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Extraction of some pollutive ions using different biomasses in oxidation ponds

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ABSTRACT

In this work the advantage of mechanism of self purification of oxidation pond is explored in controlling the pollution of Phosphate, Nitrogen compounds, Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, and Pb^{2+} by cultivating biomasses: Chlamydomonas, Cosmarium, Spirulina, Schizothrix, Cylindrospermum and Chara, right in the pond itself. With increase in time, the extractability of the ions is found be increasing and after 30 days of growth of biomasses, more than 96% of these pollutants have been extracted by the biomasses. Once the biomasses are removed, the pond waters are purged.

Key words: Pollution control, biomasses, oxidation ponds

INDTRODUCTION

Man in the advent of industrialization, urbanization and modernization and un-ending longing for comforts, is causing the environmental pollution and thereby endangering his own existence (Gerard Kiely, 1998; Metcalf and Eddy, 2003; Lenore S. Clesceri et. al 1998). The gifted feature of the nature is its self-purifying capacity and environmental imbalance occurs only when the intensity of the pollutant crosses the buffering capacity of the nature. Although stringent environmental norms have been made by the regulatory agencies to control and mitigate the damages cost to the environment by the human activity, the efficiency of implementation of the regulatory measures, turns to *be "bane" to the habitation*.

One of the consequences of pollution is the entry of toxic metal ions into the water bodies resulting significant threat to public health due to their non-degradable and persistent nature and moreover by the processes of bio-amplification.

The use of micro–organisms and other agricultural waste products as bio-adsorbents for the removal of polluting ions offer a potential alternative to the existing methods for detoxification and for the recovery of toxic and valuable ions from industrial discharges/ polluted waters. The biological approaches for the removal and accumulation of pollutants from aqueous solutions during the last decade have shown interesting results (Shukla et al., 2002; Tshabalala et al., 2004; Vaughan et al., 2001; LuzE, De-Bastan et al, 2004; Majetin, N.V. et al. 200; Dakiky M et. al, 2002; Mehrota et al 1998), which have stimulated continuous and expanding research in this field.

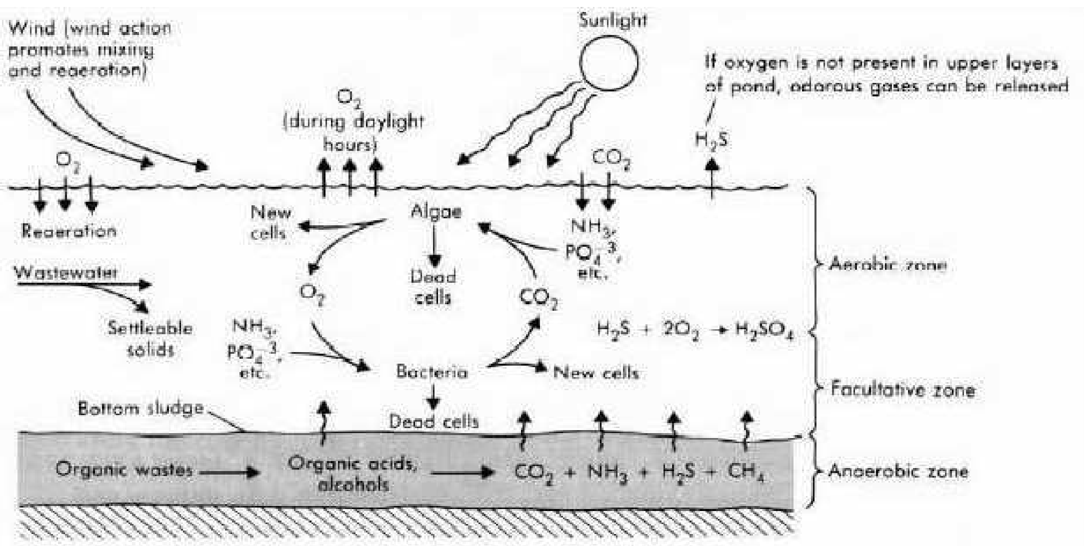
Increasing interest is also being envisaged in using Lignocelluloses materials in controlling the metal ion pollution in natural waste waters as Bio-adsorbents **(**J.S.Han et. al. 2003; LuzE.De-Bastan and Yoav Bashan, 2004).Tea wastes (Amir, Hussein Mahvi et. al. 2005), Agricultural byproducts (Marshall, 1995,Teixeria Tarley,2004), Cork biomass (Chubar et al, 2003), Mangifera Indica leaves (Sing, D.K. et. al 1993, 2000), Clinoptilolite (Inglezakis, V.J. et. al, 2003), cationized milled pine bark (Tshabalaka, 2004), activated red mud (Yanzhong Li et. al, 2006; Xin Feng Zhu et. al 2011), cotton and mustard seed cakes (Iqbal,M et al 2002), natural and modified Peanut and onionskins have also been tried to remove some of the pollutants from solutions. Some researchers used the bone Charcoal, bituminous coal (Rawat, N. S.et al, 1992)), activated carbons (Srinivasan, 1988; Singh, D.K ,1993; Majju, G.N et al, 1997; El-sayed Ghazy et al 2006), sphagnum moss peat (Sharma, D.C,1993), and blast furnace flue dust for controlling pollutants. Chitosan (Ng. J et al 2002; Evans J.R. et al 2002; Sa˘g, Y. Aktay , 2002; Wan Ngah et al 2005), Crab Shells (Pradhan, S et al 2005), treated saw dust (Unnitha, M.R., 2002), Mucilanginous seeds of Ocimum vasilicu (Melo M et al 2004) and Chemically modified refined aspen wood fiber (Thomas L et al 2006) have been explored in controlling pollutants in waste waters.

The use of Aqueous plants in controlling *the pollution of water is another novel idea* and except water hyacinth, scanty are the efforts made in this regard (Trivedy R.K 1985, 95; Grover et al, 1987, Oklieimen et al., 1989, Meera et al. 2006, Khan et al., 2006).

Thus, immense is the potentiality of these bio-processes and they can go along with other chemical processes hand in hand and may prove to be economical and more viable in agricultural countries in controlling the pollutants.

In this contest the *oxidation ponds* seems to be interesting as they provide a methodology in *the self-purification of water by evoking the natural phenomenon*. The advantages of natural processes of self-purification may be explored to control the large amounts of ions of pollution importance. This aspect of the subject is less trodden.

Oxidation ponds:
These are large, shallow ponds designed to treat wastewater through the interaction of sunlight, bacteria, and algae. The credit of inventing oxidation ditch goes to Dr.A.Pasveer, an engineer scientist of Netherlands(Holland)and hence, this low cost sewage treatment device is popularly known as 'Pasveer Ditch' in many parts of the world and its functions can be depicted as follows:



Within an oxidation pond, heterotrophic bacteria degrade organic matter in the wastewaters, which results in production of cellular material and minerals. The production of these supports the growth of algae in the oxidation pond. Growth of algal populations allows further decomposition of the organic matter by producing oxygen. The production of this oxygen replenishes the oxygen used by the heterotrophic bacteria. Typically oxidation ponds need to be less than 1 meter deep in order to support the algal growth. In addition, the use of oxidation ponds is largely restricted to warmer climate regions because they are strongly influenced by seasonal temperature changes. Oxidation ponds also tend to fill, due to the settling of the bacterial and algal cells formed during the decomposition of the sewage. Mechanical aerators are sometimes installed to supply yet more oxygen and thereby reducing the required size of the artificial pond of shallow depth formed for the retention of waste waters for sufficient time. These ponds may be used to treat polluted waters or partially treated sewage. The treatment of latter is more popular with these ponds.

The use of these ponds for controlling the pollution of phosphates and Nitrogen compounds along with other metal ions of pollution interest while various biomasses are being cultivated in the same pond, is a novel idea and except water hyacinth, much effort has not been envisaged. Abe Katsuya et al (2003) cultured aerial microalga Trentepohlia aurea and found that relatively high removal rate of Nitrogen ions.

In this work we made an attempt to understand the absorption criteria of the compounds of phosphorus and nitrogen (inorganic) along with other metal ions of pollution interest namely Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, and Pb^{2+} by cultivating the biomasses Chlamydomonas, Cosmarium, Spirulina, Schizothrix, Cylindrospermum and Chara in the oxidation ponds with respect to time. This "in situ" method of cultivating biomasses along with polluted waters having ions of our interest under natural conditions, gives an opportunity to explore the sorption abilities of living biomasses for said ions of interest.

EXPERIMENTAL SECTION

CONSTRUCTION OF OXIDATION PONDS:

Six oxidation ponds of dimensions: 10 x 5 x 1meters were used. Free board was about 0.5 meters. The slopes of the bunds were kept 2-3 horizontal to 1 vertical. The inner sides were lined with stones and concrete and plastered. The bottom was well compacted and lined with fine sand admixed with clay such that no seepage occurs. The ponds were filled with common water that had been analyzed for its constituents and the characteristics were presented in the Table 1. Then the measured quantities of Phosphates, Nitrates, Nitrites, Ammonia, Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, and Pb^{2+} *were fed at the inlet of the tanks such that the initial concentration of the ions were maintained as given in the 2^nd^ and 3rd columns of Table: 2:* and water levels in the ponds were marked. The algal culture *of 5 plants per liter was* introduced into the ponds form the nearby pond. Each day thereafter only small quantity of raw water was admitted to maintain the marked levels in the ponds so as to balance evaporation losses. As the time proceeded, the ponds were turned to green patches.

ANALYSIS:

At equal periods of interval, samples of pond waters were analyzed for the ions given in Table: 2 as per the standard procedures available in the Literature (Vogal 1989, Lenore.S. Clesceri 1998). Iron was analyzed spectrophotometrially by O-Phenanthroline method; Manganese by "Persulphate method"; Zinc by "Zincon method"; Copper by Bicyclohexanone oxalyldihydrazone method , Lead by "Dithizone method"; ammonia by Nessler's method and nitrite by developing color using Sulphanilamide and N-(1-naphtyl)-ethylenediamine dihydrocloride. Nitrate was analyzed by reducing to Nitrite using Cadmium reducer and then spectrophotometrically determining the Nitrites. The results are presented in the Table: 2.

RESULTS AND DISCUSSION

From the Table: 2, the following significant results can be inferred:

1. The concentration of phosphate, nitrate, nitrite and ammonia decrease progressively as the time increases with all biomasses taken for study. As for example in the case of Biomass: Chlamydomonas the initial concentration of phosphate decreases from 100ppm to 50.2 ppm after 5 days, to 35.4 ppm after 10 days, to 21.6 ppm after 15 days, to 6.4 ppm after 20 days, to 1.5ppm after 25 days, to 0.4 ppm after 30 days. The same trend is observed in the case of other biomasses: Cosmarium, Spirulina, Schizothrix, Cylindrospermum and Chara.

2. After 30 days of cultivation, Phosphate, Nitrate, Nitrite and ammonia are found to be extracted to an extent of 99.6%, 97.6%, 98.2%, 99.2% with Chlamydomonas; 99.6%, 96.2%, 97.8% and 99.8% with Cosmarium; 99.9%, 99.6%, 96.9% and 98.2% with Spirulina :99.8%, 96.6%, 97.6% and 99.2% with schizothrix; 99.9%, 95.8%, 96.8% and 98.4% with Cylindrospermum; 98.5%, 96.8%, 97.6% and 99.4% with Chara.

3. These biomasses are showing remarkable absorption abilities towards the heavy metal ions: Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, and Pb^{2+} of pollution importance. As for example, with Chlamydomonas the initial concentration of Cu^{2+}

decreases from 50 ppm to 46.9 ppm after 5 days; to 35.7 ppm after 10 days, 21.4ppm after 15 days, 8.4 ppm after 20 days; 2.7 ppm after 25 days and 0.3 ppm after 30 days. The same trend is noticed with other bio-masses.

After 30 days of cultivation % of extraction of Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, and Pb^{2+} is found to be 99.8%, 99.6%, 99.8% ,99.4% and 99.2% respectively with Chlamydomonas; 99.4%, 99.6%, 99.2%, 98.2% and 95.2 % in the case of Cosmarium; 99.6%, 99.4%, 99.6%, 99.8% and 94.8% in the case of Spirulina; 99.6%, 89.6%, 99.2%, 99.4 and 96.4% with Schizothrix; 99.6%, 99.8%, 99.7%, 99.6% and 95.2% with Cylindrospermum; and 99.6%, 99.6%, 99.8%, 99.8% and 97.2% with Chara.

4. The Dissolved oxygen progressively increasing from 3.9 ppm to 5.8 ppm in the case of Chlamydomonas; to 5.8 ppm in the case of Cosmarium , to 5.5 ppm in the case of Spirulina , to 5.8 ppm in the case of Sehizothrix, to 5.8 ppm in the case of Cylindrospermum and to 4.2 ppm in the case of Chara.

TABLE: 1 The analysis report of the local surface water used as feed for the Oxidation Ponds

Sl.No.	Characteristics	Concentration of the presented species
1	Turbidity	2.5 NTU
2	Color	5.0 units Pt scale
3.	Taste and odor	Less in palatability; almost no odor
4.	pH	6.7
5.	Total Dissolved salts	500 ppm
6.	Total Hardness	200 ppm in terms of CaCO3
7	Total Alkalinity	189 ppm
7.	Chlorides	220 ppm in terms of Cl-
8.	Sulphates	321 ppm in terms of SO42-
9.	Fluorides	0.2 ppm in terms of F-
10.	Nitrates	39 ppm in terms of NO3-
11.	Nitrites	1.0 ppm
12.	Ammonia	0.5 ppm
13	Calcium	86 ppm in terms of Ca
14	Magnesium	38 ppm in terms of Mg
15	Iron	2.0 ppm in terms of Fe
16	Manganese	0.8 ppm ppm as Mn
17	Copper	4.9 ppm as Cu
18	Zinc	8.0 ppm as Zn
19	Phenolics	0.01 ppm
20	Anionic Detergents	1.0 ppm
21	Mineral Oil	0.5 ppm
22	D.O	4.1 ppm
23	BOD	35 ppm
24	COD	98 ppm

Table 1: Extractability of pollutants by different bio-masses in Oxidation Ponds

Name of the Biomass	Ion	Initial conc. (in ppm)	CONCENTRATIONS (in ppm)						% of extraction
			After 5days	After 10days	After 15days	After 20days	After 25days	After 30days	
1.Chlamydomonas	Phosphate	100.0	50.2	35.4	21.6	6.4	1.5	0.4	99.6
	Nitrites	50.0	45.6	29.1	12.5	5.5	2.0	1.2	97.6
	Nitrates	100.0	75.1	45.6	22.4	12.8	3.0	1.8	98.2
	Ammonia	50.0	41.6	28.3	10.2	5.0	1.0	0.4	99.2
	Fe^{2+}	50.0	40.2	32.2	20.8	9.0	1.5	0.1	99.8
	Mn^{2+}	50.0	43.5	35 .9	18.9	7.6	2.0	0.2	99.6
	Zn^{2+}	50.0	44.8	32.8	12.5	5.0	1.0	0.1	99.8
	Cu2+	50.0	46.9	35.7	21.4	8.4	2.7	0.3	99.4
	Pb2+	25.0	18.2	12.4	8.7	4.0	1.1	0.2	99.2
	D.O.	3.9	4.1	4.2	4.4	4.7	5.5	5.8	
	pH*	6.8	6.9	7.2	7.4	7.6	7.6	7.9	
2. Cosmarium	Phosphate	100.0	54.5	33.9	12.3	2.4	1.1	0.2	99.6
	Nitrites	50.0	33.6	18.5	11.4	6.8	4.2	1.9	96.2
	Nitrates	100.0	56.9	35.4	13.1	5.1	3.7	2.2	97.8
	Ammonia	50.0	47.2	27.6	7.1	1.5	0.6	0.1	99.8
	Fe^{2+}	50.0	40.4	32.2	11.6	2.0	1.0	0.3	99.4
	Mn^{2+}	50.0	45.2	32.1	10.5	4.1	1.4	0.2	99.6

	Zn^{2+}	50.0	46.2	34.6	12.4	3.5	1.0	0.4	99.2
	Cu2+	50.0	47.1	48.3	14.3	5.6	2.4	0.9	98.2
	Pb2+	25.0	21.6	18.4	11.3	6.1	3.4	1.2	95.2
	D.O.	3.9	4.2	4.4	4.5	4.9	5.3	5.8	
	pH*	6.8	7.0	7.3	7.5	7.8	7.8	7.9	
3. Spirulina	Phosphate	100.0	59.2	36.7	15.6	2.4	1.2	0.1	99.9
	Nitrites	50 .0	47.8	38.2	12.8	3.6	1.4	0.2	99.6
	Nitrates	100 .0	60.6	52.3	23.7	11.8	7.4	3.1	96.9
	Ammonia	50 .0	46.4	39.4	17.9	9.6.	2.6	0.9	98.2
	Fe^{2+}	50 .0	47.0	38.9	18.5	10.1	1.5	0.2	99.6
	Mn^{2+}	50.0	44.7	36.8	19.4	11.3	1.7	0.3	99.4
	Zn^{2+}	50.0	43.4	32.6	16.6	7.2	2.0	0.2	99.6
	Cu2+	50.0	42.6	33.4	15.3	6.5	1.6	0.1	99.8
	Pb2+	25.0	23.1	17.7	13.4	8.5	3.2	1.3	94.8
	D.O	3.9	4.3	4.5	4.6	4.8	5.1	5.5	
	pH*	6.8	7.1	7.4	7.8	7.9	7.9	7.9	

Table 1(continued): Extractability of Pollutants by different bio-masses in Oxidation Ponds

Name of the Biomass	Ion	Initial conc. (in ppm)	CONCENTRATIONS (in ppm)						% of extraction
			After 5days	After 10days	After 15days	After 20days	After 25days	After 30days	
4. Schizothrix	Phosphate	100.0	70.5	56.4	32.4	15.1	2.5	0.2	99.8
	Nitrites	50.0	47.9	38.9	19.9	8.2	4.1	1.7	96.6
	Nitrates	100.0	71.6	55.5	31.5	16.7	7.3	2.4	97.6
	Ammonia	50 .0	48.7	39.6	18.6	9.6	2.4	0.4	99.2
	Fe^{2+}	50 .0	46.5	37.3	17.2	7.3	1.7	0.2	99.6
	Mn^{2+}	50.0	47.4	36.4	16.1	9.5	1.8	5.2	89.6
	Zn^{2+}	50.0	45.3	35.8	14.3	8.1	1.1	0.4	99.2
	Cu2+	50.0	48.2	37.4	19.4	7.1	1.3	0.3	99.4
	Pb2+	25.0	22.1	15.7	9.4	6.5	2.8	0.9	96.4
	D.O	3.9	4.4	4.6	4.9	5.1	5.3	5.8	
	pH*	6.8	7.1	7.4	7.6	7.8	7.9	7.9	
5.Cylindrospermum	Phosphate	100.0	75.2	48.2	22.6	9.1	1.3	0.1	99.9
	Nitrites	50 .0	46.6	38.6	19.5	7.2	4.1	2.1	95.8
	Nitrates	100 .0	78.5	63.5	17.9	19.5	11.4	3.2	96.8
	Ammonia	50 .0	45.4	38.5	16.8	8.4	1.3	0.8	98.4
	Fe^{2+}	50 .0	46.9	37.6	14.7	6.8	1.5	0.2	99.6
	Mn^{2+}	50.0	47.8	34.6	15.4	7.6	1.2	0.1	99.8
	Zn^{2+}	50.0	48.7	32.5	12.1	4.5	1.5	0.15	99.7
	Cu2+	50.0	46.5	31.9	13.6	5.9	1.6	0.2	99.6
	Pb2+	25.0	21.6	14.7	11.5	6.2	3.4	1.2	95.2
	D.O	3.9	4.2	4.4	4.7	5.2	5.5	5.8	
	pH*	6.8	6.9	7.3	7.7	7.9	7.9	7.9	
6. Chara	Phosphate	100.0	70.6	50.5.	41.5	22.4	8.5	1.5	98.5
	Nitrites	50 .0	46.5	39.4	20.4	9.5	5.4	1.6	96.8
	Nitrates	100 .0	72.9	51.5	39.1	19.1	7.5	2.4	97.6
	Ammonia	50 .0	37.3	38.6	19.2	85.1	1.5	0.3	99.4
	Fe^{2+}	50 .0	48.2	37.4	19.5	10.3	1.6	0.2	99.6
	Mn^{2+}	50.0	46.4	38.3	18.6	8.2	1.0	0.2	99.6
	Zn^{2+}	50.0	45.1	39.4	17.4	7.1	1.0	0.1	99.8
	Cu2+	50.0	46.7	36.5	18.1	8.5	1.0	0.1	99.8
	Pb2+	25.0	22.1	17.6	8.1	4.2	2.1	0.7	97.2
	D.O	2.1	2.5	2.7	3.2	3.6	3.8	4.2	
	pH*	6.8	6.9	7.3	7.7	7.9	7.9	7.9	

in pH scale

CONCLUSION

In this work an attempt is made to understand the absorption criteria of ions of pollution importance namely, Phosphates, Nitrogen compounds, Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, and Pb^{2+} by the biomasses Chlamydomonas, Cosmarium, Spirulina, Schizothrix, Cylindrospermum and Chara while the biomasses are being cultivated in the oxidation ponds with respect to time. *It is observed that in one month period of culture growth the chosen Bio-masses have been found to be effective in extracting more than 96% of Phosphates, Nitrite, Nitrate ,ammonia, Fe^{2+}, Mn^{2+}, Zn^{2+} Cu^{2+} and $Pb^{2.}$* When these Biomasses are removed from the oxidation ponds after one month, *the ponds waters are* *free from these pollution ions*. In other words, *we claim that these bio-masses shows strong affinity towards the ions chosen for study and skims of the ions from the waster waters by incorporating them in their growth metabolic processes and thus rendering waste waters purged from the polluting ions.*

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REFERENCES

[1] Abe Katsaya, Kue Matsumura, Atsue Imamaki and Morio Hirano, (**2003**) *World J of Microbiology and Biotechnology*, 19(3), 325
[2] Alaerts, G. J., Jitjatuarant, V. and Kelderman, P (**1989**),. *Wat. Sci. Tech***., *21***: 1901
[3] Amir, Hossein Mahvi, Dariush, Naghipur, Forugh, Vaezi and shahrokh, Nazamara., (**2005**),. *American Journal of Applied Sciences., 2(1):*372-375
[4] Chubar, Natalia, Carvalho, Jorge R. and Neiva Correia, M.J. (**2003**), *Colloids and Surfaces A:Physicochemical and engineering aspects , 230(1-3)*: 57- 65
[5] Dakiky, M., Khamis, M., Manassra, A. and Mereb, M., **2002**. *Advances in Environmental Research.,6(4):*533-540(Cross Ref in it).
[6] El-Sayed Ghazy,S,. El-Sayed Samra,S, A. El-Fattah M. Mahdy, S.M. El-Morsy, (**2006**), *Anal. Sci. 22* , 377–382
[7] Englande, A.J. and Kaigate,B., **1981**. "Removal of persistent Heavy metals by ascular aquatic plant system". Ann.Meeting , American Institute of Chemical Engineers, New Orleans.U.S.A
[8] Evans, J.R. , W.G. Davids, J.D. MacRae, A. Amirbahman,(**2002).** *Water Res. 36* , 3219–3226
[9] Gerard Kiely., **1998**. *Environmental Engineering*, McGraw-hall International Editions
[10] Grkover, M. and Narayanaswamy, M.S., **1987**, *J.Inst. Eng. 63*: 36-39
[11] Han, J.S., N. Hur, B. Choi, Min S.H. ,(**2003**) "Removal of phosphorous using chemically modified lingocelluloses materias" In: 6th Inter-regional Conference on Environmnent-Water,"Land and Water Use Planning and Management", Albacete, Spain, pp. 1-11
[12] Inglezakis,V.J.,. Zorpas,A., Loizidou, M.D.,Grigoropoulou, H.P (**2003**), *Microprous and Mesoporous* materials, 61, 167-171
[13] Iqbal, M., Saeed, A. and Akhtar, N. Petiolar., **2002** *Bio Resource Technology, 81(2):*153-155
[14] John, N., (**1983**), *Int. Conf. Water Hyacinth*. Feb 7-11
[15] Khan, S.V and Moheman, A., (**2006**) , *Poll.Res*. 25(1) p.99.
[16] Lenore S. Clesceri, Arnold E. Greeberg, Andrew D. Eaton (Editors, **1998**, "Standard Methods for Examinationof Water and Waste Water", 20 th Edition, American Public Health Association.
[17] LuzE. De-Bastan and Yoav Bashan, (**2004**) *Water Research***, *38***, pp 4222-4246 , **2004** - a review article and other reference in it.
[18] Majju, G.N and Anirodhan. T.S. (**1997**) *Indian J. of Envi. Health*, 39,289-298
[19] Majeti, N.V. and R. Kumar, R.(**2000**) *React. Funct. Polym*. 46 1–27.
[20] Marshall, W.E. and Champagne, E.T., **1995**. *Journal of Environmental Science and Health- part A Environmental science and Engineering.*, ***30(2***):241-261.
[21] Meera ,D.Charan., (**2006**), *Poll. Res.25(1)*, .97
[22] Mehrotra, R. and Dwivedi N.N. (**1998**) *Journal of Indian water work association* .Oct- Dec.322-327.
[23] Melo M. and Dsouza S.F.,**June2004** *Bio-Resource Technology***, *92(2***):151-155 (Cross References in it)
[24] Metcalf and Eddy., **2003**. Wastewater Engineering: Treatment of Reuse. 4th. Ed., McGraw Hill Co., New York
[25] Ng, J.C.Y. Cheung,W.H., McKay G. ,(**2002**) *J. Colloid Interface* ***Sci*. *255***, 64–74.
[26] Oklieimen, F.E. and Onyenkpa, V.U., (**1989**), *Biol Wastes*. 29: 11-16
[27] Onar A.N. Balkaya N and Akyurz, T, (**1996**), *Environmental Technology*, **17 (2)**: pp 207-213(7)
[28] Pradhan, S.S. Shukla, K.L. Dorris, (**2005),** ***J. Hazard. Mater. B125,*** 201–204.
[29] Rawat, N. S. and Singh, D. (**1992**), *Asia Environ*., 14:30
[30] Saeed, A., Iqbal, M. and Akhta M.W., (**2002**), ***Pa****kistan Journal of scientific and Industrial Research, 45(3):* 206-211.
[31] Sa˘g, Y. Aktay ,(**2002**) "Kinetic studies on sorption of Cr(VI) and Cu(II) ions by chitin, chitosan and Rhizopus arrhizus", Biochem. Eng. J. 12 143–153.
[32] Sharma, D.C. and Forster, C.F.,**1993**. *Wat. Res***., *27***: 1201.
[33] Shukla,A., Y.H. Zhang, P. Dubdey, J.L. Margrave, S.S. Sukla , (**2002**), *J. Hazard Mater*, ***95***, 137-152.
[34] Singh D.K.,Tiwari D.P. and Saksena D.N.,(**1993**),.*Poll.Res.,**12 (4):***223-228.

[35] Singh, D.K. and Srivastava, B. (**2000**), *Ind. J. of Industrial Polltion Control**, 16(1)***: 19-24
[36] Srinivasan, K., Balasubramanian, N. and Ramakrishnan, T.V., (**1988**), *Ind. J. Environ. Hlth., **30***: 376 .
[37] Teixeria Tarley, Cesar Ricardo and Zezzi Arruda, Marco Aurelio.,(**2004**), . *Chemosphere 54(7)*:905-915
[38] Trivedy, R.K. and B. V. Khommane *Com. Physion, Ecol*, **10**; 123-128 (**1985**)
[39] Trivedy,R.K., " Pollution Management in Industries", Environmental Publications, Ed:2, Karad, India, **1995**
[40] Thomas L. Eberhardt, Soo-Hong Min James, S. Han (**2006**) *Bioresource Technology**, 97***, 2371-2376
[41] Tshabalaka,M.A., Karthikeyan,K.G., Wang D.,(**2004**), *J. Appl.Polym. Sci*. ***93***,1577-1583, 2004
[42] Unnithan,M.R. Vinod, V.P., Anirudhan T.S., (**2002**), *J. Appl. Polym. Sci***.,**84,2541-2553
[43] Vaughan, T., C.W. Seo, W.E. Marshal,(**2001**), *Bioresour. Technol*. 78, 133-139
[44] Vogel's Textbook of Quantitative Chemical Analysis (revised by G.H. Jeffery, J J. Bassett, J. Mendham and R.C. Denney) Fifth Edition,**1989**, Addison Wesley Longman Limited
[45] Wan Ngah, W.S. , S. Ab Ghani, A. Kamari (**2005**), *Biores. Technol**. 96*** , 443–450
[46] .Xin Feng Zhu et. Al *Advanced Materials Research Vols*., 291**,** 1804 and various references in it (**2011**)
[47] Yanzhong Li et. al *J. of Hazardous Materials*, 137(1), 374 (**2006**)