Aquatic Environmental Pollution in the Egyptian Countryside and Its Effect on Fish Production (Review)

Mona S. Zaki[1]; Mohammad M.N. Authman[1]; Abdel Mohsen M. Hammam[2] and Samy I. Shalaby[2]

[1] Hydrobiology Department, National Research Centre, Cairo, Egypt
[2]Animal Reproduction & A.I. Department, National Research Centre, Cairo, Egypt
dr_mona_zaki@yahoo.co.uk

Abstract: There is no doubt that, the rate of pollution in the River Nile, irrigation and drainage canals increase steadily with increasing rates of population activity and the surge of economic and industrial transformation in the country. There are about 550 million tons of wastes, whether liquid or solid, which find their way into water bodies after initially treatment or without treatment, which is reflected on the environment of plant, animal and fish and then on human health. The heavy metals, such as mercury, cadmium, copper, lead and zinc one of the most important pollutants that lead to the pollution of aquatic environment and fish. They are extremely dangerous for the health of fish and Humans. This is because most of these metals are characterized by the bioaccumulation in tissues, and lead to the poisoning of fish and Human. It was found that, when these metals found in levels much higher than the limit globally set by the World Health Organization influence the vital operations and reproduction of fish, as well as weak immune system of the fish body, and increasing the proportion of infections where external or internal parasites that attack fish first and then fouling other bacterial diseases such as (Columnaris disease and Vibriosis) and fungi (Saprolegniasis). It proved recently that there is a strong relationship between the incidence of bacteriological and fungal diseases and concentration of heavy metals. In addition, heavy metals affecting the fish eyes and induced tumors in fish when water contaminated by vanadium and selenium in large quantities. This project comes up for studying the ratios of heavy metals pollution in the drainage canals in different areas of the Egyptian countryside, and the impact of pollution on human health and the attempt to find appropriate solutions to eliminate this pollution and protect fish consumers. This project includes analysis of water quality (chemical, physical microbial, etc) and detection of heavy metals residues in the canal's fishes and conforms to established ratios approved by the World Health Organization for protection of human health. Also, studying of the parasitic, bacterial and fungal diseases affecting fish; studying of the pathological, clinicopathological and histopathological affections of such fishes, and the impact of pollution on fish resources. Detection of heavy metals residues in fish musculatures. This study also includes the study of the economical, public health importance impact of pollution in the drainage canals and trials to find solutions for such problem.

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Introduction

Pollution is considered as one of the most serious problems that faces human societies in the whole world especially in the developing countries. Though produced by man himself and his activities, it has deleterious effects on human's environments and resources (Khallaf *et al.,* 1995; Mendil & Uluözlu, 2007). So, pollution and its effects are considered as one of man's greatest crimes against himself.

Aquatic habitats, especially the freshwater ecosystems, are more subjected to pollution than other environments, because of water use in industrial processes as well as discharge of effluents from industry and urban developments (Mason, 1983; Demirak *et al.,* 2006; Fernandesa *et al.,* 2007). Most aquatic ecosystems can cope with a certain degree of pollution, but severe pollution is reflected in a change in the fauna and flora of the community, which suffer such pollution.

There are several categories of water pollutants, which include domestic sewage and oxygen-demanding wastes, infectious agents, plant nutrients, chemicals such as insecticides, herbicides and detergents, and heavy metals.

The River Nile is recognized as the longest river, and can be considered as one of the most important rivers in the world. The River Nile is the life artery of Egypt. Throughout the known Egyptian history, the Nile had dominating influences on the economy, culture, public health, social life and political aspects. According to the National Water Research Center (NWRC, 2000), the River Nile from Aswan to El-Kanater Barrage receives wastewater discharge from 124 point sources, of which 67 are agricultural drains and the remainders are industrial sources. The total amount of wastewater discharged into the main stem of River Nile has been estimated to be 2628 million cubic meters per year, of which the industrial wastewater

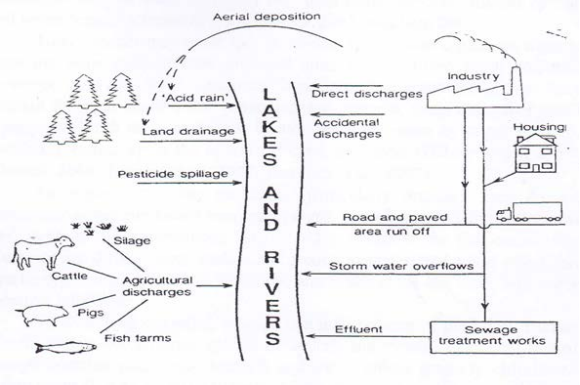
constitutes 15%. On the other hand, the annual discharge of the River amounts to 55 milliard cubic meters per year, therefore, the high dilution rate of the River amounting to be neglected (Abo-El Ella *et al.*, 1990). Another source of pollution in River Nile is fish culture in floating. Cages at Kfr Al-Sheikh and Damietta governorate. This type of fish culture is one of the reasons for deterioration of water quality because of the potential negative effects of oxygen depletion, increasing poisonous ammonia, increasing the proportion of total dissolved solids (TDS), chemical contamination resulting from the hormonal treatment of fish and nutritive materials and remnants of fish output. In addition, using serious kinds of fish food such as blood, meat, fish and poultry remnants, dry sludge and sewage that lead to low water quality, transport these dangerous wastes into potable water, and transmitted to humans, causing several health problems.

Of the 5.5 billion cubic meters of water released from the Aswan High Dam, about 50 percent ends up in the drainage system where Egypt possesses approximately 50000 Km of irrigation and drainage canals (Redding & Midlen, 1990); actually the total length of the main irrigation and drainage canals in Egypt are 31182 and 16231km, respectively (Khattab, 1984). Drainage water is returned to the Nile River, recycled downstream and reused.

It was also recognized that the construction of canals and drains in the River Nile valley including its delta has attracted farmers to locate villages onto the banks of the canals and to lesser extent drains. Both canals and drains have been polluted by discharge from these developing communities. This has occurred when the canal or drain water is used for washing dishes and clothes, washing of animals, the discharge of urine and /or human faeces, and the disposal of refuse and dead animals. Some canals and drains have been contaminated with heavy metals, pesticides, insecticides, fertilizers, possible domestic/industrial wastes, and other chemicals (E.S.G., 1989).

Drainage water, however, consists not only of irrigation return water but also in many cases industrial and domestic wastewater where huge volumes of untreated wastewater are discharged into agricultural drains daily. Drainage water is therefore contaminated with salts, agricultural chemicals (Pesticides & Heavy metals) and other pollutants as pathogens from domestic sewage and industrial discharge.

The problems of irrigation and drainage canals include the presence of high concentrations of different heavy metals and pesticides in both water and various fish organs (Khallaf *et al.*, 1994, 1995 and 1998; Alne-na-ei, 1998). Most of these toxic substances exceed the internationally agreed threshold levels for foodstuffs, which, of course, adversely affect the human health of fish consumers. The different sources of inputs of wastes into freshwaters are shown in the following diagram:



The heavy metals in freshwater are a matter of concern because of their toxic potential ability to be accumulated in food chains, therefore mercury and zinc are on first list percent of dangerous substances (Svobodova *et al*. 1993; Dalman *et al.*, 2006). The most important heavy metals from the point of view of water pollution are Zn, Cu, Pb. Cd, Hg, Ni and Cr. Some of these metals (e.g. Cu. Ni, Cr and Zn) are essential trace metals to living organisms, but become toxic at higher concentrations. Other such as Pb and Cd have no known biological function, but are toxic elements (Dudka & Adriano, 1997).

The domestic, agricultural and industrial wastes, either partially or without treatment are being discharges into surface water. The natural levels of cadmium, lead mercury, copper and zinc in surface water were 0.07, 0.20, 0.01, 1.80 and 1.00 µg/liter, respectively, while the maximum allowable levels of these metals in surface water 10, 50, 2, 1000 and 5000µg/liter, respectively. Fish may absorb metals from water through gills, skin and the digestive tract. Mirenda (1996) and Yilmaz *et al.* (2007) reported bioconcentration and bio-magnification for heavy metals. The impact of heavy metals pollution on man is of more concern. The most striking incident was "Minamata" disease in which hundreds of Japanese were seriously affected and many died through consuming mercury contaminated fish. The effect of lead poisoning on man was described. Also, chronic cadmium poisoning or "Itai-Itai" disease was reported. Other heavy metals such as copper and zinc when discharged into the water can enter the food chain, bio-accumulated by fish and hence become a threat to man (Pereira, 2003, Stephen, 2004).

Heavy metals may enter fish in several ways. These organisms directly from the water through their gills and other tissues absorb small amounts. However, most of the pollutant found in aquatic organisms arrives there through the food chain. First,

phytoplankton, bacteria, fungi and other small organisms absorb these materials. In turn, these are eaten by larger animals, eventually ending up in the organisms eaten by people (Hilmy *et al.,* 1987; Girault, 2004; Lamas *et al.,* 2007: Burgera *et al.,* 2007).

As opposed to other pollutants (particularly organic), they do not decompose or get eliminated from ecosystems. Therefore, special attention was paid to study the accumulation rate of heavy metals in the fish community (Jung *et al.,* 2006). Such studies are needed to understand toxic effects on aquatic organisms, cycles and pathways, and fluxes at the air, water and water sediment interfaces.

In developing countries, sewage is a major source of pollution. Human excreta 400 different species of bacteria and virus, unless properly chlorinated before being discharged into any water course. Sewage is a major contributor to water-borne diseases and affects the health of people and other organisms in the environment in many ways. sewage may also expose fauna to infectious organism and lower resistance to infection, fish pathogens are important as health hazards to man and animals which fish and aquatic fauna act as vehicle for certain zoonotic agents and as handicaps to fish production (Robert, 1989). Fish are vulnerable to most types of infectious organisms, which affect mammals.

In subtropical countries, the parasitic diseases affecting fish health, growth and survival have a superior position and have received a significant attention. The availability of water organic pollution is positively correlated with parasitosis (Sinderman, 1990). Sewage pollution in particular is also considered as one of the most important sources for parasitic infestation in fishes (Jackson, 1975). In Egypt, sewage pollution is common in water resources namely freshwater as River Nile, brackish as lakes or seawater. Parasites of fish can indicate natural and anthropogenic environmental effects, if carefully analyzed according to the kind of parasite, stage of parasite, biology of host and environmental conditions (Overstreet, 1992).

The organisms found in these polluted freshwater habitats differ due to the organic matter concentration, as well as to other vital factors such as oxygen, phosphates and nitrates (Sleigh, 1989). Therefore, the measuring of physico-chemical characters of water; such as temperature, electrical conductivity, total solids pH, nutrient salts, etc. is important to investigate the water quality and the ecological variations in the fauna and flora of water body. Additionally, histological bioindicators provide powerful tools to detect and characterize the biological end points of toxicant and carcinogen exposure (Moore & Simpson, 1992).

Pathological effect of heavy metals on exposed fish

Pathological conditions that are recognized in mammals, e.g. inflammation, wound repair, hemorrhage, necrosis septicemia, atrophy, metaplasia, hyperplasia, and neoplasia, are also observed in fish, due to pollution of heavy metals and other (Higginson, 1999; WHO, 2004).

Ocular diseases of fish are common and represent a significant problem within the aquaculture industry. The decreased visual acuity associated with ophthalmic diseases may produce poor growth rates and feed wastage. Moreover, sometimes, ocular abnormalities are associated with fish losses. Since 1990, eye affection syndrome has become serious problem in European aquaculture that triggered the need to uncover causative factors and means of preventing and controlling this condition (Branson *et al.,* 1999). Eye lesions and other clinical abnormalities are positively associated with water pollution by heavy metal (El-Bouhy, 1995).

Effects of ingestion of polluted fish with heavy metals on human health

Ingestion of metals such as lead, cadmium, mercury, arsenic and chromium my pose great risks to human health.

Lead

Because of size and charge similarities, lead can substitute for calcium and be included in bone. Children are especially susceptible to lead because enveloping skeletal systems require high calcium levels. Lead that is stored in bone is not harmful, but if high levels of calcium are ingested later, the lead in the bone may cause nephrotoxicity (where a toxic agent inhibits, damages or destroys the cells and/or tissues of the kidneys), neurotoxicity (where a toxic agent or substance inhibits, damages or destroys the tissues of the nervous systems, especially neurons, the conducting cells of the central nervous system), and hypertension (be normally high blood pressure) (Luckely, 1977).

Cadmium

Cadmium may interfere with the metallothionein's ability to regulate zinc and copper concentrations in the body. Metallothionein is a protein that binds to excess essential metals to render them unavailable. When cadmium induced metallothionein activity, it binds to copper and zinc, disrupting the homeostasis (the maintenance of equilibrium, or constant conditions, in a biological system) levels (Alabaster & Lloyd, 1982; Bakir *et al.,* 2003). Its intoxication was first noted in Japan In 1955, itai- itai (ouch –ouch) disease, due to releasing cadmium-laden effluent into the River Jintsu, and characterized by severe back and joint pains, a duck-like gait, kidney lesions, protein and sugar in the urine and a decalcification of the bones, leading to multiple fractures (Hora & Fillary, 1962).

Friberg (2004) reported that, in Swedish school children showed severe gastrointestinal symptoms after the consumption of soft drinks made with water

containing 16.000 µg/L cadmium. It was estimated that more than 500.000 people may be at risk from cadmium induced kidney damage worldwide, though freshwaters are only one of a number of routes of exposure. The amount of cadmium ingested by humans is very close to the tolerable weekly intake, so that releases of cadmium to the environment need to be more tightly controlled (Mary, 1994).

Mercury

Mercury poses a great risk to humans . Mercury occurs naturally in the environment and it can be released into the air through industrial pollution. Bacteria in the water cause chemical changes that transform mercury into methyl mercury, which binds tightly to the proteins in fish tissues. It appears that in aquatic organisms, as well as man tend to concentrate mercury within their bodies which is buildup with time to the extent that the accumulated mercury can become toxic and, eventually, lethal. Even low concentrations of mercury may be considered potentially harmful to humans. Methyl mercury is believed to inhibit enzyme activity in the cerebellum, which is responsible for neuron growth in early developmental stage. Chronic exposure to mercury leads to mental retardation. Clinically observable effects on adults occur at blood levels of 0.2-0.5µg/ml and body concentrations of 0.5-0.8µg/kg, or a concentration in hair as low as 15-20µg/kg. The toxic effects of methyl mercury are dominated by neurological disturbances. A tolerable weekly intake for mercury is set at 0.005 mg/kg body weight; however, people eating fish from contaminated lakes are susceptible to exceed this level significantly. Increased concentrations of mercury were recorded in hair with the highest concentration (30 mg/kg) in middle-aged people who are consuming substantial amounts of fish. The European Union has suggested that maximum average mercury content for fish taken for consumption should be 300µg/kg (Bano & Hasan 1990; Bakir *et al.*, 2003; Evans, 2005).

Copper

Under excessive copper intake-excessive buildup of copper in the liver and central nervous system caused by a metabolic inability to excrete copper is the fundamental cause of Wison's like disease which is copper toxicosis in humans (and most higher animals) characterized by affection of liver and central nervous system (Lucky & Venugopal, 1977).

Chromium

Under natural conditions, chromium as a metal is considered biologically inert. Cr particularly hexavalent chromium has a low order of toxicity. A wide margin of safety exists between the amounts ordinarily ingested and those likely to induce deleterious effects. Bown (2003) noted that even though Cr hexavalent is more toxic to fish and caused liver cancer dark skin and ulcers. It appears to be more likely soluble and mobile in soil and water than Cr. Chromium as a metal and produces toxic effects in man or animals. People who work with hexavalent chromium have, however, developed cutaneous and nasal mucous-membrane ulcers and contact dermatitis. The lung is the only organs that appeared to accumulate chromium, and this may be related to airborne exposure to chromium containing dust.

Vanadium

Vanadium is an essential element for human and animal health, ubiquitous in nature and is widely distributed in most biological material. It is distributed as a building material of bones, and teeth. Skimmed milk, lobster, vegetables, oils grains and cereals are rich sources of vanadium. Recently, vanadium has shown therapeutic potential in clinical studies, patients of diabetes mellitus. Although vanadium is an essential element, it has been shown to be toxic to human. There are in the literature, however, report of workers who were exposed to vanadium oxide dust or aerosols for several days developing vanadium toxicosis in the form of eye and nose irritations, cough, wheezing productive sputum, and green tongue (Chiu, 2003).

Aluminum

Aluminum is a trivalent cation unable to undego redox reactions and has been linked to many disease such as renal failure, senile dementia and microcytic anemia even without iron deficiency. It has also been implicated in Alzheimer disease although this is controversial, because of cell death due to oxidative injury. Toxicity of aluminum comes from substitution of Mg++ and Fe++ ions causing disturbances in interacellular signaling, excretory function and cellular growth. Neurotoxic action of Al probably comes form substitution of Mg++ ions in ATP (Jahn, 1980; Robert, 1989; Global 1997).

Conclusion

The aim of this study is to study the relationship between heavy metal pollution and fish disease. The purpose is to provide some specific data on the known toxic levels of such elements that may reach potentially dangerous concentrations in the aquatic fauna as results of water pollution. We have limited our goal to the main hematological, biochemical and clinicopathological changes in fish as well as some fish disease and tumors as results of exposure to the toxic effects of these elements. We will give a great emphasis to the effects of this hazardous chemical compounds on human health and the economic method of treatment.

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