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Comparative evaluation of natural adsorbent for pollutants removal from distillery spent wash

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Adsorption capacity of three different adsorbents (activated charcoal, fly ash and wood ash) has been tested and compared for the removal of various pollutants and heavy metals from distillery-spent wash. Adsorption was brought about at polyhouse conditions and the changes in pH, colour, COD, TS, TDS, TSS, Ca, Mg, Na, K and heavy metals (Cu, Zn, Fe) of distillery effluent using various adsorbents has been examined. Activated charcoal was found to be best adsorbent followed by fly ash and wood ash.

Keywords: Activated charcoal, Adsorption, Distillery-spent wash, Fly ash, Wood ash

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Introduction

Industrial wastewater causes deleterious environmental impact upon the receiving water body[1]. Distillery wastewater, which is characterized by high organic matter, dissolved solids, COD, low pH and dark brown colour with a foul smell[2], creates toxic conditions in the receiving streams and results in massive destruction of aquatic flora and fauna[3]. This warrants adoption of safe and effective means of effluent treatment to fulfill both a practical necessity and a social responsibility[4].

Among wastewater treatment technologies, adsorption has gained considerable interest during recent years[5-8]. This study assesses pollutant removal efficiency from distillery-spent wash by three adsorbents (activated charcoal, fly ash and wood ash).

Experimental Procedure

Activated charcoal, fly ash and wood ash were procured from the laboratory at Pantnagar, bricklins at Baheri and from secondary units of Century Pulp & Paper mill, Lalkuan, respectively. Experiment consisted of three adsorbents of two effluent concentrations (50% and 100% with distilled water) in three replicates involving 18 plastic pots (capacity, 3 kg soil per pot). The pots were filled with soil (sand 49%, clay 18%, silt 33%). Wheat (*Triticum aestivum* L. variety UP-2329) was grown in the pots and the pots were kept in polyhouse at 30° C (humidity 75°C) with 35% reduction in natural sunlight. After 10 days of growth, adsorbents (15 g each) were added separately to the pots soil and irrigated with two different concentrations (50% and 100%) of the effluent. One set of the pots was maintained as control. On each irrigation date, effluent (1 l) was poured in a pot. Subsequent irrigation, with respective concentration of effluent was done at 12 days interval. After 6 h of irrigation, treatment-wise leachate was collected, brought to the laboratory and all the selected parameters [pH, colour, COD, total solids (TS), total dissolved solids (TDS), total soluble solids (TSS), Ca, Mg, Na, K and heavy metals (Cu, Zn, Fe)] were analyzed[9].

Results and Discussion

Analysis of distillery spent wash (pH 4.8, colour 1543.33 CU) gave following parameters: COD, 7566.6; TS, 40116.6; TDS, 26146.6; TSS, 13970.0; Ca, 110.3; Mg, 21.33; Na, 98.66; K, 78.3; Cu, 1.78; Zn, 1.42; and Fe, 6.03 ppm. COD concentration is higher than the permissible limit. Considerably high reduction in all physico-chemical parameters was observed when the effluent was treated with activated charcoal followed by fly ash and wood ash at 50% effluent concentration (Tables 1 & 2; Figs 1 & 2). Relatively greater efficacy of activated charcoal as adsorbent was due to its organophillic character[10,11]. Charcoal has matrix of micro-pore, which yields relatively greater active surface area (1400 m^2/g) and thus making it suitable for adsorption[12]. However,

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Table 1 —Physico-chemical characteristics of 50% diluted distillery spent wash treated with different adsorbents at varied irrigation period

Parameters	Untreated	Fly ash			Activated charcoal			Wood ash		
	effluent	20 d	30 d	40 d	20 d	30 d	40 d	20 d	30 d	40 d
pH	4.8±0.0	6.6±0.0	6.4±0.0	6.8±0.2	6.4±0.1	6.61±0.02	6.6±0.3	6.8±0.3	6.7±0.0	6.4±0.1
Colour, CU	1543.3±1.3	486.66±2.3	329.33±0.33	291.66±2.2	370.00±0.01	321.66±1.8	281.33±1.2	513.33±1.18	349.33±0.23	299.33±0.3
COD, ppm	7566.6±2.4	4806.66±2.6	3856.66±0.14	1253.33±0.8	3213.33±0.6	2126.66±5.2	966.66±1.8	4966.66±2.3	3920.00±0.16	1303.33±0.2
TS, ppm	40116.6±0.33	13733.33±5.2	9566.66±2.4	2733.33±2.6	10033.33±1.12	7666.66±3.3	2266.66±1.6	14666.67±3.4	8666.66±1.4	3666.66±2.6
TDS, ppm	26146.6±2.6	9500.00±2.2	6866.66±1.6	1666.66±1.5	6233.33±1.8	5133.33±4.4	1266.66±0.03	7866.66±3.6	6500.00±0.02	1733.33±1.8
TSS, ppm	13970.0±1.4	4233.33±3.4	3033.33±0.6	1066.66±0.2	3800.00±0.6	2533.33±2.6	1000.00±0.14	6800.00±3.32	2166.66±0.06	1933.33±1.8
Ca, ppm	110.3±1.2	107.33±0.1	98.33±2.4	86.00±0.02	104.33±0.2	94.33±0.3	80.66±1.8	105.66±0.01	96.66±1.12	84.33±0.04
Mg, ppm	21.33±2.2	16.33±0.2	12.00±1.4	9.33±0.06	13.33±1.8	10.33±3.3	7.66±0.04	17.66±1.16	12.66±1.16	9.66±2.3
Na, ppm	98.66±0.2	96.33±1.2	86.66±2.3	61.33±1.18	94.33±1.8	84.33±1.8	55.33±0.15	97.66±1.18	90.66±2.3	63.33±0.4
K, ppm	78.3±0.03	71.33±1.16	68.33±1.8	57.33±2.4	68.66±0.6	61.66±2.4	51.33±1.5	70.33±1.18	67.33±0.02	59.33±1.8
Cu, ppm	1.78±2.4	1.58±0.18	1.36±2.2	1.24±3.2	1.28±0.2	1.16±0.3	1.02±1.6	1.60±2.18	1.50±1.12	1.48±0.03
Zn, ppm	1.42±1.6	1.38±0.1	1.24±1.8	1.06±1.16	1.03±0.03	.98±0.4	0.83±2.6	1.38±0.02	1.22±2.3	1.06±0.03
Fe, ppm	6.03±0.2	5.23±0.12	5.02±1.6	4.50±0.4	4.20±0.02	3.98±0.01	3.62±0.3	5.6±1.16	5.02±0.02	4.64±3.3

Table 2 —Physico-chemical characteristics of 100% distillery spent wash treated with different adsorbents at varied irrigation period

Parameters	Untreated	Fly ash			Activated charcoal			Wood ash		
	effluent	20 d	30 d	40 d	20 d	30 d	40 d	20 d	30 d	40 d
pH	4.38±0.1	6.6±0.0	6.4±0.2	6.6±0.1	6.5±0.0	6.6±0.0	6.4±0.1	6.3±0.0	6.6±0.2	6.4±0.3
Colour, CU	1363.66±2.3	984.66±0.33	686.66±0.66	586.66±1.4	883.33±5.2	492.66±	3151.66±0.1	996.66±2.2	546.33±0.5	426.03±1.5
COD, ppm	8066.66±2.2	7203.33±3.3	6423.33±0.12	4260.0±1.8	6866.6±3.3	5466.66±2.5	3266.66±3.2	7866.66±3.2	6020.00±4.2	4860.66±1.6
TS, ppm	42185.33±1.4	25733.3±1.8	13466.66±0.12	7833.33±2.2	19533.3±1.6	11823.33±0.3	7686.66±0.4	26833.33±3.2	14633.33±2.3	7866.66±3.6
TDS, ppm	28686.33±1.6	17366.6±1.4	8623.33±2.3	5600.00±2.3	12666.6±1.4	7506.66±1.6	4800.00±2.3	17633.33±4.4	8466.66±2.36	5846.33±4.2
TSS, ppm	13499.00±3.2	8366.7±0.6	4843.33±2.4	2233.33±1.6	6866.7±2.2	4316.64±1.2	2886.66±1.8	9200.00±2.2	6166.67±1.8	2020.33±3.2
Ca, ppm	98.66±0.02	87.33±2.3	90.33±0.3	76.33±0.4	96.06±2.4	88.33±0.4	68.33±2.3	97.66±0.3	94.33±3.2	72.66±1.5
Mg, ppm	18.33±0.1	16.66±1.6	14.66±1.6	11.66±1.2	15.33±3.2	12.33±0.6	10.33±0.3	17.33±3.2	14.66±2.4	12.33±0.5
Na, ppm	110.33±0.06	108.66±1.4	102.33±1.8	95.33±1.6	107.66±0.3	101.66±0.4	94.33±3.4	109.00±0.32	103.33±1.36	98.66±5.2
K, ppm	79.66±0.06	74.33±0.3	70.66±2.4	68.66±2.3	70.66±0.4	64.00±2.3	60.60±2.3	75.33±1.2	70.66±1.24	69.33±0.06
Cu, ppm	1.78±0.1	1.69±0.02	1.56±0.2	1.48±1.6	1.38±0.1	1.24±1.4	1.18±0.02	1.69±1.1	1.58±0.4	1.52±1.8
Zn, ppm	1.42±0.3	1.38±0.2	1.34±0.1	1.29±1.5	1.36±0.02	1.26±0.1	1.20±1.4	1.38±1.11	1.35±2.6	1.30±2.3
Fe, ppm	6.03±0.4	5.8±0.1	5.76±0.3	5.55±1.2	5.24±1.2	5.06±1.2	4.28±0.2	5.83±2.14	5.78±10.2	5.61±1.2

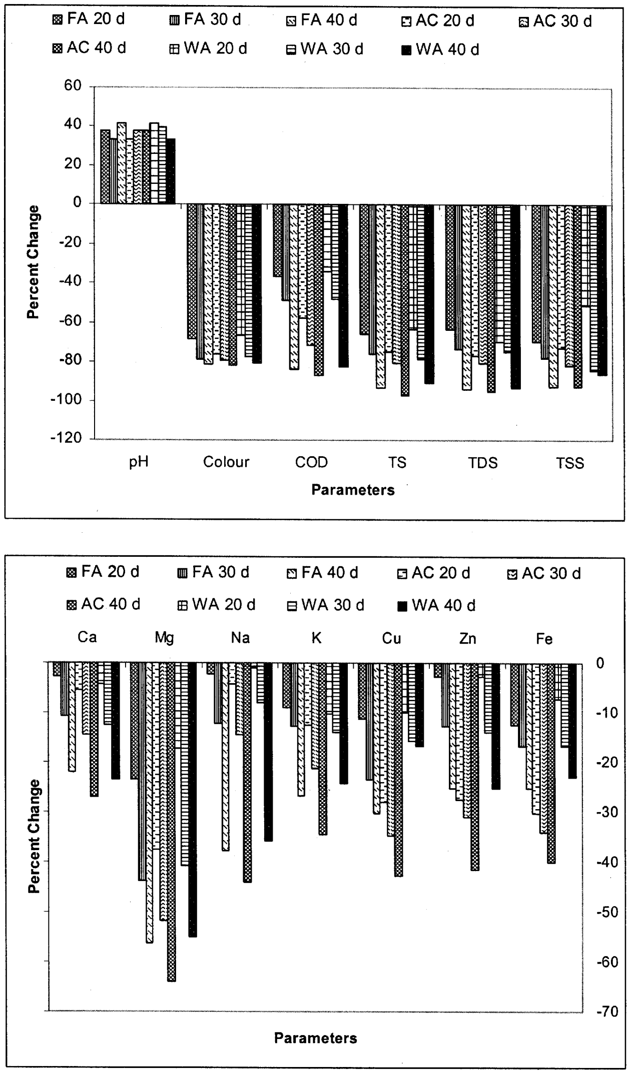

Fig. 1 — Percent change (+ increase, - decrease) over control in physico-chemical characteristics of 50% diluted distillery effluent treated with different adsorbents at varied irrigation period FA, Fly ash; AC, Activated charcoal; WA, Wood ash

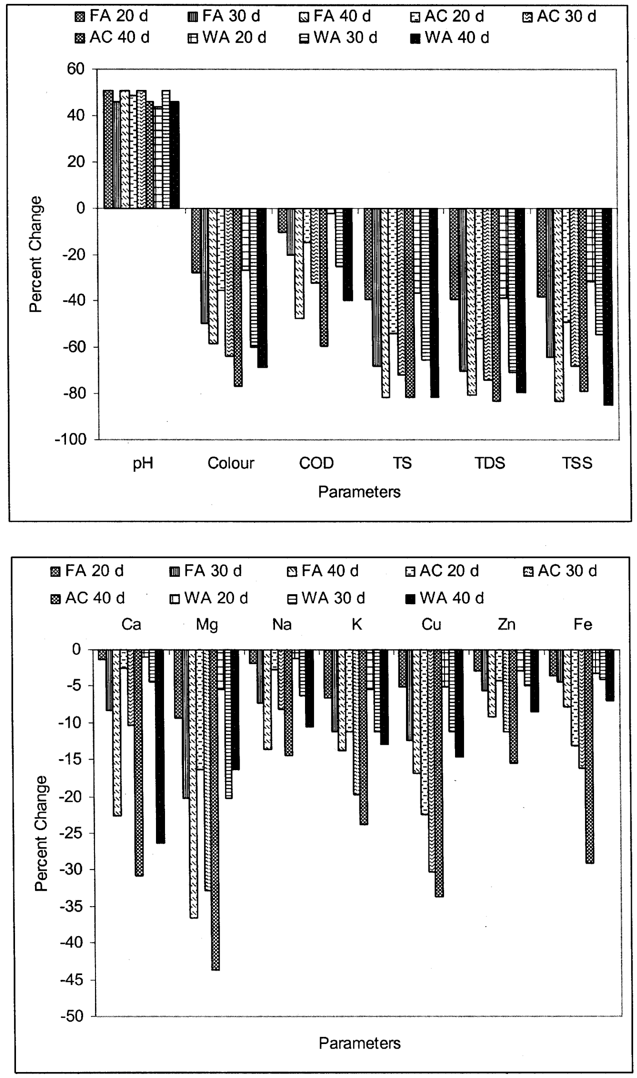

Fig. 2 — Percent change (+increase, -decrease) over control in physico-chemical characteristics of 100% distillery effluent treated with different adsorbents at varied irrigation period FA, Fly ash; AC, Activated charcoal; WA, Wood ash

exact mechanisms governing initial rapid rate for the pollutant removal due to surface adsorption followed by intra-particle diffusion, which appears to be the rate governing steps[13] in this experiment.

Fly ash is predominantly siliceous, besides insoluble oxides of Al, Fe, Ca, Mg, Ti and alkali oxides. In case of fly ash, metal salts hydrolyse in the presence of natural alkalinity to form metal hydroxides. Multivalent cation present on fly ash can reduce zeta-potential while metal hydroxides are good adsorbents, which form monomolecular layer on the surface of suspended organic matter to remove organic pollutants by enmeshing and setting[7,14]. Adsorption capacity of fly ash increases with increasing carbon content of fly ash[15]. Wood ash has lowest efficiency to remove the pollutants from distillery-spent wash. Besides, phenomenon of adsorption can be attributed to various mechanisms such as electrostatic attraction and repulsion, chemical interaction and ion exchange.

Conclusions

Activated charcoal has been observed best adsorbent than fly ash and wood ash to remove the pollutants from distillery spent wash.

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References

1 Seth K N & Soni V M, Comparative study of removal of Cr (VI) with PAC, GAC and adsorbent prepared from tobacco stems, *J Ind Pollut Cont,* **20** (2004) 45-52.

2 Nanjundaswamy C, Jain N, Kumar P & Srivastava A K, Biodegradation of predigested distillery waste water by Aerobic Bacterial Stress, *J Indian Assoc Environ Manage,* **18** (1998) 658-661.

3 Vasanthy M, Thamaraiselvi C & Velmurugan R, Physico-chemical characterization of untreated and anaerobically treated distillery effluent, *J Ind Pollut Cont,* **20** (2004) 125-130.

4 Vaidhyanathan R, Meenambal T & Gokuldas K, Biokinetic coefficients for the design of two stage anaerobic digester to treat distillery waste, *Indian J Environ Hlth,* **37** (1995) 237-242.

5 Mckay G, Geundi M E & Nassar M M, Equilibrium studies during the removal of dye stuffs from aqueous solutions using baggase pith, *Water Res,* **21** (1987) 1513-1520.

6 Kanchana N, *Removal of dyes from aqueous solution onto banana pith*, M Phil Thesis, Bharathiar University, Coimbatore, 1991.

7 Rao M & Bhole A G, *Removal of chromium using low cost adsorbents*, *J IAEM,* **27** (2000) 291-296.

8 Krishanan A & Anirudhan T S, Removal of lead (II) in the presence of organic ligands from aqueous solution using activated carbon, *Indian J Environ Protec,* **22** (2002) 52-59.

9 APHA, *Standard Methods for Examination of Water and Wastewater* (American Public Health Association, American Water Works Association, Water Pollution Control Federation, Washington D C, USA) 1995.

10 Sanghi R & Bhattacharya B, Comparative evaluation of activated carbon with natural adsorbents for decolourization of dye solution, *J Sci Ind Res,* **61** (2002) 432-436.

11 Chandra R & Pandey P K, Decolourization of anaerobically treated distillery effluent by activated charcoal adsorption method, *Indian J Env Prot,* **21** (2000) 134-137.

12 Low K S, Lee C K & Tan K K, Bio-sorption of basic dyes by water hyacinth roots, *Biores Technol,* **52** (1995) 79-83.

13 Gupta G S, Prasad G & Singh S N, Removal of chrome dye from aqueous solutions by mixed adsorbents: flyash and coal, *Water Res,* **24** (1990) 45-50.

14 Mall I D, Mishra N & Mishra I M, Removal of organic matters from sugar mill effluent using bagasse, flyash, activated carbon, *Res & Ind*, **39** (1994) 115-119.

15 Banerjee K, Cheremisinoff P N & Cheng S L, Sorption of organic contaminants by flyash in a single solute system, *Environ Sci Technol,* **29** (1995) 2243-2251.