

VOCs and POPs are two of the most insidious forms of toxic contamination which are now thought to affect almost all human beings and, potentially, all life on earth. They may well play a role in the modern epidemic of cancers, diabetes and chronic disease.

VOCs, or volatile organic compounds, are organic chemicals that can vaporise, pollute the air and be absorbed or inhaled by humans, animals and plants. They are generally man-made carbon-based molecules such as paint thinners, dry cleaning fluid, nail polish remover, grease solvents and the emissions of crude oil, fuels and plastics. However, trees also give off natural VOCs such as terpenes and isoprenes – the characteristic eucalyptus smell of summer or the turpentine smell of fresh pinewood.

POPs, or persistent organic pollutants, are also carbon-based organic compounds that have the special abilities to be long-lasting and to resist breakdown into safer substances. Because of this, they persist in the environment, can move over immense distances in air or water, can build up in human or animal fat, and can accumulate in food chains with serious consequences for health and the natural environment. POPs are often solvents, pesticides or the by-products of industrial processes. POPs are nicknamed ‘poisons without passports’ because they ride around on air and sea currents without breaking down.

Some substances are both VOCs and POPs. The banned pesticide DDT, for example, can both vaporise under warm conditions and lasts for many years in the environment or in human and animal fat.

Air pollution

Air pollution consists of toxic gases and vapours, particulate matter (smoke or dust) and disease-causing organisms. It is a major killer, especially in cities and in developing countries.

Both VOCs and POPs contribute to air pollution, especially VOCs which are vapours. Air pollution is normally regarded as affecting outdoor air, especially in major cities and industrial centres with poorly controlled emissions.

However VOCs also are major contributors to indoor air pollution which causes ‘sick-building syndrome’ – persistent ill-health and time off taken by workers who are affected by their toxic work environment. VOCs can be released by photocopiers, carpets, paint and office furnishings either when they are new or when the substances in them oxidise. A notable airways irritant, formaldehyde, is emitted by many kinds of office equipment, including laminates, chipboard and plastic-coated furniture and wall covers. It also evaporates from paints, varnishes, and chemicals used for sealing. Tobacco smoke is another well-known source of high levels of VOCs. Sick-building syndrome is estimated to cost the Australian economy over \$12 billion a year.

For the same reasons, many homes today suffer from indoor air pollution at levels far higher than their inhabitants would encounter on the street, even in a polluted city. The US EPA has found indoor concentrations of VOCs to be generally 2–5 times higher than in outdoor air and on occasion up to 1000 times higher! Furnishing, paint, carpets, cleaning agents and plastic items are the major sources, but so are wood preservatives and pest treatments. Sometimes items made of plastic contain VOCs, but these do not emerge unless the plastic is warmed: summer can sometimes be the worst time for indoor air pollution, especially in climates where people keep buildings closed in order to air condition them.

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Global pollution

The key feature of POPs is that they persist – often for years, sometimes for decades, and are capable of long distance transport. They consist of molecules whose structure strongly resists breakdown by other chemicals, by bacteria or by light – which are the usual ways these chemicals are broken down into harmless substances.

This means POPs last for very long times in their toxic form in air, soil and water, where they may cause harm to humans, animals and plants; they often build-up – or bioaccumulate – in human and animal tissues especially in predators at the top of the food chain (which includes us); they can increase as they go up the food chain – or biomagnify – and as a result cause chronic or even acute poisoning.

One of the most striking features of POPs is the vast distances they can travel in air and water, attached to dust or soil particles, due to their hardness which makes many of them semi-volatile and insoluble. POPs produced by industrial society in temperate climates have been found even in places as remote as the Arctic and Antarctic and in the deep oceans. They have been identified in the tissues of animals, birds and fish as well as humans who live in the Arctic and feed off these creatures. Even though it was banned decades ago in most countries, the persistent pesticide DDT and its daughter products (e.g. DDE) have been found in the tissues of whales and dolphins as well as many humans.

Persistent poisons

Many POPs were originally designed as long-lasting pesticides at a time when this was thought to be a virtue. Others are by-products of industrial processes or used in the production of materials such as PVC (polyvinyl chloride) and pharmaceuticals. Almost all POPs have been created, deliberately or unintentionally, by humans.

Among POPs the most toxic compounds are known as the 'dirty dozen'. These are: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and toxaphene.

Exposure to POPs can occur through diet, through drinking water and air, the inhalation of dust, through infants eating contaminated soil, or by accidents. Exposure to these chemicals causes many forms of illness including disruption of the endocrine, reproductive and immune systems, nerve disorders, cancers (including, possibly, breast cancer) and they have recently been linked to diabetes. In acute cases they can cause death.

An unresolved issue is the health consequences of the 'cocktail' of these toxic substances to which many people are daily and continually exposed in the home, the workplace and in big cities.

Remediation

The most common way of cleaning up VOCs and POPs is to break them down into simple, harmless molecules, usually including carbon dioxide and water. To do this a wide range of techniques are used including chemical breakdown, treatment with heat or light and biodegradation, in which microbes use the pollutant as a food source and literally chop its molecules up into harmless fragments.

CRC CARE's role

CRC CARE scientists are at the cutting edge of devising ways to detect, measure and clean up POPs and VOCs. They are developing both new treatments, such as bacteria which break down organic compounds super-efficiently or the use of daylight to cleanse air in air-conditioning systems, and novel ways to deploy clean-up technologies, such as permeable reactive barriers, which are used to intercept and break down pollutants in flows of contaminated underground water.

CRC CARE is a partnership of organisations providing research, technologies and knowledge in assessing, preventing and remediating contamination of soil, water and air.

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