TOXIC METALS

Toxic metals comprise: aluminium, arsenic, beryllium, cadmium, chromium 6, copper gadolinium, iron, lead, manganese, mercury, nickel, palladium, polonium, selenium, silver, thallium, titanium, uranium. Some of these are essential in low doses (copper, iron, manganese, selenium) and only toxic in higher doses.

Principal sources

Non-organic foods and cans/linings	Aluminium, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, palladium, silver, titanium
Fish, shellfish	Arsenic, cadmium, iron, mercury, nickel.
Infant formula/food	Aluminium, arsenic, cadmium, lead, manganese, mercury
Cooking pots and pans, aluminium foil, cooking knives	Aluminium, steel
Drinking water	Aluminium, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, palladium, uranium
Pharmaceuticals	Aluminium in aspirin and other analgesics, antacids (including Gaviscon), anti-diarrhoea medication, nasal sprays; Copper: birth control pills and IUDs Mercury: thiazide diuretics, laxatives, suppositories, antiseptics, ointments Palladium: chemotherapy; antimicrobial agent Titanium: antimicrobial; in the 'safety' coating on low dose aspirin Imported traditional medicines may contain lead and other metals.
Cosmetics/toothpaste	Aluminium, arsenic, cadmium, chromium, lead, mercury, nickel, silver, titanium
Toiletries	Aluminium, arsenic, nickel
Vaccines	Aluminium as adjuvant, mercury (as thimerosal)
Dental materials	Cadmium, chromium, copper, mercury, nickel, palladium
External/internal air	Aluminium, arsenic, cadmium, iron, lead, mercury, nickel, silver, titanium, uranium.

Don't assume that just because a toxic metal is banned in food in the EU that all imported food is similarly free of it (e.g. arsenic found in US rice, animal feed and fruit juice and some pesticides).

Particular risks for babies, toddlers and infants

- Contaminated breast milk (particularly with mercury) from toxic mothers.
- Infant formula, particularly if made from soya. Formula may contain aluminium, cadmium, manganese.
- Baby food: may contain lead or arsenic if imported from US.
- Toys: cadmium, lead (imported or old).
- Children's jewellery: cadmium, silver, thallium, lead (use of lead in plastics has not been banned!)
- Lead and mercury from peeling paint in old homes: attractive to infants

PERSISTENT ORGANIC POLLUTANTS
(Organic = Carbon-containing)

POPs are resistant to environmental degradation, taking up to 100 years to biodegrade (Fisher BE. Environ Health Perspect. 1999). They bioaccumulate in the environment and in fatty tissue. Most POPs are semi-volatile i.e. may travel thousands of miles before depositing on the earth or water.

POPs comprise some pesticides, solvents, industrial chemicals, metals and pharmceuticals. Some POPs are also volatile organic compounds (VOCs).

The UN Binding Convention on Persistent Organic Pollutants in 2001 banned 11 POPs, mostly organochlorine pesticides. Since 2001, this list has been expanded to include some polycyclic aromatic hydrocarbons (PAHs), brominated flame retardants and other compounds. Many other remain in use.

Prevalence in the body

- A US NHANES study found that 75% of participants aged >5 had phthalate metabolites in urine; (Silva, Environ Health Perspect, 2004).
- The US EPA studied fat tissues from corpses and liposuction patients and found that:
  All samples contained a dioxin, styrene, 1,4-dichlorobenzene, xylene and ethylphenol.
  91-98% of samples contained benzene, toluene, ethylbenzene, DDE, 3 dioxins and 1 furan.
  83% of the samples contained polychlorinated biphenyls (PCBs).
- A US NHANES study found that 93% of the population have BPA in their urine (Calafat AM, 2008).
- The World Wildlife Fund 2004 conducted the 'Bad Blood Study' by testing the blood of 14 EU environment and health ministers. All the ministers were contaminated with PCBs, pesticide residues, brominated flame retardants and perfluorinated chemicals and most were contaminated with phthalates. Many of these chemicals had already been banned but have a long half-life in the body.
- PFOA is widespread in oceans and rivers has been found in most fish, mammals and birds and in human serum throughout the world. PFOA has been detected in the blood of more than 98% of the general US population in the low range, with higher levels in chemical plant employees and surrounding subpopulations.

Principal sources of POPs

Polychlorinated biphenyls (PCBs)	Used in insulation; found in much old electrical equipment, office products and pesticides. Found in meat, fish, dairy, cord blood and breast milk.
Polychlorinated dibenzofurans (PCDFs, furans)	Produced by incineration of organochlorine chemicals: paints, solvents, pesticides, plastics. Found in electrical equipment.
Polychlorinated dibenzo-*p*-dioxins (PCDDs, dioxins)	Produced by incineration of organochlorine chemicals: paints, solvents, pesticides, plastics. Used in manufacture of pesticides and white paper products. Found in animal fat.
Phthalates	Used in any plastics, including cling film and other food packaging and manufacture of cosmetics, pharmaceuticals, toiletries and pesticides. Found in air, food and water.
Alkylphenols, their metabolites nonylphenol, octylphenol	As surfactants in pesticides and detergents (domestic in the US and industrial in Europe). Added to some plastics (polystyrene, polyvinylchloride – PVC) to soften them. Found in paints, lubricating oils and farm chemicals. Their use has been scaled down in Europe over the last decade through voluntary industrial measures.
Bisphenol-A (BPA)	In plastic products, fungicides, pesticides, dyes, flame retardants, dental resins. Also found in food and drink packaging and cans, soft drink and water bottles, milk and juice cartons, baby bottles, eyeglass lenses, medical equipment, toys, CDs/DVDs, mobile phones, consumer electronics, household appliances, sports safety equipment, aircraft, vehicles, microwaveable dishes and water supply pipes. BPA easily leaches into food at room temperature but the effect is more pronounced when heated, such as with babies' bottles (Rubin, J Steroid Biochem Mol Biol, 2011).
Polycyclic aromatic hydrocarbons (PAHs)	Created by incineration of industrial plastic waste, such PVC, and domestic burning of biomass fules, smoking and frying food. Found in asphalt, creosote, coal-tar pitch, roofing tar, coal and crude oil. A few are used in pharmaceuticals, plastics, dyes and pesticides.
Perfluorooctanoic acid (PFOA)	A synthetic perfluorinated carboxylic acid and surfactant, used in the manufacture of fluoropolymers, including Teflon (on 'non-stick' pans), and as a water and oil repellent in clothing (Gore-Tex), leather, carpets, carpet-cleaning liquid, house dust, water, fire-fighting foam and as insulation. It has been detected in industrial waste.

VOLATILE ORGANIC COMPOUNDS (VOCs)
(Organic = carbon-containing)

VOCs are chemicals that have a high vapour pressure at room temperature, which means they can easily evaporate into the air as gases from some solids or liquids. Because they are ingredients in many commonly used products, they are present in virtually all indoor air.

Formaldehyde	Embalming, paints, adhesives, plastics, soft furnishings, building materials, insulation, natural gas, kerosene, cigarette smoke
Vinyl and polyvinyl chloride (PVC)	Wallpaper, upholstery, carpets, building materials, vehicles, plastic products, rubber, paper, glass.
Polycyclic aromatic hydrocarbons (PAHs)	All forms of cooking, incense, cigarette smoking, vehicle exhausts, industrial emissions, mothballs, tar, pitch, creosote, pesticides, toiletries, synthetic turf. Incineration of plastic waste such as PVC.
Ethanol (alcohol)	Perfume, air fresheners, toiletries, hairspray, nail polish/removers, detergents, paints, varnishes/removers, industrial cleaners, de-icers.
Benzene	Cigarette smoke, fuels, vehicle exhausts, plastics, adhesives, cleaners.
Perchloroethylene	Also tri- or tetrachloroethylene. Dry cleaning, carpets, paints, degreasing.

VOCs: routes in and out of the body

- VOCs are highly lipophilic and have small molecule size, so they can easily enter the lungs and be absorbed across the lung membranes and enter the blood supply. Blood from the lungs moves directly to the brain and other organs before reaching the liver, where metabolism of the VOC occurs.
- VOCs are also well absorbed from the gut, although the presence of food may delay absorption.
- The skin offers little barrier to lipophilic VOCs. Skin exposure can result in local irritation and increased blood levels of the chemical.
- VOCs are eliminated from the body by metabolism or exhalation.
- Metabolism occurs mainly in the liver by CYP450 enzymes. Generally this results in reduced toxicity and increased elimination but not in the case of benzene, which is metabolised to a more toxic chemical.

Extent of VOCs in the body

- A US study found that xylene, dichlorobenzene, ethylphenol and styrene were present in 100% of tissue samples tested across the country (EPA 1982).
- The US EPA studied fat tissues from corpses and liposuction patients and found that:
    - 100% of samples contained styrene, 1,4-dichlorobenzene, xylene and ethylphenol
    - 91-98% of samples contained benzene, toluene and ethylbenzene

PESTICIDES

Pesticide exposure can occur through ingestion of contaminated foods or drinking water, inhalation (including from showering or bathing) or skin contact. Pesticides used on foods during growth and storage cannot be washed off. In the UK, pesticides are found particularly in beef, organ meats, fruits, chocolate and lettuce (1999 Annual Report by the Working Party on Pesticide Residues). Drinking water is similarly contaminated (Environmental Working Group, 1997).

Indoor exposure (domestic spraying, soft furnishings, floors) is often underestimated (Hore P, Zartarian V, 2005), as is exposure in aircraft. Virtually all public buildings and spaces now have some form of pest control, they are included in bathroom and kitchen cleaners and they are in the water supply from agricultural run-off.

Regulation

2009 EU pesticide legislation banned certain pesticides from use in Europe; this is the strictest legislation in the world. Similarly, the EU Drinking Water Directive has a general limit for all pesticides of 0.1mcg/l, with the sum of all pesticides being below 0.5mcg/l; however, few pesticides are included in the routine monitoring of drinking water.

Principal classes of pesticides

Organochlorine insecticides	The oldest, and generally the most toxic, pesticides. Most of them are POPs and have been banned.
Organophosphate insecticides	Slightly less toxic than organochlorines. Includes malathion, dursban, diazinon, trichlorofon, parathion, chlorpyrifos, malathion and mevinphos.
Carbamate insecticides	Similar to organophosphates. Includes aldicarb, carbaryl, methomyl, propoxur, thiophanate methyl and carbofuran (N-methyl carbamate).
Pyrethroid insecticides	The newest class, based on pyrethrin from chrysanthemums. Includes allethrin, cismethrin, fenvalerate and remethrin.
Herbicides	Some (e.g. paraquat) banned in the EU. Most common: Glyphosate, developed by Monsanto as RoundUp, designed for use with GM crops.
Fungicides	Widely used in agriculture/supermarkets. Mancozeb, maneb, tributyltin.

OTHER ENDOCRINE DISRUPTING TOXIN SOURCES

Tobacco smoke	Particulate matter, toxic metals, toxic gases, VOCs, nitrosamines.
Landfill, hazardous waste sites	Poorly lined landfill sites allow toxins to leach out, contaminating the soil and water sources. Air pollution from landfill sites: toxic gases, mercury vapour, VOCs .
Incinerators	Emissions from incinerators can emit particulate matter, acidic gases and aerosols, toxic metals, dioxins, furans, PCBs and polycyclic aromatic hydrocarbons (PAHs). Although modern incinerators show much reduced emissions compared to old uncontrolled incineration facilities, an incinerator will always emit some dioxins.
Disinfectant byproducts (DBPs) in drinking water, showering/bathing	Many DBPs are halomethanes: chloroform (most common), bromoform, dichloromethane, dibromomethane, trichloroacetic acid, mutagen X.
Fluoride	Drinking water in some areas of UK, toothpaste.
Parabens	Preservatives found in toiletries, cosmetics, pharmaceutical products and as food additives. Some now banned for products targeting children aged <3.
Nitrates/nitrites,	Food additives and drinking water
Ionising radiation	Medical and dental diagnostics (X-rays, CT scans etc), medical therapeutics (radiation therapy for cancers), screening of luggage and passengers at ports and airports, nuclear power production and nuclear waste, occupational exposure among medical and nuclear workers, components of TV sets and other electronic devices.
Non-ionising radiation	Mobile phones, masts, electricity pylons
Pharmaceutical hormones	Birth control pills, HRT and growth hormone in animals. They are excreted in urine where they contaminate the water supply and end up back in the food chain.
Fish	BCBs, pesticides, methylmercury, organochlorines
Phytoestrogens	Particularly from soya
Goitrogens	Soyabeans and cruciferous vegetables (turnips, cabbage, broccoli, cauliflower, Brussels sprouts, mustard greens, kale, kohlrabi, rutabaga) (Doerge DR, Chang HC 2002; Doerge DR, Sheehan DM 2002; Stoewsand GS 1995).
Food packaging	