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Treatment of Natural Zeolite and Fly Ash Zeolite¹ on Waste Water Containing Metallic Salts

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ABSTRACT: The accumulation of heavy metals Cu, Zn, Fe, Sr, Pb, As and Cr have been studied in industrial waste water. This work describes the detection of concentration of these metals in industrial waste water by ICP-AES (Inductively Coupled Plasma Atomic Emission Spectroscopy) technique. In industrial waste water samples Cu, Zn, Fe, Cu and Sr were detected while Pb and As were not detected. For the accumulation of metals by the waste water were collected and analyzed. This concentration of metals is due to industrialization. The waste water samples were collected from near by area of Hindustan Zink Ltd. Company, Udaipur. At this point the soil is getting polluted by the disposal of different industrial waste water. Detected some of the metals are toxic.

KEYWORDS : Accumulation, Heavy Metals, ICP-AES, waste water

I. INTRODUCTION

Industrial growth is an eminent feature of the developing country. Without industrial growth a nation cannot stand amongst the global scenario. Pollution in various forms is thrown into the nearby areas by industries. These pollutants pollute air, soil, surface water as well as ground water (1-2). The heavy metals present in industrial effluents interact with organic and inorganic species and form complexes. Insoluble complexes are deposited on the surface of the soil but soluble complexes formed so far have a tendency to percolate through the soil, which affect the quality of ground water and soil get deteriorated influencing the plant growth in the area (3).

The industrial wastewater causes soil, river and ground water pollution besides causing number of adverse effects on agriculture product, animal and health of people. Since it contains west chemical and heavy metals. The effluents from chemical industry contain a variety of organic and toxic heavy metals. Now a day's in our country so many rivers are being polluted by heavy metals due to the disposal of domestic and industrial waste in river water (4).

Heavy metals like lead, nickel, copper, cobalt, aluminium, phenolic compounds and DDT etc. are usually not present in the environment. These either do not degrade or degrade very slowly and there by pollute the environment (5). The heavy metals like Cu, Zn, Fe, Sr, Pb, As and Cr that have been a major focus in water and waste water has been considered to be more hazardous due to carcinogenic properties (6-8). The industrial waste water percolate through the soil and affects the ground water, soil and plants growth in the nearby area (9-10).

Numerous studies have been reported for detection and identification of organics in western countries (11-12). Pollutants released into the air, water and soil can find their way enter into the human body by breathing, eating and drinking (13). A number of treatment methods for the removal of metal ions from aqueous solutions have been reported. Other methods are ion exchange, electro dialysis, electrochemical precipitation, evaporation, solvent extraction, reverse osmosis and adsorption on activated carbon (14-15). But these methods suffer from drawbacks like capital or the safe disposal of the toxic metal sludge.

The objective of this study was to investigate the heavy metals and to study the characterization of natural zeolite and Fly Ash based zeolite¹ by treatment with wastewater samples 1 and 2.

In the previous work number of adsorbents used were Clarified sludge, Rice husk ash, Saw dust (tea wood origin), Activated carbon and a mixture of Fly ash and Activated Carbon (16). The adsorbents were selected on the basis of their cost effectiveness and ready availability. Many reports have appeared in literature on the development of low-cost adsorbents developed from cheaper and readily available materials (17-22).

Adsorption is highly effective, cheap and less trouble method for the removal of heavy metals from industrial waste water (23-28). Hence adsorption has been tried as method for the removal of Cr using rice husk, bone powder, human hair, activated charcoal, lignite coal, lime, washing soda, saw dust, waste tea leaves, Alibizialebbeck pods, rice straw, coconut fiber pith, fly ash etc. have been attempted as possible substitute for activated carbon with varying degree of success.

Collection of Natural Zeolite and Fly Ash:

Natural zeolite of India was collected from Dhule and Jalgaon district (M.S.) India. This zeolite was then crushed, dried and stored in a clean glass bottle. The zeolites are generally built from (AlO_4) and (SiO_4) tetrahedrons, which have three dimensional structures. The natural zeolite exhibits considerable ion exchange capacity due to exchanging functional group like hydroxyl group and its porous nature which is present in zeolite. Natural zeolite obtained was crushed and sieved for desirable particle size. These particles were dried and stored in glass bottle. Natural zeolite was used as an adsorbent material without any pre-treatment.

In this present work the fly ash used was collected from thermal power plant, Eklahare (Nashik), Maharashtra, which was used after treatment.

Preparation of Fly Ash Zeolite1:

The material used in this study was the fly ash; a waste product resulted in thermal power plant from burning of pit coal. About 500 gm of ash sample (fly ash) have been manually collected at different sites (plants) from the warehouse of a power plant located at Eklahare, Nashik, Maharashtra (INDIA).

Fly Ash zeolite1 material was obtained by direct alkaline conversion processes in autoclaves at 353 K and at time interval 8 hours. The fly ash was added to a 2M NaOH solution. The zeolite obtained was filtered, washed and dried for 4 hours at 373 K. The experimental condition was the mixture continuously stirred.

Collection of Waste Water Samples:

The industrial waste water samples were collected from near by area of Hindustan Zink Ltd. Company, Udaipur and one sample of mixed industrial waste water, collected for the study of heavy metals and their removal and for characterization.

Equipments:

- 1) ME-MAX Digital pH meter model ME-962-P was used to measure pH.
- 2) The magnetic stirrer was used for continuous stirring.
- 3) Remi R4 laboratory centrifuge was used for separating solution containing adsorbent and adsorbate.

DISCUSSION OF RESULTS :

The results obtained during the course of present study are being tabulated in table 1-3. The results obtained for heavy metals are tabulated in table-1. This result shows the concentration of heavy metals in industrial wastewater samples. The concentration of metals like Pb and As was found to be not detected ($< 0.01 \mu\text{g/ml}$) in both of the industrial waste water samples. The concentration of Cu was found to be in the range 0.104 to 0.110 $\mu\text{g / ml}$. The concentration of Zn was found to be detected in the range of 0.773 to 0.847 $\mu\text{g / ml}$, where as the concentration of Fe, Cr and Sr were found to be in the range of 1.704 to 5.186, 0.092 to 0.421 and 0.149 to 1.577 $\mu\text{g / ml}$ respectively.

Table-1) Metal Concentration in Waste Water Samples:-

Sr. No.	Samples	Cu (ppm)	Zn (ppm)	Fe (ppm)	Pb (ppm)	Cr (ppm)	Sr (ppm)	As (ppm)
1	Sample-1	0.110	0.847	5.186	ND	0.421	0.149	ND
2	Sample-2	0.104	0.773	1.704	ND	0.092	1.577	ND

EFFECT of pH on waste water sample-1 and sample-2 and contact time on the adsorption by Natural Zeolite :

50 ml of waste water sample solution added with 1 gm of Natural zeolite as an adsorbent taken in a Borosil beaker and the mixtures were continuously stirred on the magnetic stirrer. The pH of waste water sample solutions were adjusted to 3.0 by adding 1% HCl solution. The mixture was continuously stirred and the values of pH were recorded on digital pH meter ME-MAX model ME-962-P with contact time of 5 minute interval. The readings were recorded from 0 to 150 minutes.

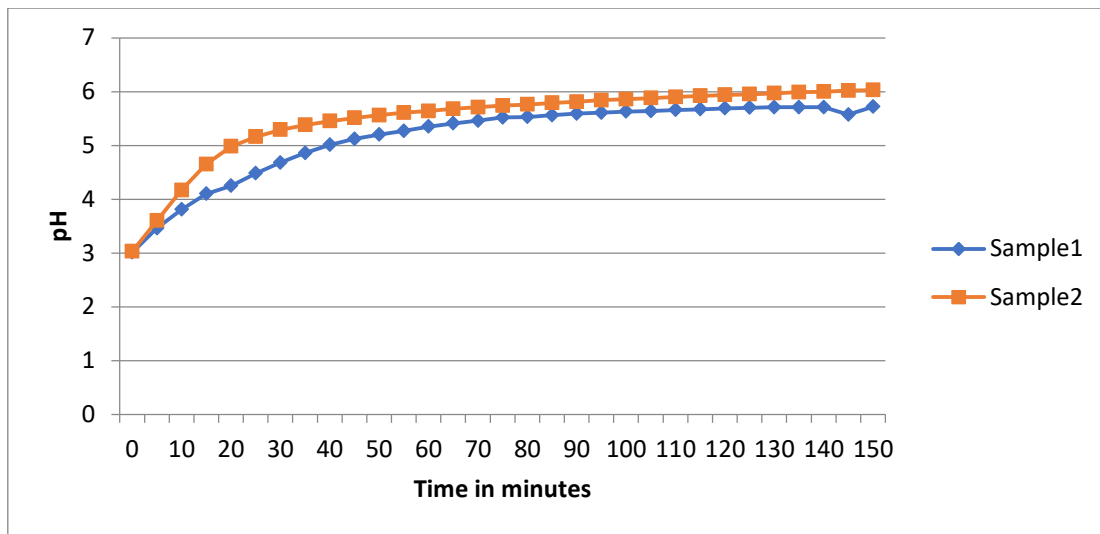


Fig.1) Effect of adsorption contact time (min) on the pH Waste water samples by using Natural Zeolite

As shown in Fig.1, as increasing the adsorption contact time, the pH of the remaining waste water sample increases up to a maximum value of 6.0 at 2.5 hours. We observe that in the first 60 minutes pH rapidly increases up to 5.5 and the pH of the remaining aqueous solution slightly increases over the time from 60 minute to 2.5 hours at room temperature. This is due to the adsorption and/or ion exchange equilibrium.

CHARACTERIZATION OF NATURAL ZEOLITE BY USING THE TECHNIQUES LIKE IR, XRD, SEM AND EDX :

a) IR Spectrum of Natural-Zeolite :

The IR spectra of the natural zeolite has been used to determine structural changes due to cation exchange and adsorption between 4000 cm⁻¹ – 400 cm⁻¹ in KBr using FTIR spectrometer model SIMADZU 8400 S PC with 4.0 per cm resolution.

The obtained characteristic bands, IR frequencies and organic compounds are given in table-2 and 3. The saturated and unsaturated hydrocarbons, alcohols, esters, amides, ketone, aromatic dione, heterocycles, phenols are found in both the industrial waste water samples. Hydrocarbons are naturally occurring compounds; they are emitted to the environment by trees, petroleum industries, coal and automobile emission. The fumes of chimneys and paint thinner contain a mixture of volatile hydrocarbons. Phenolic and acidic compounds impart typical odor and test of water and are hazardous to aquatic life and vegetation even at low concentration. When animal and human beings used such polluted water they frequently affected the disease of elementary track and stomach. It provides toxic effects on brain, liver and lungs etc (29-30).

Table-2) The IR spectrum of CH₂Cl₂ extracted mass:-

Sample	Wave Length	Characteristic Bands	Sample	Wave Length	Characteristic Bands
Sample-1	3783.41	O-H - stretching	Sample-2	3780.68	O-H - stretching
	3704.58	O-H – stretching		3444.27	O-H - stretching
	3441.07	O-H – stretching		2921.66	C-H - stretching
	2924.73	C-H – stretching		2854.44	C-H - stretching
	2857.87	C-H – stretching		1790.09	C=O - stretching
	1729.59	C=O – stretching		1734.18	C=O - stretching
	1690.60	C=O – stretching		1624.45	N-H def.
	1605.90	N=O – stretching		1579.00	N=O - stretching

	1460.94	C-H – def.		1542.07	N=O - stretching
	1374.17	C-H – def.		1466.66	O-H - bending
	1276.64	C-O – stretching		1426.83	O-H - bending
	1188.12	C-C – stretching		1275.36	O-H - bending
	1123.48	C-C – stretching		1182.67	C-C - stretching
	1081.88	C-C – stretching		1081.52	C-C - stretching
	1033.88	C-C – stretching		968.30	C-C - stretching
	968.45	C-C – stretching		868.87	C-C - stretching
	854.07	C-H – rocking		772.62	C-H – rocking
	719.24	C-H – rocking		718.37	C-H – rocking
	533.50	C-I – stretching		537.14	C-Br - stretching

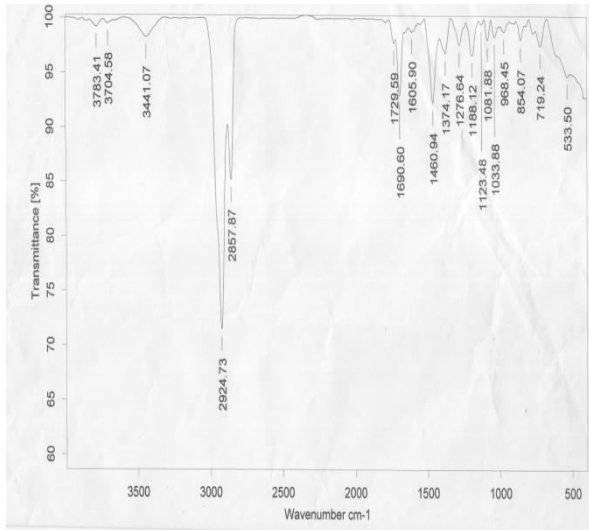


Fig.2) IR spectrum of waste water sample-1

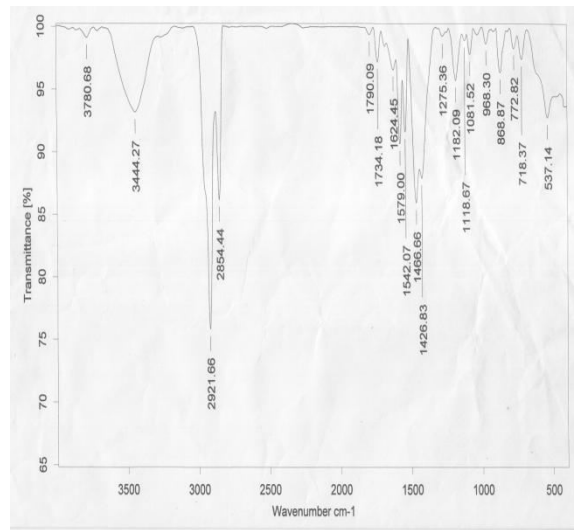


Fig.3) IR spectrum of waste water sample-2.

b) XRD Analysis

The X-ray diffraction pattern of the natural zeolite (Fig.3) shows that it is crystalline, monoclinic and orthorhombic (31-32). The intensity of the peak is also changed but the XRD analysis of the natural zeolite shows crystalline nature (33).

In order to study crystal structure of natural zeolite, X-ray diffractogram of the samples were examined with $2\theta = 10^\circ$ to $2\theta = 80^\circ$. X-ray pattern for natural zeolite match with JCPDS card no. 83-1566. The calculated and standard d values, 2θ values of natural zeolite are reported in table-2.



Fig.4) X-Ray diffraction pattern of Natural Zeolite doped with waste water sample-1 :

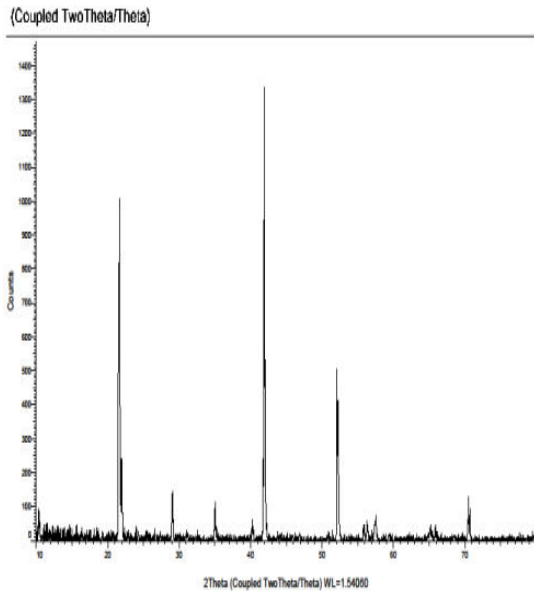


Fig.5) X-Ray diffraction pattern of Natural Zeolite doped with waste water sample-2 :

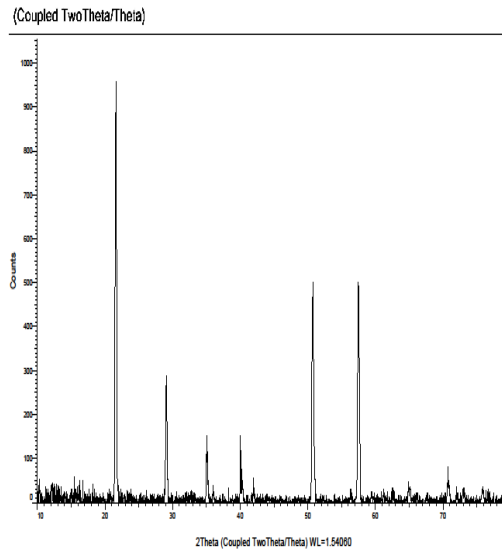


Fig.6) X-Ray diffraction pattern of Fly Ash Zeolite1 doped with waste water sample-1

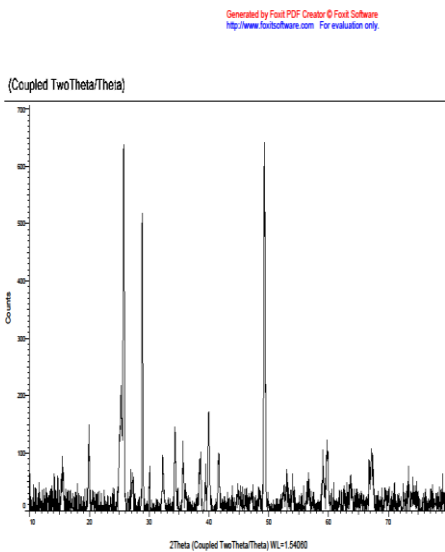


Fig.7) X-Ray diffraction pattern of Fly Ash zeolite1 doped with waste water sample-2

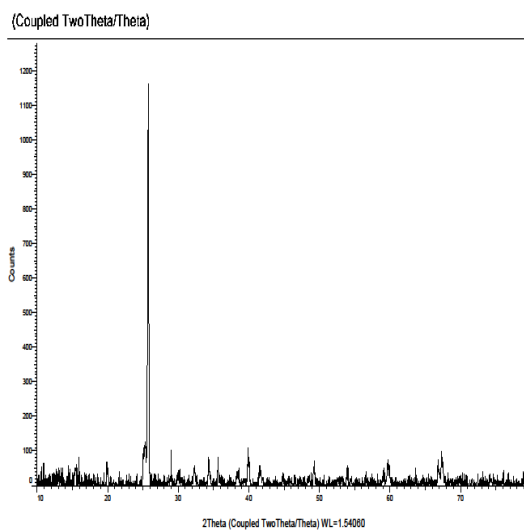




Table-4: The maximum observed and calculated ‘d’ values for the waste water samples:

Sr.No.	Sample Name	d (observed) average value	d (calculated) average value
1.	Natural Zeolite	3.6572	2.6500
2.	Natural zeolite doped with waste water sample1	2.1507	2.2512
3.	Natural zeolite doped with waste water sample2	1.8768	1.8769
4.	Fly Ash Zeolite1 doped with waste water sample1	2.3663	2.3721
5.	Fly Ash Zeolite1 doped with waste water sample2	2.5890	2.5884

Table-5) Crystalline size “D” of the samples :

Sr. No.	Sample Name	D (observed) value in nm	D (calculated) value in nm
1.	Natural Zeolite	25.2 nm	24.26 nm
2.	Natural zeolite doped with waste water sample1	8.1 nm	7.5199 nm
3.	Natural zeolite doped with waste water sample2	3.7 nm	3.7971 nm
4.	Fly Ash Zeolite1 doped with waste water sample1	5.5 nm	4.8985 nm
5.	Fly Ash Zeolite1 doped with waste water sample2	610.4 nm	580.6173 nm

Table 6) : Result of XRD Analysis of waste water samples 1 and 2 :

Sample	2θ	Standard d	Calculated d
Natural Zeolite doped with waste water sample1	21.611	4.1088	4.1088
	29.071	3.0692	3.0691
	35.059	2.5575	2.5574
	41.948	2.1520	2.1430
	55.893	1.6437	1.6436
	57.494	1.6016	1.6017
	65.951	1.4153	1.4153
Natural Zeolite doped with waste water sample2	70.643	1.3323	1.3323
	21.609	4.1092	4.1092
	29.089	3.0673	3.0673
	35.111	2.5538	2.5538
	41.984	2.1502	2.1502
	50.763	1.7971	1.7971
	57.523	1.6009	1.6009
Fly Ash Zeolite1 doped with Waste water sample1	65.022	1.4332	1.4332
	70.784	1.3300	1.3300
	15.516	5.7063	5.7060
	19.925	4.4525	4.4526
	25.297	3.5178	3.5173
	28.870	3.0901	3.0899
	32.313	2.7683	2.7684



	34.354	2.6083	2.6085
	35.678	2.5145	2.5144
	39.963	2.2542	2.2543
	41.644	2.1670	2.1671
	49.299	1.8469	1.8470
	54.025	1.6960	1.6959
	59.803	1.5452	1.5452
	69.595	1.3498	1.3497
	73.336	1.2899	1.2898
Fly Ash Zeolite1 doped with Waste water sample2	15.450	5.7306	5.7314
	19.940	4.4491	4.4487
	25.263	3.5225	3.5221
	28.985	3.0780	3.0775
	32.298	2.7695	2.7694
	34.359	2.6079	2.6077
	41.606	2.1688	2.1689
	49.255	1.8485	1.8485
	53.985	1.6972	1.6973
	59.781	1.5457	1.5457
	67.381	1.3886	1.3886

c) FESEM Analysis (Field Emission Scan Electron Microscopy):

The field emission scanning electron microscopy (SEM) is a primary tool uses for characterization of surface morphology and fundamental physical properties of natural zeolite. It is useful for determining the particle size, shape, porosity. Scanning electron micrograph of natural zeolite doped with waste water sample-1 and sample-2 (Fig.8-9), also scanning electron micrograph of Fly Ash zeolite1 doped with waste water sample-1 and sample-2 (Fig. 10-11), the images were taken on the external surfaces of the natural zeolite and Fly Ash zeolite1. The structure of natural zeolite and Fly Ash zeolite1 can be observed and shows clearly crystalline and micro pores.

Fig.8) SEM analysis for Natural Zeolite doped with waste water sample1:



Fig.9) SEM analysis for Natural Zeolite doped with waste water sample2 :

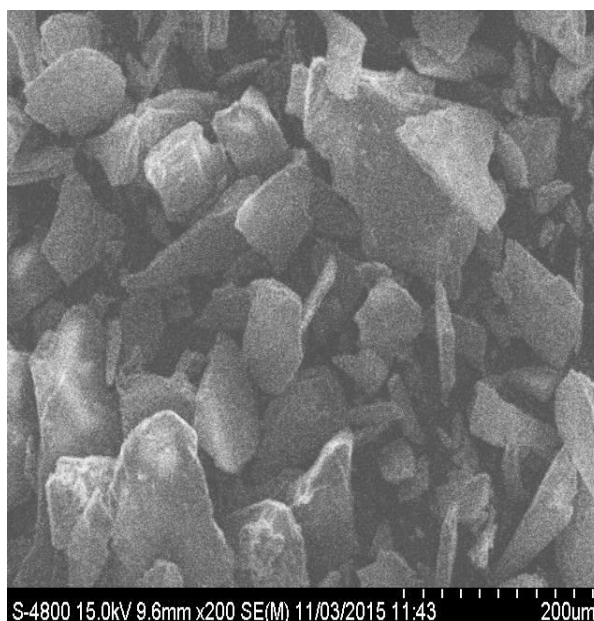


Fig.10) SEM analysis for Fly Ash Zeolite1 doped with waste water sample1:

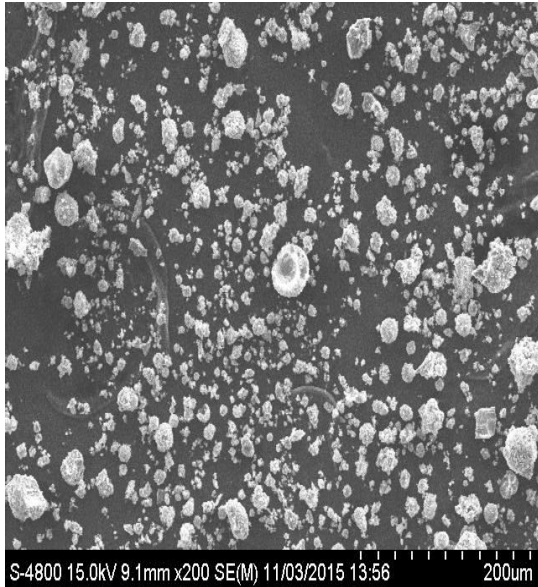
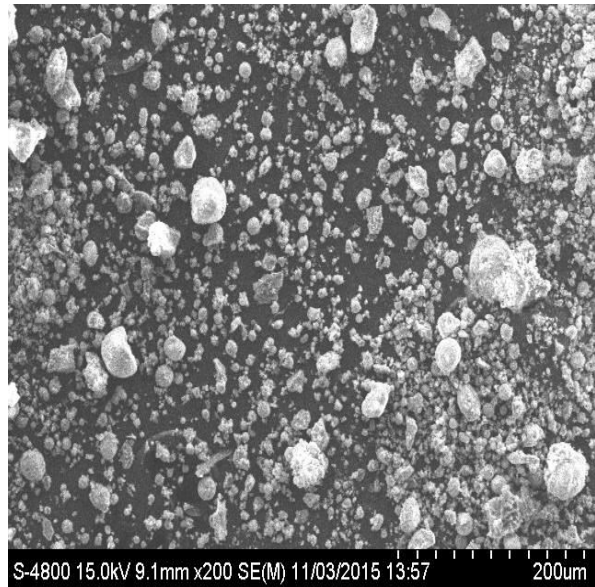


Fig.11) SEM analysis for Fly Ash Zeolite1 doped with waste water sample2 :



d) EDX or EDS Analysis (Energy Dispersive X-ray spectroscopy)

Energy dispersive X-ray spectroscopy is a chemical microanalysis technique used in conjunction with SEM (34). EDX was used to characterize the elemental composition of the natural zeolite. The typical EDX pattern of the natural zeolite doped with waste water sample1 and sample2 are shown in (Fig.12-13) while the EDX pattern of the Fly Ash Zeolite1 doped with waste water sample1 and sample2 are shown in (Fig.14-15). EDS data obtained from characterization shows some other elements are detected in analysis such as Si, O, Al, Ca, Cl, Br, Na, Sr etc (35-40).

Fig. 12) EDX Spectrum of Natural Zeolite doped with waste water sample-1:

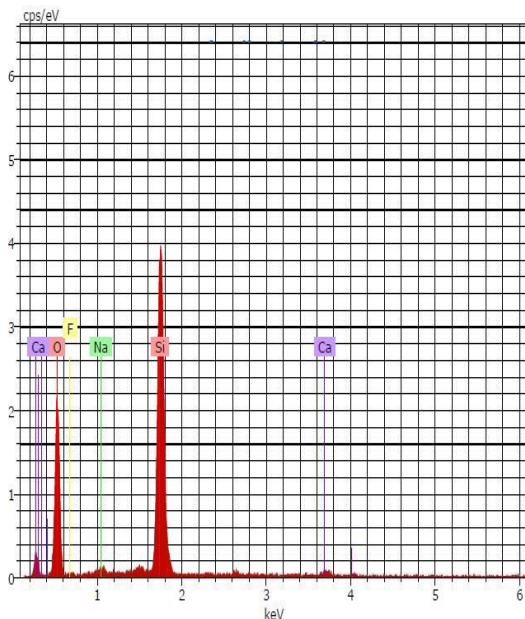


Fig. 13) EDX Spectrum of Natural Zeolite doped with waste water sample-2

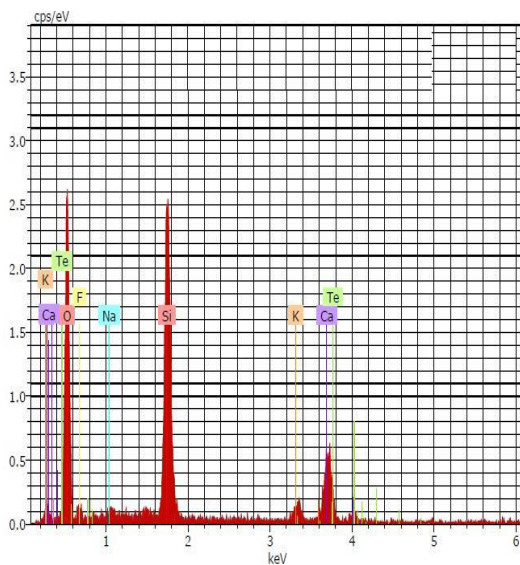


Fig. 14) EDX Spectrum of Fly Ash Zeolite1 doped with waste water sample-1:

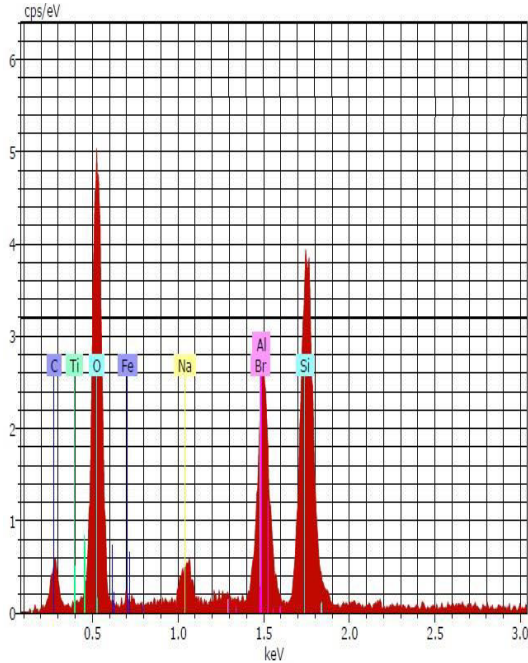
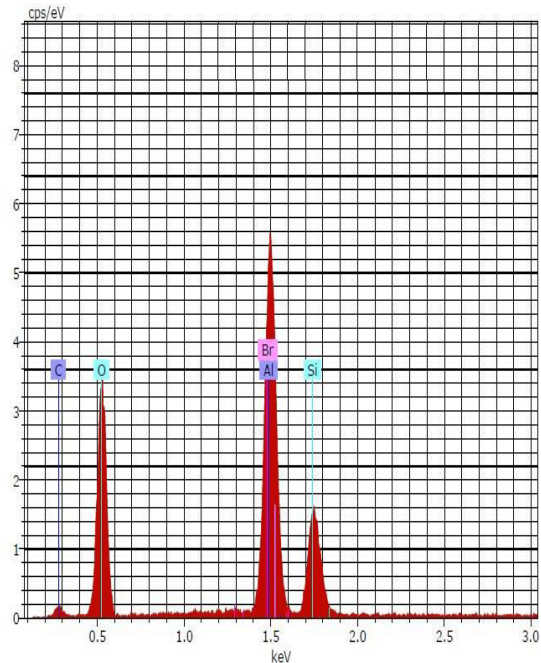


Fig. 15) EDX Spectrum of Fly Ash Zeolite1 doped with waste water sample-2:



The Natural zeolite and fly ash based zeolite1 can be used as an efficient adsorbent. Hence the use of low cost natural zeolite and fly ash based zeolite1 prepared were used as an adsorbent for removal in this study is of practical importance and is expected to be economical.

Fig.16) TGA graph of Natural Zeolite :

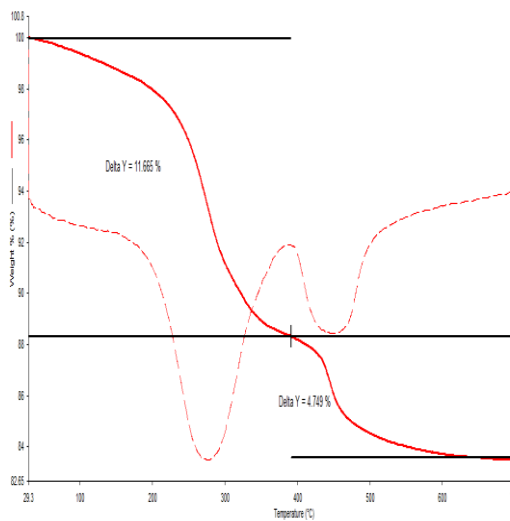
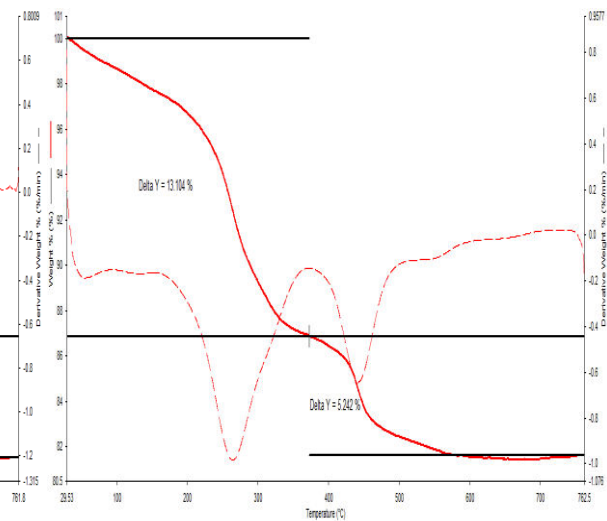


Fig. 17) TGA analysis of Waste water Sample-1 treated with Natural Zeolite (After Treatment) :



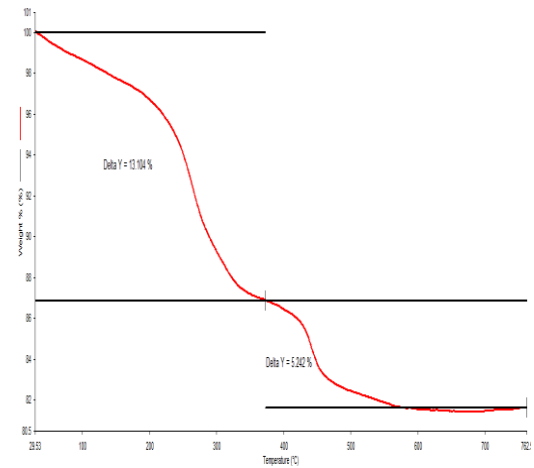
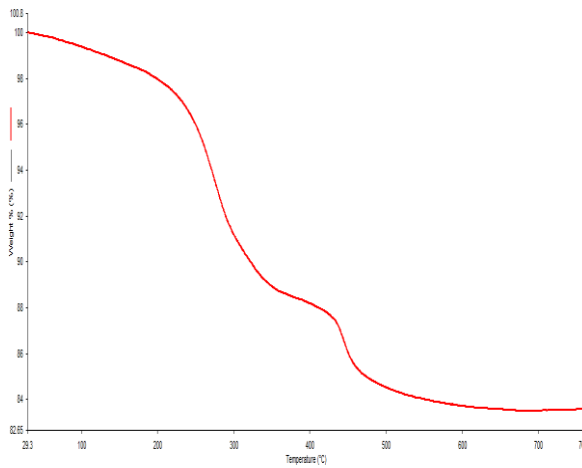
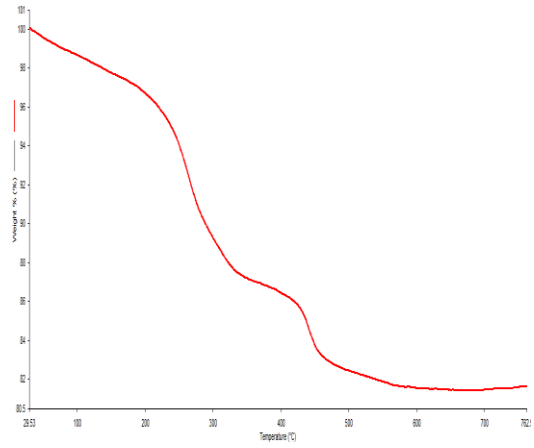
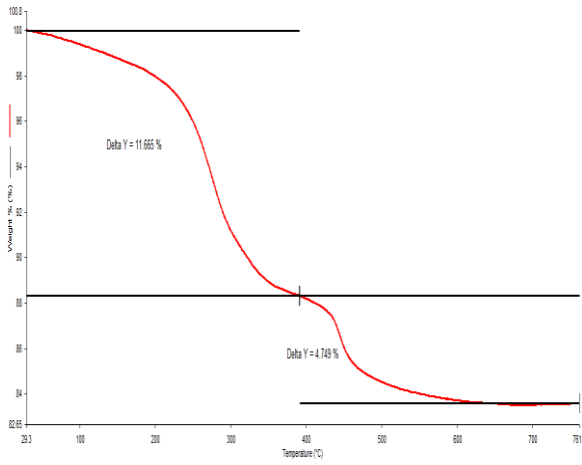
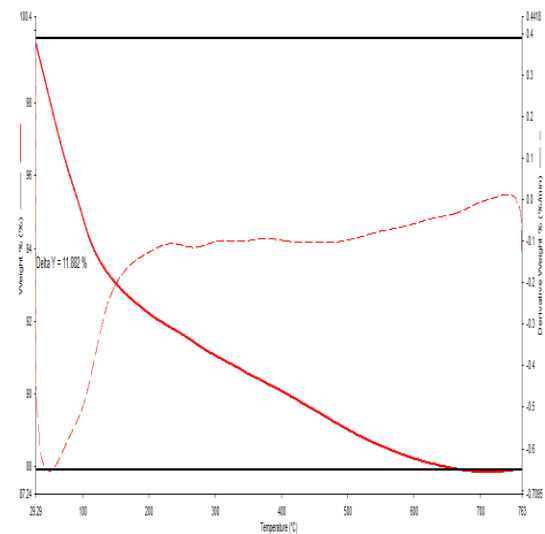
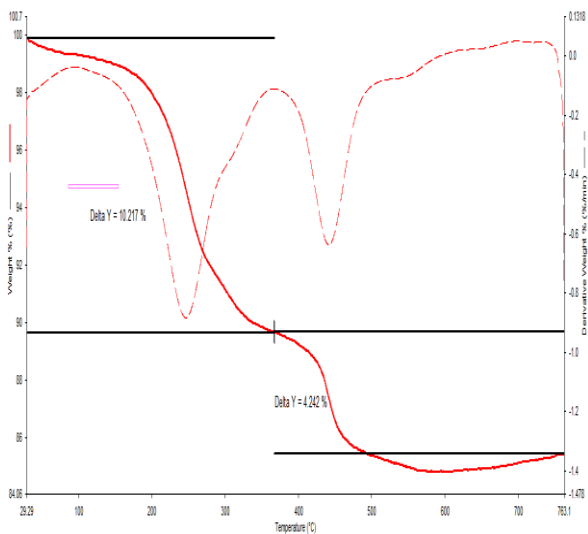


Fig. 18) TGA analysis of Waste water Sample-2 treated with Natural Zeolite (After Treatment):

Fig 19) TGA Analysis of Waste water sample1 treated with Fly Ash zeolite1 (After Treatment) :



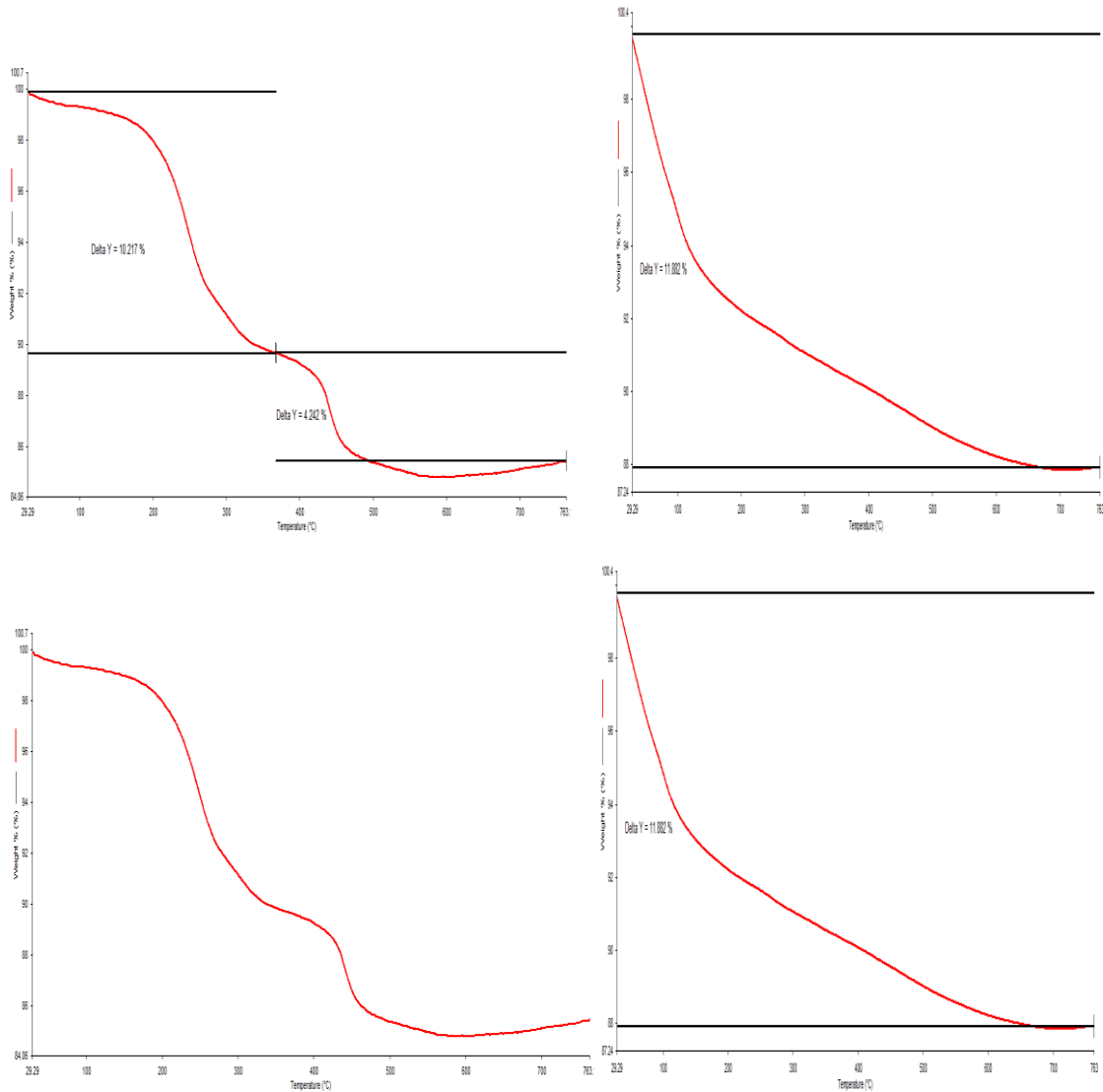
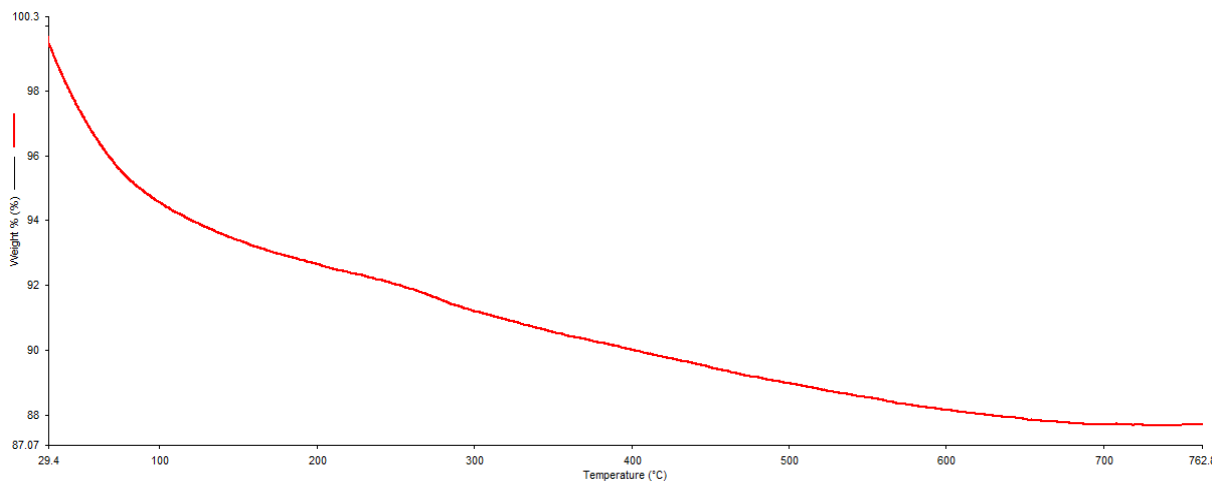
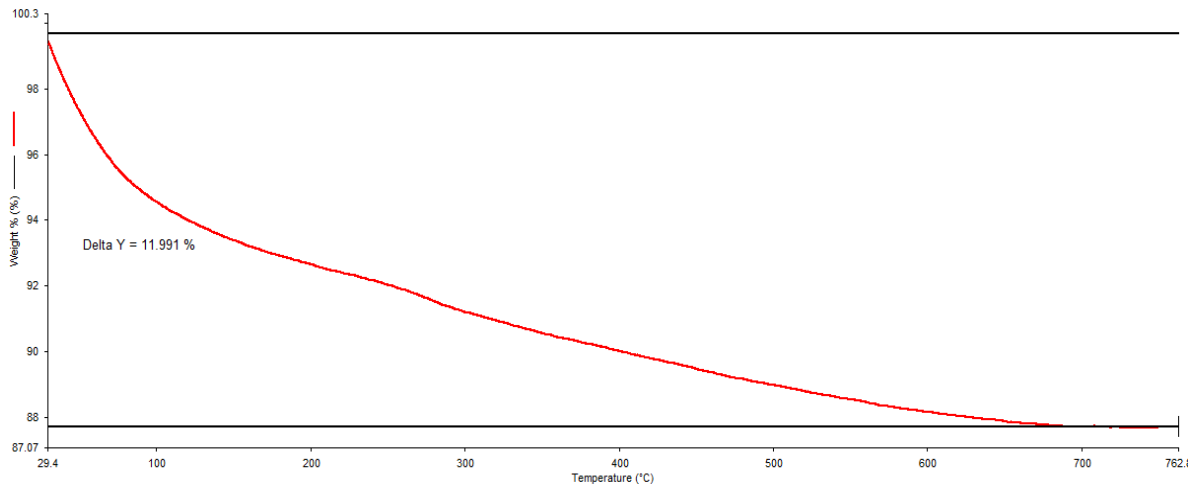
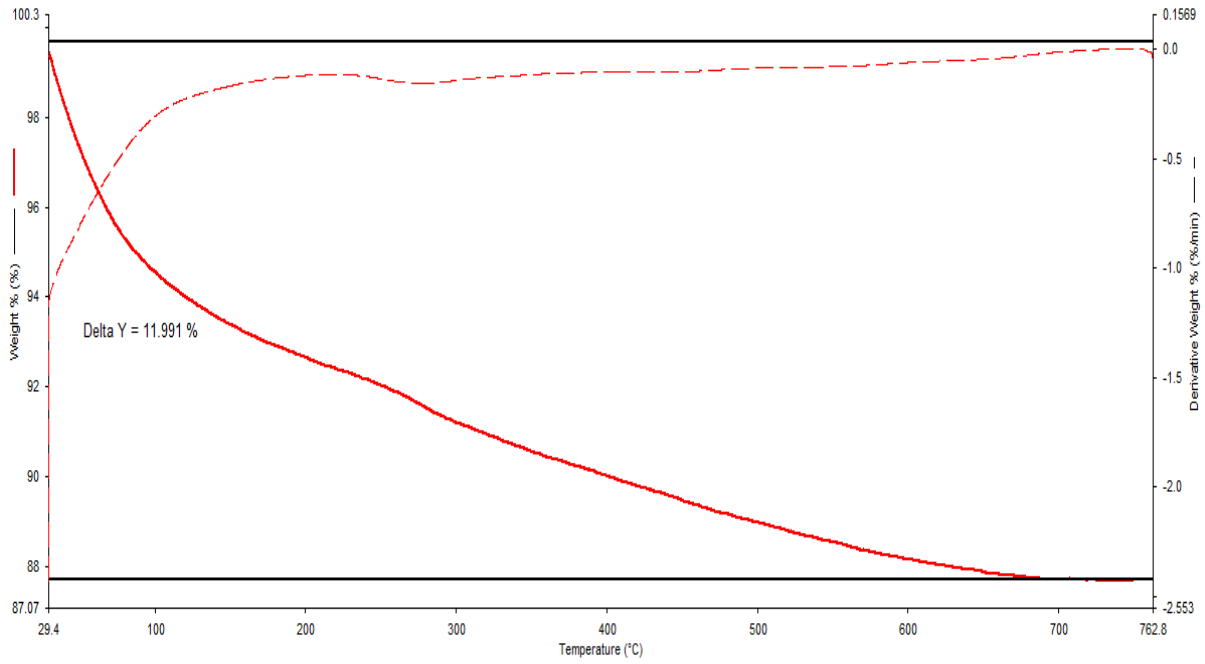


Fig. 20) TGA Analysis of waste water sample-2 treated with Fly Ash Zeolite1 (After Treatment):



e) TGA Analysis :

The TGA curve of natural zeolite shows the total weight loss of 16.414 % in two steps (fig.16). In the first step total weight loss is 11.665 % of which initial rate of weight loss is higher up to the temperature of 280 °C due to loss of adsorbed water followed by rate of weight loss decreased up to temperature 800 °C due to dehydration. At last from 390 °C temperature again loss in weight of sample observed up to 600 °C temperature which is about 4.749 % may be due to dehydration present in the core of zeolite. Followed by as the temperature increases there is no loss of weight and the graph becomes a straight line.

Thermal analysis of natural zeolite treated with waste water sample1 helps to understand the effect of dehydration as well as heat treatment. The thermal stability of host lattice increased with increase in the size of exchanged cations (41). The TGA curve of natural zeolite treated with waste water sample1 shows the total weight loss of 18.346 % in two steps (fig.17). In the first step total weight loss is 13.104 % of which initial rate of weight loss is higher up to the temperature of 380 °C due to loss of adsorbed water followed by rate of weight loss decreased up to temperature 763 °C due to dehydration. At last from 380 °C temperature again loss in weight of sample observed up to 500 °C temperature which is about 5.242 % may be due to dehydration present in the core of zeolite. Followed by as the temperature increases there is no loss of weight and the graph becomes a straight line.

The TGA curve of natural zeolite treated with waste water sample2 shows the total weight loss of 18.346 % in two steps (fig.18). In the first step total weight loss is 14.459 % of which initial rate of weight loss is higher up to the temperature of 380 °C due to loss of adsorbed water followed by rate of weight loss decreased up to temperature 763 °C due to dehydration. At last from 380 °C temperature again loss in weight of sample observed up to 500 °C temperature which is about 4.242 % may be due to dehydration present in the core of zeolite. Followed by as the temperature increases there is no loss of weight and the graph becomes a straight line.

Similarly thermal analysis of fly ash zeolite1 treated with waste water sample1 helps to understand the effect of dehydration as well as heat treatment. The TGA curve of Fly Ash zeolite1 treated with waste water sample1 shows the total weight loss of 11.882 % in two steps (fig.19). In the first step total weight loss is 11.882 % of which initial rate of weight loss is higher up to the temperature of 500 °C due to loss of adsorbed water followed by rate of weight loss decreased up to temperature 763 °C due to dehydration. At last from 500 °C temperature up to 763 °C temperature there is no loss of weight and the graph becomes a straight line.

Thermal analysis of fly ash zeolite1 treated with waste water sample2 helps to understand the effect of dehydration as well as heat treatment. The TGA curve of Fly Ash zeolite1 treated with waste water sample2 shows the total weight loss of 11.991 % in two steps (fig.20). In the first step total weight loss is 11.991 % of which initial rate of weight loss is higher up to the temperature of 500 °C due to loss of adsorbed water followed by rate of weight loss decreased up to temperature 763 °C due to dehydration. At last from 500 °C temperature up to 763 °C temperature there is no loss of weight and the graph becomes a straight line. The result of this thermal stability of zeolite studied in our core is in good agreement with previous results (reports) (42).

REFERENCES

- 1) DE, A.K. Environmental chemistry, New Age International Publication, 7th ed. (2010).
- 2) Apha, "Standard methods for Examination of water and waste water, 19th ed. Washington D.C., (1995).
- 3) Tripathi, B.P. and Sudha Rani, Goyal, "Water pollution on CBS Publication", (1), 1-5 (2001).
- 4) Jain, J.K., and Shrivastava, N., Water pollution by dyes and heavy metals some remedial aspects: a review, Asian J. of Chemical and Environmental Res., **1(2-3)**, 76-86 (2008).
- 5) Lagona, A., Bacaloni, A, De Leva, Fabori G., Marina A., Analytical Methodologies for determining the occurrence of endocrine disrupting chemicals in sewage treatment plants and natural water, Analytica Chimica Acta, **501**, 79-88 (2004).
- 6) Forester, I.J. and William, G.T.W., Metal pollution in aquatic Environment springer Verlag, Berlin (1981).
- 7) Gupta, D.K., Rai, U.N., Singh, A. and Inoche M., Cadmium Accumulation and Toxicity in Cicerarientium L., Poll. Res., **22**, 457, (2003).
- 8) More, T.G., Rajput, R.A., Bandela, N.N., Impact of heavy metal on DNA content in the body of fresh water Bivalve, Lamelleidens, Marginalis, Poll. Res., **22**, 605 (2003).
- 9) Trivedy, R.K. and Goel, P.K., Chemical and biological Methods for water pollution studies, Environmental publication, Karad (2000).
- 10) Jha, N.N., Yadav, J. and Rao, K.D., Int. J. Chem., Sci., **3(2)**, 371-373, (2005).



- 11) Alishareef, Raikookana and Mike Williams, Detection of Organic contaminants of Emerging Concern In domestic waste water from Urban Sources, CSIRO (2010).
- 12) Lagona, A., Bacaloni A., De Leva, Faberi A., Fago, G., Marina, A., Analytical Methodologies for determining the occurrence of endocrine disrupting chemicals in sewage treatment plants and natural waters, *Analytica Chimica Acta*, **501**, 79-88, (2004).
- 13) Chandra, S., Kamato, C.T., Chary, N.S., Anjaneyulu, Y., *Int. J. of Mineral Processing*, **12**, 1-4, (2003).
- 14) Korngold E., Belfer, S. & Urtizbera C, *Desalination*, **104**, 197 (1996).
- 15) Gajghate, D.G., Saxena, E.R. & Aggarwal, L., *Water, Air, Soil Pollution*, **187**, 329 (1992).
- 16) Babel, S. & Kurniawan, T. A., *J. Hazard Mater*, **97**, 219 (2003).
- 17) Bailey, S. E., Olin, T. L., Bricka, R. M. & Adrian, D. D., *Water Res.*, **33**, 2469, (2003).
- 18) Gupta, V. K., Singh, P. & Rahman, N., *J. Colloid Interface Sci.* **275** (2) 398 (2004).
- 19) Gupta, V. K. & Sharma, S., *Ind. Eng. Chem Res.* **42** (25), 6619, (2003).
- 20) Gupta, V. K. & Ali, I., *Encyclopedia of Surface and Colloid Science*, **1**, 136 (2002).
- 21) Gupta, V. K., Jain, C. K., Ali, I., Sharma, S. & Saini, V. K., *Water Res.*, **17** (16) 4038 (2003).
- 22) Gupta, V.K. & Sharma, S., *Environ. Sci. Technol.*, **36** (16), 3612 (2002).
- 23) Reddad, Z., Gerente, C., Andres, Y. & Cloiree, P., *Environ. Sci. Technol.*, **36**, 2067 (2002).
- 24) Gupta, V. K. & Ali, I., *J. Colloid Interf. Sci.*, **271**, 321 (2004).
- 25) Dupond, I. & Guillon, E., *Environ. Sci. Technol.*, **37**, 4235 (2003).
- 26) Selvi, K., Pattabhi, S. & Kadirvelu, K., *Bioresour Technol.*, **80**, 87 (2001).
- 27) Dakiky, M., Khamis, M., Manadra, M. & Merleb, M., *Adv. In Environl. Res.* **6**, 533 (2002).
- 28) Cimino, G., Passerini, A. & Toscano, G., *Water Res.*, **34**, 2955 (2000).
- 29) Foster, C.F., *Biotechnology and waste water Treatment*, Cambridge University Press, (1945).
- 30) Mehrotra, R.C. and Sing, A., *Organometallic Chemistry: A Unified Approach*, John Wiley and sons, New Delhi, (1989).
- 31) Breck, D.W., *Zeolite molecular Sieves*, Krie publishing Co; (1984).
- 32) Treacy, MMJ, Higgins, J., *Collection simulated XRD powder patterns for zeolite 4th Ed.* Elsevier; (2001).
- 33) Fuoco, Domenico. "A New Method for Characterization of Natural Zeolites and Organic Nanostructure Using Atomic Force Microscopy." *Nanomaterials* **2**, 1, 79-91 (2012).
- 34) Devi Prasad, A.G., Abdullah, M.A., Removal of Nickel from wastewater using Environment Friendly Bio-materials : A cost Effective and Eco-friendly Technique, *Int. J. Chem. Eng.* **1**, 77. (2009).
- 35) Nida Salem M, Akl Awwad M., Biosorption of Ni(II) from electroplating wastewater by Modified (*Eriobotrya japonica*) loquat bark, *J Saudi Cheml Soci.* doi:10.1016/j.jscs. 07, 008 (2011)
- 36) Ayhan Sengil, I., Mahmut Ozacar., Removal of Zn(II) ions from aqueous solution and industrial waste water using leaves of *Araucaria Cookii*, *J of Hazardous mater*, 277 (2008).
- 37) Ayhan Sengil I, Mahmut Ozacar, Harun Turkmenler., Equilibrium and kinetics studies of copper solution on Chitosan adsorbent, *J of Hazardous Mater* 162, 1046 (2009).
- 38) Israel, U., Eduok, U.M., Archives, Adsorption of Zn(II) from aqueous solution by using Chitin extraction, *Applied Sci research.* **4**(2) 809 (2009);
- 39) Saeed, A., Akhter MW., Iqbal, M., Saeed A, Akhter MW, Iqbal M., Removal of Lead(II) and Copper(II) from aqueous solution using pomegranate peel as a new adsorbent, *Separ. Purif. Technol.* **45**, 25.
- 40) Monika Jain, Garg VK, Kadirvelu K., Removal of Ni(II) from aqueous system by chemically modified Sunflower biomass, *Bioremediation J.*, **17**(1), 30 (2013).
- 41) T. Vengris, R. Binkien, A. Sveikauskait, *Applied Clay Scienc*, **18**, 183-190 (2001).
- 42) G. Vazque, A.J. Gonzalez, A.L. Garcia, M.S. Freire, G. Antorrena, Adsorption of phenol on formaldehyde pretreated pinus pinaster bark equilibrium and kinetics, *Bioresour Technol*, **98** (8) 2535 (2007).



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