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Review Article

CONTAMINATION OF POLYCHLORINATED BIPHENYLS IN FISHES LEADING TO TOXICITY IN FISH CONSUMING POPULATION

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ABSTRACT
The pollution of rivers and streams with chemical contaminants has become one of the most critical environmental problems. Similar to humans and other species of animals, fish have also been found to be polluted with a large number of pollutants/contaminants. Unintentionally added chemicals causing fish toxicity include organochlorine pesticides, polychlorinated biphenyls (PCBs) and other persistent chemicals in feed, chemicals in construction materials, and metabolites and degradation products of intentionally added chemicals. High levels of PCBs have been reported in farmed fishes. The fishes caught in highly polluted water could cause cells of some kinds of cancers to multiply rapidly. The PCBs are persistent environmental contaminants that are ubiquitous in the environment due to intensive industrial use. Many PCB congeners persist in ambient air, water, marine sediments and soil at low levels throughout the world. Humans may be exposed to detectable quantities of PCBs when they eat fish, use fish oils in cooking, or consume meat, milk or cheese. The general population is exposed to PCBs by inhaling contaminated air and ingesting contaminated water and food. The toxic responses to PCBs are dermal toxicity, immunotoxicity, carcinogenicity, and adverse effects on reproduction, development and endocrine functions. Epidemiological studies indicate that consumption of background levels of PCBs may cause slight but measurable impairments in physical growth and learning behaviour in children.
KEYWORDS: Contamination, environmental pollutants, fishes, humans, polychlorinated biphenyls (PCBs), toxicity.

INDRODUCTION

Fish are exposed from different environmental pollutants, drugs and chemicals. Fish are widely used to evaluate the health of aquatic ecosystems because pollutants build up in the food chain, and are responsible for adverse effects and death in the aquatic systems. Communities that relied on fish intake for daily nutrient sustenance may be at risk from chronic, high exposure to persistent organic environmental pollutants[1]. Like humans and other species of animals, fish have also been found to be polluted with a large number of pollutants/contaminants. Unintentionally added chemicals causing fish toxicity include organochlorine pesticides, polychlorinated biphenyls (PCBs) and other persistent chemicals in feed, chemicals in construction materials, and metabolites and degradation products of intentionally added chemicals. High levels of PCBs, dioxins and other contaminants have been reported in farmed salmon. The fish caught in highly polluted water could cause cells of some kinds of cancers to multiply rapidly. The extracts from catfish caught from water high in sewage and industrial waste caused breast cancer cells to multiply[2].

The PCBs are persistent environmental contaminants that are ubiquitous in the environment due to intensive industrial use. PCBs were used as commercial mixtures (Aroclors) that contain up to 209 different chlorinated biphenyl congeners, which are structurally similar compounds that vary in toxicity. A smaller subset of 50 to 60 congeners is commonly found in Aroclor mixtures[3]. PCBs' lipophilic character and resistance to metabolism enhances concentration in the food web and exposure to humans and wildlife. Because PCBs do not burn easily and are good insulators, they were commonly used as lubricants and coolants in capacitors, transformers and other electrical equipment. Over the years, PCBs have been spilled, illegally disposed, and leaked into the environment from transformers and other electrical equipment. PCBs in the environment have decreased since the 1970's but are still detectable in our air, water, soil, food and in our bodies. Lower chlorinated PCBs are more easily broken down in the environment, while adsorption of PCBs generally increases as chlorination of the compound increases. The highly chlorinated Aroclors resist both chemical and biological degradation in the environment. Microbial degradation of highly chlorinated Aroclors to lower chlorinated biphenyls has been reported under anaerobic conditions, as has the mineralization of biphenyl and lower chlorinated biphenyls by aerobic microorganisms. Although they are slow processes, volatilization and biodegradation are the major pathways of removal of PCBs from water and soil, and volatilization is more significant for lower chlorinated congeners. Many PCB congeners persist in ambient air, water, marine sediments and soil at low levels throughout the world. In Puget Sound and other water bodies, sediment-associated PCBs are accumulated in the bodies of aquatic organisms, which are in turn consumed by creatures higher in the food web. Fish, birds and mammals tend to accumulate certain congeners in their fatty tissues[4].

PCBs can biomagnify in fresh and salt water ecosystems. Humans may be exposed to detectable quantities of PCBs when they eat fish, use fish oils in cooking, or consume meat, milk or cheese. The half life of PCBs in humans is estimated to be 2 to 6 years[5]. The pollution of rivers and streams with chemical contaminants has become one of the most critical environmental problems. An example of the effect of environmental pollution on nutrition is contamination of fish by polycyclic aromatic hydrocarbons (PAHs)[6]. The general population is exposed to PCBs by inhaling contaminated air and ingesting contaminated water and food. The dominant source of PCBs to humans is through consumption of meat, seafood and poultry. Of particular concern to this report is the exposure to citizens from consumption of fish. Some groups may consume greater amounts of fish than others; for example, Native Americans, Asian immigrant populations and sport anglers are three groups with high rates of seafood ingestion in the Puget Sound area[7-10]. Fish is an essential component of the diets of certain local minority populations and Native Americans, and these persons also eat fish that have higher levels of contaminants. However, knowledge of and adherence to health advisories for sport-caught fish differs by population. An epidemiologic study of Native American men found that 97% were aware of the advisories regarding eating local fish[11]. The knowledge of fish advisories may be low among minority populations, and that these populations tend to consume fish that have higher levels of contaminants (e.g., catfish and buffalo)[12].

In view of the above facts, the present article has been aimed to emphasize about the contamination of PCBs in fish and their toxicities to fishes as well as to fish-consuming population (i.e., humans).

TOXICITY AND HEALTH EFFECTS OF POLYCHLORINATED BIPHENYLS

The toxic responses to PCBs are dermal toxicity, immunotoxicity, carcinogenicity, and adverse effects on reproduction, development and endocrine functions. Many epidemiological studies indicate that consumption of background levels of PCBs may cause slight but measurable impairments in physical growth and learning behaviour in children[13]. The PCBs are probable human carcinogens and assigned them the cancer weight-of-evidence classification B_2 based on animal studies. Human studies are being updated; current available evidence is inadequate but suggestive regarding cancer to humans. The upper bound cancer slope factor for PCBs is 2.0 (mg/kg/day)-1. Some information on pattern changes is available from studies in the Great Lakes[14]. The early human effects observed from exposure to PCBs within the Great Lakes and St. Lawrence River basins have been reported[15]. More recent research findings support these earlier reports of an association between consumption of contaminated Great Lakes sport fish and body burdens of PCBs. The PCB body burdens of fish-consuming populations in the Great Lakes basin who eat this fish are two-fold to four-fold higher than those in the overall US population. At-risk populations (i.e., Native Americans, sport anglers, the elderly pregnant women, and foetuses and nursing infants of mothers who consume contaminated Great Lakes fish) continue to be exposed to PCBs and other persistent substances such as dioxins, chlorinated pesticides and mercury. Persons who ate Great Lakes sport fish for more than 15 years have 2 to 4 times more pollutants in their serum than non-fish eaters[16]. Men annually consumed more fish than women. The amount of fish consumed determines the level of exposure; fish consumption appears to be the major pathway of exposure; and a significant trend of increasing body burden is associated with increased fish consumption. Thus, the primary pathway of exposure to persistent toxic substances (e.g., PCBs) is from fish consumption[11]. Persons who eat sport-caught fish consumed 2 to 3 times more fish than the overall US population[11,16]. Women ate fish obtained from the Great Lakes during most of their reproductive years[12].

The investigators indicated that the reduction in breast milk PCB concentrations over time paralleled a corresponding decrease in local fish consumption by the tribal women, and they concluded that this reduction in fish consumption might have resulted from the fish advisories that were issued recommending against the consumption of local fish by pregnant and nursing women. Their data indicated that 95% of both men and women in the tribe are aware of these advisories and that 66% of men and 40% of women have changed fish consumption patterns[17]. The PCB blood levels of the frequent fish consumers have been found to be significantly associated with non-Hodgkin's lymphoma[18]. It has been reported that PCBs would contribute the majority of the non-cancer risks from Great Lakes fish consumption, although organochlorine pesticides could contribute some to the overall risk[19]. There has been found a modest association of sport-caught fish consumption with the risk for conception failure in men[20]. It was observed that the women who had regularly eaten PCB contaminated fish during the preceding 7 years had their shorter menstrual cycles. The frequency of fish consumption and an index of a lifetime of PCB exposure appear to have a stronger relationship with menstrual cycle length than the number of years of fish consumption[21]. A study was conducted on the pregnant women and the effects of maternal exposure to PCB contamination in fish on their newborns. The investigators found that in utero, the exposure was associated with neurobehavioural deficits that can be assessed soon after birth. The newborns of mothers in the high-exposure category exhibited a greater number of abnormal reflexes, less mature autonomic responses, and less attention to visual and auditory stimuli in comparison with newborns of low- or no-fish-consuming mothers, after adjustment for a variety of potentially confounding factors[22]. Further, the Michigan investigators found that the infants born to mothers who had eaten the greatest amount of PCB contaminated fish during pregnancy had more abnormally weak reflexes, greater motor immaturity and more startle responses, and less responsiveness to stimulation[23].

A follow-up examination of children indicated that the neurodevelopmental deficits found during infancy and early childhood still persisted at age 11 years. The children had been exposed in utero through the consumption of PCB-contaminated fish by their mothers during the 6 years before and during pregnancy. After adjustment for many confounding factors, including maternal alcohol consumption, cigarette use, socioeconomic status, maternal age, parity of the mother and exposure to lead and mercury, the results indicated that the most highly exposed children (based on maternal milk PCB concentration) were three times more likely than controls to have low full-scale verbal IQ scores, were twice as likely to lag behind at least 2 years in reading comprehension and have difficulty paying attention. These intellectual impairments were attributed to in utero exposure to PCBs and to related contaminants at concentrations slightly higher than those found in the overall population[24]. The findings of early nervous system dysfunction among adults exposed to PCBs and other persistent toxic substances have also been reported. The findings suggest that nervous system alterations are associated with eating PCB-contaminated fish, and that the deficit increases with consumption[25]. The investigators have concluded that the Native Americans in their study tended to be higher consumers of fish, have elevated levels of mercury and PCBs in comparison with the overall population, and may be at higher risk for health effects[26].

CONCLUSION

High levels of PCBs have been reported in farmed fishes. The fishes caught in highly polluted water could cause cells of some kinds of cancers to multiply rapidly. Humans may be exposed to detectable quantities of PCBs when they eat fish, use fish oils in cooking, or consume meat, milk or cheese. The toxic responses to PCBs are dermal toxicity, immunotoxicity, carcinogenicity, and adverse effects on reproduction, development and endocrine functions. Consumption of background levels of PCBs may cause slight but measurable impairments in physical growth and learning behaviour in children. The PCBs are probable human carcinogens. The PCB blood levels of the frequent fish consumers have been found to be significantly associated with non-Hodgkin's lymphoma. Keeping these facts in mind, the consumption of PCB-contaminated fish must be avoided by the fish-consuming population.

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