Trace Organic Compounds

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New organic chemicals (compounds that contain carbon and at least one hydrogen) are being synthesized in ever-increasing numbers. The mass of synthetic organic chemicals produced increased from ~50 million tons to ~150 million tons between 1970 and 1995 (Goldman, 2002). Our society relies on organic chemicals for use as food additives and in cleaning products (detergents, dry-cleaning chemicals), personal care products (toothpaste, soaps, shampoos, etc.), cosmetics, pharmaceuticals, pesticides, and transportation-based industries (gasoline, diesel, asphalt). Organic chemicals play huge roles in peoples' lives and provide benefits to society.

However, many of these organic chemicals have been associated with risk to human health and the environment (Pierzynski et al., 2010). Of the detrimental effects that can be exerted by organic chemicals, cancers of various types and interference with the function of the human endocrine system are some of the most deleterious. The endocrine system is made up of glands that secrete hormones that regulate the activity of cells or organs. Organic chemicals that disrupt endocrine systems often affect growth, reproductive, and immune functions.

Potential for contaminating our environment and impacting humans and other animals with organic chemicals occurs via industrial discharges to air and water, everyday use of products that include organic chemicals, and accumulation of these compounds in land-applied manures, biosolids, and industrial sludges. The most direct and impactful exposure to organic compounds is likely via the use of pharmaceuticals and personal care products (PPCPs) and detergents at home (Pierzynski et al., 2010).

Organic chemicals enter wastewater treatment plants from both industries and households. Examples of organic chemicals include:

- Polycyclic aromatic hydrocarbons (PAHs): burning of fossil fuels (coal, oil, gasoline, and wood).
- Polychlorinated dibenzo-p-dioxins (PCDDs) and Polychlorinated dibenzofurans (PCDFs), commonly called dioxins: incineration and chemical manufacturing sources.
- Polychlorinated biphenyls (PCBs): leaks of electrical transformers, disposal of PBC-containing consumer products.
- Polychlorinated n-alkanes (PCAs) or chlorinated paraffins: lubricant additives, plasticizers, flame retardants, and paint additives
- Pesticides: agriculture and urban pest management.
- Polybrominated diphenyl ethers (PBDEs): flame retardants or compounds that leach from plastics
- Bis (2-ethylhexyl) phthalate (DEHP): plastics, tablecloths, floor tiles, scented candles, and air fresheners.
- Detergent residues
- Pharmaceuticals and personal care products (PPCPs): including antibiotics, endogenous hormones, and synthetic steroids.
- Perfluorooctanoic acid (PFOAs) and perfluorooctane sulfonate (PFOS): fluorinated compounds that repel oil and water, used in many industrial and consumer products such as carpet and clothing treatments and firefighting foams.

What happens to organic chemicals in biosolids?

- They can degrade through wastewater treatment processes
  - Some organic chemicals, such as solvent compounds (benzene, toluene, trichloroethane, etc.) are highly volatile and will most likely be lost in air during wastewater treatment or soon after land application, which makes them very unlikely to persist in the soil or cause adverse effects on human health with biosolids use (Semblante et al., 2015).
  - Other organic compounds can stay in the solids; however, many organic compounds are biodegraded through microbial decomposition processes during wastewater treatment such as aerobic and anaerobic digestion (Semblante et al., 2015).
  - Some organic compounds, such as PCBs and dioxins, have been phased out and are no longer a concern for biosolids use.
  - Studies on new organic chemicals of concern, such as PPCPs, have shown a wide variety of biodegradability. For instance, some bacteria has shown to completely degrade 17-ethinylestadiol (estrogen medication used widely in birth control pills) in biosolids, while other bacteria has been able to degrade 60% of the same compound (Larcher et al., 2013).
  - Composting might be one of the best ways to degrade organic chemicals in biosolids, as composting has shown significant degradation of both dissolved and sorbed organic chemicals (Xia et al., 2005; Semblante et al., 2015)
- They can degrade and become less available after land application
  - Sorption to soil particles and organic matter can reduce organic chemical bioavailability.
  - Sunlight and heat may also help degrade organic compounds in the soil.

However, the specific chemical structures and properties of organic chemicals can affect their degradation and movement in the environment, making them either more or less bioavailable for microbe and plant uptake, as well as human exposure. For instance, while many studies have shown that degradation of organic chemicals in the soil significantly decrease their bioavailability for plant uptake, a few organic chemicals such as carbamazepine and triclosan have been detected in plant tissues (Wu et al., 2015).

Risk assessment

The U.S. EPA has screened organic chemicals in biosolids and evaluated pathway risk for environmental and human exposure. The impact of these organic chemicals on health was assessed based on their potential to cause cancer in humans from continual exposure. Results from risk assessment showed that the regulation of these organic chemicals in biosolids applied to land was not necessary because 1) the pollutants had very low levels of detection according to the results of the National Sewage Sludge Survey, 2) the pollutant had been banned, restricted or not used anymore in the USA, and/or 3) the concentration of organic chemicals in biosolids did not exceed limits for toxicity of these organic chemicals according to exposure assessments(U.S. EPA, 1995).

In the early 2000s, the U.S. EPA conducted second round of screenings to determine levels of pollutants of concern including dioxin-like compounds such as polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and dioxin-like coplanar PCBs in biosolids that were land applied. Risk assessment showed that land applied dioxin-like compounds did not pose a significant risk to human health or the environment; thus, the U.S EPA final decision was to not regulate dioxin-like compounds on biosolids because existing regulations already adequately protect human health and the environment to limit exposure to these pollutants (U.S. EPA, 2003). In addition to U.S. EPA risk assessments, the available research reported to date has determined that human exposure to new organic chemicals such as PPCPs is likely very small through the consumption of crops grown in biosolids-amended soils, representing a minimum risk to human health (Wu et al., 2015).

Organic chemicals of recent concern that have been in use for more than 50 years are perfluoroalkyl acids (PFAAs). These organic chemicals can be present in biosolids and other residues such as paper mill, and there are concerns with regards to how these organic chemicals impact the environment and human exposure after land application of biosolids. While small amounts of PFOA and PFOS have been found in biosolids, the fact is that most human exposure to many of these organic chemicals occurs in the environment we live in, and through objects we use such as cooking tools, carpets, furniture, outdoor clothing, among others. However, researchers and biosolids managers are currently in the processes of studying and further understanding the presence and movement of PFOA and PFOS from biosolids after land application in order to reduce any potential risks to the environment (NEBRA, 2017).

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