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Removal Of Aluminium (Iii) Ions From Polluted Waters Using Bio-Sorbents Derived From Moryngea millingtonia And Cygium arjunum Plants

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Abstract: Thermally activated powders of leaves, stems/barks and their ashes of ***Moryngea millingtonia*** and ***Cygium arjunum*** plants have been probed for their sorption abilities towards Aluminium (III) ions from polluted waters. Various Physicochemical parameters such as pH, time of equilibration and sorbent dosage have been optimized for the maximum removal of Aluminium (III) ions using simulated waters. Procedures have been established to remove 100% of Aluminium (III) quantitatively from waste waters. Common cations and Sulphate, Nitrate and Carbonate are not interfering, even in tenfold excess, while Fluoride and Chloride are markedly interfering; Phosphate is synergistically maintaining the extraction at 100%.The methodologies developed are applied to diverse waste water samples collected from industrial effluents and polluted lakes. The procedures are found to be remarkably successful in removing the Aluminium (III) ions from waste waters.

Key Words: Aluminum (III), pollution control, bio-sorbents, Moryngea millingtonia Cygium arjunum, applications.

1: INTRODUCTION

Aluminum and its salts are being extensively used in the present industrialized world in various industries based on food and beverages, drugs, packing materials and dyeing industry[1, 2]. The effluents discharging from these industries possess noticeable amounts of Aluminum and if proper care is not envisaged in removing them, the Aluminum compounds get into the nearby water bodies. Due to their non-degradable nature, the process of bio-amplification occurs resulting the enhanced levels of Aluminum in waters bodies causing environmental threat.

Further, Aluminum alum is traditionally used as coagulants in the treatment of municipal waters and the residual aluminum is reported to be undesirable [3,4]. Moreover, the earth crest has 8% of Aluminum and the acidic conditions resulting due to intensive human activity, volcanic eruptions and improper disposal of effluents from industries leach the trivalent Aluminum into the nearby water bodies [5, 6]. Thus, the concentrations of Aluminum are progressively increasing due to human activity in rivers, lakes, ground waters and Oceans.

Elevated concentrations of Al (III) ions in water bodies are highly objectionable as they are reported to be neurotoxins[7], effect the crop production[8] and harmful to fish[9-11], zooplankton [12,13], cyanobacteria[14] , algae[15] and water weeds[16] and further, it is *implicated in dialysis dementia, Parkinson and Alzheimer's diseas*[17], *bone softening*[18], *renal insufficiency, pulmonary fibrosis and microcytic anemia in human beings*[19].

The toxic nature of Aluminum[17, 20, 21] has forced the Pollution control agencies to have strict regulations on the concentration of aluminum in drinking waters. As per WHO and US drinking water standards, the maximum permissible limit is 0.2 ppm and in Canada and Sweden, the limit is 0.1 ppm[22, 23].

Literature survey indicates that growing interest is being envisaged in developing the methodologies to remove or control Aluminum (III) from polluted waters. Methodologies have been developed based on Cation exchange, reverse osmosis and electro-dialysis phenomenon [24-26] but these methods suffer from high cost and are not viable in developing countries like India and are less encouraging for adoption for treating waters in large scale.

In this context the use of biomasses or bio-wastes of flora or fauna origin in controlling the pollution either in their native state or chemically modified by evoking their surface sorption phenomenon is another new trend and it is stimulating the continuous and expanding research in this field[27-35]. Algal biomass[27], powdered marble wastes[30] and modified activated carbons[31] and Chitosan[33] have been explored for their sorption ability towards Aluminum (III) ions. By growing water hyacinth under different nutritional conditions, Aluminium removal has been studied and found some interesting results[32]. Tony Sarvinder Singh (2006)[35] investigated the sorption of Aluminum from drinking waters using a low-cost adsorbents such as rice husk char and activated rice husk char.

The objective of the present work is to probe the plant materials for their sorption nature towards Aluminium (III) ions from polluted waters. The effect of different process conditions such as pH of the agitating equilibrium, time of equilibration, sorbent dosage and the presence of foreign ions on the % removal Aluminium has been investigated and the extractions conditions have been optimized.

2: MATERIALS AND METHODS

(A)CHEMICALS*:* All chemicals used were of analytical grade.

1. Stock solution of Aluminium (III) of concentration 75.0 ppm, was prepared using A.R. Aluminium potassium sulphate in double distilled water and was suitably diluted as per the need.

2. Buffer solution: concentrated: 27.5 g of ammonium acetate and 11.0 g of hydrated Sodium Acetate were dissolved in 100 ml water and then 1.0 ml of glacial acetic acid was add and mixed well.

3 .Buffer solution: Diluted: To one volume of concentrated buffer solution, five volumes of distilled water was added and the pH of the solution was adjusted to 6.1 by adding solutions of Acetic acid or Sodium hydroxide.

4. Eriochrome cyanine R solution: 0.1 g of solid Eriochrome Cyanine R was dissolved in 100 ml of distilled water and filtered through a Whatman No. 541 filter paper. This solution was prepared daily.

5. Hydrogen Peroxide solution: 5 volumes of Hydrogen Peroxide Solution was prepared.

(B) ADSORBENTS:

Of the various plant materials probed, it was observed that the leaves of ***Moryngea millingtonia*** and ***Cygium arjunum*** had affinity towards the Aluminium (III) ions.

The leaves and stems/barks of ***Moryngea millingtonia*** and ***Cygium arjunum*** were freshly cut from plants, washed with tap water, then with distilled water and then sun dried. The dried materials were powdered to a fine mesh of size: > 75 microns and activated at 105^o C in an oven and then employed in this study. Further these leaves and stems/barks were burnt to ashes and these ashes were also used in this work.

(C) ADSORPTION EXPERIMENT:

Batch system of extraction procedure was adopted [36-38]. Weighted quantities of adsorbents were taken in to previously washed 1 lit/500 ml stopper bottles containing 500 ml/250 ml of Aluminum Potassium Sulphate solution of predetermined concentrations. The various initial pH values of the suspensions were adjusted with dil HCl or dil NaOH solution using pH meter. The samples were shaken vigorously in mechanical shakers and were allowed to be in equilibrium for the desired time. After the equilibration period, an aliquot of the sample was taken for Aluminum determination. Aluminum (III) was determined spectrophotometrically by using "Eriochrome cyanine R" method [39.]

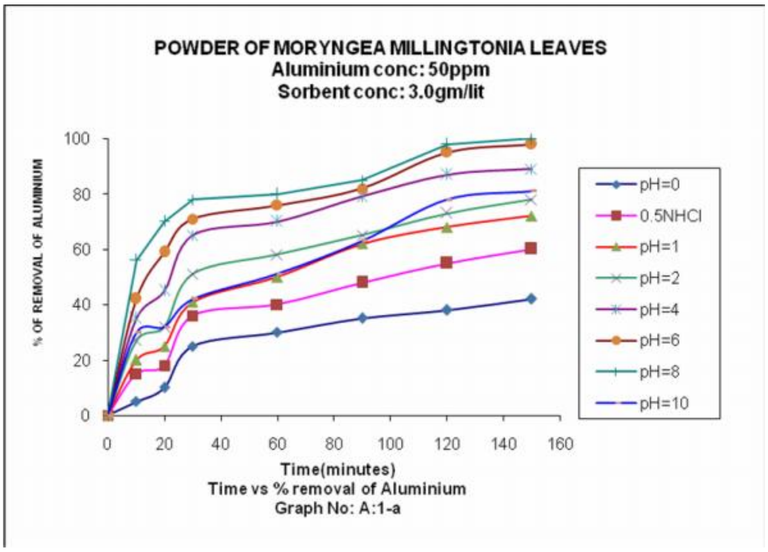
Estimation of Aluminium (III): An aliquot amount of Aluminum (III) solution was taken in a 250 ml beaker. To it 5 ml volume H_2O_2 solution was added and mixed well and the pH of the resulting solution was adjusted to 6.0 using either 0.2 M sodium hydroxide or 0.2 M hydrochloric acid with the help of pH-meter. At this stage 5 ml of Eriochrome cyanine R solution was added and mixed well. Then 50 ml of the dilute buffer solution was added and the solution was quantitatively transferred to a 100 ml volumetric flask with the help distilled water and thus resulting solution was diluted to 100 ml. The solution was well shaken to ensure thorough miscibility. Red to Pink colour was developed depending on the concentration. After 30 minutes, the O.D of the developed colour was measured against blank at 535 nm using U.V. and visible spectrometer (Systronics make). Thus obtained O.D value was referred to standard graphs (drawn between O.D and concentration) prepared with known amounts of Aluminum by adopting method of Least Squares to find concentration of Aluminum (III) in unknown solutions. The sorption characteristics of the said adsorbents were studied with respect to time of equilibration, pH and sorbent dosage. At a fixed sorbent concentration, the % removal of Aluminum (III) from sample waters was studied with respect to time of equilibration at various pH values. The results obtained were presented in the Graph Nos. A: 1-a to 1-d, A: 2-a to 2-d and B: 1 & 2. To fix the minimum dosage needed for the maximum removal of the Aluminum ions for a particular sorbent at optimum pH and equilibration times, extraction studies were made by studying the % of extraction with respect to the sorbent dosage. The results obtained were presented in the Graph Nos. C: 1 & 2.

(D)EFFECT OF OTHER IONS (INTERFERING IONS):

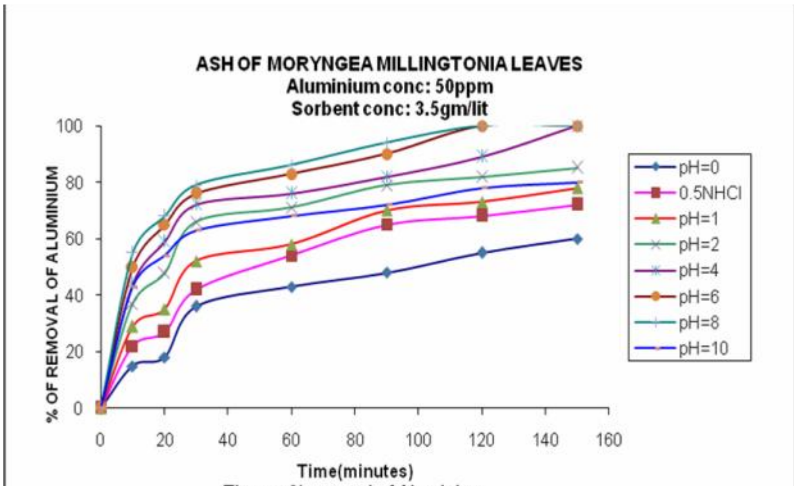
The interfering ions chosen for study were the common ions present in natural waters viz. Sulphate, Fluoride, Chloride, Nitrate, Phosphate, Carbonate, Calcium (II), Magnesium (II), Copper(II) Zinc(II) and Nickel (II). The synthetic mixtures of Aluminum and of the foreign ions were so made that the concentration of the foreign ion was maintained at tenfold excess than the Aluminum (III) concentrations as cited in the Table: 1. 500ml of these solutions were taken in stopper bottles and then correctly weighted optimum quantities of the promising adsorbents (as decided by the Graph Nos. A, B and C) were added. Optimum pH was adjusted with dil.HCl or dil.NaOH using pH meter. The samples were shaken in shaking machines for desired optimum periods and then small portions of the samples were taken out, filtered and analyzed for Aluminum (III). % of extraction was calculated from the data obtained .The results were presented in the Table: 1.

(E)APPLICATIONS OF THE DEVELOPED BIO-SORBENTS:

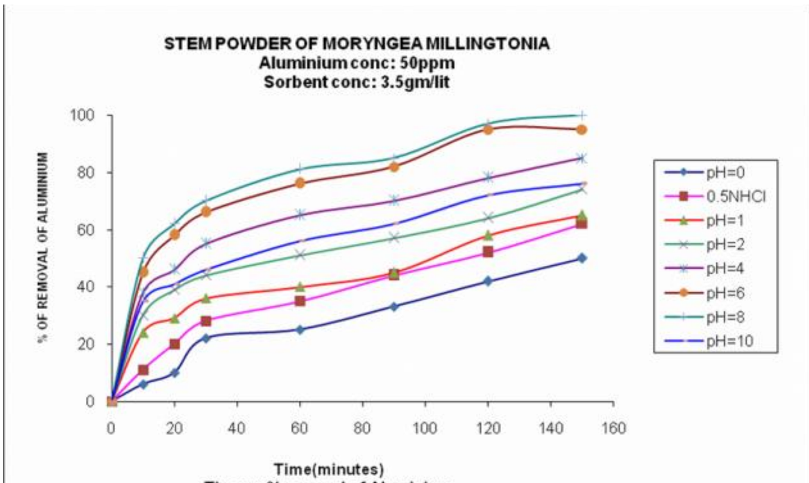
The adoptability of the methodology developed with the new bio-sorbents derived from ***Moryngea millingtonia*** and ***Cygium arjunum*** plants in this work for removing Aluminum (III), is tried with some real sewage/effluent samples of some industries. For this purpose, three samples were collected from Alum manufacturing industries in Hyderabad and three from Aluminum sulphate manufacturing industries in Chennai and these samples were analyzed for the actual concentration of Aluminium (III). Further, three more natural samples from three polluted lakes at different places in Bapatla mandalam of Guntur Dt of Andhra Pradesh were collected and these sample were fed with known amounts of Aluminum (III). Then these samples were subjected to extraction for Aluminum (III) using the bio-sorbents developed in this work at optimum conditions of extraction. The results obtained were presented in the Table 2.



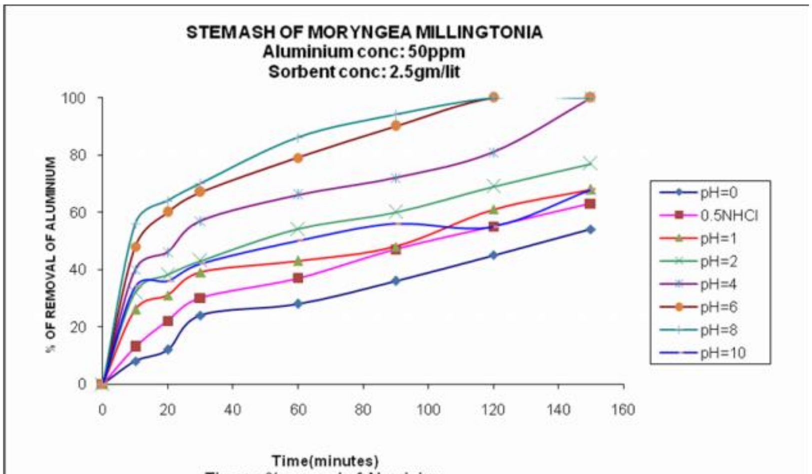
Time vs % removal of Aluminium
Graph No: A:1-a



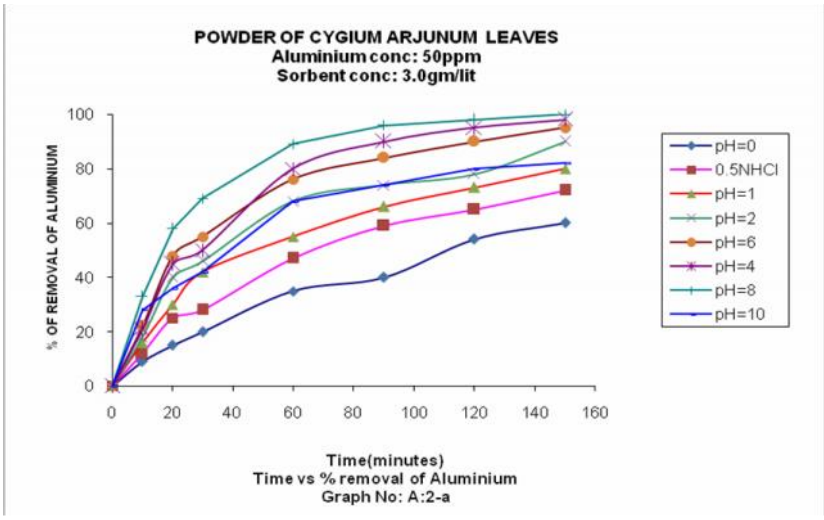
Time vs % removal of Aluminium
Graph No: A:1-b



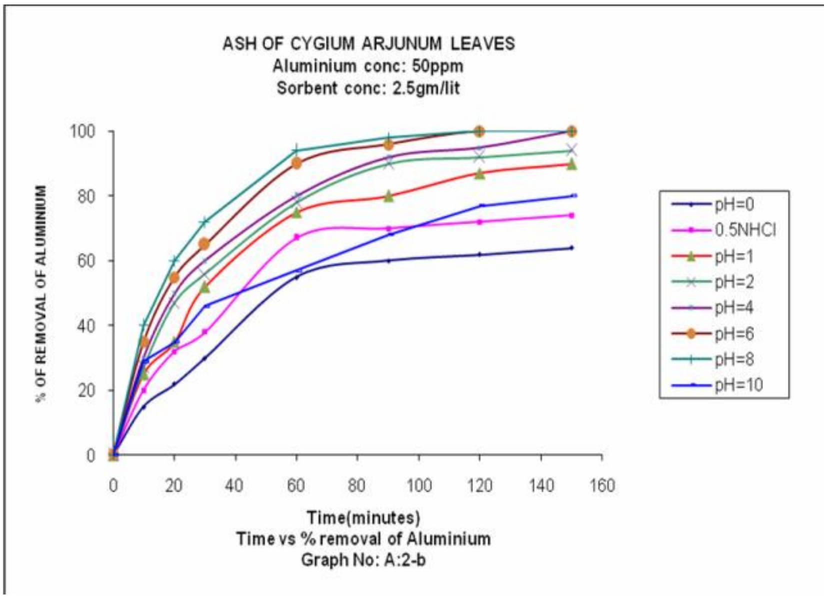
Time vs % removal of Aluminium
Graph No: A:1-c



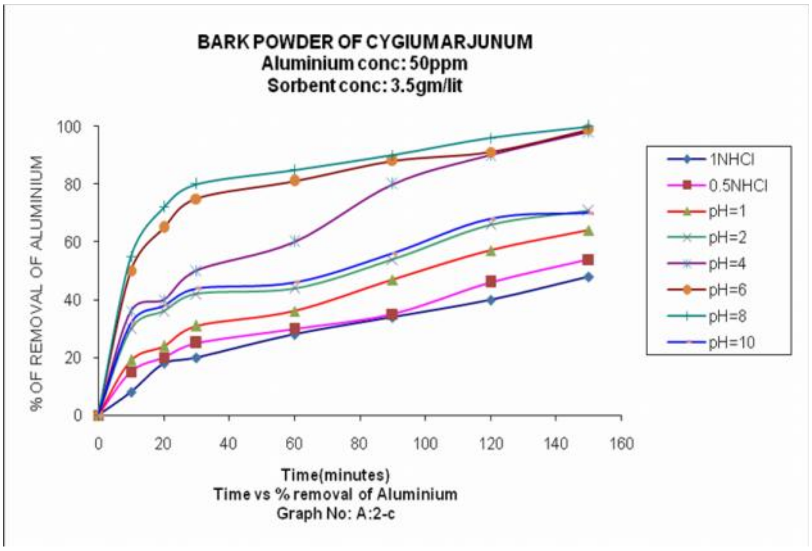
Time vs % removal of Aluminium
Graph No: A:1-d



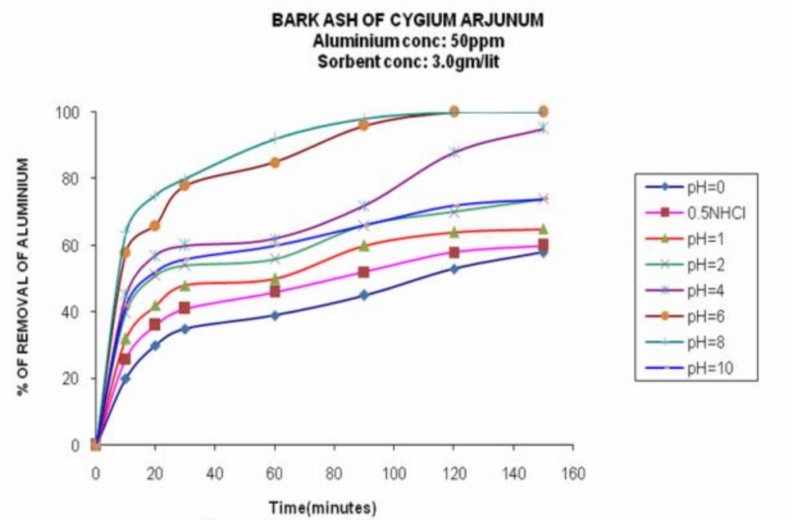
Time vs % removal of Aluminium
Graph No: A:2-a



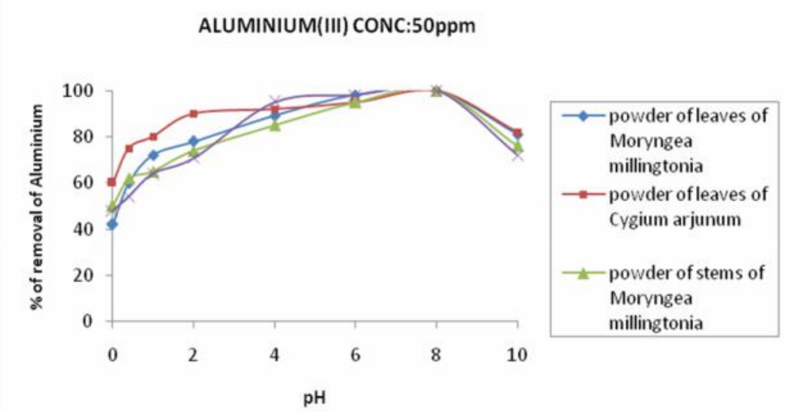
Time vs % removal of Aluminium
Graph No: A:2-b



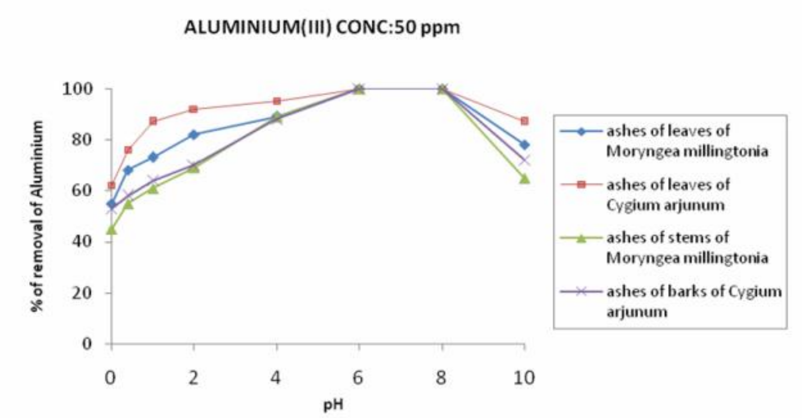
Time vs % removal of Aluminium
Graph No: A:2-c



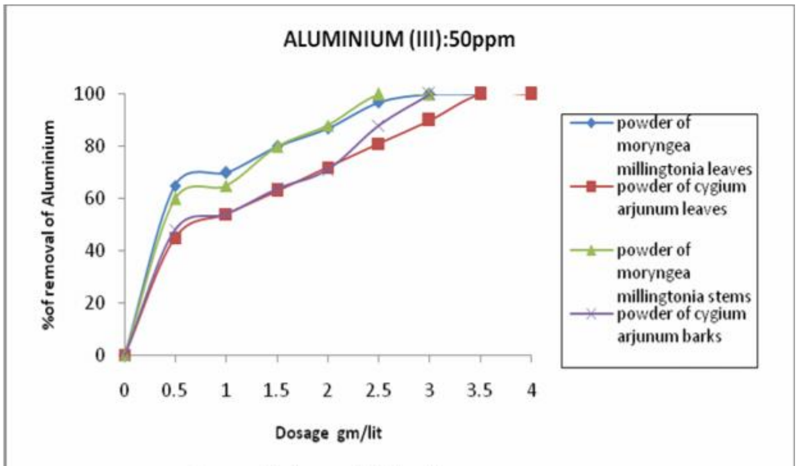
Time vs % removal of Aluminium
Graph No: A:2-d



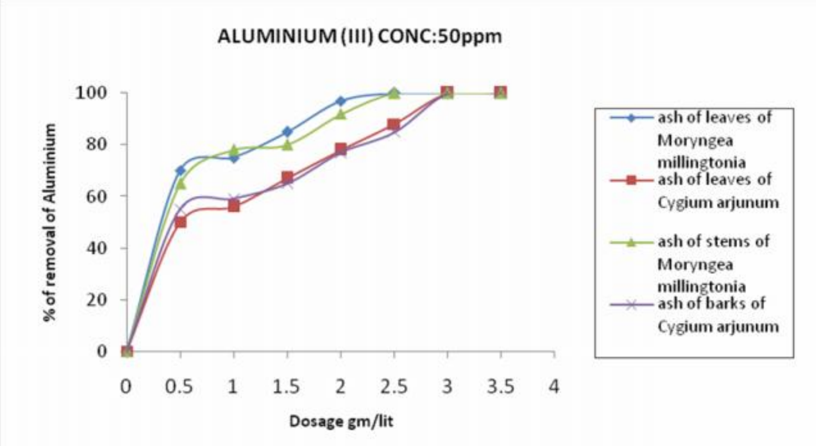
pH vs % of removal of Aluminium
Graph No:B-1



pH vs % of removal of Aluminium
Graph No:B-2



Dosage vs % of removal of Aluminium
Graph No : C-1



Dosage vs % of removal of Aluminium
Graph No : C-2

3: RESULTS AND DISCUSSIONS

The surface sorption abilities of leaves, stems/barks or their ashes of ***Moryngea millingtonia*** and ***Cygium arjunum*** towards the Aluminium (III) ions have been studied with respect to various physicochemical parameters such as pH, time of equilibration and sorption concentration. The results obtained are presented in the Graph No. A: 1-a to 1-d; A: 2-a to 2-d; B: 1&2, C: 1&2. The following salient points are significant to note:

1. Time of equilibration:

Percent of extractability has been found to be increasing with time for a fixed adsorbent at a fixed pH and after certain duration, the extractability remains constant, i.e. an equilibrium state has been reached. In other words, there will not be any further adsorption after certain time of equilibration time (videGraphNos.A: 1-a to 1-d, 2-a to 2-d) As for example, in the case of leaf powder of ***Moryngea millingtonia*** as sorbent, the extractability of Aluminium is found to be 50%, 70%, 78%, 80%, 85%, 99%, 100% at the equilibration times of 10 minutes, 20 minutes, 30 minutes, 60 minutes, 90 minutes, 120 minutes and 150 minutes respectively at the optimum pH 6-8 and at sorption concentration 3.0 gm/lit.(vide Graph No.A:1-a).The the same trend is observed in the case of other sorbents probed in the study.

2. Effect of pH:

% of extraction is found to *be pH sensitive*. The optimum pH range is found to be 6 to 8 and below and above this range, % of extraction decreases (Vide Graph: B: 1 &2). As for example, in the case of ***Moryngea millingtonia leaves powder***, the % of maximum extractability is found to be 42% in 1.0N HCl; 60% in 0.5N HCl; 72% at pH: 1; 78% at pH:2; 89% at pH:4; 95% at pH:6; 100% at pH:8; and 81% only at pH:10 after an equilibration time of 150 minutes and at sorption concentration of 3.0 gm/lit. With the ***ashes of leaves of Moryngea millingtonia***, the % of maximum extractability is found to be

55% in 1.0N HCl; 68% in 0.5N HCl; 73% at pH:1; 82% at pH:2, 89% at pH:4; 100% at pH:6; 100% at pH:8; and decreased 78% at pH:10 after an equilibration time of 120 minutes and with sorption dosage of 2.5gm/lit.

With ***powders of stems of Moryngea millingtonia***, the maximum extractability is found to be 50% in 1.0N HCl; 62% in 0.5N HCl; 65% at pH :1; 74% at pH:2; 85% at pH:4; 95% at pH:6; 100% at pH:8; and 76% only at pH :10 after an equilibration time of 150minutes and with sorbent concentration of 3.5gm/lit.

With the ***ashes of stems of Moryngea millingtonia***, the maximum extractability is found to be 45% in 1.0N HCl; 55% in 0.5N HCl; 61% at pH:1; 69% at pH :2; 81% at pH:4; 100% at pH:6; 100% at pH:8;and 65% only at pH:10 *after an equilibration time of 120 minutes* and with sorbent dosage 2.5gm/lit. Similarly in the case of ***powders of leaves of Cygium arjunum***, the maximum extractability has been found to be: 60% in 1.0N HCl; 72% in pH: 0.5N HCl; 80% at pH: 1; 90% at pH: 2; 91 % at pH: 4; 95% at pH: 6; 100% at pH: 8 and decreased to 82% at pH: 10 after an equilibration period of 150 minutes with sorption concentration of 3.0gm/lit. With the ***ashes of leaves of Cygium arjunum***, the maximum extractability after 120 minutes is found to be 62% in 1.0N HCl; 76% in 0.5N HCl; 87% at pH: 1; 92% at pH:2; 95% at pH:4; 100% at pH:6; 100% at pH:8; and decreased to 77% at pH:10, at sorbent concentration of 2.5gm/lit.

With the ***powders of bark of Cygium arjunum,*** the maximum extractability has been found to be: 48% in 1.0 N HCl; 54% in 0.5NHCl; 64% at pH: 1; 71 % at pH: 2; 98% at pH: 4; 99% at pH: 6; 100% at pH: 8 and 70% only at pH: 10 after 150 minutes**,** with sorbent dosage of 3.5gm/lit. In the case of ***ashes of barks of Cygium arjunum,*** the maximum extractability has been found to be 53% in 1.0N HCl; 58% in 0.5NHCl; 64% at pH: 1; 70% at pH: 2; 88% at pH: 4; 100% at pH: 6; 100% at pH: 8; and decreased to 74% at pH: 10 after an equilibration period of 120 minutes, with the sorbent concentration of 3.0gm/lit.

3. The maximum% of extractability is found to be more with ashes of leaves and stems/barks than with the corresponding leaves and stems/barks powders, at optimum extraction conditions. (videGraphNos.A: 1-a to 1-d, 2-a to 2-d).

4. In most of the sorbents time of equilibration needed for maximum extractability of Aluminium(III) is found to be less for ashes than with the raw powders of leaves and stems. The equilibration time needed for maximum extraction is found to be 150 minutes for the leaves and stems/barks powders of ***Moryngea millingtonia*** and ***Cygium arjunum*** at optimum pH: 6 while with their ashes the optimum equilibration times found to be 120 minutes at optimum pH: 6 .(videGraphNos.A 1-2).

5. *Sorbent Concentration*: The optimum sorbent dosage needed for maximum extractability of the Aluminium (III) is found to be more in the case of leaves and stem powders than with their ashes. Optimum sorbent concentration is found to be 3.0 gram/lit for the ***powders of leaves of Moryngea millingtonia*** and 2.5 gms/lit with its ***ashes; 3.5 gm/lit with stems powder of Moryngea millingtonia*** and 2.5 gm/lit with its ashes. Similarly, in the case of ***Cygium arjunum, the optimum dosage is found to be :*** 3.0gm/lit for leaves powders and 2.5 gms/lit with its ashes; 3.5 gms/lit with ***barks and 3 gm/lit with its ashes.*** (Vide GraphNo.C:1 and 2).

6. We claim 100% extraction of Aluminium (III) with the leaf, stem/bark powders and ashes of ***Moryngea millingtonia*** and ***Cygium arjunum*** **from synthetically prepared simulated waters at optimum conditions of extraction as cited in the Table 1.**

7. **Interfering Ions**: The data in the Table 1 indicates that:

- Cations even in tenfold excess envisaged the *marginal effect* on the % extractability of Aluminium (III).
- *Anions like* SO_4^{2-}, NO_3^- and CO_3^{2-} have least affected the % of extraction while Chlorides and Fluorides markedly affected the % of extraction. Phosphates synergistically maintained the 100% of extraction. As for example with ***powder of leaves of Moryngea millingtonia***, the extractability has been marginally effected from 100.0% to 99.5%, 99.7% and 99.1% in presence of tenfold excess of SO_4^{2-}, NO_3^- and CO_3^{2-} respectively; but, Chlorides and Fluorides markedly effected the extractability from 100.0% to 69.2% and 65.2% respectively, while the presence of phosphate synergistically maintained the extraction at 100.0%. With the ***powder of leaves of Cygium arjunum***, % of extraction has been found to be marginally decreased from 100.0% to 96.6%, 99.0% and 98.1% in presence of SO_4^{2-}, NO_3 , and $CO_3^{2\ -}$ respectively while the Chloride and fluoride decreased the % of extraction from 100.0% to 71.9% and 64.1% respectively and further, the

presence of phosphate synergistically maintained the extraction at 100.0%.

- With the ***ashes of leaves of Moryngea millingtonia*** the maximum % of extractability of Aluminum has been found to be marginally decreased from 100.0% to 99.3%, 98.4% and 98.0% in presence of SO_4^{2-}, NO_3^- and CO_3^{2-} respectively while Chloride and Fluoride markedly decreasing the extractability to 68.1% and 63.2% respectively; the presence of Phosphate synergistically maintained the extraction at 100.0%. With the ***ashes of leaves of Cygium arjunum,*** % of extraction has been found to be effected from 100.0% to 99.5%,99.2% and 98.0% in presence of SO_4^{2-}, NO_3^- and CO_3^{2-} respectively***;*** markedly effected from 100.0% to 72.2% and 64.0% in presence of Chloride and Fluorides respectively; Phosphates synergistically maintained at 100%.
- Similarly, in the presence of SO_4^{2-}, NO_3^- , CO_3^{2-},Chloride , fluoride and phosphate , the % of extraction has been found to be effected from 100.0% to 99.6%, 99.2% , 98.3% 69.3%, 65.3% and 100% respectively with the ***stem powders of Moryngea millingtonia; 100% to*** to 98.5%, 98.1%, 97.0%, 69.3% , 66.9% and 100% w***ith the bark powders of Cygium arjunum.*** In the case of ***ashes of stem of Moryngea millingtonia*** % of extraction has been found to be effected from 100.0% to 99.3%, 98.4%, and 98.0%, in presence of SO_4^{2-}, NO_3^- and CO_3^{2-} respectively***;*** markedly effected from 100.0% to 67.1% and 63.2% in presence of Chloride and Fluorides respectively; Phosphates synergistically maintained at the 100%. With the ***bark ash of Cygium arjunum*** % of extraction has been found to be effected from 100.0% to 99.2%, 99.7%, and 98.7% in presence of SO_4^{2-}, NO_3^- and CO_3^{2-} respectively***;*** markedly effected from 100.0% to 72.2% and 64.2% in presence of Chloride and Fluorides respectively; Phosphates synergistically maintained the % of extraction at 100.0%.

DISCUSSIONS:

For a thorough understanding of the sorption mechanism of these bio-adsorbents, surface morphological studies using such modern instruments like X-ray Photo Electron Spectroscopy (XPS), Fourier Transform Infrared spectroscopy (FTIR), Scanning Electron Microscope (SEM) and Energy Dispersive Spectrum (EDS) in addition to the classical elemental chemical analysis before and after the sorption of the Aluminum (III) species on the sorbent surface, are needed. It is beyond the aims of this work.

However, a rough nature of sorption characteristic may be Accounted from the pH-dependent dissociation of surface functional groups namely –OH-or –COOH present in these biomaterials. At high pH values these groups dissociate importing negative charge to the surface and so the surfaces are surged with electrostatic thrust for positively charged ions. But as the pH decreases, the dissociation of functional groups is less favoured and further, protination occurs and nature of sorption is reversed. Hence, at low pHs, the surface positive charges develops affinity towards anions.

At low pH values ($pH < 5$), the main species for Aluminum (III) is $Al[(H_2O)_6]^{3+}$. However, as the pH increases, $Al(OH)^{2+}$, $Al(OH)_2^+$ are gradually formed and at neutral pH amorphous $Al(OH)_3$ precipitates; at basic pH this precipitate dissolves to form $Al(OH)^{4-}$. In the pH range 6 to 8 , the Aluminum essentially exists as hydrated $Al(OH)_3$ but it is not precipitated from dilute solutions of $Al(OH)_2^+.(H_2O)_3$ in spite of insolubility, because the formation of $Al(OH)_3$ is inhibited[40]. The bio-sorbents having functional groups OH/COOH bind the *hydrated* Aluminum hydroxide either due to ***electrostatic interactions or via hydrogen bonding*** resulting in the increase in the % of extraction. As the pH is increased to 10, the species exists is anion, $Al(OH)_4^-$ [33,40] and is having less affinity towards the sorbent. Hence, % of extraction is decreased.

Ashes are the oxides of some heavy metals containing large amounts of silica. The ashes, contains '-OH' groups and '–O-'. The observed behaviors of extractability as pH varies may be understood in the same lines as described in the case of raw leaves or stem powders .In fact, in the literature it is reported that the silica possesses cation exchanging nature [41-43] and this supports the proposed logic for the observed behaviour.

The decrease in the rate of adsorption with the progress in the equilibration time may be due to the more availability of adsorption sites initially and are progressively used up with time due to the formation of adsorbate film on the sites of adsorbent.

TABLE: 1 Effect of Interfering Ions on the Extractability of Aluminum (III) With Different Bio-sorbents

S.No	**Adsorbent**	**Maximum extractability at optimum condition**	**% of Extractability of Aluminum (III) in the presence of tenfold excess of interfering ions at optimum extraction conditions**										
			SO_4^{2-}	**NO_3^-**	**Cl^-**	**PO_4^{2-}**	**F^-**	**CO_3^{2-}**	**Ca^{2+}**	**Mg^{2+}**	**Cu^{2+}**	**Zn^{2+}**	**Ni^{2+}**
1.	Powder of Moryngea millingtonia leaves	100.0% ,pH:6, 150 minutes, 4.0 gm/lit	99.5%	99.7%	69.2%	100.0%	65.2%	99.1%	96.2%	99.2%	98.1%	99.0%	96.3%
2.	Powder of Cygium arjunum leaves	98.0%, pH:6, 150 minutes, 3.0gm/lit	96.6%	99.7%	71.9%	100.0%	64.1%	98.1%	96.4%	99.0%	97.1%	97.9%	96.5%
+3.	Powder of Moryngea millingtonia stems	100.0%, pH:6, 150 minutes, 3.5gm/lit	99.6%	99.2%	69.3%	100.0%	65.3%	98.3%	96.3%	99.1%	98.2%	99.1%	95.4%
4.	Powder of Cygium arjunum barks	100.0% ,pH:6, 150 minutes, 3.5gm/lit	98.5%	98.1%	69.3%	100.0%	66.9%	98.1%	95.3%	99.6%	96.8%	97.9%	96.0%
5.	Ash of Moryngea millingtonia leaves	100.0%,pH:6, 120 minutes, 3.5gm/lit	99.3%	98.9%	69.1%	100.0%	65.1%	98.0%	95.9%	99.1%	97.9%	98.7%	96.5%
6.	Ash of Cygium arjunum leaves	100.0% ,pH:6 , 120 minutes, 2.5 gm/lit	99.5%	99.2%	72.2%	100.0%	64.2%	98.2%	96.4%	99.9%	98.1%	99.0%	98.0%
7.	Ash of Moryngea millingtonia stems	100.0 %, pH:6, 120 minutes, 2.5 gm/lit	99.3%	99.4%	70.1%	100.0%	64.2%	98.2%	96.2%	99.5%	97.2%	98.9%	97.7%
8.	Ash of Cygium arjunum barks	100.0% ,pH:6, 120 minutes, 3.0gm/lit	99.2%	99.7%	72.2%	100.0%	64.2%	98.1%	96.2%	99.4%	97.2%	98.1%	97.8%

Table No: 2: Applications: Extraction of Aluminium (III) from Different Industrial Effluents and Natural polluted Lake Samples using Bio-sorbents developed in this work

SAMPLES COLLCETED AT DIFFERENT PLACES	***Conc. of Al(III) in the Sample***	***% of Maximum extraction of Aluminum(III)***							
		Moryngea millingtonia				***Cygium arjunum***			
		Leaves Powders (mesh:<75 µ) :pH:6; 150 min & 4.0 g/lit	***Leaves Ashes pH: 6; 120 min & 3.5 g/lit***	***Stems Powders (mesh:<75 µ) pH:6;150 min & 3.5 g/lit***	***Stems Ashes pH: 6; 120 min & 2.5 gms/lit***	***Leaves Powders (mesh: <75 µ) :pH:6;150 min& 3.0 g/lit***	***Leaves Ashes pH: 6;120 min & 2.5 g/lit***	***Barks Powders (mesh: :<75 µ) pH:6;150 min& 3.5 g/lit***	***Barks Ashes pH: 6; 120 min & 3.0 g/lit***
Alum manufacturing Industrial effluents:									
1	12.5 ppm	90.2%	91.3%	88.5%	88.5%	90.5%	89.5%	87.5%	90.0%
2	15.5 ppm	91.5%	90.2%	89.0%	89.5%	91.4%	90.1%	90.5%	91.2%
3	18.0 ppm	92.5%	89.5%	87.5%	90.6%	89.5%	91.2%	89.2%	89.5%
Aluminium Sulphate manufacturing Industrial effluents:									
1	21.5 ppm	95.5%	88.9%	90.5%	92.5%	91.5%	92.5%	92.5%	91.6%
2	32.5 ppm	92.0%	90.5%	91.5%	93.4%	92.5%	94.6%	90.5%	92.5%
3	40.2 ppm	93.0%	89.0%	92.5%	94.5%	93.5%	93.5%	90.5%	90.3%
Natural polluted Lake Samples(fed with known amounts of Aluminium (III)):									
1	5.0 ppm	93.6%	92.5%	93.5%	95.0%	93.5%	94.5%	92.5%	93.0%
2	10.0 ppm	94.2%	93.3%	94.5%	96.5%	94.6%	92.7%	93.7%	92.5%
3	15.0 ppm	91.5%	91.5%	92.8%	94.0%	95.3%	95.0%	91.5%	94.5%

The observations made with respect to the interfering ions are interesting to note. Sulphate, nitrate and carbonate are not interfering the extraction of Aluminium (III) while chlorides and fluorides markedly decrease the extraction. This may attributed to the fact that chlorides and fluorides desorb the Aluminium (III) from the adsorption sites of the sorbent by the formation of anionic complexes, AlF_4^- and $AlCl_4^-$. In presence of phosphate, the % removal of Aluminium is maintained at 100% and it may be due to the formation of sparingly soluble Aluminium Phosphate, $AlPO_4$ which is gelatinous in nature and is trapped or occluded in the matrix of the sorbents and thus enhances the % of extractability of Aluminum (III) species.

4: APPLICATIONS

The Applicability of the methodologies developed in this work have been tested with respects to the real samples of diverse nature, collected from the sewages/effluents of aluminium based industries and also in natural polluted lakes. The results have been presented in the Table No: 2.

It is found that the sorbents developed in this work are successful in removing Aluminum (III) at optimum conditions of pH, equilibration time and sorbent dosage as cited in the Table No.2. Percentage of removal of Aluminum is found to be: 90.2% to 95.5% with leaves powder of ***Moryngea millingtonia*** and 89.0% to 93.3% with their ashes; 89.5% to 95.3 % with leaves powder of ***Cygium arjunum*** and 89.5% to 95.0% with their ashes; 87.5% to 94.5% with the stem powders of ***Moryngea millingtonia*** and 88.5% to 96.5% with their ashes; 87.5% to 93.7% with the bark powder of ***Cygium arjunum*** and 89.5% to 94.5% with their ashes.

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5: CONCUSIONS

1. Bio-adsorbents derived from leaves and stems/barks of ***Moryngea millingtonia*** and ***Cygium arjunum*** are found to be effective in the removal of Aluminium (III) species from waste waters at optimum conditions of pH:6-8 , sorbent dosage and time of equilibration.
2. Percentage of extraction of Aluminum (III) is found to be 100% with all the sorbents developed in this work from the synthetically prepared simulated waste waters at optimum conditions of extraction.
3. Most of the common cations, even at tenfold excess, envisaged marginal effect on the % of extraction of Aluminum (III) at optimum extraction conditions.

   Anions like Sulphate, nitrate and carbonate have least affected the % of extraction while chlorides and fluorides markedly affected the % of extraction. Phosphates have synergized the % of extraction at 100.0%.
4. The procedures developed are successfully applied for some industrial and polluted lake samples.

6: REFERENCES

1. E Yoshimum; M Kshi; K I Twsunoda, *Anal. Sci.*, *2004,* 20:373.
2. W L Lindsay; Walthal "The Environmental Chemistry of Aluminium" Ed. G Sposito, 2nd Ed.,CRC Press, Boca Raton, Florida, 1996, 334 .
3. P T Srinivasan; T Viraraghavan; K S Subramanian, "Aluminum in drinking water: An overview", Water, *SA:* 1999, 25(1): 47-56.
4. P T Srinivasan; T Viraraghavan, "Characteri zation and concentration profile of aluminium during drinking-water treatment", Water, *SA*, 2002, *28* (1) 99-106 .
5. John R. Sorenson; Irere R. Campbell; Lloyd B. Stepper; Robert D. Lingg; "Aluminium in the Environment and Human and Health", *Environmental Health Perspectives*, 1996, 8:3-95 (1974) (818 cross references in it).
6. I R Campbell, "Aluminium in the Environment of man", *ArchInd. Health,* 1957; Trond Peder Flaten, "Aluminium in tea-concentrations,speciation and bioavailability", Coordination Chemistry Reviews, 2002, 228, 385-395.
7. T P. Flaten; A C Alfrey; J.D. Brichall; J. Savory, R.A. Yokel, *J. Toxicol. Environ. Health,* 1996, 48:525.
8. LV Kochian, *Annu. Rev. Plant Physiol. Plant Mol. Biol.*, 1995, 46:237.
9. G R Miller; C.F.Kopler; C.K. Kelty; A.J. Sober, S.N. Ulmer, " The occurrence of aluminum in drinking water",*J.AWWA*, 1994, 76 (1) :184 .

10. P G C Campbell; M Bisson; R. Bougie; A. Tessier; ,J.P. Villeneuve, *Anal. Chem.,* 1983, 55:2246.
11. J D Birchall; C Exley; J S Chappell, M J Phillips, *Nature (London*), 1989, 46:338.
12. K E Haven; R T Heath, *Environ. Pollution*, 1989, 62: 195.
13. K E Haven, *Can. J. Aquat. Fish Sci*., 1992, 49:2392.
14. A Pettersson; L Hallbom; B Begman, *Plant Physiol*, 1988, 86:112.
15. R W Gensemer, *Limnol. Oceanogr*. 1991, 36: 123.
16. D R Parker; T B Kinraide; L W Zelazny, *Soil. Sci. Soc. Am. J.*, 1989, 53:789.
17. T.P. Flaten, *Brain Res. Bull*., 2001 55:187.
18. JMcClure, P.S. Smith,*J. Path*., 1984, 142:293.
19. J. Desccotes, "*Immune-Toxicology of Drugs and Chemicals*" 1988, Elsevier, Amsterdam
20. R C Massey; D. Tyler, "*Aluminium in Food and Environment*, 1989, Royal Society of Chemistry, Cambridge.
21. D R Crapper; McLachlan; V. De Boni, *Neurotoxicology*, 1980, 1:3.
22. S Lenore; Clesceri E; Arnold Greenberg; D Andrew, Easton (Editors), *Standard Methods for the Examination of Water and Wastewater*,20th Edition, American Public Health Association, 1998, 3-65.
23. RD Letterman; C T Discroll, "*Control of Residual Aluminium in Filtered Water*", *AWWA RF Report, AWWA*, Denver, CO 80235, 1994, .1-93.
24. M Pesavento; G Alberti; R Bieuz, "Investigation of the speciation of aluminium in drinking waters by sorption on a strong anionic-exchange resin AG1X8", *Anal. Chim. Acta, 1998*, 367 (1-3): 215-222 (1998).
25. P Matus; J Kubova, "Complexation of labile aluminum species by chelating resins Iontosorb-a new method for Al environmental risk assessment",. *Journal of Inorganic Biochemistry,* 2005, *99*: 1769-1778.
26. T S Singh; K K Pant, "Equilibrium, kinetics and thermodynamic studies for adsorption of As(III) on activated alumina", *Sep. Pur. Technol.*, 2004, *36* (2) 139-147.
27. B Paul; R Oaykm Zimnik; Joseph Sneddon, "Binding and removal of Aluminium ions in water by an Algal Biomass, *Analytical letters,* 1988, *21*: 1383-1396.
28. A Denizli; R Say; E. Pikin, "Removal of aluminium by Alizarin Yellow attached magnetic poly (2-hydroxyethyl metha-crylate) beads", *React. Funct. Polym.*, 2003, *55* (1) 99-107.
29. M R Jekel, "Aluminum in water: How it can be removed? Use of aluminum salts in treatment", *Proc. of the Int. Water Supply Ass.*,Copenhagen, Denmark, 1991,May 25-31.
30. S E Ghazy ; S E Samra; A M Mahdy;, S M El-Morsey , "Kinetic investigation of the removal of aluminum from water samples by adsorption onto powdered marble wastes" , *Separation Science and Technology*,2005, 40. 1797-1815.
31. Shaban El-Sayed GHAZY, Salem El-Sayed SAMRA, Abd El-Fattah Mohammed MAHDY, and Sherin Mohammed EL-Morsy, *Analytical Sciences* , 2006, *22:*377.
32. M W Javaweera; J C Kasturiarachchi; R K Kularatne; S L Wijeyekoon, *J. Envi. Sci. Health A. Tox Hazard Subsst.Envirfon Eng.,* 2007, 42(2):185-191.
33. C Septhum; S Rattanaphani; , J B Bremner; V Rattanaphani, *J of Hazardous Materials*, 2007, *148*:185-191.
34. Mohamad Nasir Othman; Md Pauzi Abdullah;Yang Farina Abi. Aziz, "Removal of Aluminum from Drinking Water", *Sains Malaysiana* 2010, *39*(1): 51–55(2010).
35. Tony Sarvinder Singh, Bhavik Parikh and K K Pant, *Water SA, 2006, 32 (1).*
36. R K Trivedy, "*Pollution Management in Industries*", Environmental Publications, KARAD, INDIA, 1979.
37. Gerard Kiely, Environmental Engineering, McGraw-Hall International Editions, 1998.
38. Metcalf and Eddy, *Wastewater Engineering: Treatment of Reuse*. 4th. Ed., McGraw Hill Co., New York 2003.
39. *Vogel's Textbook of Quantitative Chemical Analysis* (revised by G H Jeffery; J J Bassett; J Mendham; R C Denney) Fifth Edition, Addison Wesley Longman Limited, 1989, 678.
40. F Albert Cotton, Geoffrey Wilkinson, *Advanced Inorganic Chemistry,* 5th Edn.John Wiley and Sons, New York, 1988, 216
41. G A Parks, *Chem Rev*. 1965, 65, 117.
42. G A Parks, *Advan Chem*, 1967, Ser No 67,121.
43. K Ravindhranath; P B Janardhan, *Proc. Indian Natn. Sci. Acad.*, 1987, *53*, A: 650-669.

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