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Removal Efficiency of Physico-Chemical Parameters and Heavy Metals Using Some Natural Materials and Industrial Wastes

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Abstract - The search of efficient methods for the treatment industrial wastewater of motivated the use of economically viable waste and natural materials. Consequently attempts have been made to assess the feasibility of using red mud, fly ash, activated carbon, china clay, montmorillonite, used tea leaves, etc for the waste water treatment.

Adsorption on red mud, china clay, montmerillonite, fly ash and used tea leaves has been found to improve the quality of water by reducing the values of the necessary parameters (physico-chemical as well as heavy metals). Maximum removal efficiency has been demonstratred by using activated carbon.

Key-words - Red mud, clay, montmorillonite, coal fly ash, activated carbon, used tea leaves, etc.

1. Introduction

With rapid urbanization and industrialization, there is an exponential increase in the demand for water. Most of the human activities involving industrial and agricultural development and the inadequate management of land and water resources have directly or indirectly resulted in the degradation of hydrological environment. The impact is notable on the quality and quantity of ground resources and the fertility of soil.

Due to industrial effluent the surface and ground water quality at Kalmeshwar in Nagpur district has been drastically contaminated by a large chunk number of pollutants. Especially, the parameters like hardness, COD, metal content, etc. are very high as compared to the standard values. Most of the people of this area use water directly from the available resources without any treatment for different domestic purposes and hence are exposed to a variety of water related diseases. It seems therefore, necessary to minimize the water pollution in the form of COD, calcium and magnesium hardness, chlorides, metals, etc. in Kalmeshwar (the study area).

2. Materials and Methods

The adsorption process is technically and economically feasible. The advantage of adsorption over other technologies is that no additional sludge is produced. The search for uses of industrial effluents and efficient methods for water treatment motivated the need for economically viable materials for protection of environment and public health. With the aim of addressing all these problems at a single stroke, efforts have been oriented to assess the feasibility of using foresaid materials for the water treatment.

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2.1 Red-mud

Red mud (RM) is a by-product of bauxite processing via the Bayer's process. It presents a promising application in water treatment for removal of toxic heavy metal and metalloid ions, inorganic anions such as nitrate, fluoride and phosphate as well as organisms including dyes, phenolic compounds and bacteria [1 - 6]. Red mud was collected from Indian Aluminum Company Belgaum, Karnataka, India. It was washed several times using distilled water followed by drying in muffle furnace at 600^0C for 2 hours.

2.2 Clay

It is the decomposition product of different rocks. Over the time, it undergoes a natural process of transformation from one to another group. Therefore, clay found in nature is usually a mix of different clay groups, one group being dominant. The action of clay is mostly due to its dual property of adsorption and absorption that are expressed at different degrees in different clays [7, 8]. China Clay for the present work was collected from Ajmer. It was powdered using grinder and sieved through fine sieve to get identical particle size. It was washed several times with distilled water and dried in oven at 105^0C for sufficiently long period.

2.3 Montmorillonite

These clays are recognized as good adsorbents due to their ability to exchange interlayer cations for charged organic or metal cations in solution [9 - 11]. Montmorillonite was purchased locally and was powdered using grinder and sieved through fine sieve to get identical particle size. It was also washed several times and dried in oven at 105^0C for a few hours.

2.4 Fly ash

Fly ash is a major by-product in the coal thermal power plants, i.e., it is the residue obtained by burning of coal. Fly ash has been reported to be an amorphous ferroalumino

silicate with major matrix elements being Si, Al and Fe together with significant amount of Mg, Ca, K, Na and Ti. Trace elements like As, Cd, Cu, Mo, Pb, S, Ti and Zn has a tendency to be associated with the lighter fraction or the finer fraction of the fly ash [12 - 16]. For the present work it was collected from Koradi Thermal Power Plant. It was washed with deionized water several times and dried in muffle furnace at 600^0C for 2 hours.

2.5 Activated Carbon

Activated carbon either granulated or in powder form is capable of removing dissolved organic contaminants from wastewater. Activated carbon treatments considerably help in removing the last traces of metals in the range 1 – 2 ppm [17 - 19]. Carbon particles were collected from Koradi thermal power plant. They were washed with deionized water several times and then dried in oven at 105^0C. Dried coal or carbon particles were converted into powder using a grinder to get identical particles in size by sieving.

2.6 Used tea leaves

Adsorption behavior of used tea leaves for removal of heavy metals from aqueous solutions and industrial wastewater has elsewhere been reported [20 - 22]. Used tea leaves were collected and washed several times with distilled water to remove the surface adhered particles and water soluble materials. These leaves were then dried at 50 – 60^0C for 24 hours, grinded and sieved to 50 mesh size. The powder was preserved at room temperature in sealed bottles until used.

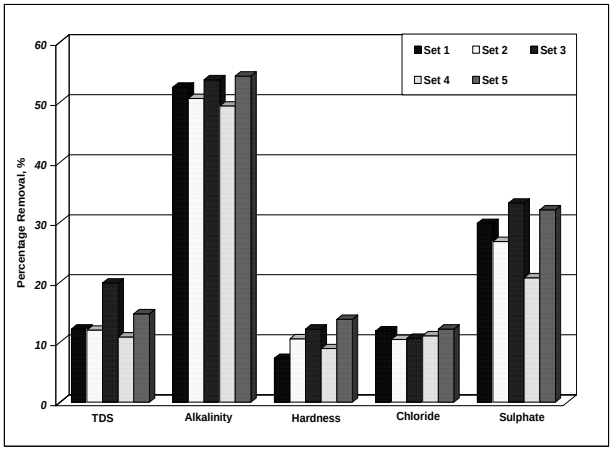
Continuous adsorption process for the above materials was studied. In this process adsorbent was held in glass columns (height 30 cm and width 3 cm) with the adsorbent height of 20 cm and the water to be treated was allowed to flow through it. Watson Marlow Pump was used for delivering the predetermined volumes of liquid into the column in the upward direction. The flow of treated effluent was maintained as 5 ml/min. Each column was run for 15 hours. During the run five samples were collected at an interval of 3 hours each, i.e., every time 900 ml sample was collected for the analysis. Three sets of experiments were run simultaneously for each adsorbent material. The reported data are thus the average of three results.

3. Result and Discussion

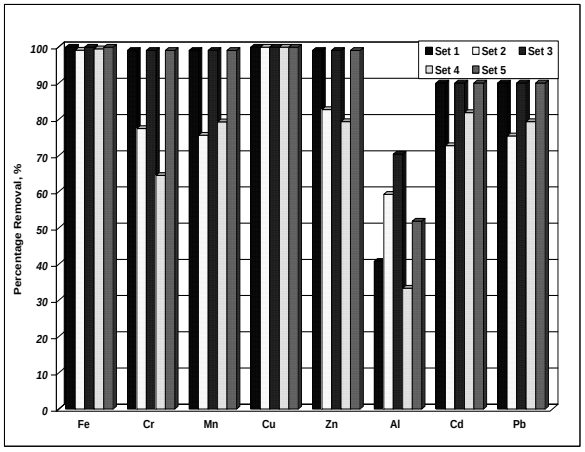
The analysis result for different adsorbents are shown in the table 1 to table 6 and the percentage removal efficiency for the physico-chemical parameters and for heavy metals is given in figures 1(a) & (b) to figures 6 (a) & (b) respectively.

TABLE 1 : ANALYSIS RESULT USING RED MUD

Sr. No.	Parameters	Unit	Original Value	Set - 1	Set - 2	Set - 3	Set - 4	Set - 5
1	pH	-	7.6	8.2	8.2	8.2	8.2	8.1
2	Colour	Hazen	4	7	5	6	4	4
3	Conductivity	µS/cm	4340	3800	3820	3515	3860	3695
4	TDS	mg/l	3120	2740	2745	2500	2780	2660
5	COD	mg/l	< 8	< 8	< 8	< 8	< 8	< 8
6	BOD	mg/l	< 5	< 5	< 5	< 5	< 5	< 5
7	Alkalinity	mg/l	320	152	158	148	162	146
8	Hardness	mg/l	1230	1140	1100	1080	1120	1060
9	Ca ++	mg/l	212	204	205	204	215	202
10	Mg ++	mg/l	168	151	141	137	140	133
11	Na +	mg/l	731	637	648	641	652	634
12	K +	mg/l	30	20	22	19	22	17
13	Chloride	mg/l	976	860	874	872	868	857
14	Sulphate	mg/l	265	186	194	177	210	180
15	Iron	mg/l	2.420	BDL	0.023	BDL	0.014	BDL
16	Chromium	mg/l	0.031	BDL	0.007	BDL	0.011	BDL
17	Manganese	mg/l	0.082	BDL	0.020	BDL	0.017	BDL
18	Copper	mg/l	0.003	BDL	BDL	BDL	BDL	BDL
19	Zinc	mg/l	0.150	BDL	0.026	BDL	0.031	BDL
20	Aluminum	mg/l	0.027	0.016	0.011	0.008	0.018	0.013
21	Cadmium	mg/l	0.011	BDL	0.003	BDL	0.002	BDL
22	Lead	mg/l	0.126	BDL	0.031	BDL	0.026	BDL



1 (a)



1 (b)

Figure 1(a) Percentage removal efficiency for physico-chemical parameters using Red Mud

(b) Percentage removal efficiency for heavy metals using Red Mud

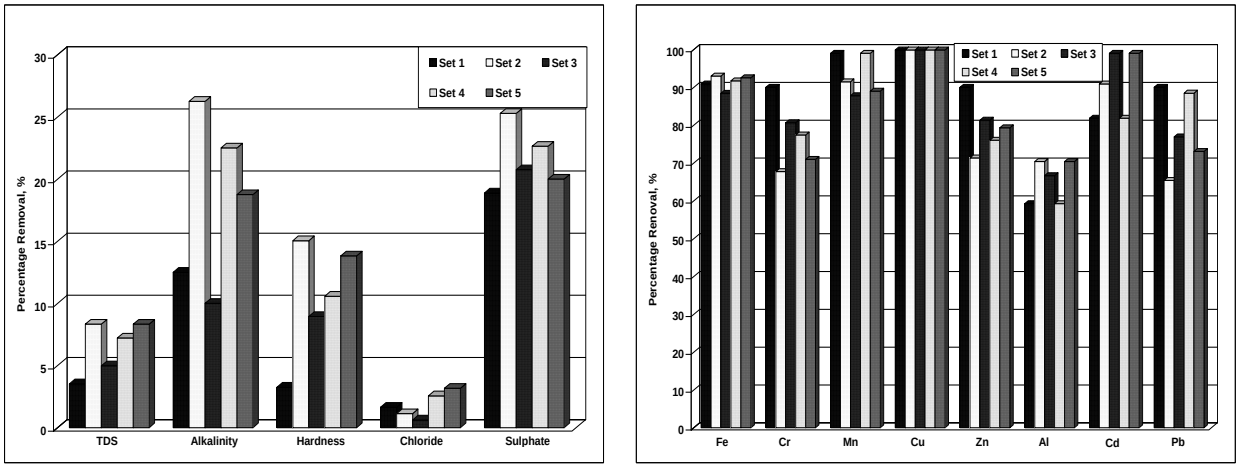
Table 1 show that there is decrease in values for nearly all the parameters except for pH and color. The pH of the treated water showed marginally higher value 8.2 which falls in the range prescribed by Indian Standard for drinking as it lies well below the upper limit of IS code. It thus, is not a problem at all. The values for color also show a slight increase in the beginning but goes on decreasing with time. The highest value for color obtained is 7 Hazen and the permissible value for color according to Indian Standards for Drinking Water is 25 Hazen, which again is well in the prescribed range of IS code.

Figure 1(a) shows the percentage removal efficiencies for TDS, alkalinity, hardness, chlorides and sulphates. The highest percentage removal efficiency is shown by alkalinity 49.37 - 54.37 followed by sulphate 20.75 – 33.20. Whereas the percentage removal efficiencies for TDS, hardness and chloride are seen to lie in the range 10.89 – 19.87, 7.32 – 13.82 and 10.45 – 12.19 respectively. Figure 1(b) shows the percentage removal efficiencies for metals. The highest removal efficiency is obtained for Fe and Cu followed by Cr, Mn and Zn. The percentage removal efficiencies for Cd and Pb fall in the range 72.72 – 90.00 and 75.39 – 90.00 respectively. The lowest percentage removal efficiency is obtained for Al 33.33 – 70.37.

TABLE 2 : ANALYSIS RESULT USING CHINA CLAY

Sr. No.	Parameters	Unit	Original Value	Set - 1	Set - 2	Set - 3	Set - 4	Set - 5
1	pH	-	7.6	7.7	7.5	7.6	7.7	7.7
2	Colour	Hazen	4	8	5	5	4	6
3	Conductivity	µS/cm	4340	4180	3970	4100	4020	3975
4	TDS	mg/l	3120	3010	2860	2965	2895	2860
5	COD	mg/l	< 8	< 8	< 8	< 8	< 8	< 8
6	BOD	mg/l	< 5	< 5	< 5	< 5	< 5	< 5
7	Alkalinity	mg/l	320	280	236	288	248	260
8	Hardness	mg/l	1230	1190	1045	1120	1100	1060
9	Ca ++	mg/l	212	242	217	237	224	215
10	Mg ++	mg/l	168	140	120	126	129	125
11	Na +	mg/l	731	708	706	715	700	700
12	K +	mg/l	30	28	26	26	25	25
13	Chloride	mg/l	976	960	965	970	951	945
14	Sulphate	mg/l	265	215	198	210	205	212
15	Iron	mg/l	2.420	0.220	0.170	0.280	0.200	0.180
16	Chromium	mg/l	0.031	BDL	0.010	0.006	0.007	0.009
17	Manganese	mg/l	0.082	BDL	0.007	0.010	BDL	0.008

18	Copper	mg/l	0.003	BDL	BDL	BDL	BDL	BDL
19	Zinc	mg/l	0.150	BDL	0.043	0.028	0.036	0.031
20	Aluminum	mg/l	0.027	0.011	0.008	0.009	0.011	0.008
21	Cadmium	mg/l	0.011	0.002	0.001	BDL	0.002	BDL
22	Lead	mg/l	0.126	BDL	0.009	0.006	0.003	0.007



2 (A) 2 (B)

FIGURE 2 (A) : PERCENTAGE REMOVAL EFFICIENCY FOR PHYSICO-CHEMICAL PARAMETERS USING CHINA CLAY

(B) : PERCENTAGE REMOVAL EFFICIENCY FOR HEAVY METALS USING CHINA CLAY

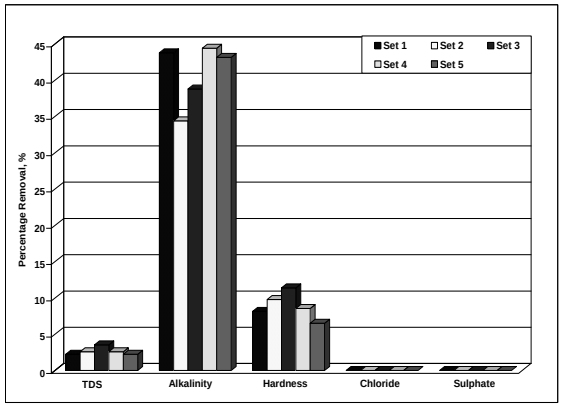
It is apparent from the data recorded in table 2 that the parameters like pH and color are more or less constant, i.e., the china clay is ineffective in this regard. However metals show a good reduction in the values in comparison to water sample.

Figure 2 (a) shows the highest percentage removal efficiency for alkalinity 10.00 – 26.25 followed by sulphate 18.87 – 25.28, whereas for TDS, hardness and chloride lies in the range 3.52 – 8.33, 3.25 – 15.04 and 0.61 – 3.17 respectively. The data recorded in figure 2 (b) is seen to be very interesting as far as the removal of metals is concerned. The highest removal efficiency is obtained for Cu followed by Mn, Cd and Fe. The percentage removal efficiencies for Cr, Zn and Pb lie in the range 67.74 – 90.00, 71.33 – 90.00 and 65.38 – 90.00 respectively. The lowest percentage removal efficiency is obtained for Al 59.26 – 70.37.

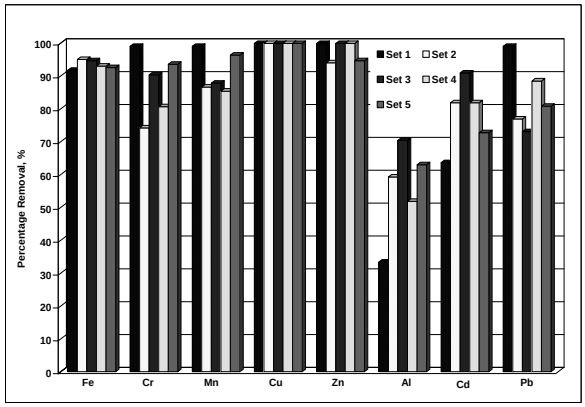
TABLE 3 : ANALYSIS RESULT USING MONTMERILLONITE

Sr. No.	Parameters	Unit	Original Value	Set - 1	Set - 2	Set - 3	Set - 4	Set - 5
1	pH	-	7.6	8	7.9	8	8	8
2	Colour	Hazen	4	4	4	4	4	4
3	Conductivity	µS/cm	4340	4260	4230	4200	4250	4250
4	TDS	mg/l	3120	3050	3040	3010	3040	3050
5	COD	mg/l	< 8	< 8	< 8	< 8	< 8	< 8
6	BOD	mg/l	< 5	< 5	< 5	< 5	< 5	< 5
7	Alkalinity	mg/l	320	180	210	196	178	182
8	Hardness	mg/l	1230	1130	1110	1090	1125	1150
9	Ca ++	mg/l	212	235	235	231	234	243
10	Mg ++	mg/l	168	130	125	123	129	130
11	Na +	mg/l	731	740	745	739	740	731
12	K +	mg/l	30	28	29	28	28	29
13	Chloride	mg/l	976	972	980	970	972	960

14	Sulphate	mg/l	265	266	265	265	265	265
15	Iron	mg/l	2.420	0.200	0.120	0.130	0.170	0.180
16	Chromium	mg/l	0.031	BDL	0.008	0.003	0.006	0.002
17	Manganese	mg/l	0.082	BDL	0.011	0.010	0.012	0.003
18	Copper	mg/l	0.003	BDL	BDL	BDL	BDL	BDL
19	Zinc	mg/l	0.150	BDL	0.009	BDL	BDL	0.008
20	Aluminum	mg/l	0.027	0.018	0.011	0.008	0.013	0.010
21	Cadmium	mg/l	0.011	0.004	0.002	0.001	0.002	0.003
22	Lead	mg/l	0.126	BDL	0.006	0.007	0.003	0.005



3 (A)



3 (B)

FIGURE 3 (A) : PERCENTAGE REMOVAL EFFICIENCY FOR PHYSICO-CHEMICAL PARAMETERS USING MONTMERILLONITE

(B) : PERCENTAGE REMOVAL EFFICIENCY FOR HEAVY METALS USING MONTMERILLONITE

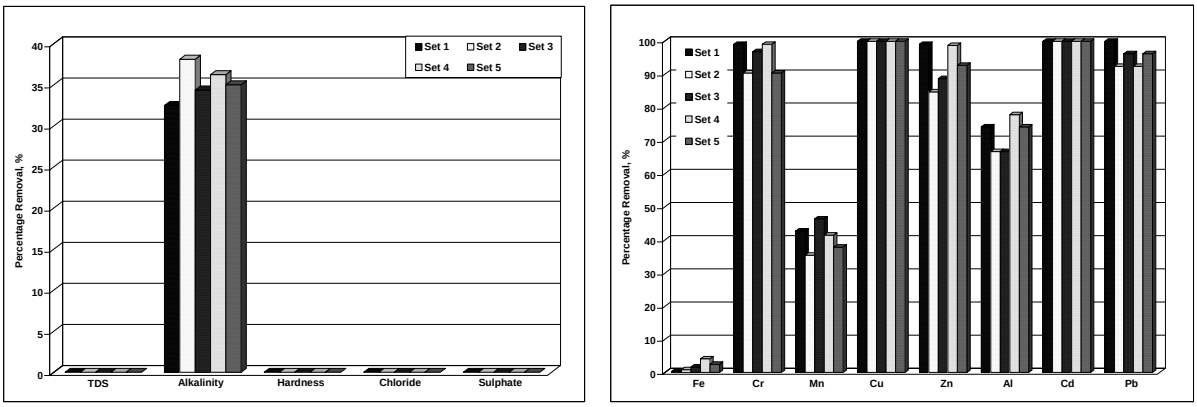
The data recorded in table 3 depicts that similar to china clay, the montmerillonite also does not appear to be effective in changing the colour and pH of the treated water as the values for treated and original wastewater are found to be more or less same. But it does not carry any weightage as the values fall much below that prescribed in IS Code. The COD and BOD show similar behavior which is a matter of concern. TDS and alkalinity are seen to follow decreasing trend in their values in treated water with reference to the sample water. Further the montmerillonite again fails to remove chloride and sulphate as their values does not differ significantly from that of the sample water, whereas heavy metals show a good reduction in their values.

The data shown in figure 3 (a) depicts the percentage removal efficiency of TDS, alkalinity, hardness, chlorides and sulphates. The highest percentage removal efficiency is shown by alkalinity in the range 34.37 – 44.37 followed by hardness 6.50 – 11.38. Figure 3 (b) shows conclusively the percentage removal efficiencies of metals. The highest removal efficiency is obtained for Cu and Zn followed by Fe, Cr and Mn. The percentage removal efficiencies for Cd and Pb lies in the range 63.63 – 90.91 and 73.07 – 99.00 respectively which are known to be highly hazardous. The lowest percentage removal efficiency is obtained for Al 33.33 – 70.37. It may be mentioned here that Ca+2 ion concentration is found to be significantly higher in the treated water probably due to exchangeable Ca+2 ions are present in montmerillonite.

TABLE 4 : ANALYSIS RESULT USING FLY ASH

Sr. No.	Parameters	Unit	Original Value	Set - 1	Set - 2	Set - 3	Set - 4	Set - 5
1	pH	-	7.6	7.8	7.7	7.7	7.7	7.6
2	Colour	Hazen	4	2	2	2	2	2
3	Conductivity	µS/cm	4340	4675	4700	4660	4560	4600
4	TDS	mg/l	3120	3365	3380	3350	3280	3315
5	COD	mg/l	< 8	< 8	< 8	< 8	< 8	< 8
6	BOD	mg/l	< 5	< 5	< 5	< 5	< 5	< 5

7	Alkalinity	mg/l	320	216	198	210	204	208
8	Hardness	mg/l	1230	1310	1280	1240	1230	1210
9	Ca ++	mg/l	212	272	256	256	248	252
10	Mg ++	mg/l	168	151	153	144	146	139
11	Na +	mg/l	731	789	805	805	789	802
12	K +	mg/l	30	38	40	42	36	39
13	Chloride	mg/l	976	1050	1065	1073	1052	1058
14	Sulphate	mg/l	265	280	296	289	273	298
15	Iron	mg/l	2.420	2.410	240	2.380	2.320	2.360
16	Chromium	mg/l	0.031	BDL	0.003	0.001	BDL	0.003
17	Manganese	mg/l	0.082	0.047	0.053	0.044	0.048	0.051
18	Copper	mg/l	0.003	BDL	BDL	BDL	BDL	BDL
19	Zinc	mg/l	0.150	BDL	0.023	0.017	0.002	0.011
20	Aluminum	mg/l	0.027	0.007	0.009	0.009	0.006	0.007
21	Cadmium	mg/l	0.011	BDL	BDL	BDL	BDL	BDL
22	Lead	mg/l	0.126	BDL	0.002	0.001	0.002	0.001



4 (A) 4 (B)

FIGURE 4 (A) : PERCENTAGE REMOVAL EFFICIENCY FOR PHYSICO-CHEMICAL PARAMETERS USING FLY ASH

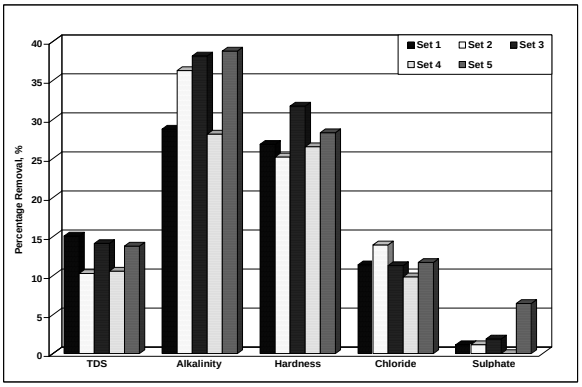
(B) : PERCENTAGE REMOVAL EFFICIENCY FOR HEAVY METALS USING FLY ASH

The results reported in table 4 show that there is considerable decreasing trend in alkalinity and heavy metals concentration whereas the pH of the treated water is almost equivalent to that of sample water which is immaterial as the values fall within the range for potable water as per IS code. Slight increase is seen in the values of chloride and sulphate which may be attributed to presence of these ions in fly ash itself. The hazardous heavy metals however, seen to be considerably reduced. Figure 4 (a) shows the percentage removal efficiency for TDS, alkalinity, hardness, chlorides and sulphates. The percentage removal efficiency is shown only by alkalinity in the range 32.50 – 38.12 whereas TDS, hardness, chlorides and sulphates remain more or less unaffected as compared to their concentration in the sample water. Figure 4 (b) shows the percentage removal efficiencies for metals. The highest removal efficiency is obtained for Cu and Cd followed by Cr, Zn and Pb. The percentage removal efficiencies for Al and Mn lies in the range 66.66 – 77.78 and 35.36 – 46.34 respectively. The lowest percentage removal efficiency is obtained for Fe in the range 0.41 – 4.13.

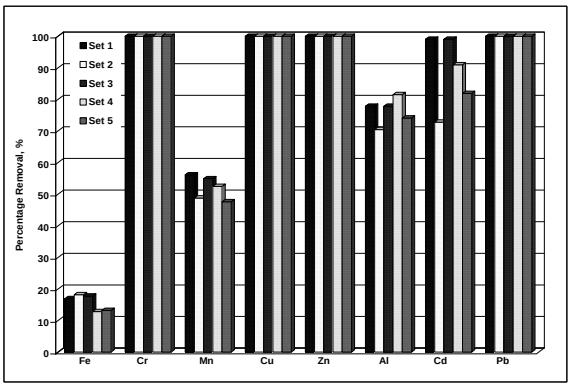
TABLE 5 : ANALYSIS RESULT USING ACTIVATED CARBON

Sr. No.	Parameters	Unit	Original Value	Set - 1	Set - 2	Set - 3	Set - 4	Set - 5
1	pH	-	7.6	7.8	7.8	8	7.9	8
2	Colour	Hazen	4	4	2	4	2	2
3	Conductivity	µS/cm	4340	3720	4050	3800	3980	3840

4	TDS	mg/l	3120	2650	2800	2680	2790	2690
5	COD	mg/l	< 8	< 8	< 8	< 8	< 8	< 8
6	BOD	mg/l	< 5	< 5	< 5	< 5	< 5	< 5
7	Alkalinity	mg/l	320	228	204	198	230	196
8	Hardness	mg/l	1230	900	920	840	904	882
9	Ca ++	mg/l	212	204	204	184	197	187
10	Mg ++	mg/l	168	93	98	91	99	99
11	Na +	mg/l	731	659	651	668	680	661
12	K +	mg/l	30	28	28	28	28	27
13	Chloride	mg/l	976	865	840	866	880	862
14	Sulphate	mg/l	265	262	262	260	265	248
15	Iron	mg/l	2.420	2.010	1.980	1.990	2.110	2.100
16	Chromium	mg/l	0.031	BDL	BDL	BDL	BDL	BDL
17	Manganese	mg/l	0.082	0.036	0.042	0.037	0.039	0.043
18	Copper	mg/l	0.003	BDL	BDL	BDL	BDL	BDL
19	Zinc	mg/l	0.150	BDL	BDL	BDL	BDL	BDL
20	Aluminum	mg/l	0.027	0.006	0.008	0.006	0.005	0.007
21	Cadmium	mg/l	0.011	BDL	0.003	BDL	0.001	0.002
22	Lead	mg/l	0.126	BDL	BDL	BDL	BDL	BDL



5 (A)



5 (B)

FIGURE 5 (A) : PERCENTAGE REMOVAL EFFICIENCY FOR PHYSICO-CHEMICAL PARAMETERS USING ACTIVATED CARBON

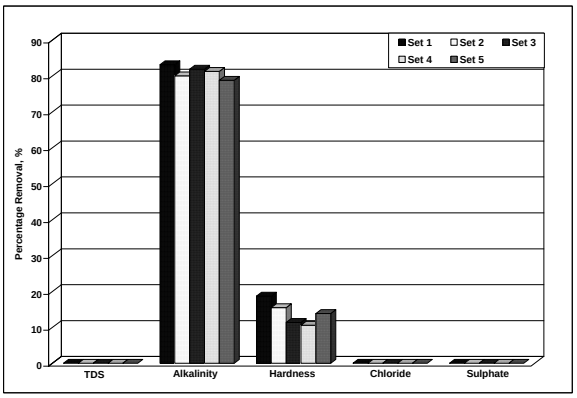
(B) : PERCENTAGE REMOVAL EFFICIENCY FOR HEAVY METALS USING ACTIVATED CARBON

The results recorded in table 5 clearly depict that the values of all the parameters decrease except that of the pH and color. Both these parameters are found to be more or less constant in comparison to the water sample reflecting that activated carbon is significantly inefficient to cause any change in them. It is quite surprising to note that activated charcoal known as one of the best decolourizers fails in this case.

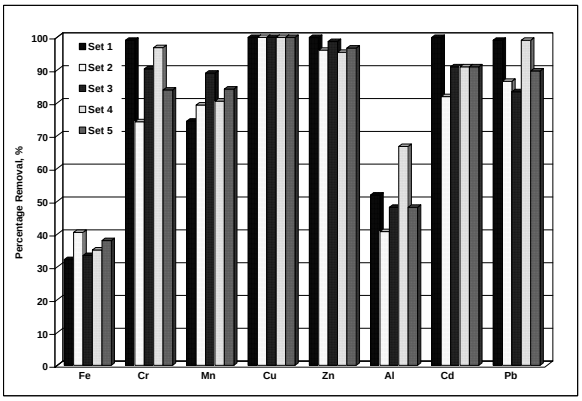
The results reported in figure 5(a) show the percentage removal efficiency for TDS, alkalinity, hardness, chlorides and sulphates. The highest removal efficiency in terms of % is shown by alkalinity 28.12 – 38.75 followed by hardness 25.20 – 31.70 whereas those for TDS and chloride lies in the range 10.25 – 15.06 and 9.83 – 13.93 respectively. Sulphate showed the least percentage removal efficiency 0.01 – 6.41. The results presented in both the table 5 and figure 5(b) reveals that the cations of Cr, Cu, Zn, Pb, Cd, Al and Mn are drastically reduced. The most hazardous cation out of the above such as those of Cr, Cd, Pb and Mn are almost completely removed except for Mn (50 %) showing thereby that activated carbon is highly efficient in removing not only the general parameters but also those which are known to cause severe health hazard. The highest removal efficiency is obtained for Cr, Cu, Zn and Pb followed by Cd. The percentage removal efficiencies for Al and Mn lies in the range 0.37 – 81.48 and 47.56 – 56.10 respectively. The lowest percentage removal efficiency is seen for Fe in the range 12.81 – 18.18.

TABLE 6 : ANALYSIS RESULT WITH USED TEA LEAVES

Sr. No.	Parameters	Unit	Original Value	Set - 1	Set - 2	Set - 3	Set - 4	Set - 5
1	pH	-	7.6	5.7	5.8	5.8	5.8	5.8
2	Colour	Hazen	4	14	13	12	13	12
3	Conductivity	µS/cm	4340	4400	4505	4640	4620	4425
4	TDS	mg/l	3120	3167	3250	3340	3325	3190
5	COD	mg/l	< 8	20	16	20	20	12
6	BOD	mg/l	< 5	5	< 5	5	5	< 5
7	Alkalinity	mg/l	320	54	64	58	60	68
8	Hardness	mg/l	1230	1000	1040	1090	1100	1060
9	Ca ++	mg/l	212	208	214	224	224	220
10	Mg ++	mg/l	168	115	121	127	129	122
11	Na +	mg/l	731	821	837	850	840	808
12	K +	mg/l	30	32	37	42	41	36
13	Chloride	mg/l	976	1030	1086	1102	1076	1047
14	Sulphate	mg/l	265	360	328	344	357	319
15	Iron	mg/l	2.420	1.640	1.440	1.610	1.570	1.500
16	Chromium	mg/l	0.031	BDL	0.008	0.003	0.001	0.005
17	Manganese	mg/l	0.082	0.021	0.017	0.009	0.016	0.013
18	Copper	mg/l	0.003	BDL	BDL	BDL	BDL	BDL
19	Zinc	mg/l	0.150	BDL	0.006	0.002	0.007	0.005
20	Aluminum	mg/l	0.027	0.013	0.016	0.014	0.009	0.014
21	Cadmium	mg/l	0.011	BDL	0.002	0.001	0.001	0.001
22	Lead	mg/l	0.126	BDL	0.017	0.021	BDL	0.013



6 (A)



6 (B)

FIGURE 6 (A) : PERCENTAGE REMOVAL EFFICIENCY FOR PHYSICO-CHEMICAL PARAMETERS USING USED TEA LEAVES

(B) : PERCENTAGE REMOVAL EFFICIENCY FOR HEAVY METALS USING USED TEA LEAVES

Table 6 shows that there is in general decrease in the values of alkalinity, hardness and metals ion content. The treated water has been found to inherit a pH of 5.7 as compared to that of 7.6 for water sample, though not covered by IS code for potable water, indicates that this is due to leaching of acidic materials from waste tea leaves. This is problematic and needs further study. The results also demonstrate that increase in the values of chlorides and sulphates which might have found their way in treated water from waste tea leaves. All metals show a good reduction in their values in treated water.

The estimated removal efficiency in percentage also recorded in figure 6(a) shows TDS is not removed as the sample and treated water has almost the same values. Alkalinity is seen to be tremendously removed while hardness is not removed to that extent. Chlorides and

sulphates are found to significantly increase in treated water as compared to sample water. It is obvious that these increments originate from waste tea leaves used as adsorbent. Figure 6(b) shows the percentage removal efficiencies for metals. The highest removal efficiency is obtained for Cu and Zn followed by Cr, Cd and Pb. The percentage removal efficiencies for Al and Mn lies in the range 74.39 – 89.02 and 40.74 – 66.66 respectively. The lowest percentage removal efficiency is obtained for Fe in the range 32.23 – 40.49.

4. Conclusion

Adsorption on red mud, china clay, montmerillonite, fly ash, activated carbon and used tea leaves has been studied and found to improve the quality of water by reducing the values of the necessary parameters (physico-chemical as well as heavy metals). Maximum removal efficiency has been demonstrated by activated carbon followed by red mud, china clay, montmerillonite and fly ash. The least percentage removal efficiency is shown by waste tea leaves due to its leaching characteristics.

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