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# METAL POLLUTION OF RIVER MSIMBAZI, TANZANIA

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The Msimbazi River in Dar es Salaam is polluted with industrial, urban and agricultural waste waters. A preliminary investigation on the extent of metal pollution (Hg, Cr, Cu, Zn, Fe, Ni, Cd, Mn, Al) was made from samples of sediments and biological indicators. The metal concentrations were in general low, but some of our results indicated industrial pollution.

## Introduction

In many tropical countries there has been a rapid industrialization without a corresponding legislation and control of environmental effects. The knowledge of the extent of environmental pollution in most of the developing nations is very limited.

Tanzania has a few industrial centers one of which is the Dar es Salaam area. As this area is also densely populated, the environmental pollution might have direct influence on the public health. River Msimbazi flows through the Dar es Salaam industrial area. Dar es Salaam, the capital city of Tanzania, is a fast growing city. Its present population is estimated at two million, a growth from one million in 1980. The Msimbazi river basin is one of the densely populated areas of Dar es Salaam because of the basin is a major industrial area and many people have moved into it seeking jobs. The area is also a significant agricultural zone. Vegetables (tomatoes, cabbage, eggplant, spinach, etc.), fruits (oranges, pineapples, etc.) and even sustenance crops (sugarcane, cassava, bananas) are raised in the basin using river water for irrigation.

The Msimbazi basin is characterized by great amounts of industrial wastes. At the Tabata point, for example, the average sewage flow rate from 24,000 residents (1984) was 63 $m^3/h$ (with a peak of 221 $m^3/h$). A bit further, the domestic sewage is joined by the industrial effluents. This raises the flow rate up to six times — 378 $m^3/h$ (peak 783 $m^3/h$). At another point (south of the Msimbazi river just before it enters the ocean) the average sewage flow from a mere 2,500 inhabitants (1984) was 8.6 $m^3/h$ (peak 35 $m^3/h$), but with industrial effluents included, this rises up to 256 $m^3/h$ (peak 606 $m^3/h$) — an 18–30 fold increase in flow volume.

In view of the above observations and in light of the already expressed government fear that the Msimbazi basin is grossly polluted with industrial effluents, the newly formed National Environment Management Council has embarked on assessing the extent of the pollution in the basin river water, sediments and aquatic plants. This study is aimed at fostering such efforts.

## Study Area

Msimbazi River is a small — about 35 km long — river running through the city of Dar es Salaam, E. Tanzania. The catchment area is approximately 300 $km^2$ and it has three tributaries: Sinza, Ubungo and Luhanga (Fig. 1). The river flows through the Dar es Salaam industrial area and it is polluted from industrial, urban and agricultural sources. The most important pollutant sources are shown in Fig. 1.

Work on the assessment of industrial pollution in this basin is very scanty. The only known work is by Lann and Mbaggi (1986), in which they present elementary analyses of some physical parameters in various parts of the river. The results show that some sections are grossly polluted. The dissolved oxygen was in some parts of the river as low as 0.5 mg/l, the conductivity

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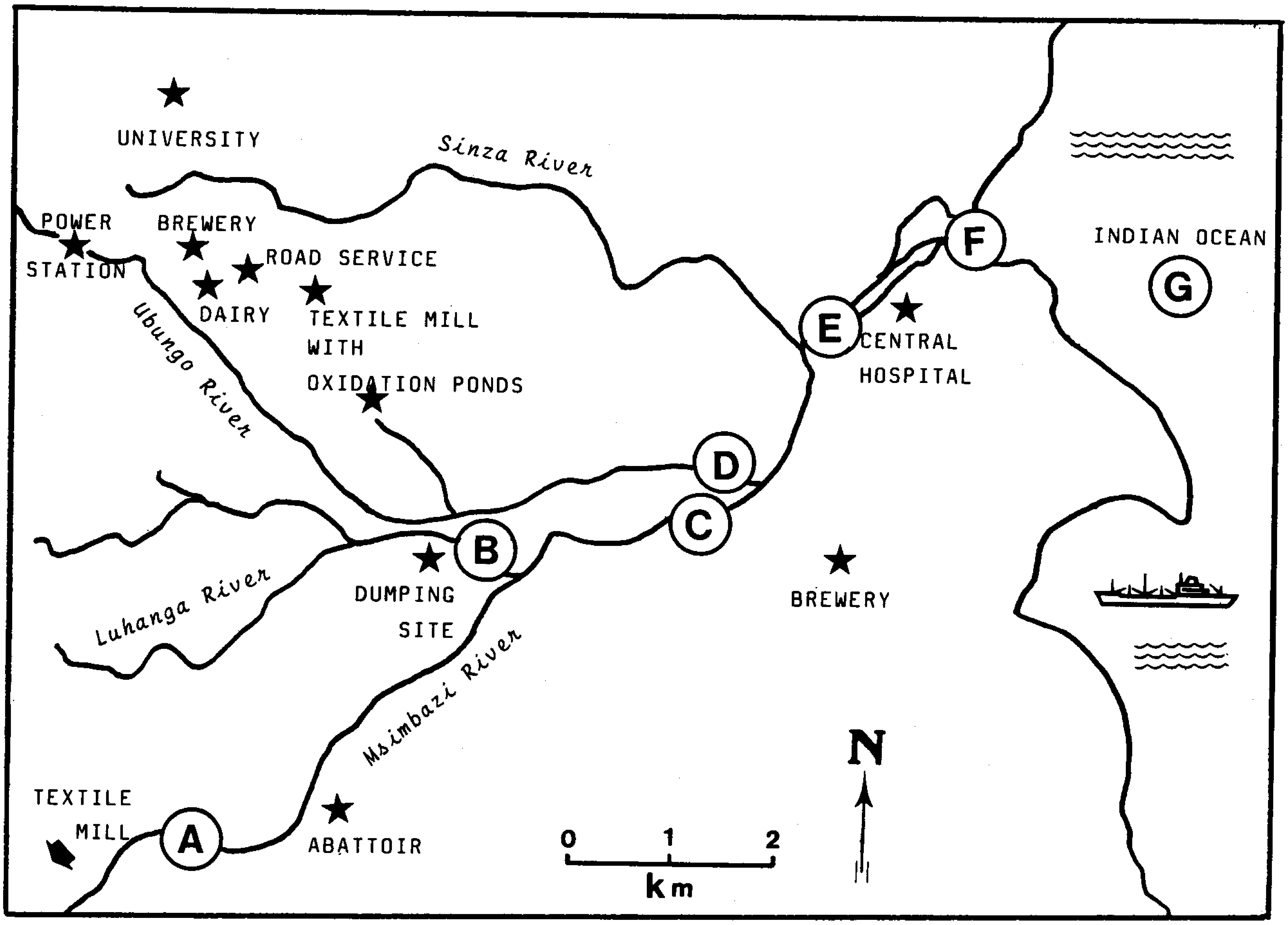


Fig. 1. The catchment area of River Msimbazi, city of Dar es Salaam, Tanzania. Some potential pollution sources are indicated with asterisks. The sampling sites are indicated A–G.

as high as 28 mS/cm, pH as high as 10 and $BOD_5$ so high as to indicate nonexistence of life.

## Material and Methods

The sampling was carried out in December 1986 from six sites along the river. Samples of littoral and aquatic plants, sediments and aquatic animals were collected, oven-dried in +45 °C, homogenized and analyzed for their metal contents at the University of Helsinki.

*Mercury analysis*

0.5–1 g of homogenized sample was digested in 10 ml of $H_2SO_4$ + $HNO_3$ (4:1) for four hours in +85 °C. After oxidation with $KMnO_4$, $NH_4OHCl$ and $SnCl_2$ were added. The amount of Hg was measured using the cold vapour AAS technique (Perkin-Elmer Coleman MAS-50). *Pro analysi* grade reagents from Merck Ltd. were used. The instrument is routinely calibrated by using blanks and standard $HgCl_2$ solutions. The method has been intercalibrated with good result by using NBS standard (Pine Needles No. 1575).

*Analysis of other metals*

0.5–1 g of animal samples were digested in 105 °C by conc. $HNO_3$ overnight. $H_2O_2$ was then added, and the mixture boiled for six hours. 0.5–1.5 g of plant or sediment samples were dry ashed in oven at +460 °C. The ash was digested in 5 ml conc. HCl and boiled for one hour. The solutions were filtered and diluted to 25 ml. The instrument was calibrated using blanks (distilled water + reagents) and 7–10 concentrations of each metal standard solution. The calibration was repeated after every 10 determinations. The metal contents were measured using flame AAS (Perkin-Elmer 360). *Pro analysi* grade reagents from Merck Ltd. were used. The method has been intercalibrated with good result by using NBS standards (Pine Needles No. 1575 and Bovine Liver No. 1577A).

## Results and Discussion

There was in general only moderate variations between the metal contents at different sampling sites (Table 1). However, the samples from Luhanga River and the upper part of Msimbazi River (A and B) usually contained less metals than samples collected further downstreams (C, D and E). A comparison with existing data shows that the metal contents in the River Msimbazi ecosystem in average are at a normal level (Table 2).

Table 1. Metal contents (mg/kg dry weight) of environmental samples from River Msimbazi, Dar es Salaam, Tanzania.

| Site | Sample | Hg | Cr | Cu | Zn | Fe | Ni | Cd | Mn | Al |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sediments | | | | | | | |
| A | sediment | 0.03 | 1.4 | 1.9 | 26 | 880 | 1.1 | 0.2 | 31 | 810 |
| B | sediment | 0.05 | 6.8 | 1.3 | 10 | 2700 | 2.9 | 0.1 | 160 | 4300 |
| C | sediment with shells | 0.25 | 27 | 52 | 360 | 6200 | 24 | 2.7 | 390 | 5300 |
| D | sediment | 0.26 | 13 | 26 | 91 | 37 | 6.3 | 0.4 | 32 | 5900 |
| E | sediment | 0.11 | 24 | 12 | 49 | 8600 | 17 | 1.6 | 150 | 15000 |
| F | sediment | 0.03 | 2.7 | 1.6 | 4.7 | 630 | 6.6 | 0.8 | 56 | 530 |
| F | rock with shells | 0.02 | 7.5 | 4.5 | 11 | 1400 | 3.3 | 0.5 | 110 | 2800 |
| mean | | 0.11 | 2.7 | 1.5 | 79 | 2900 | 8.7 | 0.9 | 130 | 4900 |
| | | | Littoral and aquatic plants | | | | | | | |
| A | Colocasia esculenta (6) | 0.37 | 7.3 | 19 | 260 | 3100 | 6.7 | 0.8 | 560 | 4100 |
| B | grass (8) | 0.21 | 4.1 | 7.6 | 35 | 1400 | 2.7 | 0.1 | 220 | 2800 |
| D | Trianthema portulacastrum (10) | 0.15 | 3.2 | 7.3 | 33 | 84 | 2.6 | 0.4 | 140 | 1200 |
| F | Crotalaria laburnoides (1a) | 1.2 | 0.8 | 9.0 | 32 | 350 | 2.3 | 0.4 | 72 | 280 |
| F | Ipomoea pese-caprae (1b) | 0.32 | 0.2 | 11 | 10 | 120 | 2.1 | 0.4 | 85 | 98 |
| F | moss (2) | 0.17 | 17 | 9.0 | 44 | 5500 | 10 | 0.9 | 460 | 6600 |
| mean | | 0.40 | 5.4 | 10 | 69 | 1800 | 4.4 | 0.5 | 260 | 2500 |
| | | | Aquatic animals | | | | | | | |
| E | Crustacea: crab, shells 12a | 0.04 | 1.8 | 160 | 420 | 620 | 13 | 0.3 | 110 | 40 |
| E | Tenebralia palustris 12b soft parts | 0.10 | 14 | 33 | 19 | 79 | 45 | 0.1 | 27 | 200 |
| E | Crustacea: crab (13) shells | 0.04 | 5.7 | 41 | 97 | 500 | 17 | | 24 | 110 |
| E | Crassostrea cucullata, shells (14) | 0.03 | 5.9 | 5.5 | 5.5 | 83 | 21 | | 100 | 100 |
| F | Lucinidae spp., shells (3a) | 0.01 | 6.2 | 5.2 | 3.7 | 80 | 21 | | 9.9 | |
| F | Terebra sp., shells (3) | 0.02 | 17 | 16 | 0.6 | 78 | | | 13 | 170 |
| | Crustacea: shrimps (16 market) | 0.04 | 1.3 | 67 | 62 | 280 | 6.1 | | 21 | |
| mean (shells) | | 0.03 | 7.3 | 46 | 105 | 270 | 18 | | 51 | 110 |

The mercury content in all samples were generally low and comparable with data from the Niger delta (Kakulu and Osibanjo 1986) from Lake Nakuru, Kenya (Greichus *et al.*, 1978a), from Lake McIlwaine (Greichus *et al.* 1978b) and from two South African dams (Greichus *et al.*, 1977; Table 2). The mean mercury content of some preindustrial Swedish lake sediments has been calculated to 0.09 mg/kg dry wt (Håkansson, 1984). Slightly elevated concentrations were found in sediments C, D and E and in *Crotalaria laburnoides* from site F. The mercury content of contaminated soils near a battery factory 8 km SW of the centre of Dar es Salaam ranged 0.025–470 mg/kg (Semu *et al.*, 1986).

The chromium level in the sediments is rather low compared with sediments from other rivers. Slightly elevated values were found from the sites C, D and E. The chromium content in moss from site F is significantly higher than in the other plants analyzed and also higher than reported for terrestrial mosses (Scandinavian background value below 1 mg/kg; Rühling *et al.*, 1987).

The mean copper content of sediment is near background values from other countries (Table 2). The values from sediments C, D and E were clearly elevated compared to the other concentrations. There was a wide variation in the sediment zinc contents with a maximum at site C. The mean zinc content of the sediments did not indicate any significant pollution source of this metal. The concentration was quite high in the plant *Colocasia*.

Also, the iron contents showed a wide variation in both sediments and plants. The mean is significantly higher than in preindustrial Swedish lake sediments, which probably is more due to edafic factors than to pollution.

The mean nickel and cadmium contents of the sediments are at the same level as reported elsewhere except a slight increase for cadmium at site C. The values for plants and animals also seem to be normal. The mean manganese content of the sediments is much higher than the value from Sweden but at the same level as in other tropical countries.

There was a wide variation in the aluminium contents of both sediment and biological samples. An especially high value was found in the sediment from site E, but as in the case of iron this is not necessarily caused by pollution. The high aluminium content of tropical soils is reflected in the plant aluminium concentrations, which are higher than in Finland.

Table 2. Metal contents (mg/kg dry weight) of some environmental samples. References: 1: present study, 2: Seenayya & Prahalad, 1987, 3: Kakulu & Osibanjo, 1986, 4: Håkansson, 1984, 5: Greichus *et al.*, 1977, 6: Greichus *et al.*, 1978b, 7: Greichus *et al.*, 1978a, 8: Deelstra *et al.*, 1976, 9: Kouadio & Trefry, 1987, 10: Sridhar, 1986, 11: El Nabaui, 1987, 12: Groot *et al.*, 1971, 13: Houtman, 1973, 14: Nikanorov *et al.*, 1985, 15: Salanki *et al.*, 1982.

| sediment | Hg | Cr | Cu | Zn | Fe | Ni | Cd | Mn | Al |
|---|---|---|---|---|---|---|---|---|---|
| Tanzania[1] | 0.11 | 12 | 14 | 79 | 2900 | 8.7 | 0.9 | 130 | 4900 |
| Nigeria[3] | 0.02–1.5 | | | | | | | | |
| South Africa[5] | 0.06–0.6 | | 15–41 | 49–260 | | 0.2–0.9 | 340–680 | | |
| Rhodesia[6] | 0.28 | | 38 | 100 | | | 0.4 | 350 | |
| Kenya[7] | <0.05 | | 6.2 | 140 | | | 0.3 | 550 | |
| Ivory Coast[9] | 0.07 | | 18.7 | 150 | | 30.8 | | 373 | |
| Thailand[12] | | | 100 | 50 | 30 | | | | |
| Indonesia[13] | | 20 | 40 | 37 | 80 | | | | |
| India[2] | | | 121 | | | | | 912 | |
| Sweden[4] | | | | | | | | | |
| natural backgr. | 0.09 | 23 | 21.5 | 210 | 107 | 14.2 | 0.83 | 6.4 | |
| surficial 0–1 cm | 1.1 | 490 | 100 | 1550 | | | 4.55 | | |
| **littoral & aquatic plants** | **Hg** | **Cr** | **Cu** | **Zn** | **Fe** | **Ni** | **Cd** | **Mn** | **Al** |
| Tanzania[1] | 0.40 | 5.4 | 10 | 69 | 1800 | 4.4 | 0.5 | 260 | 2500 |
| South Africa[5] | 0.7 | | 12 | 42 | | | 0.23 | 840 | |
| Nigeria[10] | | | | | | | | | |
| polluted lake | | 6.4 | 17.5 | 210 | 11000 | 8.8 | 0.88 | 7200 | |
| **aquatic animals** | **Hg** | **Cr** | **Cu** | **Zn** | **Fe** | **Ni** | **Cd** | **Mn** | **Al** |
| Tanzania[1] | 0.03 | 7.3 | 46 | 105 | 272 | 18 | | 51 | 110 |
| Bivalvia USSR[14] | | | | | | | | | |
| soft parts: | 0.04–1.4 | 0.10–1.5 | 2.9–130 | 26–890 | 310–8200 | | | 29–1100 | |
| shells: | | 2.5–37 | 1.8–26 | 120–1100 | | | | | |
| Crustacea USSR:[14] | | | | | | | | | |
| | 0.1–1.3 | 0.1–3.4 | 7.5–240 | 31–870 | 96–5200 | | | 59–120 | |
| Bivalvia, Lake Balaton[15] | | | | | | | | | |
| mantle | 0.02–3.6 | | 1.1–23 | 7.1–380 | | | 1.0–4.6 | | |
| foot & muscle | 0.05–2.8 | | 1.3–13 | 13–320 | | | 0.94–6.0 | | |

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## References

Deelstra, H., Power, J. L., and Kenner, C. T. (1976) Chlorinated hydrocarbon residues in the fish of lake Tanganyika, *Bull. Environ. Contam. Toxicol.* **15**, 689–698.

El Nabaui, A., Heinzov B., and Kruse, H. (1987) As, Cd, Cu, Pb, Hg, and Zn in fish from the Alexandria region, Egypt, *Bull. Environ. Contam. Toxicol.* **39**, 889–897.

Greichus, Y. A., Greichus, A., Ammann, B. D., and Hopcraft, J. (1978a) Insecticides, polychlorinated biphenyls and metals in African lake ecosystems III. Lake Nakuru, Kenya, *Bull. Environ. Contam. Toxicol.* **19**, 454–461.

Greichus, Y. A., Greichus, A., Draayer, H. A., and Marshall, B. (1978b) Insecticides, polychlorinated biphenyls and metals in African lake ecosystems II. Lake McIlwaine, Rhodesia, *Bull. Environ. Contam. Toxicol.* **19**, 444–453.

Greichus, Y. A., Greichus, A., Ammann, B. D., Call, D. J., Hamman, D. C. D., and Pott, R. M. (1977) Insecticides, polychlorinated biphenyls and metals in African lake ecosystems I. Hartbeespoort Dam, Transvaal and Voëlvlei Dam, Cape Province, Republic of South Africa, *Arch. Environ. Contam. Toxcicol.* **6**, 371–383.

Groot, A. J. de, Zschuppe, K. H., Bruin, M. de, Houtman, J. P. W., and Amin, Singgih (1968) Activation analysis applied to sediments from various river deltas, Proc. 1968 Int. Conf. Modern Trends in Activation Analysis, Gaithersburg (USA), pp. 62–71.

Houtman, J. P. W. (1973) Trace element behaviour in soil of some Indonesian sawahs and in sludge of an Indonesian river, Delft Progress Report 1A, 5–16.

Håkansson, L. (1984) Metals in fish and sediments from the river Kolbäcksån water system, Sweden, *Arch. Hydrobiol.* **101**, 373–400.

Kakulu, S. E. and Osibanjo, O. (1986) A baseline study of mercury in fish and sediments in the Niger dalta area of Nigeria, *Environ. Pollut.* **B 11**, 315–322.

Kouadio, I. and Trefry, J. H. (1987) Sediment trace metal concentration in the Ivory coast, west Africa, *Water Air Soil Pollut.* **32**, 145–154.

Lann, H. and Mbaggi, Y. (1986) The River Msimbazi, Dar es Salaam. Investigations on the water-quality and discharges of waste-water into the river and its tributaries, 1984–1986. Publ. Min. Lands Water Housing Urban Development, Dar es Salaam, Tanzania.

Nikanorov, A. M., Zhulidov, A. V., and Pokarzevskij, A. D. (1985) Biomonitoring tjazelyh metalllov v presnovodnyh. Leningrad gidrometeoizdat, 142 p.

Rühling, Å., Rasmussen, L., Pilegaard, K., Mäkinen, A., and Steinnes, E. (1987) Survey of atmospheric heavy metal deposition in the Nordic countries 1985 monitored by moss analyses. Nordic Council of Ministers, NORD 1987, 21, 44 pp.

Salanki, J., Katalin, V.-B., Erzsebet, B. (1982) Heavy metals in animals of Lake Balaton, *Water Res.* **16**, 1147–1152.

Seenayya, G. and Prahalad, A. K. (1987) In situ compartmentation and biomagnification of chromium and manganese in industrially polluted Husainsagar Lake, Hyderabad, India, *Water Air Soil Pollut.* **35**, 233–239.

Semu, E., Singh, B. R., and Selmer-Olsen, A. R. (1986) Mercury pollution of effluent, air, and soil near a battery factory in Tanzania, *Water Air Soil Pollut.* **27**, 141–146.

Sridhar, M. K. C. (1986) Trace element composition of Pistia stratiotes L. in a polluted lake in Nigeria, *Hydrobiol.* **131**, 273–276.