Technical note

Chemical and ecological studies on *Tilapia nilotica*

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Abstract

Atomic absorption spectrophotometry was utilised for the determination of Ag, Au, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr and Zn in 42 *Tilapia nilotica* fish samples collected from the Nile River at Aswan (15 samples from the point between the conservation area of Aswan and Gebel Tagoug, and 27 samples from the main stream; 15 of the latter samples were placed in the middle of the Kima Drain and the remainder in the Nile River just north of where Kima Drain enters the Nile). The average length ranged from 13 to 26 cm, mass ranged from 98 to 400 g and water content equaled 74,37 to 75,40%. The results showed that trace element concentrations were clearly proportional to the size of the fish species (length and mass); in particular, relatively large sizes of fish contained higher concentrations of Na, Mn, K, Cu, Cr, Sr, and Zn. In addition, contaminated Kima Drain water may not reflect any change in the metal concentrations in the fish. The trace element concentrations in the investigated fish samples were within the safety baseline levels for man. Statistical relative errors equaled 4,8 to 8,5% and standard deviation was 0,026 to 303,557.

Introduction

Tilapia nilotica (locally known as Bolti) has a wide distribution, ranging from Lake Galilee and the Jordan River southwards to the Great Lake and East Africa, and westwards through the Chad Basin in Chad to Senegal, Niger and Ubanghi (Middle Africa). *Tilapia nilotica* is very common and of economic importance in the High Dam Lake and in the Nile River and is notable because it appeared in the well-done graphic representations of the ancient Egyptians. The oldest known representation, before 500 BC, is a glazed pottery model of Hierakoplis. Numerous figures of this fish are recognisable for instance in the mural paintings in the Tomb of Ti (Sakkara, Giza), and the Tomb and Chapel of Ptah Hotep (Latif, 1974).

Many trace elements play an important role in the metabolism of living cells. Their importance is very pronounced on the vitality or ill health of living organisms which depend on e.g., soil, fertilisers and water for their necessary trace elements. The latter are also important as indicators and guide elements for plants, mineral resources and geochemical and biogeochemical reactions (Valkovic, 1973).

Further to our earlier studies on water (Sherif *et al.*, 1978; 1980; Awadallah, 1984; 1990); sediments (Sherif *et al.*, 1981); crops (Sherif *et al.*, 1978; 1979; 1980; Awadallah *et al.*, 1986); Egyptian cane sugar (Awadallah *et al.*, 1984; 1985; 1986); Egyptian molasses (Mohamed *et al.*, 1989); and on fish (Awadallah *et al.*, 1985; Awadallah, 1986; Horris and Lake, 1984), this paper assesses the value of determining and studying trace element concentrations in 42 *Tilapia nilotica* samples in the Nile River on the basis of the results of chemical analyses and to indicate the relationship between the ecology and the distribution of trace metal pollution. A further aim is to provide information on trace metal concentrations in *Tilapia nilotica.*

Experimental

Sample collection

Forty-two different specimens of *Tilapia nilotica* (locally called Bolti), of varying mass (98 to 400 g) were collected from the Nile River at Aswan City in April 1988. The localities are shown on Fig. 1. Fifteen fish samples (numbers 1 to 15) weighing 98, 101, 105, 120, 135, 142, 151, 170, 172, 183, 190, 195, 198, 202 and 210 g respectively, were collected from the point between Gebel Tagoug (closer to Kalabsha Hotel) and Awada conservation area (an island in the Nile River and in front of Aswan Nassr City). the other samples (27) were collected from the main stream of the Nile River. From these, 12 samples (numbers 16 to 27) weighing 116, 121, 127, 138, 160, 185, 196, 206, 212, 216, 224 and 230 g, respectively, were held in a cage in the Kima Drain (Kima Company manufactures nitrate fertilisers and the Kima Drain runs from

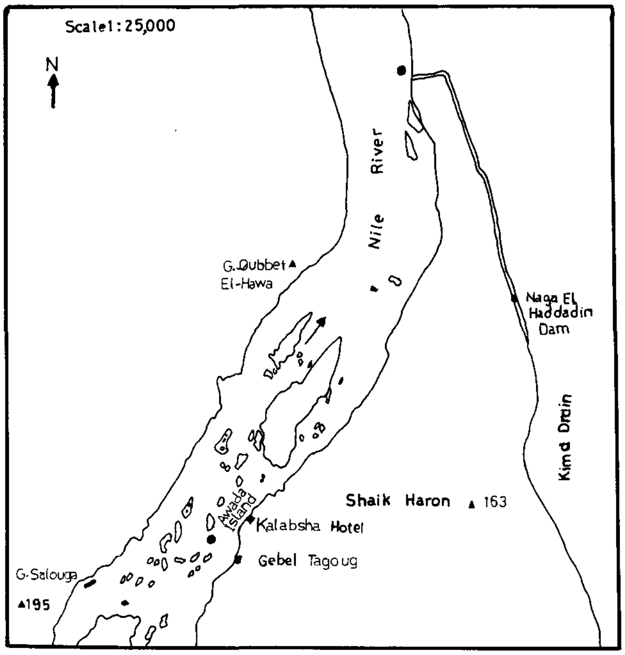

Figure 1
Map showing the sampling localities in the Nile River and the Kima Drain.

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Kima Company to the Nile River). The remaining 15 samples (numbers 28 to 42) weighing 145, 168, 198, 227, 242, 280, 310, 325, 340, 352, 371, 375, 382, 392 and 400 g respectively, were placed in the Nile River just north of where the Kima Drain enters the river. After 4 h the fish were taken out and killed.

Sample preparation

The 42 fish samples were washed well using tap water, and then the kidney, liver, gills and the alimentary canal were removed. The samples were washed again several times with tap and with double distilled water. The samples were dried on filter paper and placed in an electric furnace at 105°C for 48 h to remove moisture. After drying and cooling, the samples were collected, powdered and stored in small polyethylene bottles.

Working procedure

Portions of 5 g each of the dried fish samples were wet ashed with 50 mℓ concentrated nitric acid (A.R. 70%, Riedel de Haën) in a teflon beaker. The beaker was placed on a sand bath till all the nitric acid fumes ceased to evolve. Near dryness, 25 mℓ of nitric acid was added to the beaker, then 2 mℓ hydrofluoric acid (A.R. 40% BDH) was added and the mixture was placed on a sand bath again and heated for complete digestion. After cooling, the clear liquid was transferred into a volumetric flask and made up to 100 mℓ using double distilled water.

Ca was determined by EDTA.

Preparation of standard solutions

Standard solutions of Ag, Au, Ca, Co, Cr, Cu, K, Mg, Mn, Na, Ni, Pb, Sr, and Zn were prepared by dissolving the appropriate amounts of the AnalaR salts (99,9% BDH, E. Merck or Riedel de Haën) of $AgNO_3$,Au metal (99,999%), $CaCO_3$, $CoCl_2$. $6H_2O$, $K_2Cr_2O_7$, $CuSO_4$. $5H_2O$, KCl, $MgCl_2$, $MnSO_4$. H_2O, NaCl, $NiSO_4$. $7H_2O$, $Pb(NO_3)_2$), $SrCl_2$ and $ZnSO_4$ in double distilled water ($CaCO_3$ was dissolved in HCl (1:1) and then diluted with double distilled water to 100 mℓ).

Calibration graph

A standard curve for each metal was constructed by plotting the absorbance values versus the concentration of the metal salt solutions. Atomic absorption spectrophotometric measurements were undertaken at the Faculty of Science, Aswan, on a Pye Unicam SP 1900 atomic absorption spectrophotometer, with digital display of concentrations. Measurements were made at the characteristic wavelengths of the elements using hollow cathode lamps.

Results and discussion

The data obtained after analysing 42 *Tilapia nilotica* samples are recorded in Table 1. The elements Ca, Co, Cr, Cu, Fe, Mg, Mn, Ni and Zn are essential nutrients to sustain the life of fish and human beings. They may act as active centres and have vital biological and biochemical roles and metabolic functions. Ca and Mg are very important as they act as binding agents to fuse the walls of the cells together (Oser, 1979). Ca has an interesting effect on the absorption or utilisation of other heavy metals such as Pb, Cu, and Zn by fish as is evident from the results [high calcium intake leads to deficient Zn absorption by fish in hard water (Kima Drain water, [Ca] = 136.27 mg/ℓ, [Mg] = 31,13 mg/ℓ) than soft water (Nile River water, [Ca] = 26,45 mg/ℓ, [Mg] = 8,27 mg/ℓ)]. K is an essential nutrient element and has an important role in the synthesis of amino acids and proteins from ammonium ions and there is a relationship between K and hypertension (Oser, 1979). NaCl exists in the gastric juice, regulates osmotic pressure and is released during later stages of digestion in the extracellular fluids. Mn is an essential element and is necessary for bone growth and egg production (Leach and Muenster, 1962). It is an activator and metal cofactor for enzymes (Vallee, 1964) and fatty acid synthesis (Leach, 1972). The darker centres on scales, dark spots on the operculum, dull purplish red colour over the head and on the lower parts of the body, and the oblique dark streaks on dorsal, anal and caudal fins may be attributed to the presence of Mn (Latif, 1974; Oser, 1979). Co and Fe are essential activators involving vitamin B_{12} synthesis and catalyse amino acids (Vallee *et al.*, 1971). Fe and Cu (Fridovich, 1972) are important essential metals. They form a number of copper and iron proteins. The presence of copper may reflect its usefulness in the growth of fish as dietary food. Ag, Au, Cr and Ni are also essential nutrient elements. Ag interferes with Cu^{2+} and Zn^{2+} interferes with Cu^{2+} metabolism (Graddon, 1968). Cr is an essential nutrient element and increases the rate of fish growth. Ni is an essential element and activates a number of metals and it has an important role in pigmentation and coloration of fish (Oser, 1979). Pb may be present in tissues and in bones of fish (Oser, 1979). The presence of Pb in the fish samples may be traced to the presence of Pb in Nile River water polluted by gasoline (gasoline contains tetraethyl lead) from boats operating in the Nile River, particularly in the hotel district. Zn is a cofactor and essential micronutrient element for enzyme and RNA and DNA syntheses. It has an important role in cell replication. Firm fish may be ascribed to Zn as it stabilises the lysosomal membranes.

The concentration of trace elements in the investigated fish samples (Table 1) is within safety baseline levels for man. The results show that trace element concentrations (e.g. Ag, Au, Cr, Cu, Mn, Na, Sr, and Zn) are clearly consistent with the size of fish species (length and mass) and contaminated (Kima Drain) and uncontaminated (Nile River) waters have no effect on trace element levels in fish. The work has provided new information on the levels of these trace elements in *Tilapia nilotica* fish.

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TABLE 1
TRACE ELEMENT CONCENTRATIONS IN *TILAPIA NILOTICA* SAMPLES DETERMINED BY AAS METHOD (Ca BY EDTA)

Sample No.	Element (mg/g except Ca in %) Ag	Au	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Sr	Zn
1	0,03	0,18	0,025	0,18	1,42	0,41	17,38	1023,61	198,40	2,07	339,98	1,05	0,54	0,57	3,58
2	0,03	0,09	0,032	0,20	1,05	0,29	18,38	838,61	178,40	1,72	289,98	0,74	0,36	0,36	3,02
3	0,06	0,22	0,096	0,32	1,67	0,33	24,58	1223,61	218,40	5,07	589,98	1,24	0,00	0,62	4,67
4	0,04	0,19	0,090	0,25	2,12	0,36	25,98	1053,61	143,40	1,73	289,98	1,45	0,74	0,64	4,84
5	0,03	0,12	0,054	0,23	1,79	0,32	21,48	1168,61	213,40	1,55	439,98	1,05	0,52	0,45	4,04
6	0,03	0,14	0,050	0,20	1,48	0,69	18,98	1488,61	208,40	2,16	419,98	1,07	0,93	0,44	4,07
7	0,00	0,17	0,074	0,25	1,19	0,33	24,58	643,61	128,40	1,86	289,98	0,98	0,60	0,60	3,36
8	0,02	0,13	0,054	0,16	0,99	0,18	18,18	663,61	103,40	1,27	219,98	0,67	0,21	0,28	3,22
9	0,02	0,15	0,032	0,19	0,18	0,31	16,98	848,61	138,40	1,56	274,98	0,80	0,33	0,39	2,86
10	0,03	0,11	0,049	0,17	1,22	0,47	13,48	948,61	148,40	1,30	314,98	0,92	0,44	0,37	3,03
11	0,04	0,18	0,115	0,21	1,28	0,38	18,48	978,61	208,40	2,99	419,98	0,93	0,53	0,47	3,75
12	0,03	0,22	0,069	0,22	1,62	0,69	14,28	698,61	168,40	1,98	324,98	1,16	0,46	1,28	3,70
13	0,03	0,20	0,063	0,19	1,43	0,41	17,88	1463,61	203,40	1,69	434,98	1,41	0,42	0,36	3,89
14	0,04	0,21	0,101	0,27	1,73	0,46	17,48	1253,61	188,40	2,37	454,98	1,27	0,72	0,69	3,63
15	0,04	0,25	0,108	0,30	1,76	0,41	24,88	1513,61	253,40	2,39	514,98	1,12	0,76	0,61	5,15
16	0,02	0,00	0,076	0,24	1,80	0,18	12,00	933,04	38,79	1,24	365,75	1,60	0,10	0,25	1,47
17	0,04	0,04	0,101	0,32	1,54	0,24	13,90	1038,04	83,79	3,78	550,75	1,68	0,35	0,65	1,70
18	0,02	0,00	0,040	0,16	0,41	0,08	7,70	408,04	13,79	0,83	130,75	0,65	0,10	0,25	0,66
19	0,01	0,04	0,094	0,17	2,72	0,15	14,60	678,04	8,79	0,50	130,75	2,08	0,04	0,16	0,87
20	0,04	0,02	0,050	0,33	1,99	0,23	13,50	583,04	33,79	3,34	230,75	3,89	0,34	0,65	1,93
21	0,01	0,00	0,078	0,26	1,75	0,16	12,10	628,04	33,79	1,81	200,75	1,51	0,15	0,60	1,17
22	0,04	0,01	0,06	0,27	1,87	0,15	14,20	883,04	53,79	2,99	270,75	1,65	0,31	0,65	2,32
23	0,03	0,00	0,081	0,25	1,50	0,27	11,30	1008,04	53,79	2,22	295,75	1,36	0,22	0,51	1,87
24	0,02	0,00	0,110	0,17	1,51	0,17	11,10	678,04	18,79	1,11	175,75	1,40	0,11	0,29	1,09
25	0,04	0,00	0,072	0,28	0,98	0,14	8,20	878,04	33,79	3,34	210,75	1,15	0,23	0,59	1,60
26	0,03	0,05	0,06	0,26	1,37	0,18	11,00	913,04	63,79	2,91	275,75	1,34	0,22	0,56	1,71
27	0,00	0,00	0,102	0,04	0,00	0,05	3,60	153,04	0,00	0,78	50,00	0,22	0,01	0,36	0,35
28	0,03	0,20	0,105	0,22	1,50	0,31	18,18	1378,61	218,40	0,99	404,98	1,14	0,50	0,42	4,25
29	0,04	0,27	0,092	0,29	2,00	0,33	20,38	1223,61	203,40	2,15	424,98	1,41	0,41	0,77	5,21
30	0,04	0,28	0,104	0,32	1,77	0,47	55,48	1268,61	213,40	4,29	344,98	1,29	0,74	0,60	7,12
31	0,05	0,27	0,067	0,18	1,73	0,33	43,98	1378,61	223,40	2,58	414,98	1,31	0,73	0,76	2,67
32	0,03	0,17	0,078	0,29	1,06	0,32	30,68	828,61	148,40	1,09	299,98	1,04	0,54	0,59	5,46
33	0,07	0,42	0,045	0,45	2,44	0,52	20,00	1248,04	178,79	5,52	1060,75	1,97	0,78	1,14	4,96
34	0,07	0,32	0,038	0,41	1,81	0,40	16,50	778,04	123,79	2,17	605,75	1,67	0,74	0,80	4,58
35	0,08	0,36	0,054	0,50	2,11	0,35	19,40	1403,04	218,79	3,64	880,75	1,87	0,70	1,06	4,24
36	0,08	0,31	0,038	0,47	2,33	0,41	20,80	1058,04	168,79	2,69	790,75	2,00	0,60	0,98	4,87
37	0,06	0,29	0,074	0,43	2,06	0,33	17,30	843,04	83,79	2,87	695,75	1,69	0,38	1,00	4,03
38	0,07	0,28	0,050	0,44	2,08	0,35	17,10	903,04	123,79	3,10	655,75	1,77	0,63	1,16	4,01
39	0,06	0,13	0,047	0,41	2,03	0,32	19,30	968,04	173,79	2,42	890,75	1,72	0,49	0,80	4,14
40	0,10	0,32	0,047	0,48	2,58	0,36	19,60	1373,04	123,79	2,52	975,75	2,05	0,77	0,14	5,00
41	0,05	0,18	0,056	0,37	3,91	0,30	25,40	1013,04	138,79	1,95	670,75	2,97	0,42	0,66	4,03
42	0,07	0,16	0,029	0,40	1,99	0,34	12,50	818,04	118,79	1,91	620,75	1,76	0,50	0,76	3,53
$\overline{x}$	0,042	0,191	0,068	0,281	1,716	0,32	18,638	977,954	134,575	2,296	434,413	1,427	0,455	0,626	3,373
S.D.	0,206	0,099	0,026	0,108	0,568	0,137	8,925	303,557	71,28	1,097	237,864	0,623	0,235	0,273	1,516
S.E.	0,003	0,017	0,004	0,017	0,089	0,021	1,377	46,839	11,132	0,169	36,703	0,096	0,037	0,042	0,234

$\overline{x}$ = mean element concentration, S.D. = standard deviation, S.E = Standard error

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Erratum

Vol. **16**(1) 79-84

Physical and chemical properties of Aswan High Dam Lake water by RM Awadallah.

Page 80, **Table 1,** column 1, λ,mS/m should read λ,mS/m x 10

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