Pollution from Industry, Mining & Agriculture

Water, Sanitation and Health Theme Article

LINKS: Other theme articles related to this topic include Natural Hazards, Water and disasters, Water and Sanitation, Water and Food, Water for Positive Health, Water and Biodiversity.

Disease fact files:

Anaemia
Arsenicosis (arsenic poisoning)
Lead poisoning
Mercury poisoning
Methaemoglobinaemia

For further information, see end of fact sheet.

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Summary

• Water contains a great variety of trace elements and mineral compounds. Industrial and agricultural activity and urban waste increase these constituents and add others.

• This fact sheet focuses on water pollution due to human activity: such as by lead, mercury, cyanide, nitrates, radioactivity and pesticides. While some may be found as traces in water sources remote from obvious sources of pollution, the main threat to human health is through contamination from industry, mining, chemicals used in agriculture, intensive livestock husbandry leading to contamination of drinking-water supplies.

• It can be difficult to assess exposure since humans may take in small amounts of trace elements and other compounds via air and food as well as in water. The effects
depend on factors such as the duration of exposure, varying susceptibility by age and the presence of disease or malnutrition that may increase vulnerability to the effects of exposure.

- The growing world population and industrialisation has focused concerns both on the implications of water pollution and also on the threat to water supplies from industrial accidents. There are also the ‘future spectres' of the long-term effects of pollutants, including substances that may affect our hormones. On the positive side, trends towards less polluting industry and agricultural reform are helping to reduce contamination, for example by control of industrial emissions and by promotion of integrated pest management.

Introduction

Water, unless it is distilled, is not simply 'H₂O' (the chemical formula for pure water) but also contains many natural elements. Water gathers constituents from the rocks and ground through which it permeates. Some benefit health, others are harmful. Water constituents are defined as a hazard when they have the potential to impair health. The risk posed by such hazards is the quantitative calculation of the probability of causing harm, based on the degree of exposure. In contrast to other health hazards, the risks posed by chemical pollutants may be quantified described through research and modelling or dose-response curves. In addition to the natural hazards, humans add to the constituents through industrial processes, mining operations and agriculture, often with a lack of awareness or insufficient knowledge of the potential risks to health.

This fact sheet focuses on undesirable contaminants that may enter water. For most of these contaminants, something can be done to make the water safe or identify an alternative supply - if we know about the contamination in good time and water treatment facilities are available. Monitoring, treatment and preventive action may, however, be costly. This theme article also covers future threats of pollution from our growing world population, increasing industrialisation and the possible increase in industrial accidents. The Chernobyl nuclear power station explosion in Ukraine in 1986 showed how quickly radioactive contaminants can spread into waters far away from the pollution source. Similarly, the Bhopal disaster in India (1984) included pollution of large volumes of water. A fire at a large pharmaceutical company in Switzerland (1986) caused water pollution in neighbouring countries. In the UK, an accident at a water works in 1988 showed the problems that can occur with the chemicals used for water treatment, in this case aluminium sulphate. These are not just past spectres, for the history of such catastrophic events suggests that they will surely occur in future. They are examples of accidents whose impact is of an order of magnitude that they make the headlines. The cumulative effect of many other, smaller accidents that do not make it to the headlines poses an insidious threat to our health. Water supplies are also vulnerable to pollution from other sources related to human production systems: pesticide run-offs from agriculture or toxic waste from mining operations. Bioavailability from pollution depends upon the form of the chemical in the water body and factors such as water solubility that affect entry into the food chain. The residues of many first and second-generation pesticides function as so-called endocrine disruptors: chemicals with the potential to affect the hormone system in humans and animals. Prolonged exposure to some chemicals may also cause cancer. Risk assessment for water pollution thus requires long term monitoring, as the harmful effects may take years to develop.
Understanding the risk posed by contaminants in water in our environment involves viewing the environment as a whole: the physical, chemical, biological, social, cultural, and economic conditions with which human beings interact. Exposure to toxic substances can occur by multiple routes: air, food, discarded containers on refuse sites, unsafe containers of chemicals within the home, leakage from transport containers, contaminated soil, as well as water. A 'safe' level in one of these exposures may combine to produce toxic effects if multiple exposures are involved. The risk is much greater if health is already compromised by malnutrition, poverty and poor sanitation. Children are particularly susceptible to such combined exposures: 61% of poisoning cases in the Americas that are not work-related occur in children under the age of 6 years (American Association of Poison Control Centers, PAHO, 2000) Sixteen percent of fatalities due to such pesticide poisoning are children (PAHO, 2000).

Contaminated water often combines with other hazards such as inadequate ventilation to add to the toxic load experienced by children, for example child labourers in the mining industry in Latin America. While hazards from some elements, such as lead and mercury, are decreasing due to risk-based interventions, the rapid expansion and spread of industry also means that an increasing proportion of the world's population is exposed to new industrial processes and their discharges into the environmental water sources. New chemical compounds are constantly introduced into the market place, some safer than previous chemicals, others with unknown effects on health. Around 100,000 chemical substances are presently used in commerce, with 2000 new compounds coming onto the market every year (WHO-IPCS, 2000). There is no reliable information on the health impact of almost two thirds of the 70,000 chemical products used in industry in the USA (PAHO, 2000). This lack of data limits preventive measures or advice on precautions.

The health risks can also be defined in terms of acute or long-term (chronic) exposure. Acute exposure is defined as exposure for less than 24 hours and usually involves a single dose of a chemical. Long-term exposure refers to repeated or continuous exposure for more than 3 months. The health effects differ markedly between acute and chronic exposure: in most cases of contamination via water, there is more concern about long-term effects, for example linked to accumulation of the chemical in the sediments of rivers and reservoirs, or where industrial discharge continues over a long period. Guideline values for chemicals in water are based on available evidence, frequent presence of the contaminant in water and international concern about particular substances. In many cases the values are much lower than those described in documented toxic effects, but in other cases the evidence is unclear and guidelines may not be available on substances not normally present in water, or where the evidence of health effects is inadequate (WHO, 1993; WHO 2000).

**Industrial pollution**

Where waterborne sewerage systems are used to dispose of human excreta, the system tends to be used also for disposal of industrial waste, especially liquid discharges. Municipal sewage sludge may contain high concentrations of heavy metals, such as cadmium, lead and chromium. Poisons in industrial discharges can quickly exceed the safety limit: levels may be 10 or 20 times higher than those of municipal waste only (Chang, Page and Asano 1995). Disposal of industrial waste by incineration or land-fill may also contaminate water sources, if the waste filters into groundwater or drains to rivers. Heavy metals eventually accumulate in filter-feeding shell fish and plants.
Mercury: the Minamata case

One of the most infamous cases of industrial water pollution occurred in Minamata, Japan (Box 1). This demonstrated the links between water pollution and food: the main contaminant, methyl mercury entered the food chain via fish, the chief source of protein in the local diet. Fishing was an important means of livelihood, as was the factory responsible for the pollution: this contributed to the delay in identifying and accepting that mercury was the cause of the mysterious Minamata disease in the community. Even when pollution was suspected, other elements in the wastewater were initially suspected, such as manganese, selenium and thalium. The now classic Minamata story was a key lesson in the enduring effects of water pollution and the problems in removing it. Chemical contamination of fishing waters often reduces the fish harvest, as in Minamata; and this may be the first sign of the potential human health risks. Industrial discharge from a textile factory in Mauritius reduced fishing harvests: the fishermen went on strike until the government offered compensation (Box 2), but the underlying problem is harder to address. Industry is essential to a country’s wealth, and dealing with industrial discharges is expensive, although it may be cost effective to a society when account is taken of the hidden costs of health care and reduced productivity due to ill health and other effects. As a result of the investigation of the Minamata case, there is now much more awareness of the importance of mercury pollution, for example due to mining in Amazonia, where the greatest health hazard index values have been estimated for people eating contaminated fish (Lodenius & Malm 1998).

Box 1: Mercury contamination in Minamata

Between 1932 and 1968, a factory producing acetic acid discharged waste liquid into Minamata Bay, Japan. The discharge included high concentrations of methyl mercury, increasing as the industrial activity expanded with production of polyvinyl chloride, using mercury as a catalyst. The Bay was rich in fish and shellfish, providing the main livelihood for local residents and fishermen from other areas. For many years, no one realised that the fish were contaminated with mercury, and that this was the cause of the strange disease that appeared in the local community and in other districts where the discharge reached the fish population. Minamata disease reached high levels in the 1950s, with severe cases suffering brain damage, paralysis, incoherent speech and delirium. Because the disease seemed to affect whole families and their neighbours, an infectious cause was suspected, especially when cats also became sick and died.

The disease was officially recognised in 1956 but epidemiological studies were slow to start and incomplete. Mercury poisoning was suspected in 1959 when sediments and shellfish from the Bay were found to have high levels, but this was not officially recognised to be the cause of Minamata disease until 1968. The industrial discharge was stopped at this time, but removing the contamination from the Bay involved a ten-year dredging operation, completed in 1987. By 1995, mercury levels in fish were below 0.4mg/litre and no longer considered to be a significant hazard (WHO guideline value for total mercury in water is 0.001mg/l). Okada and Peterson (2000) estimated that up to 100 kg of methyl mercury had been discharged annually at the peak of the pollution, in the late 1950s and early 1960s. Over the long period of mercury discharge from the factory, at least 50,000 people were affected to some extent and over 2000 cases of Minamata Disease have been certified (Baxter, 1990). Sources: Baxter 1990, Okada & Peterson, 2000; WHO (IPCS), 2000; W.E. Smith & A.M. Smith, 1975
Box 2: industrial and sewage pollution in Mauritius

Fishermen in Port-Louis, Mauritius, blockaded a ship carrying material for the laying of sewerage pipes, because of their concerns about pollution of a lagoon used for fishing. The fishermen claimed that industrial pollution from the textile industry had already decimated the fish population: they now feared that a planned outfall sewer would further pollute the seawater. The authorities claimed that the sewage would be treated before disposal into the sea: the blockage ended when the government promised them financial compensation for lagoon pollution (PANA, 2000).

Mining and water

Mining for precious metals, coal, and other commodities forms an important part of many countries' economies. Developing countries, for example Brazil, China, India and Peru, contribute a large proportion of the world's mining products. For example, of the total world production of iron ore (1,020,000 metric tons), 21% is produced by China, 19% by Brazil and 7% by India (USA National Mining Association, 2002). The largest producer of copper is Chile (30% of total world production), while Mexico produces the largest proportion of silver (16% of world production). While large producers have modern 'mega-mines', small-scale or surface mining is common in many countries. Mining activities affect health via water through: the method of extraction (for example health effects on children of panning for gold in the Amazon or use of cyanide to leach heavy metals); contamination of local water sources (for example arsenic contamination of ground water in Thailand, Box 3), as well as having harmful effects on the environment such as beach erosion from sand mining or by longer term effects on reducing biodiversity or fish populations. The health effects may be far away from the mining source, as demonstrated in studies of methylmercury poisoning in the Amazon (Harada et al 2001): mercury levels in head hair were studied in residents of three fishing villages on the Tapajos River, an effluent of the Amazon, several hundred kilometres from the gold mining areas. Many had high mercury levels in addition to symptoms suggesting neurotoxic disease.

Box 3: Arsenic contamination from mines in Thailand (WHO-SEAR, 2001)

Past mining activities caused heavy arsenic contamination of groundwater and topsoil over a 40 square kilometer area in Nakhon Si Thammarat province, Thailand. The contamination was revealed in a study commissioned by the Japan International Cooperation Agency (JICA) in 2000. One conclusion of the study was that the contamination would last for the next 30-50 years. Testing of 1,000 samples showed the contamination in some groundwater wells to be 50-100 times higher than the World Health Organization's guideline value for drinking water. Most people in the affected district stopped drinking well water in 1993, with an associated high cost of providing tap water to residents.

Health effects tend to be associated with long-term pollution, but industrial accidents or fires may cause a sudden increase in contaminants. Following a fire at a chemical storehouse in Switzerland, the issues included the lack of knowledge about the potential effects of many of the substances that discharged into the River Rhine (Box 4). Lessons were learned about prevention and the effects of fire fighting on water pollution, but one of the future spectres is that this type of industrial accident will increase, particularly in areas where rapid industrialisation is occurring or where there
are insufficient funds to provide adequate safety measures for processes and maintenance of equipment. A recent assessment of chemical safety and governance in Brazil identified a wide range of problems and accidents relating to water, many with implications for water safety and assessing levels of vulnerability in the local population (de Freitas et al 2001).

**Box 4: The Red Rhine Incident (Dieter, 1994)**

In 1986 a fire destroyed a chemical store in Basel, Switzerland, near the borders of France and Germany. Chemicals reached the water through the plant's sewage system when huge amounts of water (10,000-15,000 m$^3$) were used to fight the fire. The store contained large quantities of 32 different chemicals, including insecticides and raw ingredients, and the water implications were identified through the presence of red dye in one of the substances. The main wave of chemicals destroyed eels and fish, as well as habitats for small animals on the riverbanks. The highest concentration of organic thiophosphates (40 µg/l) was 362 km downstream from the fire and the total eel population was destroyed 500 km downstream, from Basel to Loreley. Concentrations of contaminants reached normal values 3 months after the incident. Human health effects were harder to assess, as the potential toxic effects are likely to be long-term and not yet well understood. As a result of this incident, the permanent chemical load in the Rhine has been reduced and information systems on potential incidents improved.

**Nuclear accidents and water**

Nuclear accidents (and explosions) pose a risk of radioactive contamination of water supplies, through fall out onto soil and water catchments. While water contamination usually accounts for only a small proportion of the risk following a nuclear accident, it may persist for some years due to wash-off from contaminated soil and persistence of radioactive nuclides in sediment. The explosion at Chernobyl in 1986 released a radioactive cloud that passed over several countries (Box 5). This was the largest radiation accident to have ever occurred in the world. To some, it was an accident 'waiting to happen' and poor maintenance was one of the factors implicated in the Chernobyl disaster. The Chernobyl example provided a frightening example of the peacetime threats from nuclear power stations, particularly where dwindling national resources prevented appropriate safety and maintenance procedures. The accident prompted better planning of appropriate monitoring of health and the environment, including the presence of radioactive residues in water supplies. The accident also forced governments to acknowledge the possibility of another massive release of radiation from an accident.

**Box 5: The Chernobyl nuclear accident (WHO, 1995)**

The Chernobyl explosion occurred on 26 April, 1986, killing 30 workers at the reactor site and causing various degrees of radiation sickness in hundreds of other staff and local residents. Its wider effects are still being monitored.

**Cause of the accident:** Staff were testing a turbo generator at night, just prior to shutting the reactor down. Test procedures were poorly written and operating rules, including safety measures, were not followed: this is a common finding in industrial accidents, but particularly tragic in the case of Chernobyl. A huge power surge in the
reactor should have triggered an automatic shutdown, but the appropriate safety system had been disabled. The system could not be controlled manually and the power surge triggered the explosion. Early attempts to control the explosions and fires included dropping 5000 tonnes of boron, dolomite, sand, clay and lead onto the unit: this increased the core temperature in the early stages and increased the plumes of particles pouring out of the reactor. The reactor did not begin to cool down until 5 May.

Health effects and water contamination: The radioactivity of the material released in the Chernobyl explosion was estimated to be 200 times higher than the combined releases of the atomic bombs dropped on Hiroshima and Nagasaki, Japan, in 1946, during World War II. Hundreds of people in the heavily contaminated areas around Chernobyl required hospital treatment and five million people in Belarus, the Russian Federation and Ukraine were exposed to harmful levels of ionising radiation. The early effects included increased levels of thyroid cancer in children, due to the radioisotope iodine-131. Lower levels of radiation reached many other countries, including evidence of contamination of water supplies and in rainfall. Increases in radioisotopes in water were reported from Finland and the Baltic Sea (Nielsen et al 1999, Saxen and Ilus 2001). However drinking water contamination in nearby countries such as Austria compromised only about 5% of the exposure to radioactive nuclides following exposure to the Chernobyl radiation (Hennighausen, 1999). An initial lack of information increased fears of health damage in the exposed populations, and the psychological trauma of enforced evacuation.

Lead and water

Lead is a general toxicant that builds up in the skeleton and its effects are most serious in infants, young children up to the age of six years and pregnant women. Lead is toxic to the nervous system and its other effects include interference with Vitamin D metabolism, anaemia and possible cancers from long-term exposure. The risk to children and babies growing in the womb is due to the much greater absorption of lead at these ages. Lead exposure comes from a wide range of sources, broadly grouped into industrial and domestic exposures. Sources include lead-acid batteries, solder and alloys, paint, dust, petrol and water. Lead additives are being phased out in petrol, paint and in solder used in the food processing industry; air and food levels are also declining. This has led to a greater emphasis on the previously small proportion of total lead intake from water.

Natural lead levels tend to be higher in soft and more acidic waters where metals and their salts dissolve more easily. While natural levels are rarely high enough to cause toxic effects, combined exposure from other sources may lead to symptoms and signs of lead poisoning. Lead pipes, gutters and drains are still common throughout the world: the amount of lead dissolved from plumbing depends on factors such as acidity, temperature, water hardness and standing time of the water. Concentrations of lead in water tend to be higher in the morning, so water has to be flushed out before use for human consumption. Lead poisoning is rare where pipes are made of other materials: the threat of lead from water can be almost eliminated by removing all lead pipes and fittings in the water and plumbing systems. This is an expensive intervention and it is likely that lead pipes will persist in many countries for several decades. Meanwhile, the policy is to reduce total exposure to lead from other sources, such as car exhausts. The tolerable weekly intake of lead is 25 µg/kg of body weight for infants and children. The health based guideline figure for water is a maximum of 0.01 mg/litre.
Cyanide and water

Cyanide is highly toxic to humans: it is readily absorbed by the gut and causes symptoms even in very small concentrations, particularly in malnourished adults and children. It lowers vitamin B12 levels and damages the thyroid gland, reducing the iodine uptake essential for hormone production. Exposure during pregnancy also causes malformations. It is usually only present in water as a result of industrial contamination. Cases of goitre and cretinism in Zaire reduced after improvement in industrial processing methods, as well as in general nutritional status. The guideline value for drinking water is 0.07mg/litre (WHO 1996).

In January 2000 a cyanide spill in the Băia Mare region of North Western Romania contaminated rivers as far as the River Danube. Cyanide in solution was used to dissolve heavy metals out of exposed piles of waste rock, a leaching process that allows extraction of precious metals such as gold and silver. The impoundment containing the contaminated water burst, quickly reaching local watercourses and then spreading as a polluted plume across countries in Eastern and central Europe. Ice on the rivers and low water levels in Hungary delayed the dilution of the cyanide and increasing the risk to municipal water supplies. Increased concentrations of copper, zinc and lead, leached by the cyanide, compounded the problem.

Agricultural pollution

Agriculture to feed growing populations, and to provide food for export, requires careful management to avoid pollution. Intensive agricultural practices, essential to achieve high crop and livestock yields, presents particular risks to water sources. Fertilisers and pesticides can readily penetrate the ground water sources and run off during rainfall adds to the level of contaminants in surface waters, such as rivers and lakes (Box 6). Adverse weather events add to the contamination risk: after a hurricane in North Carolina, USA, contamination of seawater with large quantities of chicken waste caused algal blooms and affected shellfish production. Pesticides - chemicals used to control pests, weeds or plant diseases - cause particular concern, as some use carrier agents toxic to humans, such as carbon tetrachloride and chloroform. Such carrier agents may be classified as 'inert' for the purposes of the pesticide use, thus they may be ignored in discussion of health effects. Impurities in agricultural chemicals, for example dioxins in phenoxy acid herbicides, may be more toxic than the named compound and these need to be taken account in the general health risk assessment.

Box 6: Pesticide contamination of water in Mali (UN OCHA 2000)

Pesticides were found to have polluted the water in villages in northern Mali in a survey conducted in 1999. A European Commission Humanitarian Office (ECHO) grant enabled a water quality improvement programme, including construction of new wells, cleaning up storage depots of expired pesticides, and sealing contaminated wells; it also provides medical care for the victims of poisoning. ECHO has estimated that there at least 85,000 litres of obsolete pesticides throughout northern Mali.

Acute pesticide poisoning is largely a problem of the developing world: it has been estimated that 5-10% of the agricultural population in some of these countries are likely to have significant exposure to pesticides (WHO, 1990). Much more is known
about direct effects than about the exposure via water and accumulation in the environment; and the extent and severity of chronic pesticide exposure is still controversial. Epidemiological studies are mostly confined to small geographical areas, which may not be representative of other regions or other climates: use of pesticides, fungicides and insecticides tends to be seasonal, varying with the growing period of crops and known breeding cycle of pests. For accurate risk assessment, pesticide and other agricultural chemical exposure need to be quantified: a five stage pattern of use has been described, from very low (Stage I) to very high (Stage V), with corresponding definitions of dosage, number of products in use and other factors (WHO, 1990), which helps to define the dose-response relationship with observed health effects.

Pesticides of various types have been used in agriculture for centuries and safer alternatives have been found to arsenicals and other agricultural chemicals used in the past. An ecosystems approach to pest management now replaces concepts linked to economic threshold of damage that prevailed during the 1970s and 1980s. As with many other water related pollution issues, the task now is to find the right balance that protects the ecosystem while also allowing efficient agriculture and pest control. All substances, whether natural or made by humans, have the potential to cause adverse health and environmental effects, and alternatives to synthetic chemicals may have unexpected side effects, so the solution is not necessarily a biological means of control. As with all environmental hazards, a balanced approach is needed in assessing the risks, compared with advantages for crop yield, the cost of alternative agents and the health damage caused by insects and other pests. The balanced assessment includes taking account of intentional and unintentional exposures, as well as the ecosystems approach to pest management. Globally, unintentional exposure accounts for an estimated million cases of pesticide poisoning each year (WHO 1990), the greatest source being in agricultural chemical pest control, with a relatively small contribution from vector control campaigns. Unintentional exposure to agricultural pollutants may also arise due to drainage into ground water. Poor irrigation practices, for example using untreated or insufficiently treated wastewater, adds to the load of contaminants. Irrigation with polluted wastewater in China may have been linked to disease such as cancers, congenital malformations and liver damage (Yuan 1993). Organochlorine pesticides are now little used because of concerns about environmental accumulation and associated health effects, for example neurological damage. The Stockholm Convention on Persistent Organic Pollutants (POPs), agreed in May 2001, requires action on elimination of POPs, including recognition of the importance of water sources. Resistance of pests to chemicals has led to introduction of other agents with toxic effects on humans and other organisms.

**Methaemoglobinemia and other effects of nitrate contamination in water**

Nitrates can build up to high concentrations in groundwater, for example due to wash-off from agricultural use and in wastewater. Nitrate in groundwater is associated with methaemoglobinemia (blue baby syndrome) when contaminated water is used to prepare infant feeds. Chronic nitrate exposure in drinking water has also been suggested as a cause of cancer, thyroid disease and diabetes (Knobeloch et al, 2000). Excessive nutrients including nitrate from manure and fertilisers may also cause eutrophication in water sources - undesirable levels of algal growth and cyanobacteria, associated with loss of biodiversity. The toxins produced by some cyanobacteria cause a range of health effects, from skin irritation to liver damage (Chorus and Bartram 1999).
Endocrine disrupters and water

A number of substances, including some pesticides, have the potential to interfere with normal functions of the body, particularly the endocrine system that regulates physiological functions through hormonal signals. Endocrine disrupting chemicals (EDCs) (Box 7) include many natural and synthetic chemicals. While not all persist in the soil and water environment, many are classed as persistent organic pollutants (POPs). Most of the implicated chemicals are widely distributed in the environment and are found across national boundaries. The health concerns are difficult to assess because of limited information about exposures and mechanisms. While the contribution of water to endocrine effects is still unclear, Water is an issue in these concerns because of the accumulation of the substances in water sources and particularly in the fatty tissues of fish that enter the food chain. The International Programme on Chemical Safety is preparing a state-of-the-science report on the human and environmental impacts of EDCs and has established a global inventory on current research in the field.

Box 7: Endocrine disruptors (EDCs): definition and suspected health effects (IPCS 1998)

Endocrine disruptors are substances originating outside the body that alter functions of the endocrine system, with resulting adverse health effects on an intact organism, its offspring, or in subpopulations. Examples include natural and synthetic hormones, natural plant constituents, pesticides, monomers and additives used in the plastics industry. Industry adds to the natural levels of these substances in the environment, including accumulation in water sources, with insufficient information as yet on the contribution of water consumption to these exposures. Some of the effects have been observed in studies of invertebrates, fish, amphibia, reptiles, birds and mammals; others have been suspected in human studies, although research is still at an early stage. For example, dibromochloropropane (DBCP), a nematocide (worm killer) has been associated with male infertility (WHO 1990) but studies of the reproductive effects of other substances have produced inconsistent results. The following potential human health effects are a guide to the suggested risk posed by endocrine disruptors:

• cancers of the breast, prostate and testes;
• reduced quantity and quality of semen;
• impaired behavioural and mental function in children;
• impaired function of the immune system and thyroid, particularly in children.

There is a general lack of information on specific exposures, how the disruptors may act and the influence of other factors such as the quality of the diet. This makes it hard to be precise about cause and effect for these substances.

Reducing water pollution

Water is essential to life and to general health, so do we have a choice about this increasing spectre of water as a poison? All too often, it has seemed that an environmental disaster has to occur before lessons are learned and preventive measures put in place. Minamata disease demonstrated the dreadful effects of methyl mercury contamination and led to identification of similar poisoning in other countries, linked to both water and food pollution. One of the Minamata lessons was the need for
good epidemiological surveillance, including collecting and analysing reports of unusual cases: many cases of the mercury poisoning were misdiagnosed or common exposure factors were unrecognised, before the mystery was solved. The Chernobyl disaster led to better programmes of maintenance and monitoring of radioactive hazards, which may make us better prepared for a similar disaster. Such tragic incidents have provided more precise data on numbers, types and timescales for the diseases linked to environmental hazards: this is an essential basis for risk assessment. They also provided a basis to verify and corroborate dynamic exposure models that had been developed on a theoretical base. Risk identification and management is now an established approach for controlling industrial pollution, with far fewer excuses for pleading ignorance of the potential health effects (Box 8). Yet the risks remain in all countries. The economical necessity of industry, and of keeping down the costs of processing and maintenance, tends to take priority over risk assessments, especially where the evidence is still unclear or speculative, for example in the potential effects of endocrine disruptors. In the example of pollution in Mauritius (Box 2), fishermen took action against a planned sewerage system for mainly economic reasons, because industrial discharges were already damaging the fishing harvests in a lagoon.

Box 8: Basic principles of risk management

1. Risk management includes prevention, control, mitigation (remedies) and risk reduction, based on scientifically sound characterisation of specific risks.

2. Effective risk management involves the participation of all who have significant and legitimate interest in the exposures - the stakeholders

3. Equity issues must be included, for example the distribution of costs for controlling the risk and the interests of the risk producer as well as those who are subjected to the risk

4. Risks may be voluntary or involuntary or otherwise out of control of individual choice: the risk assessment includes identifying vulnerable groups and the risk management includes providing adequate compensation for those affected.

While these principles apply to all environmental risks, they may be particularly important in control of hazards from water and sanitation, because the exposures affect large proportions of the population; thus they frequently raise issues of cost, multiple responsibility for control and debate about relative risks and the quality of the scientific evidence.

Interventions to reduce risk include those possible at the international, national and local community levels. At the international level, commitment to reduce pollution at inter-governmental conferences and summits provides goals and targets, as well as pressure to conform to international guidelines. Agenda 21, an action plan to guide national and international activities, was agreed in Rio de Janeiro, Brazil in 1992, with a specific chapter devoted to the environmentally sound management of toxic chemicals (WHO-IPCS, 2000). The POPs Convention (2001) has been adopted as an international legally binding instrument. Legislation on pollutants is an important intervention at the national level, although it must be linked to monitoring and means of enforcement. Legislation may be ineffective if economic pressures combine with low risk perception to allow hazardous exposures to continue unchecked, or to persist in
poor communities without sufficient political power to affect planning decisions. The health link between clean water, nutrition and livelihood needs to be more clearly understood by communities, before the short and long-term pollution effects on health can gain more priority. Education, starting with the primary school level, is essential for developing awareness of risk and the environmental interaction with health (Box 9).

**Box 9: Ten positive actions for reducing industrial water pollution**

1. **International and national agreements** on safety precautions; banning dangerous chemicals or prohibiting their discharge into water sources; improving drinking water and sanitation; also **legislation**: environmental protection laws to protect and monitor water sources, including fishing areas, recreational water areas and drinking water sources at risk from industrial discharges, clear labelling of chemicals used in industry and use of marker chemicals (e.g. harmless dyes) in case of water contamination.

2. **Public-private partnerships** to foster joint ownership of environmental issues and ways of reducing water pollution.

3. **'Think globally, act locally'**: encourage community agreement on the causes of environmental water contamination.

4. **Improved surveillance of health effects**: epidemiological evidence of effects of contaminated water is essential to convince and influence legislators and industrialists.

5. **Education**: community environmental projects for schools, national campaigns, local community initiatives. Education at all levels should promote an understanding of risk, the interactions of the ecosystem and the importance of biodiversity in water sources. Also education about the importance of diet and general health in minimising the impact of environmental hazards.

6. **Improving the health and living conditions** of disadvantaged groups, such as women and children: clean water and improved sanitation contribute to reducing pollution risks.

7. **Conservation activities**: recycling; cleaning up refuse areas, reducing risk of harmful substances reaching water sources; voluntary restriction on use of chemicals.

8. **Learning from past disasters**: studying the 'classic' water pollution cases such as Minamata to ensure that the lessons are understood - and remembered.

9. **Developing risk assessment and health and environmental impact assessments** (HIAs and EAs) for industry and urban planning: environmental impact assessments in the past have not given enough priority to the cross cutting nature and scale of health impacts. Also, potential water pollution needs to be specified in public health impact assessments (Birley, 1995).

10. **Developing and promoting the use of environmentally safe technologies** in developing countries, for example use of pesticides of biological origin and integrated pest control management, which has less cumulative effect on ground water and other...
Further information

Arsenic pollution in Thailand:

UN SEAR: Arsenic contamination in groundwater affecting some countries in the South East Region (Regional Committee 54th session). http://w3.whosea.org/rc54/54_8.htm


Cyanide contamination in Romania: http://www.zpok.hu/cyanide/baimare/accidentdescription.htm


Pollution permit laws in India:


Pollution of Lake Tanganyika:


Pollution in Mauritius:
Pesticide contamination in Mali:

UN Office for the Coordination of humanitarian affairs (OCHA). Update 629 of events in West Africa. Integrated Regional Information Network (IRIN) for West Africa, 10 Jan 2000: http://www.reliefweb.int/IRIN/wa/countrystories/mali/20000110.htm


Water pollution in China:


