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A PRELIMINARY STUDY OF HEAVY METAL POLLUTION IN THE SEDIMENTS OF THE GREATER COLOMBO CANAL SYSTEM OF SRI LANKA

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INTRODUCTION

The heavy metal pollution of aquatic ecosystems by both natural and man-made causes is an important environmental problem. Aquatic systems often act as final receptacles of these metals. The soluble form of metals is more dangerous for life as it is easily transported and more readily available to plants and animals. However, mostly metal cations get bound to sediments, stay in place and become adsorbed and insoluble. Thus, analysis of heavy metals in sediments provides a better picture of the pollution status in an aquatic system. There are many industries discharging effluents consisting heavy metals into the Greater Colombo Canal System. Since comprehensive studies on heavy metal pollution of Greater Colombo Canal System have not been carried out, this study was undertaken as a preliminary survey to find out the extent of heavy metal pollution in the sediments of canal system, to compare the values with U.S. Environmental Protection Agency's (USEPA) maximum permissible limits for sediments and common ranges in soils, and to find out the pollution intensities using Geo-Accumulation Index. These data giving the level of pollution would be useful for policy makers.

METHODOLOGY

Ten sampling stations were selected for the study (Figure.1) representing less polluted, polluted, industrial and residential areas. The selected sites are Beira Lake (East), St. Sebastian canal, Orugodawatta, Buthgamuwa Bridge, Senanayaka Mawatha, Royal Park, Kirimandala Mawatha, Nawala Bridge, Open University of Sri Lanka (OUSL) Bridge and St. Peters Bridge. This order of stations starts near north outlet and goes through a polluted industrial area towards a less polluted residential area bordering east city limits and finally to polluted canal draining to south outlet. Samples were collected twice within the period October 2008 to December 2008, from the bank and corresponding centre of each station using a bottom sampler ensuring equal depth and volume. Samples were preserved by acidifying with 1.5 ml of conc. HNO_3 to lower pH to 2 or below. They were packed air tight in labeled polythene bags and transported to the laboratory. Samples were dried in an oven at 103^0C - 105^0C for 24 hours initially, later 30 minutes at a time until constant weights obtained. Each dried sample was ground to powder and sieved through a fine mesh (62.5μm) and stored separately in plastic bottles at room temperature. Sediments were analysed for heavy metals Cu, Fe, Pb, Mn, Ni and Zn using X-Ray Fluorescence Spectroscopy (XRFS - *X*-MET5000) and volatile Cd and Cr using Flame Atomic Absorption Spectrometry

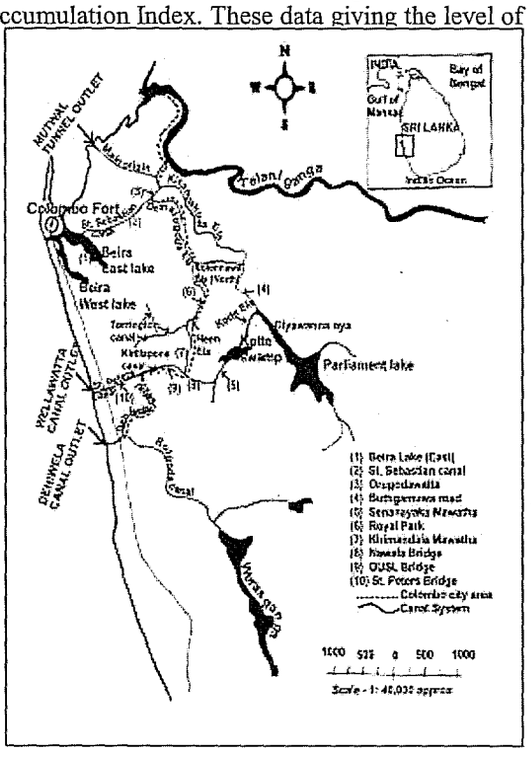


Figure 1: Greater Colombo Canal System illustrating the sampling stations

(FAAS - Spectra BQ20). Nitric acid digestion was done before FAAS analysis by burning samples at 450 ^{0}C for 4 hours and adding 1 ml conc. HNO_3. Digested heterogeneous solutions were filtered and final volumes were made to 100 ml and preserved in air tight plastic bottles. Digested samples were subjected to FAAS to determine the Cd and Cr content. The preserved samples were ground well again with agate mortar and pestle to bring homogeneity. Nearly 0.5 g of finely ground powder was weighed from each sample and made into pellets using a pelletizing press machine. Pellets were subjected to XRFS for the determination of heavy metal concentrations.

Average values of the heavy metal concentrations were plotted in bar charts. The values were also compared with the maximum permissible limits for sediments given by USEPA and common ranges in soils compiled by Balentine & Jung (2001). Sediment Geo-Accumulation Indexes (I_{geo}) for each selected site and all heavy metals tested were calculated using the equation given below. Then, the pollution intensities for all I_{geo} values were found out using Table 1.

$$I_{geo} = \log 2 \, (Cn/1.5 \, Bn)$$

Where: Cn - concentration of targeted metal in sediment sample

Bn - background value (reference value) of targeted metal in an uncontaminated sediment environment in water bodies. These values are based on USEPA's maximum contaminant levels for heavy metal concentrations in sediments.

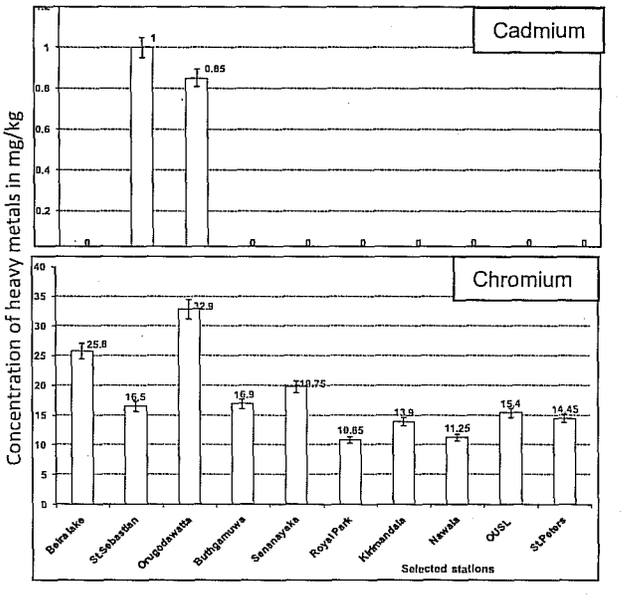
Geo-accumulation index	Class	Pollution Intensity
<0	0	Unpolluted
0-1	1	Least polluted
1-2	2	Moderately polluted
2-3	3	Moderately to strongly polluted
3-4	4	Strongly polluted
4-5	5	Strongly to very strongly polluted
>5	6	Extremely polluted

Table 1: Pollution intensities for different Geo-accumulation indices of heavy metals in sediments (Muller, 1979)

RESULTS AND DISCUSSION

The concentrations of heavy metals found in the sediment samples of selected stations of the Greater Colombo Canal System are shown in Figure 2.

Two patterns of heavy metal distribution could be identified. One type has low concentrations in the less polluted upstream and increasing the concentrations towards downstream. Cr, Cu, Pb and Zn showed this type of distribution pattern. The other type has high concentrations in the inner stations and concentrations decreased towards downstream. Fe, Mn and Ni showed this pattern. Low oxygen contents in more polluted downstream seems causing reduction of Fe, Mn and Ni ions releasing them to water column making these ions unavailable in sediments.



Therefore, in order to find out the actual concentrations of these three heavy metals, the concentrations in water too, need to be determined. Cd was found only in two adjacent stations indicating point source pollution.

When the pollution status of the heavy metals were compared with the maximum permissible limits and common ranges in soils (Table 2), it was evident that the canal system is not polluted by Cr and Ni. High levels of Fe and Mn occur probably due to their high levels in soils or due to pollution occurring in almost every site. Cd pollution occurs at the two stations, St. Sebastian canal and Orugodawatte. Cu and Pb pollution occur towards downstream in the industrial areas. Zn pollution is evident at most of the places of the canal.

When the Geo-accumulation index values were considered to estimate pollution status by heavy metals, it is evident that the canal system is not polluted by Cr or Ni. Although Mn levels were high in all stations, when compare with natural levels, Mn is present in unpolluted or least polluted state. In the two stations mentioned earlier, Cd pollution occurs in moderate levels. Pb pollution occurs downstream in moderate levels. Cu pollution is low at inner stations and high at downstream industrial areas. The canal system is heavily polluted with Fe and Zn.

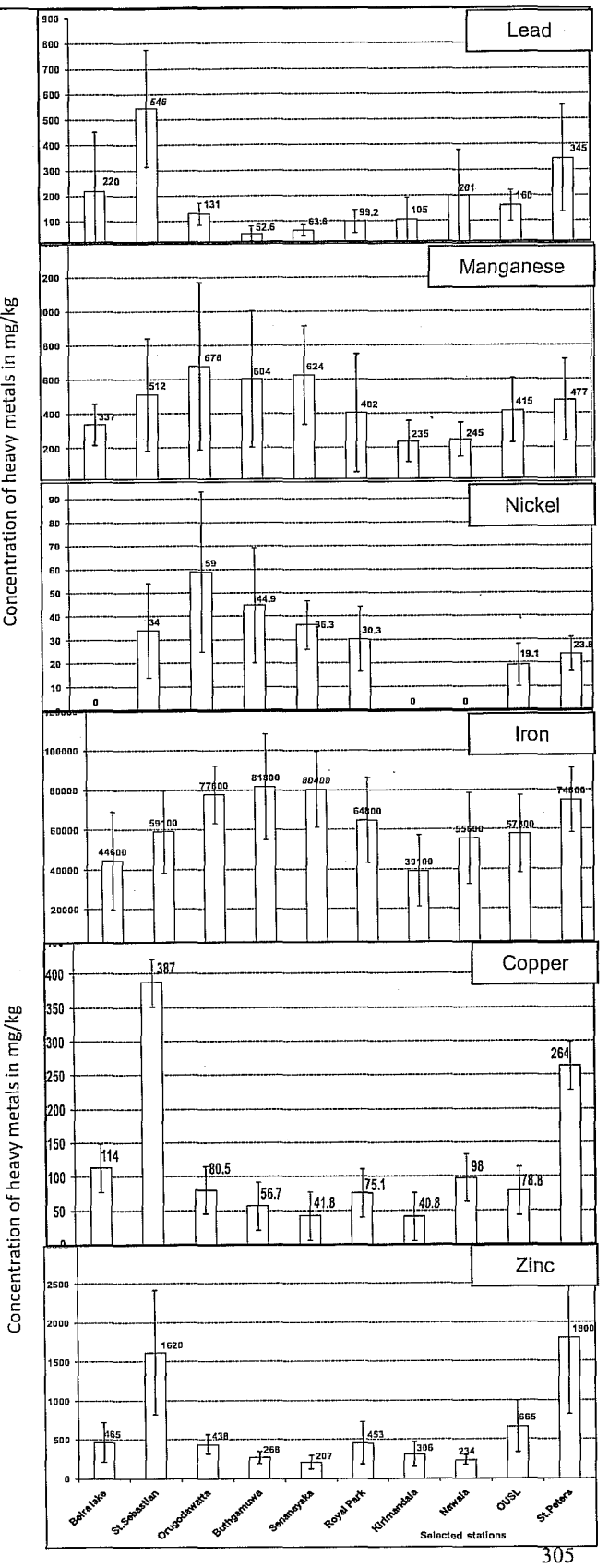


Figure. 2: The concentrations of different heavy metals found in the sediment samples of selected stations of the Greater Colombo Canal System.

Stations	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Mn (mg/kg)	Ni (mg/kg)	Zn (mg /kg)
Beira Lake	0	25.8	114	44600	220	337	0	465
St. Sebastian	1	16.5	387	59100	546	512	34	1620
Orugodawatta	0.85	32.9	80.5	77800	131	678	59	438
Buthgamuwa	0	16.9	56.7	81800	52.6	604	44.9	268
Senanayaka	0	19.75	41.8	80400	63.6	624	36.3	207
Royal Park	0	10.85	75.1	64800	99.2	402	30.3	453
Kirimandala	0	13.9	40.8	39100	105	235	0	306
Nawala	0	11.25	98	55600	201	245	0	234
OUSL	0	15.4	78.8	57800	160	415	19.1	665
St.Peters	0	14.45	264	74800	345	477	23.8	1800
USEPA maximum permissible limits for sediments		< 25	< 25	< 17,000	< 40	< 300	<75	< 90
Common ranges in soils	**0.01 – 0.7**	**1 - 1000**	**2 – 100**	**7000 – 50000**	**2 – 200**	**20 – 3000**	**5 – 500**	**10 – 300**

Table 2: Mean values of sediment heavy metals with maximum permissible limits and common ranges in soils

Selected Stations	Pollution status of heavy metals							
	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Zn
Beira Lake	U	U	M	L	M	U	U	M
St. Sebastian canal	M	U	S	M	S	L	U	S
Orugodawatta	M	U	M	M	M	L	U	M
Buthgamuwa road	U	U	L	M	U	L	U	L
Senanayaka Mawatha	U	U	L	M	L	L	U	L
Royal Park	U	U	M	M	L	U	U	M
Kirimandala Mawatha	U	U	L	L	L	U	U	M
Nawala Bridge	U	U	M	M	M	U	U	L
OUSL bridge	U	U	M	M	M	U	U	M.S
St. Peters Bridge	U	U	M.S	M	M.S	L	U	S

U- Unpolluted
L - Least polluted
M - Moderately polluted
M.S - Moderately to strongly polluted
S - Strongly polluted
S.V - Strongly to very strongly polluted

Table 3: Pollution status of selected stations of Greater Colombo Canal System in terms of sediment heavy metals

CONCLUSIONS

Of the 8 metal studied, Cr, Mn and Ni are not present in polluted levels in this canal system. Cd pollution occurs in moderate levels at two stations only. The three heavy metals; Pb, Cu and Zn show downstream concentration. This accumulation is not visible in Fe probably due to reduction into more soluble ferrous compounds making ferric compounds unavailable in sediments. A similar phenomenon may occur in Mn and Ni as these metals behave similar to Fe.

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