COMPARISON OF PHYTOREMEDIATION AND FILTRATION IN REMEDIATION OF CONTAMINATED WATERS

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(Received: 15th May, 2014; Accepted: 16th March, 2015)

ABSTRACT

An experimental work was carried out on contaminated waters using filtration and phytoremediation methods to determine the most appropriate remediation method. Filtration method was by passing Arsenic acid of 100.0 mg/L concentrations through four different geo-materials (marble, activated charcoal, filtration carbon and clay) placed on layers of sand in glass filtration tanks ; while Phytoremediation method was done by cultivation of matured water hyacinth (*Eichhornia crasspipes* Mart. Solms) in arsenic acid solution of equal concentration (100.0 mg/L). Plants were harvested, dried, pulverized and analysed for metal content using inductively coupled-ion chromatography and filtrates analysed using inductively coupled plasma-optical emission spectrometry. Arsenic concentration in filtrates showed no arsenic loss, indicating poor absorption capacity of the geo-materials. Highest arsenic bio-accumulation was found at 100 mg/L in matured water hyacinth. Remediation of arsenic using water hyacinth proved to be a better method for arsenic removal compared to filtration.

Keyword: Arsenic, Absorption, Contamination, Phytoremediation, Filtrates

INTRODUCTION

Bioaccumulation of trace elements has been a crucial problem in environmental studies (Kabata-Pendias and Veter, 1984; GazsÓ, 2001, and Cyle *et a.,l* 2006). The release of heavy metals such as Cu^{2+}, Zn^{2+}, Fe^{2+} and As^{2+} in biologically available forms into the environment by human activity may damage or alter both natural and man-made ecosystems (Tyler *et al*., 1989; Williams *et al*., 2000). Arsenic (As) a toxic metal occurs naturally in soil and minerals and may get into water and land through water run-off, wind-blown dust and leaching by man (Seth *et al*., 2002). The metal has harmful effects on both humans and environment, even at low concentration (Nriagu, 1994; Chowhury *et al*., 2000; Chwirka *et al*., 2000; DeMarco *et al*., 2003; Wasserman *et al*., 2004 and Patlolla *et al*., 2005). Plants absorb arsenic fairly easily and also have the ability to accumulate nonessential metals such as As, Cd and Pb. This ability allows for high amount of the metal to be present in food and could be harnessed to remove pollutant metals from the environment (Lenntech, 2006). Plants based bioremediation technologies have received recent attention as strategies to clean-up contaminated soil and water. The submerged macrophytes are particularly useful in the abatement and monitoring of heavy metals (Salt *et al*., 1995; Das *et al*., 1997; Zayed *et al*., 1998; Sadowsky, 1999 and Rogers *et al*., 2000). Water hyacinth, (*Eichhornia crassipes)*, a floating macrophyte has been put to use in cleaning up municipal and agriculture wastewater because of its easy way of absorption into the various part of the plant (such as the leaf, shoot, and root) that helps in the growth of the plant. Geomaterials are geologically derived materials used primarily in building construction, in both the unprocessed condition and as processed construction material they are hazard-resistant construction materials (Hodgson *et al*., 2000) These geo-materials which are also known as geotechnical materials can be found between the ground surface and the rock and influences the structural damage examples of such are marble, clay, soil, activated charcoal/carbon, this materials can also be used as filter materials in remedial works. Considering the high rate of heavy metals such as arsenic found in the metropolis and the long term effect it could have on man, it became imperative to evaluate the best possible method of experimental remediation method between phytoremediation and filtration for possible pollution that could occur in the water sources of the study area in the future.

MATERIALS AND METHOD

Experimental Methods

Two methods were utilized in the experimental remediation study to determine the better remedial method. These were Filtration and Phytoremediation methods.

Preparation of As Solution

Arsenic solution of 1.32 mg/L was prepared from 197.84g of As_2O_3 into 100mL bottle, and dissolved in de-ionized water. Different measurements of arsenic acid solution (0 mg/L (that is, de-ionized water), 10 mg/L, 20 mg/L, 50 mg/L, and 100 mg/L), were measured into 100 mL plastic bottles.

Filtration Method

Geo-materials used as filters were black and white marble; filtration carbon; activated charcoal and clay (Figure 1). To begin the project, each geo-material was washed with de-ionized water to remove impurities. These washed geo-materials were then placed to cap layers of pebbles and coarse sand materials stacked to about 0.5cm thickness in the constructed glass filtration bottle (Figure 1). Generally each washed geo-material was left to drain for 15 minutes in order to reduce the dilution effect it may have on the acid solution prior to the experiment. Arsenic acid solution prepared was then poured into the filtration bottle, and allowed to drain for 30 minutes. The stopper was then removed from the filtration bottle for the filtrates to drain into a conical (collection) flask. The process was allowed to continue for 30 minutes before the filtrate was poured into a clean 100mL plastic bottle for analysis. The geo-material and different layers of grain sizes of sand (coarse sand and pebbles) used were removed from the filtration bottle and thrown away at the end of each process.

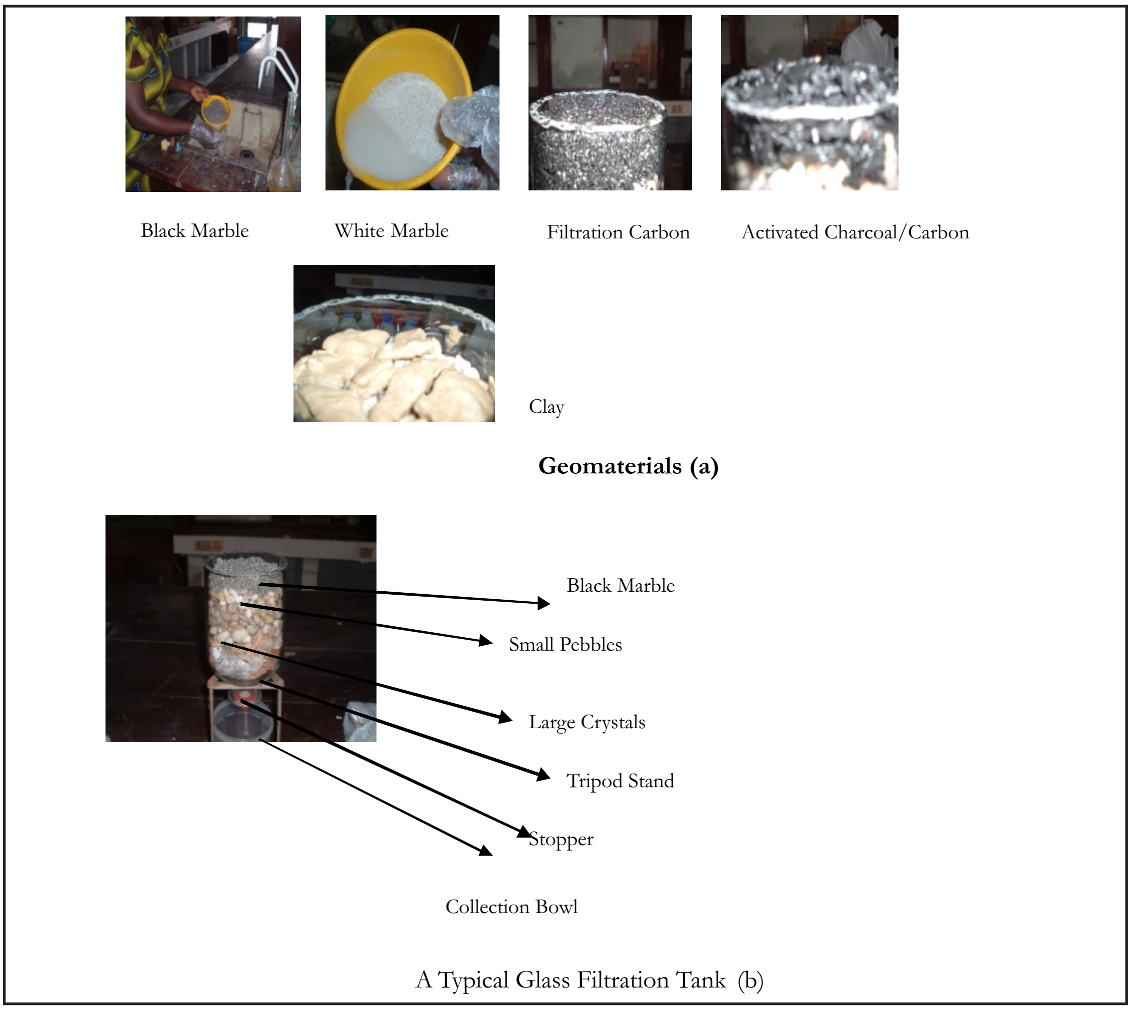

Figure 1: Different Geo-materials (a) and Glass Filtration Tank (b)

Phytoremediation Method

The Green House

Green house was designed to contain the cultivated plants (Figure 2). The length, breadth, and height of the house were 170 cm by 245.5 cm by 245.5 cm respectively, and a green roof was placed on the house to reduce the rate at which sunlight penetrates the plants.

Water Hyacinth (*Eichhornia crasspipes Mart. Solms*)

Water Hyacinth (*Eichhornia crasspipes* Mart. Solms) (Figure 2) was rinsed with de-ionized water to remove any epiphytes and insect larvae grown on plants, and then it was cultivated in the green house. The uptake of metals is greater in plants grown in pots of water in the greenhouse than from the same water in the field (De Vries and Tiller, 1978; Page and Chang, 1978)

The Green House

The Water Hyacinth

Figure 2: The Green House and Water Hyacinth

Experimental Procedures

In this experiment, 100 mg/L of arsenic acid was measured into all the five 10litre plastic buckets that Water Hyacinth (*Eichhornia crasspipes* Mart. Solms) was cultivated within twenty- four hours. The plants were harvested, dried, pulverized and then sent for analysis using the ICP-OES methods; while, the water samples in each bucket were analyzed for to determine the rate of arsenic removal by the plants.

RESULTS AND DISCUSSION

Geochemical results of the geo-materials (Table 1) revealed that geo-materials cannot absorb the metals but rather increase the arsenic level in the water (Figure 3). Comparing the results with raw metal content of the geomaterials it was observed that the materials have arsenic as a by-product. High arsenic content found in clay could be associated to arsenic adsorption which is significantly positively correlated with clay content of soils apart from being a by-product of clay mineral (Elkhatib *et al.*, 1984a, b) (Table 2).

The experiment based where same concentration of arsenic solution 100 mg/L was measured into the pots, revealed the Geochemical results of the water to show no evidence of arsenic in the water (Table 3), this depicts that all the arsenic content has has being absorbed by the water hyacinth plant. Rate of absorption was highest in the roots and leaf of the plant.

Table 1: Geochemical Results of Water from the Geo-materials in the Filtration Method

Physical materials	Concentrates(g)	Pbmg/l	Cumg/l	Znmg/l	Femg/l	Kmg/l	Camg/l	Namg/l	Bamg/l	**Asmg/l**
A	0.00	0.06	0.238	2.89	1.92	3.5	103	625	0.02	**1.02**
A	0.01	0.05	0.176	1.06	2.79	3.6	49.3	589	0.02	**27.2**
A	0.02	0.02	0.02	0.396	1.34	1.5	7.4	75.4	0.02	**58.8**
A	0.05	0.01	0.01	0.207	0.36	0.9	9.4	23	0.02	**183**
A	0.1	0.01	0.002	0.113	0.38	0.7	8.6	11	0.02	**381**
B	0.00	0.01	0.002	0.673	0.01	3.4	578	7.8	0.07	**1.37**
B	0.01	0.01	0.013	0.428	0.01	3.2	603	6.4	0.08	**14.9**
B	0.02	0.01	0.02	0.353	0.01	2.4	609	0.7	0.06	**27.9**
B	0.05	0.01	0.023	0.072	0.01	1.7	635	0.7	0.05	**77.7**
B	0.1	0.01	0.006	0.749	0.01	1.6	609	0.1	0.06	**168**
C	0.00	0.01	0.005	0.052	0.05	12.1	12.9	2.3	0.1	**1.44**
C	0.01	0.01	0.005	0.158	0.02	9.4	10.7	1.3	0.13	**37.2**
C	0.02	0.01	0.004	0.136	0.04	4	4.2	1	0.05	**38.7**
C	0.05	0.01	0.004	0.124	0.03	3.6	4.5	0.9	0.04	**131**
C	0.1	0.01	0.004	0.142	0.02	3.2	4.1	0.6	0.04	**269**
D	0.00	0.01	0.005	0.015	0.01	76.3	28.7	7	0.08	**7.94**
D	0.01	0.01	0.002	0.06	0.01	49.5	38.2	6.3	0.08	**59.3**
D	0.02	0.01	0.002	0.07	0.01	18.3	13.2	1.6	0.05	**40.2**
D	0.05	0.01	0.003	0.082	0.01	11.1	8.9	1.1	0.03	**186**
D	0.1	0.01	0.002	0.096	0.01	8.6	8.5	0.6	0.03	**398**
E	0.00	0.01	0.002	0.019	0.01	3.5	10.3	32.3	0.06	**0.15**
E	0.01	0.01	0.004	0.022	0.01	3.1	8.3	26.4	0.08	**31.4**
E	0.02	0.01	0.002	0.078	0.01	3.8	13.9	18.5	0.27	**135**
E	0.05	0.01	0.003	0.034	0.01	2.3	5.9	17	0.08	**500**
E	0.1	0.01	0.004	0.026	0.01	3.9	6.4	22	0.07	**998**

Notes: A-black marble; B – white marble; C – filtration carbon; D – activated charcoal; E – clay

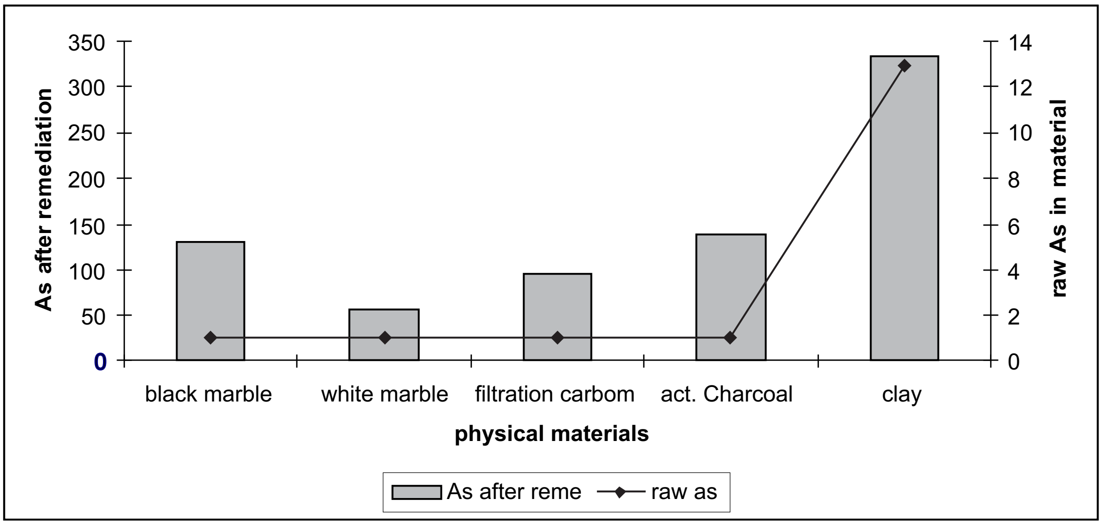

Figure 3. Statistical Plot of Bar Chat of As mg/L Concentrations in the Water of Geo-materials after Experiment in the Filtration Method

Table 2. Comparison of the Geo-materials with the By-component

Geo-materials	As content of the raw geo-materials (μg/g)	As content after remediation (mg/l)
Black Marble	1	130.204
White Marble	1	57.974
Clay	13	332.91
Activated charcoal	1	138.288
Filtration carbon	1	95.468

Table 3: Geochemical Results of Water as the Arsenic Concentration Increases

Sampling_l	As concentration (mg/l)	Pb(mg/l)	Cu(mg/l)	Zn(mg/l)	Ba(mg/l)	As(mg/l)
W1	0	0.01	0.009667	0.019	0.36333333	0.01
W2	10	0.01	0.002667	0.034333	0.39	0.01
W3	20	0.01	0.002333	0.037	0.38	0.01
W4	50	0.01	0.008667	0.026	0.36333333	0.03
W5	100	0.01	0.002	0.089667	0.36333333	0.066667

The filtration method involves the use of different geo-materials (marble (white and black), carbide, charcoal, and clay). The geo-materials were of no effect since the materials were not able to remediate arsenic, because the geomaterials contain arsenic as part of their by-products. The second experiment which was based on addition of same arsenic concentration to ascertain the plants rate of accumulation revealed arsenic to have been absorbed completely from the pots.

CONCLUSION

The study concluded that remediation of arsenic using water hyacinth was a better method for arsenic removal compared to filtration.

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