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Original Research Paper

Biosorption Study of Textile, Dye and Printing Industry Effluent Using Natural Biological Adsorbents

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ABSTRACT

The study was conducted to treat the textile, dye and printing industry effluent using natural occurring biological adsorbents (*Areaca catechu, Moringa pterygosperma, Quercus infectoria* and *Tamarindus indica*). The treatment was carried out on various concentrations (25%, 50% 75% and 100%) of dye effluent. Highest removal of pollutant was observed at lower effluent concentrations (25% and 50%) as compared to higher effluent concentrations (75 % and 100%). The addition of biological adsorbents has brought significant reduction in various parameters of textile, dye and printing industry effluent. The reduction in pollution load may be due to the coagulative and chelative property of *Areaca catechu, Moringa pterygosperma, Quercus infectoria* and *Tamarindus indica*, which can be used as low cost and safe biological adsorbents for removing toxic substances in textile, dye and printing industry effluent.

INTRODUCTION

Among various industries, the textile industry ranks first in usage of dyes for coloration of fabrics. Today, more than 900 types of dyes have been incorporated in the colour index (Rashmi et al. 2006). Decolourisation has become an integral part of the textile waste treatment process. Textile processing consumes enormous quantity of water and chemicals for various operations like washing, dyeing, etc. Among different water pollutants, dyes are important group of chemicals, since they are widely used in textile to colour their products (Baskar et al. 2006). Dyes absorb and reflect sunlight entering water and so can interfere with the growth of bacteria and hinder photosynthesis in aquatic plants (Allen & Kuovama 2005). Dyes are generally synthetic aromatic compounds, some may be embodied with heavy metals in their structure. Dyes also cause allergic dermatitis, skin irritation, cancer and mutation. During dye production and textile manufacturing processes, a large amount of wastewater containing dyestuffs with intensive colour and toxicity can be introduced into the aquatic systems. On an average 200-300 litre of freshwater is used for each kg of textile material produced. Nearly 10-25 percent of effluent comes from the final washing process, called wash water, contains traces of colouring materials, heavy metals and other chemicals. Therefore, it is desirable to remove colouring materials from effluents.

Pollutants generally occur in industrial effluents and cause direct toxicity both to humans and other living beings due to their presence beyond specific limits. Due to high water consumption in the textile industry, it is essential to study its reuse. Many processes have also been studied to treat textile industry effluent. The conventional methods for treating dye containing effluent are chemical coagulation, chemical oxidation, photochemical degradation, membrane filtration, and aerobic and anaerobic biological degradation (Kara & Folkared 2006). These methods are either expensive or cannot cope with high concentrations of contaminants. All these methods have disadvantages such as incomplete ion removal, high energy requirement and production of toxic sludge or other waste products that require further disposal.

Traditional methods may not be able to meet the effluent standards where several strongly complexing organic and inorganic ligands are present. On the other hand advanced technologies may be economically unacceptable. For solving the problems of heavy metal removal and recovery from industrial wastes entails a choice between simple and relatively economical traditional and advanced technologies.

Several nonconventional materials available in the form of industrial wastes (fly ash, blast furnace slag and flue dust) and agricultural wastes (saw dust, rice husk, waste tea, coffee, bagasse and coconut shell) have been used as adsorbents by several researchers. Recent investigations on the chemical modification of low cost adsorbents have revealed the possibility of maximizing the adsorption potential of nonconventional materials for removal of pollutants (Sarvanane et al. 2002).

The use of natural biological adsorbents to remove pollutants (biosorption) is an alternative and cost effective technology emerging in past years based on the active sites of biomaterial and metallic ions in the system (Veglio 1997, Volesky 1999, Pagnanelli et al. 2002). Adsorption offers great potential for treating effluents containing undesirable components, and renders them safe and reusable (Rai et al. 1998, Kapadia et al. 2000, Ranganathan 2000, Anima et al. 2004). The major advantages of adsorption process for water pollution control are low investment in terms of cost, simple design, easy operations and no effect by toxic harmful substances (Annadurai 2000).

Growing popularity of natural biological adsorbents in industrial effluent treatment is emerging as an effective alternative technology to overcome the problems associated with physico-chemical methods and can be treated as a new application area, which has put this technique at par with other techniques. Keeping in view this fact, the present study was an attempt to remediate textile, dye and printing industry effluent through use of natural biological adsorbents.

MATERIALS AND METHODS

Textile, dye and printing industry effluent was collected in sterile cans from a textile industry, Maral Overseas Ltd., Madhya Pradesh. For characterization of the dye effluent, the physicochemical analysis of the effluent was made using methods of APHA (1998). The selection of the natural biological adsorbents for the present study, though was not based on any specific reasons, but their sorption, coagulation/chelation property was taken into consideration after a preliminary study. The natural biological adsorbents selected were:

1. Fruit (powered) of betel nut (*Areaca catechu*) Linn. var. name supari, Family-Arecaceae
2. Fruit (powered) of gall oak (*Quercus infectoria*) Linn. var. name Manjuphal, Family-Fagaceae
3. Pod (powered) of drumstick (*Moringa pterygosperma*) Gaertn. var. name sajana, Family-Moringaceae
4. Seeds (powered) of tamarind (*Tamarindus indica*) var. name imli, Family-Caesalpinioideae

Batch experiments were conducted to evaluate the percentage of adsorption by the four selected natural biological adsorbents. 200 mg fine powder (oven dried at 100°C for 1 hour) of each natural biological adsorbent was transferred in conical flask containing 50 mL of textile, dye and printing industry effluent of different known concentrations (25%, 50%, 75% and 100%). The conical flask contents were thoroughly shaken on mechanical shaker at 150 rpm for 30 min. The flask contents were allowed to settle for another 30 min and the supernatant was filtered through Whatman filter Paper No. 42, and the filtrate was tested for pH using digital pH meter and other parameters following standard procedures of APHA (1998).

RESULTS AND DISCUSSION

Textile dye and printing industry produces effluents in large amounts and also faces disposal problems. As the effluent may affect the land surface and water bodies adversely, proper disposal is necessary. According to Allen & Kuovama (2005) the constituents of textile dye and printing industry effluent are synthetic chemicals and have various salts and toxic heavy metals. The colour was dark blue and pH was alkaline 10 (Table 1). The colour is the major problem of dyeing industries.

pH study: pH plays a significant role in adsorption. With the use of natural biological adsorbents viz., betel nut, gall oak, sajana, and tamarind, the initial pH and the final pH (after treatment with biological adsorbents) varied. After treatment with all the four biological adsorbents the final pH value decreased at all the concentrations (25%, 50%, 75% and 100%). The decrease was maximum at lower concentrations (25 % and 50%) as compared to higher concentrations (75% and 100%) (Tables 2-5). The change in pH value was maximum in case of gall oak followed by betel nut, drumstick and tamarind. The hierarchy of biological adsorbents was: Gall oak > Betel nut > Drumstick > Tamarind. The change in pH can be attributed to the higher degree of ionization of metal ions at higher pH, and the reduced competition of H^+ ions with the metal ion for adsorption sites. The physicochemical characteristics of the adsorbent may also play an important role (Anima et al. 2004 and Ranganathan 2000). Similar results have been reported by Renu Bala et al. (2005), Sharma et al. (2006) and Beltran et al. (2009). The sorption capacity is considered to be a function of pH value (Singh et al. 1993, Shrivastava et al. 2001). Singh et al. (1993) have observed that the adsorption usually increases at higher pH value which may be due to enhanced ion exchange and adsorption. It was reported that the seeds of *S. potatorum* and *Moringa oleifera* contain natural polyelectrolytes, which can be used as coagulants to clarify turbid water.

Conductivity study: In case of conductivity, a general increase was noticed with treatment of all the four natural biological adsorbents at all the concentrations (25%, 50%, 75% and 100%) of textile dye and printing industry effluent. The trend of conductivity increase was maximum in case of drumstick followed by betel nut, gall oak and tamarind. The increase was maximum at lower concentrations (25% and 50%) as compared to higher concentrations (75% and 100%) (Tables 2-5). The descending order of biological adsorbents was Drumstick > Betel nut > Gall oak > Tamarind. It appears that the adsorption and neutralization of various free H^+ ions is responsible for increased conductivity of the effluent that took place with the addition of various biological adsorbents. They either released certain cations, which in turn neutralized and removed H^+

Table 1: Physico-chemical parameters of textile, dye and printing industry effluent.

Sl. No.	Parameters	Value (mg/L)
1.	pH	10.9
2.	Conductivity	10.75
3.	Colour	Dark blue
4.	(COD)	2122
5.	(BOD)	236
6.	Total hardness	620
7.	Sulphate	4032
8.	Nitrate	175
9.	Carbonate	1224
10.	Bicarbonate	610
11.	Chloride	10656
12.	Calcium	2400
13.	Magnesium	960
14.	Sodium	7176
15.	Potassium	312
16.	Zinc	4.56
17.	Copper	2.69
18.	Iron	10.26
19.	Manganese	5.79
20.	Lead	0.89
21.	Mercury	0.06
22.	Nickel	0.19
23.	Chromium	2.49
24.	Cadmium	2.06

Table 2: % Removal of textile, dye and printing industry effluent using biological adsorbent *Areaca catechu* at different concentrations.

S.No.	Parameters	Conc. (%)	Initial Conc. (%)	Remaining Conc. (%)	Reduction in Conce. (%)	Qe	Log Ce	Log Qe	IN Cl/Ce	k*10-3	% Reduction
1	pH	25	9.1	8.03	1.07	0.0214	0.90	-1.66959	1.13	4.2	11.758
		50	9.6	8.54	1.06	0.0212	0.93	-1.67366	1.12	3.9	11.042
		75	10	9.43	0.57	0.0114	0.97	-1.9431	1.06	2.0	5.700
		100	10.9	9.76	1.14	0.0228	0.99	-1.64207	1.12	3.7	10.459
2	Conductivity (mMho)	25	9.63	10.12	-0.49	-0.0098	1.01	#NUM!	0.95	-1.7	-5.088
		50	10	10.38	-0.38	-0.0076	1.02	#NUM!	0.96	-1.2	-3.800
		75	10.33	10.65	-0.32	-0.0064	1.03	#NUM!	0.97	-1.0	-3.098
		100	10.75	11.23	-0.48	-0.0096	1.05	#NUM!	0.96	-1.5	-4.465
3	Total Hardness	25	162	65	97	1.94	1.81	0.287802	2.49	30.4	59.877
		50	287	198	89	1.78	2.30	0.25042	1.45	12.4	31.010
		75	473	404	69	1.38	2.61	0.139879	1.17	5.3	14.588
		100	620	589	31	0.62	2.77	-0.20761	1.05	1.7	5.000
4	COD	25	989	811	178	3.56	2.91	0.55145	1.22	6.6	17.998
		50	1106	989	117	2.34	3.00	0.369216	1.12	3.7	10.579
		75	1608	1513	95	1.9	3.18	0.278754	1.06	2.0	5.908
		100	2122	2045	77	1.54	3.31	0.187521	1.04	1.2	3.629
5	BOD	25	116	49	67	1.34	1.69	0.127105	2.37	28.7	57.759
		50	191	138	53	1.06	2.14	0.025306	1.38	10.8	27.749
		75	213	169	44	0.88	2.23	-0.05552	1.26	7.7	20.657
		100	236	203	33	0.66	2.31	-0.18046	1.16	5.0	13.983
6	Sulphate	25	1276	1195	81	1.62	3.08	0.209515	1.07	2.2	6.348
		50	2117	2047	70	1.4	3.31	0.146128	1.03	1.1	3.307
		75	3651	3594	57	1.14	3.56	0.056905	1.02	0.5	1.561
		100	4032	3987	45	0.9	3.60	-0.04576	1.01	0.4	1.116
7	Nitrate	25	38	52	-14	-0.28	1.72	#NUM!	0.73	-10.5	-36.842
		50	89	113	-24	-0.48	2.05	#NUM!	0.79	-8.0	-26.966
		75	132	161	-29	-0.58	2.21	#NUM!	0.82	-6.6	-21.970
		100	175	209	-34	-0.68	2.32	#NUM!	0.84	-5.9	-19.429

from the medium (Baisakh et al. 1996, Verma & Rehal 1996, Ahmed Ram 1996, Verma & Shukala 2000, Vasudevan & Latha 2000). The similar trend was observed by Renu Bala et al. (2005), Sharma et al. (2006) and Beltran et al. (2009). The increased trend of conductivity shows the ionizable nature of dye, which was present in dye effluent. The increase could be due to the release of anions present within the biological adsorbents.

COD and BOD study: COD and BOD in the effluent decreased in all concentrations of effluent (Tables 2-5). These were lowered in high concentrations and were normal in low concentrations. The decrease was maximum in case of drumstick followed by tamarind, betel nut and gall oak. The hierarchy of biological adsorbents was for COD: Drumstick > Tamarind > Betel nut > Gall oak and for BOD: Drumstick > Tamarind > Betel nut > Gall oak.

The decrease of COD and BOD of the different concentrations of the effluent due to the addition of biological adsorbents can be ascribed to their good adsorbent and bioflocculant property interacting with pollutants present in the dye effluent.

Renu Bala et al. (2005) reported that the decreased trend of COD and BOD is due to the coagula-

Table 3: % Removal of textile, dye and printing industry effluent using biological adsorbent *Moringa -pterygosperma* at different concentrations.

S.No.	Parameters	Conc. (%)	Initial Conc. (%)	Remaining Conc. (%)	Reduction in Conce. (%)	Qe	Log Ce	Log Qe	IN Ci/Ce	k*10-3	% Reduction
1	pH	25	9.1	7.8	1.3	0.026	0.89	-1.58503	1.17	5.1	14.286
		50	9.6	8.61	0.99	0.020	0.94	-1.70333	1.11	3.6	10.313
		75	10	9.76	0.24	0.005	0.99	-2.31876	1.02	0.8	2.400
		100	10.9	10.2	0.7	0.014	1.01	-1.85387	1.07	2.2	6.422
2	Conductivity (mMho)	25	9.63	10.19	-0.56	-0.011	1.01	#NUM!	0.95	-1.9	-5.815
		50	10	10.44	-0.44	-0.009	1.02	#NUM!	0.96	-1.4	-4.400
		75	10.33	10.79	-0.46	-0.009	1.03	#NUM!	0.96	-1.5	-4.453
		100	10.75	11.36	-0.61	-0.012	1.06	#NUM!	0.95	-1.8	-5.674
3	Total Hardness	25	162	59	103	2.06	1.77	0.313867	2.75	33.7	63.580
		50	287	202	85	1.7	2.31	0.230449	1.42	11.7	29.617
		75	473	401	72	1.44	2.60	0.158362	1.18	5.5	15.222
		100	620	600	20	0.4	2.78	-0.39794	1.03	1.1	3.226
4	COD	25	989	802	187	3.74	2.90	0.572872	1.23	7.0	18.908
		50	1106	983	123	2.46	2.99	0.390935	1.13	3.9	11.121
		75	1608	1509	99	1.98	3.18	0.296665	1.07	2.1	6.157
		100	2122	2053	69	1.38	3.31	0.139879	1.03	1.1	3.252
5	BOD	25	116	43	73	1.46	1.63	0.164353	2.70	33.1	62.931
		50	191	131	60	1.2	2.12	0.079181	1.46	12.6	31.414
		75	213	161	52	1.04	2.21	0.017033	1.32	9.3	24.413
		100	236	197	39	0.78	2.29	-0.10791	1.20	6.0	16.525
6	Sulphate	25	1276	1164	112	2.24	3.07	0.350248	1.10	3.1	8.777
		50	2117	2038	79	1.58	3.31	0.198657	1.04	1.3	3.732
		75	3651	3571	80	1.6	3.55	0.20412	1.02	0.7	2.191
		100	4032	3974	58	1.16	3.60	0.064458	1.01	0.5	1.438
7	Nitrate	25	38	49	-11	-0.22	1.69	#NUM!	0.73	-10.5	-28.947
		50	89	110	-21	-0.42	2.04	#NUM!	0.79	-8.0	-23.596
		75	132	158	-26	-0.52	2.20	#NUM!	0.82	-6.6	-19.697
		100	175	206	-31	-0.62	2.31	#NUM!	0.84	-5.9	-17.714

tion and flocculation processes of the biological adsorbents in the effluent. Achalya et al. (2005) stated that the galactomanans are effective in the removal of heavy metals. Preetha & Virthagiri (2005) also observed that the biosorption property of *R. arrihizus* for Zn (II) uptake was decreased with increased biomass loading. Kumar et al. (2008) noticed that the seed powder of *Strychnos potatorum* effectively removes toxic pollutants at higher concentrations and low pH. Jackson et al. (1990) reported that live or dead cultured cells of *Datura innoxia*, a higher plant can be used to remove Ba^{2+} from solutions. Kadirvel (1993) recorded complete removal of BOD and COD from the dyeing waste water by using carbonized coir pith.

Total hardness study: The total hardness of the effluent is mainly governed by Ca and Mg ions in different forms. The total hardness was also decreased in all the concentrations of the effluent, after treatment with biological adsorbents. The decrease in total hardness was maximum in case of drumstick followed by betel nut, gall oak and tamarind. The decrease was maximum at lower concentrations (25 % and 50%) as compared to higher concentrations (75% and 100%) (Tables 2-5). The descending order of biological adsorbents was Drumstick > Betel nut > Gall oak > Tamarind. This indicates that the solids formed in this process get adsorbed on surface of biological adsorbents,

Table 4: % Removal of textile, dye and printing industry effluent using biological adsorbent *Quercus infectoria* at different concentrations.

S.No.	Parameters	Conc. (%)	Initial Conc. (%)	Remaining Conc. (%)	Reduction in Conce. (%)	Qe	Log Ce	Log Qe	IN Ci/Ce	k*10-3	% Reduction
1	pH	25	9.1	8.1	1	0.020	0.91	-1.69897	1.17	3.9	10.989
		50	9.6	8.7	0.9	0.018	0.94	-1.74473	1.11	3.3	9.375
		75	10	9.5	0.5	0.010	0.98	-2	1.02	1.7	5.000
		100	10.9	10.6	0.3	0.006	1.03	-2.22185	1.07	0.9	2.752
2	Conductivity (mMho)	25	9.63	10.22	-0.59	-0.012	1.01	#NUM!	0.95	-2.0	-6.127
		50	10	10.51	-0.51	-0.010	1.02	#NUM!	0.96	-1.7	-5.100
		75	10.33	10.89	-0.56	-0.011	1.04	#NUM!	0.96	-1.8	-5.421
		100	10.75	11.36	-0.61	-0.012	1.06	#NUM!	0.95	-1.8	-5.674
3	Total Hardness	25	162	63	99	1.98	1.80	0.296665	2.75	31.5	61.111
		50	287	211	76	1.52	2.32	0.181844	1.42	10.3	26.481
		75	473	416	57	1.14	2.62	0.056905	1.18	4.3	12.051
		100	620	589	31	0.62	2.77	-0.20761	1.03	1.7	5.000
4	COD	25	989	811	178	3.56	2.91	0.55145	1.23	6.6	17.998
		50	1106	992	114	2.28	3.00	0.357935	1.13	3.6	10.307
		75	1608	1511	97	1.94	3.18	0.287802	1.07	2.1	6.032
		100	2122	2062	60	1.2	3.31	0.079181	1.03	1.0	2.828
5	BOD	25	116	49	67	1.34	1.69	0.127105	2.70	28.7	57.759
		50	191	143	48	0.96	2.16	-0.01773	1.46	9.6	25.131
		75	213	173	40	0.8	2.24	-0.09691	1.32	6.9	18.779
		100	236	210	26	0.52	2.32	-0.284	1.20	3.9	11.017
6	Sulphate	25	1276	1174	102	2.04	3.07	0.30963	1.10	2.8	7.994
		50	2117	2043	74	1.48	3.31	0.170262	1.04	1.2	3.496
		75	3651	3589	62	1.24	3.55	0.093422	1.02	0.6	1.698
		100	4032	3986	46	0.92	3.60	-0.03621	1.01	0.4	1.141
7	Nitrate	25	38	44	-6	-0.12	1.64	#NUM!	0.73	-4.9	-15.789
		50	89	107	-18	-0.36	2.03	#NUM!	0.79	-6.1	-20.225
		75	132	154	-22	-0.44	2.19	#NUM!	0.82	-5.1	-16.667
		100	175	203	-28	-0.56	2.31	#NUM!	0.84	-4.9	-16.000

thereby making the total hardness of the dye effluent to fall. Decrease in hardness at different concentrations of the dye effluent suggests that the biological adsorbents either have adsorbed various ionic species present in the media or have caused their chelation. Similar observations have been reported by Ansari et al. (2000) and Muyibi & Alfugara (2003).

Sulphate and nitrate study: The concentration of SO_4^{2-} and NO_3^- was also varied in the studied dye effluent. Sulphate concentration was decreased while NO_3^- concentration was increased at all the concentrations of the effluent. The decrease of SO_4^{2-} and increase of NO_3^- are higher at lower effluent concentration (25 % and 5%) and lower at higher effluent concentration (75% and 100%) (Tables 2-5). The decrease was maximum in case of drumstick followed by betel nut, gall oak and tamarind. Similarly, increase was maximum in case of tamarind followed by gall oak, drumstick and betel nut. The decrease in SO_4^{2-} is due to the adsorbent and coagulant property of the biological adsorbents and increase in NO_3^- indicating the presence of nitrogen in the dye molecule. Similar results have been reported by Renu Bala et al. (2006), Sharma et al. (2006) and Beltran et al. (2009). Vasanthy & Thamaraiselvi (2007) also reported that the suitability of utilization of the powdered peel of *Citrus reticulate* for the nitrate removal, which does not pose any health hazard later.

Table 5: % Removal of textile, dye and printing industry effluent using biological adsorbent *Tamarindus indica* at different concentrations.

S.No.	Parameters	Conc. (%)	Initial Conc. (%)	Remaining Conc. (%)	Reduction in Conce. (%)	Qe	Log Ce	Log Qe	IN Ci/Ce	k*10-3	% Reduction
1	pH	25	9.1	7.9	1.2	0.024	0.90	-1.61979	1.15	4.7	13.187
		50	9.6	8.6	1	0.020	0.93	-1.69897	1.12	3.7	10.417
		75	10	9.4	0.6	0.012	0.97	-1.92082	1.06	2.1	6.000
		100	10.9	10.5	0.4	0.008	1.02	-2.09691	1.04	1.2	3.670
2	Conductivity (mMho)	25	9.63	10.31	-0.68	-0.014	1.01	#NUM!	0.93	-2.3	-7.061
		50	10	10.54	-0.54	-0.011	1.02	#NUM!	0.95	-1.8	-5.400
		75	10.33	10.78	-0.45	-0.009	1.03	#NUM!	0.96	-1.4	-4.356
		100	10.75	11.31	-0.56	-0.011	1.05	#NUM!	0.95	-1.7	-5.209
3	Total Hardness	25	162	66	96	1.92	1.82	0.283301	2.45	29.9	59.259
		50	287	213	74	1.48	2.33	0.170262	1.35	9.9	25.784
		75	473	414	59	1.18	2.62	0.071882	1.14	4.4	12.474
		100	620	592	28	0.56	2.77	-0.25181	1.05	1.5	4.516
4	COD	25	989	809	180	3.6	2.91	0.556303	1.22	6.7	18.200
		50	1106	986	120	2.4	2.99	0.380211	1.12	3.8	10.850
		75	1608	1501	107	2.14	3.18	0.330414	1.07	2.3	6.654
		100	2122	2054	68	1.36	3.31	0.133539	1.03	1.1	3.205
5	BOD	25	116	52	64	1.28	1.72	0.10721	2.23	26.7	55.172
		50	191	140	51	1.02	2.15	0.0086	1.36	10.4	26.702
		75	213	167	46	0.92	2.22	-0.03621	1.28	8.1	21.596
		100	236	198	38	0.76	2.30	-0.11919	1.19	5.9	16.102
6	Sulphate	25	1276	1169	107	2.14	3.07	0.330414	1.09	2.9	8.386
		50	2117	2038	79	1.58	3.31	0.198657	1.04	1.3	3.732
		75	3651	3582	69	1.38	3.55	0.139879	1.02	0.6	1.890
		100	4032	3980	52	1.04	3.60	0.017033	1.01	0.4	1.290
7	Nitrate	25	38	46	-8	-0.16	1.66	#NUM!	0.83	-6.4	-21.053
		50	89	104	-15	-0.3	2.02	#NUM!	0.86	-5.2	-16.854
		75	132	151	-19	-0.38	2.18	#NUM!	0.87	-4.5	-14.394
		100	175	207	-32	-0.64	2.32	#NUM!	0.85	-5.6	-18.286

The biological adsorbents were selected in the present study were promising and appeared to be efficient in reducing the pollution load of textile dye and printing industry effluent. Possibly, the chelative action and adsorption potential of the test materials could cause the reduction in the pollution load. Thus, the experiment showed the possible use of agricultural wastes for pollutant removal and the adsorbents have good potential as pollutant scavengers from wastewaters.

REFERENCES

Achalya, N., Kanamadi, R. D. and Ramachandra, T. V. 2005. Biosorption of chromium from aqueous solutions by the husk of bengal gram (*Cicer arientinum*). Electronic J. Bitechol., 6: 0717-3458.

Ahmed, M.N. and Ram, R.N. 1996. Removal of basic dye from wastewater using silica as absorbent. Env. Pollution., 77: 79-86.

Allen, S. J. and Kuovama, K. 2005. Decolourization and reuse of textile industry dye effluent with different adsorbent materials. J. Dyes Oigments, 7: 127-136.

Anima, S.D., Shaik, K.B. and Kavitha, G.V. 2004. Adsorption of Ni (II) using agro waste rice husk. J. of Env. Sci. Engg., 46(3): 179-185.

Annadurai, G. 2000. Adsorption of direct dye from aqueous solution by chitin. Ind. J. Env. Prot., 20(2).

Ansari, N.H., Deshker, A.M., Dharmadhikari, D.M. and Sahib, P. 2000. Neem (*Azadiracata indica*) bark for removal of mercury from water. Env. Mang., 22(2).

APHA. AWWA and WEF 1998. Standard Methods for the Examination of Water and Wastewater. 20th ed., American Public Health Association, Washington D.C.

Baisakh, P.C., Patnaik, S.N. and Patnaik, L.N. 1996. Removal of COD from textile mill effluent using fly ash. Ind. J. Env. Protection, 16(2): 135-139.

Baskar, R., Meera, K. M. and Sundram, S. 2006. Characterization and reuse of textile effluent treatment plant waste sludge in clay bricks. J. Chemical Technol. Metallurgy, 4: 473-478.

Beltran-Heredia, J., Sanchez-Martln, J. and Delgado-Regalado, A. 2009. Removal of carmine indigo dye with *Moringa oleifera* seed extract. Ind. Eng. Chem. Res., 48(14): 6512-6520.

Jackson, P.J., Torres, A.P., Delhaize, E, Pack, E. and Bolender, S.L. 1990. The removal of barium ions from solution using *Datura innoxia* suspension culture cells. J. Env. Quality, 19644-648.

Kadirvel, S. 1993. Studies on the Treatment of Dyeing Industry Using Carbonized Coir Pith Waste. M. Phil. Dissertation, Bharathiar University, Coimbatore.

Kapadia, M.G., Farasram, R.P. and Desai, D.H. 2000. Removal of heavy metals from effluents by fly ash. IJEP, 20(8).

Kara, T. and Folkared, T. 2006. Effect of synthetic chemicals on environment. J. Water Health, 12: 276-298.

Muyibi Suleyman, A. and Alfugara Akif, M.S. 2003. Treatment of surface water with *Moringa oleifera* seed extract and alum-A comparative study using a pilot scale water treatment plant. IJES, 60(6): 617-626.

Pagnanelli Francesca, Esposito Antonio and Veglio Francesco 2002. Multi-metallic modeling for biosorption of binary systems. Water Research, 36: 4095-4105.

Preetha, B. and Virthagiri, T. 2005. Biosorption of zinc (II) by *Rhizopus arrhigus*: Equilibrium and kinetic modeling. African J. Biotechnol., 4(6): 506-508.

Rai, A.K., Upadhayay, S.N., Kumar, S.N. and Upadhyay, Y.D. 1998. Heavy metal pollution and its control through cheaper method. A review. J. IAEM, 25(3).

Ranganathan, K. 2000. Chromium removal by activated carbon prepared from *Casurina equiselifolia* leaves. Bioresources Technology, 73(2).

Rao, N.S., Lathasree, S., Sivasankar, B., Sadasivam, V. and Rengaraj, K. 2004. Removal of Azo dyes from aqueous solutions using activated carbon as an adsorbent. J. of Env. Sci. Engg., 46(2): 172-178.

Rashmi Sanghi, Bani Bhattacharya, Awantika Dixit and Vanadana Singh 2006. *Ipomoea dasysperma* seed gum: An effective natural coagulant for the decolorization of extile dye solutions. J. Environ. Management, 81: 36-41.

Raveendra Babu and Malay Chaudhuri 2005.Home water treatment by direct filtration with natural coagulant. J. Water Health, 03: 27-30.

Renu Bala, I., Sharma, I.K. and Verma, P.S. 2005. Electrochemical treatment of dye effluent using sajana (*Moringa olicitera*) pods. Nat. Env. Poll. Tech., 4(4): 639-640.

Kumar Sampath, P., Dheeba, B., Abdulla Sheik, S., Stalin, S., Vinoth Kanna R., and Venkatesan R. 2008. Bioflocculation of heavy metals from textile dye effluent by *Strychnos potatorum*. J. Ecotoxiol. Environ. Monit., 18(6): 609-613.

Sarvanane, R., Sundarajan, T. and Sivamurthy Reddy, S. 2002. Efficiency of chemically modified low cost adsorbents for the removal of heavy metals from wastewater: A comparative study. Ind J. Env. Hlth., 44(2): 78-87.

Sharma, P., Kumari, P., Srivastava, M.M. and Srivastava, S. 2006. Removal of cadmium from aqueous system by shelled *Moringa oleifera* Lam. seed powder. Bioresource Technology, 97(2): 299-305.

Singh, D.K., Tiwari, D.P. and Saxena, D.N. 1993. Removal of lead from aqueous solutions by chemically treated tea leaves. Ind J. Env. Hlth., 35: 169-177.

Srivastava, R.K., Seghal, V. and Sen, A. 2001. Sorption studies on cadmium removal by *Ipomea* leaves. Eco. Env. Cons., 7(4): 373-377.

Vasanthy, M. and Thamaraiselvi, C. 2007. Removal of the nitrate from aqueous solutions using powered peel of *Citrus reticulate* fruits. Nat. Env. Poll. Tech., 6(4): 737-740.

Vasudevan, N. and Latha, A. 2000. Treatment of phenolic wastewater by *Marexella* sps. Ind. J. Env. Hlth., 20(2).

Veglio, F. and Beolchini, F. 1997. Removal of metals by biosorption: A review. Hydrometallurgy, 44: 301-316.

Verma, B. and Shukala, N.P. 2000. Removal of nickel (II) from electroplating industry effluent using agro waste carbons. Ind. J. Env. Hlth., 42(4): 145-150.

Verma, N. and Rehal, R. 1996. Removal of chromium by *Albizia lebeck* pods from industrial wastewater. J. of Ind. Pollu. Contl., 12(1): 55-59.

Volesky, B. 1999. Biosorption for the next century. In: Amlis R, Ballester A, ed., Biohydromettalurgy and Environment Toward the Mining of the 21st century. Part B, Elsevier, Amsterdam, 161-170.