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RESEARCH ARTICLE OPEN ACCESS

Evaluation of activated carbon efficacy for the treatment of pharmaceutical wastewater

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ABSTRACT:
Pharmaceutical residues, which occurrence in natural water system are in many cases virtually unaffected by conventional wastewater treatment. Accumulated in the environment, however, they can significantly impact aquatic life. The present study indicates that many pharmaceutical residues found in wastewater can be removed with activated carbon in a cost-efficient system that delivers higher resource utilisation and security than other carbon systems.Recent research has put a closer focus on adsorption with powdered activated carbon (PAC) than on granular activated carbon (GAC). Various experiments were studied using batch adsorption technique under different conditions of reaction time, initial pollutant concentration, adsorbent dosage, and pH. The treatment of the optimum conditions found is reaction time of 45min, pH of 7, and adsorbent dosage of 1000mg/l that is of 94+2%.

KEYWORDS: Adsorbent, granular activated carbon, pharmaceuticals, wastewater.

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I. INTRODUCTION:

In the past few decades, there has been a significant increase in the consumption of pharmaceuticals, which leads to an increase in their content in various environmental emission (1,15). Water is the most essential element to life on earth. In its purest form it is odourless, colourless and tasteless. Level of contaminants in aquatic ecosystems has increased due to discharge of industrial effluents in water which in turn has led to water demand for domestic and industrial purpose (1, 9, 11, 12, 15,16, 17, 18, 19).Organic micropollutants are ubiquitously found in the effluent wastewater of municipal wastewater treatment plants at concentrations in ng-µg/L range (thus the name), due to various human caused discharge (18). It is recognized that public perception of water quality is greatly influenced by the organic content. The presence of very small amounts of organics in water (less than 1ppm) is highly toxic and undesirable (2, 8).

Pharmaceutical compounds are typically produced in batch processes leading to the presence of a wide variety of products in wastewaters which are generated in different operations, wherein copious quantities of water are used for washing of solid cake, or extraction, or washing of equipment. The presence of pharmaceutical compounds in drinking water comes from two different sources: production processes of the pharmaceutical industry and common use of pharmaceutical compounds resulting in their presence in urban and farm wastewaters. The wastewaters generated in different processes in the manufacture of pharmaceuticals and drugs contain a wide variety of compounds. Further, reuse of water after removal of contaminants, whether pharmaceuticals or otherwise, is required by industry. In view of the scarcity of water resources, it is necessary to understand and develop methodologies for treatment of pharmaceutical wastewater as part of water management. This has to be removed from the wastewater before its discharge in to the environment (3, 10).

The adsorption process is one of the effective methods for removal organics and color from the waste effluent. The process of adsorption has an edge over the other methods due to its sludge free clean operation and completely removed pollutants, even from the diluted solution. Activated carbon (powdered or granular) is the most widely used adsorbents because it has excellentadsorption efficiency for the organic compound. Furthermore, regeneration using solution produced smalladditional effluent while regeneration by refractory technique.

In this study the treatment of pharmaceutical wastewater using activated carbon.

II. MATERIALS AND METHODS:

Pharmaceutical sample has been collected from the jeedimetla industrial estate. The initial characterization of the effluent has been done using standard methods for water and wastewater 2005 (APHA,2005).

Commercially available activated carbon has been used in this study. The four factors effect of contact time, concentration, pH and adsorbent dose have carried. The experiment performed by changing one of the parameters at a time while the other parameters were fixed. The batchadsorption tests have been carried out by shaking 250ml working solution in a stoppered conical flask. The conical flasks were placed on rotary shaking machine for one hour at 150 rpm. The progress of adsorption during the experiment was determined by removing the flask after desired contact time and analyzing the supernatant solution spectro-photometrically and APHA, 2005. Different concentration of the pollutants maintained using dilution method. Adsorption tests were performed attemperature 29°C ±2. The spectrophotometric readings were recorded and further calculations were doneto see the removal efficiency of the adsorbents. The removal efficiency was calculated using following formulae:

$$\% \text{ Removal efficiency} = \frac{(Ci-Cf) \times 100}{Cf}$$

Where, Ci is the initial concentration of pollutant in solution and Cf is final concentration of pollutant in solution.

III. RESULTS AND DISCUSSION

Table. 1: Initial characterization of the pharmaceutical sample

S. No.	Parameters	Concentration (mg/l)
1	pH	7.2 + 0.2
2	COD	1700 + 10
3	TOC	1200 + 10
4	BOD	940 + 5
5	TS	1940 + 10

3.1 Effect of Initial Concentration and Contact Time

It is well-known that the pollutants concentration plays as an important role in the adsorption process, which can impel strongly the solute molecules to overcome mass transfer resistance between the liquid and the solid phases (4). Figures-1 show the effect of different initial concentrationson the adsorption capacity of GAC. As seen from the Figure the percentage of adsorption decreases with increasing initial concentrations of pollutants with AC. Almost 71.5% of COD removal was observed for 4times dilution with AC. Figure shows that the initial concentration has a marked effect on the contact time necessary to reach adsorption equilibrium. It can be found that a rapid uptake occurred for the initial concentration at 3times dilution, where over 70.4% of COD removed with AC within 45 min. Whereas, for the initial concentration of direct sample found relatively slow uptake and could be observed 46% removal with AC. At low concentration, the ratio of dye molecules to the number of available adsorption sites on adsorbent may be limited and consequently the adsorption process may mainly occur on the exterior surface. The rate of adsorption is fast in this stage, resulting in short time. With an increase in the amount of pollutant molecules, the situation changes and lots of dye molecules are probably adsorbed by the interior surface of adsorbent by pore diffusion after the adsorption of the exterior surface reaches saturation. Similar discussion has been reported by Hameed et al. for studying adsorption processes for methylene blue (5).

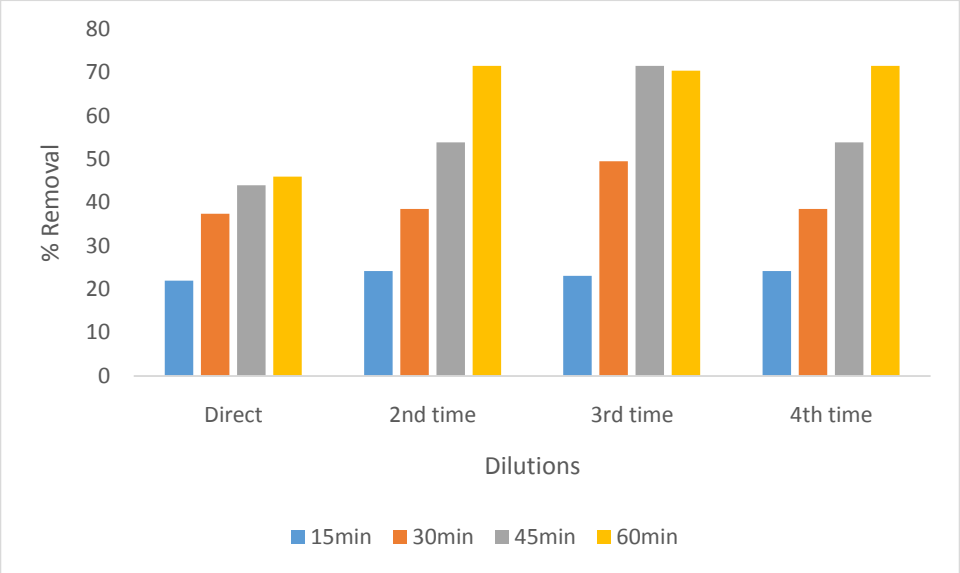

Fig-1 Effect of Initial Concentration and Contact Time

Conditions: Volume of the sample: 250ml; Adsorbent dosage: 100mg/l; Reaction time: 15, 30, 45, 60min, Dilution: Direct, 2, 3, 4 times, pH-7.

3.2 Effect of Adsorbent Dosage

To understand the effect of adsorbent dosage and initial concentration, the adsorbent dosage varied between 100mg/l and 1000mg/l and the typical results are shown in Figure-2. As expected, an increase in adsorbent dosage leads to an increase in the percentage removal of COD Initially, a rapid enhancement of COD removal was observed with increasing the dosage from 100 to 1000 mg that is of 44 to 94.6. As the adsorbent dosage increases, the adsorbent sites available for the dye molecules also increase and consequently better adsorption (4).

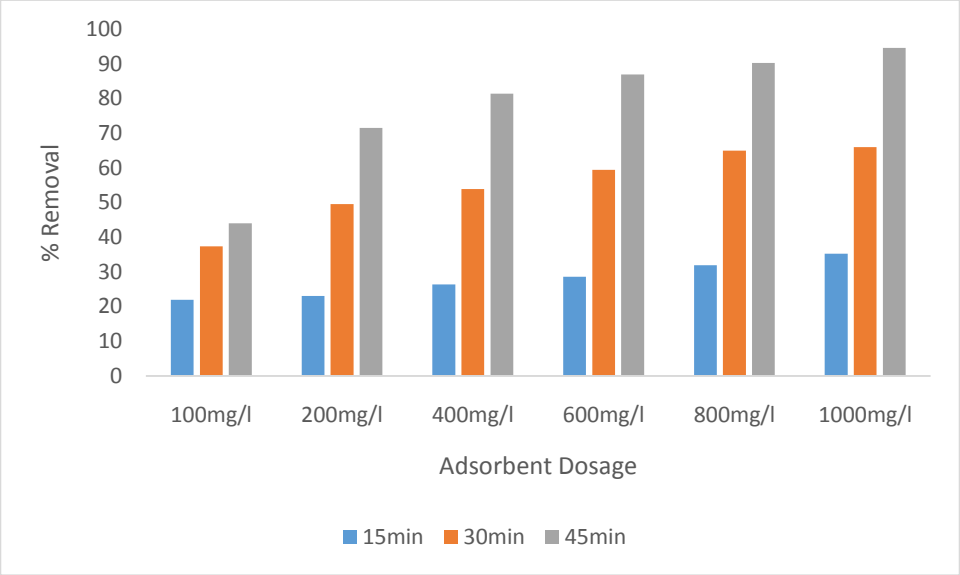

Fig-2 Effect of Adsorbent Dosage

Conditions: Volume of the sample: 250ml; Adsorbent dosage: 100, 200, 400, 600, 800, 1000mg/l; Reaction time: 15, 30, 45min, Dilution: Direct; pH-7.

3.3 Effect of pH:

The pH of the solution plays as an important factor in the adsorption process, which may alter the surface properties of the adsorbent as well as the degree of ionization of the dye. The influence of pH on the organics adsorption onto AC was studied and amount of adsorbent 1000 mg/l in the pH range of 2–11 and the results are shown in Figures. Clearly, the amount adsorbed and the percentage removal efficiency of COD on adsorbent increased as the pH of aqueous solution increased from 2 to 11. This might be due to cationics presence in its structure. In carbon-aqueous systems the potential of the surface is determined by the activity of H^+ ions, which react with the carbon surface. For the carbon surface the potential determining ions are H and OH_2 and complex ions formed by bonding with H1 and OH_2. The broken bonds along the surface of the carbon result in hydrolysis.

At low pH

Carbon- OH + H^+ ⟶ Carbon- OH_2^+

At high pH

Carbon-OH + OH^- ⟶ Carbon-O^- + H_2O

In our studies the rate of adsorption is high at higher pH.With the increase of pH value, the negative charge increaseson the surface of adsorbent and the surface will then exhibita cation exchange capacity (6, 7).

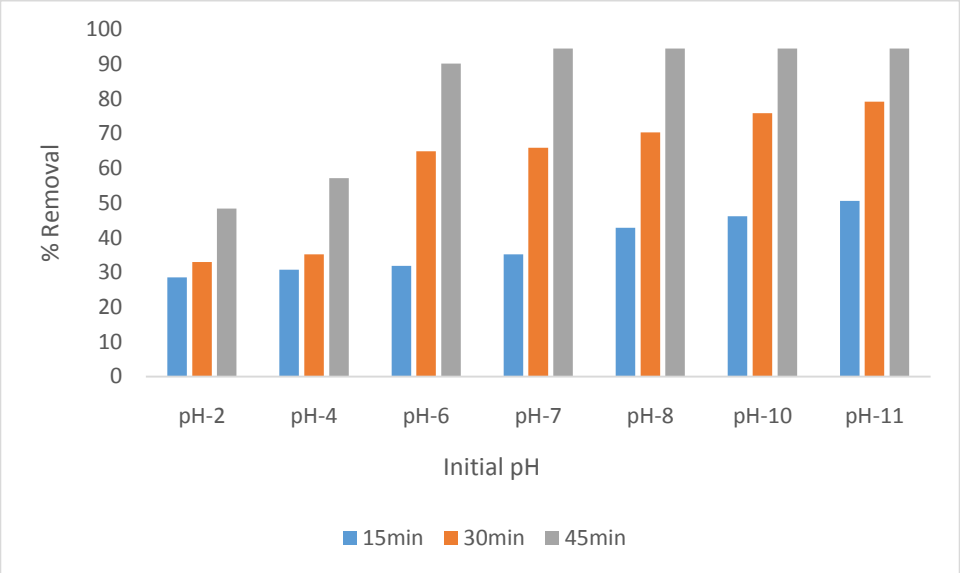

Fig-3 Effect of pH

Conditions: Volume of the sample: 250ml; Adsorbent dosage: 1000mg/l; Reaction time: 15, 30, 45min, Dilution: Direct; pH-2,4,6,7,8,10,11.

IV. CONCLUSION:

1.The optimum reaction time, pH, and adsorbent dosage isof 45min, 7 and 1000mg/l and found the maximum removal of 94.6% of COD.

2. This study concludes that the Activated carbon is useful for the treatment of the pharmaceutical wastewater.

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