Resources and Environment 2014, 4(6): 268-273
DOI: 10.5923/j.re.20140406.03

Analysis of Pollution Removal from Compost Leachate by Vetiver Grass (L.) Nash Plant (*Vetiveria zizanioides*)

Albert Chukwuemeka Ibezute[1,*], Prekeyi Tawari-Fufeyin[2], Osayomwanbor Ebenezer Oghama[1]

[1]Department of Environmental Science, College Science, Federal University of Petroleum Resources, Effurun, Nigeria
[2]Department of Animal and Environmental Biology, Faculty of Life Science, University of Benin, Benin City, Nigeria

Abstract The pollution removal ability of *Vetiveria zizanioides* (L.) Nash plant was investigated using compost leachate. Fifty (50) litres of untreated compost leachate from shell farm, Jeddo, Delta state was filtered and transferred to a treatment tank of about 60 litre capacity containing vetiver grass. The experiment was allowed to stand for 112 days without aeration. Leachate and plant samples were collected and analyzed before and after the treatment. The result showed that all physical, chemical and microbial parameters analyzed in the untreated leachate were within the WHO limit except for TDS, TSS, EC, colour, DO, BOD_5, COD, chloride, lead, iron, cadmium and total coliform. However, after treatment pH was reduced by 5.53%, total dissolved solid 97.96%, total suspended solids 64.35%, electrical conductivity 98.11%, biological oxygen demand 63.67%, chemical oxygen demand 63.11%, colour 95.24%, chloride 98.71%, sodium 96.98%, magnesium 97.17%, sulphate 98.89%, nitrate 95.71%, phosphorous 97.50%, lead 100.00%, iron 97.57%, zinc 85.85%, cadmium 100.00%, copper 100.00%, total fungi count 94.28%, total bacterial count 93.28% and total coliform count 96.45%; while dissolved oxygen increased by 30.00%. Comparison of the results of the analyses after treatment with WHO standards showed that the values of dissolved oxygen and total coliform count were still not within WHO limit. Again, the concentration of lead, cadmium, iron and copper in Vetivera grass used for the treatment of compost leachate reduced after the treatment period. The chemical characteristics of the leachate clearly indicated that it is of a high threat to the environment especially the aquatic environment which is the final recipient of this waste. However, Vetiver grass exhibited quite a distinct response and is recommended for the bio-purification of compost leachate.

Keywords Compost, Leachate, Bioremediation, Phytoremediation, Vetiver grass, Pollution

1. Introduction

The generation and disposal of waste is an intrinsic part of any developing or industrial society. The percentage of Nigeria's population living in cities and urban areas has doubled in the last 15 years [1]. The cities and urban areas experience continuous growth which contributes to the enormous generation of solid and liquid waste. However, amongst the different types of waste generated worldwide, management of sewage and organic waste posses the greatest challenge to government authorities and waste managers. Biological reprocessing of the organic fraction of Municipal Solid Waste such as composting has been found to be more environmentally effective than landfill and incineration.

At the simplest level, the process of composting simply requires making a heap of wetted organic matter (leaves, food waste) and waiting for the materials to break down into soil after a period of weeks or months. Modern, methodical composting is a multi-step, closely monitored process with measured inputs of water, air and carbon- and nitrogen-rich materials. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning the mixture. The organic products – compost manure, maggot and compost effluent (commonly known as leachate) - is recycled or reused for more economic purposes. The leachate produced from the composting process is as a result of water introduced during the shredding process and retained in the organic waste.

There appears to be no database in existence of the composition of liquors from composting facilities in Nigeria in stark contrast to that available for landfill leachates. Although, recent study of leachate from a green waste compost facility concluded that the concentrations of readily biodegradable compound and nutrient were of a similar order to those found in untreated urban leachate [2]. However available evidence suggests that compost leachate is variable in terms of its chemistry and that this variability is influenced by factors such as nature of feedstock, the maturity of the compost giving rise to the leachate, composting technology employed, the degree of cover, the environment and the duration of composting [3].

* Corresponding author:
emekaibezute@gmail.com (Albert Chukwuemeka Ibezute)
Published online at http://journal.sapub.org/re

Krogmann and Woyczechowski [4] determined the pollution loads of liquid by-products of composting. They reported that parameters including settleable solids, pH, conductivity, biological oxygen demand (BOD_5), chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), NH_4^+-N,NO_3^--N, NO_2^--N; Cl^-, Zn, Pb, As, Cd and volatile fattyacids (VFA) needed to be pretreated before released into public sewers unless diluted with other waste streams.

Improper disposal of compost leachate could lead to transmission of pathogens to humans [5] and environmental pollution. This itemizes the need for leachate purification at least to levels acceptable to various regulatory bodies hence this study; which is aimed at exploring the treatment of compost leachate using vetiver grass (L.) Nash plant.

2. Materials and Methods

2.1. Collection of Experimental Plant

Vetiver grass (L.) Nash plant (*Vetiveria zizanioides*) obtained from an NGO (Poverty Alleviation for the Poor Initiatives (PAFPI)), Ughelli, Delta state, were thoroughly washed with tap water to remove any soil/sediment particles attached to the plant surfaces. The plants were placed in 60liters capacity tanks.

2.2. Experimental Setup

Fifty (50) litres of compost leachate from Fomas Venture Nigeria Ltd, Delta state,; managers of organic waste from Shell Petroleum Development Company; was collected, filtered using a very fine mesh (2.0mm) and transferred into a 60 litres capacity tank with *Vetiveria zizanioides* (vertiver grass) as bio-purificator. The experiment was carried out under natural condition for 112 days without aeration.

Before and after the experiment began, the untreated leachate and plant sample were collected and analyzed; in other to monitor the pollution removal process.

2.3. Water and Plant Analysis

Acceptable standard methods and instrumentations were followed during sample collection procedures [6]. During each sampling, water samples for physicochemical analyses were collected into thoroughly cleaned 1liter polyethylene bottles and tightly closed. Each bottle was rinsed with the appropriate sample before the final sample collection. The samples were placed in a cooler box and then taken to the laboratory for analyses. For dissolved oxygen (DO) determinations, separate samples were collected in 300 ml plain glass bottles and the samples fixed using the azide modification of Winkler's method [6]. Samples for biochemical oxygen demand (BOD) were collected into dark glass bottles for incubation and subsequent DO determination. Also vegetative parts of the plants consisting of the leaf, stem and root were collected in sterile bags, sealed, labelled appropriately and taken to the laboratory for digestion as described by USEPA [7].

In the laboratory, pH, total dissolved solids, electrical conductivity, dissolved oxygen, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), colour, chloride, sodium, magnesium, sulphate, nitrate, phosphate, lead, iron, zinc, cadmium and copper were determined according to procedures outlined in the Standard Methods for the Examination of Water and Wastewater [6]. pH was measured using a HACH digital meter, total dissolved solid was determined using a TDS meter (Model 4076), electrical conductivity was measured using Cybersan 510 conductivity meter. Titrimetric method was used in the determination of chemical oxygen demand (COD), chloride, sodium and magnesium. Sulphate, nitrate and phosphate were determined spectrophotometrically at 380nm, 470nm and 680nm respectively. Heavy metals such as lead, iron, zinc, cadmium and copper in the water sample were determined using Atomic Absorption Spectrophotometer (Buck Scientific Model-210) at 217.0nm, 248.0nm, 213.9nm, 228.8nm and 324.8nm respectively. Microbiological parameters monitored included total bacterial count, total fungi count and total faecal coliform counts, which were carried out according to Standard [6].

3. Results

A summary of the results of physical, chemical and microbial analyses of both untreated and treated effluent are presented in Table 1. These values were placed alongside WHO guideline values [8]. The heavy metals concentrations in Vetivera grass before and after treatment are also shown in Table 1.

The mean pH in untreated leachate which was slightly alkaline (7.95) was slightly reduced after treatment. Total dissolved solids in the untreated leachate which was higher than WHO limit was reduced by 97.96% after treatment. Total suspended solids and Electric conductivity were also reduced by 98.11% and 64.35% below the initial concentration in the untreated leachate respectively. Dissolved oxygen which was completely absent in the untreated leachate was increased to 1.50mg/l after treatment for 112day. However, high biological and chemical oxygen demand which was noted in the leachate was reduced after treatment; again, colour in the untreated was also reduced below acceptable limit. Chloride alongside sodium, magnesium, sulphate, nitrate, phosphorus were reduced by 98.71%, 96.94%, 97.17%, 98.89%, 95.71% and 97.50% respectively after treatment period. Heavy metals such as lead, iron, zinc, cadmium and copper were reduced from 1.71 to 0.00mg/l, 38.22 – 0.93mg/l, 4.10 – 0.58mg/l, 0.24 – 0.00mg/l and 0.02 – 0.00mg/l respectively.

Microbiological assessment showed that Vetiver grass; after 112 days of bio-purification reduced total fungi count by 94.28%, total bacterial count by 93.28% and total coliform count by 96.45. However, after treatment of compost leachate dissolved oxygen and Total Coliform were still not within accepted limit.

The concentration of lead, cadmium, iron and copper in Vetivera grass used for the treatment of compost leachate reduced by 21.01%, 39.56%, 30.28%, 100.00% and 82.36% respectively after 112 days (Fig 1 and 2).

Table 1. Physical, chemical and microbial changes in leachate purified using vetiver grass

Parameters	Before treatment	After treatment	% treatment	WHO, 2011
pH	7.95	7.51	5.53	6.5-8.5
TDS (mg/l)	5920.00	121.00	97.96	1000
TSS (mg/l)	33.27	11.86	64.35	-
EC (µs/cm)	9570.00	181.20	98.11	-
DO (mg/l)	**0.00**	**1.50**	**30.00**	**5**
BOD_5 (mg/l)	35.19	12.89	63.37	28-30
COD (mg/l)	87.31	32.21	63.11	-
Colour (Pt.Co)	21.00	1.00	95.24	15
Cl (mg/l)	2876.00	37.19	98.71	250
Na (mg/l)	17.34	0.53	96.94	50
Mg (mg/l)	3.18	0.09	97.17	150
SO_2 (mg/l)	192.43	2.14	98.89	400
NO_2 (mg/l)	2.10	0.09	95.71	50
P (mg/l)	5.19	0.13	97.50	-
Pb (mg/l)	1.71	0.00	100	0.01
Fe (mg/l)	38.22	0.93	97.57	1.0
Zn (mg/l)	4.10	0.58	85.85	5
Cd (mg/l)	0.24	0.00	100	0.003
Cu (mg/l)	0.02	0.00	100	2.0
$TFC\times10^3$ (cfu/ml)	13.82	0.79	94.28	100
$TBC\times10^7$ (cfu/ml)	15.02	1.01	93.28	100
TC×10 (MPN/100ml)	33.23	1.18	96.45	0

NB: Bold face signifies increase in concentration
Unbold face signifies decrease in concentration

4. Discussion

Vetiver grass under investigation has exhibited quite distinct responses to the treatment of compost leachate. Total solid is a measure of all the suspended, colloidal, and dissolved solids in a sample of water. This includes dissolved salts such as sodium chloride (NaCl) and solid particles such as silt and plankton. In this study, high concentrations of total dissolved and suspended solids may have resulted from grinding of the organic waste before composting. This was done in order to increase surface area for increased bacterial activity. However, total dissolved and suspended solid were reduced well below maximum acceptable limit [8] by Vetiver grass after treatment period. Excessive concentration of suspended and dissolved solids might be harmful to aquatic life, because they decrease water quality, inhibit photosynthetic processes and eventually lead to increase of bottom sediments and decrease of water depth [10].

Conductivity of water is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability is a function of the presence of ions, their total concentration, mobility, valency and the temperature of measurement. Example of such ions is chloride. High conductivity has been reported in water with high chloride content [9]. Higher value of conductivity and chloride found in the untreated leachate may be as a result of common salt which is used extensively in cooking all types of food and its presence in naturally occurring food in limited quantity [9]. However Vetiver grass significantly reduced the concentration of chloride alongside other cations and anion; which has consequently reduced the value of conductivity in the leachate. This was in agreement with the report of Girija *et al.* [11] when they investigated the potential of vetiver for phytoremediation of waste in redding area.

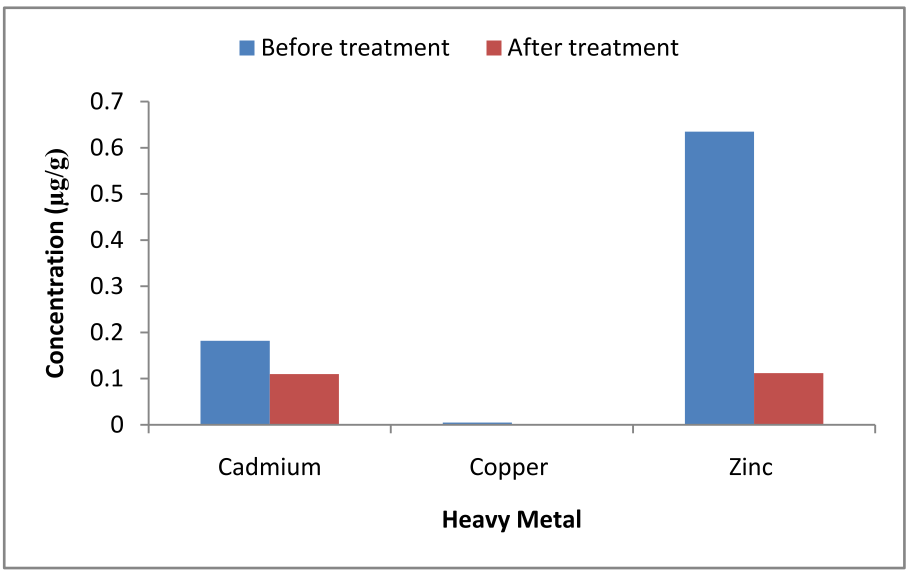

Figure 1. Changes in the cadmium, copper and zinc concentration of vetiver grass during purification of compost leachate

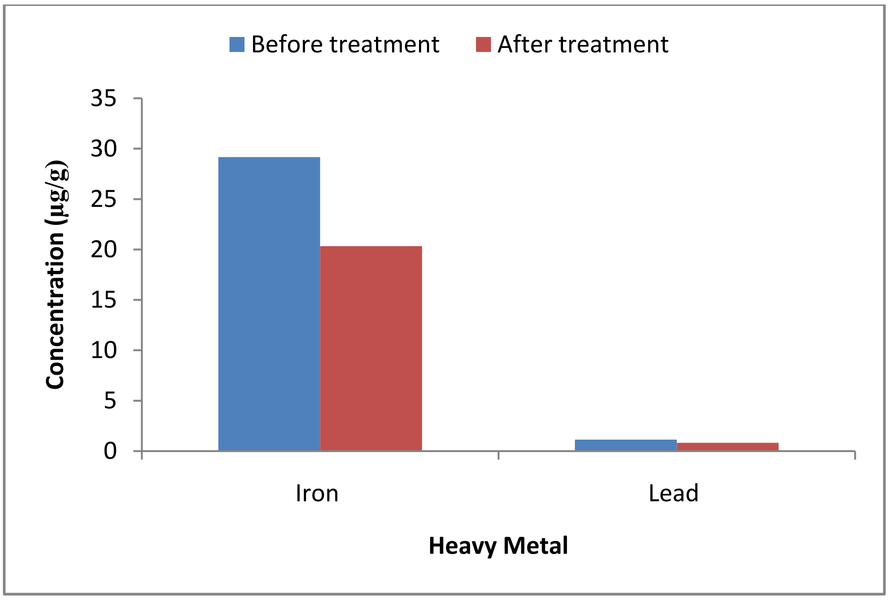

Figure 2. Changes in the iron and lead concentration of vetiver grass during purification of compost leachate

The dissolved oxygen level in the untreated leachate which was completely absent cannot sustain aquatic productivity [9]. This correlated positively with the report of Roghanian *et al*. [12] when they studied the effects of composted municipal waste and its leachate on some soil chemical properties and corn plant responses. This could be attributed to high level of microbial activities consequent of high concentrations of degradable organic and inorganic matters which resulted in a tendency to be more oxygen demanding. After treatment, Vetiver grass increased DO concentration in the leachate. This is in agreement with Girija *et al.* [11] who reported that DO increased from 0 to 4.5 mg/L after 1 month which is in agreement with Stefanie *et al*. [13] when they investigated the response of vetiver grass to extreme nitrogen and phosphorus supply.

BOD and COD represent the amount of oxygen required for the biological and chemical decomposition of organic and inorganic matter respectively under aerobic condition at a standardized temperature [9]. High BOD and COD values as recorded in untreated leachate is an indication of high level of pollution which could result in high biodegradation activity by microbes. Discharging the leachate directly into water without aeration would deplete the dissolved oxygen of water that is needed by aquatic animals for respiration. High BOD and COD vary inversely with dissolved oxygen and is detrimental to aquatic lives [14]. However the study of Boonsong and Chansiri [15] on BOD and COD reduction efficiency using vetiver grass was consistent with my findings.

Colour may be the first indication of a hazardous situation. High value of colour reported in the untreated leachate may be due to the presence of coloured organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil. Colour is strongly influenced by the presence of iron, other metals, and contamination of the water source with industrial effluents [9]. After treatment for 112days, Vertiver grass was very efficient in improving the colour of the leachate as a 95.24% reduction was reported

Lead, iron and cadmium are toxic heavy metals in the body when present beyond required levels. It can bind with important enzymes and inactivate them. It can also displace biologically important metals, such as Calcium, Zinc and Magnesium, interfering with a variety of the body's chemical reactions [16]. Lead, iron and cadmium in untreated leachate was found to be beyond WHO [8] limit. The organic waste; from which the compost leachate for this study was obtained is usually from petroleum processing facilities which may have been the source of the heavy metals. However vetiver grass significantly reduced lead, iron and cadmium after treatment bringing it to concentration within acceptable limit. Similarly Roongtanakiat *et al.* [17], Truong and Hart [18] reported the vetiver grass has successfully been used to clean up heavy metals from landfill leachate and leachate treatment respectively.

The presence of faecal contamination in the untreated leachate is an indication that a potential health risk exists for an individual exposed to this leachate. This may be as a result of high organic matter and essential nutrients supporting the growth of microorganism [19, 20]. Chukwu *et al*. [21] stated that the presence of faecal contamination indicates the presence of waste from warm blooded animals. Total coliform count was reduced by vertiver grass after 112 days; which is similar to the report of Wagner *et al.* [22] and Truong and Hart [18]. However, the persistence of total coliform after the treatment period shows that it may persist in the environment longer as earlier reported by Kinberly et al. [23]. The World Health Organization identifies the greatest human health risk of microbial contamination as being through the consumption of water contaminated by human or animal faeces [9].

The reduction in heavy metal concentration of Vetiver grass after treatment of compost leachate may imply that the plant was able to excrete or convert the metals to other forms. Ensley [24] stated that plants have the ability to convert metals that are toxic to them into other forms which are less harmful to them.

5. Conclusions

Compost leachate disposal is one of the important problems in the composting process as it could contaminate ground water and surface water when disposed into the environment without treatment. Though it can be recirculated as a wetting agent in further composting processes as replacement for fresh unpolluted water, which consequently increases the amount of leachate produced; however, recirculation is not possible in some situations. Hence other arrangements have to be made for onsite treatment of the leachate before discharge into the environment. The use of vetivera grass in the treatment of compost leachate as reported in this research have proved to be very efficient; and can be integrated into various techniques for removal of water contaminants and advances in leachate treatment and control of water pollution.

ACKNOWLEDGEMENTS

We are grateful to Mr Omonade Kejekpo, the Executive Director of Poverty Alleviation for the Poor Initiative (PAFPI) for providing me with Vetiver grass used for this research and also to Sir F.I. Ogunleye of FOMAS Ventures for the compost effluent and for giving me a space in his facility for this research. We are grateful to the staff of FOMAS ventures for their encouragement and support during my research in the facility. We are also thankful to the family of Mr and Mrs Abroziekeya who provided us accommodation by accepting us into their family during the period of research.

REFERENCES

[1] Jimoh I.A., 2005, A new Approach to Municipal Waste Management in Nigeria, International Conference on Energy, Environment and Disasters- INCEED 2005, Charlotte N.C, USA- July 24-30, 2005. 245pp.

[2] Tyrrel, S.F., Seymour, I. and Harris, J.A., 2005, Biological treatment of compost leachate usinf waste-derived filter media. Report to the Sita trust. 35pp.

[3] Frederickson, J., 1997, Compost leachate; effect of composting duration on its composition and on its use as a fertilizer. Orbit 97. International conference, Harrogate, 3-5th September, 1997. 112pp.

[4] Krogmann, U. and Woyczechowski, H., 2000, Selected characteristics of leachate, condensate and runoff released during composting of biogenic waste. Waste Management and Research 18(3), 235–248.

[5] Cadmus, S.I.B., Olugasa, B.O. and Ogundipe, G.A.T., 1999, The prevalence of Zoonitic Importance of Bovine Tuberculosis in Ibadan, Nigeria. Proceedings of 37th Annual Congress of the Nigeria Veterinary Medical Association. 71pp.

[6] American Public Health Association, 1998, Standard methods for the Examination of Water and Waste water. 20th edn. American Public Health Association, Washington. 1134 pp.

[7] United States Environmental Protection Agency (USEPA), 1996. Acid digestion of sediments sludges and soils, Method-3050B.USEPA: Washington, DC.

[8] World Health Organization, 2011, Guidelines for Drinking Water Quality, 4th Edition, Geneva, Switzerland.

[9] World Health Organisation, 2011, Guidelines for Drinking Water Quality.4rd Edn., Geneva, Switzerland. 678pp.

[10] Ogbeibu, A.E and Anagboso, M.U., 2004, Baseline Limnological Investigation of the Utor River in Essan South-East, Edo State, Southern Nigeria: 1. Physical and Chemical Hydrology. Trop. Freshwat. Biol., 12 (13). 45 – 62.

[11] Girija, N., Pillai, S.S and Koshy, M., 2011, Potential of vetiver for phytoremediation of waste in retting area. The Ecoscan., 1, 267-273.

[12] Roghanian, S., Hosseini, H.M., Savaghebi, G., Halajian, L., Jamei, M. and Etesami, H., 2012, Effects of composted municipal waste and its leachate on some soil chemical properties and corn plant responses. International Journal of Agriculture: Research and Review., 2(6), 801-814.

[13] Stefanie, W., Paul, T., Alison, V. and Cameron, S., 2003, Response of vetiver grass to extreme nitrogen and phosphorus supply. Available: http://www.vetiver.com/ICV3-Proceedings/AUS_Extreme%20N%26P.pdf Accessed 10th Oct., 2012.

[14] Jha, P., Barat, S. and Nayak, C.R., 2008, Fish Production, Water Quality and Bacteriological Parameters of Koi Carp Ponds Under Live-food and Manure Based Management Regimes. Zoological Research Approach, 29(2), 165—173.

[15] Boonsong, K. and Chansiri, M., 2008, Domestic waste water treatment using vetiver grass cultivated with floating platform technique. Australian Journal of Technology, 12(2), 73-80.

[16] Ahameda, M. and Siddiqui. M.K.J., 2007, Low level lead exposure and oxidative stress: current opinions. Clinica Chimica Acta, 383, 57–64.

[17] Roongtanakiat, N., Nirunrach, T., Chanyotha, S. and Hengchavanich, D. (2003). Uptake of heavy metals in landfill leachate by vetiver grass. Kasetsart Journal of Natural Science, 37, 168-175.

[18] Truong, P. and Hart, B., 2001, Vetiver grass for wastewater treatment., Pacific Rim Vetiver Network Technical Bulletin No. 2001/2, Available Online: http://www.vetiver.org/PRVN_wastewater_bul.pdf.

[19] Rheinheimer, G., 1991, Aquatic Microbiology. 4th edn. John Wiley and Sons. NY. 363pp.

[20] Sayler, G.S., Nelson, J.O., Justice, A., Colwell, R.R., 1975,

Distribution and significance of faecal indicator organisms in the upper Chasepark Bay. Appl. Ind. Microbiol., 30(4), 625–638.

[21] Chukwu, O., Mustapha, H.I. and Abdul-Gafar, H.B., 2008, The Effect of Minna Abattoir Waste on Surface Water Quality. International Environmental Research Journal, 2, 334-338.

[22] Wagner, S., Truong, P., Vieritz, A. and Smeal, C., 2003, Response of vetiver grass to extreme nitrogen and phosphorus supply., In: Proc. of the 3rd International Conference on Vetiver and Exhibition, Guangzhou, China.

[23] Anderson K.L., Whitlock, J.E. and Harwood, V.J., 2005, Persistence and Differential Survival of Fecal Indicator Bacteria in Subtropical Waters and Sediments. Appl. Environ. Microbiol., 71(6), 3041-3048.

[24] Ensley, B., 2000, Rationale for use of phytoremediation. In: Raskin, I. and Ensley, B. (eds) *Phytoremediation of toxic metals: Using plants to clean up the environment.* Wiley Interscience, New York, pp 3-12.