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Blood chemistry of the Nile tilapia, *Oreochromis niloticus* (Linnaeus, *1757*) under the impact of water pollution

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Abstract

The present study is an attempt to relate environmental factors of ambient water to the physiology of the cichlid, *Oreochromis niloticus*. Fish were collected at 3 stations along Lake Maryût and a fourth one in an authorized hatchery as reference. Water analysis showed that many attributes of the water quality, in particular in the main basin, were far beyond admissible levels. In response, functional damage of the heart and liver in polluted fish was pointed out in view of the elevated serum enzymes (alanine aminotransferase, lactate dehydrogenase, creatine kinase, alkaline phosphatase and cholinesterase). Alkaline phosphatase seemed to potentially indicate excess phosphate in ambient water, whereas, aspartate aminotransferase was suppressed in fish caught from waters with the highest metal concentrations. Serologic data of carbohydrate, lipid and protein metabolites drew attention to the adverse effects on liver, heart and kidney functions of industrial and municipal discharges into the fishes habitats.

Introduction

Due to the enormous growth of technology and industry, pollutants have been dramatically amplified in natural environments. In particular at the urban and municipal levels, seas, rivers and lakes became a big eventual sink for many man-disposed pollutants. Lakes of Manzala, Borollus, Edku and Maryût that fringe the northern side of the Nile Delta are not an exception. These shallow brackish-water lakes, that used to have high fishery production (El-Rayis and El-Sabrouti 1998), gradually became loaded with polluted discharge from the adjacent urban and industrial settlements. Among these Delta Lakes, Lake Maryût is the smallest and most polluted one.

Polluted water habitats exert extensive stress impacts upon aquatic animals. Changes brought about by a stressor could be metabolic in nature, affecting molecular and cellular components such as enzymes or impairing functions such as metabolism, immune response, osmoregulation, and hormonal regulation (Barton and Iwama 1991). Variability in environmental factors combined with synergistic and cumulative interactions of these factors in aquatic ecosystems complicate the interpretation and evaluation of stress-related responses of organisms towards contaminants (Adams et al. 1992). According to Neff (1985), changes in certain biochemical parameters in fish blood have potential for detecting acute or chronic pollutant-induced damage.

Blood chemistry has long been a helpful diagnostic tool in pathological, toxicological and general clinical tests. Until recently, there were few attempts to introduce these techniques into aquatic toxicology studies (Raccicot et al. 1975; Mehrle and Mayer 1980; Casillas and Ames 1986; Casillas et al. 1983). As with mammals, it was proved that after functional damage to the tissues and organs of fish, some specific cellular enzymes would leak into the blood where they could be detected (Bouck 1966; Bouck et al. 1975). Aalanine aminotransferase (ALAT, formerly SGPT), aspartate aminotransferase (ASAT, for-

merly SGOT), lactate dehydrogenase (LDH), creatine kinase (CK) and alkaline phosphatase (ALP) were selected as relevant enzymes for evaluating liver intoxication (Krajnović-Ozretić 1991). CK represents 10–20% of muscle cytoplasmic protein, while LDH is a hydrogen transfer enzyme, which catalyzes the oxidation of liver lactate to pyruvate with the mediation of NAD^+ as hydrogen acceptor (Moss et al. 1986). LDH is known to occur in all glycolyzing cells (Moss et al. 1986; Almeida-Val et al. 1995) and plays an important role in ammonia detoxification in fish (Hochachka and Somero 1973; Ruzak-Skocir and Trbojevic-Cepe 1990) and may determine the direction of amino acid metabolism (catabolism versus anabolism). ASAT is mainly located in the liver (i.e., liver guiding enzyme) and could reflect the physiological state of the liver (Kaplan et al. 1988). ALAT was suggested to be even more sensitive than ASAT as an indicator of liver dysfunction (Neff 1985). Cholinesterases (ChEs) are a class of serine hydrolases that could be inhibited by many pesticidal and nonpesticidal pollutants (Van Vuren et al. 1994). Glucose, triglycerides, cholersterol, urea, uric acid and creatinine are major degradation products and indicators of carbohydrate, lipid and protein metabolism (Kaplan et al. 1988).

Nile tilapia, *O. niloticus* represents the main fishery in Lake Maryût. As a standard bioassay fish and one of the most marketable freshwater species, *O. niloticus* fairly satisfied selection criteria and was chosen in this study as an experimental model. Some major blood indices (ALAT, ASAT, LDH, CK, ALP, glucose, triglycerides, cholesterol, urea, uric acid & creatinine) that proved significant in disease diagnosis were carefully quantified and related to various stressors that could be created by the altered water quality in different basins of Lake Maryût. To assess the extent to which lake water was deteriorated, a wide array of trace metals (cadmium, Cd; chromium, Cr; cobalt, Co; copper, Cu; iron, Fe; lead, Pb; magnesium, Mg; manganese, Mn; mercury, Hg; nickel, Ni; zinc, Zn) and some other indices of water quality [pH; turbidity; dissolved oxygen, DO; chemical oxygen demand, COD; biochemical oxygen demand, BOD; hardness; alkalinity; Cl^-, chlorides and nutrient salts (orthophosphate- phosphorus PO_4^{3-} -N; ammonia-nitrogen, NH_4^+ -N; nitrate-nitrogen, NO_3^- -N; nitrite-nitrogen, $NO_2{}^-$-N)] were compared to data of an authorized commercial pond.

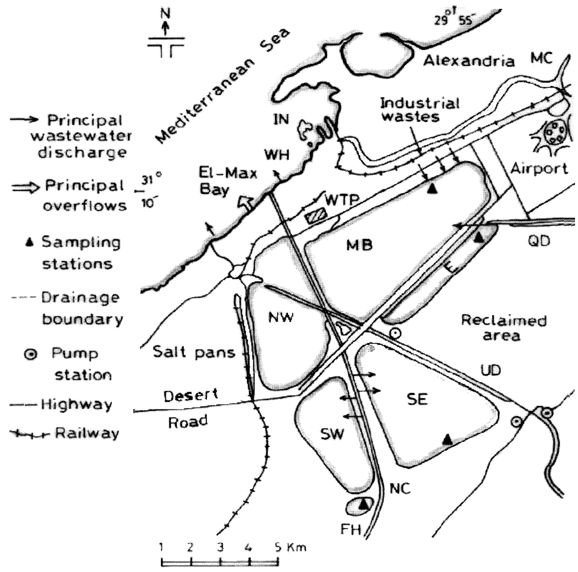

Figure 1. General surface structure of Lake Maryût showing its position in relation to the Mediterranean Sea and supporting canal system; MB, main basin; E, east basin; NW, northwest basin; SE, southeast basin; SW, southwest basin; FH, fish hatchery; IN, inner harbor; WH, west harbor; MC, Mahmoudiya Canal; NC, Nubarriya Canal; QD, Qualaa Drain; UD, Umoum Drain; WTP, west treatment plant; sampling stations are shown in the MB, E, SE and FH (see triangles). For more information about positions, see the Materials and methods section.

Materials and methods

Lake Maryût is situated south to the City of Alexandria (5 million inhabitants) and is said to be in existence for more than 6000 years. Upon time, the lake was markedly reduced in size; this is particularly true during the past 50 years due to extensive urbanization schemes. The total area of Lake Maryût dropped from about 66,000 acres during the fifties of the past century into less than 17,000 acres at present. This was due first to reclamation projects, second, to digging Umoum Drain and Nubarriya Canal, third to the construction of the Alexandria-Cairo Desert Road and several artificial dykes and fourth to assigning several parts of the lake for the production of solar salts. The leftover area was again divided into 5 sub-basins (Figure 1): the main basin (MB), east (E), southeast (SE), northwest (NW) and southwest (SW) basins. These water bodies, in particular the main basin, receive massive flux of industrial, agronomic and anthropogenic discharges (El-Rayis and El-Sabrouti 1998).