Persistent organic pollutants (POPs): a global issue, a global challenge

Abstract

Since the Second World War, scientists have identified certain chemical contaminants that exhibit toxic characteristics and are persistent in the environment, bioaccumulative, prone to long-range atmospheric transboundary migration and deposition, and expected to impose serious health effects on humans, wildlife, and marine biota adjacent to and distant from their origin of emission. These chemical pollutants are referred to as persistent organic pollutants (POPs) (Ashraf et al. 2015).

POPs have long half-lives in soils, sediments, air and biota. No consensus exists on how long the half-life in a given medium should be for the word "persistent" to be applicable; nevertheless, the half-life of a POP might be years or decades in soil/sediment and a number of days in the atmosphere. Several thousand POP chemicals are known. Many of them are members of a definite series or "families" of chemicals. For instance, 209 diverse groups of polychlorinated biphenyls have been identified; they differ from each other by the level of chlorination and the substitution position (Jones and Voogt 1999). The carbon-chlorine bond is very stable toward hydrolysis and larger numbers of chlorine substitution and/or functional groups lead to greater resistance to biological and photolytic degradation. Because POPs break down very slowly, they will be present in the environment for a long time, even if all new sources are immediately eliminated (Chu et al. 2006).

POPs in the environment are transported at low concentrations by movement of fresh and marine waters; in addition, because they are semi-volatile, POPs are transported over long distances in the atmosphere. The result is widespread distribution of POPs across the globe, including regions where they have never been used (Buccini et al. 2003). The POP levels observed in the Arctic region are surprising to many people because some of these pollutants have been banned from the USA and Canada for

many years. POPs travel toward colder areas such as Alaska and then sink because of the colder temperatures. The settled contaminants remain in the area for a long period because the temperature does not allow them to easily breakdown. Consequently, they move from the air and water to soil and plants and then to animals and humans with ease. The persistence of contaminants in the Arctic from distant sources first came to light in the late 1970s when pesticides were found in polar bear fat tissue. The reality of atmospheric POPs and their effects on wildlife and human health then became evident. In addition to the Arctic, researchers have begun to search for evidence of airborne POPs in other cold ecosystems and mountain environments (Zhao et al. 2007).

POPs are usually hydrophobic (i.e., "water-hating") and lipophilic (i.e., "fat-loving") chemicals. In marine and terrestrial systems, they bind strongly to solids, particularly organic matter, evading the aqueous segment. They also enter the lipids of organisms more easily than the inside of the aqueous medium of cells and are stockpiled in fatty tissue. This stockpiling in fatty tissue allows the compounds to persevere in biota, where the metabolism rate is low. Consequently, POPs may climb the food chain. POPs tend to move in the gas phase under environmental temperatures. Therefore, they may volatilize from soils, vegetation, and aquatic systems into the air and, because of their resistance to breakdown reactions in air, migrate long distances before being re-deposited. The sequence of volatilization and condensation can be repeated frequently; as a consequence, POPs are detected in regions far removed from where they were used or discharged. POPs can partition between particles and aerosols in the air and are reliant on ambient temperature and the physico-chemical characteristics of the substances. In summary, the combination of permanency and the tendency to form a gas under suitable environmental conditions causes POPs to migrate long-range atmospheric distances. The combined effects of confrontation, metabolism, and lipophilicity result in the accumulation of POPs in food chains (Jones and Voogt 1999).