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Research Article

Adsorption of Reactive Dyes from Textile Wastewater Using Corn Stalk Activated Carbon

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ABSTRACT

Extensive use of synthetic dyes in textile industry has created a major pollution problem. Among various treatments, adsorption has been considered as a better process due to its effectiveness of removing color from wastewater. In this present work, the efficiency of activated carbon prepared from corn stalk for removal of reactive dye from textile wastewater was studied. Corn stalk was chemically activated with KOH, followed by carbonizing in a muffle furnace. The carbonized corn stalk was characterized by SEM and FTIR spectroscopy. Adsorption of three reactive dyes were carried out by preparing dye samples in laboratory and taking dye wastewater from BDTSC. Adsorption was carried out under the control of three different factors namely contact time, adsorbent dosage and pH. Optimum time, pH and adsorbent dosage for adsorption process were found to be 60 minutes, 3.8 pH and 4 g/L respectively. Using those optimum operating parameters, the adsorption capacity of prepared activated carbon for Reactive yellow-145, Reactive red-2, Reactive blue-19 and wastewater taken from BDTSC was 96.9%, 95.5%, 97.1% and 88% respectively. Langmuir and Freundlich adsorption isotherm models were used to simulate the equilibrium data for the adsorption process. The result indicates that the adsorption process best fits with Freundlich isotherm. The produce activated carbon was also shown a reduction of BOD, COD, TDS, TSS and turbidity.

Keywords: Activated carbon; Corn stalks; Reactive dye; Adsorption; Textile waste water; Adsorption isotherm

INTRODUCTION

Contaminants such as color, heavy metals, cyanides, toxic organics, nitrogen, phosphorous, phenols and suspended solids from the industries and untreated sewage sludge from the domestic processes have become a great concern to the environment and public health. Color is the first sign of contamination recognized in wastewater, since dye concentrations in watercourse higher than 1mg/L caused by the direct discharges of textile effluent is highly visible and affect the aesthetic merit, water transparency and gas solubility in lakes, rivers and other water bodies [1]. Therefore, textile industry is one of the industries that produce a high volume of waste water and cause water pollution. Dyes in wastewater from textile and dyestuff industries are difficult to remove. This is because dyes are usually synthetic and have complex aromatic structures which make them more stable consequently they are difficult to biodegrade [2].

Over 50% of cotton products are colored with reactive dyes which offer good proportion of the total market ranges from 20% to 30%. The reason behind this popularity of reactive dyes for dyeing of cotton fiber is that its molecules, containing one or several reactive groups, chemically react with the fiber polymers to form a stable chemical linkage (covalent bond) between the dye molecules and fiber polymer [3]. Wastewaters from textiles do not only deface the look of natural waters, but are also highly toxic. Some dyes are reported to harm mammalian cells by causing kidney tumors and reproductive difficulties. These dyes are also potentially carcinogenic in many mammalian species [4]. Accumulation of dyes in wastewater from industries such as textiles, paper, cosmetics, rubber, and plastics has been regarded as a significant source of water pollution. Reactive dyes, an anionic in water, are most commonly used due to their provision of bright colors, excellent color fastness, and easy application. [5] However, many reactive dyes are toxic to organisms and may cause direct harm to aquatic life. As the dyes are structurally complex, are of synthetic origin, and have high water solubility, their removal from effluent by the use of conventional physico-chemical and biological processes is difficult [6]. However, it has been reported that the adsorption technique provides a potential for the removal of dyes from aqueous solutions. It has been estimated that the total dye consumption in textile industry worldwide is more than 10,000 tons per year and about 10–15% of these dyes are released as effluents during the dyeing processes. These effluents can cause

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potential pollutants to human beings and to aquatic life. Various Physical, Chemical and Biological separation technologies are used in the removal of this effluent. All of these methods have their own advantages and disadvantages. However, adsorption process is considered to be a very effective physical separation technique in wastewater treatment in terms of simplicity of design, ease of operation and insensitivity to toxic substances provided adsorbents are locally available with little or no value.

The full introduction of adsorption technology in to the practice of deep cleaning of dye wastewater is inhibited by the high cost of activated carbons and by problems with their regeneration. In recent years, attention of chemists has been focused on low-cost adsorbents (bio sorbents) from agricultural waste. The agricultural countries have abundant source of straw, stalks, hulls, The full introduction of adsorption technology in to the practice of deep cleaning of dye wastewater is inhibited by the high cost of activated carbons and by problems with their regeneration. In recent years, attention of chemists has been focused on low-cost adsorbents (bio sorbents) from agricultural waste. The agricultural countries have abundant source of straw, stalks, hulls, leaves etc. Plant biomass is a natural renewable source that can be converted into useful material and energy. Disposal of residue from agriculture is currently a major economic and ecological issue. However, the abundance and availability of corn stalk as agricultural by-product make them good sources of raw materials for a lot of uses, and converting it to adsorbents such as activated carbon represents a possible outlet. In this present work, use of activated carbon from corn stalk for adsorption of reactive dyes from textile, wastewater has been investigated. The main aim this research work is to study the efficiency of carbonized corn stalks for the removal of reactive dyes from textile waste water; to produce activated carbon from corn stalks and to study the effect of the operating parameters, such as absorbent dose, pH and mixing time on the treatment performance of absorption process.

MATERIALS AND METHODS

The equipment and tools used to achieve the objective of this present work were Oven drier, Nabertherm muffle furnace, desiccator, measuring cylinder, beakers, magnetic stirrer, weighing balance, pipette, filter paper, pH meter, DO meter, COD digester, Turbidity meter, TDS meter, Perkin Elmer UV-visible spectroscopy lambda 25, Perkin Elmer FTIR spectroscopy, Scanning Electron Microscope (SEM), BOD incubator and corn stalk.

Reactive dyes (Reactive yellow 145, Reactive red 2, Reactive blue 19), hydrochloric acid, potassium dichromate, silver sulphate, ferrous ammonium sulphate, sulphuric acid, potassium hydroxide and sodium hydroxide, mono potassium phosphate, sodium hydrogen phosphate, sodium bicarbonate, acetic acid and sodium acetate were used.

Carbonization and adsorption process. Central composite design was selected for designing and optimizing operating parameters. Corn stalk has been collected from local agricultural field found around Bahir Dar city in Zenzelima farm land. The leaves were manually removed from the stalk (Figure 1). The collected corn stalk was chopped into small pieces, washed with tap water to remove dirt and suspended impurities. The washed stalk was sun dried for three days. According to the stalk was soaked in 3mol/L potassium hydroxide for 8h, followed by neutralizing in 2mol/L HCL. KOH was used as activating agent to reduce the formation of tar, and help to generate pores by partial oxidation. After soaking, the stalk was washed and sun dried for three days. Then, the sun dried stalk was further dried in an oven drier at 110°C for two hours. The dried stalk was carbonized in Nabertherm muffle.

Figure 1: Corn Stalk.

At the end of each carbonization experiment, the samples were withdrawn from the Nabertherm muffle furnace and put in Dissector for cooling purposes. The produced activated carbon was then crushed to small particles using Jaw crusher (BB50). Then, the samples were sieved to identify its particle size. Sieve of pores size 0.075 mm – 0.5 mm were used, and the smallest particle size was used for adsorption purposes. The sieved activated carbon at particle size of 0.075 mm was stored in plastic bottle for further adsorption process.

Moisture and ash content of the produced activated carbon was determined according to ASTM D-2866-89. Volatile matter content was determined according to ISO 56/1974. The functional group and morphology were studied using Perkin Elmer FTIR spectroscopy and Scanning Electron Microscope respectively.

Conducting adsorption

Batch adsorption experiments were conducted to study the influence of parameters such as; contact time (min), adsorbent dose (g/L) and pH on the removal of color from textile wastewaters. Three factors; contact time, pH and adsorbent dosage were considered for conducting the experiment. The contact time, pH and adsorbent dosage used for adsorption process were 30-60 min, 3-11 and 2-4 g/L respectively. Surface response methodology was used for analyzing and optimizing the operating parameters; each experiment was conducted with three replicas. Totally, 45 experimental runs were conducted for adsorption process (Figure 2).

The adsorption process is usually studied through graphs known as adsorption isotherm. That is the amount of adsorbate on the adsorbent as a function of its concentration at a constant temperature. Standard solution of Reactive yellow-145 dyes with known concentration was prepared to determine calibration curve. Dye concentrations of 5 mg/L-25 mg/L were prepared to draw a calibration curve. Adsorption was carried using initial dye concentrations of 100 mg/L-500 mg/L at room temperature. The value of equilibrium dye concentration (Ce) and equilibrium adsorption (qe) were calculated from calibration curve and absorbance values after treatment. Langmuir and Freundlich isotherm models were used to analyze the equilibrium data. The obtained data was converted to linear form of Langmuir and Freundlich model, the value of R2 was computed.

Effect of pH and contact time on dye adsorption

The result indicates that variation of pH affects the adsorption capacity of the prepared activated carbon. It was indicated that the prepared activated carbon has higher adsorption capacity in an acidic media. At low pH there is an increase in the H+ ions in solution. The dye molecule is negatively charged; this result in electrostatic interaction between the dye molecule and the adsorbent resulting in higher percentage dye removal.

The efficiency of adsorption is dependent on the solution pH, since variation in pH leads to the variation in the degree of ionization of the adsorptive molecule and the surface properties of adsorbent. Solution pH determines the surface charge of the adsorbent and the degree of ionization of the adsorbate, which affects the adsorption of dyes on activated carbon.

The result indicates that adsorption capacity of the prepared activated carbon was increased with increasing contact time. As time increases from 30 to 60 min the adsorption capacity increases since it reaches saturation point at this point.

CONCLUSION

Corn stalks activated carbon can be used as a very efficient and cheap adsorbent for the removal of reactive dyes and other several pollutants from textile wastewater. Carbonization temperature and time are important parameters in corn stalks activated carbon preparation. Parameters such as contact time, pH and adsorbent dosage should be controlled for effective adsorption processes.

This present research work establishes that corn stalk activated carbon was excellent low cost adsorbent for removal of reactive dyes from textile wastewater.

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