International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Heavy Metal Pollution in a Lake: An Assessment of the Ecological Threat

Raju Potharaju[1], M. Aruna[2]

[1]Department of Botany, City Womens Degree college, Hanamkonda, Telangana, India.
[2]Professor Department of Botany, Hydrobiology and Algal Biotechnology Laboratory, Telangana University, Dichpally, Nizamabad, Telangana, India

ABSTRACT
The purpose of this study was to investigate and evaluate the presence of different heavy metals in sediment samples collected from water of Durgam Cheruvu . The concentrations of six heavy metals, namely arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), and zinc (Zn), were quantified using the technique of inductively coupled plasma-atomic emission spectroscopy (ICPAES). The investigation employed relative enrichment factors and prospective ecological risk indices to examine the contamination levels of heavy metals in sediment samples and evaluate their potential ecological impact on the surrounding ecosystem. The order of heavy metal sediment enrichment factors was determined to be as follows: chromium (Cr) exhibited the highest enrichment factor, followed by arsenic (As), cadmium (Cd), zinc (Zn), copper (Cu), and lead (Pb). Several potential ecological risk indices for heavy metals were identified. The order of decreasing reactivity of the elements is as follows: Cadmium (Cd) > Arsenic (As) > Chromium (Cr) > Copper (Cu) > Lead (Pb) > Zinc (Zn). The prospective ecological risk indices, as determined through calculations, indicate that the lake has been low contaminated by heavy metals. Cadmium (Cd) exhibited a moderate level of potential ecological risk within the ecological environment and emerged as the primary factor contributing to the possible toxicity response indices associated with different heavy metals in Durgam cheruvu. The application of analysis of variance was employed to determine the statistical significance of the observed fluctuations in heavy metal concentrations. The analysis of mean seasonal concentrations of metals revealed statistically significant variations across different seasons and sampling sites. The pollution in Durgam Cheruvu may be attributed to industrial and anthropogenic activity. We have put up a series of techniques that can be implemented to mitigate the accumulation of heavy metals in the lake.

Keywords: Heavy Metals, Sediments, Durgam Cheruvu, Potential ecological risk index.

I. INTRODUCTION

Research on the presence of heavy metals in sediments plays a crucial role in comprehending their influence on aquatic ecosystems. Heavy metals have a significant role as environmental pollutants, posing a hazard to both human populations and natural ecosystems in terms of their health impacts.[1] Sediments, as fundamental constituents of the natural environment, serve as a source of nourishment for various creatures. Sediments fulfil the role of both a sink and reservoir for a diverse range of environmental contaminants.[2] Additionally, sediments typically serve as a valuable source of information, documenting the intake of catchments into aquatic ecosystems.[3]. Heavy metals are typically found in aquatic settings at low concentrations. However, the introduction of anthropogenic wastes has resulted in elevated concentrations of heavy metals, leading to environmental issues in lakes. There has been a growing scholarly interest in determining the levels of metal concentration within marine and freshwater sediments. Numerous studies have revealed the presence of heavy metals, including cadmium (Cd), chromium (Cr), and copper (Cu), in natural water bodies, soil, and biota.[4]. These metals are considered vital micronutrients for living organisms, although their toxicity becomes apparent when they reach particular amounts. The concentrations of these substances are influenced by both local geological factors and human activity.[5]

The presence of heightened concentrations of these metallic elements in the surrounding ecosystem can be attributed to both natural and human-induced pathways, which may include the ingestion of food sourced from polluted settings. Lakes offer a wide range of recreational opportunities, such as engaging in fishing, boating, and swimming activities. Additionally, wetlands serve as crucial wildlife habitats for aquatic organisms, underscoring the need to accurately determine the levels of heavy metal concentration and assess their possible ecological risks [6]. Several methods have been developed to estimate the danger associated with heavy metals, which include:

The concept of sediments enrichment factor refers to the measurement used to assess the degree of enrichment of certain elements or substances in sediment samples. The pollutant load index is a metric used to assess the level of pollution in a given area. The prospective ecological risk index is a measure used to assess the possible risks posed to the environment[7]

The objective of this study is to evaluate the water quality of Durgam Cheruvu. This will be accomplished by analyzing the concentrations of heavy metals in samples collected from various places within the lake. The study employed relative enrichment factors and the potential ecological risk index to examine the contamination levels of heavy metals in sediments and evaluate their potential ecological harm. Systematic analysis was conducted to determine the amounts of various heavy metals in sediment samples, together with their seasonal fluctuations.[8]

The findings offer a thorough assessment of the presence of heavy metals in the sediment and the possible sources of pollution in the lake.[9]. This information provides valuable knowledge for making informed decisions regarding the security of the water source.

II. MATERIALS AND METHODS

Description of the Study Area :

Durgam Cheruvu, alternatively referred to as Raidurgam Cheruvu, is a body of freshwater situated inside the Rangareddy district of Telangana, India, It coordinates 17.42886°N 78.387794°E, namely in the vicinity of Jagathgiri Gutta. The lake, spanning an area of 83 acres (34 hectares), is situated in close proximity to the city of Hyderabad. Durgam Cheruvu Max depth 28 feet, water volume 1,679,430 cubic meters(1,361.54 acre. Ft). The body of water in question is commonly referred to as Secret Lake due to its concealed location nestled between the regions of Jubilee Hills and Madhapur. During the reign of the Qutub Shahi dynasty, which spanned from approximately 1518 to 1687, the lake in question played a crucial role as the primary source of potable water for the inhabitants of Golconda fort.

The Durgam Cheruvu Cable Bridge is an extradosed bridge located in the city of Hyderabad. The aforementioned route serves as a connection between Jubilee Hills, Madhapur, and Hitech City.

Entering of effluents both home garbage and industrial into lake. The drainage volume has much the capacity for self-purification. A significant quantity of air particles originating from industrial processes.

The lake receives sediments, trash, and contaminants that have been eroded from surrounding area and are transported into the lake through inflowing water. The topic under consideration is streams. The rising concentration of fish, coupled with the influx of wastewater originating from urban areas and industrial facilities.

The phenomenon has resulted in a swift alteration in the lake's biota. The lake has seen notable transformations in previous years, resulting in increased pollution as a consequence of human actions such as the release of domestic wastewater and the construction of road embankments. Over an extended period, this system has emerged as a paradigmatic framework for doing research on freshwater ecosystems(Fig-1). In 2006, the local pollution control board established sewage treatment plants as a means to address the issue of pollution in the lake. Over the course of time, the factory ceased to operate. In 2022, the Hyderabad Metropolitan Water Supply and Sewerage Board established a distinct sewerage treatment plant (STP) at Durgam Cheruvu, after the approval of the Government of Telangana.[10]

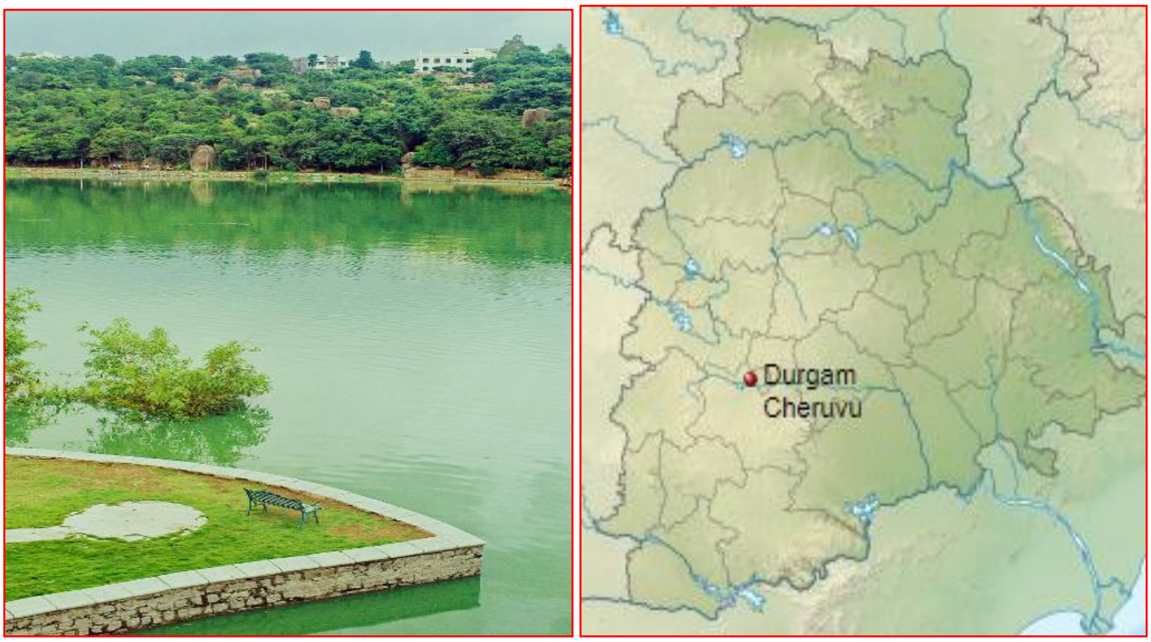

Fig.1 Showing Durgam Cheruvu over view-Map

The process of collecting and treating the samples

Monthly sediment samples were collected over the course of one year, from September 2022 to August 2023. These samples were obtained from four distinct sites inside the lake, specifically designated as S1, S2, S3, and S4. The sample water enclosed within glass containers with a volume of 1000 cm3, which had undergone a thorough cleaning process using a solution consisting of 5% hydrochloric acid (v/v) and 5% nitric acid (v/v).[11] Subsequently, the samples were sent to the laboratory in order to undergo examination.

The selection of sampling locations was based on the dimensions and morphology of the lake. Appropriate measures were implemented to mitigate the risk of cross contamination throughout the process of sample collection. A distinct identification was assigned to each sample in order to accurately represent its source and the date it was collected. The collected samples were promptly kept in a refrigerator set at a temperature of -20ºC within a time frame of 24 hours, until they were ready for analysis.[12]. The aforementioned samples were subjected to air drying at ambient temperature and subsequently passed

through a 2-mm nylon screen in order to eliminate any large particles. For the purpose of analyzing total heavy metals, the powdered samples underwent digestion using a mixture of HClO4, HNO3, and HF in Teflon tubes.[13]
The digested sample was subjected to analysis using inductively coupled plasma atomic absorption spectrometry (ICP/AES).[14] The assessment of quality assurance and control involved the utilization of duplicates, method blanks, and standard reference materials. The lake has been partitioned into four distinct sample locations.[15]. The geographical region surrounding the lake. East, West, North and South regions are Named as S1,S2,S3 and S4 sites.

Heavy Metal Accumulation Status in Ecological Risk Assessment:
The coefficients of heavy metal accumulation in sediments collected from four distinct locations were calculated and utilized to assess the accumulation levels of heavy metals in the sediments at each sampling site. The mathematical expression used to calculate the cumulative coefficient C^i_f in computing is as follows.[16]

$$C^i_f = C^i_m \ / \ C^i_n$$

Where C^i_m is the heavy-metal content in the sediment samples and C^i_n is the pre-industrial background concentration in sediments, in mg/kg. Because pre-industrial reference levels (Pb 70.00 mg/kg, Cd 1.00 mg/kg, As 15.00 mg/kg, Cu 50.00 mg/kg, Zn 175.00 mg/kg, and Cr 90 mg/kg) have been most often used in this field of study, they were used for C^i_f calculations.[17]

III. RESULTS AND DISCUSSION

Heavy metals in sediments of durgam Cheruvu As :S1-2.95,S2-4.08,S3-3.68 S4-3.53,Mean-3.51. Cd values are in S1-2.09,S2-2.39,S3-2.29,S4-2.34,Mean-2.26. Pb value noted as S1 0.25,S2-0.23,S3-0.25,S4-0.20,Mean-0.24. Zn values are S1-1.33,S2-1.02,S3-1.01,S4-0.82,Mean-0.95. Cu values S1-0.81,S2-0.70,S3-0.66,S4-0.65,Mean-0.70 and Cr values are S1-3.71,S2-4.11,S3-4.20,S4-4.31,Mean-4.08(Table-1,Fig -2)

Table 1. C^i_f of heavy metals in sediments collected from Durgam Cheruvu

Stations	**As**	**Cd**	**Pb**	**Zn**	**Cu**	**Cr**
S1	2.95	2.09	0.25	1.33	0.81	3.71
S2	4.08	2.39	0.23	1.02	0.70	4.11
S3	3.68	2.29	0.25	1.01	0.66	4.20
S4	3.53	2.34	0.20	0.82	0.65	4.31
Mean	3.51	2.26	0.24	0.95	0.70	4.08

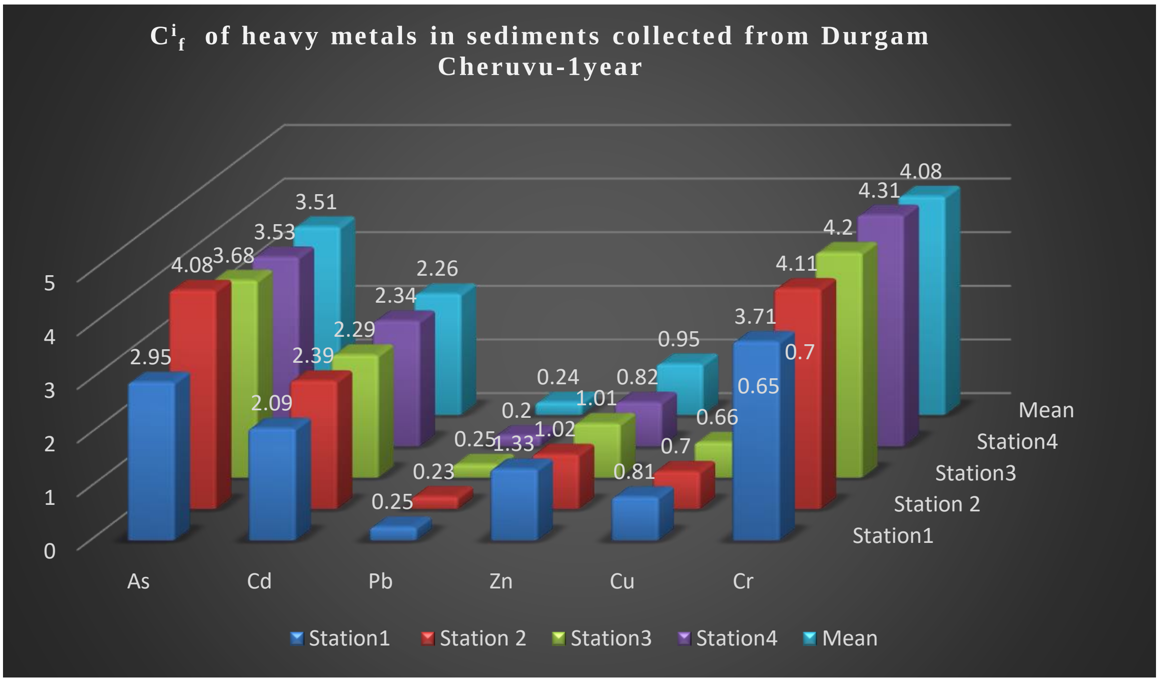

Fig 2. C^i_f of heavy metals in sediments collected from Durgam Cheruvu

Table 2. The Mean Concentration in season-wise from Durgam Cheruvu water samples

Seasons	As	Cd	Pb	Zn	Cu	Cr
Rainy	55.40	2.32	39.81	366.12	190.80	21.08
Winter	54.67	2.14	38.80	374.32	186.23	14.10
Summer	50.62	2.16	27.62	390.23	158.65	18.96

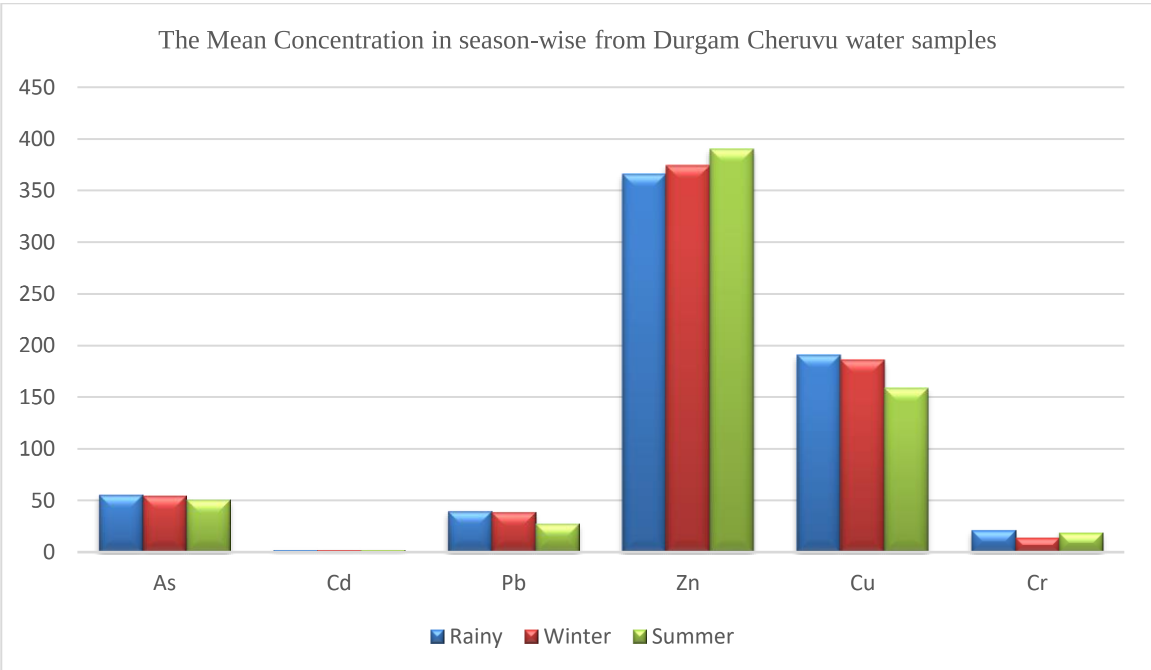

Fig-3. The Mean Concentration in season-wise Graphical data

With the exception of arsenic, which presented a moderate ecological danger to the whole lake, and cadmium, which offered a moderate ecological risk to the entire lake, the heavy metals under analysis in sediments indicated a low ecological risk to the water body.[18]

Changes in heavy metals with the seasons

The fluctuations in concentrations of heavy metals in Durgam Cheruvu are influenced by changes in input and environmental conditions. These variations may lead to modifications in the distribution of elements within particulate matter, potentially resulting in their release into the solution. The 2022 rainy season was characterised by a substantial increase in precipitation, resulting in significant fluvial inflows. The influx of water into the lake, which transports metals originating from industrial waste, has been identified as the primary factor contributing to the elevated levels of various metals throughout the winter season(Table 2,Fig 3).

The fluctuations in the levels of heavy metals in Durgam Cheruvu during the duration of the investigation are shown in Tables 1 and 2.Fig 2 and 3. The seasonal concentration was quantified by calculating the average monthly values within each season.

Based on the prevailing meteorological conditions in Hyderabad. The findings indicate that there are significant variations in the concentrations of heavy metals in Durgam Cheruvu throughout different seasons ($p<0.05$). During the winter season, elevated concentrations of As, Cd, and Cu were observed.[19] (Table,fig-2)Conversely, the greatest concentration of Cr 21.08 mg/kg and Pb 39.81 mg/kg was seen during wet periods, while Zn exhibited its peak concentration during the summer season 390.23 mg/kg. It has been shown that low quantities of Pb27.62 mg/kg summer suggest a limited significance of human activity, but increased Pb concentrations in surface waters indicate anthropogenic influence.[20]

IV. CONCLUSION

The elevated concentrations of Cd and Pb in the water may be ascribed to the geological characteristics of the lake's surrounding environment, fishing practices, and the outflow of sewage.[21] Based on the conducted study, it was found that the second station exhibited the highest accumulation of trace metals, followed by the first station, the third station, and finally the fourth station, which demonstrated the lowest level of pollution. Elevated levels of metal concentrations may be ascribed to the amplification of industrial waste, as well as other anthropogenic activities. The disparity in heavy metal concentrations may be ascribed to the varying loading levels across various geographical areas[22]. The sediments in Durgam Cheruvu were examined for heavy metals, and the findings indicate that there is generally a low ecological risk associated with these metals. However, it is worth noting that cadmium presents a moderate ecological danger to the whole lake, while arsenic poses a moderate ecological risk specifically to Durgam Cheruvu. The analysis of sediment samples collected from four distinct places indicates that the lake has experienced a minor level of heavy metal contamination. The pollution seen in the lake may be linked to human activities in close proximity to the lake, as well as the introduction of pollutants from industrial sources. The aforementioned facts indicate the need for the Pollution Board of Hyderabad to guarantee that sewage disposal facilities in residential complexes are efficient, sufficient, and effectively run. The potential mitigation of industrial pollution may be achieved via adherence to the requirements for wastewater discharge. The preservation of water quality in Lake is contingent upon the elimination of possible future sources of contamination.

Compliance with ethical standards:

Acknowledgments

We are grateful to Prof. Vidyavati, former Vice Chancellor of Kakatiya University, Warangal for her valuable suggestions and constant encouragement.

Disclosure of conflict of interest

The authors (Dr Raju Potharaju, Prof M. Aruna) declare no conflict of interest.

V. REFERENCES

1. Santoyo E, Gutierrez S. Santoyo, Verma Surendra P**.,** Traceanalysis of heavy metals in groundwater samplesbyionchromatography with post-column reaction andultraviolet–visibledetection Journal of Chromatography A, 2000, 884,229241
2. KUCUKSEZGIN F. Distribution of Heavy Metals in the Surficial Sediments of Izmir Bay (Turkey). Toxicol. Environ. Chem. **80**, (3-4), 203, **2001**.
3. El-Sammak, A., 2001. Heavy metal pollution inbottom sediment, Dubai, united Arab emirates.Bull. Environ. Contam. Toxicol., 67: 295-302.DOI: 10.1007/s001280124
4. Pophali, S., Siddiqui, S. and Khan, L. H., (1990). Sources and distribution of heavy metals in the abiotic components of a polluted urban stream in Bhopal. IJEP **10** (8) , 600-603.
5. Prapurna, N. and Shashikanth, K., (2002). Pollution level in Hussain Sagar Lake of Hyderabad-A case study, Pollut. Res., **21**(2) , 187-190
6. M Kishe, and J Machiwa, "Distribution of heavy metals in sedimentsof Mwanza gulf of lake Victoria Tanzania" in Paper presentedat LVEMP conference, Kisumu, Kenya, 2001.
7. Khalifa K. M., Hamil A. M, Al-Houni A. Q. A., Ackacha M. A. Determination of Heavy Metals in Fish Species of the Mediterranean Sea (Libyan coastline) Using Atomic Absorption Spectrometry. International Journal ofPharmTech Research.2010, 2, 1350-1354.
8. Shiraz**,** *Qishlaqi* Iran *Afshin and Moore Farid***.** Statistical Analysis of Accumulation and Sources of Heavy Metals Occurrence inAgricultural Soils of Khoshk River Banks**,** American-Eurasian J. Agric. & Environ. Sci. 2007, 2, 565-573.
9. Singh, S. P., Deepa, P. and Rashmi, S., (2002) Hydrobiological Studies of two ponds of Satna (M.P.), India, Eco. Environ. Cons., **8** (3) , 289-292.
10. K., Venkateshwarlu (28 November 2002). "Threat to Durgam Cheruvu". *The Hindu*. Archived from the original on 23 January 2005. Retrieved 3 October 2010.
11. De, A. K., (2002). Environmental Chemistry, 4th. Ed, New Age International (P) Ltd., New Delhi, 232-272.
12. G Nabulo, HO Origa, GW Nasinyama and D Cole, "Assessmentof Zn, Cu, Pb and Ni contamination in wetland soils and plants inthe Lake Victoria basin" *International Journal of EnvironmentalScience and Technology, vol. 5, No.1, pp.* 65-74, 2008.
13. APHA, (1985). Standard Methods for the examinationof water and waste water. 16th. Ed. *APHA,AWWAWPCF*,Washington, D.C
14. Eaton, A.D. *et al*., 2005. Standard Methods for theExamination of Water and Waste Water. 21th Edn.,American Public Health Association, Washington,ISBN: 0875530478.

15. JM Onyari, "The concentrations of Mn, Fe, Cu, Zn, Cd, Pb insediment and fish from the Winam Gulf of lake Victoria and fishbought from Mombasa town market", MSc. Thesis, University ofNairobi, Nairobi, Kenya, 1985.
16. PM Linnik and IB Zubenko, "Role of bottom sediments in thesecondary pollution of aquatic environments by heavy metal compounds"*Lakes and Reservoir: Research and Management*, vol. 5,pp. 11-21, 2000.
17. Agemian, H. and Chau, A. S. Y., (1975). An atomic absorption method for determination of 20 elements in the lake sediments after acid digestion. Anal. Chem. Acta., **80**, 61-66.
18. Jain, S. and Salman, S., (1995). Heavy metal concentration in highly eutrophic lake sediments and overlying water. Pollut. Res., **14** (4) , 471-476
19. SO Wandiga and JM Onyari, "The concentration of heavy metalsMn, Fe, Cu, Zn, Cd and Pb insediments from Winam Gulf", *KenyanJournal of Science*, vol. 8, pp. 5-18, 1987.
20. Moore, J. W. and Ramamoorthy, S., (1984). HeavyMetals in Natural Waters: Applied Monitoring andImpact Assessment, Springer-Verlag; New York, 28-246.
21. JM Onyari and SO Wandiga, "Distribution of Cr, Pb, Cd, Zn, Feand Mn in Lake Victoria sediment, East Africa", *Bulletin of EnvironmentalContamination and Toxicology*, vol. 42, pp. 807-813,1989.
22. Abbasi, S.A., N. Abbasi and R. Soni, 1998. Heavy Metals in the Environment. 1st Edn., MittalPublications, ISBN: 81-7099-657-0, pp: 314.