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Reduction of Chemical Oxygen Demand by using Coconut Shell Activated Carbon and Sugarcane Bagasse Fly Ash

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Abstract: ***To minimize the industrial pollution, advanced wastewater treatment techniques, such as adsorption, are economically and environmentally essential in the removal of organic and inorganic compounds from industrial wastewater. Pharmaceutical industries are one of the problematic groups due to disposing of highly toxic industrial effluents, which creates the harmful effects on marine environment. The present study focuses on the use of low cost adsorbents such as sugarcane bagasse fly ash and coconut shell activated carbon to adsorb COD content of the pharmaceutical industrial wastewater. By combination and individually, adsorbents were used for treatment of waste water with different dosages and contact time The results of COD removal is up to 46 % for sugarcane bagasse ash and 68 % for coconut shell activated carbon and for the combination of both removal of COD is up to 50%.***

Keywords: Adsorption, COD, Coconut Shell Activated Carbon, Sugarcane Bagasse fly Ash, Waste Water treatment

1. Introduction

Pharmaceutical Industrial waste water streams are emerging contaminants in the aquatic environment and they are adversely affecting aquatic life and humans. In today's condition it becomes necessary to treat industrial wastewater using environmental green technologies. The quality of wastes from production of pharmaceutical varies a great deal, owing to variety of basic raw materials, working process and waste products. The Wastewater is generated through washing activities of equipments. Though wastewater generated is small in volume, is highly polluted because presence of substantial amounts of organic pollutants Level of wastewater varies from industry to industry depending on type of process and size of industry. Wastewater generated is valuated in terms of temperature, pH, BOD, COD, Oil, Grease, Chlorides, Sulphates. Numbers of technologies have been developed over the years to remove organic matter from industrial wastewater.

The technologies include coagulation, flocculation process, membrane filtration, oxidation process. These methods are expensive, complicated, time consuming and required skilled personnel [1]. Adsorption is a surface phenomenon with common mechanism for organic and inorganic pollutant removal. For removal of the organic contaminants from industrial waste water adsorption has become one of the best effective and economical method, thus this process has aroused considerable interest during recent years. Current research has focused on modified or innovative approach that more adequately address the removal of organic pollutants [11]. Adsorption capacity of adsorbent principally depends on the characteristics of materials as specific surface area, pore size, and its distribution.

In present study, it was aimed to carry out experiments using low cost material Sugar cane bagasse from sugar manufacturing unit and coconut shell activated carbon for reduction of COD from the pharmaceutical industrial wastewater. Sugar cane bagasse is an industrial waste which is used worldwide as fuel in the same sugar-cane industry. The combustion yields ashes containing high amounts of unburned matter, silicon and aluminum oxides as main components. These sugar-cane bagasse ashes (SCBA) have been chemically, physically and mineralogically characterized, in order to evaluate the possibility of their use as a cement replacing material in the concrete industry and as an adsorbent in surface chemistry [11]. Coconut shells litter around streets they constitute environmental nuisance. It is anticipated that, this work would abate the environmental nuisance if the coconut shell are been processed into granulated activated carbon (GAC) for the removal of different contaminants likely to be encountered in industrial wastewater. Hence, agricultural wastes such as coconut shell sugarcane bagasse could be important for the removal of contaminants in wastewater.

The objectives of this study were to compare the adsorption efficiency of coconut shell based activated carbon and sugarcane bagasse fly ash in the treatment of a pharmaceutical industrial wastewater for the reduction of COD.

2. Methodology and Materials

2.1 Adsorbent collection

During the production of Sugar, bagasse Fly ash is obtained as a waste product in large quantities from Sugar mill. The total amount and physico-chemical characteristics of Fly ash which is occurred on burning Bagasse generated in boiler varies from boiler to boiler depending upon the boiler's efficiency. Bagasse Fly ash used in present research work is collected from Rajgad Sahkari Sakhar Karkhana ltd., Anantnagar-Nigde, Bhor, Dist-Pune, Pune, and Maharashtra. For series of experiments, it was washed to remove excess fines and oven dried at 100^0C for 24 hours before its use in experiments. It is light black colored material. Bagasse Fly ash mainly consists of unburned carbon, SiO2 - 51 to 55%, Al2O3 – 10 to 11%, CaO -5 to 6 %, Fe2O3 - 4 to 5%, and trace of MgO.

Granular activated carbon manufactured from Coconut shell is designed for reduction of tastes, odors and dissolved organic chemicals from municipal and industrial water supplies. It is manufactured from select grades of coconut shell coal to produce a high density, durable granular product. Activated carbon manufactured from coconut shell is considered superior to those obtained from other sources mainly because of small macro pores structure which renders it more effective for the adsorption of gas/vapour and for the removal of colour and odour of compounds. Coconut shell activated carbon is black in colour, mainly consists of, pH 7-10, Moisture content < 5%, Ash content < 8%, Mean particle diameter 1.2 – 1.4 mm, Iodine Number 500 mg/g, Hardness value 99%.

2.2 Sampling

Sampling was done using standard method from a pharmaceutical industry situated in the Ranjangaon MIDC. Samples were collected from industrial outlet in plastic bottles and then preserved at 4˚C. The experiments were carried out in batch mode for measurement of adsorption capacities. By combination and individually, adsorbents CSAC and SBFA were used for treatment of waste water with different dosages and contact time. The known quantity (250 ml) of sample was treated with different amount of Coconut shell Activated Carbon and Sugarcane bagasse fly ash viz 1, 1.5, 2, 2.5, 3, 3.5 gm/ml, stirred well and kept in contact for 24 hours at room temperature. Then the samples were filtered and analyzed especially for COD removal. The method for determination of COD used is dichromate reflux method.

2.3 Testing Parameter

COD was estimated before and after addition of adsorbents.

2.4 Adsorption isotherm

The adsorption experiments were carried out by batch method. Percentage of removal of COD concentration calculated by following equation:

$$\text{Removal \%} = (C_0 - C) / C_0 \times 100$$

Where, C_0 is the initial concentration of COD (mg L-1) of the wastewater sample and C is the final concentration of COD (mg L-1) after addition of adsorbent. An adsorption isotherm is the presentation of the amount of solute adsorbed per unit weight of adsorbent as a function of the equilibrium concentration in the bulk solution at constant temperature. Langmuir and Freundlich adsorption isotherms are commonly used for the description of adsorption data.
The Langmuir equation is expressed as:

$$\frac{Ce}{qe} = \frac{1}{bXm} + \frac{Ce}{Xm} \quad \text{--- Langmuir}$$

Where, Ce is the equilibrium concentration of solute (mmol L−1), qe is the amount of solute adsorbed per unit weight of adsorbent (mmol g−1 of clay), Xm is the adsorption capacity (mmol g−1), or monolayer capacity, and b is a constant (L mmol−1).

The Freundlich isotherm describes heterogeneous surface adsorption. The energy distribution for adsorptive sites (in Freundlich isotherm) follows an exponential type function which is close to the real situation. The rate of adsorption/desorption varies with the strength of the energy at the adsorptive sites. The Freundlich equation is expressed as:

$$\text{Log}q_e = \log k + 1 / n \log C_e \quad \text{--- Freundlich}$$

Where k (mmol g−1) and 1/n are the constant characteristics of the system.

3. Results and Discussion

Various dosages of the Coconut shell activated carbon and Sugarcane bagasse fly ash were used to treat the industrial wastewater. The COD concentration is reduces as we increased the adsorbent dosage. The effects of adsorbent dosage were varied from 1, 1.5, 2, 2.5, 3, 3.5 gm/ml for Coconut shell activated carbon and Sugarcane bagasse fly ash individually. Hence 3.5 gm/ml was found to give maximum value of COD in treating the wastewater. By using 3.5 gm/ml as optimum dose contact time was varied and tested for after 30, 60, 90, 120, 150 min respectively. Removal efficiency was calculated and graph was plotted. Following graph shows the reduction in COD concentration after adding adsorbent dosages.

3.1 Effect of Adsorbent Dosage

Following graph shows reduction of COD concentration after increasing the adsorbent dosage. As we increase adsorbate dosage more than the optimum the increase in adsorption is very less and it becomes cost ineffective. Figure no. 1, 2, 3 respectively shows effect on reduction of COD after increasing the dosage of adsorbents.

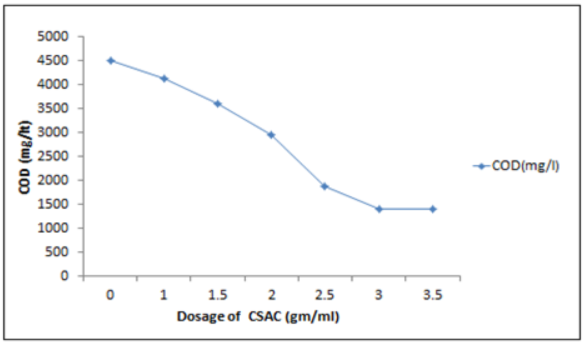

Figure 1: Reduction of COD concentration using CSAC

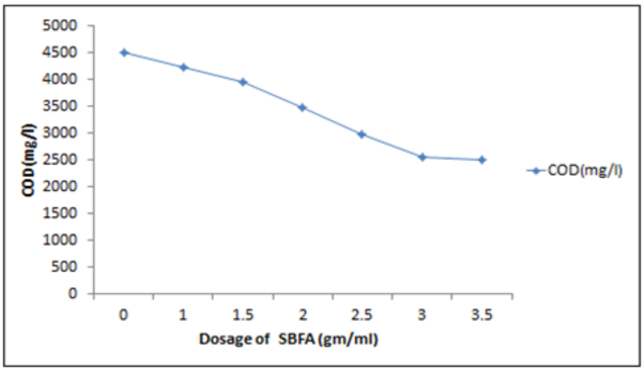

Figure 2: Reduction of COD concentration using SBFA

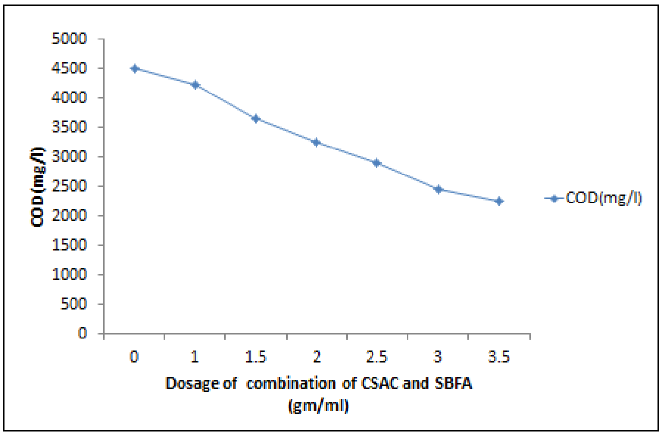

Figure 3: Reduction of COD concentration using Combination of SBFA and CSAC with proportion 1:2

3.2 Effect of Contact Time

Adsorption tends to increase with contact time. At first the increase in adsorption is very rapid as there are lots of free sites for the adsorption to take place. Rate of adsorption decreases at later stages till saturation is reached due to saturation of active sites. The optimum contact time for equilibrium was found to be 150 min. Fig no. 4, 5, 6 shows effect on reduction of COD by varying contact time.

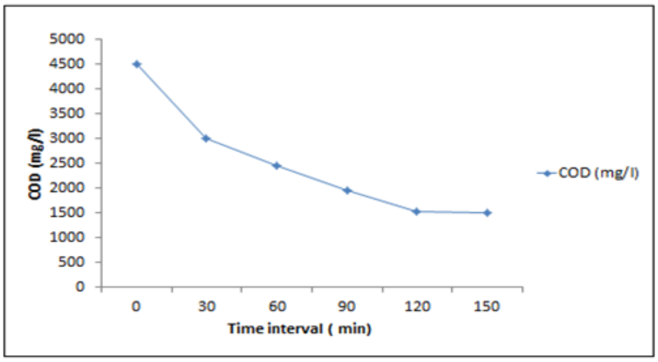

Figure 4: Effect of contact time on reduction of COD after adding CSAC (gm/ml)

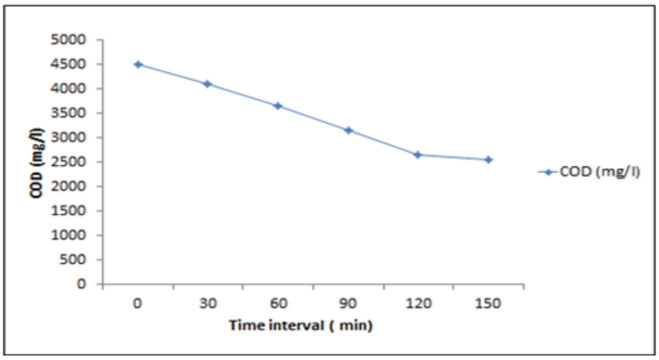

Figure 5: Effect of Contact time on Reduction of COD after adding SBFA (gm/ml)

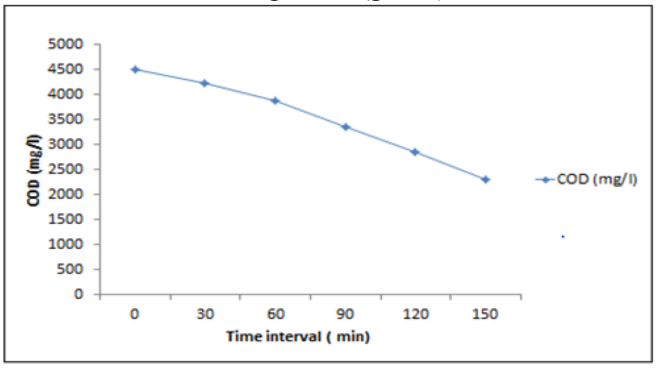

Figure 6: Effect of Contact time on Reduction of COD after adding Combination of CSAC and SBFA

4. Conclusion

Reduction of COD from wastewater using Coconut shell activated carbon and Sugarcane bagasse fly ash as adsorbents has been experimentally determined and the following observations are made:

This study leads us to the conclusion that, efficient techniques for the removal of highly toxic organic compounds from water and wastewater have drawn significant interest. Adsorption is recognized as an effective and low cost technique for the removal of organic pollutants from water and wastewater, and produce high-quality treated effluent. The wastewater of pharmaceutical industry is highly polluted having higher COD value as adsorbent dose increases adsorption increases due to the availability of free sites. Coconut shell activated carbon gives maximum reduction efficiency constant time than sugarcane bagasse fly ash and combination of both the adsorbents. The problems will arises regarding the disposal of exhausted adsorbent can be solved either by activation or incineration or disposal after proper treatments.

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