept from 25°C to 55°C and adsorbent particle size as 0.5mm to 2 mm. The treated samples were withdrawn from shaker at predetermined time intervals, filtered and the residual COD concentration was measured.

III. RESULTS AND DISCUSSION

The physico-chemical analysis of the wastewater collected from the industrial plant was done as shown in Table 1.

It was evident that this wastewater was polluted with organic load besides dissolved and suspended matter. Organic load was presented in terms of COD and BOD.

In this paper, study was done only for reduction of COD concentrations using discarded material-based carbon made up of *Mangifera indica* parts (Leaves, stems and roots).

Parameters	Values
pH	10.85
Turbidity NTU	12.7
Total solids (mg/l)	12489
Suspended solids (mg/l)	848
Dissolved solids (mg/l)	11256
Total hardness (mg/l)	552
Oil and grease (mg/l)	2
COD (mg/l)	1500
BOD (mg/l)	270
Chloride (mg/l)	1488.1
Sodium (mg/l)	1400
Potassium (mg/l)	49

Table 1: Characteristics Of Textile Industry Wastewater Sample

A. A. EFFECT OF pH:

Fig.1. represents the graph of % COD removal v/s pH (2-13). The results reveal that the pH is maximum attained at acidic range from 3-5. SR showed the highest removal of

COD when compared to other biosorbents. The lowest perfomane in context of pH was observed with SL. Whereas, other biosorbents proved to be an average adsorbents with % COD removal with varying pH.

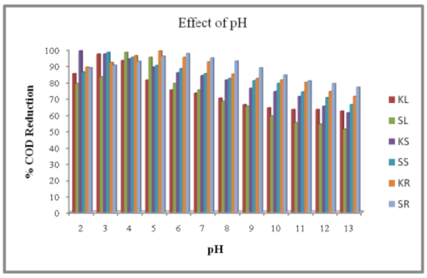

Fig.3: Effect of pH on % COD reduction by biosorbents

B. B. EFFECT OF CONTACT TIME:

Fig.2. shows the graph of % COD removal vs. contact time (5 to 60 min). The results reveal that the rates of percent color removal was higher at the beginning (5 to 25 min). That is probably due to the larger surface area of natural materials at the beginning for the adsorption. As the surface adsorption sites become exhausted, the uptake rate is controlled by the rate at which the adsorbate is transported from the exterior to the interior sites of the adsorbent particles. Also, Parallel bars after contact duration of 30 min suggested that equilibrium attained at 30 min.

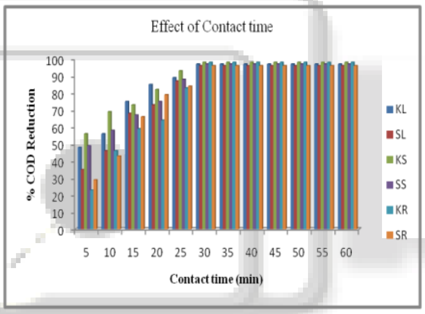

Fig.4: Effect of contact time on % COD reduction by biosorbents

C. EFFECT OF TEMPERATURE:

The effect of temperature on the % COD removal was investigated at 25°C to 55°C (Fig. 3). The percentage of removal is continuously increases as increasing temperature. It was evident that best removal was found at 35°C for all the biosorbents and then after equilibrium was attained. Increasing the temperature is known to increase the rate of diffusion of the adsorbate molecules across the external boundary layer and in the internal pores of the adsorbent particle, owing to the decrease in the viscosity of the solution. Thus, a change in temperature will change the equilibrium capacity of the adsorbent for a particular adsorbate.

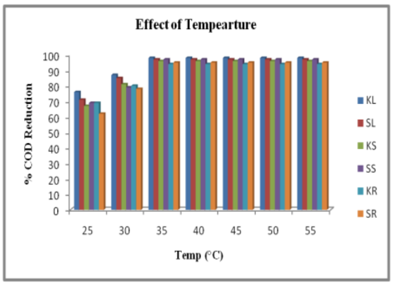

Fig. 5: Effect of temperature on % COD reduction by biosorbents

D. EFFECT OF ADSORBENT DOSAGE:

Fig. 4 represents the effect of various adsorbent doses (0.4-4 g/L) onto COD using biosorbents. The percentage removal was found from 49to 98% for COD, it can be seen that equilibrium was attained after charcoal dosage of 2 g/L. This is due to the fact that the active sites could be effectively utilized when the dosage was low (i.e. low adsorbent/adsorbate ratio). When the adsorbent dosage is higher (high adsorbent/adsorbate ratio) it is more likely that a significant portion of the available active sites remain uncovered, leading to lower specific uptake

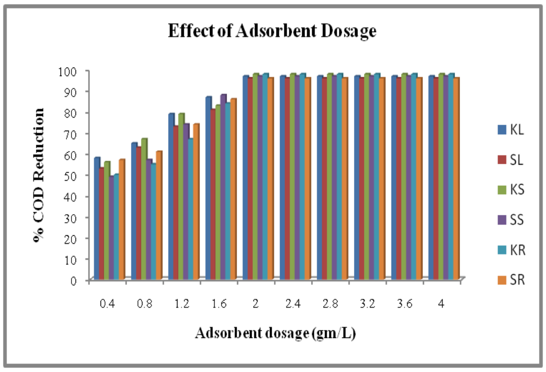

Fig.5: Effect of adsorbent dosage on % COD reduction by biosorbents

E. EEFECT OF INITIAL CONCENTRATION:

Fig. 5 represents the effect of varying initial COD conc. (500-1500 mg/l) on % COD reduction at the optimum pH, adsorbent dose and the contact time as predicted from fig 1, 2 and 4, respectively. The KL, SL, KS, SS, KR, SR seems to be fairly active adsorbent even at higher initial concentrations. At lower initial concentrations, the ratio of the initial number of moles available to the adsorbent surface area is low and subsequently the fractional adsorption becomes independent of initial concentration. At higher concentrations, the available sites of adsorption become fewer and hence the % removal of COD depends upon the initial concentration. The COD removal of over 96%-98.8% obtained with KR within the concentration range investigated. The comparison in trend of % COD reduction by the various biosorbents under this condition is depicted in the figure.

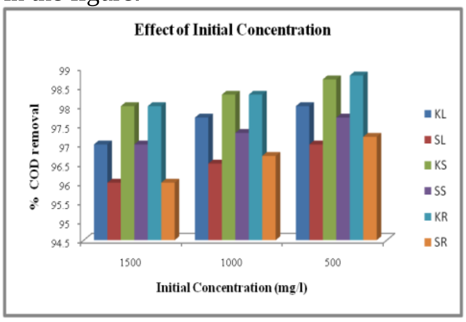

Fig. 6: Effect of initial concentration on % COD reduction by biosorbents.

F. EFFECT OF PARTICLE SIZE:

Fig. 6 represents the effect of particle size (0.5-2 mm) on % COD reduction. It was observed that the extent of adsorption decreased with increasing particle size. In general, the intra-particle mass transfer effect will increase with the increasing particle size. However, the surface area per unit mass of adsorbent as well as diffusional transport might be larger in case of smaller particles, which increases the adsorption rate. Rao et al., 2000, observed similar characteristics for the adsorption of COD on activated carbon. In case of 2 mm particles, 76% COD reduction was observed with SR within 30 minutes, but it was 98.8% for 0.5mm particles.

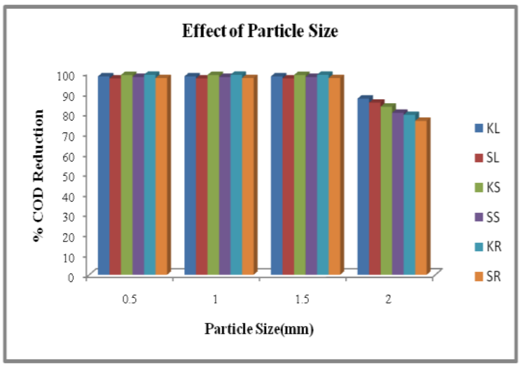

Fig.7: Effect of particle size on % COD reduction by biosorbents

IV. CONCLUSION

From the present work, we conclude that all the biosorbents prepared out of two different species of *Mangifera indica* proved to be can be used as an adsorbent for removal of COD from the textile wastewater. In batch studies, the adsorption increased with the increase in the contact time and adsorbent dosage. Whereas, the adsorption decrease with the increasing COD initial concentration. Removal of COD was higher at acidic pH range. The observations obtained revealed that leaves, stem and roots of the plant are capable of removing the COD by 96-98.8%. The performance of parts of Subja species of the pant proved to be less efficient than the parts of Kesar species. The roots showed the best performance out of all the other parts of the plant species. Further investigation is needed to explore the removal of COD from other wastewaters.

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