Treatment of Dairy Wastewater Using Saw dust as a Natural Low Cost Adsorbent

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Abstract – *The main aim of this experimental study is to compare the efficiency of saw dust activated carbon in treating dairy wastewater in both batch and column adsorption method. The parameters like turbidity, Total suspended solids, Total dissolved solids, Chloride, Biochemical oxygen demand(BOD), Chemical oxygen demand (COD) are effectively reducing in both batch and column adsorption method using saw dust activated carbon as an adsorbent. Batch study was conducted by taking adsorbent dosage as a variable parameter. Saw dust activated carbon was added into the dairy wastewater in the order of 20g, 40g, 60g, 80g and 100g respectively for a contact time of 60 min in the batch adsorption study. Column adsorption study was performed by taking flow rate and contact time as a variable parameter. Flow rate was varied in the order of 10 ml/min, 8 ml/min, 6 ml/min, 4 ml/min and 2 ml/min respectively. Contact time was varied in the order of 20 min, 40 min, 60 min, 80 min and 100 min. The maximum removal efficiency was obtained at 60 g adsorbent dosage for 60 min contact time in batch adsorption study. The maximum removal efficiency was obtained at a flow rate of 6 ml/min for a contact time of 60 min in column adsorption study. Saw dust activated carbon showed a maximum removal efficiency of 76 %, 72 %, 65.8 %, 72.9 %, 62.9 % and 57.7 % for turbidity, total dissolved solids, total suspended solids, Chloride, Biochemical oxygen demand and Chemical oxygen demand respectively in batch adsorption study and 68.6 %, 64.5 %, 60.7 %, 67.2 %, 53.8 %, 57.9 % for turbidity, total dissolved solids, total suspended solids, chloride, biochemical oxygen demand and chemical oxygen demand respectively in column adsorption study. This work shows sawdust activated carbon as an effective adsorbent in treating dairy wastewater*.

Key Words: Dairy wastewater, Saw dust activated carbon, Adsorbents, Batch adsorption study, Column adsorption study

1.INTRODUCTION

Water pollution has become one of the most serious problems in our society. Water is the most important resource and due to increased concern for the future of today's water supplies humans have been forced to develop new technologies to protect these bodies of water from contamination. Nowadays industrial growth creates environmental pollution and generates hazardous wastewater which is one of the major concerns for the mankind. The biggest problem due to the dairy industry is the disposal of wastewater which is not meeting the standards *(Bharati.S. Shete et al.,2013).* The dairy industry wastewater contains high concentrations of organic matter and therefore proper treatment prior to discharge is required. The dairy industry wastewater is generated primarily from the cleaning and washing operations in the milk processing plant which includes recovering product residues from the system, pre- rinse, detergent cycle, rinse, disinfectant cycle, potable water rinse. *(N.P.Shinkar et al.,2013)*.Dairy process equipment cleaning is an essential aspect of dairy production. The milk collected through cooperatives goes through many channel containers and thus is highly susceptible to bacterial as well as dirt contamination. The present study focuses on the effect of saw dust activated carbon in treating dairy wastewater by conducting batch adsorption and column adsorption study.

2.MATERIALS AND METHODOLOGY

Saw dust is the waste material generated by wood based industries. It is formed as small irregular chips or small trash of wood during chopping of logs of wood into different sizes *(Adeosun Jhonson et al.,2018)*.The dimension of saw dust depend on the varieties of wood and dimension of saw teeth. Dumping of saw dust on open land is posing threat to the environment. Therefore saw dust can be used as an adsorbent material to make water samples safe against almost all the physicochemical parameters but unsafe against bacteriological parameters. Though the saw dust adsorbent bring about the slight increase in the level of some elements in the water samples the contaminant level of those elements is still within the water quality guidelines. The surface charge of the sawdust and the electrostatic force between the adsorbent and the impurities may be responsible for the adsorption efficiency. Sawdust as a bio-waste of industry and agriculture has lots of applications in vast areas. A wood dust allergy can be characterized by sneezing, irritation of the nose and lungs and itchy skin. Exposure to excessive amounts of wood dust may irritate the eyes, nose, and throat. Workers may also experience shortness of breath, dryness and sore throat, conjunctivitis and rhinitis. Dermatitis is common and may be caused by the chemicals in the wood. For dermatitis, the skin may become red, itchy, dry, or blister. Allergic contact dermatitis may also develop. Respiratory system effects include decreased lung capacity, and allergic reactions in the lungs such as hypersensitivity pneumonitis, and occupational asthma. Hypersensitivity pneumonitis may develop within hours or days following exposure and is often confused with cold or flu symptoms because it begins with headaches, chills, sweating, nausea, breathlessness, etc. Tightness of the chest and breathlessness can be severe, and the condition can worsen with continued exposure. Some hypersensitivity pneumonitis conditions may be caused by moulds that grow on the wood. Occupational asthma may also develop. Western red cedar is a wood that has a clear association with the development of asthma (*Ednei Bruce Da Silva et al., 2019).*

Fig-1: Saw Dust

1.2 Activation of Adsorbent

Saw dust is burned in a furnace to obtain carbon from them. Saw dust ash obtained from carbonization is then ground for 5 minutes. The required amount of sawdust ash is mixed with 1M H_3PO_4 such that ratio of mass of saw dust ash to acid concentration is 1:1.The solution is then boiled at 80°C for 2 hours. After this second activation, the sample is dried for 24 hours at 100°C in an oven. Adsorbent is activated both thermally and chemically to improve the surface properties of adsorbents to increase the treatment efficiency.

Saw dust char contain more than 50% of ash which creates problem for pore development in the activated carbon. After removing the ash from the husk char the porosity of char is increased significantly. After activation with chemicals like phosphoric acid the char develops more pores. . Saw dust does not dissolve in water but very small particles of sawdust can create a colloidal suspension and change the colour of water.

Fig-2: Activation of Saw dust ash

Phosphoric acid rapidly oxidize the organic carrier, split off water and CO_2 from the organic material and oxidize the substrate to form a scorched brown to a black charcoal like powder which remains in the mix.

Fig-3: Saw dust activated carbon

2. Batch adsorption study

A batch adsorption experiment from the liquid phase, also known as immersion experiment, is one of the most common tests used to measure adsorption equilibrium and kinetics from solutions. It consists of the addition of a known mass of sample to a fixed volume of liquid at an initial concentration. The dairy wastewater was treated with saw dust activated carbon by varying its dosage as 20g, 40g, 60g, 80g, 100g for a period of one hour by agitating it under the jar test apparatus. Sawdust has usually low bulk density, high water porosity, low air porosity, and low cation exchange capacity. The main chemical components of saw dust are carbon 60.8 %, hydrogen 5.19 %, oxygen 33.83 % and nitrogen 0.90 %. The specific gravity of saw dust ash is 2.03 and loss in ignition is 4.27 %.

Fig-4: Experimental set up for batch study

The dairy wastewater was treated with saw dust activated carbon by varying the rate of flow of wastewater as 10 ml/min, 8 ml/min, 6 ml/min, 4 ml/min and 2 ml/min respectively. The time of collection of dairy wastewater through the column set up after filtration was varied in the order of 20min, 40min, 60 min, 80 min and 100 min respectively. The dosage of adsorbents was kept constant as 60g since the optimum dosage of adsorbents were 60 g in the batch adsorption study performed by taking adsorbent dosage as a variable parameter.

Fig-5: Experimental set up for column study

Ashing of sawdust eliminates high carbon content, and creates charged centres on its structure capable of removing specific water pollutants .While performing the column adsorption study using these adsorbents, there is a chance for the filter to get clogged. As a result to prevent clogging filter aids are used. Filter aids are the substances used to prevent the filter medium from becoming blocked and to form an open, porous cake, hence reducing the resistance to flow of the filtrate. Filter aid forms a surface deposit which screens out the solids and also prevents the plugging of the supporting filter medium. Usually cotton balls, diatomaceous earth, saw dust and rice husk are used as filter aids.

3. RESULTS AND DISCUSSIONS

For batch adsorption study optimum results were obtained at 60 g of adsorbent dosage. Saw dust is having a maximum removal efficiency of 76% for turbidity. After treating with saw dust, the sample is still in the alkaline range. Saw dust is having a maximum removal efficiency of total dissolved solids upto 72% Saw dust is having a maximum removal efficiency of total suspended solids upto 65.8%.Saw dust is having a maximum removal efficiency of chloride upto 72.9 % . Saw dust is having a maximum removal efficiency of biochemical oxygen demand upto 62.9 %. Saw dust is having a maximum removal efficiency of chemical oxygen demand upto 57.7 %.

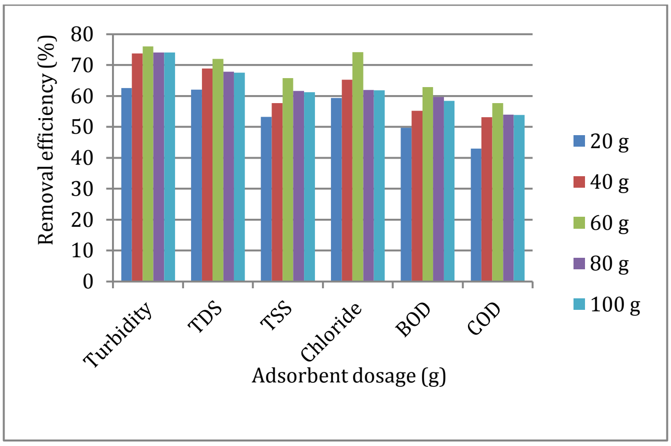

Fig-6: Removal efficiency of parameters in batch adsorption study

Adsorption study was performed with saw dust activated carbon by the column adsorption method by varying the rate of flow of wastewater and time of collection of treated water through the column set up to find out the best suited conditions to get maximum removal efficiency of impurities from aqueous media. For column adsorption study optimum results were obtained at 6 ml/min flow rate and contact time of 60 min. Taking flow rate as a variable parameter, saw dust is having a maximum removal efficiency of 68.6 % for turbidity. pH of dairy wastewater is still in the alkaline range. The saw dust is having a maximum removal efficiency of 64.5% for total dissolved solids and a maximum removal efficiency of 60.7 for total suspended solids. The saw dust is having a maximum removal efficiency of 64.5% for total dissolved solids. The saw dust is having a maximum removal efficiency of 67.2 %, respectively for chloride and a maximum removal efficiency of 53.8 % for biochemical oxygen demand. The saw dust is having a maximum removal efficiency of 57.9 % for chemical oxygen demand.

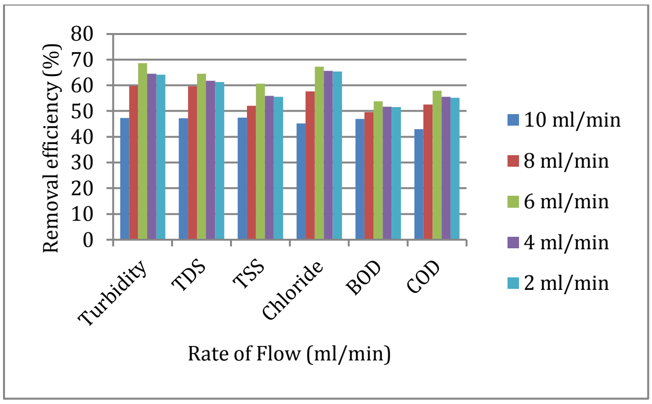

Fig-7: Removal efficiency of parameters in column adsorption study taking flow rate as a variable parameter

Taking contact time as a variable parameter, saw dust is having a maximum removal efficiency of 55.6 % for turbidity. Sawdust is able to keep the pH of dairy wastewater still in the alkaline range. The saw dust is having a maximum removal efficiency of 65.4 % for total dissolved solids and a maximum removal efficiency of 64.2 % for total suspended solids. The saw is having a maximum removal efficiency of 64.6 % for chloride and a maximum removal efficiency of 63.3 % for biochemical oxygen demand. The saw dust is having a maximum removal efficiency of 65.9 % for chemical oxygen demand. Optimum results were obtained at a contact time of 60 min.

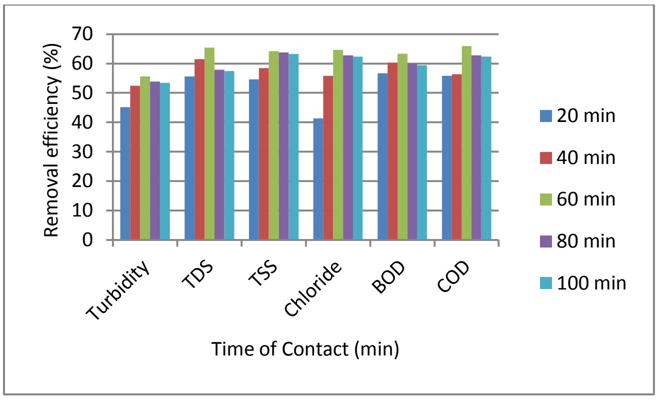

Fig-8: Removal efficiency of parameters in column adsorption study taking contact time as a variable parameter

3. CONCLUSIONS

In batch adsorption method, saw dust showed a maximum removal efficiency of 76% for turbidity. Saw dust is able to keep the pH of wastewater still in the alkaline range. Sawdust is having a maximum removal efficiency of 72 % for total dissolved solids and a maximum removal efficiency of 65.8% for total suspended solids. Saw dust is showing a maximum removal efficiency of 72.9 % for chloride and a maximum removal efficiency of 62.9 % for biochemical oxygen demand. The saw dust is having a maximum removal efficiency of 57.7% for chemical oxygen demand. Optimum results were obtained at 60 g of adsorbent dosage for a contact period of 60 min. In column adsorption method the rate of flow of wastewater and the time of contact of wastewater with the sawdust activated carbon filled in the column study apparatus was varied. While taking flow rate as a variable parameter, saw dust is having a maximum removal efficiency of 68.6 % for turbidity. Sawdust is able to keep the pH of dairy wastewater in the alkaline range. Sawdust is having a maximum removal efficiency of 64.5% for total dissolved solids and a maximum removal efficiency of 60.7 % for total suspended solids. The saw dust is having a maximum removal efficiency of 67.2 % for chloride and a maximum removal efficiency of 53.8 % for biochemical oxygen demand. The saw dust is having a maximum removal efficiency of 57.9 % for chemical oxygen demand.

While taking time of contact as a variable parameter, saw dust is having a maximum removal efficiency of 55.6 % for turbidity. Sawdust is able to keep the pH of wastewater still in the alkaline range. The saw dust is having a maximum removal efficiency 65.4 % for total dissolved solids and a maximum removal efficiency of 64.2 % for total suspended solids. The saw dust is having a maximum removal efficiency of 64.6 % for chloride and a maximum removal efficiency of 63.3 % for biochemical oxygen demand. The saw dust is having a maximum removal efficiency of 65.9 % for chemical oxygen demand. Optimum results were obtained at a flow rate of 6 ml/min and contact time of 60 min.

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