23. Introduction

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A very large number of human activities related to the production and use of toxic substances were identified and suggested as pressure indicators by members of the European scientific community. From these, 31 were chosen for a list of proposed indicators to be ranked by respondents of the second-round questionnaire.¹

1. RESULTS OF THE SECOND-ROUND QUESTIONNAIRE

The 15 highest-ranked indicators in the second questionnaire are presented in Figure 23.1. The figure provides the ranking of each indicator for policy relevance, analytical soundness and responsiveness. Also, the core ranking of the indicators is presented expressed as a percentage of experts who included the indicator in their top five list of essential indicators.

The ranked list of essential core indicators is in general comparable to the ranking of the three quality criteria. The one clear exception to this is TX-18 ‘Emissions of dioxins by economic activity’, which is ranked lower as an essential core indicator than for the quality criteria. The reason for this is not clear but may be related to the fact that even though dioxins are known by society as a component of high toxicity, the amounts in use are low due to reduction measures that have already been undertaken.

The indicators on the proposed list can be divided into two groups: those focusing on specific elements or substances, for example, emissions of lead, mercury, polychlorinated biphenyls (PCBs) or dioxins; and those focusing on general groups of elements or substances, for example, heavy metals, radioactive materials, pesticides or chlorinated compounds. In the short-list of 15 most favoured indicators given above, all the specific indicators are missing except dioxins, which suggests a need for general indicators. However, general indicators are likely to be less feasible than specific indicators and may be limited if elements or substances treated as a group have inherently different properties. Ways of overcoming these difficulties may be to introduce
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effect-related weighting such as those used for the estimation of the contribution of a substance to global warming (expressed as global warming potential, GWP), or depletion of stratospheric ozone (ozone formation factor, ozone depletion factor).

There are three basic clusters of the ranked indicators (Figure 23.1). Thirteen of the 15 indicators focus on organics, metals and/or radioactive substances. Four deal only with organics, three only with heavy metals, two with radioactive materials and the remaining four with both organics and metals.

2. DELIMITATION OF THE POLICY FIELD AGAINST OTHER POLICY FIELDS

It is important to note that some of the other policy fields also deal with issues closely related to the Dispersion of Toxic Substances policy field.
These related policy fields, such as Waste, Air Pollution and Water Pollution, Marine Environment and Coastal Zones, and Urban Environmental Problems, concentrate on substance flows in society, or on societal activities where the substances are used. In this context society comprises both its physical dimensions and its activities. Societal activities are, for example, industrial production, farming, forestry, power production, combustion processes, pesticide use and diffusive spreading of substances.

**Toxic Substances**

Toxic substances are chemical substances that are harmful to biological systems. The term ‘toxicity’ can be defined in several ways, such as the ability for a given substance to cause damage to living tissue, impairment of the central nervous system, reproductive malfunctions, genotoxic effects or, in extreme cases, death, when ingested, inhaled or adsorbed. However, it has often been stated that it is the dose which makes a chemical substance toxic. That is, any chemical substance *per se* can be toxic to an organism above a critical concentration. The critical dose or potential of exposure varies widely from one substance to another, and also from one type of organism to another. Those substances or elements for which the critical dose is generally small, and thus the potential of exposure large, are referred to as ‘toxic’.

The way chemicals cause damage to biological systems varies. Some substances and elements that an organism is unfamiliar with, and does not possess mechanisms to deal with, are toxic because they interact with functional processes like protein synthesis or the transfer of signals in the central nervous system. Other substances are toxic due to their interaction with the organism at a molecular level, for instance breakage of chemical bonds in bio-molecules by radicals or ionizing radiation.

Toxicity is only one of the properties that governs the ability of a given substance to be harmful. Other properties that must be considered are persistence of the substance as well as its ability to be accumulated in an organism. One factor which is related to persistence is the fate of the substance in an environment. The chemical and (micro)biological interaction with a substance or element affects the properties of the substance in a way that is often difficult to foresee. These processes include the formation of new species, for example methylated mercury or arsenic species, and organic metabolites. Many of these new species and substances often have toxicity properties totally different from their mother substances. The number of chemical elements, limited to just over one hundred, may appear in an unknown number of different species. The number of organic and inorganic substances that may be transformed to new substances in the environment is huge, and only a
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Some toxic substances are produced and used by society due to their toxic properties, for example, biocides, pesticides, fungicides, herbicides, disinfectants, and antifouling substances. Others are related to industrial production processes, waste incineration and energy production, or to use in building and construction materials. The dispersion of toxic substances from the latter group is more complex since the emissions are often diffuse and take place over a long time period, during the whole life-cycle of the products. For example, emissions of metals from a car start during the mining of component materials and continue during production and use, and end when the car is deconstructed or handled as waste after use. This perspective is often referred to as ‘a life-cycle perspective’. To some extent, toxic substances are also produced by organisms (for example, botulinus toxin produced by bacteria) or emitted by natural processes like volcanic eruptions or forest fires.

Indices of Toxic Substances

To be able to measure the pressure of toxic substances on society from a certain area, the ideal would be to know the emissions, fate and the toxic effects of every substance. Preferably, the combined effects of several substances should also be known. Unfortunately, this knowledge is far from what is known today, and will probably never be fully available due to the speed at which new chemicals are invented and used. Instead, the index for toxic substances, as indeed the environmental activities to reduce the spreading of toxic substances, will always be limited to current knowledge. This means that if a certain list of substances is chosen for an index, new substances are likely to be added over time. If all the substances are weighted together, this will make comparisons from year to year, and between different countries, rather difficult. However, this situation may have to be accepted, for lack of better alternatives.

In the framework of international conventions, slightly different approaches are used for metals and organic substances. With regards to metals, a small and fixed number of high-priority metals (Cd, Hg and Pb) has been selected. By focusing on these most relevant metals, the improvement of the heavy metal pressure on the environment is most cost-effective. At the same time, they can be used as indices of the progress of emission reductions for heavy metals in general since they represent various source types. Organic substances are treated differently and as a larger group since new substances...
frequently appear, and older ones are phased out. Effect-related assessment systems are also used to rank substances, for example chlorinated organic compounds (UNEP) or different types of radioactive materials.

3. APPROACHES USED IN THE CONTRIBUTIONS

In the chapter by Renzoni (Chapter 24), a straightforward description of the current global environmental situation is given. Environmental pressure due to unevenly distributed population growth with an uncontrolled need for energy and materials is seen as the cause of adverse effects such as acidification, climate changes and worldwide contamination.

Renzoni suggests that ‘to evaluate environmental pressure in a selected site, one of the key requirements is to quantify the dispersal of toxic substances, their environmental fate and toxic potential’ and that quantitative data can be classified in different groups, each corresponding to a numerical index to be combined into a general ‘Dispersion of Toxic Substances Index’.

The message of this chapter is that changes in human pressure on environmental systems are needed. The necessary measures and technologies for these changes are known. The general approach to reducing human pressure is to relocate man into nature. To achieve this needs international coordination in changing social, economic and conservation strategies. Global changes may be achieved only by adopting global policies for sustainable development. These will ultimately cause a drastic reduction in environmental pressure and a recovery in quality of life.

The chapter by Dr Feidler and Professor Hutzinger concentrates mainly on the question of how to arrive at analytically sound pressure indicators for the dispersion of toxic substances. It explains that the ‘risk’ from toxic substances is not simply defined by the toxicity of emitted chemicals, but also by such factors as dose, exposure and human acceptability. Two approaches to categorizing environmental pressures are outlined, the substance-based approach and the activity-based approach. The authors then explain the process of assessing pressure on the environment using a substance-based approach by reference to their own research into the assessment of harm to the aquatic environment by chlorinated organic compounds and by the example of risk assessment for chlorinated pesticides.

The authors stress that, in the case of persistent compounds, recent actions to stop their release can prevent further environmental damage, but possibilities for reducing the impact of past emissions are limited. The recovery from contamination will often depend on the environmental media that are degraded, for example, the atmosphere and vegetation will have faster recovery times than soil, sediment or the human body. The chapter concludes that
harmonized international action for reductions in pressures is necessary because the transport of pollutants is not contained within national boundaries.

4. INTERNATIONAL FRAMEWORK OF THE POLICY FIELD

International cooperation to address global and regional environmental problems, including the degradation of natural resources, has grown dramatically in the past 25 years. This is reflected in the adoption of a large number of international conventions (approximately 180). Before 1970, most of the signed treaties were directed towards the protection of flora and fauna in different regions. These agreements related to the dispersion of toxic substances such as oil spills at sea, the use of nuclear power and protection of transboundary watercourses, including the Convention on the High Seas (United Nations, 1958), the Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention, 1960), the Nordic Mutual Emergency Assistance Agreement in Connection with Radiation Accidents (1963) and the Vienna Convention on Civil Liability for Nuclear Damage (1963).

There was a major breakthrough for international cooperation on environmental issues at the 1972 United Nations conference in Stockholm, which led to the establishment of the United Nations Environment Programme (UNEP). This has resulted in a large number of conventions, protocols and treaties mostly covering regions or sub-regions, such as a number of regional sea conventions, negotiated under UNEP and outside UNEP, aimed at protecting the marine environment from toxic substances. Among these, the Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft (The Oslo Convention, 1972) and the Convention for the Prevention of Marine Pollution from Land-based Sources (The Paris Convention, 1974) have had the largest impact.

Some other conventions function as frames within which the parties concerned accept principles and methods for cooperation. An example of such a convention is the Convention on Long-Range Transboundary Air Pollution (1979). Five protocols were later added to this convention, of which at least two are related to emissions of toxic substances. These two are the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Long-Term Financing of the Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) (Geneva, 1984), and Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution concerning the control of Emission of Volatile Organic Compounds or their Transboundary Fluxes (Geneva, 1991).

Other conventions of importance for the regulation of toxic substances are:
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel, 1989), and the amendment to this (Geneva, 1995)

Convention on the Protection and use of Transboundary Watercourses and International Lakes (HELCOM) (Helsinki, 1992)

Convention on the Transboundary Effects of Industrial Accidents (Helsinki, 1992)

Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention, 1992)

A protocol on atmospheric transboundary transport of persistent organic pollutants was negotiated in 06/1998 under the UN-ECE LRTAP convention

A protocol on atmospheric transboundary transport of the heavy metals Hg, Cd and Pb was negotiated in 06/1998 under the UN-ECE LRTAP convention.

Also, reductions of emissions of radioactive materials to waters are agreed upon in the OSPAR and HELCOM conventions. Nuclear safety, which is under the control of IAEA (International Atomic Energy Agency), is regulated in a large number of guidelines but also in a number of signed conventions, for example the Convention on the Physical Protection of Nuclear Material (1979) and the Convention on Nuclear Safety (came into force in 1996).

NOTES

1. First questionnaire: December 1995; second questionnaire: October 1996. See Editors’ introduction and section 1 of this chapter. See indicator lists in Annex I A and I B.

2. See also information on targets on TEPI Web site (http://e-m-a-i-l.nu/tepi/what’s new/the documents/download example).