Chemicals in the environment

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Governments, intergovernmental bodies and community members have been increasingly aware of the presence in the environment of industrial chemicals. Some of these chemicals are unwanted by-products of industrial activity, while others have beneficial uses. Most concern is related to their persistence and their possible toxicity.

Substantial compilations of monitoring data are available for Europe and North America, but comparatively few data are available for Australia. Persistent organic pollutants like dioxins and polychlorinated biphenyls (PCBs), brominated flame retardants and a range of potential endocrine disruptors are fat-soluble and can spread widely in the environment and be concentrated at the top of the food chain, including humans. Inorganic pollutants like lead, arsenic and mercury – despite biomethylation of the latter – tend to have more local impacts.

Australia's National Dioxin Program reported in 2004 on concentrations of dioxins, furans and dioxin-like PCBs derived from limited sampling of agricultural commodities, human blood and breast milk, soils, sediments, air and fauna. The levels were generally low by international standards. The environmental risk assessment was hampered by lack of toxicological data for Australian animals, but concluded that only marine mammals living near industrial areas and some raptors were at risk.

Most human exposure to dioxin-like compounds is through the diet, with foods of animal origin such as meat, dairy products and fish being the main sources. For Australians aged 2 years or older, the estimated monthly intake of dioxins is 15.6 picograms TEQ/kg body weight/month, which is at the low end of the scale of levels reported internationally. The mean blood serum concentration across the population was 10.9 nanograms TEQ/kg of lipid (range: 4.6-28 ng TEQ/kg of lipid). In milk of Australian nursing mothers, collected over late 2001 to 2003, the mean concentration was 9.0 nanograms/kg of lipid. The levels were similar across all regions of Australia but low by international standards.

PCBs have been detected in biosolids and in the fat of fish and marine mammals as a result of leakage of these substances from electrical equipment.

In 2005, the National Measurement Institute reported preliminary studies of the concentrations of the polybromodiphenyl ether (PBDE) flame retardants that are widely used

in office and household products (e.g computers, carpet, furniture fabrics and mattresses) . For the small numbers of samples examined, the sums of a range of PBDE isomers (nanogram/gram) were: human breast milk, 12; Atlantic salmon, 30-34; cetaceans, 4-51; raptors, 0.4-221; biosolids from sewage treatment, 440-1325. These figures are comparable to those found in other industrial countries but far below the worst international examples. In the case of biosolids, it was observed that one of the least toxic members of this group, decabromodiphenyl ether, constituted over 50% of the total PBDE.

The presence of persistent organic pollutants such as aldrin, dieldrin, and DDT can still be detected at contaminated sites, in sewage biosolids, and in the fat of fish and marine mammals even though the use of these chemicals was phased-out over a decade ago. A major stockpile of hexachlorobenzene remains at Botany, NSW, and there is significant contamination of groundwater in the area from other chemicals. There are also legacy issues with persistent organic pollutants at Sydney's Homebush Bay, where remediation is progressing.

The discharge of metals to the environment has also left legacy issues. Where land is to be reused, remediation is required under state and territory legislation and large quantities of contaminated soil have been removed to secure landfills. In rural areas of New South Wales and Queensland, a large number of cattle dip sites contaminated with arsenic and slowly-degrading DDT are under management.

Where marine sediments are concerned, typically close to industry sites in major coastal cities, they are normally identified but left undisturbed lest attempts at their removal result in significant dispersal into the environment. Likely reduced biodiversity or other impacts on marine fauna in such areas are accepted as the lesser evil. Probably the most notable example is the Derwent estuary near Hobart, where lead and zinc from smelting operations and mercury from electrolytic production of chlorine contaminate the sediments. The discovery in 2006 that biota in Sydney Harbour contained significant levels of dioxins, and that people consuming much seafood were thereby affected, emphasises the need for careful monitoring around hotspots. At a number of inland sites, mercury contamination from former gold mining operations can be detected in local streams and, courtesy of biomethylation, in their biota.

Some issues fester for many years before enough evidence is at hand to see them qualify as serious and requiring attention, or below levels of concern on grounds of low hazard (toxicity) or exposure. An example is the capacity of some substances to disrupt endocrine activity in animals. While possibly pernicious, the effects are below detection by human epidemiology and so data from animal studies and cell cultures are used to screen candidate chemicals. Certain esters of phthalic acid (phthlates), widely used as softening agents in some plastics, have been identified as endocrine disruptors and, in cautionary responses, removed from use in some countries but not yet in Australia.

The history of the discovery of unacceptable risks posed by substances already in commercial use suggests that other cases will arise, although better screening – both prospective and retrospective - will help to avoid such instances. In some cases, the reconsideration by

governments and communities will be based on new toxicological or epidemiological data, or on the rejection of what were formerly regarded as acceptable risks. For example, increased recycling of water in Australia could lead to concerns over the environmental impact of low concentrations of endocrine disruptors, pharmaceutical drugs and their metabolites, cosmetic materials, and natural hormones, all have which have been detected in fresh water in Europe and North America.

Concerns about chemicals in the environment - 'the coming stuff' - are akin to those over climate change ('the coming storm') and global epidemics of disease ('the coming plague'), and merit the same precautionary approach.

Glossary

Biomethylation – the conversion of metals to methyl compounds through the actions of bacteria and other micro-organisms.

Biosolids - solid or semisolid material obtained from treated wastewater, often used as fertiliser

DDT - an powerful insecticide which was banned in Australia in 1987. It is listed in the Stockholm Convention on Persistent Organic Pollutants

Lipid - one of the principal classes of macromolecules in our body, the others are proteins and carbohydrates. Lipids include fats and oils (triglycerides), fatty acids, waxes, steroids, phospholipids, glycolipids and lipoproteins.

Nanogram ng = 10^{-9} gram (0.000 000 001 g)

PCBs polychlorinated biphenyls are organochlorine compounds which are mixtures of up to 209 individual chlorinated compounds referred to as congeners. They are persistent chemicals that are very heat resistant. They were phased out due to impacts on the environment including bioaccumulation in fish and mammals.

Picogram pg = 10^{-12} gram (0.000 000 000 001 g)

TEQ - Since dioxins occur as complex mixtures of congeners in most environmental media (air, water, soil), the concept of toxic equivalents (TEQs) has been developed. This concept allows the toxicity of a complex mixture to be estimated and expressed as a single number. Available animal-based toxicological data have been used to generate a set of weighting factors, each of which expresses the toxicity of a specific congener in terms of its equivalent mass of TCDD (2,3,7,8-Tetrachlorodibenzo-p-dioxin). Multiplication of the mass of the congener by its weighting factor (or toxic equivalency factor, TEF) yields the corresponding TCDD mass (or TEQ). The total toxicity of any mixture is then simply the sum of the individual congener TEQs