Analysis of Heavy Metal Content in Water hyacinth (Eichhornia crassipes) from Lake Victoria, Kenya

Matindi, C. N., Njogu, P. M., Kinyua, R., Nemoto, Y.

Abstract--A study was conducted to determine the concentration of heavy metals in *E. crassipes* along the shoreline of Winam Gulf on Lake Victoria, Kenya. Sampling from the Cereals Board, to Kiboko Bay was conducted between 18th May, 2013 and 31st August, 2013 based on the growth of fresh water hyacinth. Plants were harvested whole, washed twice with tap water and once with distilled water then weighed. The leaves, stems and roots were separated using stainless steel cutters and weighed. Simultaneously, water samples were also harvested and later filtered of algae and sediments before storage.

Plant samples were dried under room temperature for two weeks followed by overnight oven drying at 105^0c. They were then ground using an electric grinder. Dry ashing on 2g of powdered plant material was conducted at 600^0c in a furnace for 4hrs.For water samples, 5ml was measured and dry ashed for 2hrs. The ash was then digested in 5ml of concentrated nitric acid and made to 100ml with distilled water. The digested samples were then analyzed for eight metals. Pb^{2+}, Fe^{2+}, Cu^{2+}, Zn^{2+}, Mn^{2+}, Cr^{2+}, $Cd^{2+}$and Ni^{2+} were detected in the samples with concentrations ranging from 0.02≤ 21ppm of dry mass. Concentration of some metals in roots was found to be up to 3 times higher than in leaves and stems. Fe^{2+} and Mn^{2+} were the highest recorded at 21 and 16 ppm of dry weight, respectively. The study shows that water hyacinth can be used as an indicator for pollution. It can also be utilized for water purification due to its high metal intake capacity.

Key Words--Heavy metals, Lake Victoria, Phytoremediation, Water Hyacinth

I. INTRODUCTION

Water hyacinth in Lake Victoria was first reported in 1989. It was observed in the Ugandan and Tanzanian sector in 1989 and Kenyan sector in 1990 [1]. The plant has eventually grown to cover approximately 77 square miles of the water body's surface area [2]. The plant is hardy and very difficult to eradicate because it can survive extremely harsh conditions such as polluted with organic contaminants and high concentrations of plant nutrients. This is because it can absorb into its tissues large quantities of heavy metals from the water column [3].

Phytoremediation by Water hyacinth

Phytoremediation consists of mitigating pollutant concentrations in contaminated soils, water or air with plants able to contain or eliminate heavy metals and various other contaminants from the media that contain them [4]. A study on phytoaccumulation of trace elements in wetlands by [5] showed that water hyacinth accumulates trace elements such as Ag, Pb, and Cd and also found it efficient for phytoremediation of wastewater polluted with Cd, Cr, Cu and Se. Shao et.al. [6] reported that water hyacinth has the ability to absorb and translocate heavy metals such as Cd, Pb, Cu, Zn, and Ni at constructed wetlands in Taiwan. On a similar endeavor, Mahamadi [7] while reviewing water hyacinth as a biosorbent reported that the weed contains many polyfunctional metal-binding sites for both cationic and anionic metal complexes and can remove several heavy metals and other pollutants. In Pakistan Hussain et.al. [8] investigated phytoremediation technologies for Ni^{++} by water hyacinth and observed that the roots of water hyacinth growing in the over bank soils accumulate several metals. In California, water hyacinth leaf tissue was found to have the same mercury concentration as the sediment beneath, suggesting that plant harvesting could help mediate mercury contamination [9].All these research activities show that water hyacinth can be used as an indicator for pollution and be utilized for water purification.

II. MATERIALS AND METHODS

A. Sampling

Sampling points as shown in Fig.1 were selected based on the activity surrounding the area. Most activities conducted along the Winam gulf involve tourism and eateries. Water hyacinth and water samples obtained from 10 points along the shore

Matindi, C. N., Institute of Nuclear Science and Technology, University of Nairobi (phone: +254726904547,email:christinematindi@gmail.com ,)

Njogu, P. M., Institute of Energy and Environmental Technology, JKUAT(emai:;njogupl@yahoo.com)

Kinyua, R Institute of Energy and Environmental Technology, JKUAT, (email:kinyua@fsc.jkuat.ac.ke)

Nemoto, Y., Division of Renewable Energy and Environment, Ashikaga Institute of Technology(email: nemoto@asitech.ac.jp)

line of Winam gulf and a point of maximum dilution between shorelines.

B. Preparation of samples

The plants were washed twice with tap water, once with distilled water then weighed. The leaves stem and roots were then separated weighed and dried under room temperature for two weeks. After this, they were dried overnight in an oven at 105^0c. They were then ground separately using an electric grinder.

Water samples were filtered of algae and sediments, measured for pH, turbidity and electric conductivity.

C. Analysis

Dry ashing on 2g of powdered plant material was conducted at 600^0c in a furnace for 4hrs. For water samples, 5ml was measured and dry ashed for 2hrs. The ash was then digested in 5ml of concentrated nitric acid and made to 100ml with distilled water. The digested samples were then analyzed for eight metals; Pb^{2+}, Fe^{2+}, Cu^{2+}, Zn^{2+}, Mn^{2+}, Cr^{6+}, $Cd^{2+}$and Ni^{2+} using Shimadzu AA-6800 Atomic Absorption Spectrophotometer.

III. RESULTS AND DISCUSSION

The maximum dilution point was used as a natural control for the analysis. Water hyacinth growing here was found to have the least concentrations of all metals and demonstrating below detectable levels for Ni^{2+} and Cd^{2+} .Water hyacinth was found to be a high accumulator for heavy metals manganese and iron. This is also an indicator that there are high deposits of these metals in the Lake Victoria waters. The bioabsorption of heavy metals in Winam gulf was found to be in the order $Fe^{2+} > Mn^{2+} >> Zn^{2+} > Cu^{2+}$, $Cr^{2+} > Ni^{2+} > Pb^{2+} > Cd^{2+}$. The concentration of metals was shown to decrease further down the shoreline as the level of human activities was also minimal.

Table I shows average (± SD) for variation in concentration of the absorbed of metals in the plants and in the water over the four month period. Iron and manganese were recorded at highest levels. The occurrence of these metals in the shoreline which is usually common in ground water can be due to erosion caused by conventional rainfall in the region whose surrounding is slightly uphill. The two metals which are commonly found together generally do not pose a health risk unless in very high concentrations but cause red discoloration in water [10]. It was also observed that these metals were highly concentrated at the roots than in other parts of the plant with iron having as much as three times more in the roots than in the leaves and stem. This is true for all other metals except zinc, copper and lead. The amount in the leaves for these metals was the same as that in the water in which the plant grew. For zinc and copper this could be attributed to the fact that they are micronutrients for plant growth hence the high translocation factor on leaves.

TABLE I
CONCENTRATIONS OF HEAVY METALS WATER HYACINTH AND VARIATIONS IN WATER CONCENTRATION

ION	Pb^{2+}	Zn^{2+}	Cu^{2+}	Cr^{2+}	Mn^{2+}	Fe^{2+}	Ni^{2+}	**Cd^{2+}**
SITE								
CEREALS BOARD	**0.0457±0.02**	**0.9677±1.1**	**0.3599±0.02**	**0.2567±0.01**	**14.2884±2.84**	**14.6118±1.72**	**0.0345±1.02**	**0.0237±0.00**
KICHINJIO BAY	**0.2401±0.01**	**1.801±2.4**	**0.1923±0.06**	**0.3912±0.08**	**14.6724±2.98**	**20.5382±1.66**	**0.0476±3.02**	**0.0106±0.01**
BOAT PIER	**0.1258±0.31**	**1.5095±2.07**	**0.2±0.5**	**0.4107±1.3**	**16.7253±1.2**	**20.6354±1.91**	**0.030±3.01**	**0.02±0.1**
IMPALA CLUB	**0.241±1.1**	**1.1396±1.92**	**0.223±0.87**	**0.12±0.06**	**16.922±1.44**	**19.6814±0.45**	**0.1842±1.2**	**-**
YACHT CLUB	**0.0229±0.61**	**1.3115±3.5**	**0.1603±0.02**	**0.430±0.02**	**16.3311±1.08**	**19.0447±2.1**	**0.1917±2.3**	**0.0393±0.00**
WIGWA INLET	**0.7058±0.5**	**2.2007±3.02**	**0.3292±0.01**	**0.1085±0.05**	**15.9815±1.56**	**21.5081±1.5**	**0.4358±1.01**	**0.1007±0.02**
HIPPO-POINT	**0.1943±0.32**	**0.5754±3.02**	**0.1232±0.01**	**0.1502±0.04**	**15.0172±1.22**	**13.2869±2.96**	**0.2671±1.00**	**0.0049±0.01**
KWTP	**0.1943±0.55**	**0.6726±3.00**	**0.1232±0.12**	**0.2409±0.01**	**13.7347±1.57**	**12.2019±1.88**	**0.1553±1.01**	**0.1300±0.01**

KIBOKO BAY	**0.2629±0.02**	**0.2224±0.04**	**0.7484±0.06**	**0.1622±0.02**	**11.62±0.5**	**5.362±1.7**	**0.2288±0.01**	**0.0073±0.01**
POINT OF MAX. DIL.	**0.0056±0.01**	**0.0211±0.00**	**0.0175±0.03**	**0.0582±0.02**	**0.8763±0.1**	**0.9650±0.2**	**-**	**-**

IV. CONCLUSION

The results from this study show that *Eichhornia crassipes* is a good biosorbent for heavy metals from Lake Victoria.

Roots of water hyacinth are better accumulators of the metals than leaves. This however is dependent on the metal as demonstrated for Zinc and copper which are translocated to the leaves more than in the roots as compared to other metals. The study also reveals that underground minerals; iron and manganese are highly leached into the Lake Victoria's water. High concentrations of these metals cause discoloration of water and an awful taste if not properly treated while being processed for domestic use. Water hyacinth can be used as a means to treat the water. It is however worth noting that results from this study show that Winam Gulf was found not to have high levels of extremely toxic metals lead and cadmium.

Therefore, it can be proposed that *Eichhornia crassipes* act as a means of removal for heavy metals from Lake Victoria and also be utilized as an indicator for pollution. Since this plant grows extensively on the Lake's water surface it can be used for this purpose and later be converted as biomass. Hence a means of eradication by utilization.

REFERENCES

[1] Gichuki, J., Omondi, R., Boera, P., Okorut,T., Matano,A. S., Jembe,T.,and Ofulla, A. (2012). Water Hyacinth Eichhornia crassipes (Mart.) Solms-Laubach Dynamics and Succession in the Nyanza Gulf of Lake Victoria (East Africa): Implications for Water Quality and Biodiversity Conservation. *East Africa Communuty Lake Victoria Basin Commission*.

[2] Mehrhoff, J., DeGoosh, K., Center, T., and Brown, K. (2010). Freshwater Invasive Species in Rhode Island Water Hyacinth. Office of Water Resources Rhode Island..

[3] Chunkao, K., Nimpee, C, and Duangmal, 2012. The King's initiatives using water hyacinth to remove heavy metals and plant nutrients from wastewater through Bueng Makkasan in Bangkok, Thailand. Ecological Engineering 39: 40–52.

[4] Wikipedia. (2012). Phytoremediation. Available: http://en.wikipedia.org/wiki/Phytoremediation.htm

[5] Zhu, Y. L., Zayed, A. M., Qian, J.H., De Souza, M. and Terry, N. (1999). Phytoaccumulation of Trace Elements by Wetland Plants: II. Water hyacinth. J Environ Qual. 1999; 28(1):339–344.

[6] Shao W. L., Chang, W. L. (2004). Heavy Metal Phytoremediation by Water Hyacinth at Constructed Wetlands in Taiwan. *Journal. Aquat. Plant Manage.* 42: 60-68.

[7] Mahamadi, C. (2011). Water hyacinth as a Biosorbent: A review. *African Journal of Environmental Science and Technology*, 5(13), 1138-1139.

[8] Hussain, S. T., Mahmood, T. and Malik S.A. (2010). Phytoremediation Technologies for Ni++ by Water hyacinth. African Journal of Biotechnology Vol. 9(50), pp. 8648-8660.

[9] Greenfield, B. K., Siemering, G.S., Andrews, J.C., Rajan, M., Andrews, S.P. and Spencer, D.F. (2007). Mechanical shredding of water hyacinth (*Eichhornia crassipes*): Effects on water quality in the Sacramento-San Joaquin River Delta, California. Estuaries and Coasts 30: 627-640.

[10] Land, B. (1999). Iron and Manganese in Drinking Water.United States Department of Agriculture Forest Service, Technology and Development Program. [Online].Available:http://www.fs.fed.us/eng/pubs/html/99711308/99711308.html

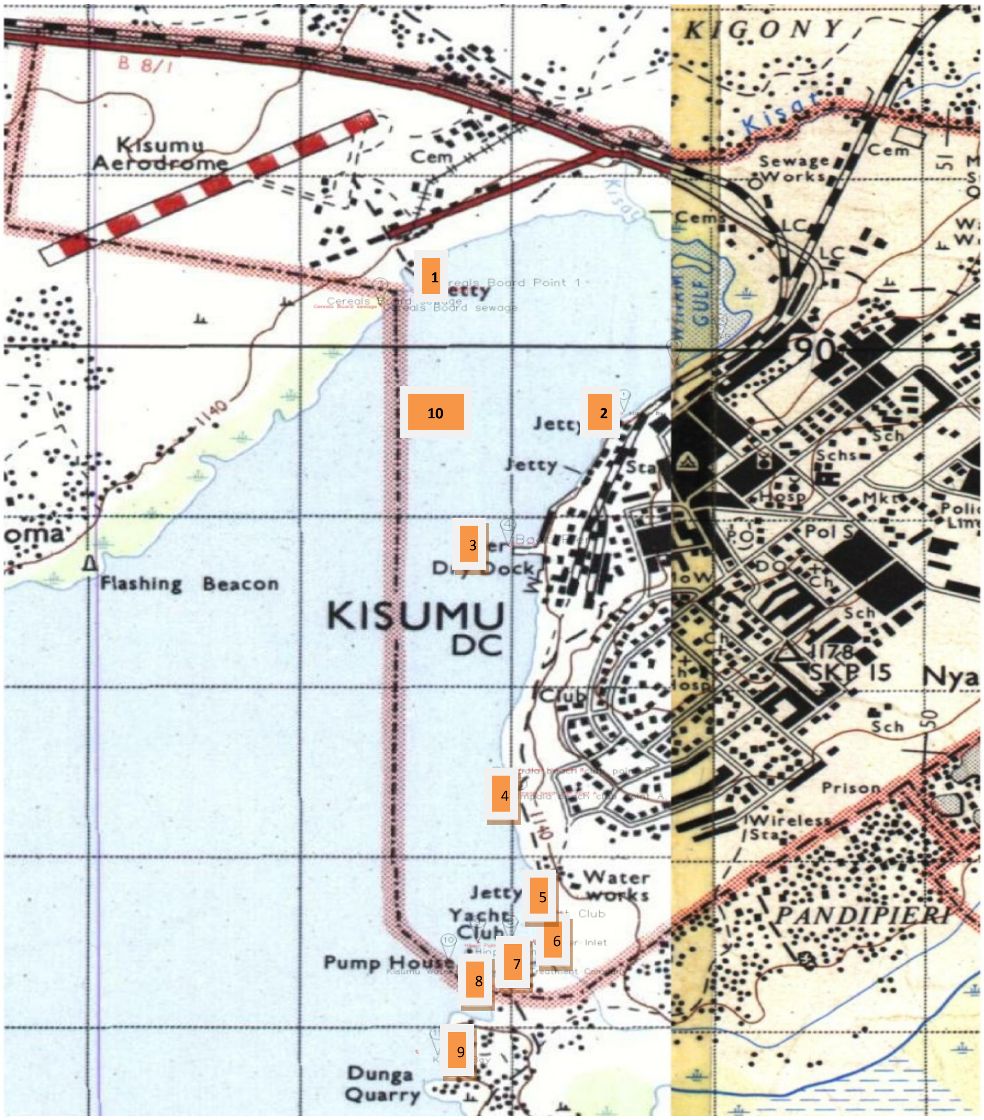

Fig. 1. Map of sampling points

1. Cereals Board
2. Kichinjio Bay
3. Boat Pier
4. Impala beach club
5. Yacht Club:
6. Wigwa River Inlet
7. Hippo Point
8. Kisumu Water and Sewerage Treatment Plant
9. Kiboko Bay
10. Maximum dilution Point