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Pesticides and Metals in Lake Jipe, N. Tanzania

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Abstract: Pesticides and heavy metals were determined from water, sediments and aquatic organisms in Lake Jipe, northern Tanzania. The lake water was slightly alkaline with variable conductivity. With the exception of two sampling sites, the water contained enough dissolved oxygen. Low levels of organochlorine pesticides (DDE, Dieldrin, Lindane and Endosulfan) were detected in water. In the sediments, the concentrations were up to 40 times higher. The metal (Al, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Hg) concentrations of sediments were low. Some biological samples including aquatic plants and fish were also analysed.

INTRODUCTION

The use of pesticides in agriculture and the industrialization in developing countries has increased the presence of toxic chemicals in the environment. Improper use of insecticides and other chemicals may cause even extensive pollution of air, soils and biota (e.g. Müller 1990). Tanzania, like many other developing countries, has scanty information on the pollution level in the environment.

The aim of this study was to evaluate the extent of pesticides and metal pollution in water and sediments of Lake Jipe, northern Tanzania. The study also includes determination of some metals in samples of fish, snails and aquatic plants.

STUDY AREA

Lake Jipe is located in the northern part of Tanzania on the border between Tanzania and Kenya (3°37' – 3°33' S and 37°44' – 37°47' E; Fig. 1). The lake covers an area of 16 km^2. The lake receives water mostly from Lumi and Taroha rivers and

surface runoff from the North Pare mountains. River Ruvu flowing to the north is the only outlet from the lake. The water level in the lake closely follows the Lumi River discharge which is probably a more important input than rainfall.

The lake is exposed to pesticides through water runoff from neighbouring areas with intensive agricultural activities. Crops grown in these areas include coffee, beans and maize, for which substantial amounts of pesticides are used. The lake also receives inputs from River Lumi in the north and River Taroha in the south which may both contain pollutants such as heavy metals and pesticides from the basins through which they flow.

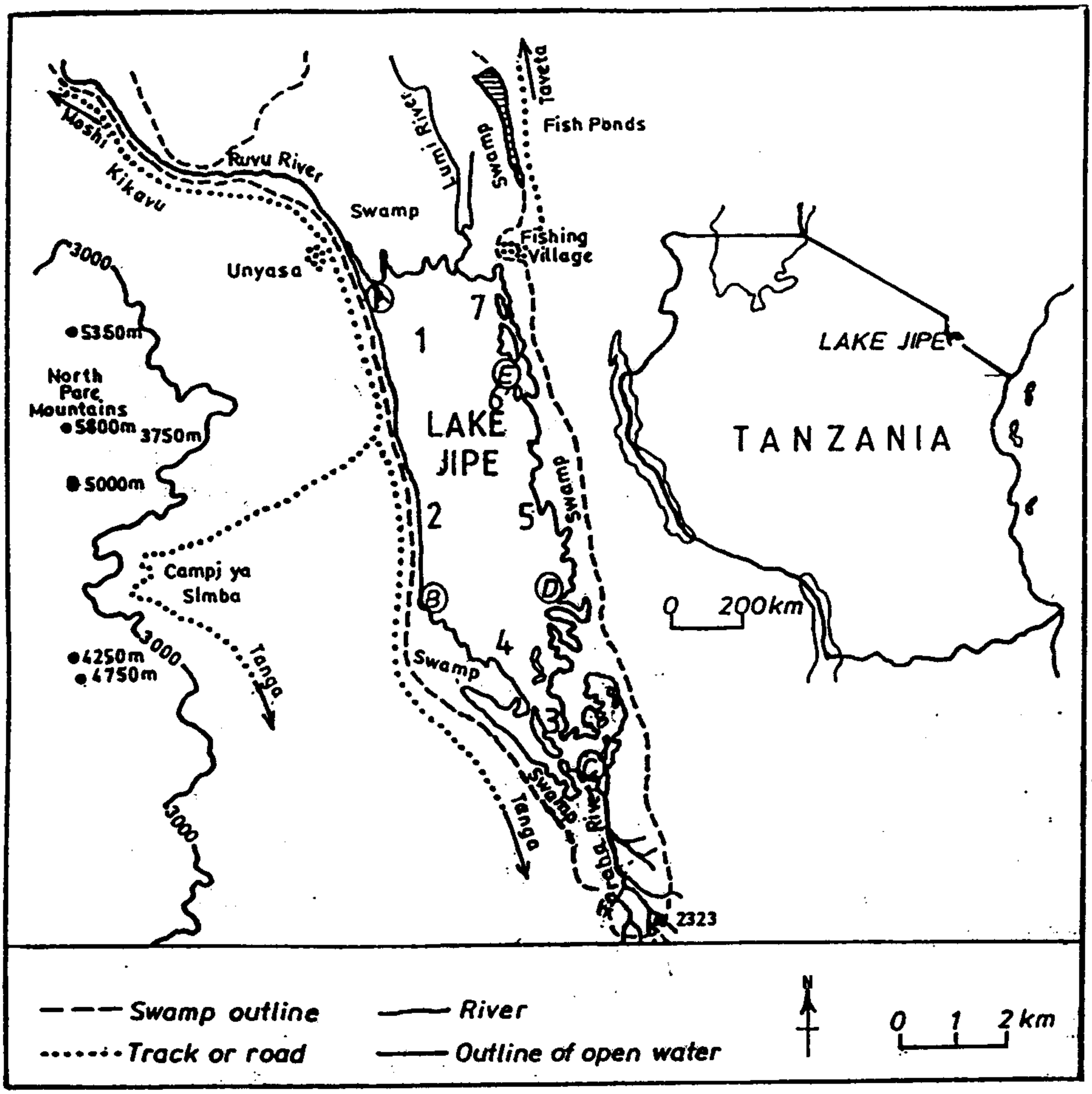

Fig. 1. Sampling sites in Lake Jipe: 1–7 (water samples) and A-E (biological samples).

Emergent plants growing in shallow water are the most prominent vegetation around the lake. The most dominant plant species around the lake and in swampy areas nearby is *Typha domingensis*. This weed has been interfering very much with fishing activities in the lake for many years. There is very little work done on the chemical analysis of the lake water. So far no study has been carried out on the pollution level of Lake Jipe. Fishing is a major activity around the lake. In 1981 fish production was approximately 1440 tons. The lake can support about 3 000 fishermen (Gaudet 1976).

MATERIAL AND METHODS

Samples were collected in 1990 from various sites in the lake: water samples from sites 1–7 and biological samples from sites A-E (Fig. 1). Samples for metal analysis were dried in Arusha and sent the University of Helsinki for AAS determination.

Physico-chemical analyses

pH, dissolved oxygen (DO) and conductivity were determined *in situ* by using a portable, multipurpose meter (Hanna Instruments Ltd).

Pesticides

Animal and plant samples were milled and extracted by soxhlet with a solvent mixture hexane-acetone-diethyl ether-petroleum ether (bpt 40–60) 2,5:5,5:1,0:9 (v/v/v/v) for six hours. A column was made by pouring a 6 cm layer of aluminium oxide (previously heated to 700 °C for 8 hours and after cooling deactivated by adding 5% of water) to a pasteur pipette. The sample extracts were rinsed into the column and chlorohydrocarbon fraction eluted 10 ml hexane. The hexane eluate was evaporated with nitrogen gas to 1 ml.

For water samples 1000 ml was passed through a C-18 column (6 ml) which was pre-conditioned using one volume of both methyl hydroxide and distilled water. After passing the sample, the column was washed with 1 ml of distilled water and dried in vacuum for 10 min. The chlorohydrocarbon fraction was eluted with hexane. The hexane eluate was evaporated with nitrogen gas to 1 ml volume.

The clean extracts were injected into a GC (Hewlett Packard) equipped with an EC detector and capillary column cross-linked methyl silicon. Organochlorine pesticide residues were identified with reference standards of DDT, DDE, Aldrin, Dieldrin, α-Endosulfan and β-Endosulfan.

Metals

The homogenized samples were dried overnight at 40 °C for Hg analyses and at 105 °C for other metals. After drying, those plant samples to be analysed by flame absorption spectrophotometer for analyses of metals other than Hg were weighed to 1 g, dry-ashed for 4 h at 460 °C, dissolved in 10 ml concentrated HCl, evaporated to 5 ml and diluted to 50 ml with distilled water. For the determination of Al, NaCl was added to the sample solutions to make concentration at least 500 µg/ml of Na^+.

Those plant samples to be analysed by graphite furnace AAS technique were digested according to the following procedure: 0,5 g subsamples were weighed and digested in 5 ml 65% extremely pure nitric acid for 1 h at 75 °C, 4 h at 105 °C and 4 h at 170 °C. The wet ashed samples were filtered and diluted to 25 ml with distilled water.

The animal samples were weighed to 0. 5 g or less and heated in 5 ml of suprapure HN03 for 2 h at 50°C, and after that for 16–18 h at 110°C. Five millilitres of H_2O_2 was added, and the samples were heated for an additional 6 h. The samples were filtered and diluted with distilled water to 25 ml. Finally, the sample solutions were analysed for their metal concentrations by a flame atomic absorption spectrophotometer (Varian SpectrAA-40) or by graphite furnace AAS (Varian SpectrAA 40 equipped with GTA-96).

For Hg-analyses the plant and animal samples (dried at 40 °C) were digested in 5 ml of suprapure $HNO_3 - H_2SO_4$ -mixture (1:4) for 4 h at 85 °C. Then the samples were diluted to 100 ml by distilled water and analysed by a cold vapour atomic absorption spectrophotometer (Perkin-Elmer MAS-50).

RESULTS AND DISCUSSION

The pH and conductivity of lake water (Table 1) are acceptably good for many aquatic organisms. The level of dissolved oxygen is also fairly good even at the north-eastern sites (6 and 7). Here the oxygen level is lowest because of the slowly moving swampy waters and the nearby intensive fishing activities including discharge of oxygen – consuming human and fish wastes.

Small amounts (<1 µg/kg) of organochlorine pesticides were detected from water samples (Table 1). The concentrations showed little difference at different sites. The concentrations are somewhat higher than those reported from Lake Victoria, where only traces of DDE and Endosulfan were detected (Stephens 1985). In Lake McIlwaine, Zimbabwe, concentrations of total DDT in the range of < 0,01–0,70 µg/kg have been reported (Mhlanga & Madziva 1990).

In the sediments, the concentrations are clearly higher than in the water (Table 2). However, they are much lower than those obtained from the Nyumba ya Mungu Dam (Paasivirta *et al.* 1988) and those from Lake McIlwaine (Mhlanga &

Table 1. Quality of water samples

Site	pH	Conduct mS/cm	Oxygen mg/1	DDE µg/kg	Dieldrin µg/kg	Lindane µg/kg	Endosulfan µg/kg
1	7.4	2.0	7.6	0.1	0.3	0.8	0.1
2	7.5	12	7.0	0.2	0.5	0.0	0.4
3	8.1	0.6	7.0	0.3	0.2	0.2	0.4
4	7.5	0.3	7.7	0.4	0.8	0.0	0.3
5	8.7	0.6	8.1	0.3	0.6	0.1	0.1
6	7.3	7.8	3.8	0.2	0.9	0.1	0.1
7	7.4	0.15	3.1	0.3	0.3	0.4	0.3

Madziva 1990). At site B the Lindane concentration was rather high whereas no Lindane was detected at sites A and C.

Aluminium concentrations showed high variation in biological samples and sediments. The same was found in River Msimbazi (Ak'habuhaya & Lodenius 1988). In fish and snails aluminium concentrations are lower than in plants, especially those in plant roots.

The chromium concentrations in sediments are very high at sites B and C, but rather low at site A. The same applies to Ni, Fe, Mn, Cu and Zn. Snails at sites A and B showed high Cr concentrations in comparison to other organisms.

In plants the concentrations of Mn were higher than in snails and fish (Table 3). For Fe concentrations the variations were high in both plants, animals and sediments. The Cu concentrations were generally low in biological samples. The zinc level was low in sediments, animals and plants. Similar results were obtained from Lake Tanganyika (Benemaryia *et al.* 1991).

Table 2. Concentrations of pesticides (µg/kg) and metals (µg/g) in sediments of Lake Jipe.

Site	DDE	Dieldrin	Lindane	Endo-sulfan	Al	Cr	Mn	Fe	Ni	Cu	Zn	Cd	Hg
A	2.6	3.6	0.0	2.2	3100	4,1	190	2400	3.7	2.9	6.8	0.02	0.005
B	1.4	3.1	4.3	1.1	30000	30	570	17000	21	22	25	0.05	0.012
C	2.4	2.3	0.0	1.4	28000	31	520	17000	22	25	24	0.05	0.016

Table 3. Metal concentrations of biological samples (µg/g dry weight, Cd&Hg µg/kg dry weight).

Sample	Al	Cr	Mn	Fe	Ni	Cu	Zn	Cd	Hg
Snail A, muscle	280	22	220	230	22	75	36	87	31
Snail A, shell	480	44	200	330	20	21	15	33	19
Snail B, muscle	390	32	620	460	26	99	56	180	25
Snail B, shell	210	38	170	120	18	34	16	28	14
Fish A, muscle	1 100	9.6	70	1 600	3.0	9.3	60	70	75
Fish A, scales	380	16	110	270	5.7	9.1	110	230	56
Fish B, scales	1 500	12	100	1 100	4,2	8,8	80	140	11
Fish C, muscle	310	10	60	310	3.6	6.2	60	130	120
Fish C, scales	520	13	70	480	5.2	80	120	73	20
Fish D, muscle	320	10	90	300	3.3	19	67	45	31
Fish D, scales	270	11	46	250	2.6	6.3	120	49	51
Crab	2 600	23	400	1 800	17	33	67	300	78
Plant A, leaves	18 000	16	820	11 000	13	62	37	190	38
Plant B, leaves	2 800	6.2	1 400	2 200	4.5	8.7	21	41	46
Plant C, leaves	700	2.4	230	450	2.4	6.4	9.1	40	17
Plant C, roots	13 000	9.8	790	8 400	10	50	32	130	14
Plant D, leaves	9 800	12	8 100	6 500	20	19	55	660	23
Plant E, leaves	5 700	5.1	450	4 100	4.8	11	23	100	20
Plant E, roots	12 000	9.3	260	9 200	9.2	14	15	53	45

The metal concentrations of sediments were considerably higher at site B and C than at site A. In sediments the Zn concentrations were much lower than in River Niger (Ndiokwere 1984) while those of Hg and Cd were lower. However, the concentrations of Cd in plants and animals were very high in comparison to concentrations reported from River Msimbazi (Ak'habuhaya & Lodenius 1988).

The amounts of pesticides in sediments are up to 40 times higher than those in water, and those of metals are up to 10 times higher in aquatic organisms than in the lake sediments. Consequently, this seems to be biomagnification of pesticides and metals in the lake's food chains.

In fish the muscle concentrations of Mn and Fe were considerably higher than in *Lates stapersii* from Lake Tanganyika (Sindayigaya *et al.* 1994). The cadmium concentrations were higher than in Egyptian *Tilapia* fishes while the Hg, Cu and Zn levels were similar (El Nabawi *et al.* 1987).

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