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Impact OfHeavy Metal Pollution On Fish And Effects On Human Health After Dietary Consumption.

Mona S Zaki*.

Hydrobiology Department, National Research Centre, Dokki, Giza, Egypt.

ABSTRACT

Water pollution is one of the major problems in the world especially in the developing countries.It could by physical, chemical or biological. Heavy metals pollution is the most dangerous form of water pollution. It results from industrial, agriculture or domestic effluents in water.It also resulted from geologic weathering, mining effluent, agricultural and industrial effects, storm run-off and atmospheric sources (environment). Water pollution is considered a devastating problem in the world especially in the developing countries including Egypt.Industrial effluents are harmful for aquatic life and agriculture land with secondary effects on human health. Human wastages that contain different kinds of pathogen; and are considered the major contributor that affects health of people and organisms if drained in any water course.There is no method of legislation and enforcement that can guarantee the safety of fish from pollution. Also Human Health is affected by dangerous diseases after eating infected fish. A general public acceptance that a flourishing fish community is an important measure of an acceptable quality of water in our rivers, lakes and seas.Fisheries managers must define the status of the fish population which they would expect to find in their water, so that deviations attributable to chemical pollution specifically heavy metals can be identified. Chemical pollution from factories must be controlled as it affects the well-being of fish and so human health. Well treated sewage is highly recommended before being discharged, as well as, properly chlorination of water. These are highly essential in order to protect the fish communities that form a most valuable and precious resources in our river, lakes and seas.
Keywords: water, pollution, heavy metal, fish, dietary.

Corresponding author

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INTRODUCTION

Water pollution is one of the major problems in the world especially in the developing countries including Egypt.The majority of our watercourses receive a great variety of potential pollutants from industrial, agricultural and domestic effluents, and these complex situations become apparent when considering toxicity. Many industries discharge effluents to out urban waterways, where factories are concentrated because of their need for water for processing or discharging wastes ATHA, 1992, Hinton and Lauren, 1990).Aquatic fauna (the main resources for fish production) are affected mainly with water pollution especially the chemical and biological effluents **(Goyer, 1982)**.Biological pollution does not only introduce materials which are toxic for aquatic life but often destroys the healthy food resources. Since organic pollutants tend to absorb oxygen then may reduce it to a fatal level especially in winter, sewage may also expose fauna to infectious organism and lower their resistance to infection, fish pathogens are important as health hazards to man and animals where fish and aquatic fauna act as vehicle for certain zoonotic agents and as handicaps to fish production **(Mary, 1994)**. Fish are vulnerable to most types of infectious organisms which affect mammals. It is apparent that aquatic fauna are much more exposed to all elements in their environment. Fish in ponds, lakes, and rivers cannot avoid exposure to the substances or chemicals suspended or dissolved in the water being less than land animals to move in favorable regions or to avoid unfavorable elements. Fish are more sensitive indicators of their environments **(Boyd, 1982, Alan, 1995)**.The impact of heavy metals is markedly increased in the last decades after the propagation of the industrial investigation and culture projects with the continuous increase of the world population.

Many studies of element toxicities have been made, and reports of these studies are scattered through the biological, medical, geological and other literature. The present requirement for preparing environmental impact statements before certain types of industrial and other operations are undertaken necessitates that judgments be made regarding to potential health effects, if any, of elements that may be released into the environment by these operations. Although these judgments may be outside the fields of the physical and biological scientists who must predict environmental impacts that are likely to occur, certain valid estimations can be made if adequate information is available **(Rossi and Santaroni, 1976)**.However, this practice created new problems. In heavily industrialized areas, a large proportion of the sewage could be derived from industry. This could affect the efficiency of the sewage treatment processes, leading to a poor quality effluent which contained substantial quantities of the wastes derived from the industries connected to the sewage system. The obvious solution was to pre-treat the wastes before discharge to the sewer, but in many of the old industrial centers there were small factories which did not have the space to install the necessary treatment plant **(Goyer, 1982, Alabaster and Lohyd, 1982, Au, 2004)**.

The aim of this state is to study the impact of heavy metals pollution on fish. The purpose is to provide some specific data on the known toxic levels of these elements that may reach potentially dangerous concentrations in the aquatic fauna as a result of water pollution. We have limited our goal to the main hematological, biochemical and pathological changes in fish as well as some fish diseases and tumors as a result of exposure to the toxic effects of these elements. We have given a little emphasis to the effects of these hazardous chemical compounds on human health.

Respiration in Fish

The majority of fish obtain oxygen from the small amount which is dissolved as gas in the water. In order to extract this oxygen efficiently, the gill structure consists of a very fine sieve through which water is pumped by muscular action of the mouth and pharynx. The general structure is shown in Fig. (2). The primary lamellae or filaments are attached to the gill arches like teeth on a comb. These lamellae are slightly curved so that their tips meet those of the adjoining gill arch, the whole system forming a folded filter. To increase the efficiency of the filter, there are plate-like secondary lamellae on the upper and lower surface of the branchial lamellae, and the respiratory water has to pass between these plates. The structure of these plates can be compared to a sandwich consisting of a thin layer of epithelial cells on the outside and spaces through which the blood flows on the inside. Therefore, the dissolved oxygen in the water has to cross only a very short distance to get into the blood stream. Added to this, the blood flows in the opposite direction to that of the water and so acts in a similar fashion to a heat exchanger, which increases the efficiency of oxygen extraction. As a result of this arrangement, trout, for example, can extract up to 80% of the oxygen dissolved in the respiratory water. But, this very same efficiency that makes fish vulnerable to toxic substances in the water.

Uptake of Heavy Metals by fish

Heavy metals in the water can be absorbed by the gills, pass into the bloodstream and circulate through the body. Furthermore, if the concentrations of toxic heavy metal are high enough (fig.3), the delicate cells of the gill secondary lamellae can be damaged and this adversely affects the vital functions of respiration and salt regulation. The gills are of primary importance as a route whereby toxic chemicals in the water can be taken up by fish, and in the majority of cases the intake of such substances in the food is of a much lesser secondary importance **(Kiyaura, 1962, Lucky, 1977, Lall, 1991)**.

Uptake of small particles

Another route of entry, but about which very little is known, is the uptake of very small particles by the skin and gills. Bacteria can pass between the cells of the surface epithelium and once inside they are nonnally countered by disease defense mechanisms. However, inert particles of bacterial size can likewise gain entry and in high concentrations may disrupt the defenses. It is also possible that such particles with toxic substances on their surface mechanisms are weakened, then bacteria can multiply and cause skin ulcers and fm rot. It is obvious that those species of fish which live in contact with sediments will be most at risk for such sources of heavy metal pollution, especially flatfish in the marine environment. Some protection may be given by the film of mucus which covers the skin and gills, but this may be lost if netting, handling or other abrasive actions and so open the way to chemical attack and/or the entry of disease organisms. Much more research in required to establish whether this route is important for theuptake of harmful substances adsorbed onto micro particulate matters **(Goyer, 1982, Lall, 1991, Mirenda, 1996 ,Zaki et al., 1996)**.

Defense mechanism in the body

Once past the surface epithelium, toxic chemicals can affect any one of a whole range of bodily functions depending on their specific mode of toxic action. In turn, fish have a number of defense mechanisms to prevent such effects occurring; organic chemicals can be detoxified in the liver and their metabolites may be excreted via the bile and the gut. So-called heavy metals such as zinc and cadmium can be attached to special proteins in the blood any may be deposited within insoluble granules which are then stored or excreted **(Alabaster and Lloyd, 1982)**.These defenses can be triggered or activated by the presence of the toxic substance and, if its concentration is low, the fish may develop a resistance which enables it to withstand a higher dose that would otherwise be harmful. On the other hand, a prolonged exposure to a toxic substance in the water may exhaust the defenses mechanism so that the fish becomes weakened and subsequently may succumb. This short-term adaptation is called "acclimation", to distinguish it from an increased resistance in a population caused by the natural selection of hardier individuals, which is termed "acclimatization" **(WHO, 2004)**.

Environmental Pollution

Heavy metals are persistent contaminants in the environment and come to the forefront of dangerous substances causing serious health hazard in human. Cadmium, lead, mercury, copper and zinc are among the most dangerous of these elements. Metal pollution of the environment originates from geologic weathering; mining effluents; domestic, agricultural and industrial effluents; urban storm runoff; metal from ruralareas and atmospheric sources. Like clean air, fresh water is also becoming a scarcity. The limited availability of fresh water and its unequal distribution make water pollution a matter of great concern. Water pollution is generally localized and confined, making it more severe. The pollutants undergo many reactions and can become hazardous. 70% of India's fresh water is polluted, including several high altitude lakes. While water pollution is easier to study and manage, its control is highly complex and very costly **(Naplatrova et al., 1975, Panigraphi and Misra, 1980, Goyer, 1981)**.

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 pig/liter, respectively, while the maximum allowable levels of these metals in surface water were 10, 50, 2, 1000 and 5000 µg/liter, respectively. Fish may absorb metals from water through gills, skin and the digestive tract. Bio-concentration and biomagnification for heavy metals were reported by **Mirenda, (1996)**. 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. Small amounts are absorbed by these organisms directly from the water through their gills and other tissues. However, most of the pollutantsfound in aquatic organisms arrive 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)**.

Sources of Water Pollution:

In developing countries, sewage is a major source of pollution. Human excreta contain 400 different species of bacteria and viruses. Even well-treated sewage contains pathogenic 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.Industrial effluents from sugar factories, distilleries, tanneries and paper industries are accompanied by very high organic loads. Byproducts of paper and pulp industry cause depletion of fish up to as far as 40 km downstream. The wastes from oil refineries and steel industries contain phenol which imparts a strong odor, apart from poisoning the water body. Fertilizer industry wastes contain ammonia, urea, phosphate and sulphate which, in water, cause algal bloom and are toxic to aquatic fauna and flora. Alkaline industry wastes contain mercury which can kill human beings who consume mercurized fish. Mercury pollution poses serious risks to wildlife and people. Electric power plants are responsible for approximately 30 percent of the country's mercury emissions and are the only major mercury polluters that remain uncontrolled. Smokestacks spew mercury pollution into the air, where it rains and snows down into waterways and accumulates up the food chain. Lead generated from battery, printing, petrol and paste-processing industries, trace and toxic elements such as zinc, copper etc., and effluents from mining industriesre-injurious to aquatic organisms **(Hilmy et al., 1987, Panigrahi and Mis,ara, 1980)**.Water in which maximum pennissible concentration of any single or more constituents is in excess is unfit for drinking and human health.There are definite tolerance levels for water used for different activities such as drinking, bathing, irrigation and industrial purposes. Depending on its use, there are different physiochemical and bacteriological standards for water **(Koeman and Strik, 1975, Wobeser, 1975, Goyer, 1982, Towill, 2005)**.

Heavy metals pollution

The problem of appearance of toxic materials in water ecosystems is presently closely connected with increased concentrations of heavy metal ions, which enter water bodies with industrial and communal waters. Heavy metals are transferred through food chains and accumulate in organs and tissues of aquatic organisms **(Wong et al., 1977, Wotten et al., 1982)**.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. Such studies are needed to understand toxic effects on aquatic organisms, cycles and pathways, and fluxes at the air water and water sediment interfaces,**Wotten et al. (1982)** proposed five mechanisms for metal transport in large rivers, e.g. the Amazon and Yukon rivers. He suggested that metals are partitioned by suspended solids into five different phases. (1) in solution as free or complex species,.(2) by adsorption at solid-solution interface, (3) by incorporation into biological system, (4) by precipitation and co-precipitation asmetallic coatings, and (5) by incorporation into crystalline structure. He stated that under most circumstances, solid-solution interfaces become substantial in trace metal transport in these major rivers.

For the River Nile, the results obtained by **Marzauk (1994)** revealed that the trace elements have become accumulated in high concentrations in river sediments indicating the existence of localized pollutionalcontamination.Heavy metals content of aquatic animals originate from two routes of intake, free ions and simple compounds dissolved in the water are taken up directly through the epithelium of the skin,- gills and alimentary canal, while others, having been accumulated in food organisms, are incorporated by nutrition. In uncontaminated natural environments the heavy metal concentration in water and living organisms depends on the geochemical background. However, in the past few decades the occurrence in waters and accumulation in organisms of substances originating from industrial, agricultural and domestic sources have more and more common. The heavy metal concentration in aquatic organisms can be a good indicator of water quality. In the same respect, incorporated metals can influence the physiological processes of aquatic organisms and thus cause damage to the organisms themselves **(Luckey, 1977, Allaway, 2003)**.Trace metals are usually divided into two subclasses: the first one includes Fe, Mg, Mn, Co, Zn, Cu, which are "essential" for the correct functioning of biochemical processes while Cd, Hg, Cr, Pb, ect., belong to the second subclass which is made up of metals without any established biological function and includes the more important contaminants in the aquatic environment. They are usually referred as toxic metals **(Brawn and Gratzek, 1980, Bown, 2003, Friberg, 2004)**.

Since the causes and reasons for the poisoning of the biological system by metals are largely practical, it has produced a variety of operational approaches ranging from establishing lethal doses (LD50) and lethal concentration (LC50) on various organisms. When these approaches are applied to metal toxicants and aquatic organisms, major complications are uncovered. It illustrates how elements such as Zn and Cu, which under normal circumstances are considered to be essential, become toxic when present in excess amounts. Conversely, elements such as Ni or Cr, which are normally considered to be toxic pollutants, may serve as essential nutrients at low concentrations. Clearly, the whole concept of toxicity is related to the metal dose **(El Ezaby, 1994)**.Out of all heavy metals, the most toxic is chromium because of its widespread use and toxicity; chromium can be a hazard to aquatic life and is one of the 65 toxic pollutants listed in a Consent Council Degree Court order. Chromium, salts are used in many industrial processes, including electroplating, tanning and textile manufacturing. Other sources include cooling towers, paints, fungicides and wood preservatives. Chromium occurs in several valence states, of which the trivalent and hexavalent forms are biologically and environmentally significant, although they differ in chemical characteristics **(Chervinski, 1982, Daoust et al., 1984, Claude, 1990, El Bauhy et al., 1994)**.

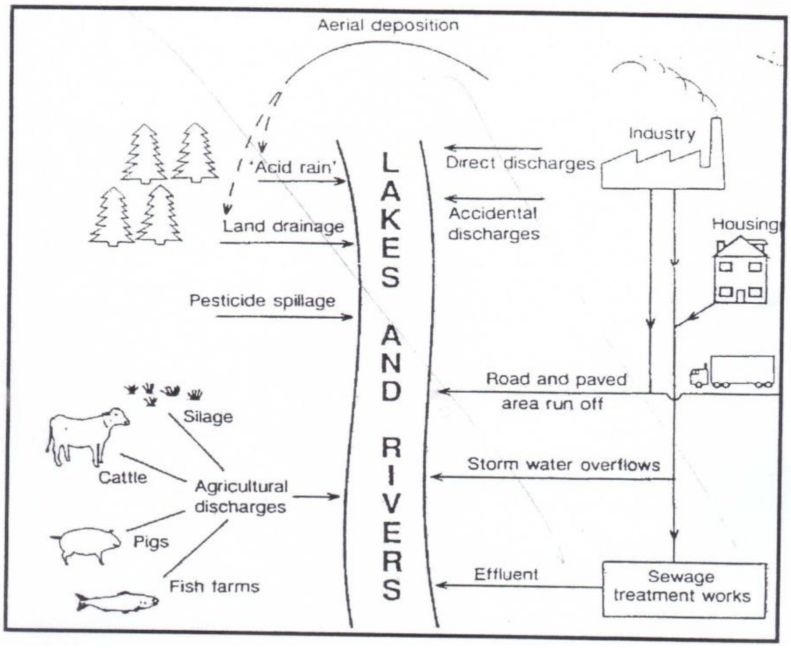

Figure 1: Sources of chemical inputs into freshwater.

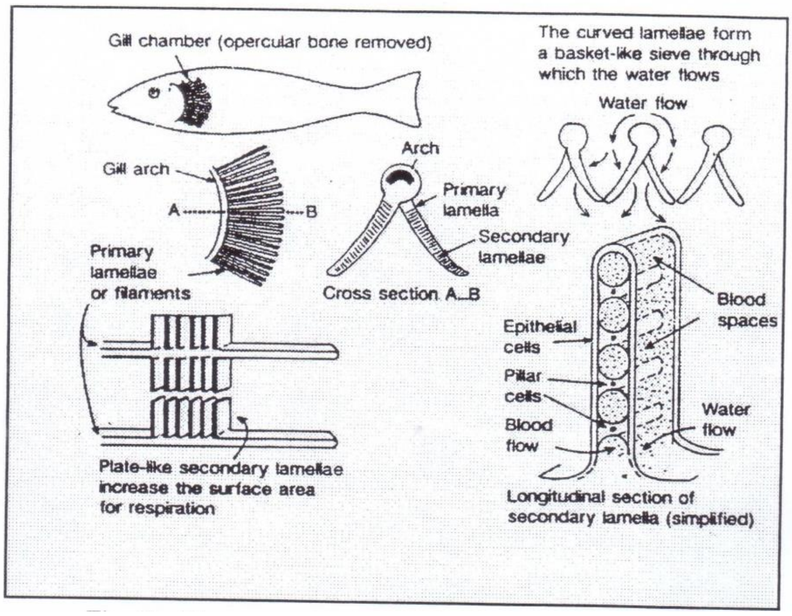

Figure 2: Diagrammatic description of fish gill structure.

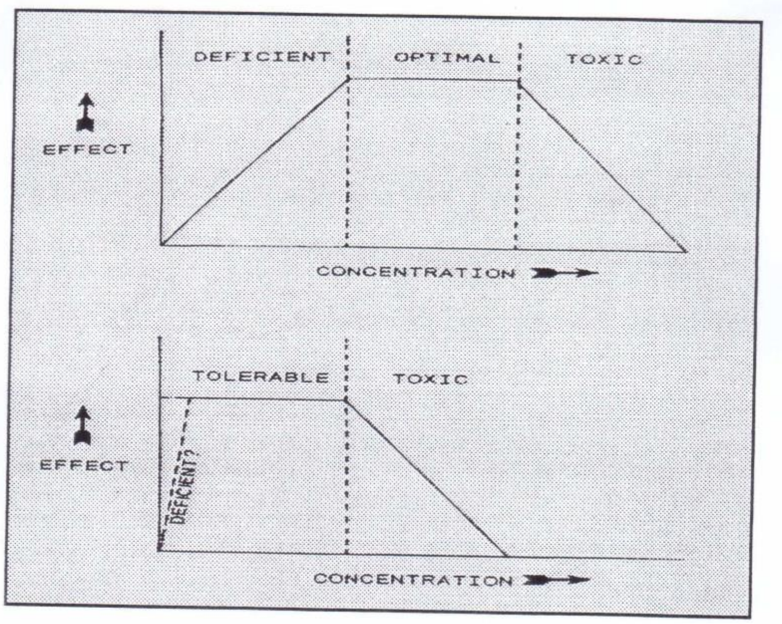

Figure 3: The effect of increasing availability of trace metals (top). In small amounts, the metal produces deficiencies in the organism, but at high concentrations the same metal may produce toxic effects

CONCLUSION

Water pollution is considered a devastating problem in the world especially in the developing countries including Egypt. Industrial effluents are harmful for aquatic life and agriculture land with secondary effects on human health. There is a problem of monitoring the concentration of chemicals in the aquatic environment in order to check that water quality standards are being met. Both chemical and biological methods have their limitations, but paradoxically their effectiveness will be increased as shortcomings are fully recognized. There is no method of legislation and enforcement that can guarantee the safety of fish from pollution; there is always the problem of unidentified and unsuspected substances which can cause harm. But when properly used the method of control can go a long way towards protecting fish from known causes of harm. Perhaps the best guarantee of success will be a general public acceptance that a flourishing fish community is an important measure of an acceptable quality of water in our rivers, lakes and seas. This will then put the responsibility on the fisheries managers to define the status of the fish population which they would expect to find in their water, so that deviations attributable to chemical pollution specifically heavy metals can be identified. But it must be emphasized that chemical pollution is only one way whereby man's activities can affect the wellbeing of fish. The most common is human wastage that contains different kinds of pathogen; and is considered the major contributor that affects health of people and organisms if drained in any water course. Well treated sewage is highly recommended before being discharged, as well as, properly chlorination of water. Continued vigilance and the further acquisition of knowledge on the totality of environmental effects will be required in order to protect the fish communities that form a most valuable andprecious resources in our river, lakes and seas. The only certain way to protect the quality of aquatic environment is to reduce all discharges and man-made inputs to a minimum and ideally to zero, however, this is clearly not a realistic goal. Therefore, researches should continue to be directed towards reducing the uncertainties that exist at present and considerable progress has been made in recent years in quantifying the effects of mixture of heavy metals on fish that bring new insight into the types of their toxicity and the prediction of their concentrations that have a harmful effects.

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