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Performance Evaluation of Fly Ash and Red Brick Dust for Recovery of Chromium from Tannery Wastewater by Adsorption Method

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ABSTRACT

Waste water contains hazardous chemicals released from industries and affects adversely aquatic life as well as deteriorates surface and groundwater quality. The industrial effluent is disposed into drains without treatment thus worsening condition. It alters the living condition of aquatic life and effects the environment adversely. It affects human being some time directly and sometime indirectly. Chromium contamination is a serious problem because of cancer-causing effect of the pollutants and low recovery rate of chromium owing to the existence of organics, such as protein as well as fat. Objective of this study was to determine viability of adsorbents like fly ash and red brick dust for chromium ions recovery from tannery wastewater. Aqueous solutions of Cr(III) was prepared by dissolving the specific amounts of chromium Sulphate in de ionized water. Concentration of Cr (III) was determined by atomic absorption spectrophotometer. The adsorption of chromium on fly ash as well as red brick dust was determined at different Cr (III) concentrations, contact time, adsorbent dosage and pH. By comparing results of both adsorbents it was concluded that performance efficiency of both fly ash and red brick dust was good for removal and recovery of chromium. But red brick dust was more effective as compared to fly ash. Because maximum recovery of chromium was observed at pH 4; adsorbent red brick dust; contact time 3hours; and adsorbent dosage 1000g. Red brick dust declared as good adsorbent for the recovery of chromium from tannery waste water.

1. Introduction

Environment is getting flimsy day by day and environmental pollution is one of the undesirable side effects of industrialization, urbanization, population growth and senseless attitude towards the environment. Industrial wastes are yielded from divergent processes and the amounts, features of discharged effluent vary from industry to industry depending upon the water consumption and average daily production [1].

Rapid industrialization in developed and developing countries has led to a substantial increase in the generation of industrial wastes. These wastes are a great concern to health scientists all over the world. The presence of these wastes in the environment may affect not only particular species of flora and fauna, but also the structure and function of entire ecosystems [2].In Pakistan industrial estate establishment was started with the introduction of 1st five years plane 1955-1960, which laid emphasis on the establishment of large estates in the country [3].Tannery industry, including leather products, is the 2nd largest export earning sector after textiles in Pakistan. Currently, this sector is contributing around $ 874 million a year but has the potential to increase volume of exports with the advancement of quality and divergence in different variety of goods, specially clothes and footwear. Currently, Pakistan is amongst the leading countries in the manufacturing of Leather goods. The leather and leather made-ups industry plays a substantial role in the economy of Pakistan and its share in GDP is 4%.

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upon groundwater resources for agricultural and drinking purposes. Pakistan, being a creating nation, is likewise confronting serious environmental dangers because of unreliable industrialization and unplanned urbanization [4].

Chromium (Cr) is recorded by the Environmental Protection Agency as one of the 129 need contaminations and one of the 14 most poisonous substantial metals. Presentation to Cr (III) through inward breath course has been announced as cancer-causing by different offices [5], [6]. However, 90% of tanneries in the world are using chromium salts to produce leather given that it provides better leather flexibility, water resistance and prevents disintegration, properties that are all important for good leather quality [7]. Excessive intake of chromium by human leads to hepatic and renal damage, capillary damage, gastrointestinal irritation and central nervous system irritation [8].

1.1 Alternative Treatment Techniques for Recovery of Chromium

The pollution of water by overwhelming metals, for example, chromium, copper, cadmium lead and mercury has turned into an expanding issue in the earth and for human wellbeing. Subsequently numerous techniques to decrease lethal toxins have been created. Of late the most widely recognized procedures for expulsion of chromium have been: filtration, reverse osmosis [9], adsorption and concoction responses i.e. lessening and precipitation [10] electro deposition, film frameworks and particle trade forms [11]. Ordinary techniques connected for chromium expulsion have numerous downsides. Henceforth, the adsorption is the most prevalent system to expel overwhelming metals from fluid arrangements [12].

1.1.1 Adsorption

Adsorption is the process where molecules are concentrated on the surface of the sorbent. The molecules go from the bulk phase to being adsorbed in the pores in a semi liquid state. The driving force for adsorption is the ratio of the concentration to the solubility of the compound. Adsorption is used widely to remove chromium metals from waters and industrial wastewaters. Adsorption offers significant advantages like low cost, availability, profitability, ease of operation and efficiency, in comparison with conventional methods (such as membrane filtration or ion exchange) especially from economic and environmental points of view [13], [14], [15], [16]. In this study two adsorbents are used for removal of chromium by adsorption method:

2.Objectives

Purpose of our study was to determine the feasibility of fly ash and red brick dust as adsorbent for removal and recovery of chromium from tannery wastewater. Second objective was to compare the performance efficiency of fly ash and red brick dust meant for removal of chromium from tannery wastewater.

3.Material and methods

3.1 Research Methodology:

Chromium containing aqueous solutions was prepared by using Chromium Sulphate salt. This salt solution was treated against two adsorbents red brick dust and fly ash at different adsorbent dosages (i.e. 250g, 500g, 750g, and 1000g). The pH of solutions was maintained at 4 and 9. This research was oriented on the recovery of chromium from aqueous solution so that it could be used for some useful purposes by using some initial treatment.

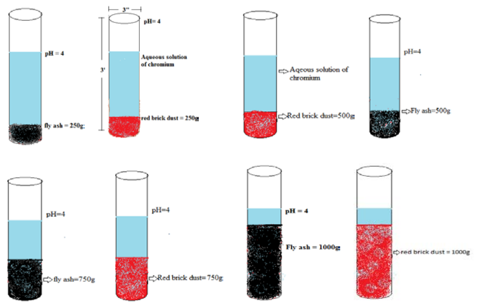

Fig 3.1: pipe arrangement for removal of chromium at pH=4 using red brick dust and fly ash

The same procedure was revised at pH 9.

3.2 Experimental Methodology:

In order to assess the performance of each adsorbent and to avoid interference by other elements in waste water, the experiments were conducted with aqueous solution of chromium Sulphate [Cr2 (SO4)3] in distilled water. A stock solution of Chromium ions was prepared by dissolving 3g of chromium Sulphate [Cr2 (SO4)3] in distilled water and solution made up toss 3000 ml. The solution pH was adjusted in the range of 4 and 9 by adding 0.1 N HCl and 0.01 N NaOH solutions and measured by a pH meter. Eight samples were prepared for pH4 and eight for pH9 before treatment. These solution samples were preserved in refrigerator to avoid any contamination. The prepared solution of different pH levels was treated against two adsorbents red brick dust and fly ash by using adsorption method. The experiment was repeated for both adsorbents at pH 4 and 9 for different amounts of adsorbent dosages 250g/l, 500g/l, 750g/l, 1000g/l.

Adsorbent	Parameters	Before Treatment	After Treatment		
			1Hr	2Hrs	3Hrs
Red Brick Dust	EC (µS/cm)	1170	4290	2450	2432
	pH	4	4.6	4.8	5
	TDS (mg/l)	550	2130	1220	1174
	Chromium (mg/l)	2.03	1.193	1.112	1.09
Fly Ash	EC (µS/cm)	1170	2400	1318	1190
	pH	4	8.3	8.1	7.8
	TDS (mg/l)	550	3751	2059	1920
	Chromium (mg/l)	2.03	0.302	0.282	0.273

Table 2: Results for all Parameters at pH4 & adsorbent dose 500g

Adsorbent	Parameters	Before Treatment	After Treatment		
			1Hr	2Hrs	3Hrs
Red Brick Dust	EC (µS/cm)	1170	2390	1598	1429
	pH	4	4.2	5.1	5.4
	TDS (mg/l)	550	2390	1598	1429
	Chromium (mg/l)	2.03	1.523	1.23	1.124
Fly Ash	EC (µS/cm)	1170	2169	1950	1568
	pH	4	8.4	8.2	8.0
	TDS (mg/l)	550	2169	1950	1568
	Chromium (mg/l)	2.03	0.701	0.589	0.43

Table 3: Results for all Parameters at pH4 & adsorbent dose 750g

		Treatment	1Hr	2Hrs	3Hrs
Red Brick Dust	EC (µS/cm)	1170	3770	3980	4210
	pH	4	4.6	3.6	3.8
	TDS (mg/l)	550	1870	1990	2000
	Chromium (mg/l)	2.03	1.102	1.08	1.023
Fly Ash	EC (µS/cm)	1170	2412	1403	1100
	pH	4	8.5	8.1	7.8
	TDS (mg/l)	550	3769	2192	1879
	Chromium (mg/l)	2.03	0.28	0.216	0.21

Table 4: Results for all Parameters at pH4 & adsorbent dose 1000g

		Treatment	1Hr	2Hrs	3Hrs
Red Brick Dust	EC (µS/cm)	1170	3650	3000	2980
	pH	4	3.6	3.8	4.2
	TDS (mg/l)	550	1810	1490	1133
	Chromium (mg/l)	2.03	0.301	0.289	0.202
Fly Ash	EC (µS/cm)	1170	4175	2565	1975
	pH	4	8.9	8.6	8.5
	TDS (mg/l)	550	6523	4008	3120
	Chromium (mg/l)	2.03	0.271	0.268	0.231

Table 5: 2ÅÓÕÌÔÓ ÆÏÒ ÁÌÌ 0ÁÒÁ Í ÅÔÅÒÓ ÁÔ Ð(ω Q ÁÄÓÏÒÂÅÎÔ ÄÏÓÅ ςυπÇ

Adsorbent	Parameters	Before Treatment	After Treatment		
			1Hr	2Hrs	3Hrs
Red Brick Dust	EC (µS/cm)	1170	3070	3100	3192
	pH	9	8.4	8.1	7.8
	TDS (mg/l)	550	1520	1540	1390
	Chromium (mg/l)	2.03	1.923	1.851	1.412
Fly Ash	EC (µS/cm)	1170	2800	1647	1135
	pH	9	9.4	11.2	11.5
	TDS (mg/l)	550	3375	2574	1920
	Chromium (mg/l)	2.03	0.302	0.282	0.273

Table 6: Results for all Parameters at pH9 & adsorbent dose 500g

Adsorbent	Parameters	Before Treatment	After Treatment		
			1Hr	2Hrs	3Hrs
Red Brick Dust	EC (µS/cm)	1170	3080	3150	3123
	pH	9	8.4	8.2	8.5
	TDS (mg/l)	550	1530	1550	1477
	Chromium (mg/l)	2.03	1.19	1.08	1.09
Fly Ash	EC (µS/cm)	1170	2975	1763	1711
	pH	9	9.4	8.6	8.2
	TDS (mg/l)	550	3810	2490	1866
	Chromium (mg/l)	2.03	0.321	0.298	0.292

Table 7: Results for all Parameters at pH9 & adsorbent dose 750g

Adsorbent	Parameters	Before Treatment	After Treatment		
			1Hr	2Hrs	3Hrs
Red Brick Dust	EC (µS/cm)	1170	4000	3280	3219
	pH	9	5.6	4.8	4.6
	TDS (mg/l)	550	3950	3390	3219
	Chromium (mg/l)	2.03	1.39	1.273	1.212
Fly Ash	EC (µS/cm)	1170	2750	1630	1355
	pH	9	10.3	9.7	9.2
	TDS (mg/l)	550	4210	2490	2100
	Chromium (mg/l)	2.03	1.231	1.22	1.20

Table 8: Results for all Parameters at pH9 & adsorbent dose 1000g

Adsorbent	Parameters	Before Treatment	After Treatment		
			1Hr	2Hrs	3Hrs
Red Brick Dust	EC (µS/cm)	1170	3101	2044	2038
	pH	9	4.9	4.2	3.9
	TDS (mg/l)	550	1952	1674	995
	Chromium (mg/l)	2.03	1.152	1.322	1.334
Fly Ash	EC (µS/cm)	1170	3001	1930	1874
	pH	9	9.8	11.1	
	TDS (mg/l)	550	3910	2490	2122
	Chromium (mg/l)	2.03	1.091	0.979	0.921

4.2. Graphical presentation of all parameters after treatment: Effect on EC:

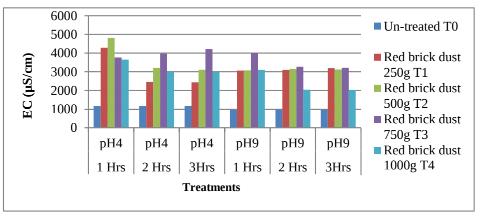

Fig 1: EC values of Red Brick Dust

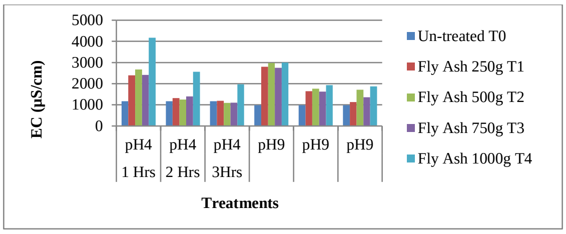

Fig 2: EC values of Fly Ash

Effect on TDS:

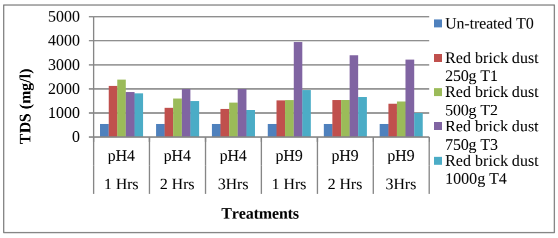

Fig 3: TDS values of Red Brick Dust

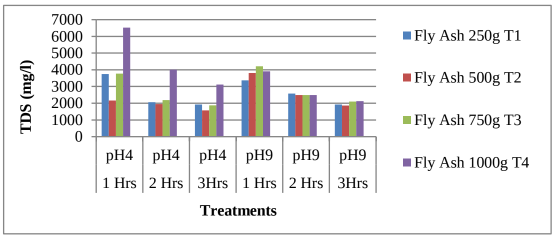

Fig 4: TDS values of Fly Ash

Effect of pH:

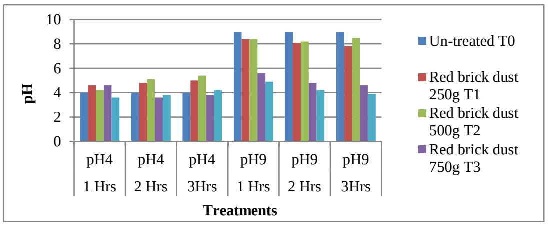

Fig 5: pH values of Red Brick Dust

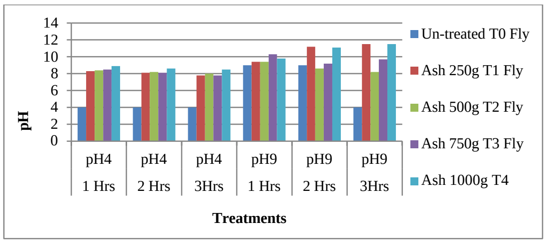

Fig 6: pH values of Fly Ash

Effect on Chromium Removal:

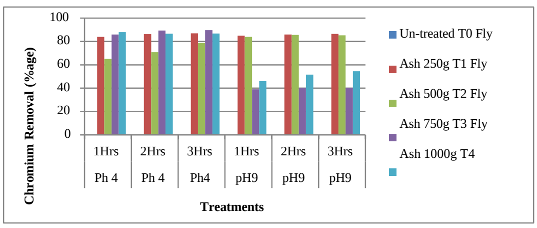

Fig 7: Chromium values of Fly Ash

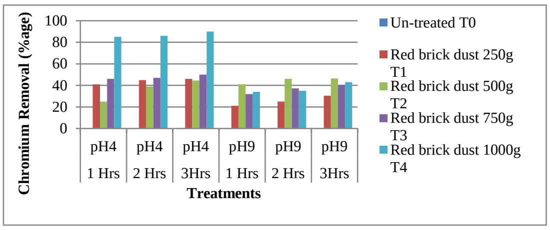

Fig 8: Chromium values of Red Brick Dust

5. Discussion

In Fig 1Experimental results showed that the red brick dust application for pH4 and pH9 indicated high results as compare to control treatment. The T4 presented lowest EC results 2980 µS/cm and 2038 µS/cm at 3 hour interval for pH4 and pH9 respectively. Fly ash exhibited the same trend as displayed the brick dust and results of treatments increased form the control treatment. For pH4 T2 showed the best results after 3 hours interval with EC value 1094 µS/cm. T1 showed the lowest results for pH9 after 3 hours interval with EC value 1135 µS/cm as shown in fig 2.

In Fig 3 results revealed that as the red brick dust application for pH4 and pH9 have shown high results as compare to control treatment. Treatment T3 showed exceptional behavior as its values were increased with increase in retention time.T_1 and T_4exposed lowest values of TDS results 1174mg/l and 1133mg/l at 3 hour interval for pH4 as well as 1390mg/l and 995mg/l for pH9 respectively. Fly ash presented the same trend as in case of brick dust and results of treatments increased from the control treatment. For pH_4 T_2 and T_3 showed the best results after 3 hours interval with TDS value 1568mg/l and 1879mg/l. For pH9 T2 and T1 showed the best results after 3 hours interval with TDS value 1920mg/l and 1866mg/l.T_4 and T_3 showed the highest results at pH4 and pH9 as shown in fig 4.

In fig 5 results revealed that as the red brick dust application for pH4 indicated with the increase of retention time pH of the solutions was turning to basic nature. At pH9, after treatment pH values were going acidic in nature. For pH4 the T_2 have shown maximum pH value result 5.4 at time interval of 3hours. For pH9 T4 showed lowest pH value as 4.2. Fly ash exposed the maximum values of pH after treatment. For pH4 T_4 showed the peak value of pH 8.9 after 1 hour interval which is basic in nature. For pH9 T_2 showed the lowest value of pH as 8.2 as shown in fig 6.Other three treatments T_1, T_3, T_4indicated increased values of pH after treatment as 11.5, 9.7 and 11.5 respectively.

Fly ash presented the same trend as the brick dust and results of treatments decreased from the control treatment. For pH4 T_3 showed the best results for chromium removal as 0.21mg/l after 2 hours interval as shown in fig 7. T_3 exposed the best results for pH9 after 3 hours interval with Chromium contents 0.273mg/l. Experimental results described that as the red brick dust application for pH4 showed better results as compare to control treatment. Same behavior was found in pH9. The T4explained best Chromium removal 0.202mg/l at 3 hour interval for pH4.Similarly T_2 exhibited best removal of chromium as 1.092mg/l at 2hour interval time as shown in fig 8.

6. Conclusion and Recommendations

Chromium was efficiently reduced by red brick dust treatment as compared to Fly ash. Best chromium recovery was achieved at pH4, contact time of 3hours; adsorbent dosage 1000g and results obtained are very close to NEQS. TDS values of the chromium solutions were also going to increase after treatment with red brick dust and fly ash. Most important thing is that the pH of solutions exhibited diversified trend after treatment of the chromium solutions. Acidic nature of solution changed into basic nature and vice versa after treating them with both adsorbents. Conclusively, recovery of chromium was achieved by using red brick dust. It means red brick dust is the cheapest material which could be used on source for treatment of tannery waste water by conserving soil and water resources. Further studies are to be continued for increasing the adsorption potential of the red brick dust by treating it with other chemicals or acids. Combined treatment plant are highly suggested under this study, so that the economical load equally distributed on industries and the proper treatment will be performed to save our ground water sources, agriculture land and aquatic life also.

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