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Removal of TDS and BOD from Synthetic Industrial Wastewater via Adsorption

Maruf Mortula[+] and Sina Shabani

Civil Engineering Department, American University of Sharjah

Abstract. The discharge limits of industrial wastewater effluents are subjected to regulations which are getting more restricted with time. The purpose of this paper is to review the process of adsorption and its effects on TDS and BOD removal of synthetic industrial wastewater prepared in the laboratory of the American University of Sharjah. Batch tests were performed using different adsorbents like limestone aggregate, activated alumina, activated carbon, and steel slag. The effect of pH as variable was studied on the most suitable adsorbent. Significant removals of TDS and BOD were observed in these experiments showing that using effective adsorbents can aid such removals to a large extent.

Keywords: Adsorption, Batch test, Synthetic wastewater, TDS Removal, and BOD Removal

1. Introduction

A significant growth has occurred in the industries of developing countries in the recent years. These industries discharge wastewaters which carry high concentrations of dissolved solids and biochemical oxygen demand (BOD). These effluents should be treated for safe disposals which meets the regulations imposed on industrial sectors. Industrial wastewaters have high concentrations of total dissolved solids (TDS) and it has been a difficult task for engineers to remove them from industrial wastewaters (Table 1) [1]. TDS values can exceed 100000 mg/L. Other characteritics such as high values of BOD and TSS are common problems associated with industrial wastewater (Table 1). BOD values can exceed 200000 mg/L. High amounts of TDS, and BOD are associated with different types of industries such as tanning, textile, milk, cheese, yogurt, buttermilk, distillery, and etc [7-14]. Food processing industries are one of the major sectors which consume a huge amount of water for their production process [2], Such industries consist of different kinds of production like diary products, beverages, vegetables and fruits, and meat [2]. Wastewaters produced by food processing industries do not have high amount of toxic pollutants, however, they are high in concentrations of organics loading, BOD, and TDS[3]. One study examined the quality of receiving soil and water for discharged food processig wastewater in Nigeria showing there is a neccesity for treatment prior to discharge since wide range of pollutants can damage the environment significantly[4]. Existing wastewater treatment technologies often find it difficult to reduce high BOD and TSS values to meet water quality regulations. There is growing necessity for finding versatile treatment technologies to be used as a polishing unit. Adsorption is one such treatment process for different types of water [5]. Removal of organic compounds has been observed using activated carbon, activated alumina, and activated bauxite as adsorbents [5], and it is one of the technologies in treatment of different water resouces or wastewaters which has been frequently used to remove organic pollutants [6].

The objectiveof this research was to evaluate the effect of different adsorbents on coupled removal of BOD and TDS from synthetic industrial wastewater. Moreover, the effect of pH on TDS removal is studied through conducting some experiment by controlling pH value with the same amount of adrobents.

[+] Corresponding author. Tel.: Tel.: + (971- 6 515 2648); fax: + (971- 6 515 2979).
E-mail address:mmortula@aus.edu

Table.1: Literature on characteristics of industrial wastewater

Srl. No.	Wastewater	TDS (mg/L)	BOD (mg/L)	TSS (mg/L)	Reference
1	Tanning factory	6850	959.66	4200	[7]
2	Textile industry	130450	3900	-	[8]
3	Dairy Industry	-	8239	7175	[9]
4	Cheese Industry	-	3000	1100	[10]
5	Tannery (soaking)	22000-33000	1100-2500	3000-7000	[11]
6	Yogurt and Buttermilk	-	1000	191	[12]
7	Distillery Wastewater	52,000–112,000	36,000–204,000	-	[13]
8	Mixed wastewaters	247	877	262	[14]

2. Materials and Methods

2.1. Materials

Wastewater samples were prepared in the Lab using commercially graded sugar ($C_6H_{12}O_{16}$) to simulate same BOD and TDS of the wastewater from food processing industries. 200 mg of sugar ($C_6H_{12}O_{16}$) was added to 2 L of deionised water. There is an approximate 1:1 ratio between sugar and biochemical oxygen demand expected. The amount of sugar added was 100 mg/L to expect a BOD value around 100 mg/L. Commercially available adsorbents such as limestone aggregate, activated alumina, activated carbon, and steel slag were used in the experiments.

2.2. Experimental Approach

Batch experiments were conducted in the laboratory. In these experiments different types of adsorbents such as limestone aggregate, activated Alumina, activated carbon, and steel slag were used. 10 bottles were used in these tests having two of them without adsorbents to check the initial TDS and BOD values, and for each adsorbent two bottles were used to check the accuracy of measurements. The initial dosage of adsorbents used in each bottle was 4 g/L followed by 1 hour of shaking with speed of 175 rpm. After shaking of the samples they were subjected to TDS and BOD analysis. Once suitable adsorbents were identified, the same dosage was used with variations of pH from 5-8 in order to check the effect of pH in TDS removal. 0.1 N of HNO_3 and NaOH were used as acidic and basic solutions to control pH in each bottle and pH was measured using a standard pH meter in these experiments.

2.3. Analytical Methods

The BOD tests were carried out using standard procedure using a DO probe. Seeds and Nutrient buffer pillows were added to the samples. Samples were diluted 15 times before the test followed by aeration to make sure enough dissolved oxygen will remain after five days of the test. 300 ml standard BOD bottles were used in these tests which were incubated at 20 ºC in a dark incubator. After five days the differences in oxygen consumption was measured to estimate BOD_5. For TDS analysis, 20 ml from each bottle were measured and collected after the batch tests. They were collected after passing through filter papers in 10 different containers which were labelled accordingly. After filtration of the samples, containers were kept in an oven with 103ºC for 24 hours. The subtraction of the weight of containers before and after the test represented the total dissolved solids in the synthetic wastewater prepared.

3. Results and Discussion

Experimental results indicated that all the adsorbents were effective in removing TDS from the samples (Fig. 1). Each adsorbent was duplicated to check the accuracy of the results and the whole experiment was repeated three times.

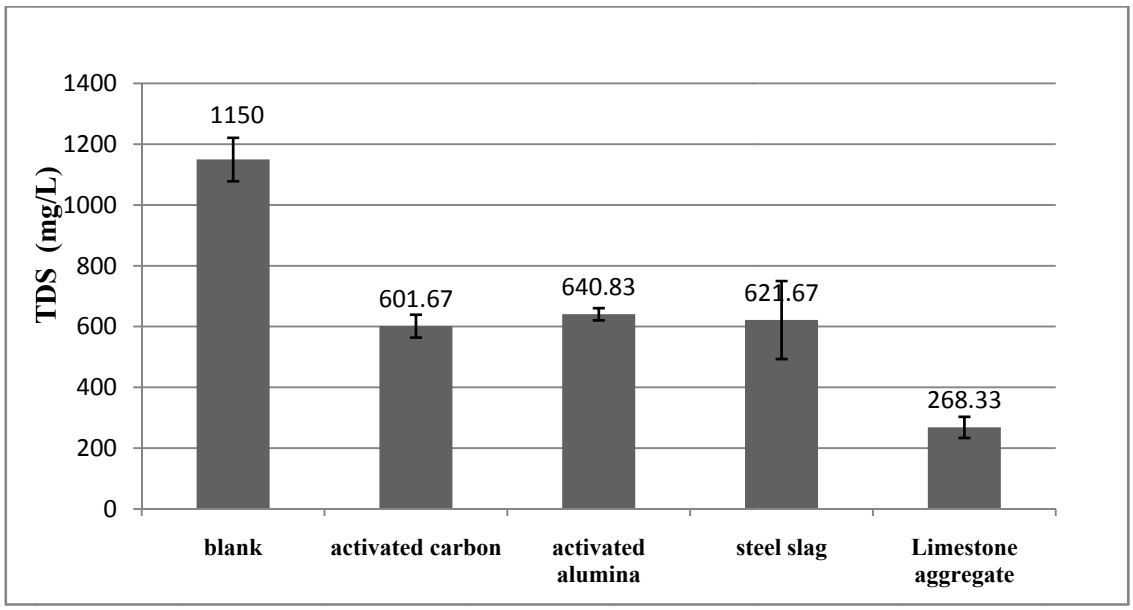

Fig. 1: Effect of Adsorbents on TDS Removal

As shown in Fig. 1, the removal of TDS was achieved using all types of adsorbents used in this experiment. Limestone aggregate was the most effective one which could remove up to 76.76 percent of original TDS present in the synthetic wastewater. Other adsorbents were less effective, especially steel slag removing 45.94 percent, activated alumina removed 44.28 percent, and activated carbon removed 47.68 percent of the TDS. Standard errors of the analytical techniques as shown through the error bars were insignificant with a maximum error of 6.2 percent.

BOD results of the same tests were shown in Fig. 2. Same as the previous graph, the vertical bars show the average values of the recorded data for BOD values of the batch experiments. All adsorbents were effective in BOD removal. The percentage removals of BOD for limestone aggregate, steel slag, activated alumina, and activated carbon were 45.6, 29.99, 49.64, and 34.20 percent in order. The error bars showing the standard deviation of all data from repeated experiments can prove the precision of the recorded data with a maximum error of 7.9 percent.

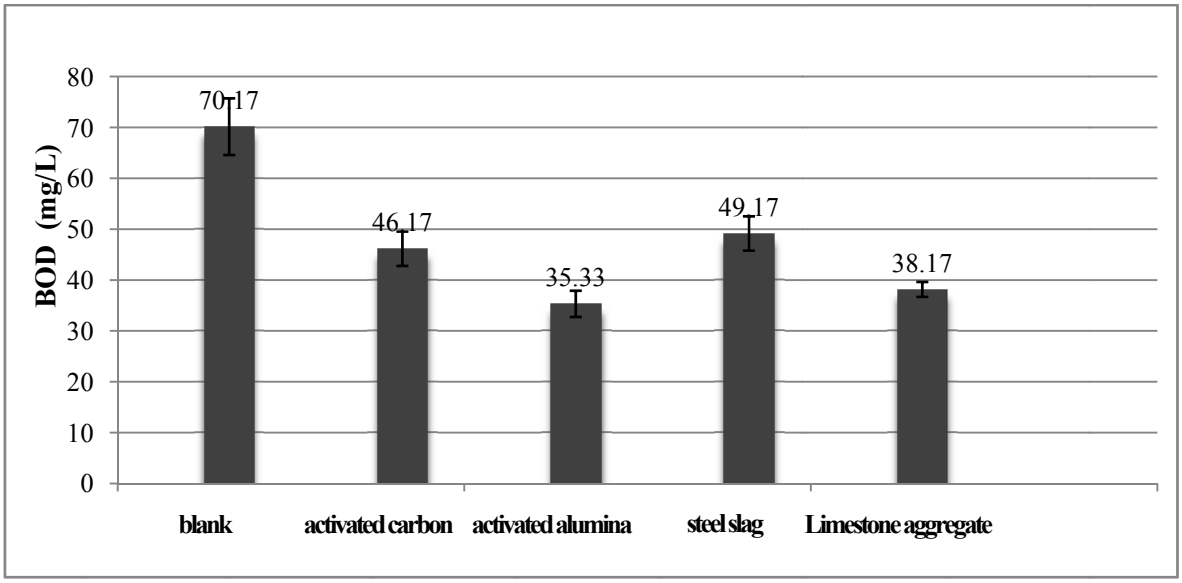

Fig. 2: Effect of Different Adsorbents on BOD Removal

As shown in Fig. 3, TDS values decreased with an increase pH levels until a pH of 7. After that, it started to increase.

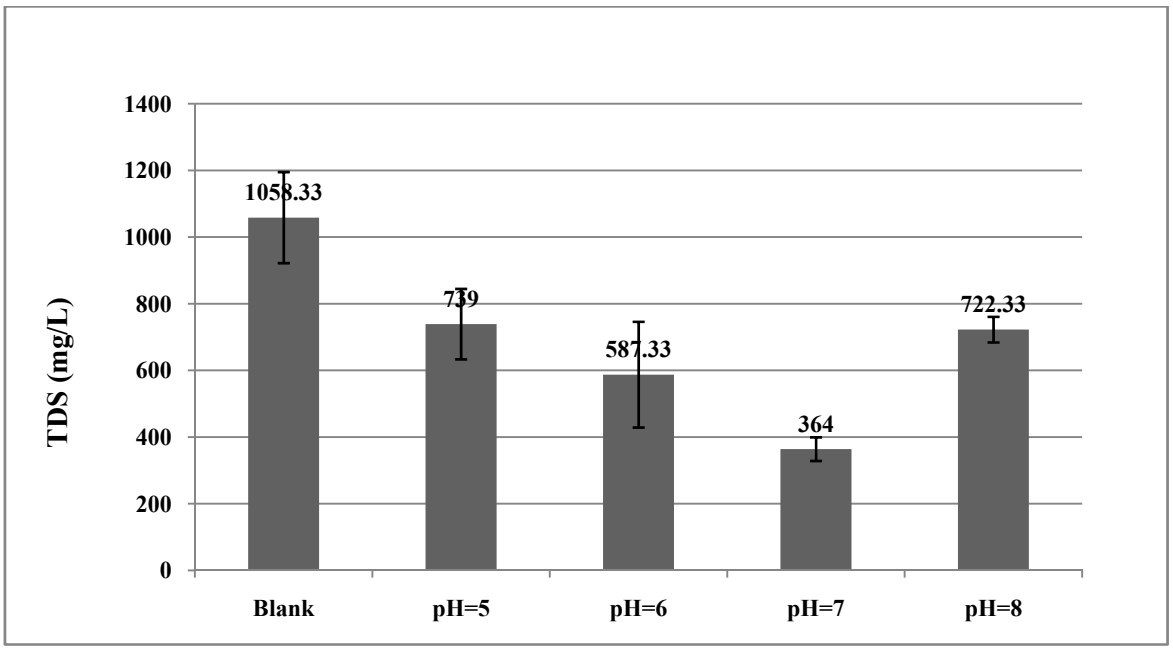

Fig. 3: Effect of pH on TDS Removal

4. Conclusion

Results of the conducted experiments showed that adsorption can significantly remove BOD and TDS from synthetic industrial wastewater. Limestone was observed to be the most effective in removing TDS and BOD. pH of 7 was observed to be the most appropriate for TDS removal. Some parameters like adsorbent dose, temperature, and other adsorbents can be used with different types of industrial wastewater for future studies.

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