The EEA and UNEP Annual Message 2
on the State of Europe's Environment

UNEP

Chemicals in the European Environment: Low Doses, High Stakes?

European Environment Agency

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Contents

The EEA and UNEP have published this state of the environment message on "Chemicals in the European Environment" in order to raise awareness of the issues, and to help build the public and political support needed for all to enjoy the benefits of chemicals, but at a reduced cost both to nature and human society.

Preface

Following the first joint annual message on water stress in 1997, the EEA and UNEP are pleased to publish a statement on another subject of prime concern: Chemicals in the Environment. As "watchers" of Europe's Environment, these statements aim to raise public and political awareness on critical or emerging issues to facilitate preventative action by governments and others.

This year's annual message comes to you at a time when international activity in chemicals and the environment is moving into higher gear. The European Commission has begun a review of EU policies on chemicals, and governments have recently agreed the text of the so-called "prior informed consent" or PIC Convention, regulating international trade in hazardous chemicals. PIC will establish an international alert list and help developing countries obtain the information they need to protect their citizens and their environment. By preventing unwanted imports of dangerous chemicals, this convention will provide a first line of defence against future tragedies.

Meanwhile, rapid progress is also being made in reducing releases and emissions of persistent organic pollutants, or POPs. We now understand that in addition to the deaths and acute effects caused by direct and immediate contact, POPs – which include some of the most toxic chemicals ever made – can cause cancer, allergies, damage to the central and peripheral nervous systems, diseases of the immune system, reproductive disorders, interference with normal infant and child development, as well as damage to wildlife.

European countries have adopted an agreement on POPs under the Convention on Long-Range Transboundary Air Pollution at the fourth European conference of environment ministers in June 1998 in Aarhus, Denmark. The global community is not far behind. Talks on a worldwide POPs treaty began soon after in Montreal. These global talks are critical for Europe because POPs released in one part of the world can be transported to regions far away from their original source.

Encouraging as these efforts may be, a great deal remains to be done because many thousands of chemicals are on the market but without adequate information on their fate and impact on people and ecosystems.

As the costs of conducting toxicity testing of these chemicals and their degradation products under realistic conditions of exposure would be very large, consideration is being given to reducing progressively – but substantially – unwanted exposures to potentially hazardous chemicals that persist and accumulate in the environment: this seems to be an appropriate application of the precautionary principle to the problems of chemicals.

At the same time, more risk assessments and improved implementation of existing laws are urgently needed if an appropriate balance is to be struck between the risks and benefits of chemicals.

These different issues require the participation of civil society and increased public awareness and education. We must also provide industry with long-term scenarios that they can adjust to by developing efficient and lower-cost alternatives which will enable them to stay in business by doing sustainable business.

Clearly, solutions must be tailored to the properties and uses of each particular chemical and groups of chemicals, as well as to each country's unique circumstances. But action must be taken quickly. Each year that passes without effective action will result in decades of additional, unintended exposure to chemicals that are likely to be harmful to human health and the environment.

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Summary

- Manufactured chemicals are **widespread** in the air, soil, water, sediments and biota of Europe's environment, following the marketing of up to 100,000 chemicals in the EU, their use and disposal, and degradation.

- There is a **serious lack of monitoring and information** on these chemicals; their concentration and dispersion in air, water, sediments, soils, species and food; and related exposures and effects on people and ecosystems.

- Various control measures have reduced risks, and **some emissions and concentrations are declining** in Europe, particularly of a few persistent organic pollutants (POPs) and heavy metals, but some of these concentrations remain at levels that **may be hazardous**.

- Current toxicity risk assessments are based mainly on **single substances**, but people and ecosystems are generally exposed to very complex **mixtures**.

- For **75% of the 2,000 - 3,000 large volume chemicals** on the market there is **insufficient toxicity and eco-toxicity data** publicly available for "minimal" risk assessment under OECD guidelines.

- The costs in time and resources of filling the toxicity and exposure data gaps for the thousands of chemicals in use, their breakdown products and relevant mixtures, will be large, as the comprehensive toxicity testing of one substance costs an estimated ECU 5 M.

- While there is **little direct scientific evidence of *widespread* ill health or ecosystem damage** being caused by most manufactured chemicals, apart from ozone layer depletion, impacts from fossil fuel combustion emissions, and acute impacts, such as from accidents or local spillages, **"no evidence" does not necessarily mean "no effects".** The difficulties and costs of detecting effects, the long time lags between exposure and some effects, and the absence of relevant studies and data mean that the widespread exposures to low doses of chemicals may be causing harm, possibly irreversibly, particularly to sensitive groups such as children and pregnant women, and to parts of the environment.

- The evidence for some chemical hazards in some people is increasing, particularly for **neurotoxins, endocrine disruptors that may damage developmental and reproductive health, cancers and allergies.** The evidence on **disturbances to wildlife and ecosystems** from low level chemical exposures is also increasing.

- Because some of these hazards are **serious, irreversible and take a long time to appear**, action to reduce exposure without waiting for certain proof of harm is now included in many international agreements (the **"precautionary principle"**).

- This encourages (as a supplement to toxicity testing) the reduction and prevention of exposure through **reducing chemical "loads"** in the environment, particularly of substances that **persist and bio-accumulate** and which therefore are a potential threat to people and the environment.

- **Many laws** exist to protect workers, consumers and the environment, but their **implementation and effectiveness can be poor.**

- Awareness of the environmental and social costs (**"externalities"**) of chemicals is increasing, along with the associated use of **taxes** on chemicals to bring these costs into market prices, thereby encouraging greater eco-efficiency in their production and use.

- There is increasing use of **public information**, both about chemicals in consumer products and about emissions of chemicals to the environment, and they appear to be effective in encouraging less hazardous production and use of chemicals.

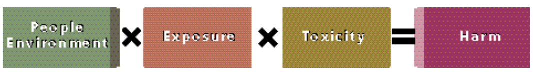
- Chemical **feedstocks** from "softer" chemicals than fossil fuels, such as plants, are being developed.

1. Introduction

Manufactured chemicals play a key role in the provision of a large range of goods and services that support our lifestyles and economies. However, even small amounts of some chemicals can endanger human health and the environment. With increasing quantities of such chemicals in the environment and improved scientific understanding of their effects on people and ecosystems, the challenge is to find the right balance between the benefits and risks of chemicals. This is a *"dilemma for modern society: we use chemical substances to solve problems, but we don't know the price we have to pay in terms of health and environment. We cannot exclude the risk of unpleasant surprises from chemicals of the kind man has repeatedly experienced in the past."* (KEMI, 1998.)

To what extent is Europe's use of chemicals affecting people and the environment? Paracelsus, the 16th century father of the science of poisons (toxicology) said *"All substances are poisons: it is the dose that determines whether they act as a poison or a remedy"* (Cassarett and Doull, 1980). A chemical may be potentially harmful (toxic), but if there is no, or very little **exposure** ("dose") to people or the environment, there is no chance, or risk of harm (Fig. 1).

Figure 1 **Both toxicity and sufficient exposure are necessary to cause harm**



However, as seen with the CFC chemicals that have damaged the ozone layer, it is very difficult to know, or predict, what the harmful level of exposure to chemicals may be, and then to ensure that actual exposures in the environment are kept below those levels. Certainty in these matters is rare, so all who have a stake in the risks of harm from chemicals – the public, businesses, policy-makers and scientists – have a role in trying to determine an acceptable "dose" of chemicals for humankind and for the planet.

Natural chemicals are also widespread in the environment and may cause problems for human health and ecosystems, but unless they enter the manufactured chemical processes, they are not covered here.

Some pesticides are mentioned, but particular legal controls on pesticides and biocides are not covered in this survey.

The current report aims to improve public awareness by exploring four key questions concerning the management of chemicals:

1. How many chemicals are there on the market and what is known about their hazards?
2. What is known about how chemicals move through and accumulate in the environment?
3. What are the known and suspected human and ecological risks from exposure to chemicals?
4. What are the current and emerging policy initiatives for reducing or eliminating these risks ?

There are many uncertainties about the impacts of chemicals on people and the environment, but the scientific and policy complexities are better appreciated and understood than they were just a decade or so ago. This has encouraged the development of a "new paradigm" in chemicals risk management based on the "precautionary principle" and on the provision of incentives to reduce the total "dose" of chemicals potentially hazardous to the environment.

In this context, the European Commission has begun a stock-taking of the legislative instruments governing chemicals, commencing in 1998 with the review of:
- the classification, packaging and labelling of dangerous substances Directive No 67/548/EEC
- the existing substances Regulation, (EEC) No 793/93.

The focus of this report is manufactured chemicals in Europe, but some information relates only to the EU, or to developments in other countries in the OECD (Organisation for Economic Co-operation and Development), which reflect the global nature of the production and use of chemicals.

2. Chemicals without borders

Most chemicals find their way into the environment via millions of consumer, agricultural and industrial products and processes. Once in the environment, they can persist for long periods of time or break down into other chemicals with their own risks. They may also produce health or environmental effects when they act together with other natural or manufactured chemicals that are already in the environment.

Tracking the pathways, fate and exposure implications of chemicals is essential for effective risk management, but it is complex. It requires:

1. identifying the flows of each chemical and its by-products through the economy, from mining or synthesis to manufacture, marketing and use, and on to possible recycling and ultimate disposal;

2. estimating emissions, pathways and depositions both to and from air, water, sediment and soil from the processes and products at each stage of their life cycle and identifying transformations of each chemical and resulting compounds;

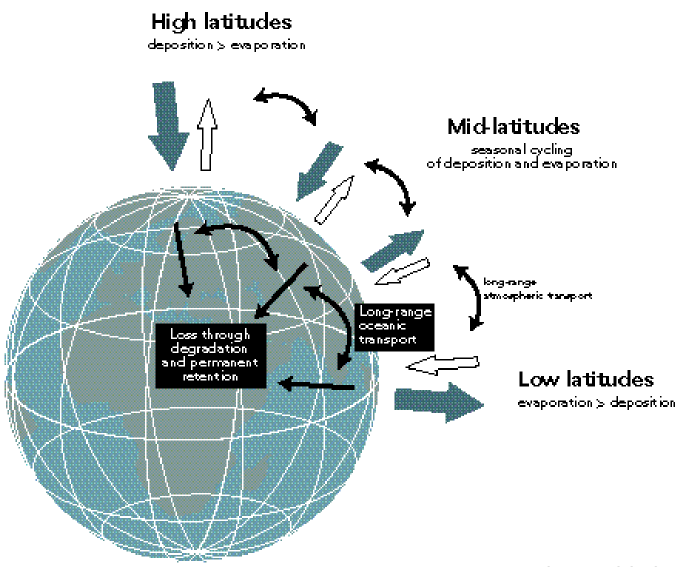
3. constructing an area pollution model (or "regional mass balance") for assessing the inputs, outputs, and fate of the chemicals on a geographic basis, and then estimating the likely exposures of people and ecosystems to the chemicals.

This kind of analysis requires data and information which is only available for very few chemical substances (EEA, 1998a).

Some organic (carbon-based) substances persist in the environment, travel long distances and consequently circulate globally. This means that although these persistent organic pollutants (POPs) can be found almost anywhere, it is difficult to identify where they originated, let alone the pathways by which they travelled.

One of the main ways that the most volatile POPs travel is through the "grasshopper" effect (Fig. 2). POPs released in one part of the world, via pesticides for example, can, through a repeated (and often seasonal) process of release, deposit, release, and deposit again, be transported to regions far away from their original source. This is why POPs can be found in the Arctic, thousands of kilometres from any major source of POPs.

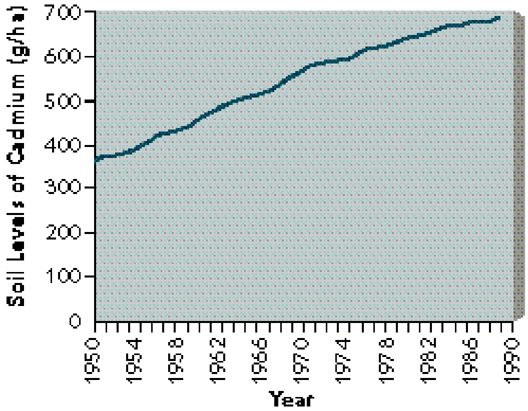
The "Grasshopper" Effect: Pathways and Processes involved in the long-range transport of semi-volatile Persistent Organic Pollutants (POPs) — **Figure 2**



Source: CCEC, 1997

Heavy metals such as lead, cadmium and more complex POPs like dioxins can also disperse over long distances. For example, cadmium in the Rhine basin in Germany has been on the increase for many years due to pollution from a number of sources, including oil combustion, steel production, zinc refining, cadmium plate manufacturing, and municipal waste disposal (Fig. 3). Because cadmium accumulates in soils and groundwater, efforts to reduce cadmium pollution could take about 15 years to start reversing the upward trend. Inhabitants of the region may be exposed to cadmium greater than the World Health Organization's recommended maximum acceptable levels, especially if the soil is acidified (Stigliani and Anderberg, 1994). Similarly, some pesticides can percolate slowly through soil

Figure 3 **Estimated build-up of cadmium in agricultural soils in the Rhine Basin 1950-1988**



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and accumulate in groundwater and river sediments long after their use has stopped. For example, pyrethroid insecticides have been detected in river *sediments* at 10,000 times the level in the river *water,* where any monitoring of chemicals is usually focused. (Neal *et al.,* 1997, 1998).

POPs can also travel through living organisms and can become increasingly concentrated in the tissues of animals at high levels of the food chain, such as predatory birds and mammals, including humans. This "bio-magnification" can, for example, increase concentrations of polychlorinated biphenyls (PCBs) to many million times their initial presence in the physical environment.

The ways in which humans and the environment are exposed to chemicals are thus multiple and complex, and exposure to mixtures, not just single substances, is common. However, enough is known about the exposures and effects of certain substances, including some POPs and heavy metals, to justify reducing exposure to them and to other chemicals that also persist and bioaccumulate. In addition, more research is needed in order to better understand the movements and metabolism of the thousands of other chemicals released and present in the environment.

3. Many chemicals, but limited toxicity data

The world-wide chemicals industry produced 400 million tons of chemicals in 1995. Europe is the largest chemicals-producing region in the world, accounting for 38% of the total; Western Europe alone accounts for 33% (UNECE, 1997). Chemicals production and use provide 2% of Europe's GDP and 7% of its employment. The EU exports 22% of its chemicals (by value) and imports 15%. Germany provides 26% of EU chemicals production, France 19% with the UK and Italy each providing 12% in 1996 (CEFIC, 1997).

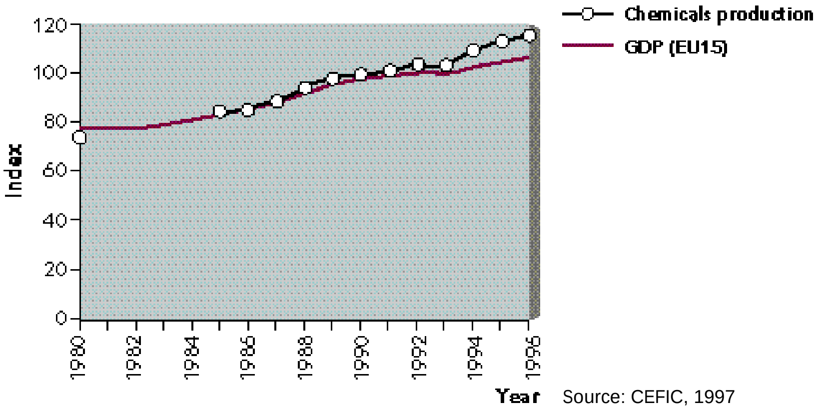
Chemicals production grew roughly in line with GDP until 1993 when it began to grow faster. The "chemicals intensity" (i.e. the volume of chemicals per unit of GDP) of Europe's economy is now therefore higher than it was five years ago (Fig. 4). This growth, however, has been limited to Western Europe. In Central and Eastern European countries (where GDP declined by 35% from 1989 to 1995), chemicals production has declined. Production seems to have bottomed out now, however, and is on the way to recovery in Bulgaria, the Czech Republic, Estonia, Hungary, Poland and Slovenia. Sales of pesticides in Europe, by value and by tons of active ingredients, fell between 1991 and 1995 but have risen since then (ECPA, 1997).

The number of ***existing*** chemicals on the market is large, but the exact number is unknown. Over 100,000 were registered in the European Inventory of Existing Commercial Chemical Substances (EINECS) in 1981, but the current estimate of marketed chemicals varies widely, from 20,000 to as many as 70,000 (Teknologi-Rådet, 1996). Little is known about the toxicity of about 75% of these chemicals (NRC, 1984; EDF, 1997). Several hundred ***new*** substances are marketed each year after some basic pre-market toxicity testing and these are registered in the European List of Notified Chemical Substances (ELINCS), which presently contains about 2,000 chemicals. Of the *existing* chemicals, some chemicals have been selected for risk assessment by the EU, in the framework of OECD's programme on co-operative investigation of High Production Volume Chemicals, based mainly on their hazardous potential. Data on these chemicals is available in the International Uniform Chemical Information Database (IUCLID) held by the European Chemicals Bureau (ECB) of the EC's Joint Research Centre, Ispra, Italy.

In addition to chemicals that are placed on the market, either as intermediates within a production process, or as part of final products, there is the unintentional formation of chemical by-products in a number of processes, such as energy production and metal refining, which can also impact on the environment.

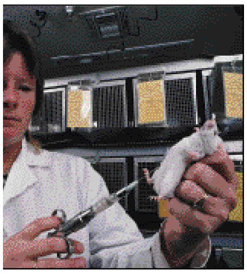
The rise in the quantities and the variety of substances released and accumulating in Europe's environment increases the potential for damage to human health and the environment. The level of these risks is determined by their toxicities and by their "doses" to people and/or ecosystems. "Risk assessment" is used to try and identify potentially harmful exposure levels so that they can be avoided.

Western European chemical industry production and GDP — **Figure 4**



Source: CEFIC, 1997

4. Risk Assessment



The EU initially focused on the hazard assessment of new chemicals put on the market after 1981 which were required to have some pre-market toxicity testing. In 1993, the EU began to assess the risks of the 100,000 existing and 2,000 new chemicals that have no, limited, or adequate toxicity and/or eco-toxicity data, starting with those whose production exceeds 1,000 tonnes a year (Fig.5). There are 2,500 of these high production volume chemicals (HPVCs) which are currently being assessed by the European Chemicals Bureau (ECB). These risk assessments are performed by the EU and Member States, and they require comprehensive information and data, which are often not available.

For about 75% of the 3,000 or so chemicals in large-scale use, the "minimal" toxicity data required by the OECD for a preliminary assessment of health hazards to humans is not publicly available (NRC, 1984; EDF, 1997). Similarly, little is known about eco-toxicity.

Although searching more databases reveals more data, the results from recent surveys by the US EPA and the Chemical Manufacturers Association of America confirms that about 75% of chemicals have insufficient toxicity or eco-toxicity data for preliminary OECD risk assessments (CMA, 1998).

More toxicity and eco-toxicity data is held by companies and regulatory authorities in the EU and elsewhere. Some of this is confidential and not available to the public for peer review, but some is being made available to the authorities and the public.

It is difficult to even broadly classify chemicals as "dangerous", under labelling requirements, for example, without minimal toxicity data (Temanord, 1997). Box 1 illustrates these main toxicity data gaps. Filling these gaps is a priority, but a costly one. Costs vary from ECU 100,000 for a basic set of toxicity data to an estimated ECU 5 million for the comprehensive toxicity testing of one substance, and up to ECU 15 million for exceptional cases where field testing and monitoring are needed (Teknologi-Rådet, 1996).

There is also a need for the toxicity testing of *mixtures* (EHP, 1997a), since current risk assessments are usually based on *single substances*. Mixtures may be more or less toxic than the additive effects of single substances. Thousands of animals are needed for these tests, a practice which itself is also a controversial issue. Steps are being taken to minimise use of animals in toxicity testing by the European Centre for the Validation of Alternative Methods of the Joint Research Centre. The relevance of animal test results for risks to humans is also difficult to establish, and is complicated by species dependent effects. For example, humans are 100 times more sensitive to the birth-defect impact of thalidomide than rats (Epstein, 1978). Some chemicals may be harmful to rats at high doses, but not to humans at lower doses.

There are also data gaps concerning the pathways and use of chemicals and related

Box 1 — Some toxicity and exposure data gaps

- No adequate toxicity data for about 75% of substances in use
- No adequate ecotoxity data for 50-75% of the priority (HPVC) chemicals reviewed by the EU
- A "major lack" of human health and exposure data for these priority chemicals
- Chemical structure data (QSARs) may provide only a reliable estimate of the aquatic toxicity of 15-20% of HPVCs.

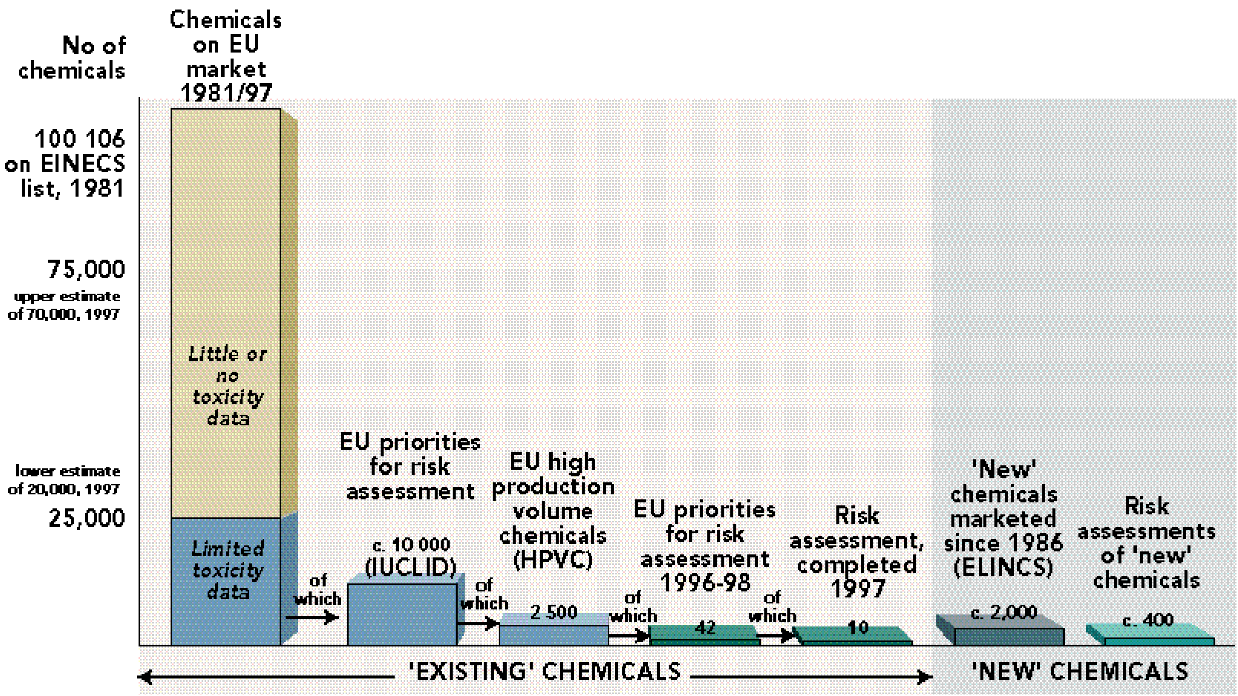
Source: European Environment Agency, based on NRC (1984), EDF (1997), van Leeuwen *et al.* (1996), and van der Wielen (1996)

Box 2 — Some other chemical data deficiencies

- Production and use of marketed substances and their presence in consumer products;
- Pathways, fate and concentrations of chemicals in the environment;
- Human and ecosystems total exposure including multiple exposures and mixtures;
- Identity of sensitive subgroups of people, other species and ecosystems;
- Nature and costs of impacts on people and the environment and their distribution;
- "Eco-efficiency" ratios for the production/use of chemicals.

Source: European Environment Agency

Many chemicals, limited toxicity data **Figure 5**



HPVC High Production Volume Chemicals, i.e. production over 1,000 tons/year

Little/no toxicity = less than OECD minimum for screening

Limited toxicity data available for OECD/EU screening (e.g. only 20-30% of substances have useable data on cancer or reproduction)

EINECS: European Inventory of Existing Commercial Chemical Substances

IUCLID: International Uniform Chemical Information Data Base

Adequate toxicity for EU risk assessment (including some cancer/ reproductive/neurotoxic data) but inadequate data on consumer or environmental exposures

ELINCS: European List of Notified Chemical Substances (New Substances)

Limited data available for basic toxicity screening

400 risk assessments carried out by Member States (confidential data)

Note: In addition to the EU existing chemicals risk assessment programme, both the OECD and WHO/IPCS have completed detailed risk assessments covering about 200 priority chemicals.

Source: EEA, based on CEC (1996), NRC (1984), EDF (1997) and ECB (1998).

exposures (Box 2), which makes risk assessment difficult, especially when the identity of the chemicals is difficult to establish (Johnston *et al.*, 1996). The time taken to complete risk assessments is causing concern (Greenpeace, 1996), and the quality of most of the toxicity data submitted by businesses to the regulatory authorities is not checked by the authorities.

More than 10,000 existing chemicals will be on the ECB database (IUCLID) by the end of 1998. This is a data source for the authorities of Member States and for risk assessments, and ECB will make the non-confidential part available to industry and the public. However, available financial resources are only sufficient for an adequate assessment of about 20-30 chemicals per year. Assessments of 10 chemicals were completed under the EU existing chemicals risk assessment programme by the end of 1997 (Fig. 5). Progress will accelerate in 1998, during which another 25 risk assessments are expected to be completed.

The EU's risk assessment programme is part of the legal scheme to reduce the risks of use of dangerous chemicals for man and the environment. Besides that it fits into the OECD programme on the co-operative testing and assessing of HPV

Chemicals. The OECD and their member countries are currently working on 240 chemicals and have completed 109 initial risk assessments over the last decade. Of these, 86 substances were considered of "low" risk, 13 needed more testing or exposure information, and, for 10 substances, further risk management measures were considered necessary, in some exposure situations (OECD, 1998a). The World Health Organization, through its International Programme on Chemical Safety (IPCS) and partners, UNEP and the International Labour Organisation (ILO), have also conducted peer reviewed risk assessments of chemicals since 1976. Over 200 assessments have been completed and published in the WHO Environmental Health Criteria Monographs, with most providing numerical "guideline values" for exposure limits designed to protect people and the environment from damage. Summaries of key scientific studies are published in their new Concise International Chemical Assessment Documents (CICAD), of which the first 6 were published in 1998 (IPCS, 1998). In addition, IPCS also evaluates chemicals in food and pesticides, producing "acceptable daily intakes" limits for over 1,000 food additives and 220 pesticides. Measures are being taken to harmonise these approaches to risk assessment and to minimise duplication between the EU, the OECD and IPCS programmes.

There is also an increasing focus on the chemical properties of ***groups*** of chemicals, such as those that ***persist*** and ***bio-accumulate,*** rather than on the specific ***toxicity*** of ***single*** substances (Teknologi-Rådet, 1996; Swedish Ministry of Environment, 1997), and this may help to speed up and focus the process of risk assessment and risk reduction. The problem of *accumulative* exposures to chemicals with similar biological effects has recently been addressed by the Food Quality Protection Act, 1996, in the USA. This requires the government to consider *total* risk from several pesticide exposures, rather than from single exposures, when setting "acceptable pesticide residues and daily intakes."

An exposure-based assessment that uses the persistence and spatial range of the chemical as an indicator of environmental threat requires less data, and can usually be performed faster, than a toxic effects based risk assessment (Berg and Scheringer, 1994). It can also help to identify any gaps between those who benefit from chemicals and those who bear the environmental or health damage, as chemicals with a high persistence and spatial range can distribute costs over a much wider area than that which receives the benefits, as, for example, with CFCs and ozone layer damage. It has been suggested that **exposure-based threat assessment** could be used for the initial screening of chemicals, complemented by **toxic effects risk assessment,** where this is likely to be cost effective and where data is available (Scheringer, 1997).

Exposure potential is also important for assessing the toxic risks from chemical emissions – those assessment methods that incorporate the most comprehensive human exposure data seem to produce the best estimates of risk, which can vary by 3 orders of magnitude (i.e. by 1,000 times), depending on the method chosen (Hertwich *et al.*, 1998).

5. Ecological and human impacts

Ecological Impacts

Although the **ecological** impacts of chemicals are complex, some effects are well-documented. The effects on various animals, birds (Campbell and Cooke, 1997) and fish (Cameron & Berg, 1994; Stebbing *et al.,* 1992), include birth defects, cancers, and damage to nervous, reproductive and immune systems (see Box 4). For example, dichlorodiphenyl trichloroethane (DDT) was implicated in the early 1970s as the cause of reproductive failure in eagles and other birds, due to the thinning of egg shells. Since then, a number of other cases involving wildlife have been studied, including large fish kills and declines in sea mammal populations. Contamination of fish by mercury, PCBs and other toxic chemicals appears to be increasing in the USA (NRDC, 1998) and evidence about the effects of low-level but possibly widespread contamination of fish is increasing in Europe (Matthiessen, 1998; Tyler, 1998). Recent results from the UK, for example, suggest that the incidence of feminisation and other sexual disruption in fish *"is higher than previously thought and is associated with discharges from sewage treatment works"* (EA, 1998).

The complexity of ecosystems, such as the North Sea, makes risk assessment very difficult without extensive multi-disciplinary research and integrated assessments (MacGarvin, 1994; Neal, *et al.,* 1998).

Human Impacts

Clear scientific evidence for many impacts of manufactured chemicals on **human health** (except for some occupational exposures) is also complex and difficult to identify. This is partly because people are exposed to many different substances and their breakdown products via indoor and outdoor pollution from several pathways, including air, water, food and passage through the skin. Since the 1970s, there has been increasing concern in particular about consumer goods, including food, which can be one of the main routes of exposure to chemicals for many people. Major stationary and mobile sources of exposure, such as factory chimneys, may now account for less than 25% of total exposure, according to US estimates (Wallace, 1993).

Another problem in identifying risks from chemicals arises from the need to account for the effects of other causal agents such as smoking, radiation, and natural toxins, which can also cause ill-health or ecological damage, either separately, or sometimes in combination with manufactured chemicals (EEA, 1998b). Furthermore, there are usually large gaps in time between an exposure to a chemical, the observation of possible ill effects, and a medical or scientific assessment about association and causation (Box 3). Health problems, such as cancer or allergies, are difficult to understand when they involve several, often inter-dependent causes, of which "chemical cocktails" may only be a part. The level, and burden of proof of harm, are also critical issues in risk assessment (Gee, 1995; Bro-Rasmussen, 1997). People at risk and other stakeholders including consumer

Association and causality — Box 3

It is sometimes fairly easy to show that a measure of ill-health (e.g. the number of admissions to hospital per day) is ***associated*** with a possible cause, such as the day-to-day variation in levels of air pollutants. However, to show that a ***causal relationship*** exists is more difficult. A number of guidelines or tests have been developed to help assess this. These include identifying whether there is a "dose-response relationship" between the proposed causal factor and the effect, whether the sequence of events makes sense (i.e. the cause always precedes the effect), checking the consistency of results between different studies, and the way in which the results of different studies fit together (coherence).

Proof of causality is often very difficult but, by the application of these and other criteria, an expert judgement as to whether an association is likely to be causal can often be made. Where effects are likely to be serious and/or irreversible, then a low level of proof, as in the "precautionary principle", may be sufficient to justify actions to remove or reduce the probable causes (WHO & EEA, 1997).

Box 4 **Some examples of ecological impacts and possible causes**

The association/causation is assessed on the scale: 1 = no observed association, 2 = suspected association, 3 = weak association, 4 = clear association, 5 = significant association.

Observation/impact	Sensitive species	Substance	Association/ causation
Large scale			
Eggshell thinning	guillemot, eagle, osprey, peregrine falcon	DDT	5
Reproduction	seal, otter	PCB	4
Skeleton malformation	grey seal	DDT, PCB	2
Pathological changes	seal	PCB, DDT, metabolites	3
Reproduction	mink	PCB	5
Reproduction	osprey	DDT, PCB	4-5
Reproduction	eagle	DDT, PCB	2-3
Reproduction	salmon	chlorinated substances	2
Large scale - pulp and paper industry			
Induction of metabolising enzymes	perch	chlorinated/ unchlorinated organic mixture/ Dioxin compounds	3
Local/regional - pulp and paper industry			
Induction of metabolising enzymes	perch	chlorinated/ unchlorinated organic mixture/ Dioxin compounds	3-4
Spine malformations	four-horned sculpin	chlorinated unchlorinated organic mixture	3-4
Local, forest industry			
Induction of metabolising enzymes	perch	chlorinated/ unchlorinated organic mixture Dioxin compounds	4-5
Spine malformations	four-horned fish	chlorinated/ unchlorinated organic mixture	4-5
Larvae damages	sea mussel	chlorinated/ unchlorinated organic mixture	3

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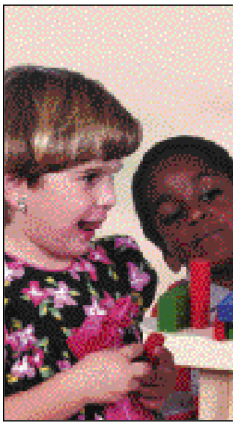


and trade union groups need to be involved in risk assessments (NRC, 1996; Consumers' Association, 1997).

Despite the difficulties of identifying and assessing potential risks, there is evidence about the health effects of manufactured chemicals in humans, including cancer, cardiovascular and respiratory diseases, allergies and hypersensitivity, reproductive disorders, and diseases of the central and peripheral nervous systems. These potential health impacts and some of their possible causes are summarised in Box 5.

Some chemicals clearly cause cancers in some exposed groups, but the role of chemicals in overall cancer causation is unclear and disputed (Doll, 1992; Epstein, 1998). Any excess cancer mortality from a chemical pollutant is likely to be restricted to a section of the population, so mortality rates for entire populations can often be weak and insensitive indicators of environmental health effects from pollution. Low levels of exposure to chemicals, including pesticides, may suppress the immune response defences of the body, leaving people more susceptible to diseases from viruses, parasites, bacteria and tumours (WRI, 1996).

The potentially hazardous effects of pharmaceutical chemicals, such as greater resistance to animal antibiotics and contamination of water supplies (Envirolink, 1998) are not covered further in this summary.

Chemical pollutants that may affect reproductive health and new-born **children** include certain metals (e.g. lead and methyl mercury), pesticides (e.g. DDT), industrial chemicals (e.g. PCBs), solvents and other substances (Foster & Rousseaux, 1995; CJPH, 1998, in press). Exposures can occur through the placenta and breast milk (Jensen, 1996; Rogan, 1996), and some may cause small abnormalities of the immune response system. However, the WHO and others conclude that the benefits of breastfeeding outweigh the risks of pollutants in breast milk (Weisglas-Kuperus *et al.,* 1996; WHO, 1996).

Children may be particularly at risk from chemicals because of their greater biological sensitivity and greater exposure to environmental pollution relative to body weight (NRC, 1993; McConnell, 1992; Bearer, 1995). Their physiological and intellectual development may be impaired by exposure to chemicals (Rodier, 1995; Rylander *et al.,* 1995; Jacobson, 1996; -Grand Jean *et al.,* 1997). Low-level pesticide contamination of food (infants consume eight times more food per kilogram of body weight than adults, making this a more significant exposure pathway; CICH, 1997) and of residential surfaces and toys in the UK and USA is being reported (Pesticides Trust, 1998, Gurunathan *et al.,* 1998). Some regulatory authorities are giving special attention to the higher levels of risk to children from pollution (US EPA, 1996). For example, the Food Quality Protection Act in the USA requires the government to add an extra margin of safety to the risk assessment of chemicals that children may be exposed to.

Cancer in children in the USA is increasing (Pogoda, 1997; EHP, 1998; Rachel's EHW, 1998), and a large-scale study of childhood leukemias and other cancers in the UK has found them to be associated with living close to industrial plants, particularly where fossil fuels were being used or processed (Knox & Gillman, 1997).

The causes of an increased incidence of testes cancer and breast cancer in humans, and of the effects on wildlife reproduction of **endocrine-disrupting chemical substances** that have been observed in many countries, are largely unknown. Changes in the environment, as well as in lifestyle, may be responsible (Colburn, 1993, CEC *et al.,* 1997; EA, 1998 – see Box 6).

It is the widespread presence of small amounts of many chemicals which is causing increasing concern, because alone, or in combination with other agents, they may contribute to cancer, allergies (UCB, 1997), impacts on reproduction and the immune response system, and neurotoxic effects (NRC, 1992; Kilburn, 1998). The

Box 5 Some health effects of chemicals

This is a summary of the main health effects of chemicals. The link with chemicals varies from well-known **causal** relationships such as benzene and leukaemia, to suggestive **associations**, such as chemical sensitivity and pesticides. **Most harmful effects are the result of many causes acting together, such as genetics, lifestyle, radiation, diet, pharmaceuticals, chemicals (manufactured and natural), smoking and air pollution, including indoor and outdoor exposures.** It is also important to consider sensitive groups, such as the elderly, children, the embryo, the sick, and pregnant women, who may be affected at much lower doses than others.

Health effect	Sensitive group	Some associated chemicals*
Cancer	All	asbestos Polycyclic aromatic hydrocarbons (PAHs) benzene some metals some pesticides several hundred animal carcinogens some solvents natural toxins
Cardiovascular diseases	especially elderly	carbon monoxide arsenic lead cadmium cobalt calcium magnesium
Respiratory diseases	children, especially asthmatics	inhalable particles sulphur dioxide nitrogen dioxide ozone hydrocarbons some solvents terpenes
Allergies and hypersensitivities	all, especially children	particles ozone nickel chromium
Reproduction	adults of reproductive age	polychlorinated biphenyls (PCBs) DDT phthalates
Developmental	foetuses, children	lead mercury other endocrine disruptors
Nervous system disorders	foetuses, children	PCBs methyl mercury lead manganese aluminium organic solvents

Examples only

Source:
EEA, based on Swedish EPA (1996); WHO (1995); EHP (1997b); Ashford, (1998); Williams (1997) and Kilburn (1998)

The "Weybridge Report" on endocrine disruptors

Box 6

The EEA has summarised the results of the *Report from the European Workshop on the impact of Endocrine Disrupters on Human Health and Wildlife* (CEC *et al.*, 1997) as follows:

There is increasing evidence and concern about rising trends of reproductive ill health in wildlife and humans, and some substances have been implicated, but there are great uncertainties about the causes of reproductive ill health.

Key conclusions are:

- Sufficient evidence exists that testicular cancer rates in humans are increasing.
- The apparent decline in human sperm counts in some countries was likely to be genuine.
- There is insufficient evidence to definitely establish a causal link between the health effects seen in humans with exposure to chemicals.
- The major route of exposure to Endocrine Disrupting Substances (EDS) is usually by ingestion of food, and to a lesser extent water. It is valid for terrestrial animals, birds and mammals, including humans.
- Compared with the situation in the US, there are few cases of reproductive ill-health in wildlife in the EU where the effects could be definitely associated with endocrine-disrupting substances.
- However, some cases exist within the EU area where adverse endocrine effects, or reproductive toxicity, in birds and mammals coincide with high levels of anthropogenic substances, shown to have endocrine-disrupting properties in some test systems.
- The considerable uncertainties and data gaps could be reduced by the recommendations on research and monitoring into exposure and effects in wildlife and humans.
- Current eco-toxicological tests, studies and risk assessments are not designed to detect endocrine-disrupting activities.
- Meanwhile, consideration should be given to reducing the exposure of humans and wildlife to endocrine disrupters in line with the "precautionary principle".

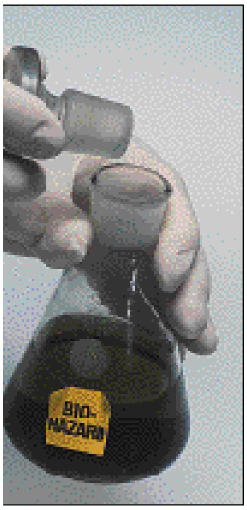
Source: European Environment Agency based on CEC *et al.*, 1997

timing of exposure to some chemicals is important, particularly for endocrine-disrupting substances, where exposures during the first 30 days after conception seem to be critical. Although exposure to chemicals may be very low for most people (i.e. in parts per million or trillion of air, water or food), some chemicals at such low doses can be potent. For example, estradiol, the body's key oestrogen hormone, operates at concentrations of parts per trillion-equivalent to one drop of water in 660 "rail tankers" (Brekine, 1997). And some chemicals may be more harmful at lower doses than at higher doses, since, for example, damaged cells may cause more harm than dead cells, and higher doses can trigger detoxification activity which is not triggered by lower doses (Lodovic *et al.,* 1994).

A recent and comprehensive review of the risk assessment of new and existing chemicals concluded: *"At the present level of understanding we cannot adequately predict adverse effects on ecosystems, nor can we predict what part of the human population will be affected. We are only able to assess risks in a very general and simplified manner"* (van Leeuwen *et al.*, 1996).

Despite the difficulties of risk assessment, there are many government and industry policies in place which have been designed to protect people and the environment by minimising the risks of manufactured chemicals.

6. Some policy initiatives for reducing risk



There are over a dozen **European Union Directives** on chemicals control (Fig. 7) concerning classification and labelling, marketing and use, risk assessment, and protection of workers, consumers and the environment. Compliance with, and enforcement of these Directives is uneven, in part because it can be difficult for industry to know how best to achieve compliance with several sets of regulations. For example, in the dyestuffs industry, a highly competitive business involving many innovative and potentially hazardous chemicals, a study of the Notification of New Substances Directive (the NONS project, VROM 1996) in the 15 Member States of the EU found that many new substances being used had not been reported to the regulatory authorities, or even identified. Their use was not properly recorded, and in some cases they were inadequately labelled. About 45% of the 96 companies visited in most countries of the EU did not conform to this Directive. However, a follow-up project revealed some improvements, with just 32% of the 100 companies inspected in this sector not conforming to the Directive (the SENSE project; VROM, 1998).

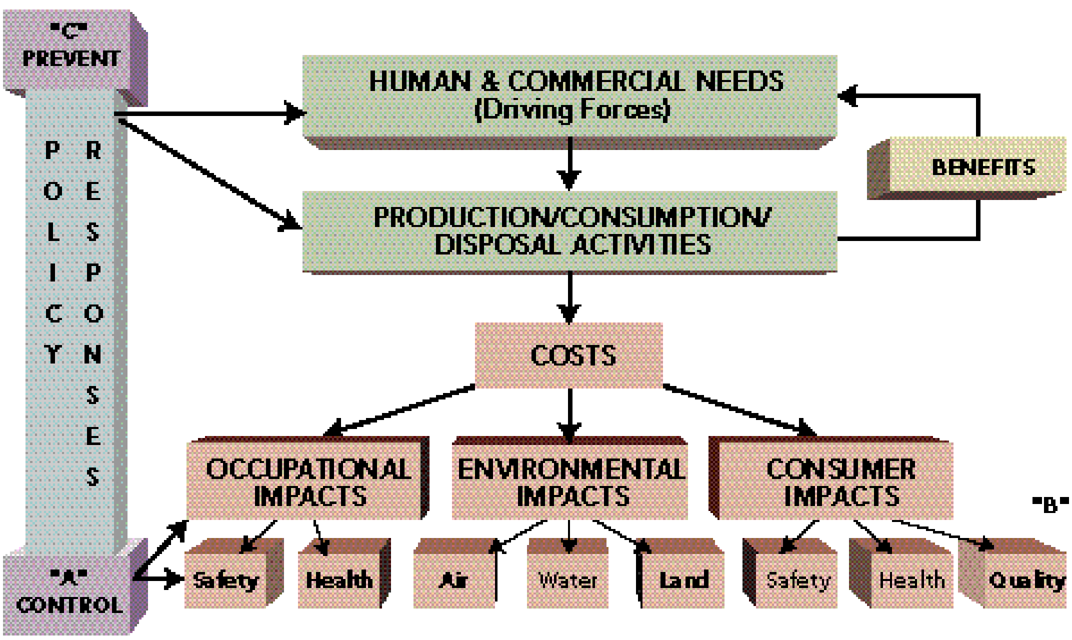
All European countries have extensive national legislation in the field of chemicals. For example, a review of UK legislation on the control of chemicals (excluding pharmaceuticals and poisons) listed 25 relevant Acts of Parliament which were overseen by seven government departments and augmented by over 50 sets of regulations (Haigh, 1995). A similar pattern of multi-departmental policy response exists in many EU countries, which is prompting efforts to streamline such legislation and to shift the focus of policy measures from “downstream” impacts of *control* on workplaces, consumers and ecosystems to “upstream” reduction of exposure potential and *prevention* (Gottlieb, 1995; Steingraber, 1997) (Fig. 6). The Integrated Pollution Prevention and Control Directive of the EU obliges large plants to adopt such a comprehensive approach to pollution prevention.

In addition to EU Directives and regional

Figure 6 **A framework for analysing policy responses to chemical impacts**

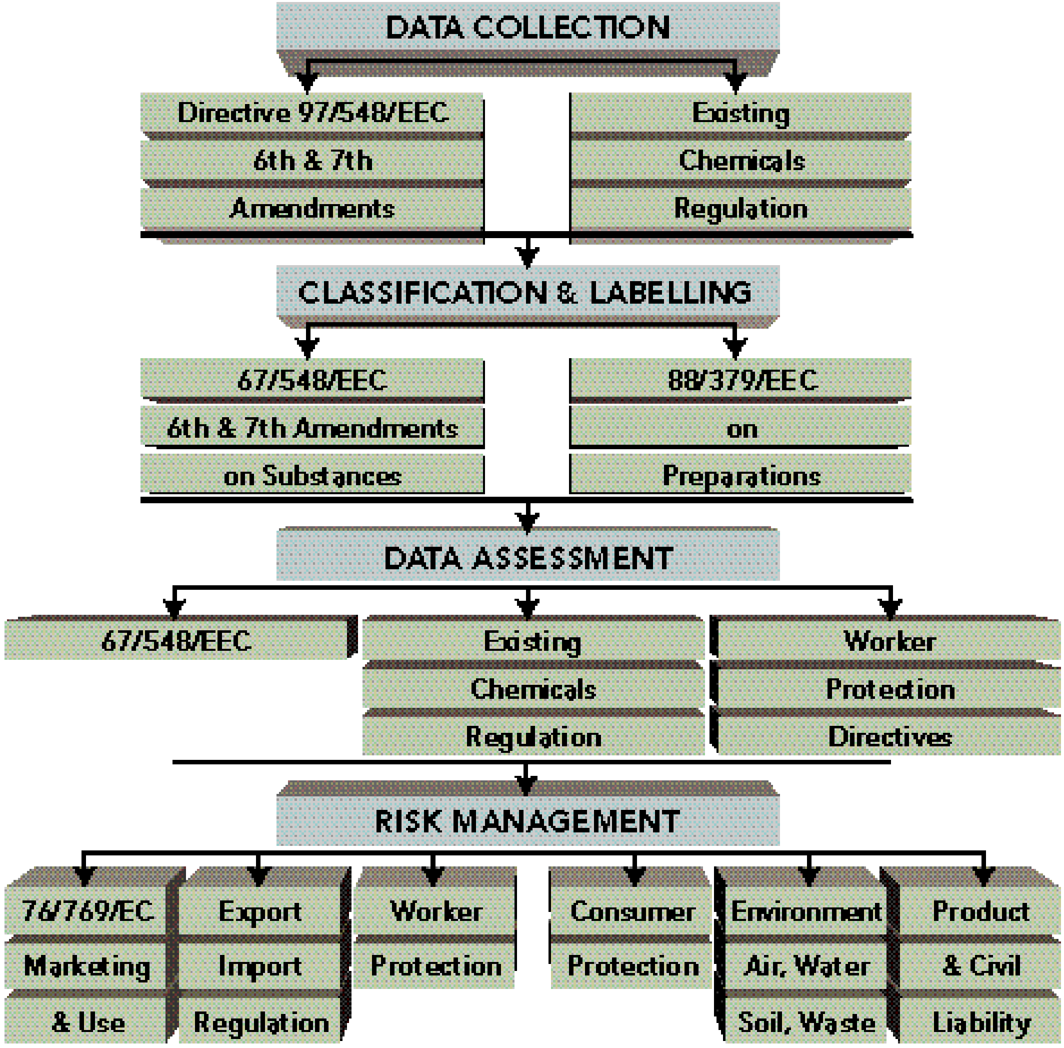
'olicy responses have mainly ocused on the “down-tream” **impact** of chemicals, ǫenerally moving from “A” o “B” over time. This has esulted in many chemical aws, enforced by several ǫovernment departments, vith associated difficulties of o-ordination.

'olicies at “C” focus on the upstream” sources of chem-icals, via the integrated pre-ention of exposures that **hreaten** health and the en-ironment, e.g. the Integra-ed Pollution Prevention and Control (IPPC) Directive. The need” for certain chemicals s also being addressed by everal stakeholders.



Source: European Environment Agency

Elements of Chemicals Control in the European Community — **Figure 7**



Source:
CEC, 1994

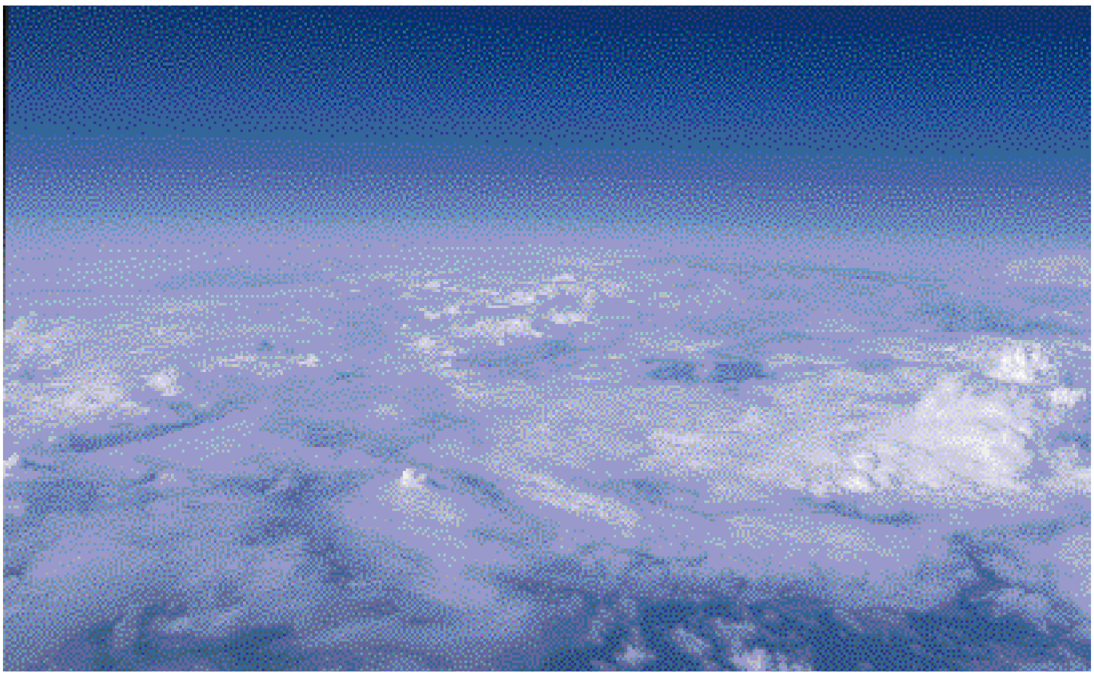
initiatives, European countries are guided by a number of regional and international treaties. The **Convention on Long-Range Transboundary Air Pollution (LRTAP)**, adopted in 1979 under the auspices of the United Nations Economic Commission for Europe (UNECE), covers Europe and North America. This Convention includes measures for eliminating or restricting use, reducing consumption and unintentional emissions or contamination, eliminating waste and improving the management of chemicals. It features two new protocols signed at the pan-European Ministerial meeting at Aarhus in June 1998. One protocol covers Persistent Organic Pollutants (POPs), including 16 pollutants: aldrin, chlordane, chlordecone, DDT, dieldrin, dioxins, endrin, furans, heptachlor, hexabromobiphenyl, hexachlorobenzene, hexachlorocyclohexane (including the isomer Lindane), mirex, polycyclic aromatic hydrocarbons, PCBs and toxaphene. The other protocol covers certain heavy metals (cadmium, lead and mercury).

The **Chemical Industry Sustainable Economic and Ecological Development programme (CHEMISEED)**, managed by the United Nations Economic Commission for Europe (UNECE), focuses mainly on harmonising legislation, cleaning contaminated sites, and promoting the eco-efficient use of chemicals in Central and Eastern Europe. The UNECE Working Group on Abatement Technology is helping countries to comply with the 1991 Volatile Organic Compounds (VOC) Protocol, under the LRTAP Convention, which came into force in 1997.

The voluntary **Prior Informed Consent (PIC) procedure** has been developed by UNEP and the Food and Agriculture Organization (FAO) of the United Nations. In March 1998, governments completed negotiations to transform PIC into a legally binding convention for strengthening the management of certain hazardous chemicals in international trade. Under PIC, governments will be required to stop the export of listed chemicals to other countries that have indicated that they do not want them imported, provided the importer does not manufacture or import the substance from another source for domestic use. Thus, chemicals can be prevented from entering countries where the risks they pose are deemed unacceptable by the recipient country.

Soon after completing PIC, governments began negotiations (June 1998) on a **global convention dealing with persistent organic pollutants (POPs).** Its purpose will be to reduce and/or eliminate the release into the environment of those POPs which pose significant threats to human health and wildlife. Although the convention negotiations are to focus initially on a list of 12 POPs, they will include the development of criteria and a process for identifying additional POPs for international action. These negotiations under the auspices of UNEP are to be completed by the year 2000.

Co-ordination of international work on chemicals has been facilitated by the IFCS which was established in 1994 as called for in Chapter 19 of Agenda 21 of the 1992 UN Conference on Environment and Development. The IFCS provides policy guidance and strategies for implementation of the major programme areas contained in this chapter, including hamonisation of risk assessments and chemical classification, information exchange, risk reduction and chemicals management capacity building.



7. A new paradigm for chemicals management?

There are many possible approaches to improving the safe management of chemicals at both the national and regional levels. Chemical risks are frequently reduced or managed through bans, use restrictions, classification and labelling schemes, contaminated-land policies, environmental liability legislation, civil actions, and other strategies. Increasingly, European policy-makers are moving towards an approach that relies more on co-operation and incentives rather than on "command-and-control" regulations. This is based on new perceptions about what is important in chemical pollution (Box 7). This "new paradigm" for chemicals management includes the following approaches:

• **The precautionary principle.** The data deficiencies described in this report and the increasing awareness of scientific complexity and uncertainty have led public authorities to emphasise the "precautionary principle" as a prudent response to potential chemical hazards. Now incorporated into many environmental treaties, this principle featured in the 1992 Rio Declaration on Environment and Development (as Principle 15):

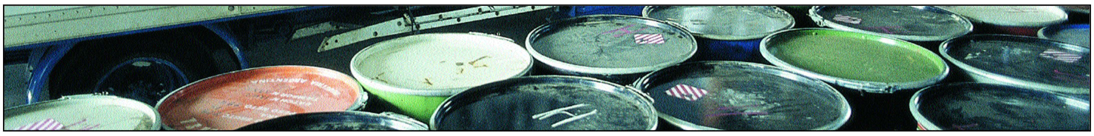
"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

The precautionary principle permits a lower level of proof of harm to be used in policy making whenever the consequences of waiting for higher levels of proof may be very costly and/or irreversible. The UN Intergovernmental Panel on Climate Change recently used the precautionary principle in concluding that *"the balance of evidence… suggests a discernible human influence on global climate"* (IPCC, 1995). When applied to chemicals, the precaution-

Perceptions of what is important in chemical pollution: 1970s and 1990s — **Box 7**

1970s	1990s – same as 1970s plus:
occupational health	consumer health, health of ecosystems
local/regional focus	national/international focus
limited, unquantified economic damage	large, quantifiable economic damage
exposures from air and surface water	total exposures via air, surface and groundwater, soil, sediments, food and consumer products
"point" sources of pollution e.g. chimneys	"diffuse" sources, e.g. agriculture, food, consumer products
single -substance approach	multi-pollutant/mixtures
single-effects e.g. leukaemia	multi-effects e.g. reproductive impacts
"end-of-pipe" approach to pollution control	"clean" production and integrated pollution control; "life-cycle" assessment of impacts
production processes	products and use
labelling and use instructions	public information on chemical releases and transfers
"sell-and-forget" chemical "products" (e.g. solvents)	product stewardship; chemical "services" (e.g. degreasing services)
specific regulations	"framework" regulations, taxes, voluntary agreements, "responsible care", etc.
toxicity-focused risk assessment of single substances	exposure reduction based on "precautionary principle" and persistence/bioaccumulation

Source: EEA expansion of Table 3, p. 248 in van Leeuwen *et al.*, 1996



ary principle can mean reducing the potential for exposure to substances that persist and bio-accumulate in the environment without waiting for certain evidence of toxicity. It also involves putting the burden of proving that a substance is “harmless” onto producers and importers (KEMI, 1998). **Instead of assuming chemicals are “innocent until proven guilty” of damage via strong evidence of toxicity and actual harm, the new approach assumes hazardous potential from the chemical’s ability to persist and bio-accumulate in animals or the environment.**

It is argued that this is a more equitable and cost-effective approach (Scheringer, 1997).

- **Exposure reduction.** The impact of chemicals can be reduced by action at different points in their environmental life-cycles, from pre-market screening to cleaning up contaminated soils. However, action can be delayed by the lack of knowledge about toxicities, persistence and other basic properties, as well as the slow progress in conducting risk assessments, which normally have to be completed before risk-reduction measures are agreed. These problems have helped to stimulate measures that increasingly focus on exposure reduction rather than on more toxicity testing. An example of this approach includes the OECD pesticide risk reduction programme (OECD, 1998b) and the Swedish pesticides reduction programme (Ekström and Bernson, 1995).

These approaches, based on weighing the costs and benefits of precautionary action to reduce **exposure** against the time, cost and uncertainty involved in single substance **toxicity testing** and risk assessments, have also been used by international agreements that address common sea or river basins. Their main objective has been to reduce overall chemical loads (or “dose”), starting with priority substances for which there is already sufficient toxicity data to cause concern. For example, a 1990 Ministers’ Declaration committed European governments to reducing the inputs from rivers and estuaries to the North Sea of a group of 36 toxic chemicals to less than 50% of their 1985 levels by 1995; total inputs of dioxins, mercury and cadmium had to be reduced by 70%. More recently, the 1995 Fourth Ministerial Conference in Esbjerg, Denmark, on the Protection of the North Sea, committed signatory states to ending all discharges, emissions and losses of hazardous substances within 25 years (Box 8). Some of the main national and international chemical reduction initiatives are shown in Box 9.

In addition, many “clean production” initiatives have led to reductions in chemical exposures in Europe both within workplaces and the general environment (MSF, 1994; UNEP, 1994; JOCP, 1997). Some business organisations, such as the World Business Council for Sustainable Development (WBCSD) encourage clean production through the idea of “eco-efficiency” which includes the proposal to “minimise toxic dispersion” (WBCSD, 1996). In the USA, the Massachusetts Toxic Use Reduction Act, 1989, has resulted in firms using 20% fewer toxic chemicals and generating 30% less toxic waste (Becker and Geiser, 1997).

Box 8

4th North Sea Conference of Ministers – Esbjerg, 1995

The prevention of pollution by hazardous substances

“The Ministers Agree that the objective is to ensure a sustainable, sound and healthy North Sea ecosystem. The guiding principle for achieving this objective is the precautionary principle.

This implies the prevention of the pollution of the North Sea by continuously reducing discharges, emissions and losses of hazardous substances thereby moving towards the target of their cessation within one generation (25 years) with the ultimate aim of concentrations in the environment near background values for naturally occurring substances and close to zero concentrations for man-made synthetic substances.

The Ministers agree that in this work scientific assessment of risks is a tool in setting priorities and developing action programmes.”

Some current initiatives on reduction of exposure to chemicals **Box 9**

	Instrument/Proposal/Location	Year	Objectives
1	Esbjerg Declaration on the North Sea	1995	Eliminates release of persistent, bio-accumulating and toxic substances to the North Sea over 25 years
2	Basle Convention on Hazardous Waste	1989	Objectives are to control trans-boundary movements, to manage and mini mise Hazardous Wastes
3	UNECE POP protocol	1998	Reduce exposure to POPs
4	UNECE Heavy metal protocol	1998	Reduce exposure to heavy metals
5	HELCOM Convention	1998	Implementation of the Visby targets
6	OSPAR Convention	1998	Implementation of the Esbjerg target
7	UNEP POPs Convention	1998-2000	Reducing/eliminating releases of POPs to the environment
8	UNEP-FAO PIC Convention	1996-1998	Limits imports and exports of hazardous chemicals and pesticides
9	OECD Chemicals & Pesticide Risk Reduction	1994	Share information/criteria on risk reduction programmes
10	Intergovernmental Forum on Chemical Safety	1994	To implement Chapter 19 of Rio Declaration, including risk reduction programmes
11	Montreal Protocol	1987-2040	To phase out certain ozone depleting substances
12	EU Fifth Environment Action Programme	1991-1994	To achieve “significant reduction of pesticide use per unit of Land”
13	EU Sustainable Use of Plant Protection Products	1994-1998	Analyse use, impacts and reduction potential for agricultural pesticides
14	Danish Minister Report on Future Initiatives on Chemicals	1997	25 substances/groups of substances dentified for priority phase-out, selected from 100 “undesirable” substances
15	Swedish Government Report on Chemicals Policy	1997-2007	10-year phase out of all products containing persistent & bio-accumulating substances; giving rise to serious/irreversible effects; or containing lead, mercury, cadmium
16	Norwegian targets for prioritised chemicals	1996-2010	Discharges of hazardous chemicals to be substantially reduced by 2010 (e.g. lead, cadmium, mercury, dioxins, PAHs; or phased out by 2005 (e.g. halons, PCBs, PCPs)

Source: European Environment Agency

- **From Products to Services.** As users of chemicals do not want the chemical “products” as such, but just the “services” that their chemical properties bring, some chemical suppliers of solvents or pesticides, for example, are beginning to sell “degreasing **services**” or “pest management **services**” rather than just solvent or pesticide **products**. This is similar to the change in focus from products to services in other sectors such as energy and water where companies are now selling energy or water services, including demand-side management measures, rather than just supplies of energy or water. This shift in focus from products to services can transform the relationship between chemicals, profits and the environment because the chemical itself shifts from being the source of profit to being a cost item for the chemical supplier. The chemical becomes part of a wider package of added-value services, including greater responsibility on the supplier for the chemical's safe use and related equipment. This increases the incentive on the supplier to reduce both the quantity and hazards of the chemical, per unit of service delivered, and to increase its durability by, for example, recycling. This can provide a "triple dividend": one for the customer, one for the supplier and one for the environment. Considerable innovation is needed to expand this shift from products to services beyond the solvents and pesticides parts of the chemical industry (Stahel, 1998).

• **Cost-effectiveness and Multiple Benefit/ Costs Approach.** Deciding upon appropriate policy responses requires weighing up the costs and benefits of chemicals, some of which are illustrated in Box 10. Evaluating these is difficult, especially if monetary values are needed (DoE, 1995). However, recent reports from the US, Japan and OECD illustrate how such cost/benefit and cost effectiveness evaluations can help improve policy decisions (Morgenstern, 1998; JPRHDPC, 1997; OECD, 1998c). Most firms involved in toxic use reduction in Massachusetts, for example, achieved cost savings from reduced chemicals use (Becker and Geiser, 1997). The US and Japanese studies show net social benefits from the environmental regulation of polluting substances, such as stratospheric ozone and lead in petrol.

Measures that address the contamination of just one medium – be it water, land, or air – risk merely transferring the problem to another medium. An integrated, **multiple pollutant/multi-effect approach** is therefore needed, which assesses both the main and secondary benefits as well as the costs of chemicals control.

Box 10 **Some illustrative benefits and costs of manufactured chemicals**

BENEFITS	COSTS
- fewer pests	- fires/explosions
- less infections from bacteria	- acute/chronic poisoning
- better protection/storage of food	- genetic and other health damage
- lighter/more durable attractive/ cheaper consumer products	- groundwater contamination
- profits and jobs	- species/eco-system damage
- scientific progress	- other pollution damage e.g. ozone layer
CHARACTERISTICS OF THE BENEFITS AND COSTS	
- well known	- not well known
- taken for granted	- feared
- obvious	- not so obvious
- short-term	- often long-term
- rarely irreversible	- often irreversible
- evenly distributed	- unevenly distributed
- easy to monetise	- not easy to monetise

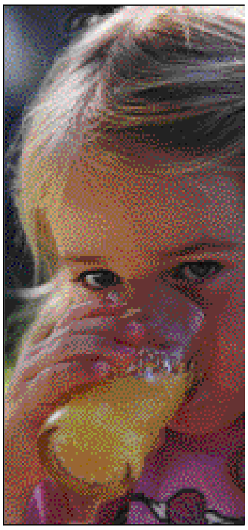
Source: European Environment Agency

• **Voluntary programmes.** Chemical risks are already being reduced through a number of voluntary industry initiatives. For example, companies in The Netherlands have initiated voluntary reduction programmes via agreements with the regulatory authorities. In 1989, they introduced a Control Strategy for reducing emissions of volatile organic compounds (VOCs) from industry, small businesses and households. The Strategy envisages a reduction of 63% in emissions by 2000 compared to 1981 levels, via reduction plans containing over 100 separate measures. Within the framework of the OECD's Risk Management Programme, companies producing certain brominated flame retardants have voluntarily agreed to stop their production. An EEA review of voluntary agreements (EEA, 1997) concluded that the Dutch chemical industry scheme has been environmentally effective and has encouraged the development of environmental management systems.

The EEA review concluded more generally that most other agreements studied could not be evaluated because there was no monitoring data or consistent reporting. Voluntary agreements seemed to be of most use as complements to other policy measures such as regulations and taxes.

Meanwhile, a "Responsible Care" programme, promoted by the European Chemical Industry Council (CEFIC, 1996), has been adopted in 21 European countries. This programme encourages the cross-fertilisation of ideas and best practices. The programme, based on the original Canadian initiative, is designed to improve the chemical industry's health, safety, environmental and quality performance, as well as communications with the public concerning products and plant operations. However, participation by employees and unions in the responsible care programmes seems to be limited (ICEM, 1997), even though some research shows union representatives to be more knowledgeable about chemicals regulations than their employers (HSE, 1997).

Even outside formal voluntary programmes, business can anticipate the need to reduce risks from conventional chemicals. For example, the increased awareness of the hazards of fossil fuel combustion and associated chemical feedstocks is encouraging some businesses to develop other raw materials based on the "soft" chemistry of agricultural products (von Gleich, 1991), an industry which was developing in the USA in the 1930s before the oil industry grew to become the dominant source of chemicals (Hale, 1934). However, not all "soft" chemistry feedstock and products, such as those described in Box 11, will necessarily be less harmful than those



Some "soft chemistry" initiatives **Box 11**

- Mitsui Toatsu of Japan has announced plans to produce biodegradable plastics in 30,000-ton facilities in Japan, Europe and the US by 2001, using a corn and potato starch base.
- The US Department of Energy, under its Alternative Feedstocks Programme, has signed a US$7M contract with Applied Carbo-Chemicals to manufacture chemical feedstock from renewable farm crops such as corn, which promises to be cheaper and better than petroleum-based feedstock. The feedstock will be targeted on the polymers, coatings, inks and dyes markets, which are growing at 10% per year in the US. The company ACC says that the new feedstock is 20-50% cheaper than conventional oil-based supplies.
- Donlar CO has won a Green Chemistry Challenge Award from the US EPA for a process that substitutes biodegradable polyasparate for polyacrylic acid, a key compound in disposable nappies, which can account for 2% of solid waste in US landfill.
- Monsanto's "Biopol" group manufactures the PHA polymer from fermented micro-organisms and is developing a plant-based route to PHA, based on soya or canola.
- The Fraunhofer institute for Holzforschung in Germany is developing industrial fibres from flax, while the German Institute for Food Packaging has developed a fibre reinforced plastic based on casein protein.
- The use of hemp seed oil to produce paints and varnishes (which was the main feedstock in the US prior to 1937), and hemp fibre for bags, shirts and paper, is increasing.

Source: European Environment Agency

based on oil. A full life-cycle assessment is needed for the evaluation of alternatives (EEA, 1998c).

- **Improved public and consumer information.** Information is playing an increasingly important role in controlling chemical pollution, both in support of specific regulations and taxes, and as a stand-alone policy tool. For example, the EU's "Seveso" Directive on Hazardous Installations obliges employers to provide information to the nearby public. The EU Classification and Labelling Directive promotes the provision of clearer product information. The proposed European Polluting Emissions Register, to which the public shall have access under the Integrated Pollution Prevention and Control Directive, by 2002, will provide chemical release data from production facilities on a three-yearly basis. Some European countries (Denmark, France, the Netherlands, Sweden, and the UK) already have some provision for public access to chemicals data. A UNECE Convention on public participation and access to environmental information was agreed in 1998, and this will further encourage the provision of chemical information to the public.

The OECD has published guidance on the Pollutant Release and Transfer Registers (PRTR) (OECD, 1996) which will help to establish emissions inventory and public right-to-know programmes. Experience with the US Toxics Release Inventory in the USA shows that it can stimulate reductions in toxic chemical emissions both directly and via stimulus to voluntary actions, such as the successful *"33/50"* chemicals-reduction programme of the US EPA, which has led to a more than 50% reduction in emissions of 33 hazardous chemicals (OECD, 1997a). The OECD guidelines on PRTR are being promoted under the IFCS programme, with support from UNITAR and UNEP.

Another type of information tool is the Chemical Product Register in Denmark, Finland, France, Norway and Sweden, which can be particularly useful in tracking chemicals contained in consumer products (KEMI, 1994).

Finally, general information for the public, particularly chemical employees and consumers, is extensively produced throughout the EU and elsewhere, such as by the International Programme on Chemical Safety (IPCS, 1996; UNEP, 1997). For example, IPCS, in co-operation with the EU, has produced over 1,300 Chemical Safety Data Cards and over 200 Pesticide Data Sheets to help reduce the risks of handling chemicals at work.

The EEA has produced a guide on Environmental Risk Assessment, Approaches, Experiences and Information Sources (EEA, 1998b).

There is as yet little data on the effectiveness of information provision in Europe on changing consumer behaviour towards chemicals, but some evidence on benzene in petrol (Fouquet, 1997) suggests that it can be effective, particularly via the mass media.

Box 12 **Some environmental "externalities" of chemicals**

- costs of cancers, reproductive and other chronic health impacts;
- costs of acute health effects;
- public costs of fire & explosions;
- costs of pollution to air, crops, inland water, soil, sediments and seas;
- costs of damage to non-human species;
- costs of damage to the stratospheric ozone layer;
- costs of registration, testing, assessing and classification not borne by companies;
- costs of permits, inspections & enforcements not borne by companies;
- cost of monitoring/sampling not borne by companies;
- cost of contamination clean up not borne by companies;
- losses of land value; fear; nuisance, smells in the vicinity of plants.

Source: European Environment Agency

• **Use of economic instruments.** In 1993, the EU's Fifth Environmental Action Programme recommended an increased use of economic instruments to help implement the "polluter pays" principle and the incorporation of environmental "external" costs, such as water pollution, into market prices, via taxes.

"Externalities", which are the environmental and social costs of economic activity that are not borne by producers and users, and therefore not included in the market price of their products, can be substantial (EEA, 1996). For example, the "externalities" of the transport sector have been estimated at around 4% of EU GNP (Maddison, 1996) and attempts are now being made to "internalise" these into prices (ECMT, 1998). The main categories of the "external" costs of chemicals which, apart from pesticides (Pearce, 1997), have yet to be evaluated, are summarised in Box 12. Although monetary evaluation of some externalities is controversial, it can help to provide a basis for the incorporation of these social costs into the market price of chemicals via environmental taxes. Current candidates for eco-taxes on particular chemicals at the Member State or EU level, based on the likely size of their "externalities", include heavy metals, chlorinated products, POPs, fertilisers and pesticides (DETR, 1997; RSPB, 1998).

Environmental taxes can be very effective if they are well-designed and form part of a package of measures, including the use of tax revenues to stimulate actions to reduce the use of a substance (EEA, 1996). Various European states already impose taxes on pesticides, fertilisers, ozone-depleting substances, sulphur dioxide, nitrogen oxides, chlorinated solvents (e.g. on tetrachloroethylene, trichloroethylene and dichloromethane in Denmark) and toxic wastes, as well as on leaded petrol and high-sulphur diesel fuel in several European countries. The use of taxes to "internalise" the social costs of chemicals into market prices, combined with other risk management measures, will encourage the more "eco-efficient" use of chemicals (WBCSD, 1996; OECD, 1997b).

8. Conclusions

This short survey of the state of information and action on manufactured chemicals in Europe reveals that we may face serious, if hard-to-identify risks, but also that measures to reduce these risks are available.

Much progress has been made since the publication of *Silent Spring*, Rachel Carson's warning about the rising costs of chemical pollution in 1962 (Carson, 1962; Lear, 1998). However, the possible effects on humans and ecology of the many combinations of chemicals available for exposure is encouraging the search for much greater "eco-efficiency" in their production and use.

The current European Commission review of chemicals will help to clarify and address "the weaknesses" (DETR, 1998a, 1998b) in present policies for managing chemicals in the EU. The aim must be to strike the right balance between different approaches to the risks of chemicals, and to the costs and benefits of their use, based on the judicious application of the "precautionary principle".

There is great scope for improvement. For example, our best chemical plants are still very inefficient in their use of energy and in their production of wastes (MSF, 1994) compared with the quiet chemical elegance involved in any natural plant such as the clover, symbol of the UK Cleaner Production Programme. Those companies and countries which first succeed in emulating nature's elegance will provide a great service to the environment and human society (Fussler, 1996).

Acronyms

CEC Commission of the European Communities
CEFIC European Chemical Industry Council, Brussels
CFC chlorofluorocarbon
CHEMISEED Chemical Industry-Sustainable Economic and Ecological Development programme
CICAD Concise International Chemical Assessment Documents
CICH Canadian Institute of Child Health, Ottawa
CMA Chemical Manufacturers Association, USA
DDT dichlorodiphenyl trichloroethane
DETR Department of the Environment, Transport and Regions, London
DoE Department of the Environment, London
EA Environment Agency, England and Wales
EDF Environmental Defense Fund, Washington
EEA European Environment Agency, Copenhagen
EC European Commission
ECB European Chemicals Bureau
ECMT European Conference of Ministers of Transport
ECU European currency unit
EDS endocrine-disrupting substances
EHP Environmental Health Perspectives, N. Carolina, USA
EINECS European Inventory of Existing Commercial Chemical Substances
ELINCS European List of Notified Chemical Substances (lists “new” substances)
EPA Environmental Protection Agency, Washington
EU European Union
EU15 All 15 Member States of the EU
FAO Food and Agricultural Organization (UN)
GDP gross domestic product
HPVCs high production volume chemicals
HSE Health and Safety Executive, London
ICEM International Federation of Chemical, Energy, Mining and General Workers Unions, Geneva
IFCS International Forum on Chemical Safety
ILO International Labour Organisation
IPCS International Programme on Chemical Safety
IPCC Intergovernmental Panel on Climate Change, UN
IUCLID International Uniform Chemical Information Database. European Chemicals Bureau of the EC’s Joint Research Centre.
JOCP Journal of Cleaner Production (Elsevier), Amsterdam
KEMI The Swedish National Chemicals Inspectorate, Stockholm
LRTAP Long-Range Transboundary Air Pollution
MSF Manufacturing Science Finance Union, London
NAS National Academy of Sciences, USA
NONS Notification of New Substances Directive – Enforcement Project
NRC National Research Council, Washington
NRDC National Resources Defense Council, Washington
OECD Organisation for Economic Co-operation and Development
PAHs polycyclic aromatic hydrocarbons
PCBs polychlorinated biphenyls
PIC prior informed consent
PRTR Pollutant Release and Transfer Registers
POPs persistent organic pollutants
RSPB Royal Society for the Protection of Birds, UK
SENSE Solid Enforcement of Substances in Europe
UCB Institute of Allergy, Brussels
UN United Nations
UNECE United Nations Economic Commission for Europe
UNEP United Nations Environment Programme
VOCs volatile organic compounds
WBCSD World Business Council for Sustainable Development
WRI World Resources Institute, Washington

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