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Review

Endocrine disrupting chemicals in the atmosphere: Their effects on humans and wildlife

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ABSTRACT

Endocrine disrupting chemicals (EDCs) are exogenous agents that interfere or disrupt the normal synthesis, secretion, transportation, binding and metabolism of natural hormones; eventually dysregulating homeostatic mechanisms, reproduction and development. They are emitted into the atmosphere during anthropogenic activities and physicochemical reactions in nature. Inhalation of these EDCs as particulate and gaseous vapors triggers their interaction with endocrine glands and exerts agonist or antagonists actions at hormone receptors. The endocrine disruption at nanogram levels of EDC's has gained concern in the last decade, due to infertility among men and women, early puberty, obesity, diabetes and cancer. Thus, the review explores the literature that addresses the major occurring EDCs in the atmosphere including phthalates, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), brominated flame retardants (BFRs), dioxins, alkylphenols (APs) and perfluorinated chemicals (PFCs). Sources, fate, half-life, mechanism, measured concentrations in air, bioaccumulation in tissues, laboratory exposures correlating to toxicological effects of these EDCs in humans and wildlife are discussed.

Contents

Abbreviations: EDCs, endocrine disrupting chemicals; PCBs, polychlorinated biphenyls; PAHs, polyaromatic hydrocarbons; BFRs, brominated flame retardants; Aps, alkylphenols; PFCs, perfluorinated chemicals; POPs, persistent organic pollutants; ER, estrogen receptor; NOAEL, no observed adverse effect level; LOAEL, lowest observed adverse effect level; MRL, minimal risk level; AhR, aryl hydrocarbon receptor; TEF, toxic equivalency factor; TEQ, toxicity equivalence; TDI, tolerable daily intake; OSHA, occupational safety and health administration; PEL, permissible exposure limit; TCDDs, tetrachlorinated dibenzo-p-dioxins; APEs, alkylphenol polyethoxylates; NP, nonylphenol; PFAAs, perfluoroalkylated acids; PFOA, perfluorooctanoic acid; PFOS, perfluorooctanesulfonic acid; FASAs, perfluorinated sulfonamides; FASEs, perfluorinated sulfonamide ethanols; N-Et-FOSA, N-ethyl perfluorooctane sulfonamide.

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1. Introduction

During the 20th century, a number of synthetic chemicals were developed to meet a wide variety of medical, scientific, agricultural and industrial needs. Though these chemicals provided economic and social benefits, their disposal led to the release of many chemicals into the environment (UNEP, 2004). Inhalation of such chemicals present in the atmosphere as pollutants is recognized as the major cause of environmental health problems (Al-Hamad et al., 2008). Combustion of municipal solid wastes, automobile exhausts, spraying of pesticides and herbicides, flaring activities, volatilization of synthetic chemicals, application of air fresheners, hair sprays, cosmetics and other activities release EDCs into the atmosphere as aerosols, dusts and particulates (Lintelmann et al., 2003) (Fig. 1).

The public concern about the impacts of EDCs on both human health and environment grew particularly during the last few decades. This was mainly focused on the endocrine system which is liable for disruption at many potential points by diverse group of chemicals (EFSA, 2013). The mechanism in disruption involves agonist or antagonist action for the receptors, interference of metabolic pathways and other bodily actions. Eventually turning on, shutting off or modified hormonal signals occur leading to decreased fertility, increased birth defects, altered sexual expression, and certain types of cancers (UNEP/WHO, 2013).

Aimed at highlighting the consequences of continued global industrialization stretches, the article offers a review about sources, fate, half-life, mechanism, molecular response, impending consequences, bioaccumulation and negative impacts on humans and wildlife due to EDCs present in the atmosphere. We have reviewed eight major endocrine disruptors of different classes affecting the atmosphere including phthalates, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, dioxins, brominated flame retardants, pesticide, alkylphenols and perfluorinated chemicals.

2. Fate and half-life of EDCs

The fate and half-life of EDCs depend on their physicochemical properties and the nature of environment they reside in (Wiberg et al., 2009). Persistent organic pollutants (POPs), EDCs are truly multimedia contaminants occurring in all parts of the environment: atmosphere, inland waters, sea waters, sediments, soils and vegetation (Wang et al., 2012). Global transport of EDCs occurs mainly through long range atmospheric and ocean water routes making their presence ubiquitous even in remote regions like the Arctic (Lohmann et al., 2007). In the environmental compartments, the EDC distribution is governed by three equilibrium partitioning coefficients: air–water, water–octanol and octanol–air. Most of the EDCs in the atmosphere are present in gaseous phase, while a few sorb onto suspended and few sorb to particles due to their semi-volatile nature. They are transported by dry and wet gaseous vapor deposition, volatilization, sorption, dissolution, sedimentation, re-suspension and erosion in the environment (Martina et al., 2013).

Natural removal of EDCs from the atmosphere is induced by both biotic and abiotic processes (Fig. 2). Biotic process involves microbial degradation in surface waters, soil and sediments; abiotic process includes: hydrolysis, direct and indirect photolysis, and oxidation/reduction reactions. EDCs that accumulated in soil and sediment are potentially volatilized back to the atmosphere when levels in the air are reduced (Lohmann et al., 2007). EDCs in water partition into particles and dissolved phases that deposit to bottom sediments or taken up by aquatic biota. From the sediment, EDCs are transported back to the water column via diffusion or resuspension (Lohmann et al., 2007). During these environmental cycling, certain EDCs enter the food chain and bioaccumulate in tissues through inhalation and ingestion causing endocrine disruption of the system.

3. Mechanism involved in endocrine disruption by EDCs

Human and wildlife exposure to atmospheric EDCs occur via inhalation and dermal contact. In vivo studies predict numerous mechanisms to be involved in the disruption of the endocrine system by the activation of receptors at nanomolar (nM) levels and non-genomic pathways at micromolar (mM) levels resulting in the genomic instability and alteration in hormone feedback regulation (Iguchi and Katsu, 2008). In a biological system, the gene networks and target cell activities are controlled by hormones through the activation of nuclear receptors and by binding to the responsive elements in the promoter of target genes. Such activation of receptors is disrupted by EDCs that mimic endogenous hormones and bind to ligands resulting in conformational changes

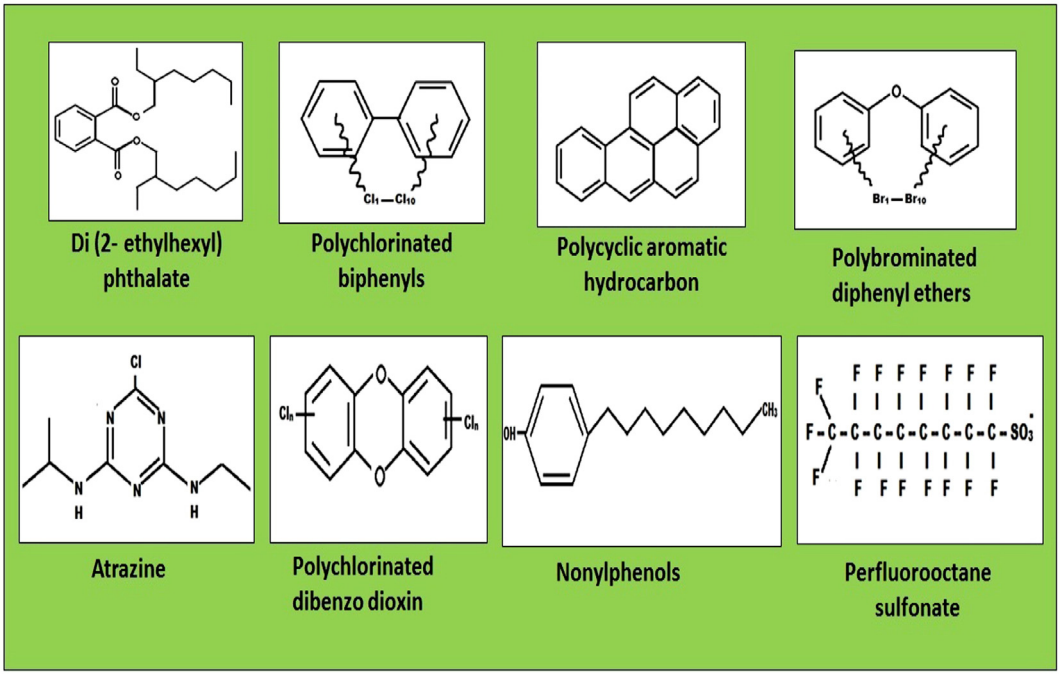

Fig. 1. Major EDCs present in the atmosphere.