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Research paper



A Study on Adsorption Capacity of Activated Carbons through Analysis of Variance (Anova)

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Abstract

Recycling and reusing the waste is one of the agenda of sustainable development. Hence this investigation was carried out on utilizing the industrial sludge as activated carbon. The sludge was collected from treatment unit of sugar mill industry, paper mill industry and tannery industry and activated carbon was prepared and named as sugar mill sludge activated carbon (SSAC), paper mill sludge activated carbon (PSAC) and tannery industry sludge activated carbon (TSAC). Batch studies were performed between dye solution and activated carbon to determine adsorption capacity of adsorbent and optimum contact time for the contact process. The optimum contact time and optimum dosage was found to be 120 min and 3.0 g respectively. The maximum adsorption capacity of SSAC, PSAC & TSAC on the concentrations of 10 mg/l of reactive dye solution for the dosage of 3.0 g was 100 %, 92.88 % and 88.54 %. The experimental data and analysis was checked by ANOVA table analysis to justify mathematically. As per ANOVA table the mean performance of SSAC is higher and TSAC is lower. So, finally it is concluded that the experimental results are justified by the ANOVA table analysis on the adsorption capacity of activated carbons.

Keywords: *adsorption; carbon; dosage; dye; sludge.*

1. Introduction

Converting the industrial sludge to activated carbon will reduce the transportation cost and cost of land filling. These carbons are used to treat industrial effluents. Various removal techniques for dye removal are followed which include photo-catalysis, coagulation and chemical oxidation. Preparing activated carbon from natural materials become expensive. Low cost adsorbent "prepared by Ashish [1]", from wood apple, removal of toxic dye by low cost agricultural by-product was "studied by Sushmita [2]", potato plant wastes were used for the removal of methylene blue and malachite green dye "by Neha [3]", Removal of methylene blue by adsorption onto activated carbon developed from Ficus carica bast was "investigated by Deepak [4]", adsorption of textile dyes on coconut shell activated carbon was " studied by Aseel [5]"", removal of a toxic dye, from aqueous solutions by a low cost agricultural by-product was "studied by Sushmita [6]", haloxylon recurvum plant stems were used for the removal of methylene blue dye "by Warda [7]" removal of toxic metals with activated carbon "prepared from Salvadora persica by Fazal Wahid" [8], blast furnace slag for "phosphate removal from waste water was used by Bruno [9]". So it essential to utilize waste materials and naturally available materials as adsorbents on conserving environment.

2. Materials and Methods

Batch study was carried out and the residual dye concentration was measured using UV-VIS Spectrophotometer. The agitation process was done in the dosage range of out with 1.0 to 4.0 g at different dosages of carbon. Since the experimental variables are more in numbers it was planned to check the results and data through analysis of variance (ANOVA) with sum of squares (SS), degree of freedom (DF) and mean square (MS).

3. Results and Discussion

Through batch adsorption studies the optimum contact time was determined as 120 min for the adsorbent dosage range of 1.0 g to 4.0 g. The maximum adsorption capacity of SSAC on higher concentrations of dye solution was 100 % and shown in Fig 1. Paper mill sludge activated carbon shows its performance through Fig.2 on dye removal and the maximum adsorption capacity reached at lower concentrations. The maximum adsorption capacity of TSAC on lower concentrations of dye solution was also 100 % and shown in Fig 3. The results shows that percentage of dye removal increases with increase in adsorbent dosage. A similar phenomenon was "reported by Chamargore [10] and Bulut and Aydin [11]". The results indicate that the percentage of dye removal decreased with increase in dye concentration for any dosage.

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3.1.1 Performance of SSAC

Analysis of Variance

Analysis of variance (ANOVA) is a statistical method used to test differences between two or more means. So to test the differences between the performance of three carbons (SSAC, PSAC & TSAC) ANOVA table was utilized.

To estimate and compare the mean performance of SSAC among different concentrations, analysis of variance was performed and the results are presented in the Table 1.

Table 1: ANOVA table of SSAC

Source	S S	D F	M S	F
Between groups	1930.217	5	386.0433	3.18**
Within groups	6541.603	54	121.1408	

**- significant at 1 % level

Since the F is significant, the null hypothesis of no difference in the mean performance of SSAC among different concentrations. The mean performance of SSAC among different concentrations is furnished in the Table 2.

Table 2: Mean performance of SSAC

Concentration	Mean	Rank
C_1= 10 mg/L	94.418	1
C_2= 20 mg/L	92.212	2
C_3= 30 mg/L	91.917	3
C_4= 40 mg/L	85.309	4
C_5= 50 mg/L	82.504	5
C_6= 60 mg/L	78.915	6

It is seen from the table 2 that the mean performance of SSAC is higher in the concentration $C_1$and is least in C_6.

3.1.2 Performance of PSAC

To estimate and compare the mean performance of PSAC among different concentrations, analysis of variance was performed and the results are presented in the Table 3.

Table 3: ANOVA table of PSAC

Source	S S	D F	M S	F
Between groups	9152.48	5	1830.496	20.93**
Within groups	4721.427	54	87.43383	

**- significant at 1 % level

Since the F is significant, the null hypothesis of no difference in the mean performance of PSAC among different concentrations. The mean performance of PSAC among different concentrations is furnished in the Table 4.

Table 4: Mean performance of PSAC

Concentration	Mean	Rank
C_1= 10 mg/L	76.245	1
C_2= 20 mg/L	72.808	2
C_3= 30 mg/L	54.307	3
C_4= 40 mg/L	52.177	4
C_5= 50 mg/L	45.739	5
C_6= 60 mg/L	45.130	6

It is seen from the table 4 that the mean performance of PSAC is higher in the concentration $C_1$and is least in C_6.

3.1.3 Performance of TSAC

To estimate and compare the mean performance of TSAC among different concentrations, analysis of variance was performed and the results are presented in the Table 5.

Table 5: ANOVA table of TSAC

Source	S S	D F	M S	F
Between groups	4681.352	5	936.2703	38.65**
Within groups	1308.027	54	24.22273	

**- significant at 1 % level

Since the F is significant the null hypothesis of no difference in the mean performance of TSAC among different concentrations. The mean performance of TSAC among different concentrations is furnished in the Table 6.

Table 6: Mean performance of TSAC

Concentration	Mean	Rank
C_1= 10 mg/L	55.453	1
C_2= 20 mg/L	50.232	2
C_3= 30 mg/L	43.777	3
C_4= 40 mg/L	35.728	4
C_5= 50 mg/L	33.501	5
C_6= 60 mg/L	31.750	6

It is seen from the Table 6 that the mean performance of TSAC is higher in the concentration $C_1$and is least in C_6.

Table 7: ANOVA table of SSAC, PSAC AND TSAC

Source	S S	D F	M S	F
Between groups	64853.96	2	32426.98	202.56**
Within groups	28335.11	177	160.0853	

Since the F is significant from the Table 7, the null hypothesis of no difference in the mean carbons among 3 different types. The mean carbon among different types is furnished in the Table 8.

Table 8: Mean performance of SSAC, PSAC AND TSAC

Type	Mean	Rank
SSAC	87.546	1
PSAC	57.734	2
TSAC	41.740	3

It is seen from the table 8 that the mean performance of carbon is higher in the SSAC and is least in TSAC.

4. Conclusion

The adsorption capacity of SSAC, PSAC and TSAC was investigated through batch studies with an optimum contact time of 120 minutes on various concentrations of dye solution. The result of batch study reveals that the adsorption capacity of carbon was higher in SSAC and least in TSAC. To check the performance of three carbons ANOVA table analysis was opted and analyzed. The ANOVA table analysis also expressed that the adsorption capacity of carbon was higher in SSAC and least in TSAC. Hence it is concluded that the experimental results are justified by the ANOVA table analysis on the performance of sludge based activated carbons.

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