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RESEARCH ARTICLE

DISTILLERY SPENT WASH AND UTILITY OF FLY ASH

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ABSTRACT

The developing and underdeveloped countries are facing the problem of mounds of fly ash and of untreated discharge of distillery spent wash which creates a serious threat to the environment. So there is a need for low cost treatment method for spent wash while distillery spent wash can be used for irrigation purpose and adsorption can play an effective role in purification of distillery spent wash. This investigation is done to design the treatment method of distillery spent wash using Soil, Fly Ash, Activated Carbon and Wood ash and the main concern is to use fly ash for spent wash treatment. Complete work is done in the Doon International School; Dehradun, India under department of chemistry during months of September to December 2016. During study, total 33 samples were treated with different adsorbents and evaluation is done for the reduction of various physical chemical properties (pH, COD, TS, TDS, Ca, Mg, Na and K) of distillery spent wash. It is treated by passing the spent wash through the adsorbents for different time periods. Original distillery spent wash was acidic (pH 4.7) and dark black brown in color with a foul smell. Use of activated carbon and Fly ash exhibited noticeable reduction in physico chemical characteristics of spent wash after 72 hour adsorption (TS - 61.50%, TDS –52.11%, COD – 45.73%, Ca –82.73%, Mg-73.99%, Na -63.75% and K -73.53%) and pH increased towards pH 7 using activated carbon + fly ash (1:1), fly ash+ wood ash (1:1). Study says that fly ash can be used successfully for this purpose. Obtained data says that mixture of activated carbon + fly ash (1:1) can be used as a low cost adsorbent for the purification of distillery spent wash thus use of fly ash in purification can reduce pollution in spent wash and fly ash disposal problem which is generally faced by thermal power plants.

INTRODUCTION

Environmental pollution caused by the distillery industry has recently been the subject of much research. Distillery waste is one of the major wastes of ecological concern. It is a complex, caramelized and recalcitrant waste containing high percentage of organic matter and heavy metal ions (Nemade and Shrivastava, 1997). This causes pollution in the receiving water bodies as well as on land. Waste water generated from various distilleries is causing sever degradation in the environment. Inadequate treatment of spent wash has led to the widespread contamination of surface and ground waters and it has made the water resources unfit for usage. Hence there is an urgent need for its treatment. At the same time mounds of fly ash are produced in thermal power plants and coal based factories in developing and underdeveloped countries. (Ghosh et al., 2015) Its disposal is a major problem because it causes soil and air pollution, creating major health issues. To achieve this, several physical, chemical and biological methods/ techniques have been developed (Pathade, 2003) and are being practiced in very few industries along with distilleries (Lin et al., 2003). The reason of the limited scope of these techniques lies with their adhered economical solution of the pollution abatement problems, adsorption is a low cost effective method and practical usage. To reduce treatment cost natural adsorbents can be used. For developing countries and under developed countries use of natural adsorbent can be a low cost method without affecting their industries. Once the industrial spent wash is treated, it could be used for crop irrigation. Its application in short rotation forestry crop is a treatment system which if properly designed and maintained could both increase the productivity of the crops and reduce the waste disposal problem (Nandy T. 2002). The present study is planned to investigate the treatment method of distillery spent wash with the following objectives:

1. To find low cost adsorption technique for distillery spent wash.

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2. To use different textures of fly ash, wood ash, activated carbon, soil and sand as adsorbent for spent wash purification.
3. To utilize fly ash as adsorbent for spent wash treatment to solve fly ash disposal problem.

Adsorption process

Treatment of distillery spent wash by adsorption systems involves the processes of adsorption, filtration and dilution. As water moves through the adsorbent, suspended particles are removed by filtration. The rate of adsorption and filtration is affected by physical properties of adsorbent i.e. the relative proportion of mineral particles of different sizes present in the adsorbent.

MATERIALS AND METHODS

Distillery spent wash collection

It was collected from the main outlet of a distillery, located in Dehradun. The factory uses molasses as the raw material. Factory claims to use purification system for spent wash but still the spent wash is highly impure. Samples were collected five times on weekly basis from September to December 2016 in clean sterile plastic containers and stored at 4^{o}C.

Place of research work

Doon International School Dehradun, 248001, Uttarakhand, India

Adsorbents used

Soil

loam soil is composed of sand (particle size > 60 µm), silt (particle size > 2 µm), and a smaller amount of clay (particle size < 2 µm). Its composition is about 40–40–20% concentration of sand-silt-clay, respectively.

Fly ash*

Purchased from Lalitpur Power Generation Company Ltd India. Moisture 4.56% *calcium 9.93% *magnesium 3.86% * LOI 1.98% *total silica 63.52% *phosphate 0.24% *potassium 7.43% *aluminum oxide 2.72% *manganese 0.17% *sodium 0.26% * iron oxide 2.08%.

Wood ash

In the present study wood ash was prepared by burning Lantana Shrub which is a major problem in the hills of Dehradun, Uttarakhand India.

Activated carbon

Purchased from Lalitpur Power Generation Company Ltd India

Experimental design

33 columns of adsorbents were prepared for the treatment of spent wash as follows:

Table 1. Design of columns of different adsorbents

Groups	Set-1 (24 H Treatment)	Set-2 (48 H Treatment)	Set-3 (72 H Treatment)
Soil(S)	S-1	S-2	S-3
Fly Ash (F)	F-1	F-2	F-3
Wood Ash (W)	W-1	W-2	W-3
Activated carbon (A)	A-1	A-2	A-3
Soil+ Fly Ash-1:1 (SF)	SF-1	SF-2	SF-3
Soil+ Wood Ash-1:1 (SW)	SW-1	SW-2	SW-3
Soil+ Activated Carbon-1:1 (SA)	SA-1	SA-2	SA-3
Activated Carbon + Fly Ash-1:1 (AF)	FA-1	FA-2	FA-3
Fly Ash + Wood ash-1:1 (FW)	FW-1	FW-2	FW-3
Activated Carbon + Wood ash-1:1 (WA)	WA-1	WA-2	WA-3

In set-1 spent wash was retained for 24 hours, in set-2 for 48 hour, in set-3 for 72 hour for adsorption. After adsorption in respective columns the samples were collected and kept overnight for adsorbent sedimentation, then stored at 4^{o}C for physico-chemical testing.

Physico chemical parameters selected for analysis

pH, TS, TDS, C.O.D., Ca, Mg, Na & K.

Measurement of total solids (TS), total dissolved solids (TDS) and chemical oxygen demand (COD)

TS and TDS were determined by measuring the residue left after evaporation of unfiltered samples as described by (APHA 1995).While COD is calculated using Titrimetric method. (Lawrence H.Keith)

Measurement of pH: The pH was checked by using a glass electrode pH meter and also by using universal pH indicator solution.

Determınatıon of Ca and Mg: It was measured by complexo metric titration using ethylene di amine tetra acetic acid (EDTA). (Tsunogai S, Nishimura M, Nakaya S.1968)

Determination of Na AND K: A characteristic light is produced due to excitation of electrons when the samples with Na/K are sprayed into air-acetylene flame. The intensity of this characteristic radiation is measured at 589/766.49mm for sodium and Potassium, respectively. (John Edward Cantle 1982)

RESULTS

Visible color of distillery spent wash was dark brown having a foul smell, with acidic nature pH 4.7 and contain TS-10000mg/l, TDS-7600mg/l, COD-8200mg/l, Ca-2200mg/l, Mg-1730mg/l, Na-800mg/l, and K-1700mg/l (Table 2). After 72 hour treatment with soil, pH of spent wash was increased significantly from 4.7 to 5.9, COD (4384 mg/l),TS (4200 mg/l), TDS (4000 mg/l),Ca (540 mg/l), Mg (440 mg/l), Na (360 mg/l) and K (480mg/l).With activated carbon after 72 hour treatment pH of spent wash was increased from 4.7 to 6.2, COD (4184 mg/l),TS (3600 mg/l),TDS (3400 mg/l),Ca (420 mg/l), Mg (380 mh/l), Na (320 mg/l) and K (420 mg/l).While reductions with fly ash were as pH increased to 6.0,COD (4727 mg/l),TS (4167 mg/l),TDS (3918 mg/l),Ca (351 mg/l), Mg (500 mg/l), Na (272 mg/l) and K (483 mg/l).

Table 2. Physico Chemical Characteristics of Distillery Spent Wash before Treatment

Parameters	Value
TS	10000 mg/l
TDS	7600 mg/l
pH	4.7
COD	8200 mg/l
Ca	2200 mg/l
Mg	1730 mg/l
Na	800 mg/l
K	1700 mg/l

Table 3. Physico Chemical Characteristics of Distillery spent Wash after Treatment with Soil, Sand and Activated Carbon at Various Irrigation Periods

Parameters	Original sample	Soil			Activated Carbon			Wood ash			Fly Ash		
		S-1	S-2	S-3	A-1	A-2	A-3	W-1	W-2	W-3	F-1	F-2	F-3
		24H	48H	72H	24H	48H	72H	24H	48H	72H	24H	48H	72H
TS	10000	5400	5000	4200	4800	4200	3600	6250	5625	5000	5625	4792	4167
TDS	7600	5490	4800	4000	4400	3800	3400	4897	4701	4505	4701	4309	3918
pH	4.7	5.5	5.7	5.9	5.6	5.8	6.2	5.0	5.3	5.9	5.2	5.5	6.0
COD	8200	5412	4952	4384	5012	4552	4184	5615	5307	5095	5467	5065	4727
Ca	2200	600	580	540	540	500	420	574	557	510	447	414	351
Mg	1730	520	480	440	480	420	380	709	688	670	562	521	500
Na	800	540	420	360	420	360	320	377	347	317	347	302	272
K	1700	720	640	480	560	500	420	752	734	698	555	519	483

All values are in mg/l except pH.

Table 4. Physico Chemical Characteristics of Distillery spent Wash after Treatment with Different Textures of Soil, Activated Carbon, Fly Ash and Wood Ash

Parameters	Original Sample	Soil + Activated carbon (1:1)			Soil + Fly Ash (1:1)			Soil + Wood Ash (1:1)			Fly Ash + Wood Ash (1:1)		
		SA-1	SA-2	SA-3	SF-1	SF-2	SF-3	SW-1	SW-2	SW-3	FW-1	FW-2	FW-3
		24H	48H	72H	24H	48H	72H	24H	48H	72H	24H	48H	72H
TS	10000	5400	4600	4000	5530	4890	4250	5800	5300	4600	5936	5200	4580
TDS	7600	4640	4225	4130	4800	4400	4000	4840	5050	4250	4780	4500	4200
pH	4.7	5.2	5.7	6.2	5.3	5.5	6.0	5.2	5.5	6.0	5.3	5.8	5.9
COD	8200	5250	4800	4600	5300	5100	4950	5500	5230	5100	5500	5150	4900
Ca	2200	550	530	440	560	530	490	587	560	520	510	480	430
Mg	1730	540	500	480	590	554	530	610	580	560	630	600	590
Na	800	460	400	360	395	345	320	450	380	320	360	325	300
K	1700	620	580	540	650	600	560	730	680	580	650	620	590

All values are in mg/l except pH.

Table 5. Physico Chemical Characteristics of Distillery spent Wash Treated with Different Textures of Active Carbon, Fly Ash and Wood Ash

Parameters	Original sample	Active Carbon +Wood Ash (1:1)			Active Carbon +Fly Ash (1:1)		
		AW-1	AW-2	AW-3	AF-1	AF-2	AF-3
		24H	48H	72H	24H	48H	72H
TS	10000	5330	4500	3950	5200	4390	3850
TDS	7600	4640	4225	4130	4560	4250	3640
pH	4.7	5.3	5.5	6.0	5.4	5.6	6.2
COD	8200	5200	4850	4600	5000	4200	4450
Ca	2200	560	530	480	490	450	380
Mg	1730	550	530	510	520	470	450
Na	800	395	345	320	380	330	290
K	1700	630	600	550	557	520	450

Table 6. Percentage Change in Physico Chemical Characteristics of Distillery spent Wash Treated With Soil, Activated Carbon, Fly Ash and Wood Ash

Parameter	Soil			Activated carbon			Wood Ash			Fly Ash		
	S-1	S-2	S-3	A-1	A-2	A-3	W-1	W-2	W-3	F-1	F-2	F-3
	24H	48H	72H	24H	48H	72H	24H	48H	72H	24H	48H	72H
TS	-46	-50	-58	-52	-58	-64	-37.50	-43.75	-50.00	-43.75	-52.08	-58.33
TDS	-27.76	-36.84	-47.37	-42.11	-50	-55.26	-35.57	-38.15	-40.72	-38.15	-43.30	-48.45
pH	+17.02	+21.28	+25.53	+19.15	+23.40	+31.92	+6.38	+12.77	+25.53	+10.64	+17.02	+27.66
COD	-34	-39.61	-46.54	-38.88	-44.49	-48.98	-31.52	-35.28	-37.87	-33.33	-38.23	-42.35
Ca	-72.73	-73.64	-75.46	-75.46	-77.27	-80.91	-73.91	-74.68	-76.82	-79.68	-81.18	-84.05
Mg	-69.94	-72.25	-74.57	-72.25	-75.72	-78.04	-59.02	-60.23	-61.27	-67.52	-69.88	-71.10
Na	-32.5	-47.5	-55	-47.5	-55	-60	-52.88	-56.63	-60.38	-56.63	-62.25	-66.00
K	-57.65	-62.35	-71.77	-67.06	-70.59	-75.29	-55.77	-56.82	-58.94	-67.35	-69.47	-71.59

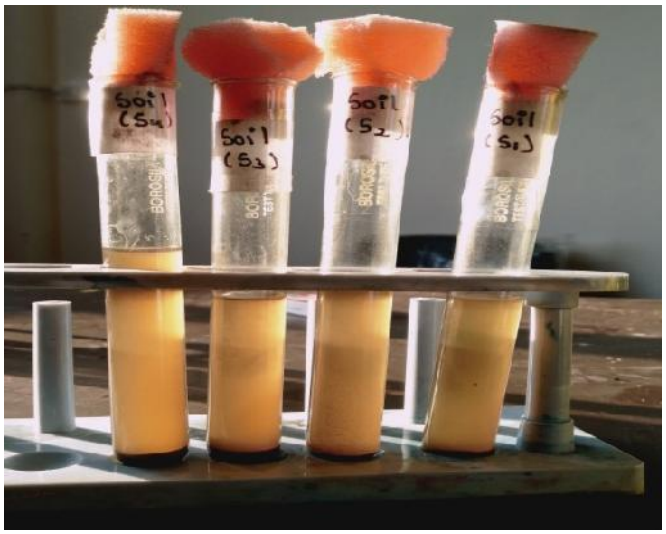
Table 7. Percentage Change in Physico Chemical Characteristics of Distillery spent Wash Treated with different Textures of soil, activated carbon, wood ash and fly ash

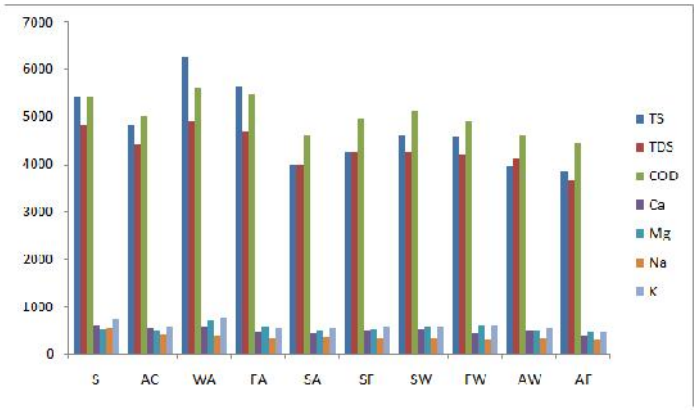
Parameters	Soil + Activated carbon (1:1)			Soil + Fly Ash (1:1)			Soil + Wood Ash (1:1)			Fly Ash + Wood Ash (1:1)		
	SA-1	SA-2	SA-3	SF-1	SF-2	SF-3	SW-1	SW-2	SW-3	FW-1	FW-2	FW-3
	24H	48H	72H	24H	48H	72H	24H	48H	72H	24H	48H	72H
TS	-46.00	-54.00	-60.00	-44.70	-51.10	-57.50	-42.00	-47.00	-54.00	-40.64	-48	-54.20
TDS	-38.95	-44.41	-45.66	-36.84	-42.11	-47.37	-36.32	-33.55	-44.08	-37.11	-40.79	-44.74
pH	+10.63	+21.27	+31.92	+12.77	+17.02	+27.66	+10.64	+17.02	+27.66	+12.77	+23.40	+25.53
COD	-35.98	-41.46	-43.90	-35.37	-37.81	-39.63	-32.93	-36.22	-37.81	-32.93	-37.20	-40.24
Ca	-75.00	-75.90	-80	-74.55	-75.91	-77.73	-73.32	-74.55	-76.36	-76.82	-78.19	-80.45
Mg	-68.79	-71.10	-72.25	-65.90	-67.98	-69.36	-64.74	-66.47	-67.63	-63.59	-65.32	-65.89
Na	-42.5	-50	-55	-50.63	-56.88	-60.00	-43.75	-52.50	-60.00	-55	-59.38	-62.50
K	-63.53	-65.88	-68.24	-61.76	-64.71	-67.06	-57.06	-60.00	-65.88	-61.76	-63.53	-65.29

Table 8. Physico Chemical Characteristics of Distillery spent Wash Treated with Different Textures of Active Carbon, Fly Ash and Wood Ash

Parameters	Active Carbon +Wood Ash (1:1)			Active Carbon +Fly Ash (1:1)		
	AW-1	AW-2	AW-3	AF-1	AF-2	AF-3
	24H	48H	72H	24H	48H	72H
TS	-46.20	-55.00	-60.50	-48.00	-56.10	-61.50
TDS	-38.95	-44.41	-45.66	-40.00	-44.08	-52.11
pH	+12.77	+17.02	+27.66	+14.89	+19.15	+31.92
COD	-36.59	-40.85	-43.90	-39.02	-42.68	-45.73
Ca	-74.55	-75.91	-78.18	-77.73	-79.55	-82.73
Mg	-68.21	-69.36	-70.52	-69.94	-72.83	-73.99
Na	-54.38	-56.88	-60.00	-56.25	-58.75	-63.75
K	-62.94	-64.71	-67.65	-67.24	-69.41	-73.53

Figure: Samples collected after treatment





All values are in mg/l.

Fig. 1. Effect of Different adsorbent Textures on Physico Chemical Properties of Spent Wash after 72 hours Treatment

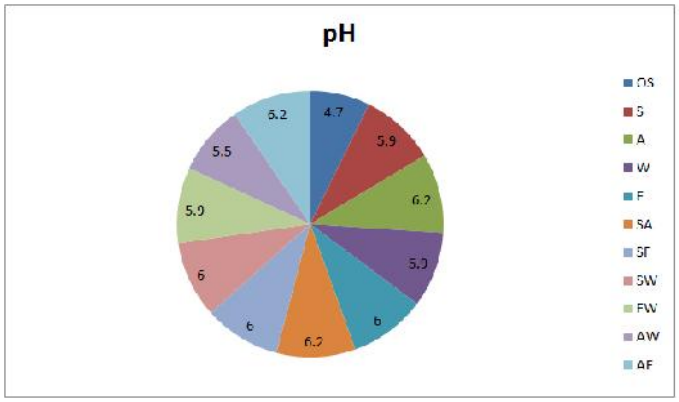


Fig. 2. Effect of Different adsorbent pH of Spent Wash after 72 hours Treatment

While wood ash adsorption increased pH from 4.7 to 5.9 and TS,TDS and COD were reduced to 5000mg/l,4505mg/l and 5095mg/l respectively. Ca, Mg, Na and K were reduced to 510mg/l, 670mg/l,317mg/l and 698mg/l respectively. When different combinations of adsorbents were used for spent wash purification, reductions in physico-chemical properties were observed at greater extent using activated carbon + fly ash (1:1) (Table 4) following by soil + fly ash (1:1), soil + wood ash (1:1) and minimum reductions were seen with Fly ash + wood ash (1:1) after 72 hours treatment. (Table 4 and 5)

DISCUSSION

Activated carbon is an ideal adsorbent for distillery spent wash treatment. Removal of COD from distillery spent wash was found maximum 48.98 % by using activated carbon, 46.54 % by using soil and 36.37 % by using sand while reduction in TS is observed 64% with activated carbon, 58% with soil and 42% with sand. Reduction in TDS is observed 55.26% with activated carbon, 47.37% with soil and 34.21% with sand. Reduction in metallic ions concentration is observed as follows: Ca(80.91%), Mg(78.04%), Na (60%), K(75.30%) with activated carbon after 72 hour (Table 1.6).Ca (75.46%), Mg (74.57%), Na (55%), K (71.76%) with soil treatment of spent wash. Ca (69.01%), Mg (66.47%), Na (37.5%), K (44.24%) with sand treatment of spent wash after 72 hours (Table 1.6). while with soil + sand (1:1), reductions after 72 hour treatment are observed as COD (42.73%), TS(48%), TDS(42.11%),Ca (73.64%), Mg (69.94%),Na (35%), K (58.82%).With soil + activated carbon(1:1) reductions are seen as COD (43.90%), TS (60%), TDS (34.47%), Ca (80%), Mg (72.25%), Na (52.5%), K (68.24%) after 72 hour treatment. With sand + activated carbon following results are observed COD (39.54%), TS (52%),TDS (34.21%), Ca (70.91%), Mg (61.85%), Na (47.5%) and K (54.12%).(Table:1.7).With fly ash after 72 hour treatment reductions were observed as TS 58.33% ,TDS 48.45% ,COD 42.35% ,Ca 84.05%, Mg 71.10%,Na 66% and K 71.59% while pH increased 27.66%.Combination of soil + fly ash (1:1) and fly ash + wood ash (1:1) gave good reductions in pollutants of spent wash. While activated carbon + fly ash (1:1) gave excellent reductions as TS 61.50%, TDS 52.11%, COD 45.73%, Ca 82.73%, Mg 73.99%, Na 63.75% and K 75.53% also pH increased by 31.92%. Changed soil characteristic resulted in an altered growth of wheat after irrigation with treated spent wash (24hrs, 48hrs, and 72 hrs treatment). Spent wash was purified more with activated carbon and fly ash.

Conclusion

On the basis of experimental results it can be concluded that activated carbon, fly ash, activated carbon+ fly ash (1:1) can be used for the treatment of distillery spent wash. This can reshape the spent wash characteristics by reducing pollutants present in it. After treatment spent wash can be used for irrigation in farming to reduce the pressure of chemical fertilizers and water irrigation. The adsorbent treatment method could be profitably practiced for removing the pollutants from distillery spent wash and can reduce the ground water contamination. Fly ash with activated carbon can be used for this purpose successfully at commercial level in industries. At the same time use of fly ash can reduce the problem of fly ash deposition at thermal power stations which is a major problem of power stations which are using coal as fuel. Solid fly ash with organic and inorganic impurities obtained after purification of spent wash can be used to produce organic manure which needs further research.

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Competing interests Authors have declared that no competing interests exist.

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