Mercury in the Everglades

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Abstract:

Water quality conditions in the Everglades are affected by mercury , the accumulation of mercury in aquatic ecosystems is of global concern due to health effects associated with eating fish with elevated Hg levels. Mercury contamination has been recognized as a critical health issue for humans and wildlife that consume fish from the Everglades. The state of Florida has advisories that restrict consumption of some species of fish Methylmercury is also produced naturally from inorganic mercury in the aquatic environment by bacteria in sediments under conditions devoid of dissolved oxygen. Once produced, is readily taken up but eliminated by fish . This results in a phenomenon referred to as bioaccumulation. The ratio of the methylmercury concentration in a fish to the concentration in the surrounding water is its bioaccumulation factor (BAF). Fish will bioaccumulate higher concentrations of methylmercury, this results in a phenomenon referred to as biomagnification

Keywords: Everglades, mercury, contamination, bioaccumulation, biomagnification.

Introduction

The element mercury (Hg) is naturally present in the earth's crust. Pure elemental mercury, which is a silver colored liquid metal at room temperature, is obtained by smelting its most abundant ore, mercuric sulfide or cinnabar. Pre-industrial human uses of mercury were surprisingly significant, with the ancient Romans reported to have used more than two tons per year. Modern human uses of mercury include gold mining, chlor-alkali production, batteries, turf and seed treatments, contact explosives, silent and pressure switches, thermometers and manometers, fluorescent lights, house paints, and fillings for dental cavities

Mercury is a liquid metal at ambient temperatures and pressures. It forms salts in two ionic states. Mercury salts are much more common in the environment, and if soluble in water are bioavailable and considered toxic. Mercury also forms organometallic compounds, many of which have industrial and agricultural uses.

The toxicity of mercury salts and elemental mercury to humans has been known since the dawn of history. Toxicity to humans increases with the form of mercury in the order inorganic mercury salts, elemental mercury vapor, and methylmercury salts. Inorganic mercury and methylmercury are also highly toxic to wildlife species

The Everglades appears to be especially susceptible to a methylmercury problema because have the highest average concentrations of mercury of any area in Florida.

The Everglades

The Florida Everglades is among the largest freshwater wetlands in the world. It covers a region about 60 Km wide by 160 Km long and extends south of Lake Okeechobee to Florida Bay*)*.

The Everglades ecosystem has been greatly altered during the last century to provide for urban and agricultural development, which has severely impacted this ecosystem.

In 1948, the Central and Southern Florida Flood Control Project was created by federal legislation in response to periods of drought in the 1930s and 1940s, and severe flooding with loss of human life in the 1920s and 1940s. This project is one ofthe most intensive public water management systems constructed that effectively provides flood control and water supply to facilitate urban and agricultural growth, as intended. The canal system quickly drains water from developed areas and the wetlands that remain.

The result is that some areas are too wet while other areas are too dry. Historically, most water slowly flowed across or soaked into the region's vast wetlands. Today, over one-half ofthe region's wetlands have been irreversibly drained. South Florida's population of about six million continues to grow and compete for the land and water of the Everglades ecosystem. One-fourth of the historic Everglades are now in agricultural production: sugar cane and vegetables are grown on the peat soils of drained sawgrass marshes. An extensive system of canals, levees, and water control structures have modified the Everglades water conditions and it is thought to provide a conduit for pollutant transport from urban and agricultural áreas

Mercury Problem

In the last two decades there has been an increased awareness of mercury contamination of game fish and wildlife in the Florida Everglades. About one million acres of the Everglades system reportedly contained large mouth bass with mercury concentrations above 2 mg/Kg double the FDA limit for human consumption. In addition, mercury accumulation may reduce the breeding success of fish-eating birds and an endangered Florida panther was found dead with a high liver methylmercury concentration of 110 ppm. In response, fish consumption advisories have been issued for almost the entire Everglades system.

To understand the biogeochemical cycling of mercury in the Everglades ecosystem, it is necessary to understand the processes and factors influencing the flux of mercurythrough this system. The mercuric ion is the predominant species in the Everglades aquatic environment. However, sulfate-reducing bacteria can transform inorganic mercury into methylmercury. Various hypotheses have been formulated to account for the apparent susceptibility of the Everglades to mercury impacts , including a high rate of net methylation of mercury and a high bioavailable fraction of methylmercury.

The sources, distribution, transport, transformations and pathways of mercury through the Everglades are not well understood. Among the possible mercury sources are natural mineral and peat deposits, atmospheric deposition, local emission sources such as medical and municipal waste incinerators, regional air emissions sources such as power plants, and local water sources such as agricultural runoff.

Sources of Mercury

Mercury in the natural environment originates in the soils and sediments deposited with the formation of the earth's crust and the early atmosphere. A significant source of atmospheric mercury is the natural evasion of elemental mercury from the surface of soil and water. Deposition from the atmosphere back to the earth's surface completes this cycle and ensures a continuous supply of newly available inorganic mercury for biogeochemical transformation, including formation of elemental mercury and methylmercury.

In addition to its natural background sources, atmospheric mercury is generated by a variety of human activities, including combustion of fossil fuel and waste, mining and smelting of mineral ores, and the use and disposal of mercury itself . Mercury may be removed from the air and deposited on water, soil, or plant surfaces in wet deposition (rain or snow) or dry deposition (particle settling and gas adsorption to the solid or liquid surface). Although the relative proportions may change depending on the source, mercury exists in the atmosphere in three forms, which differ greatly in their air chemistry and in the physical properties that determine their rates of removal from air by wet and dry deposition processes.

Cycling of Mercury

Mercury is found in aquatic ecosystems in three forms. In descending order of occurrence they are inorganic mercury, Hg, methylmercury, and elemental mercury. Once present in an aquatic environment, inorganic mercury can be converted to methylmercury by microbially mediated processes in the water but more often in the sediment.

Methylmercury is absorbed across the gut from food items . The most significant route of loss of methylmercury from fish is believed to be across the gill membrane. As a consequence, methylmercury is only slowly excreted by fish too.

Because the methylmercury depuration rates decrease and bioaccumulation factors increase with increasing size in fish and age in fish and also the average fish size increases with each trophic level , large, top predator fish will bioaccumulate methylmercury up to several million times the concentration in the water column, as is the case for several species of top predator fish at some locations in the Everglades. A number of environmental factors are believed to influence methylmercury bioaccumulation in fish in aquatic ecosystems. Methylmercury bioaccumulation tends to be higher in fish in waters with high temperature

The increase in methylmercury production first manifests itself as an increase in the methylmercury concentrations in water and the one-celled plants and animals that form the base of the food chain. This increase then propagates up the food chain with biomagnification at each link, peaking in top predator fish.

Human Health Effects from Everglades Mercury

Based upon current knowledge of mercury toxicity, there are no direct effects to human beings from drinking or contact with waters containing the levels of inorganic mercury and methylmercury that are found in the Everglades. The only quantitatively significant pathway for methylmercury to exert its toxic effects on humans by consumption of predators high in the food chain, which have bioaccumulated high levels of mercury. If humans, particularly pregnant women, were to eat sport fish from the Everglades, they would be at risk from methylmercury toxicity. Signs at some water access points warn of these effects. Literature prepared by the Game and Fresh Water Fish Commission for distribution with fishing licenses also contains these warnings.

No documented adverse human health impacts from environmental methylmercury exposures are known in South Florida. Studies of people eating fish caught in South Florida carried out by the University of Miami and the Centers for Disease Control found that mercury body burdens were proportional to fish consumed, but not sufficiently elevated to cause toxicity. However, these studies had limited representation of subsistence fishermen.

Solving the Everglades Mercury Problem

The solution to the Everglades mercury problem has several steps. The first step is to learn what level of mercury in fish is safe for both humans and wildlife. The second step is to learn what human actions are causing or contributing to the Everglades mercury problem. Potential causes include presentday atmospheric deposition, mercury in stormwater runoff and reentry into the ecosystem of mercury that was previously buried in Everglades peat soil. Potential contributing factors include changes in water quantity and quality that might liberate buried mercury for recycling in the Everglades or facilitate its accumulation in fish and wildlife. The third step is to understand how the Everglades processes inorganic mercury from atmospheric deposition, runoff, and peat soil into methylmercury, the most toxic form of mercury in the aquatic environment. The fourth step is to understand how to relate the quantities of inorganic mercury added to the Everglades ecosystem each year to the concentration of methylmercury in fish. This is to be done with mathematical models that represent all of the key processes governing methylmercury production and bioaccumulation. The fifth step is to determine the best way to reduce the levels of methylmercury in fish to safe levels by managing mercury sources and water quantity and quality using the model. Potential candidates for management are emissions from local air pollution sources, chemical constituents in stormwater runoff from the Everglades Agricultural Area, and water depth and flow.

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