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EVALUATION OF ADSORBENTS EFFICACY FOR THE REMOVAL OF POLLUTANTS FROM SUGAR MILL EFFLUENT

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ABSTRACT

Present study aims to compare efficacy of natural adsorbents, viz; activated charcoal, wood ash and bagasse pith for the removal of pollutants from sugar mill effluent. Experimental pots were filled with the adsorbents mixed soil separately and the surface sterilized seeds of *Solanum melongena* were equidistantly sown. Triplicates for a given adsorbent were maintained. Effluent irrigation to pots was done with its four concentrations i.e., 25%, 50%, 75% and 100% and the leachate collected from each treatment was analyzed. Pollutant removal efficiency of the adsorbents was found to be in the order of activated charcoal> bagasse pith> wood ash.

Keywords: sugar mill, adsorbent, activated charcoal, bagasse pith, wood ash.

INTRODUCTION

Sugar industry, the most important among agro based industries contributing significantly to rural economy in particular and national economy in general generates huge amount of waste during the manufacture of sugar. The waste contains a high amount of production load particularly, suspended solids, organic matters, press-mud and several air pollutants (Bevan, 1971, Hendrickson, 1971). Wastewater from sugar mills with its high Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Dissolved Solids (TDS) rapidly depletes available oxygen when discharged into water bodies and have adverse impact on aquatic life so much so rendering the receiving water unfit for drinking and domestic purposes, reducing crop yields if used for irrigation, and exacerbating corrosion in water systems and pipe (ETPI, 2001). Owing to high cost of dilution and inadequate sewage treatment facilities, effective and profitable utilization of the effluents is of paramount significance.

However, several conventional treatment technologies have been opted for treatment of wastewater contaminated with organic substances. Among them, adsorption as a wastewater treatment process has aroused considerable interest during recent years (Rao and Bhole, 2000) where in commercial activated carbon proved the most effective material for controlling the organic load. However, due to its high cost and about 10-15% loss during regeneration, unconventional adsorbents like fly ash, peat, lignite, bagasse pith, wood, saw dust etc. have paved way for thorough investigations, and also adsorption characteristics have been widely studied for the removal of refractory materials (Pandey *et al*., 1985) with varying degree of success. The present investigation is focused on efficiency evaluation of three natural adsorbents viz; activated charcoal, wood ash and bagasse pith for the removal of pollutants from sugar mill effluent.

MATERIALS AND METHODS

Effluent was collected from the sugar mill situated in Laksar, about 24 kms from Haridwar city, Uttarakhand. Effluent was collected from the point of its discharge. The experiment conducted under *in vivo* conditions, involves three adsorbents with four effluent concentrations i.e., 25%, 50%, 75%, 100% (v/v). The effluent was diluted with ordinary tap water to obtain the desired concentrations.

Equal quantities of adsorbent (20 g each) were taken and mixed with 4 kg soil filled in a pot. Triplicates of the treatments were maintained, ten superior quality seeds of *Solanum melongena* were sown in pots. Besides the treatment, a control set involving no application of adsorbent at a given effluent concentration was also maintained. For irrigation, 200 ml of respective concentration of the effluent was poured on per pot basis on alternate days. Leachate was collected after fixed hours of irrigation and brought to the laboratory for analysis of selected parameters such as, pH, turbidity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Dissolved Solids (TDS), Total Solids (TS), Chloride, Sulphate, Sodium, Potassium following (APHA, 1995).

RESULTS AND DISCUSSIONS

Physico-chemical analysis of different concentration of untreated and treated sugar mill effluent is shown in the Tables 1, 2, 3 and 4.

Table-1. Physico-chemical characterization of 100% sugar mill effluent treated with adsorbents.

Parameter	Control without adsorbent	Activated charcoal			Wood ash			Bagasse		
		10 d	20 d	30 d	10 d	20 d	30 d	10 d	20 d	30 d
pH	4.26	4.9	5.3	6.6	4.9	5.2	5.9	5.9	6.0	6.1
Turbidity	76.1	41.5	33.9	13.9	57.0	48.9	27.6	48.0	20.5	15.9
COD	2890.32	1102.5	968.4	688.43	1476.1	1223.3	941.34	1331.7	991.07	739.65
BOD	1711.00	993.21	633.12	502.13	1230.8	1123.0	707.67	1249.3	873.41	672.22
TDS	2998.32	1082.3	761.45	401.90	2013.0	1654.3	777.04	911.3	803.56	480.12
TS	3377.42	1109.3	931.02	703.09	2110.5	1789.6	934.12	1013.1	955.67	803.00
Na^{2+}	69.0	60	54	49	65	63	54	65	62	52
K^{+}	96.0	49	31	20	63	55	41	61	39	32
SO_4^{2-}	1410.6	980.1	745.3	460.23	1211.5	843.22	721.4	991.2	811.33	572.44
Cl^{-}	696.3	330.09	255.23	116.45	589.76	433.09	350.11	365.00	287.76	199.78

*All values are in mg/l except pH and turbidity is in NTU

Table-2. Physico-chemical characterization of 75% sugar mill effluent treated with adsorbents.

Parameter	Control without adsorbent	Activated charcoal			Wood ash			Bagasse		
		10 d	20 d	30 d	10 d	20 d	30 d	10 d	20 d	30 d
pH	4.61	6.2	6.8	7.1	5.8	5.9	6.5	6.1	6.5	6.8
Turbidity	65.6	27.1	24.4	11.5	33.4	30.1	22.1	30.0	29.3	12.7
COD	2761.20	765.90	574.9	403.45	1210.3	1105.6	901.0	1303.5	995.78	579.11
BOD	1690.45	704.32	409.12	330.90	1000.2	879.21	677.1	877.22	512.45	356.76
TDS	2860.21	981.1	580.44	245.71	1121.1	899.67	612.23	991.4	699.3	321.77
TS	3176.87	1009.4	905.43	444.12	1301.6	1056.8	877.34	1190.9	811.45	712.31
Na^{2+}	63	48	41	39	61	57	51	56	49	40
K^{+}	77	32	28	17	43	41	31	37	33	25
SO_4^{2-}	1355.11	789.02	411.5	243.09	832.7	551.98	431.1	853.12	677.33	325.11
Cl^{-}	664.61	211.11	201.67	101.9	506.2	500.0	302.91	301.50	227.11	154.99

*All values are in mg/l except pH and turbidity is in NTU

Table-3. Physico-chemical characterization of 50% sugar mill effluent treated with adsorbents.

Parameter	Control without adsorbent	Activated charcoal			Wood ash			Bagasse		
		10 d	20 d	30 d	10 d	20 d	30 d	10 d	20 d	30 d
pH	4.93	6.1	6.2	6.8	5.7	5.9	6.5	5.9	6.7	6.7
Turbidity	42.4	31.6	28.6	12.9	39.1	35.6	24.3	33.6	22.9	14.7
COD	2550.75	1543.9	1379.4	799.0	2045.5	1576.3	1023.5	1994.3	1600.0	994.4
BOD	1429.09	1187.1	1003.2	550.1	1311.8	1298.4	865.6	1321.1	1191.1	790.2
TDS	2635.35	1012.6	712.04	360.77	1123.8	1007.0	879.91	987.99	669.8	521.56
TS	2950.99	1423.0	967.56	760.81	2176.9	1209.2	986.2	1089.5	912.23	881.5
Na^{2+}	59	51	47	44	56	55	51	50	48	46
K^{+}	68	51	44	20	59	55	32	49	41	26
SO_4^{2-}	1320.5	882.21	632.7	341.67	1021.1	672.31	470.07	875.21	701.1	400.55
Cl^{-}	631.02	449.45	432.23	116.65	512.34	498.54	456.65	330.8	244.89	190.76

*All values are in mg/l except pH and turbidity is in NTU

Table-4. Physico-chemical characterization of 25% sugar mill effluent treated with adsorbents.

Parameter	Control without adsorbent	Activated charcoal			Wood ash			Bagasse		
		10 d	20 d	30 d	10 d	20 d	30 d	10 d	20d	30 d
pH	5.01	5.9	6.2	6.6	5.5	5.9	6.1	6.4	6.4	6.5
Turbidity	39.9	31.1	27.2	13.8	33.3	30.5	24.2	29.6	21.7	14.0
COD	2317.83	1447.3	1332.1	691.0	2013.4	1548.2	1342.1	1645.0	1511.0	1251.2
BOD	1406.42	1100.7	1002.5	524.7	1298.0	1206.6	866.2	1291.1	1181.2	781.5
TDS	2441.07	1383.6	633.0	390.43	1765.1	988.9	661.76	801.78	630.23	452.08
TS	2829.89	1409.0	877.90	604.56	1988.5	1109.0	703.1	888.44	709.32	632.98
Na^{2+}	52	50	49	44	51	51	49	49	47	45
K^{+}	54	45	39	21	49	41	33	46	33	28
SO_4^{2-}	1266.31	790.45	403.1	280.11	955.3	620.12	491.11	867.33	432.12	360.43
Cl^{-}	611.78	403.9	399.77	112.55	509.0	327.90	367.11	412.31	201.8	186.89

*All values are in mg/l except pH and turbidity is in NTU

Analysis of sugar mill effluent are as follows: (pH, 4.26; Turbidity, 76.1 NTU; COD, 2890.32 mg/l; BOD, 1711.00 mg/l; TDS, 2998.32 mg/l; TS, 3377.42 mg/l; Sodium, 69.0 mg/l; Potassium, 96.0 mg/l; Sulphate, 1410.6 mg/l; Chloride, 696.3 mg/l). Results revealed remarkable reduction in physico-chemical parameters of adsorbent treated leachate collected after irrigation in different concentration of effluent at 10 days interval as compared to the untreated effluent (Figures 1-4). Activated charcoal found to be most efficient in removal of pollutants from the effluent as compared to the wood ash and bagasse pith.

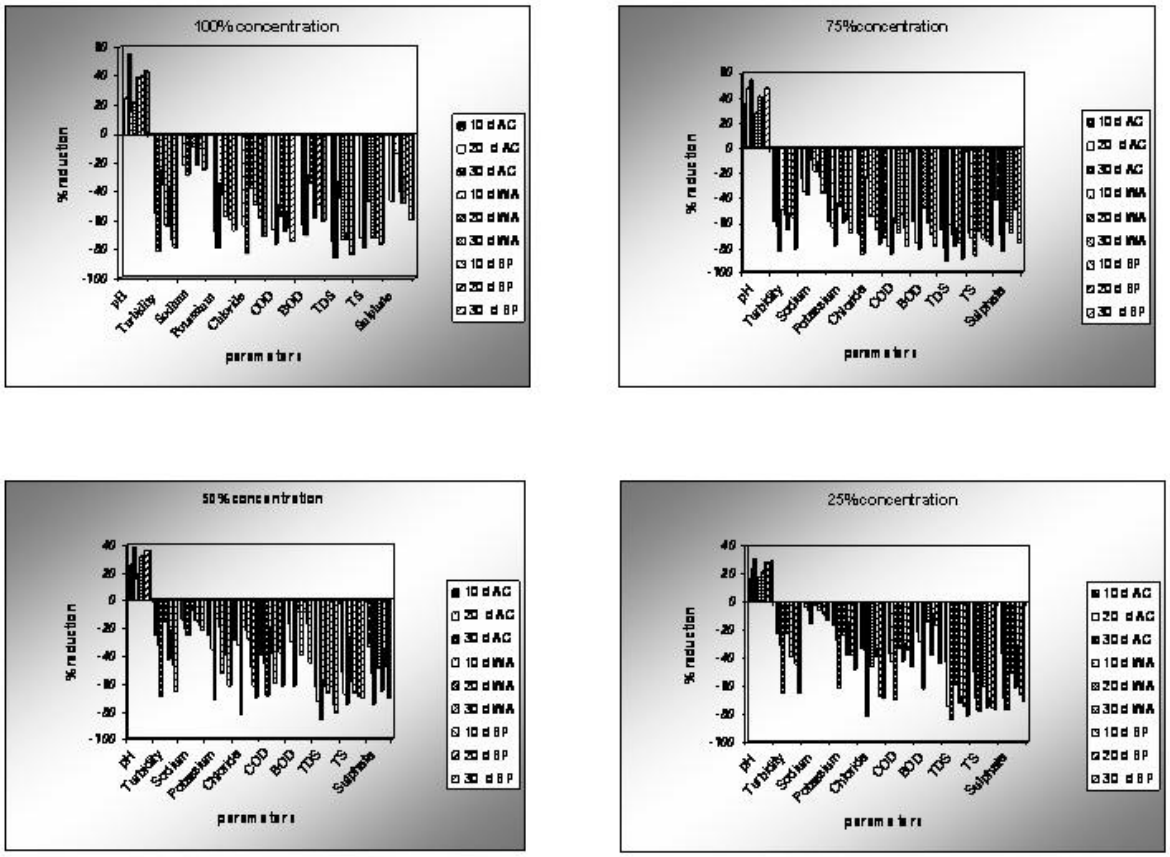

Figure-1-4. Showing % change over control in four different effluent concentrations (100%, 75%, 50%, 25%) of sugar mill effluent treated with adsorbents at varied irrigation period.

The adsorption process is one of the effective methods for pollutant removal from the waste effluent especially heavy metal ions, color, odor and organic pollution (Ganji *et al*., 2005; Georg Steinhauser, 2008). The process of adsorption has an edge over the other methods due to its sludge free clean operation and and low capital intensive nature (Viraraghvan and Dronamraju, 1993). The results of the present study clearly demonstrate that activated charcoal has excellent adsorption efficiency for the organic compound, which is reflected well by maximum reduction in all the parameters assessed. This is primarily due to the fact that activated charcoal has high and fast adsorption capacities (Sirichote *et al.*, 2002) due to its well developed porous structure and vast surface area. The matrix of micro-pore of charcoal yields relatively greater active surface area (1400 m^2/g) and thus making it suitable for efficient adsorption (Low *et al*., 1995).

In this study, low cost natural adsorbents (Bagasse pith and wood ash) used in comparison to activated charcoal demonstrated that former happen to be efficient enough to remove pollutants from the sugar mill effluent. Sugar cane bagasse, an agricultural byproduct, acts as an effective adsorbent for the treatment of effluent, owing to its structure having a combination of cellulose, lignin, and other minor components. These materials are prone to absorb hydrophilic and hydrophobic materials primarily due to the presence of hydrophilic and hydrophobic sites of bagasse that can attract organic pollutants effectively. It is also partly because of the unique architecture of the bagasse system having spaces that can trap these materials (Chiparus, 2004). On the other hand, wood ash is a natural adsorbent and, in comparison with other two (activated charcoal and Bagasse pith), treated the effluent least efficiently by moderately reducing all physico-chemical parameters.

CONCLUSIONS

The adsorption efficiency of different adsorbents was in the order, activated charcoal>bagasse pith>wood ash. Analysis of the effluent showed high values of COD, BOD, Sulphate, total solids etc., which is not recommended to be used for the irrigation of crops and for any other purpose. So, it is recommended to either dilute it with other fresh water and/or treat properly before utilizing for any purpose. Results showed that treatment by activated charcoal could be an efficient technology for removal of the pollutants from the sugar mill effluent, as its application resulted in maximum reduction of pollution load.

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