02

Environment and health and the quality of life

2.0 Introduction

A healthy environment is essential for improving development and sustaining human well-being (GEO-4, 2007; EEA, 2005). Human health is one of the key constituents of human well-being, and the need to protect it by achieving a good quality of the environment is highlighted in the EECCA Environment Strategy and the EU Sixth Environment Action Programme (6EAP).

Chapter 2 of this report 'Environment and health and the quality of life' focuses on the environmental media specified in these policy documents in the context of human health: air, water, and soil. This is complemented by the cross-cutting issue of hazardous chemicals. The chapter addresses the ways they influence and impact human health in the pan-European region, and presents some regional estimates of the burden of ill health attributable to major environmental factors. Due to lack of reliable data, these estimates are not comprehensive and will require further work.

There have been substantial developments in policies and initiatives that address environment and health hazards in the region since the Kiev conference. The chapter examines the effectiveness of the environmental measures being taken, with the focus on EECCA and SEE countries. Progress in implementation is relatively slow and varies markedly across the region.

The chapter reflects some aspects of the scientific complexity of environment and health relationships (Section 2.1, Environment and health perspective). Emerging issues related to environment and health, mostly the subject of continuing research, are not extensively discussed. This is, for example, the case for several physical stressors. The health impacts of environmental noise are probably underestimated and require further attention. Increased UV intensity and human exposure is a growing health concern. Electromagnetic fields from power lines and radio transmitters are receiving much public attention, although scientific evidence of health impacts is still weak.

Human health is also threatened by natural disasters and man-made hazards, and the consequences of many of these are currently being exacerbated by a lack of preparedness and by human activities (Section 2.1 and Chapter 5, Marine and coastal environment).

The strongest evidence of environment-related health impacts and the best known overall health effects are from air pollution (Section 2.2) and those related to poor water quality and insufficient sanitation (Section 2.3). Much less is known about the health impacts of hazardous chemicals (Section 2.5), particularly at the low exposure levels normally experienced by most Europeans over long, sometimes life-long periods, and usually from a combination of sources.

Chemical substances can be transported and accumulate in soil (Section 2.4), leading to contamination of crops or pollution of ground and surface waters, and ultimately to human exposure. Soil degradation combined with unsustainable land use is indirectly linked to human health. Knowledge of the impacts of soil quality on human health is limited, and further assessment of the scientific information is needed.

Many pollutants in air, water and soil that are known to have significant health effects are gradually coming under (regulatory) control (e.g. Clean Air for Europe (CAFE); Registration, Evaluation and Authorisation of Chemicals (REACH)). However, there is a large and probably growing number of substances entering the environment from a wide range of human activities, whose environmental pathways and effects on health are poorly understood.

Other aspects of environmental issues relevant to human health are covered in the subsequent chapters of the report. Climate change (Chapter 3) is likely to contribute directly to the global burden of disease and premature death through changing weather patterns and indirectly through changes in air, water, ecosystems, food quality and quantity (e.g. influences on plant pests and diseases), agriculture (droughts, crop failure, etc.), distribution of infectious diseases, and, overall, on the economy. The effects may currently be small but they are projected to increase in all countries and regions (IPCC, 2007). Concerted international cooperation, involving a broad range of stakeholders and the development of adaptation policies are necessary to tackle the problem.

The health benefits of maintaining biodiversity (Chapter 4) include supportive recreational outdoor environments and the provision of natural medicines and locally relevant crops (MA, 2005; BirdLife, 2006).

The quality of the marine environment (Chapter 5), including the availability and contamination of fish and other sea food, and toxic algae, can affect human health in various ways.

The sustainable use of natural resources, production and consumption patterns, and waste management (Chapter 6) can contribute to reducing hazardous exposures, and also to improving the quality of the immediate human environment and making it safer (e.g. reducing the cutting of local forests for household fuel can reduce the risk of landslides).

Transport, a major contributor to human exposure to air pollution and noise, especially in urban areas, is also linked to the patterns of human physical activity. Transport-related accidents have major direct impacts on human health (Section 7.2).

An extensive overview of current environment and health issues has recently been presented in a joint EEA/JRC report (EEA, 2005). A comprehensive assessment of environment-related health problems requires consideration of risk factors that include genetics, lifestyle, and workplace quality, as well as political, socio-economic and demographic factors (Chapter 1). In the broader context of the complex interrelations between human health, well-being, environment, socio-economy, and culture, further assessments should be based on the ecosystems approach (1) (MA, 2005a).

(1) In this conceptual framework, people are an integral part of and in a dynamic interaction with other parts of ecosystems. Human well-being is underpinned by the benefits provided by ecosystems (e.g. fresh water, air, relatively stable climate). 'Ecosystem services' can be classified as: provisioning (e.g. food and fresh water), regulating (e.g. climate regulation, water purification), supporting (needed for the production of all other ecosystem services, e.g. nutrient cycling), and cultural (non-material benefits, e.g. cultural heritage) (MA, 2005a).

2.1 Environment and health perspective

Photo: Cycling in the Silesian forest, Poland © Waldemar Jarosinski

Key messages

- Major environment-related health concerns in the pan-European region continue to be linked to poor air and water quality, hazardous chemicals, and noise. These are often interconnected through common driving forces or pressures.
- The burden of ill health attributable to environmental causes is much higher in EECCA and SEE than in WCE. One reason for this is the coexistence and combination of 'traditional' (e.g. unsafe water and sanitation) and 'modern' (e.g. urban air pollution, chemicals) hazards.
- Responses to environment-related health challenges in Europe at the international, regional and national level are improving. International action plans focus on children's health and reducing the burden of environment-related health problems in this vulnerable group. However, for many health hazards, actions lag well behind policies.
- The health toll of natural disasters such as violent storms, floods, heatwaves, landslides and droughts is being exacerbated by urbanisation, deforestation and climate change, and lack of preparedness.
- Although cause and effect relationships are hard to establish, there appear to be a number of associations between outdoor and indoor air pollution, water and soil contamination, hazardous chemicals and noise and respiratory and cardiovascular diseases, cancer, asthma, allergies, as well as disorders of reproductive and neuro-developmental systems.
- There is growing concern about adverse impacts of exposures to low levels of chemicals, often in complex mixtures. Several adult diseases are suggested to be linked to exposure in very early childhood or exposure of parents before conception. Persistent chemicals with long-term effects, and those used in long-life articles, may present risks even after their production has been phased out.
- Human health impacts of soil degradation across Europe are currently difficult to estimate. Efforts to achieve the sustainable use of soil will also have positive impacts on human health and quality of life.

2.1.1 Introduction

The major environment-related health threats in Europe are air pollution, poor water quality and, in some areas, inadequate quantity, poor sanitation, and hazardous chemicals. This is reflected in the main environmental policies. Human health has also always been threatened by natural disasters, and the health consequences of many of these are currently being exacerbated by a lack of preparedness and by human actions such as deforestation. An emerging environmental health issue is noise.

This section discusses the main human health aspects of pollution of air, water and soil, and the situation regarding chemicals, and examines the effectiveness of the environmental measures being taken to protect human health and quality of life. It presents recent developments in policies and initiatives that address environment and health hazards in Europe, with the focus on EECCA and SEE countries, given their higher burden of environment-related diseases. The human health consequences of natural and man-made hazards, including possible long-term impacts are then discussed, followed by regional estimates of the burden of ill health attributable to major environmental factors, focusing on children as a vulnerable group. Then follows the section on the health impacts of noise. Finally, some aspects of the scientific complexity of environment and health relationships are discussed, especially in the context of the potential impacts of chemicals, as well as challenges for future research and actions.

Environment and health strategies and policies

Environmental quality and the link to human health are highlighted as a priority in the EU Sixth Environment Action Programme (6 EAP), which aims to achieve 'a quality of the environment where the levels of man-made contaminants, including different types of radiation, do not give rise to significant impacts on or risks to human health'. The programme specifically addresses air pollution, water quality, supply and sanitation, and hazardous chemicals.

Four pieces of legislation — the Water Framework Directive, the Regulation on the Registration, Evaluation and Authorisation and Restriction of Chemicals (REACH), the proposal for a directive on ambient air quality and cleaner air for Europe, and the proposal for a framework directive on pesticides are highlighted in the mid-term review of 6 EAP as the foundation of the EU approach to limiting environmental threats to human health (European Commission, 2007).

In 2003, the European Commission developed a proposal for a Community Strategy for Environment and Health, followed in 2004 by the European Environment and Health Action Plan 2004–2010 (European Commission, 2004). The Commission proposes a holistic approach to address the complex issues of environmental quality and human health and to create an integrated environment and health information system where environmental and human health information can be combined.

In the EECCA Environment Strategy, reduction of urban air pollution, improved management of municipal water supply and sanitation infrastructure, and improved management of waste and chemicals are specified under the umbrella of reducing 'the risks to human (health) through pollution prevention and control'.

Environment and health policies have recently focused on children. In the Science, Children, Awareness, Legislation and Evaluation (SCALE) process, the European Environment and Health Strategy (European Commission, 2003) identified four priority diseases — childhood cancer, asthma and allergy, neuro-developmental disorders and endocrine-disrupting effects — to be addressed in the EU Environment and Health Action Plan.

WHO Europe has developed the Children's Environment and Health Action Plan for Europe (CEHAPE), adopted at the Fourth Ministerial Conference on Environment and Health in Budapest in June 2004 (Box 2.1.1). Support for the implementation of CEHAPE is reflected in the Renewed EU Sustainable Development Strategy of June 2006 (European Council, 2006).

The WHO Budapest Declaration of 2004 also reaffirmed the need for an environment and health information system based on indicators, and

Box 2.1.1 Children's Environmental Health Action Plan for Europe (CEHAPE)

Adopted at the WHO Fourth Ministerial Conference on Environment and Health, in June 2004, CEHAPE identifies four Regional Priority Goals (RPG) for action to protect children's health from harmful environmental exposures and reduce the health impacts of:

- unsafe water and sanitation;
- air pollution (respiratory diseases, asthma and allergy);
- hazardous substances; and
- insufficient physical activity and obesity; and to promote supportive environments.

formulated recommendations on public health responses to extreme weather events and the health consequences of climate change (WHO, 2004a).

European processes aiming at integration of policies are particularly relevant for environment and health. Environmental integration (the Cardiff Process), required under the EC Treaty and reaffirmed in 6EAP, means full consideration of environmental concerns in the decisions and activities of other sectors, with a view to promoting sustainable development. Integration of health in all policies was taken forward as part of the 2006 Finnish Presidency of the EU, and included organisation of a high level ministerial conference, which underlined the need to give greater consideration to health impacts in decision-making across policy sectors at different levels in order to protect, maintain and improve the health status of the population (Finnish Ministry of Social Affairs and Health, 2006).

From policies to action

Regional initiatives

In the EU, so far, more than 30 actions have been initiated in the area of 'Environment, health and the quality of life' of 6EAP (European Commission, 2005). In the 2006 consultation for the mid-term review of 6EAP, over 40 % of respondents representing various stakeholders considered progress towards meeting health-related objectives to be unsatisfactory, and the policy actions taken so far not to be sufficiently adequate and effective to protect health and the quality of life across the EU (European Commission, 2006a).

In EECCA, the 'baseline' report for the Environment Strategy concluded that a significant burden of environmental disease persists in the region, with crumbling and unaffordable water infrastructure systems, increasing urban air pollution from rapid motorisation, and largely deficient waste and chemicals management (OECD, 2005).

The recent UNDP report *Environmental Policy in South East Europe* identified air pollution (outdoors and indoors), unsafe drinking water, improper waste and waste water management, transport, and workplace safety as key environmental health hazards (UNDP, 2007).

In June 2007, the WHO Intergovernmental Mid-term Review evaluated progress in implementing the pan-European action plan to improve children's environmental health. The first outputs of the Environment and Health Information System developed through several WHO collaborative projects ([1]) were presented, forming the basis for an assessment of the current status of children's health and the environment in Europe (WHO, 2007).

Since 2006, WHO, supported by the European Commission (DG Health and Consumer Protection), has been implementing a project to facilitate the preparation of Environment and Health Performance Reviews (EHPR), expected to provide country-specific evaluations and recommendations for action. Work on the first EHPR started in early 2007 in Slovakia, and three other countries have already expressed their interest: Czech Republic, Estonia and Poland. The report from EHPR will be a contribution to the Fifth Ministerial Conference of the Ministers of Health and Environment in 2009 in Italy.

Also this year (2007), the European Commission is preparing a review to present the progress achieved

([1]) Projects ECOEHIS (2002–2004), ENHIS (2004–2005), and ENHIS2 (2005–2007) supported by the European Commission DG Health and Consumer Protection, implemented with several Member States.

at the mid-term of the EU Environment and Health Action Plan 2004–2010 (European Commission, 2004), to highlight areas that should receive more attention, to propose new orientation for the second half of the first cycle, and to open the debate for the second cycle (beyond 2010). The pilot project on Human Biomonitoring (Box 2.1.2) is an example of implementation of the Action Plan commitments.

In the countries of the UNECE region, adoption of the Protocol on Water and Health to the 1992 Convention on Protection and Use of Transboundary Watercourses and International Lakes marked progress in addressing environment and health issues related to water in an integrated manner (UNECE, 2000). It is too early to evaluate implementation of the Protocol, since it only became legally binding for the 20 ratifying countries in August 2005. The first meeting of the parties in January 2007 agreed on the work programme for the next three years, including development of indicators and reporting mechanisms, surveillance, and mechanisms to facilitate the preparation of projects to be implemented under the Protocol (UNECE, 2007).

National initiatives
There is a growing number of coordinated efforts to address environment-related health challenges at the national and regional level. Three case studies illustrate the many programmes/activities that are in place across Europe, with different designs, coverage, and range of challenges addressed (Box 2.1.3).

The WHO National Environmental Health Action Plan (NEHAP) process initiated cooperation between health, environment and other relevant sectors, and a new approach to working together on health and environmental issues. NEHAPs have proved successful in several countries, however in many there is a gap between the policy process and its implementation. Improved cooperation between health and environment ministers, adequate financial resources, and methodological support are needed for effective implementation of these innovative plans. At the time of the Budapest Ministerial Conference in 2004, NEHAPs had been developed in 46 out of 52 countries. In the post-Budapest process, by the end of 2006, national Children's Environmental Health Action Plans had been developed in 12 countries, and 16 others were revising their NEHAPs to include child-oriented activities (EEHC, 2006).

The recent UNDP report on south-eastern Europe recommends urgent implementation of NEHAPs, together with improved collaboration between ministries in charge of environment and health and with public health institutions, in order to determine priority environmental health risks, development of well-targeted policies and campaigns to reduce the risks, and integration of environmental health objectives into overall development plans (UNDP, 2007).

Box 2.1.2 The pilot project on Human Biomonitoring (HBM)

Measuring substances in the human body (e.g. blood, urine) allows estimation of exposure to chemicals from multiple sources, identification of excessively exposed people, and monitoring and evaluation of progress once measures to reduce or eliminate exposure have been introduced.

The HBM pilot project aims at developing a coordinated approach to human biomonitoring in Europe with focus on children. As of late 2006, two proposals have been put forward for discussion by the Member States. One uses biomarkers of well recognised health hazards — lead, cadmium, methylmercury, and cotinine (for environmental tobacco smoke), the other focuses on organic pollutants and proposes several biomarkers for polycyclic aromatic hydrocarbons (PAHs) and phthalates.

Source: European Commission, 2006b.

Human impacts of natural and man-made hazards

The human health consequences of many natural disasters, such as floods and landslides, are being exacerbated by a lack of preparedness and by human actions such as deforestation and inadequate storage of hazardous materials (EEA, 2004). Extensive impacts of human activity on ecosystems are increasing the risk of serious and irreversible change. Loss of the services provided by ecosystems (fresh water, clean air, etc.) and climate change may enhance the impacts of other hazards (e.g. floods, heat stress, exposures to hazardous materials)

Box 2.1.3 National initiatives in environment and health

The **Flemish Environmental Health Action Programme** (2002–2006), in one of the most populated areas in Europe, covered two urban areas (Antwerp and Ghent), fruit orchards, a rural area, and four types of industrial area. In total 4 800 participants from three age groups: mothers and their newborns, adolescents (14–15 years) and adults (> 50–65 years) were included in a biomonitoring programme in which blood and urine samples were collected. Data on exposure to selected pollutants and effects were combined with information on health. Living in different geographical areas has significant impacts on the body burdens of lead, cadmium, dioxins, PCBs, hexachlorobenzene, and DDE. Participants from rural areas showed elevated levels of persistent chlorinated compounds, compared with the rest of the population. Mothers residing in the urban areas had statistically significantly higher prevalence of asthma, and the same trend was observed in other age groups. Several hot spots could be identified, where residents had elevated levels of heavy metals, DDE or benzene metabolites. Higher blood lead levels were associated with increased asthma prevalence. Exposure to persistent chlorinated compounds was associated with increased risk of fertility problems in mothers, and with precocious puberty development in adolescents. The programme was framed within a participative communication plan based on open interaction and mutual exchange of information between participants, scientists and the authorities.

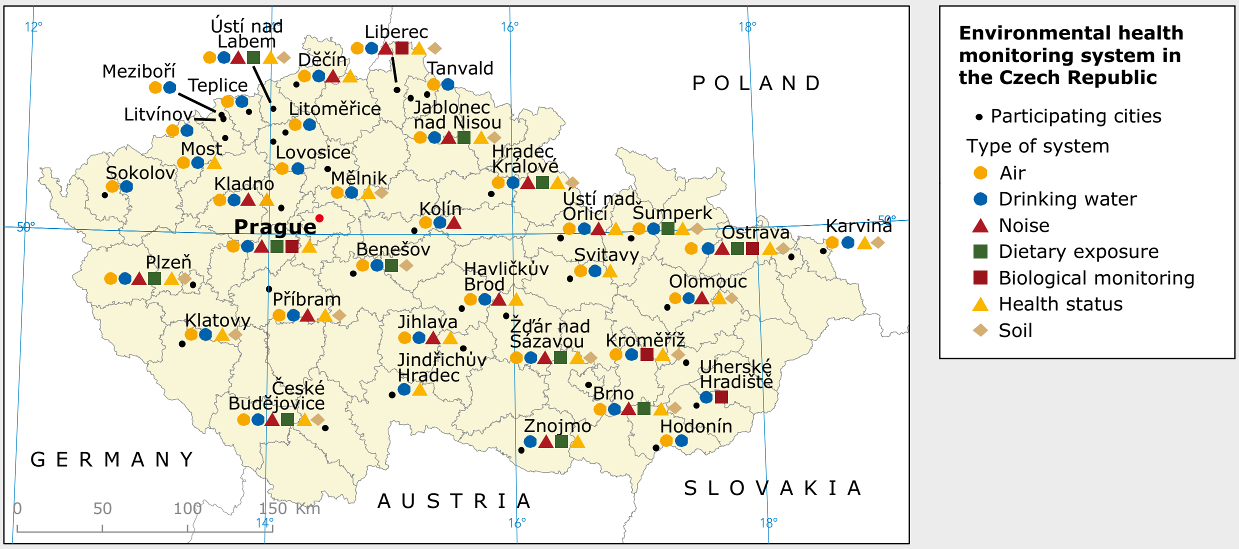
Source: Schoeters *et al.*, 2006.

The **German Environmental Survey** (GerES) has been carried out repeatedly since 1985 to analyse and document the extent, distribution and determinants of exposures of the general population to environmental pollutants. The current survey (GerES IV, 2003–2006), with a representative sample of 1 800 children aged 3–14, is a module of the 'National Health Interview and Examination Survey for Children and Adolescents'. Its design allows linking the data to analyse health-related environmental exposures. Most of the analyses were done in 2006–2007. Some preliminary results are presented further in this section. The final results will provide the basis for the identification of health risks to children and for environmental and public health policy decisions, to help develop preventive measures and advance research.

Source: German Environmental Survey, 2006.

Since 1994, the **Czech Environmental Health Monitoring System** (see Map 2.1.1) has covered outdoor and indoor air, drinking water, food safety, noise, soil pollution in cities, and human biomonitoring. Traffic-related air pollutants remain of concern. In 2005, 81 % of the monitored population was estimated to be excessively exposed to suspended PM_{10}, and 35 % to NO_2. The target limit of benzo(a)pyrene has long been exceeded at most of the urban stations. The levels of toxic metals in urban air are up to half of the limit values, except in heavily polluted areas. Human biomonitoring indicates a downward trend in the burden of chlorinated persistent organic compounds. Indications of increasing burdens of genotoxic substances in the Czech population will require more detailed analysis of the possible causes.

Map 2.1.1 Environment health monitoring system in the Czech Republic



Source: Environmental Health Monitoring System in the Czech Republic, 2006.

on human health and well-being (see Chapter 1, Europe's environment in an age of transition).

Over the past 15 years, extreme events, both natural and induced by human activity, have caused around 96 000 deaths, and affected more than 42 million people in Europe (WHO, 2006). As estimated by the European Commission Humanitarian Aid Office (ECHO), 5.5 million people were affected by natural disasters in five Central Asian republics, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, over the past decade, and about 2 500 people were killed (Eurasia, 2005) (Box 2.1.4).

The incidence of events such as floods, droughts, and heatwaves is likely to increase in the coming years. Consolidated efforts are therefore needed to achieve sustainable use of ecosystems, and to develop preparedness, response and adaptation mechanisms, and adequate environmental measures to ameliorate negative impacts on human health and well-being.

Long-term human impacts and environmental recovery
The public health consequences of natural and human-induced disasters can be very long-term, even multi-generational. These impacts remain to be fully evaluated, and adequate measures need to be taken to minimise risks to human health. However, this is a difficult task. Our ability to predict long-term environmental recovery is limited; moreover, human impacts of particular environmental conditions need to be assessed in the broader context of behavioural, socio-economic, political and demographic factors, often of a transboundary nature (Box 2.1.5). The Chernobyl accident and the Aral Sea crisis illustrate the complex interplay between environmental hazards and other factors, including substantial socio-economic changes, emergence of independent countries, disruption of health-care systems and forced migration, which can have severe, interconnected impacts on public health.

Human impacts of extreme temperatures – heatwaves
Extreme temperatures and their effects on human

Box 2.1.4 Coexistence of natural and man-made hazards poses higher risks to people in vulnerable places

In April 2005 a landslide of almost 300 000 m^3 hit an area near a town in southern Kyrgyzstan, halting the flow of a river, and causing concern because of its proximity to huge radioactive dumps from Soviet-era uranium mines. No casualties were reported directly after the event, but around 3 000 village inhabitants were temporarily cut off and needed supplies.

In the landslide-prone areas of southern Kyrgyzstan, almost half of the mountain villages need to be relocated, as estimated by local authorities. The seismically-triggered risk of landslides is being exacerbated by deforestation in the hilly parts of the south, and by the conversion of flatlands to marshes and swampy areas by the large dams in the Ferghana Valley (see also Chapter 6, Sustainable consumption and production).

Several inadequately protected uranium mining tailing dumps in Kyrgyzstan, Uzbekistan, and Tajikistan are of particular concern, since they are located directly on the flood plains of rivers, and there have already been episodes of flooding that have washed away the protective dams at uranium and lead treatment plants.

Photo: Uranium Mine Tailings, Taboshar, Ferghana Valley, Tajikistan © UNEP/ENVSEC, 2005

Sources: IRIN, 2003; IRIN, 2003a; IRIN, 2005; ENVSEC, 2005.

Box 2.1.5 Long-term environmental impacts on humans

Chernobyl — 20 years after

The long-term impacts of the Chernobyl accident on human health, quality of life, and the environment are still difficult to assess. In 2005, the United Nations (UN) and the governments of Ukraine, Belarus and the Russian Federation released a comprehensive assessment of the accident, the conclusions of which are given in the WHO report (WHO, 2006a). Based on the 600 000 people living in the vicinity of the accident site, it was estimated that roughly 4 000 will die because of Chernobyl, and out of 6.8 million that live further from the explosion site and who received much lower radiation doses another 5 000 may die because of Chernobyl exposure. In Belarus, exposure to radioactive iodine is linked to significant increases in thyroid cancer, mainly in those who were under 15 years of age at the time of exposure. Increasing numbers of younger women are being diagnosed with breast cancer. In contaminated areas fewer children are born and more people die, and life expectancy fell from 73.1 to 67.2 years between 1993 and 2001. Poverty and extreme poverty risks are higher in Gomel, Mogilev and Brest oblasts, which were the most affected by the Chernobyl accident. Psycho-social problems created by the accident (related to rapid relocation, breakdown of social networks, fear and anxiety about health effects, etc.) are considered the most serious impacts of Chernobyl, affecting several million labelled victims of the accident, living in three countries.

The environmental impacts of the Chernobyl accident are also difficult to assess. Forests, mires and lakes accumulated radionuclides and released them continually to the environment. Forest fires and the erosion of agricultural and abandoned land transfer contamination to adjacent clean areas and across the border. Flooding can be a problem in areas where agriculture has been extended to marginal lands. In the direct vicinity of the accident site, studies on birds (barn swallows) show symptoms that can be ascribed to radiation exposure. Whether the lower levels of exposure, more distant from the accident site has had or will have ecological effects remains to be elucidated. Earlier experience from radioactive spills and from nuclear testing grounds is that the impact of radioactivity in the environment on ecosystems is small.

Sources: UNDP, 2002; UNECE, 2005; Chernobyl Forum: 2003–2005; WHO, 2006a.

Ozone layer depletion, other ultraviolet radiation exposures and cancer

Increased exposure to ultraviolet (UV) radiation, especially in childhood, as a result of stratospheric ozone depletion, intense suntanning, and the use of sunbeds are major risk factors for malignant melanoma later in life. This skin cancer is increasing in Europe, also in young people. The rates in western Europe are 2–3 times higher than in eastern European countries, mainly as a result of leisure activities. Excessive solar UV exposure was estimated to cause between 14 000 and 26 000 premature deaths in Europe in the year 2000. A recent assessment suggests that the ozone layer will take 5 to 15 years longer than previously estimated to recover from damage caused by chlorinated pollutants in the atmosphere. Climate change may also alter human exposure to UV, as there are complex couplings between climate change and the recovery of the ozone layer; for example, greenhouse-induced cooling of the stratosphere is expected to prolong the effect of ozone-depleting substances.

Sources: IPCC/TEAP, 2005 ; WMO/UNEP 2006; de Vrijes *et al.*, 2006; WHO, 2007.

The Aral Sea crisis — the human health perspective

Disruption of institutional capacities to provide health services and environmental management has put extra burdens on people chronically exposed to pesticides and industrial pollution as a result of the Aral Sea crisis. Over 1.5 million people in Karakapalstan are considered the most affected. Almost all women of childbearing age suffer from anaemia, which is of highest concern in pregnant women. Most babies are born anaemic. There are increasing rates of miscarriages and pregnancy complications. Thyroid problems are common, probably due to iodine deficit. Repeated outbreaks of infectious diseases are reported and the average life expectancy has shortened (from 64 to 51 years in the Kzyl-Orda region of Kazakhstan). Studies on exposure and impacts of environmental pollutants are scarce, but of most concern are toxic organic compounds. One of the most toxic dioxin congeners dominated in milk of women from Karakalpakstan and Kazakhstan, and the levels were among the highest ever documented. A study involving children from Kazakhstan and Germany indicated high body-burdens of the product of the pesticide DDT in children living in Aralsk, formerly on the Aral Sea shore, and in central Kazakhstan. Average levels in urine were three times higher than the 'normal' values found in children in Germany.

Sources: Ataniyazova *et al.*, 2001; Erdinger *et al.*, 2004.

Box 2.1.6 Impacts of a heatwave — August 2003

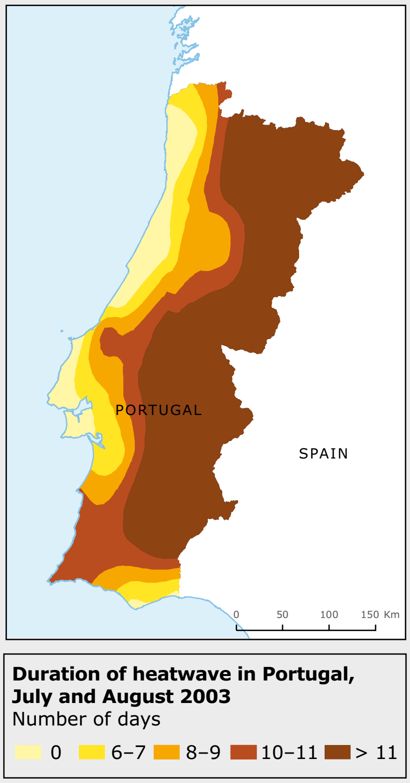
In France, Germany, Switzerland and the United Kingdom, temperatures exceeded previous record levels, and daytime maximum temperatures of 35 to 40 °C were repeatedly recorded in most southern and central European countries (Map 2.1.2). About 50 000 excess deaths were recorded in several western and central European countries, mostly among older people. People suffering from chronic diseases, on certain medications, and not physically fit were at the highest risk. Living in the city, being alone, and living on upper floors were associated with higher mortality.

The estimated costs of damage to agriculture exceeded EUR 11 billion. Many rivers, e.g. the Po, the Rhine and the Loire, were at record low levels, resulting in disruption of irrigation and power-plant cooling. Elevated temperatures led to permafrost thawing in the Alps.

In southern Europe more than 62 000 forest fires burned more than 742 000 ha of vegetation. In Portugal alone 8.6 % of the forest cover was burnt (Map 2.1.3). The 2003 fire season in southern Europe caused at least 40 deaths. In Portugal alone there were 21 deaths and the economic damage of the fires was estimated at around EUR 1 billion.

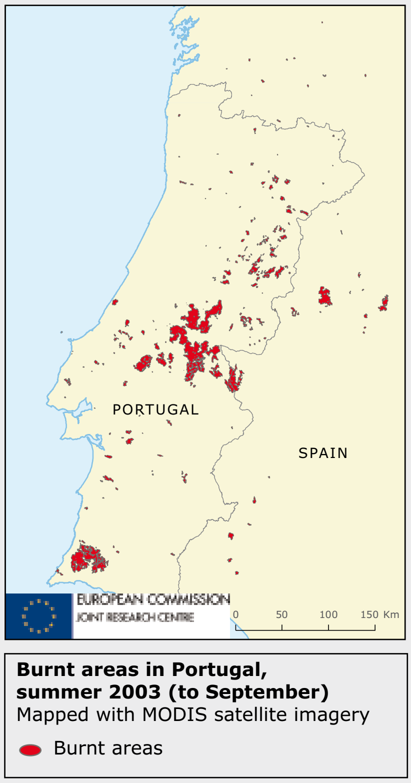
Sources: European Commission, 2004a; European Commission, 2004b; WHO, 2006b.

Map 2.1.2 Duration of heatwave in Portugal, July and August 2003



Source: Portuguese Meteorological Institute, 2007.

Map 2.1.3 Burnt areas in Portugal, summer 2003



Sources: European Commission, 2004a; 2004b.

health came to widespread public attention in summer 2003, when much of Europe was affected by unusually high temperatures (see Box 2.1.6). Regional climate simulations indicate that by the end of the 21st century, summers may regularly be as hot as that which occured in 2003. In the United Kingdom, a 250 % increase in heat mortality has been projected for the 2050s (WHO, 2006b). The increasing number of older people in Europe and their social isolation are likely to increase the number of vulnerable citizens. With the projected increase in the frequency of such episodes, the estimated costs of inaction may be large (WHO, 2005).

The summer 2003 heatwave highlighted shortcomings in public health preparation and responses, and insufficient mechanisms to predict or prevent health effects, or even to detect them rapidly (WHO, 2005). This episode triggered actions in many countries (for example Portugal and Hungary) to develop heatwave preparedness and response plans. In France, such a national plan was launched in 2004. In July 2006, a heatwave again affected Europe. It was less severe and the death toll was lower than in August 2003. At the international level, WHO has recommended strategies to reduce the health impacts of heatwaves, stressing the value of information on potential threats and impacts in preparing the public and facilitating the response (Menne and Ebi, 2006).

Which are the major environmental impacts on health in Europe?

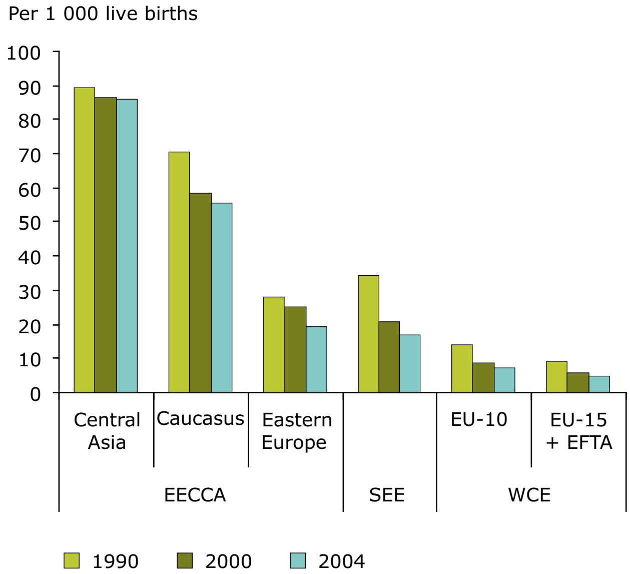
Major environment-related health concerns in Europe are linked to the quality of air and water, hazardous chemicals, and noise. These are often interconnected. The environmental burden of disease (EBD) is not equally distributed among European countries, and is much higher in EECCA and SEE than in WCE.

In the WHO study for the ministerial conference in Budapest in 2004, outdoor and indoor (solid fuel combustion) air pollution, unsafe water conditions, exposure to lead, and injuries accounted for one-third of the total burden of disease in children and adolescents aged 0–19 in the European region (WHO, 2004b). The estimates are available for three sub-regions ([2]) of the WHO European Region. The environmental burden of disease (EBD) methodology allows comparisons of health losses in populations due to risk factors or diseases in terms of mortality (death) or so-called disability-adjusted life years (DALYs), indicating loss of years of healthy life. However, EBD focuses on associations between a single risk factor and a health outcome, and does not address multiple causal pathways or interactions between factors. No estimates are yet available for hazards such as noise, endocrine-disrupting substances and environmental tobacco smoke (WHO, 2006).

In September 2006, a scientific workshop was organised jointly by JRC, EEA and WHO to discuss current approaches to measuring EBD, methodological challenges in moving from single-factor causality towards multicausality, as well as applicability of EBD estimates for communication and policy-making. The collaborative work has continued, aiming at scientific review of existing methodologies, and facilitating transfer of research topics to existing consortia or new initiatives under the Seventh Research Framework Programme (FP7).

Children are particularly vulnerable to environmental hazards in the first years of life.

Figure 2.1.1 Mortality rate (per 1 000 live births) in children under five years



Source: UNICEF, 2006.

([2]) Eur-A (very low mortality in both children and adults): EU-15, EFTA, other WCE countries, Croatia, the Czech Republic, Slovenia, Cyprus and Malta.
Eur-B (low mortality in children and adults): western Balkans (except Croatia), the Caucasus, Central Asia (except Kazakhstan), Poland, Slovakia, other SEE countries (Romania, Bulgaria, Turkey).
Eur-C (low mortality in children, high in adults): eastern Europe, Latvia, Estonia, Lithuania, Hungary and Kazakhstan.

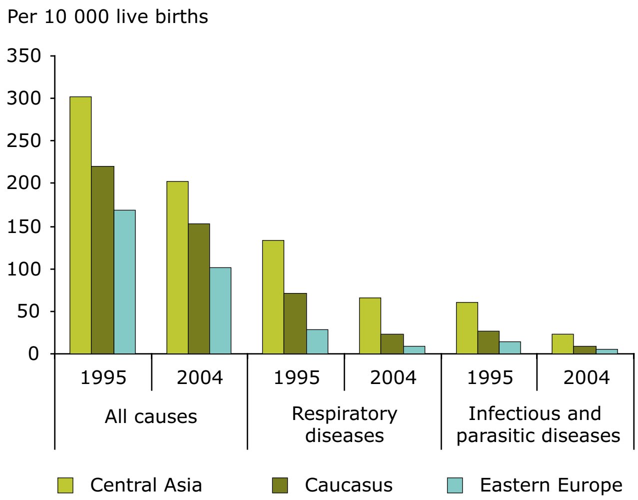
Exposures to 'traditional' environmental hazards, such as unsafe water, air pollution, poor nutrition and parental exposure to chemicals, constitute important risks to infant health. Childhood mortality in all regions has been decreasing during recent years, although at different speeds (Figure 2.1.1). The overall mortality rate in children under five in EECCA decreased from 62.7 per 1 000 live births in 1990 to 53.8 per 1 000 in 2004. In Central Asia not much progress was made over the last decade, and this contributed to widening the difference between the countries (WHO, 2005a). In the EU-25, the average mortality rate in the same period declined from 11.9 to 6.2 per 1 000 live births. Access to good preventive and curative health care is essential to reduce infant mortality, but also reduced poverty and improved environmental management are of relevance, particularly for respiratory and diarrhoeal diseases.

The quality of reporting is a relevant issue, especially in the EECCA region. There are marked differences between the official country statistics and the estimates of WHO, UNICEF and other international organisations. For example, in 2003 the official figures and the WHO conservative (low) estimate on mortality in children differed almost five times for Tajikistan, and around three times for Georgia, Kazakhstan and Azerbaijan (WHO, 2005a).

Respiratory diseases are the most common, and acute respiratory infections are among the leading causes of death in infants and young children, especially in the eastern part of the pan-European region (WHO, 2007; Interstate Statistical Committee of the Commonwealth of Independent States, 2005) (Figure 2.1.2).

There is sufficient scientific evidence that respiratory health in children benefits from reducing air pollution (WHO, 2005b; WHO, 2007). As estimated by WHO, outdoor air pollution by particulate matter accounts for 6.4 % of all deaths in children aged 0-4 in Europe. This burden is higher (7.5 %) in the countries of WHO's subregions (see footnote 2) 'Eur B' and 'Eur C', while in 'Eur A' it is less than 1 % of the total burden of disease.

Figure 2.1.2 Infant mortality (under 1 year) per 10 000 live births due to selected causes in EECCA countries



Note: Uzbekistan, Turkmenistan most recent data from 1999; Tajikistan most recent data from 2000; Georgia most recent data from 2003.

Source: Interstate Statistical Committee of the Commonwealth of Independent States, 2005.

Noise — an emerging environmental health concern

Environmental noise can affect people's health and quality of life, as it interferes with basic activities such as sleeping, resting, studying, and communicating. The overall burden of ill health due to noise in Europe has not yet been quantified. WHO is currently developing a study, addressing several health end-points: cardiovascular disease, cognitive impairment in children, hearing impairment due to leisure noise, tinnitus (commonly called a 'ringing in the ears'), annoyance, and sleep disturbance. The results are expected in 2007. In addition, the impacts of noise are enhanced when they interact with other environmental stressors, such as air pollution and chemicals. This may be particularly the case in urban areas, where most of these stressors coexist. This was highlighted recently at a workshop organised by DG Joint Research Centre (JRC) in collaboration with EEA, WHO and the Coordination of European Research for Advanced Transport Noise Migration (CALM) Network (CALM, 2007).

In accordance with the Environmental Noise Directive, exposure to noise will be monitored in the EU starting this year. Several countries already have national or local estimates of noise exposure and the associated health effects. Compared to noise from neighbours and industry, many people are severely annoyed by noise from transport-related sources. However, due to differences in the measurement of annoyance and definition of sources, only an indicative comparison between countries and regions is now possible. A Swedish questionnaire study of 19 000 12-year-olds identified noise as a disturbance to normal sleep for almost 8 % several times a week (Swedish Environmental Health Report, 2005). In the Russian Federation, about 38 million people live in areas of noise nuisance caused by road, rail, and air transport. Roughly 60 % of Moscow residents currently live in zones subject to road traffic-related noise nuisance, almost three times the average across the Russian Federation (ECMT, 2004). In Belarus, 15 % to 35 % of the population in the cities of Brest, Vitebsk, Mogilyov and Bobruisk live in conditions of acoustic discomfort (Environmental Conditions in the Republic of Belarus, 2003).

Some European countries estimate that the social cost of road noise pollution is about 1 % of GDP (Martin *et al.*, 2006). In Switzerland, about 15 % of the population live in areas where exposure limits of traffic noise are exceeded. An ongoing programme (started in 1986) to reduce noise exposure from traffic infrastructure, industry, trade, and shooting ranges will be completed by 2018, at an overall cost of around EUR 4 billion (Boegli, 2006). In Spain, general traffic noise was reported as the most annoying, and 41 % of people interviewed felt highly disturbed by it (Martin *et al.*, 2006). In Norway, noise annoyance from road traffic increased by 5 % from 1999 to 2003, while there was a drop in noise levels from industry (6 %), aircraft (22 %) and railways (20 %). Since road traffic is the major contributor to noise annoyance, the total noise annoyance in Norway increased by 2 %. Norway has a national target for noise reduction of 25 % by 2010. According to a survey, 5 % of the Norwegian population have noise-related sleep problems (Statistics Norway, 2006). A study in Sarajevo showed that one in four people living in noisy urban areas experienced disturbance of their normal sleep pattern, while one in five reported that annoyance from various noise sources disturbed their normal daily activities (UNECE, 2004).

In Germany 60 % of the population is annoyed by road traffic noise and 10 % is highly annoyed (UBA, 2005). It is estimated that approximately 16 % of the population is exposed to road traffic noise levels of more than 65 dB(A) outside their dwellings during the day and approximately 49 % to noise levels of more than 55 dB(A) (UBA, 2005), which should not be exceeded to avoid serious annoyance, according to WHO recommendations (WHO, 1999). Approximately 3 % of acute myocardial infarctions per year in Germany may be attributed to road traffic noise (Babisch, 2006).

In the Dutch national survey on annoyance, sleep disturbance, risk perception and the quality of the living environment, road traffic (mostly from mopeds) was the source of severe noise annoyance for 29 % of the respondents. Noise from air traffic and neighbours was severely annoying for 12 % of the surveyed population. The severe annoyance from mopeds, highways and building and demolition sites has a rising trend as compared with 1993. The need for quieter residential areas has increased from 8 % to 10 % (RIVM, 2004).

Air pollution and health

Air pollution is an important public health problem, as shown consistently in the studies covering various regions and using different methodological approaches. The evidence on airborne particulate matter ($PM_{2.5}$ and PM_{10}) and health indicates adverse effects at exposures experienced by urban populations across Europe. Affected are respiratory and cardiovascular systems in adults, children, and other vulnerable groups. Health impacts of urban air pollution with particulates and ozone are discussed in detail in the section on air quality (see Section 2.2, Air quality).

Industrial pollution in urban-industrial areas may still affect human health in EECCA and SEE (Box 2.1.7). Regions such as SEE have already been supported by large-scale environmental protection and cooperation efforts to address the impacts of environmental degradation, mostly transboundary (Environment and Security, 2003).

Box 2.1.7 Respiratory symptoms in children and adults living near the ash deposition of the Thermal Power Plant 'Nikola Tesla', Obrenovac

The thermal power plant 'Nikola Tesla' operates in Obrenovac, 26 km from Belgrade. The transport and deposition of fly ash particles by wind has been determined using data on the sedimentary substances (or aerial sediment) collected for many years by the network of the City Institute for Public Health, Belgrade. The wind carries ash particles from the ash deposition landfill towards Grabovac.

Between 2002 and 2004, respiratory health in relation to industrial air pollution was evaluated by a questionnaire in Grabovac — located next to the ash landfill, and in Drazevac — located in a 'clean' area, not affected by industry. With the same proportion of smokers (53 %), the inhabitants of Grabovac were 1.7 times more likely to visit the doctor because of difficulties in breathing than the inhabitants of Drazevac, and the relative risk of chronic cough or asthma was about 1.5 higher. In children, differences in respiratory symptoms between the two locations were even more pronounced. A child in Grabovac was almost three times more likely to visit the doctor because of wheezing, 1.5 times more likely to have breathing problems for three consecutive months a year, and 2.3 times more likely to suffer from asthma. Asthmatic children in Grabovac were 6.6 times more likely to be on constant medication.

A decision on investment was made on the basis of the results of this study. The European Agency for Reconstruction invested EUR 26 million to change the technology of ash landfill to solve the problem of air pollution, starting from 2006. It is expected that morbidity in the exposed population will decrease and the quality of life improve, especially among children.

Source: Paunovic *et al.*, 2006.

Indoor air quality

A substantial portion of outdoor air pollution migrates indoors, affecting the quality of this micro-environment. Specific indoor sources include building and construction materials, furnishing, paints and consumer products. Environmental tobacco smoke remains the most important indoor air pollutant across Europe. Domestic combustion of solid fuels is a relevant source of exposure to particulate matter and hazardous organic compounds, such as polycyclic aromatic hydrocarbons (PAHs) (Box 2.1.8).

The use of solid fuels in households differs markedly across Europe, and is linked to poverty. Around 16 % of the population in central and eastern Europe relies on solid fuels, more than 50 % in Albania and in Bosnia and Herzegovina, and more than 70 % in some Central Asian republics. The figure is estimated to be below 5 % in upper-, middle- and high-income countries (Rehfuess *et al.*, 2006). Economic growth and modernisation are likely to contribute to decreasing use of these fuels and consequently to a reduced health risk. Ventilation and other techniques may reduce or eliminate emissions from combustion processes. However, acute lower respiratory tract infections, attributable to indoor air pollution from solid fuel use alone, still account for 4.6 % of all deaths in children aged 0–4 in the WHO European Region, most of them in the countries of central and eastern Europe and Central Asia (WHO sub-region 'Eur B' — see footnote ([2])) (WHO, 2004b).

Exposure to environmental tobacco smoke in the home environment is still common: in EECCA and SEE more than 50 % of children are exposed. In Georgia, Armenia, Croatia, and Serbia more than 90 %. In Switzerland, Italy and the Netherlands, approximately 50 % of examined children aged 6–12 live with a current smoker (WHO, 2007). Causal links between indoor air quality and health are not clear, but several pollutants appear to exacerbate asthma, especially in children. 'Energy saving' buildings, if not adequately ventilated, may contribute to increased indoor humidity and the growth of biological pollutants. Indoor exposure to dampness, dust mites and fungal allergens (moulds) may account for 20 % of asthma prevalence (WHO, 2006c). Preliminary results of the recent German Environmental Survey (Ger ES IV) show sensitisation against common moulds in almost 10 % of examined children aged 12–14. This may be a risk factor for asthma and allergies. 23 % of examined children report irritation of the eyes, and 12 % irritation of the nose and/or throat that may be caused by volatile organic compounds (German Environmental Survey, 2006).

Box 2.1.8 Polycyclic aromatic hydrocarbons (PAHs) in the environment — a threat to human health

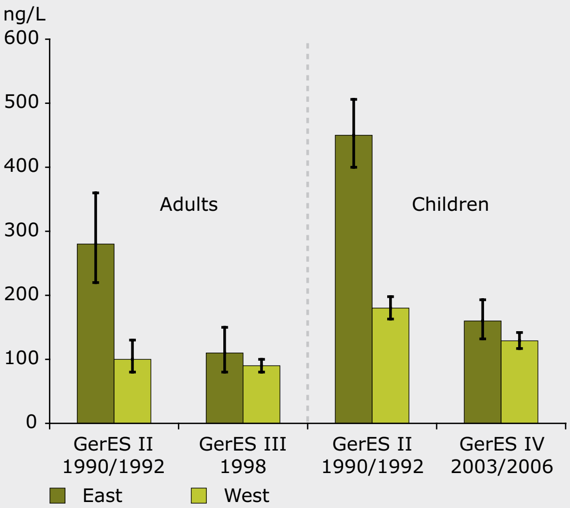
Polycyclic aromatic hydrocarbons (PAHs) are products of incomplete combustion of organic matter (e.g. fossil fuels), released to the atmosphere from industrial sources (e.g. steel or aluminium plants, coking plants), power plants, individual coal-based heating systems and residential wood burning, and from traffic (see also Section 2.2, Air quality). They occur in the environment as complex mixtures with widely varying toxicities. The effect of most concern is cancer, and epidemiological studies suggest an association between exposure to PAHs and lung cancer. Exposure to airborne PAHs can also affect the foetal growth (Choi *et al.*, 2006). People are exposed mostly by inhalation of particles or aerosols containing PAHs, both outdoors and indoors, and by ingestion of contaminated food, soil particles and water.

In Ukrainian children living near (< 5 km) a steel mill and coke oven in the industrial city of Mariupol, mean urinary levels of the PAHs biomarker, 1-hydroxypyrene (1-HP) were the highest yet reported in young children. The coking facility was reported to emit over 30 kg of benzo(a)pyrene a year into the atmosphere, and two major steel plants emit thousands of tonnes of nitrous oxides, carbon monoxide, and particulate matter a year. The highest levels in exposed children overlapped with those reported in occupationally exposed adults and smokers. Children in Mariupol had significantly higher levels of 1-HP than those living in the urban, high-traffic environment of Kiev (Mucha *et al.*, 2006).

Clean air measures and altered patterns of fuel use in Germany have dramatically reduced air pollution by PAHs in the past decade. The most likely reason for the significant decreases in the levels of 1-HP in adults living in eastern Germany between 1990/1992 and 1998 was the decreasing ambient air concentrations of PAHs, resulting from reductions in industrial emissions and in the use of coal for heating in private homes. Results from the recent German Environmental Survey in children (2003–2006) indicate substantially lower levels of 1-HP compared with the early 1990s, again with a more pronounced decline in the eastern part of the country (German Environmental Survey, 2006) (Figure 2.1.3).

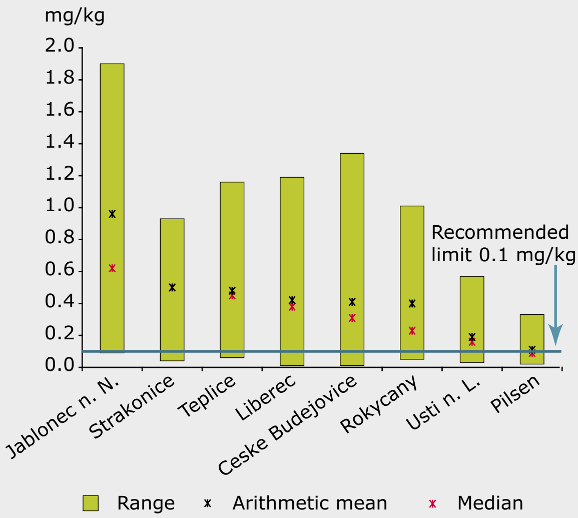
Soil contamination with PAHs may be a source of human exposure, for example in children's playgrounds (Figure 2.1.4). Children may ingest contaminated soil particles through their intensive hand to mouth activity (Environmental Health Monitoring System in the Czech Republic, 2006).

Figure 2.1.3 1-hydroxypyrene (1-HP) in urine of never smokers in Germany (geometric mean, 95 % CI)



Source: German Environmental Survey (GerES II, GerES III, GerES IV).

Figure 2.1.4 Concentration of benzo(a)pyrene (BaP) in the upper soil in kindergartens in the Czech cities monitored in 2004



Source: Environmental Health Monitoring System in the Czech Republic, 2006.

Lead

Lead exposure is probably one of the most recognised health hazards — affecting the intellectual development of infants and young children even at low levels. The estimated burden of mild mental retardation attributable to lead in children aged 0–4 is more than three times higher in the WHO 'Eur C' region than in 'Eur B' or 'Eur A' countries (see footnote (2)) (WHO, 2004b).

Banning leaded petrol has resulted in remarkable declines in blood lead levels in many European countries. The decision to eliminate lead additives was based both on human health considerations and technological developments, since leaded petrol is harmful to catalytic converters. By the end of 2006, most of the EECCA and SEE countries had banned leaded petrol. It is still being sold in Tajikistan, Turkmenistan, the Former Yugoslav Republic of Macedonia, Serbia and Montenegro. Bosnia and Herzegovina will phase it out in 2010 (OECD, 2005; UNEP, 2007). The shift towards unleaded petrol is expected to result in decreasing exposure levels and reductions of the associated health risks. However, information is insufficient to evaluate progress in many of these countries. There are no estimates of the actual consumption of leaded petrol, including the unofficial market (Box 2.1.9). Reliable information on blood lead levels from many parts of the pan-European region is lacking.

Industrial emissions remain an important source of lead exposure in some parts of Europe. Data from hot spots in Bulgaria, Poland and the Former Yugoslav Republic of Macedonia indicate impacts of lead emitted from plants on the blood lead level of children (WHO, 2007).

Box 2.1.9 Leaded petrol is still a problem in Georgia

According to current standards, the maximum level of lead in petrol is 0.013 g/L. Fuel quality should have improved from 2005 onward (max. to 0.005 g/L), but implementation was delayed until 2007, due to the possibility of negative social consequences (e.g. increased prices of products and services), and difficulties with enforcement. In practice, average lead concentrations are much higher than the permissible limits. The vehicle fleet consists mainly of second-hand European cars, with catalytic converters often destroyed or removed, as well as of Soviet-made vehicles. Soviet models can run on low-octane fuel, while European models run better on highoctane. A major problem is posed by the illegal import of low-octane fuel, which is then upgraded with lead additives to increase the octane level. Also, many older cars require leaded petrol because the lead lubricates and protects their soft valves.

Source: THE PEP, 2006.

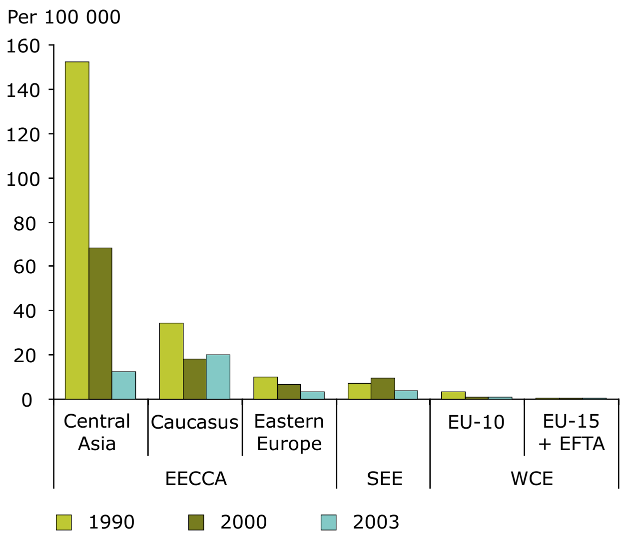
Water and sanitation and health

Insufficient water supply and sanitation, and poor water quality continue to affect public health in several countries (see Section 2.3, Inland waters). Diarrhoeal diseases annually cause the deaths of an estimated 13 000 children under the age of 15 (5.3 % of all deaths in that age group), with the largest burden in the countries of central and eastern Europe and Central Asia (WHO, 2004b). The standardised death rates for diarrhoeal diseases in children remain the highest in Central Asia, despite a marked decline from the early 1990s (Figure 2.1.5). The magnitude of the health impacts of drinking water quality is probably under-reported.

More than one-third of the population in many EECCA countries drink water that does not meet hygiene standards, and reported outbreaks of water-related diseases in the region are increasing (OECD, 2005) (Box 2.1.10). However, outbreaks of waterborne diseases occur across Europe. Between 2000 and 2005, Croatia, United Kingdom (England and Wales), Finland, Greece, Hungary, Italy and Slovakia reported outbreaks, the highest number being in Finland. Inter-country comparisons are limited by differences in monitoring and reporting systems (WHO, 2007).

Health impacts related to water quality and quantity and insufficient sanitation are priorities for action in Europe. Chemical contamination of water may also be of relevance in some areas, for example naturally occurring arsenic, as in the case of Hungary, or lead from old pipes dissolving into water. The recreational (bathing) water environment also carries a range of hazards to human health, including exposure to microbiological pollution, toxic algae products,

Figure 2.1.5 Standardised death rates (per 100 000) for diarrhoeal diseases in children under 5 years



Note: WE: 1990 — no data for Cyprus, Denmark, Iceland, Luxembourg, Malta, Slovakia, Czech Republic; 2000 — no data for Cyprus, for Belgium data from 1997 used; 2003 — no data for Belgium, Cyprus, Denmark, Italy, Sweden;
SEE: 1990 — no data for Albania, the Former Yugoslav Republic of Macedonia, Serbia and Montenegro; 2000 — no data for Bosnia and Herzegovina; 2003 — no data for Bosnia and Herzegovina, for Serbia and Montenegro data from 2002 used;
EECCA: 1990 — no data for Azerbaijan; 2000 — for Turkmenistan data from 1998 used; 2003 — no data for Georgia, Tajikistan, Turkmenistan; for Belarus, Kazakhstan, Kyrgyzstan, Republic of Moldova, the Russian Federation, Ukraine, Uzbekistan data from 2005.

Source: WHO, 2006.

occasionally to chemicals, and other related hazards (sunburn, drowning, etc.).

Complexity of interactions between chemicals and health

There is growing concern that 'even low-level exposure over decades to a complex cocktail of pollutants in air, water, food, consumer products and buildings can have a significant effect on the health status of European citizens' (European Commission, 2003). In addition, the time between critical exposures and health outcomes may be decades or even trans-generational. A new dimension is the concern about delayed health impacts of foetal exposure and even of prospective parents before conception. Since the Kiev report there has been growing evidence of 'late effects of early exposures', and new research is providing insights into the possible ways of transmitting environmental impacts through generations (Weinhold, 2006). The origins of several adult cancers can be traced back to environmental exposures early in life. It is becoming ever clearer that parents are giving their offspring an 'environmental heritage' which could result in disease later in life. The transmission is 'silent', meaning that the parent experiences no effect or ill health because of the exposure. In a recent review of animal studies, more than 50 chemicals that caused cancer in adult animals after exposure in the womb before birth were identified (Barton

Box 2.1.10 Water and health issues in EECCA

- In Belarus, the physical condition of rural drinking-water pipes has deteriorated markedly over the past seven years, leading to increased microbial contamination and a higher incidence of acute gastro-intestinal infections and viral hepatitis (UNECE, 2005).
- In Azerbaijan, deterioration of water quality and related increases in water-borne diseases were identified as one of the main problems in the National Environmental Action Plan. The State Program on Poverty Reduction and Economic Development for 2003–2005 also recognised diarrhoeal diseases as one of the primary causes of childhood morbidity and mortality (UNECE, 2003).
- In Ukraine, access to clean water is a priority issue in the Millennium Development Goals. In 1997, 70 % of the urban population, but only 24 % of the rural population, were connected to a centralised drinking-water system. Several national strategic programmes have recently been developed to improve the quality and availability of water. However, during 2001–2004 only 10 % of the necessary funds were allocated, and none of the planned water supply systems for rural communities were built (UNECE, 2006).

et al., 2005). Exposure during early life to toxicants, such as persistent organic compounds (POPs), pesticides, and heavy metals, have been linked to neuro-developmental effects. Learning disabilities, hyperactivity and other cognitive deficiencies are already manifested during the first years of life, but are important health impacts with lifelong consequences. There has been speculation that early exposure to household chemicals, POPs, ozone and other air pollutants ($PM_{2.5}$) could be responsible for the current increase in childhood asthma, particularly in western Europe and USA, but the evidence is not conclusive (EEA, 2005).

An issue of particular scientific interest is chemicals that may interfere with hormonal regulation mechanisms. Endocrine-disrupting substances have been indicated in a range of health and developmental impacts, including some hormone-dependent cancers. Evaluation of the ten years of research on endocrine disrupters since the Weybridge report (European Commission, 1996) concluded that there is increasing evidence that certain health outcomes, such as reduction in sperm count, precocious puberty, testicular and breast cancer are linked to environmental factors (EEA, the Finnish Academy of Sciences, in press).

Environment and health — challenges for research and action

The new EU framework research programme (FP7) for 2007–2013 encourages further work on environment and health issues, recognising the challenges posed by the increasing natural and man-made pressures on the environment and its resources.

'Environment and health' is being considered under the theme 'Climate change, pollution and risks' in the Environment research area. This reflects the need to improve our understanding of the potential impacts of climate change on human health, by means of multidisciplinary and integrated research to advance knowledge on the interactions between climate, biosphere, ecosystems and human activities (European Community, 2007). In March 2007, the European Centre for Disease Prevention and Control (ECDC) hosted the workshop on infectious diseases and environmental change jointly organised by ECDC, WHO, JRC, and EEA, to assess the ramifications of climate and ecological changes on the communicable disease burden in Europe.

Further advances in classical toxicology, including multi-generation models are needed to achieve a better understanding of environment and health relationships and prevent adverse impacts on human health and the quality of life. Rapid scientific development is promising to provide, in the near future, new methods and approaches for more realistic assessments of the long-term impacts of environmental factors on health.

Given the limited knowledge and understanding of the complex associations between the environment and human health, a precautionary approach is appropriate and is required under the EU Treaty (EEA, 2002). It should also apply in addressing emerging issues such as nanotechnology and genetically modified organisms.

Further development of the frameworks to assess environment and health linkages and translate knowledge into action should facilitate incorporation of new scientific findings and more informed decisions. Protecting human health from environmental hazards/threats requires broad involvement of stakeholders. Good communication and cooperation in addressing environmental problems relevant to human health may still be a challenge. Continued efforts are therefore needed to strengthen intersectoral cooperation at local, national, and international levels, as well as to develop methods to assess the effectiveness of the measures taken.

Provision of reliable, relevant, timely and accessible information must be a part of the framework of activities in environment and health, in line with the provisions of the first article of the Aarhus Convention: 'In order to contribute to the protection of the right of every person of present and future generations to live in an environment adequate to his or her health and well-being, each Party shall guarantee the rights of access to information, public participation in decision making, and access to justice in environmental matters in accordance with the provisions of this Convention' (UNECE, 1998) (see Chapter 1, Europe's environment in an age of transition).

2.2 Air quality

Photo: Moscow © Rolf Kuchling

Key messages

- Air pollution, mainly by fine particles and ground-level ozone, continues to pose a significant threat to human health: it shortens average life expectancy in WCE by almost one year and threatens the healthy development of children.

- In EECCA, the poor quality of the data precludes in-depth assessment of the state of air quality and its consequences. The limited data available indicate that the main health threat, as in WCE, is from small particles and their toxic constituents.

- In EECCA, emissions of most air pollutants have increased by more than 10 % since 2000 as a result of economic recovery, increase in transport, and the persisting poor effectiveness of air pollution protection policies. Emission projections for 2010 and 2020 expect a further increase, and greater efforts will be needed to achieve levels of air quality that do not give rise to significant threats to human health and the environment.

- In WCE and SEE, emissions of air pollutants are projected to decline during the next two decades as a result of progressive implementation of current and envisaged emission control legislation and continuing structural changes in the energy system. The largest projected reductions are for energy-related emissions, especially SO_2, NO_x, VOCs and primary $PM_{2.5}$, with lower reductions for emissions from agriculture.

- The projected emission reductions in WCE and SEE will reduce impacts on public health and ecosystems significantly by 2020, but not enough to ensure no significant threats to human health and the environment.

- The main contributor to air pollution in cities is the continuing growth in road transport. Emissions from industry, power production and households also contribute substantially in urban areas in many parts of EECCA, central and eastern parts of WCE, and SEE.

- Emissions from shipping (NO_x and SO_2) are projected to exceed emissions from land-based sources if measures to reduce these emissions are not implemented in the future.

2.2.1 Introduction

Despite a substantial body of international and national legislation and significant reductions in the emissions of some common pollutants, poor air quality is still causing hundreds of thousands of premature deaths in Europe every year and continues to damage crops and ecosystem health.

Air pollution by fine particles represents the highest risk to public health in all regions, higher than that of other air pollutants. The estimated annual loss of life is significantly greater than that due to car accidents.

However, current air quality protection policies in the EU (and SEE) and in EECCA are not yet focused on the need to abate air pollution by fine particles directly and effectively and thus need significant revision and improvement.

Acidification and eutrophication of ecosystems by air pollutants and exposure of vegetation to excessive concentrations of ground-level ozone continue to exceed critical loads and levels. They still pose a serious threat to the environment and agricultural production in many parts of Europe.

Strategic development of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and of EU air pollution protection policies needs to be focused mainly on reducing particulate pollution and on the linkages between air pollution and climate change. The emissions targets currently being discussed also recognise the need for substantial improvements in the protection of ecosystems and vegetation against acidification, eutrophication and ground-level ozone.

2.2.2 Progress in air quality protection policy since Kiev

Air pollution issues in the UNECE region are addressed by the Convention on Long-range Transboundary Air Pollution (CLRTAP), which has been one of the main means of protecting public health and the environment from the harmful effects of air pollution across the region.

All the WCE countries, and Bulgaria and Romania, are parties to CLRTAP and almost all have signed protocols under the Convention. Nine EECCA countries — Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, the Republic of Moldova, the Russian Federation and Ukraine — are parties to the Convention. Belarus, the Russian Federation and Ukraine have accepted the first three protocols. In 2002 the Republic of Moldova ratified protocols on heavy metals and POPs. The western Balkan countries are parties to CLRTAP. Croatia has ratified the 1994 Protocol on sulphur and signed protocols on heavy metals, POPs and the 1999 Protocol to abate acidification, eutrophication and ground-level ozone — the Gothenburg 'multi-pollutant' Protocol.

By March 2005, sixteen parties (most EU and EFTA countries, and Bulgaria and Romania) had ratified the Gothenburg Protocol. The ceilings of the Gothenburg Protocol represent cost-effective and simultaneous reductions of acidification, eutrophication and ground-level ozone. There has been no progress in ratification of the Gothenburg Protocol in EECCA since the Kiev assessment.

Air quality is one of the environmental areas in which the European Community has been most active. A thorough overhaul of legislation was carried out in the 1990s with the aim of developing a coherent and comprehensive EU strategy through the twin-track approach of long-term air quality objectives together with overall and specific limits on emissions. Further streamlining of air quality legislation is under negotiation (see Section 2.2.6 below).

During the period 1999–2004 the Framework Directive 96/62/EC (FWD) on ambient air quality assessment and management (European Council, 1996) was complemented by four daughter directives (European Council, 1999; 2000; 2002 and 2004). The 1996 Directive sets common objectives and basic principles, and the daughter directives set limit and target values for pollutants listed in the Framework Directive. Together these directives aim at establishing a harmonised structure for assessing and managing air quality throughout the EU.

The air quality directives require EU Member States to assess air quality throughout their territory. For zones and agglomerations where the levels of one or more pollutants are higher than the limit value, they are required to develop plans and programmes aimed at attaining the limit values within the set time limit. In addition to establishing limit or target values and alert thresholds for the identified pollutants, the daughter directives aim to harmonise monitoring strategies, measuring methods, calibration and quality assessment methods in order to arrive at comparable measurements throughout the EU and provide effective public information.

Parallel to the CLRTAP Gothenburg 'multi-pollutant' Protocol is the EU National Emissions Ceilings Directive (NECD) (European Parliament and Council, 2001). NECD is a key element of EU legislation on emissions: it sets emission ceilings for sulphur dioxide, nitrogen oxides, ammonia and volatile organic compounds (VOCs) to be attained by 2010. Under this directive, Member States are obliged each year to report their national emission inventories and their projections to 2010 to the European Commission and the European Environment Agency. They must also draw up national programmes in order to demonstrate how they are going to meet their emission ceilings by 2010. To achieve emission reductions, the EU has developed legislation aimed at reducing emissions from specific economic and societal source categories. The most important is the legislation to control emissions from large point sources (LCP Directive) and road vehicles (EURO emission standards).

In 2001 the European Commission launched the Clean Air for Europe (CAFE) programme. The main tasks of CAFE are to inform and assist the development of a Thematic Strategy on Air Pollution towards the long-term objective of the Sixth Environment Action Programme (6EAP), which is to achieve levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment, and to assess progress towards this objective. CAFE addresses health and environmental problems related to fine particles ([1]), ground-level ozone, acidification and eutrophication.

The need to revise current air quality protection legislation was revealed by analysis under the CAFE programme that showed that the health risk of pollution by fine particles was at least an order of magnitude higher than that of the other pollutants (WHO, 2004a and 2004 b; CAFE WG, 2004). In terms of lives lost the impacts are even higher than those of car accidents (Amann *et al.*, 2004; 2005b). Neither the NEC Directive nor the Gothenburg Protocol addressed the issue of air pollution by particulate matter.

Air quality protection policy in SEE is driven by the overall goal of joining the EU, and efforts and cooperation have focused mainly on this process. The countries and territories of the region are at various stages of accession or association and stabilisation. Bulgaria and Romania became Member States in 2007 and were obliged to fully harmonise their air quality protection legislation with the EU within the framework of the accession process. As EU accession is also a priority for the rest of the western Balkan countries, there is relatively good information on the process of legal transposition and institutional development at the national level. Obviously, the SEE countries will be obliged to harmonise their air quality and emission reduction targets with the EU (UNDP, 2007). Aid to the region, including for the harmonisation process, has been streamlined through the CARDS programme (Community Assistance for Reconstruction, Development and Stabilisation).

In EECCA, ministers have adopted the EECCA Environment Strategy (UNECE, 2003) which provides a political framework similar to the 6EAP for the EU.

([1]) The WHO Systematic Review of Health Aspects of Air Pollution in Europe (WHO, 2004a) indicates that many studies have found that fine particles ($PM_{2.5}$ — airborne particles smaller than 2.5 µm) have serious effects on health, such as increases in mortality rates and in emergency hospital admissions for cardiovascular and respiratory reasons. Up to now, coarse and fine particles have been evaluated and regulated together, as the focus has been on PM_{10} (airborne particles smaller than 10 µm). However, the two types have different sources and may have different effects. The systematic review therefore recommended that consideration be given to assessing and controlling coarse as well as fine particles $PM_{2.5}$.

In the area of air quality protection, the EECCA strategy is focused mainly on improving environmental legislation, policies, and the institutional framework. One of the objectives is the optimisation of environmental quality standards: to ensure that the substances regulated can be effectively monitored, and to set realistic standards based on risk management considerations and internationally accepted norms. To reduce the risks to human health, the EECCA strategy aims to implement pollution prevention and control procedures similar to the EU Integrated Pollution Prevention and Control (IPPC).

The Environment Strategy identified several urban air pollution problems:

- the major impacts on human health, particularly from pollution from mobile sources;
- the weakness of air quality control systems;
- excessively strict ambient air quality standards ([2]);
- weak technological capacity, resulting in higher emissions;
- lack of economic incentives to reduce emissions per unit of output; and
- inadequate regulation of road transport emissions.

There is no evidence of progress on air pollution control. Overall, the problems identified in the EECCA strategy persist. EECCA countries still face a major environmental policy and institutional reform challenge. Institutions suffer from weak authority, scarcity of resources, outdated management, high turnover of professionals and frequent restructuring, thereby lacking both the incentives and the means to ensure the achievement of environmental improvements. Policies in general, and specifically related to air quality protection, do not have specific targets, rely on unreformed or poorly combined instruments, and are often dominated by revenue-raising objectives. Environmental legislation is extensive but inconsistent and unenforceable. And compliance levels are very low (OECD, 2007).

A large number of policy measures can be applied to manage air quality. Some of these are under the purview of environmental authorities but many are the responsibility of other ministries or even local authorities. For example, as emissions from power generation are determined both by generation technologies and the level of electricity demand, energy efficiency measures, generally a responsibility of energy ministers, constitute an important part of a comprehensive approach to air quality management (OECD, 2007; and Section 7.3, Energy, of this report). Progress with transport-related policy measures (such as product standards for fuel and vehicles, fuel taxation and banning of leaded fuels) is discussed in Section 7.2, Transport, of this report (see also OECD, 2007).

2.2.3 Atmospheric emissions

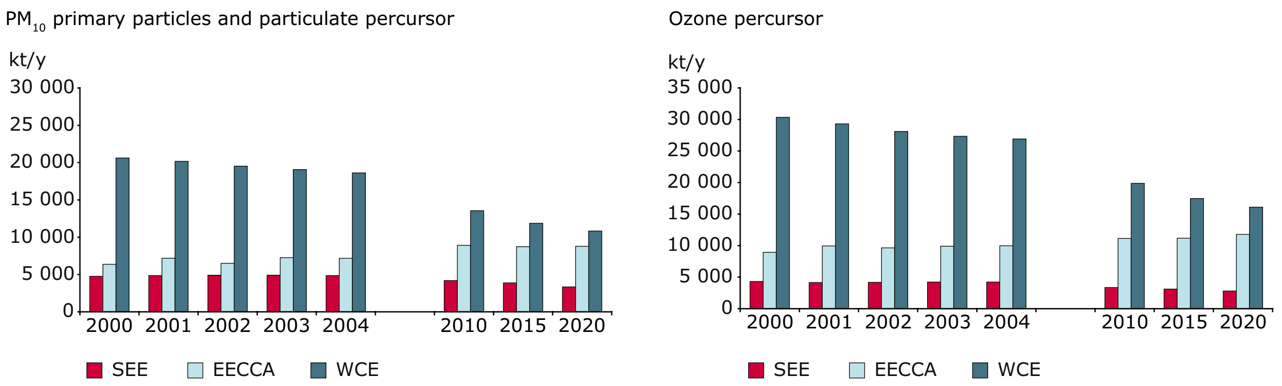
Particulate matter and ozone are the main threats to public health. This part of the report therefore focuses mainly on emissions of particulates (primary PM_{10}) and particulate precursors (SO_2, NO_X and NH_3), and on emissions of the precursors of ground-level ozone (NO_X, NMVOC, CO and CH_4), and less on emissions of acidifying (SO_2, NO_X and NH_3) and eutrophying gases (NO_X and NH_3).

Emission trends

Figure 2.2.1 shows the general trend of emissions of primary particles and particulate precursors and ozone-forming substances in EECCA, WCE and SEE for 2000–2004, and projections to 2020 (EEA, 2006b). The bars show the quantities emitted,

([2]) The EECCA countries use the maximum allowable concentrations (MAC) and Guiding Safe Exposure Levels established by the Ministry of Health of the former USSR 30–40 years ago as air quality standards. Some EECCA countries have recently updated and supplemented these standards. In the Russian Federation, for instance, the Ministry of Health approved a health standard in 2003 listing MACs for some 660 substances (MoH USSR, 1983). While an assessment of the hazards presented by such a broad range of pollutants might be justified, their comprehensive and regular control is extremely difficult and costly. However, attainment of MACs is not legally binding as is the case for EU limit values. A comparison of MACs with EU limit values and WHO standards is given in Table 2.2.3. From this comparison it is evident that for basic pollutants MACs are not stricter than WHO standards or EU limits or target values.

Figure 2.2.1 Emission trends and projections by region



Source: 2000–2004 emission data: official country reports to UNECE/EMEP.
2010–2020 emission projections (CAFE baseline current legislation with climate policies): IIASA/RAINS, 2004.

scaled to take into account their contribution to the formation of particulate matter, ground-level ozone and acidifying and eutrophying gases ([3]). Table 2.2.1 shows the percentage changes (2000–2004) for the most important pollutants.

In WCE, despite continuing economic growth, legislation on air quality, together with associated abatement measures and economic instruments, have led to a continuing decrease in emissions of air pollutants since 2000. In SEE, emissions do not indicate any clear trend since 2000.

In EECCA, economic recovery and the growth in transport since 2000 have led to increases in the emissions of most air pollutants, because of the poor effectiveness of protection policies. The reported decrease in SO_2 emissions in EECCA since 2004 is only due to decrease in these emissions in Ukraine and Belarus. Reported SO_2 emissions from other EECCA countries have increased slightly or remained constant over this period. The major problem for the urban environment has been the rapid increase in private transport. In capitals such as Ashgabat, Dushanbe, Moscow, Tbilisi and Tashkent, transport is the dominant source of air pollutants — more than 80 % of the total. Mobile sources are also important in other large cities including metropoles such as Baku, Bishkek, Chisinau, Kiev, Minsk and Yerevan. The main causative factors include the age of the vehicle fleet, low quality and high sulphur content fuel, poor infrastructure and maintenance, and a declining share of public transport. Industrial sources have declined in importance, but remain relevant and difficult to address.

The EU-15 as a whole is making good progress towards meeting the 2010 targets of the NEC

Table 2.2.1 Percentage changes in emissions, 2000–2004

Pollutant	WCE	SEE	EECCA
NO_X	– 8.7 %	+ 5.7 %	+ 13.1 %
SO_2	– 19.6 %	+ 1.5 %	– 10.3 %
VOC	– 13.6 %	– 12.3 %	+ 11.2 %
NH_3	– 2.6 %	– 5.7 %	– 14.4 %
TOFP	– 11.3 %	– 2.1 %	+ 11.5 %
PM_{10}	– 9.7 %	+ 2.2 %	+ 12.6 %

([3]) Acidifying substances: the pollutants (SO_2, NO_X and NH_3) are each weighted by an acid equivalency factor prior to aggregation to represent their respective acidification potentials. These factors are: $w(SO_2)$ = 2/64 acid eq/g = 31.25 acid eq/kg, $w(NO_X)$ = 1/46 acid eq/g = 21.74 acid eq/kg and $w(NH_3)$ = 1/17 acid eq/g = 58.82 acid eq/kg.
Tropospheric ozone formation: the relative impact of the combined contribution of NO_X, NMVOC, CO and CH_4 can be assessed based on their tropospheric ozone forming potentials (TOFP). These are: 1.220, 1.000, 0.110 and 0.014, respectively.
Particle formation: emissions are estimated using the following aerosol 'formation factors': primary PM_{10} = 1, NO_X = 0.88, O_2 = 0.54 and NH_3 = 0.64. (EEA, 2006b; de Leeuw, 2002).

Directive, but additional effort is still required in order to meet the targets for particular pollutants (mainly NO_X). The new Member States have made excellent progress in terms of meeting their NEC Directive targets, with seven countries already having met them. NO_X and NMVOC emissions reductions are due mainly to the continuing introduction of catalytic converters for cars and, for NMVOCs, and implementation of the EU Solvents Directive in industrial processes.

Between 2005 and 2020 emissions in Europe overall are projected to decline further. The largest reduction (35 %) is projected for WCE. In SEE, emissions are also projected to fall by 27 % over the period as a result of harmonisation of air quality and emission reduction targets with the EU. Emissions in EECCA are projected to be higher in 2010 than those reported for 2004, and by 2020 to have increased slightly above the 2010 levels (IIASA/RAINS, 2004; Vestreng V. *et al.*, 2005).

Ozone precursors

The WCE region was responsible for 70 % of total ozone-forming gases (expressed as TOFP) emitted in 2000 and 65 % in 2004, and the EECCA region for 20 % in 2000 and 24 % in 2004.

Transport (Figure 2.2.2) is the dominant source and contributed 44 % of total emissions in Europe in 2004, followed by energy (26 %) and industry/other (26 %). The shares have not changed since 2000 except for the transport sector where non-road transport emissions increased by 12 % while road transport emissions decreased by 10 %. NMVOCS and nitrogen oxides were the most significant pollutants contributing to the formation of ground-level ozone in 2004.

PM precursors and primary PM_{10} emissions

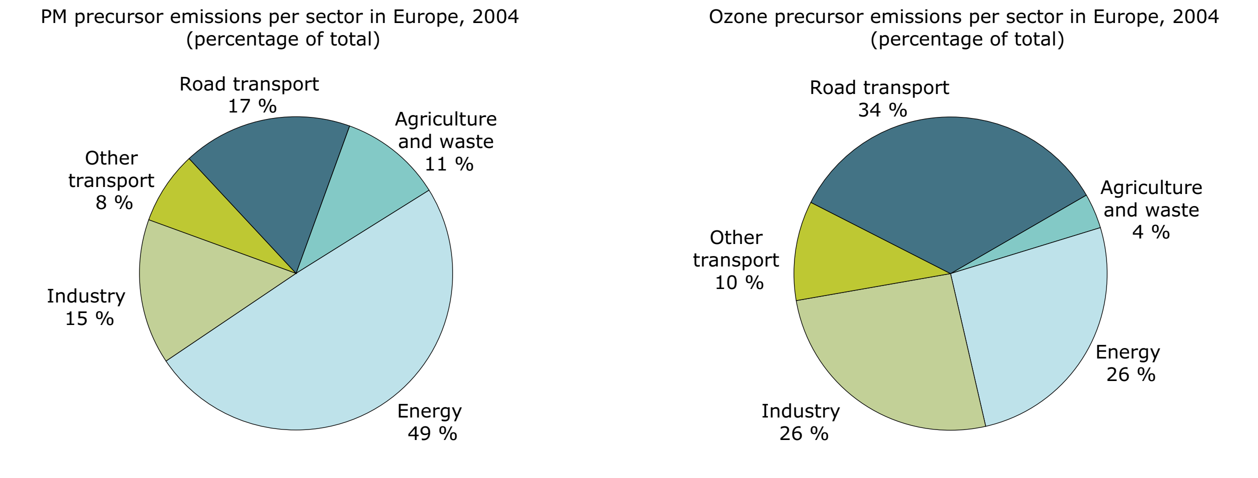
The most important sources of PM precursor emissions in 2004 (Figure 2.2.2) were the energy (49 %) and transport sectors (25 %), followed by industry (15 %) and agriculture and waste (11 %). The most important contributors to particulate formation were emissions of NO_X (49 %) and SO_2 (27 %). Most of the reductions in emissions of primary PM_{10} and secondary PM precursors between 2000 and 2004 were in the energy supply and road transport sectors.

Emissions of primary PM_{10} and secondary PM precursors are expected to decrease as further improved vehicle engine technologies are adopted and stationary fuel combustion emissions are controlled through abatement or use of low-sulphur fuels such as natural gas.

Acidifying and eutrophying precursor emissions

The most significant sources of emissions of acidifying and eutrophying gases in 2004 were

Figure 2.2.2 Sectoral contribution in 2004 to PM_{10} (left) and ozone-generating substances (right)



Source: Official country reports to UNECE/EMEP.

energy, agriculture and waste, followed by road transport and industry. In 2004, the relative weighted contributions of acidifying substances were: SO_2 42 %, NO_X 32 % and NH_3 27 %. Between 2000 and 2004, emissions of acidifying substances in EECCA decreased by 5.2 % and in WCE by 10.7 %. In SEE they increased slightly, by 1.6 %. During the same period, eutrophying emissions decreased in WCE (by 5.8 %) and EECCA (by 0.5 %) and increased in SEE (by 3.8 %).

Emissions from shipping

Emissions from international shipping and aviation are not subject to the policy controls of the Gothenburg Protocol and the NEC ceilings, so are not included above. A baseline scenario developed by the Environmental and Engineering Consultancy company (ENTEC) (ENTEC, 2002; 2005) clearly shows that emissions of all pollutants from international shipping are likely to increase dramatically. Projections suggest that emissions of NO_X in 2030 will be 87 % higher than in 2000, increasing by 25 % between 2020 and 2030. SO_2 emissions may be 82 % higher, increasing by almost 30 % between 2020 and 2030. Emissions of NMVOCs, PM_{10} and $PM_{2.5}$ are projected to more than double between 2000 and 2030, with substantial increases between 2020 and 2030. Emissions of NO_X and SO_2 from shipping seem likely to exceed all land-based emissions in the future. The scope for reducing emissions of these pollutants from shipping through best available technology is very large: 88 % and 78 %, respectively, by 2030.

2.2.4 Ambient air quality

Trends in air quality in WCE and SEE

Despite continuing reductions in the emissions of atmospheric pollutants in WCE (and in some SEE countries), exposures of the urban population have not improved significantly since the late 1990s. Across Europe, people are exposed to levels of air pollution that exceed air quality standards set by the EU and the World Health Organization (WHO). This occurs mainly within urban/suburban areas, and for PM_{10} and ozone also in rural areas.

Figure 2.2.3 shows recent changes in the percentages of urban populations exposed to concentrations of SO_2, NO_2, ozone and PM_{10} over the limit and target values [4] in EEA member countries (except Turkey).

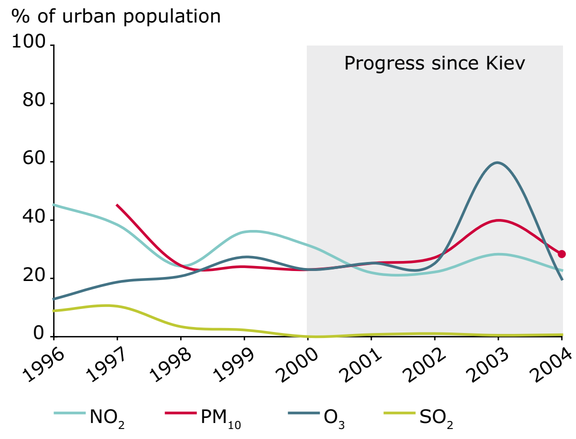
In the period 1997–2004, 23–45 % of the urban population was potentially exposed to ambient air concentrations of PM_{10} in excess of the EU limit value set for the protection of human health. There was no discernible trend over the period. Meteorological variability may explain a significant part of the slightly increasing trend since 2000.

For ozone there is considerable variation from year to year. During most years, 20–25 % of the urban population was exposed to concentrations above the target value. In 2003, a year with extremely high ozone concentrations due to specific meteorological conditions, this increased to about 60 %.

The situation for NO_2 is improving, with about 25 % of the urban population in WCE, Romania and Bulgaria now potentially exposed to concentrations above the limit value.

The percentage of the urban population exposed to SO_2 concentrations above the short-term limit values

Figure 2.2.3 Percentages of the urban population in WCE, Bulgaria and Romania exposed to air pollution over the limit and target values



Source: EEA, 2006a.

([4]) Limit values are: PM_{10} — 50 µg/m³ 24-hour average not to be exceeded for more than 35 days; NO_2 — 40 µg/m³ annual average; SO_2 — 125 µg/m³ 24-hour average not to be exceeded for more than 4 days; O_3 — 120 µg/m³ 8-hour daily maximum not to be exceeded for more than 25 days averaged over three years (European Council, 1999).

decreased to less than 1 % and the EU limit value is thus close to being met.

The patterns and significance of exposures to traditional traffic-related toxic pollutants in WCE are changing. Lead is becoming more related to isolated industrial sources. Carbon monoxide no longer appears to be an issue. Only benzene remains specifically related to traffic. There is potential for exceedances of the target values for the heavy metals cadmium and arsenic from the industry and heating sectors in both urban and rural areas (EEA, 2007a).

An increasing trend in the number of exceedances of daily limit SO_2 concentrations (125 µg/m^3) has been reported in recent years in Serbia (SEPA, 2006; see also Box 2.2.1). More than 25 % of the urban population, and about 27 % in Bosnia and Herzegovina, is exposed to exceedances lasting more than four days. The highest urban NO_2 annual concentration in Bosnia and Herzegovina in 2004 was 32 µg/m^3 (Federal Meteorological Institute in Sarajevo, 2007). The annual limit value of NO_2 was not exceeded. The limits referred to are the EU limit values.

Box 2.2.1 Exceedance of air quality limit values in urban areas in Serbia

Anthropogenic air pollution has been and continues to be viewed as a serious environmental and public health problem in Serbia. Air quality controls, carried out in Vojvodina since 2000, have included larger industrial centres as well as small settlements where there might be ambient air pollution from different sources. Traffic also has a strong influence on air quality and daily exceedances of limit values set by the Serbian national legislation for nitrogen dioxide, sulphur dioxide and soot have been recorded during the year in Vojvodina. However, annual limit values for these pollutants were not exceeded, being in the interval 12–40 µg/m^3 for nitrogen dioxide, 6–28 µg/m^3 for sulphur dioxide and 2.5-34 µg/m^3 for soot (Vujic *et al.*, 2006). For the whole of Serbia, the percentage of the urban population exposed to concentrations of nitrogen dioxide over the annual limit value (40 µg/m^3) was estimated to be around 10 % in the last five years (Popovic, 2007).

Air quality in EECCA

Air pollution is among the most serious environmental problems faced by cities in EECCA. Although air quality has been monitored in all countries for many years, the lack of data of sufficient quality precludes in-depth assessment of the state of air quality in the region. The EECCA countries have redesigned their monitoring systems in recent years, but lack of funds has inhibited any major progress. Obsolete measuring methods are therefore still widely in use (UNECE, 2006). Monitoring is under the control of different authorities with often poorly-defined responsibilities (WHO, 2005b) and/or very different functional competences. Monitoring of small particles (PM_{10} and $PM_{2.5}$) and ozone is limited at present. Positive examples are Moscow (Box 2.2.2) and St. Petersburg.

Box 2.2.2 Air quality monitoring system in Moscow

The air quality monitoring system in Moscow is based on 28 automatic control stations (ACS) that measure concentrations of the 18 most important pollutants — including PM_{10} and ozone. ACSs monitor air quality at all types of sites — residential, industrial, and sites along highways and in zones of protection.

All data from ACSs are sent to an information analytical centre — Mosecomonitoring — a state environmental protection enterprise. (http://www.mosecom.ru/).

There is no mechanism for exchanging air quality monitoring data in EECCA like the one in place in the EEA region. Some ambient air quality data have been found in various national 'state of environment' reports and websites (Bel NIC, 2006; Roshydromet, 2005; Statistica Moldovei, 2006). Seven EECCA countries (Azerbaijan, Belarus, Kazakhstan, Kyrgyz Republic, the Republic of Moldova, Ukraine and Uzbekistan) have provided 'official' urban air quality data for basic pollutants for 2004 within the framework of the TACIS project (5). Azerbaijan, Kazakhstan and the Republic of Moldova have also provided these data for 2000–2004 (Figure 2.2.4). Though the data do not cover the whole region, they indicate high levels of pollution by particulate matter (monitored as total suspended particles (TSP)) and by nitrogen dioxide. Figure 2.2.4 shows that in 2004

(5) TACIS Project (2006–2007). Support to the European Environment Agency data collection in EECCA, funded by EC.

the urban populations in Azerbaijan, Kazakhstan, Ukraine and Uzbekistan were exposed to average TSP concentrations exceeding the maximum allowable concentration (MAC) ([6]) (150 μg/m³). Population-weighted annual urban concentrations of NO_2 in these countries (including the Republic of Moldova) show an increasing trend, and in 2004 exceeded the MAC (40 μg/m³, equal to the WHO guideline).

The data indicate that large cities and industrial centres, e.g. Almaty, Karaganda, Aktobe, Shymkent, Ust-Kamenogorsk, Ridder and Temirtau in Kazakhstan, Dniprdzerzhinsk, Donetsk, Dnipropetrovsk, Krasnoperekopsk, Kryvyi Rih, Mariupol and Zaporozhia in Ukraine, Tashkent in Uzbekistan and others, regularly exceed the MACs for TSP, NO_2 and other pollutants. The reasons for high air pollution levels in these cities are outmoded production technologies, ineffective sanitation facilities, low-quality fuel, and little use of renewable and alternative energy sources.

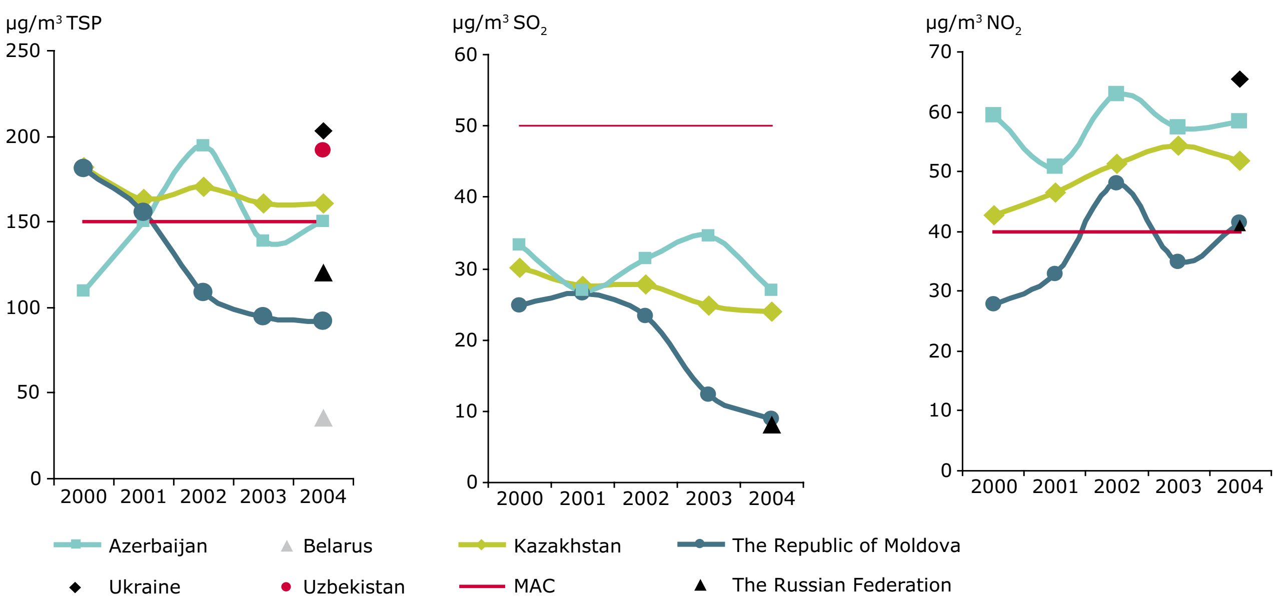
In the Central Asian republics, TSP concentrations are also high as a result of elevated concentrations from desertification, desert dust and the dried Aral Sea bed, which add to the impacts of particulates from cheap, low-quality coal used for power generation and from road transport (see also Box 2.2.3).

The levels of air pollution in the largest cities of the Russian Federation, expressed as an air pollution index (API) ([7]), have increased over recent years, mainly as a result of an increase in air pollution by benzo(a)pyrene in these cities. The number of cities with concentrations of benzo(a)pyrene

Box 2.2.3 Atmospheric air pollution in Kyrgyzstan

The problem of atmospheric air pollution in Kyrgyzstan is basically a local one, peculiar to large cities and industrial centres, particularly Bishkek. Despite significant reductions in production, air quality in Bishkek remains unsatisfactory, with high levels of formaldehyde, particulate matter and benzo(a)pyrene. Annual average concentrations of formaldehyde exceed the MAC 5 to 8 times, of particulate matter 3 to 4 times, and of benzo(a)pyrene 30 to 60 times. The main contribution to air pollution today is the transport sector, with a steady increase over recent years.

Figure 2.2.4 Population-weighted annual average concentrations of TSP, SO_2 and NO_2 in some EECCA countries



Source: Officially delivered data from the hydrometeorological offices of the EECCA countries.

([6]) See footnote ([2]).
([7]) Air pollution index, API: ECE/CEP/AC.10/2006/3, UNECE, 2006 (GOST 17.2.3.01-86).

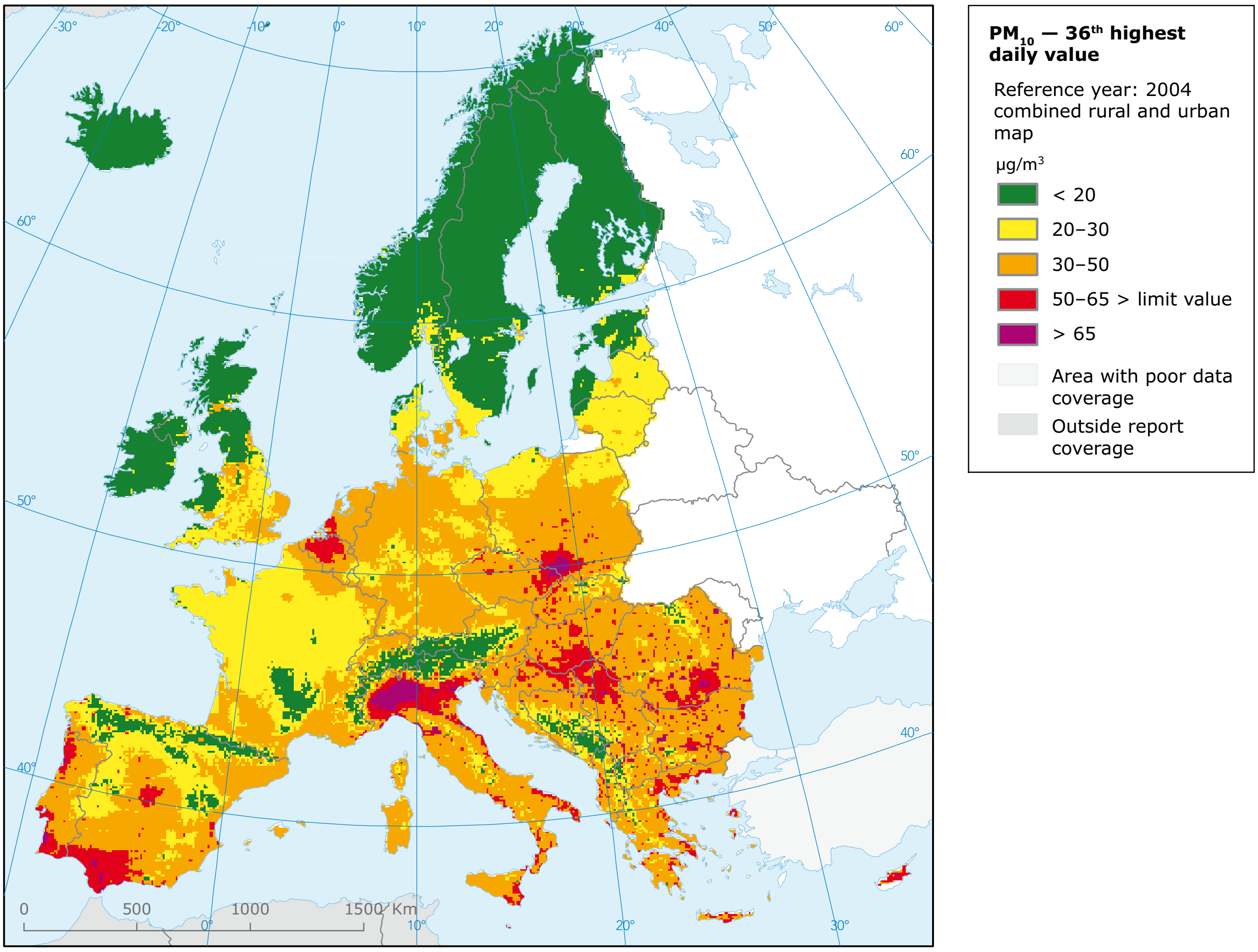
over the MAC has also increased during the last five years (to 47 % in 2004). This increase is assumed to be caused by forest fires, an increase in industrial production without implementation of appropriate abatement measures, an increase in the use of diesel cars, and waste incineration. High concentrations of benzo(a)pyrene are observed in the winter months, which reflects increased consumption of solid fuels for domestic heating (Roshydromet, 2005).

Air pollution by particles

Many areas in WCE and SEE, particularly urban areas, experience daily average PM_{10} concentrations in excess of 50 μg/m³ on more than the permitted 35 days per year (Map 2.2.1). The highest urban concentrations were observed in Belgium, Bulgaria, the Czech Republic, Greece, Hungary, Italy, Luxembourg, the Netherlands, Poland, Portugal, Romania, Spain as well as in the cities of the western Balkan countries.

Estimates based on of the EMEP unified Eulerian model for 2000, 2002 and 2003 show that regional as well as urban background PM_{10} concentrations persistently exceeded the limit of 50 μg/m³ on more than 35 days in a year in several locations (Po Valley, parts of Belgium and the Netherlands countries and the southern coast of Spain) (EMEP, 2006).

Map 2.2.1 Map of PM_{10} concentrations in WCE and SEE, 2004, showing the 36th highest daily values at urban background sites superimposed on rural concentrations. Maps constructed from measurements and model calculations (EEA-ETC/ACC Technical Paper 2005/2008)



Source: EEA, 2007a.

Figure 2.2.5 compares annual average PM_{10} concentrations to which the population was exposed in 2004 in various EU, SEE and EECCA ([8]) countries. Monitored data are displayed together with modelled urban population-weighted PM_{10} concentrations, calculated by the Global Model of Ambient Particulates (GMAPS) (Pandey *et al.*, 2005) ([9]).

Observed as well as modelled PM_{10} data indicate that the pollution levels by small particles in the cities of most WCE, SEE (see also Box 2.2.4) and EECCA countries are higher than the WHO guideline — with corresponding health effects in the populations in these cities.

Figure 2.2.5 Average annual population-weighted PM_{10} urban concentrations in WCE and SEE countries, and population-weighted PM_{10} concentrations based on monitored TSP concentrations in EECCA. Comparison of monitored data with PM_{10} concentrations modelled by the Global Model of Ambient Particulates (GMAPS)

Sources: EU data — Eurostat Structural indicators: Urban population exposure to air pollution by particulate matter. Population-weighted annual mean concentration of particulate matter. http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1133,47800773,1133_47802558&_dad=portal&_schema=PORTAL. The source of PM_{10} annual average concentrations in the EU and SEE countries (Bulgaria, Romania and Serbia* (data available for Serbia only) was AirBase. EECCA — officially delivered data from the hydrometeorological offices of the EECCA countries and data from some SoER of the EECCA; MNR RF, 2006.

([8]) Annual PM_{10} concentrations in EECCA countries were estimated on the basis of observed TSP concentrations. The monitored TSP concentrations were multiplied by a conversion factor of 0.5 which are applied in epidemiological studies (Reshetin and Kazazyan, 2004; Strukova *et al.*, 2006) to estimate PM_{10} if only monitored data on total suspended particles (TSP) are available (see also WHO, 2005a; CAFE WG, 2004).

([9]) With exception of Belarus, observed TSP concentrations in EECCA countries are quite high comparing with the modelled data. Generally applied sampling procedures — 20 minutes three or four times a day — seem to lead to rather unreliable, and to some extent, systematically overestimated results (UNECE, 2006).

Box 2.2.4 PM_{10} concentration in SEE

Air quality investigation in the Belgrade urban area has shown that annual PM_{10} concentrations are significantly higher (77 µg/m³ annual mean) than in most other European cities. The main sources of suspended particles are traffic, power stations, local heating and dust re-suspension (Tasić *et al.*, 2006).

Monitoring data collected in Albania in the framework of the CARDS project also indicate very high levels of air pollution by particles — the PM_{10} population-weighted annual mean in 2004 was more than 100 µg/m³ (IPH, 2006). However, the quality of the data is unknown and questionable.

2.2.5 Impacts of air pollution

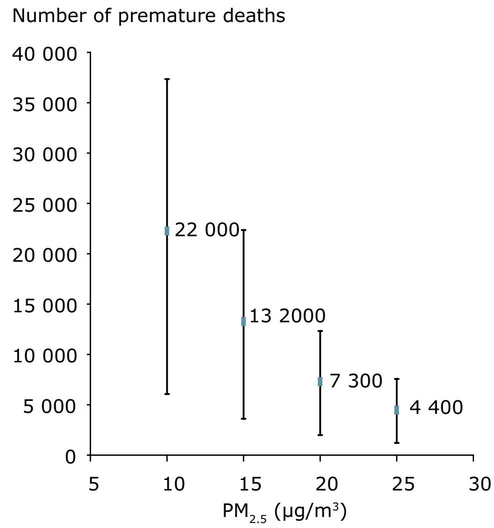
Health impacts

The impacts of air pollution on human health can be expressed in terms of a reduction in average life expectancy, additional premature deaths and hospital admissions, and increased use of medication and days of restricted activity. On the basis of the anthropogenic emissions in 2000, EU's CAFE programme estimated a total of 348 000 premature deaths per year due to exposure to anthropogenic $PM_{2.5}$. At this level of exposure, average life expectancy is reduced by approximately one year. However, in the most affected areas of Belgium, the Netherlands, northern Italy, and parts of Poland and Hungary, the average loss of life expectancy may reach two years (Watkiss *et al.*, 2005) (see Map 2.2.2, left, in Section 2.2.6).

The potential health benefits of reducing annual mean $PM_{2.5}$ levels from the current observed values to 25, 20, 15 and 10 µg/m³ were estimated for the 26 European cities of the APHEIS (Air Pollution and Health: A European Information System) network totalling 41.5 million inhabitants in 15 European countries, using well-established methods and published results of research on the effects of current air pollution on public health (APHEIS, 2006). All other things being equal, policies to reduce annual mean levels of $PM_{2.5}$ to 15 µg/m³ would prevent three times more premature deaths in the cities than a reduction to 25 µg/m³, and reducing them to 10 µg/m³ to five times more than to 25 µg/m³ (22 200 vs. 4 400 deaths) ([10]) (Figure 2.2.6).

In the EECCA region, estimates come from individual studies with different coverage and methodologies and no comprehensive estimates of the health impacts of air pollution are available due to lack of reliable data (Box 2.2.5). Monitoring of total suspended particulate matter (TSP), common in the region, is less suitable for health-oriented air quality estimation. A rather broad span of estimated health outcomes indicates a high uncertainty both in the air pollution data and in the epidemiological inputs, and shows that further assessment based on quality-assured data is needed. Nevertheless, even the most conservative estimates establish the great seriousness of the public heath risk of particulate

Figure 2.2.6 Potential reduction in total annual premature deaths (central estimate and 95 % confidence interval (CI)) among people 30 years and over in 26 APHEIS cities



Note: $PM_{2.5}$ target/limit values (annual average concentration):
25 µg/m³ — concentration cap by 2015 in the draft new Directive on ambient air quality (CAFÉ Directive)
20 µg/m³ — target value proposed by the European Parliament
15 µg/m³ — US EPA standard
10 µg/m³ — the annual WHO guideline

Source: APHEIS, 2006.

([10]) The concentration cap of 25 µg/m³ in the proposed directive on ambient air and cleaner air for Europe (European Commission, 2005c) is meant to be a legally binding level which should not be exceeded even in hot spots. However, the proposed directive introduces an exposure reduction target of 20 % of average levels in 2010 at urban background locations calculated as three year averages (for 2008, 2009 and 2010) for the overall reduction of the exposure of the population to fine particles.

Box 2.2.5 Public health impact studies of outdoor air pollution in EECCA

In the Russian Federation, an assessment of the impact of outdoor air pollution on public health, based on the 1993 and 1998 monitoring data, showed that 15–17 % of total annual mortality (up to 219 000–233 000 premature deaths) might be caused by fine particles (Reshetin and Kazazyan, 2004).

In Ukraine and the Russian Federation, estimates of health losses from urban air pollution based on TSP monitoring data in Ukraine indicated considerable health and mortality consequences. In Ukraine, the low (conservative) estimate was 27 000 excess deaths annually, and for the Russian Federation the estimate was about 85 000 excess deaths (Strukova *et al.*, 2006).

As estimated under Transport Health and Environment Pan-European Programme (THE PEP), air pollution from road transport affects the health of about 10–15 million urban Russian residents. In the large city centres, road transport may account for more than 80 % of total air emissions. In 2002, the average annual concentrations of harmful pollutants exceeded maximum permissible levels in 201 Russian cities, home to 61.7 % of the urban population. An estimated 22 000–28 000 additional deaths in the Russian Federation were attributable to road transport-related emissions in people over the age of 30 (ECMT, 2004).

The WHO project 'Comparative Quantification of Health Risks' has estimated the health impacts of outdoor air pollution in major cities (population > 100 000 people) of the world grouped in 14 regions, including EUR-C, consisting mostly of EECCA countries. The annual impact of air pollution by particulate matter for this region was estimated at 46 000 premature deaths and 320 000 years of life lost (WHO, 2004b).

air pollution in these countries. WHO is working with the EECCA countries on a framework plan to develop monitoring of particulate matter ($PM_{2.5}$ and PM_{10}) concentrations (WHO, 2006).

Exposure to ground-level ozone has long been found to impair human health; this has been confirmed in a recent WHO review (WHO, 2003). There is strengthened epidemiological evidence for the effects of ozone, independent of those of other pollutants, from short-term studies on pulmonary function, lung inflammation, respiratory symptoms, morbidity and mortality, particularly in the summer season. Excess concentrations of ozone are thought to hasten the deaths of up to 20 000 people in the EU each year (Watkiss *et al.*, 2005). Further, ozone is responsible for people vulnerable to its effects having to take medication for respiratory conditions for a total of 30 million person-days a year. Some studies also suggest that long-term exposure to ozone reduces lung function growth in children.

Acidification and eutrophication

Emissions of SO_2, NO_X and NH_3 contribute to the acidification and eutrophication of lakes, rivers, forests and other ecosystems. Acidification can result in the loss of fauna and flora, and ecosystems may take many decades to recover after acidifying inputs are reduced to sustainable levels.

In 2000, acidifying deposition was still above critical loads ([11]) in parts of central and north-western Europe. The percentage of EU-25 forest areas receiving acid deposition above their critical load is projected to decrease from 23 % in 2000 to 13 % in 2020. For those areas still at risk — above the critical loads — ammonia is projected to be the dominant source of acidification (EEA, 2007b).

Eutrophication — excess nitrogen deposition — poses a threat to a wide range of ecosystems, endangering biodiversity through changes in plant communities. Excess nitrogen deposition above critical loads is currently widespread, due to the limited reductions in nitrogen deposition over the past ten years. For the period 2000–2020, the protection of ecosystems from eutrophication is expected to improve only slightly under current legislation, mainly because of the relatively small projected decline in ammonia emissions (EEA, 2007b).

([11]) Critical load means a quantitative estimate of an exposure to one or more pollutants below which significant adverse effects on specified sensitive elements of the environment do not occur, according to present knowledge (UNECE, 1999).

Exceedances of critical loads for acidification and eutrophication in EECCA countries are usually low, due to low sensitivity of the soils (UNEP/RIVM, 1999), with the exception of Ukraine and north-western Russia where critical loads are exceeded on a regular basis.

Impact of ground-level ozone on vegetation

Ground-level ozone can damage forests, crops and vegetation where a critical level ([12]) of ambient concentration is exceeded. Exposure of ecosystems and agricultural crops to excessive ozone concentrations results in visible foliar injury and a reduction in crop yields and seed production. For vegetation under European conditions, long-term cumulative exposure to ozone concentrations during the growing season (assessed as accumulated one-hour ozone concentrations over a threshold of 40 ppb — AOT40), rather than episodic exposure is of concern. The EEA analysis shows that in 2004 the EU target value was exceeded in a substantial fraction of the agricultural area of EEA 32 countries (except Turkey), about 26 % of a total area of 2.06 million km^2 (EEA, 2007a and 2007b).

2.2.6 Prospects

6EAP calls on the Commission to develop seven thematic strategies, including one on air pollution. Informing and assisting the development of the Thematic Strategy on Air Pollution towards the long-term objectives of 6EAP has been one of the main tasks of CAFE programme.

Thematic Strategy on Air Pollution

Following a CAFE analysis of a number of possible scenarios, the Commission presented its Thematic Strategy on Air Pollution (European Commission, 2005a) in September 2005. The strategy establishes interim environmental air quality objectives for the EU up to 2020. Results of the CAFE analysis are summarised in Table 2.2.2, which also shows the estimated benefits of the strategy.

The specific air quality policies of the CAFE Strategy, if implemented, should significantly improve air quality and reduce the impacts on human health and ecosystems. The strategy is projected to have the largest effect on the air

Table 2.2.2 Summary table of the CAFE analysis and the strategy

Level of ambition	Benefits					
	Human health			Natural environment (1 000 km^2)		
	Monetised health benefits (Euro bn)	Life years lost due to fine particles ($PM_{2.5}$) (million)	Premature deaths due to fine particles and O_3	Acidification (forested area exceeded)	Eutrophication (ecosystem area exceeded)	Ozone (forest area exceeded)
2000	—	3.62	370 000	243	733	827
Baseline 2020 ([13])	—	2.47	293 000	119	590	764
Thematic Strategy 2020	42–135	1.91	230 000	63	416	699
MTFR 2020 ([14])	56–181	1.72	208 000	36	193	381

Source: European Commission, 2005b.

([12]) Critical level means the concentration of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may occur, according to present knowledge (UNECE, 1999).

([13]) CAFE baseline 2020 (also Current Legislation (CLE)) is the expected evolution of pollutant emissions in the EU-25 up to 2020 assuming that all current legislation to reduce air pollution is implemented. The baseline is based on forecasts of economic growth and changes in energy production, transport and other polluting activities.

([14]) MTFR is the Maximum Feasible Technical Reduction and includes the application of all possible technical abatement measures irrespective of cost.

pollution problem which is clearly the most crucial one: loss of life expectancy because of PM exposure (Map 2.2.2). Its benefits are projected to be smaller, but still significant, for the three other impact indicators: forest damage due to exceedance of critical loads for acidification, damage due to excess nitrogen deposition, and premature deaths due to ozone exposure. Compared with 2000, the strategy should result in a reduction of around 44 % in the area of ecosystems receiving excess acid deposition, but current data suggest only a 14 % reduction in areas affected by eutrophication, because of only modest reductions in projected ammonia emissions.

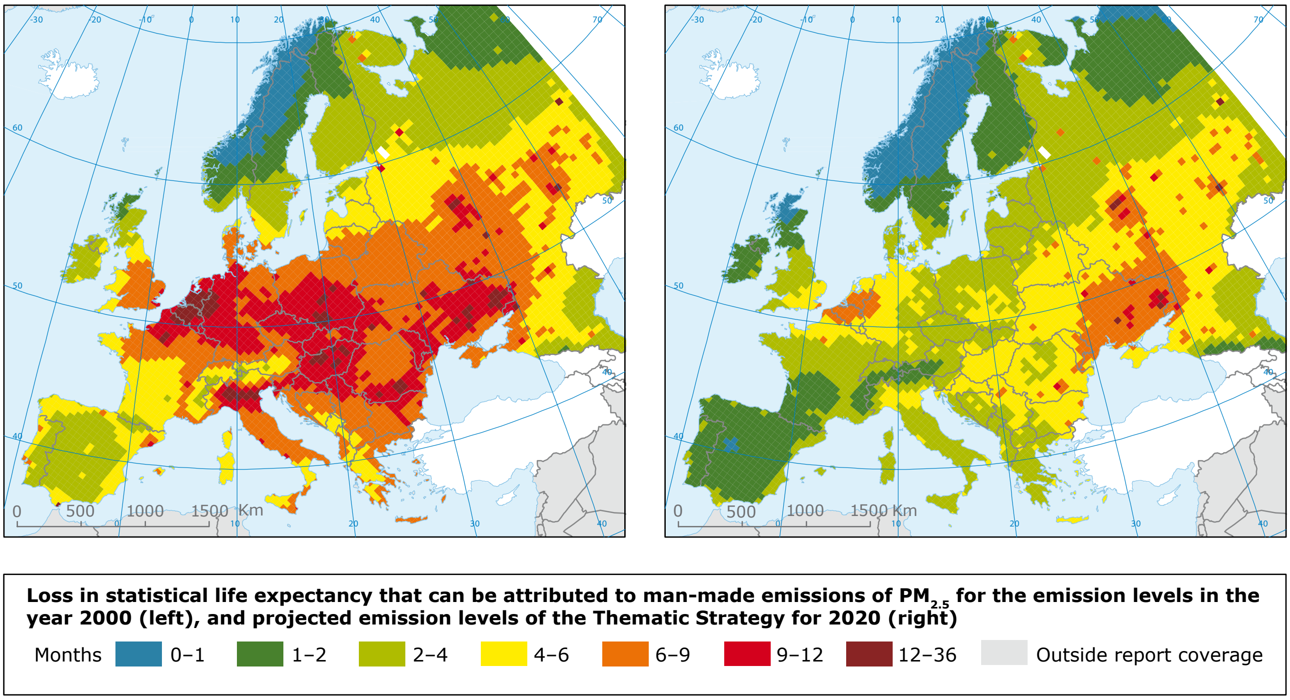
On the legislative side, the strategy is accompanied by a proposal to merge the air quality framework directive and three daughter directives into one containing minimum requirements for air quality. It will introduce new provisions for fine particles ($PM_{2.5}$). As one of the main policy instruments, the Thematic Strategy announced a revision of the Directive on National Emission Ceilings (European Parliament and Council, 2001), with new emission ceilings based on the agreed interim objectives up to 2020.

In EECCA, the projected economic growth will not immediately bring in new technology for industrial sources (Box 2.2.6). Growth in transport and a greater proportion of new vehicles can be expected, but improvements in air quality will take many years. Therefore, emissions cannot be expected to decrease, and the negative impacts of air pollution on public health and the environment are expected to persist.

Challenges for the LRTAP Convention

Future progress in air quality protection in EECCA and the UNECE region in general can be connected with envisaged future challenges for the Convention. These are focused mainly on the reduction of pollution by particulate matter and

Map 2.2.2 Loss of statistical life expectancy (months) that can be attributed to anthropogenic contributions to $PM_{2.5}$ for the emission levels in 2000 (left), and projected emission levels of the Thematic Strategy on Air Pollution for 2020 (right)



Sources: Amann M. *et al.*, 2005a (left); Amann M. *et al.*, 2005b (right).

on air pollution and climate change issues and their linkages (UNECE, 2004a) (see also Box 2.2.7).

To include particulate matter under the framework of the Convention, may require both the setting of emission ceilings for anthropogenic emissions of PM_{10} and/or $PM_{2.5}$ and a further lowering of the existing emissions ceilings for their precursors.

Air pollution and anthropogenic climate change are closely connected in a number of ways. Both are caused mainly by the burning of fossil fuels: sulphur and nitrogen oxides cause air pollution, carbon dioxide contributes to global warming. In addition, agriculture influences both acidification and eutrophication (through NO_X and ammonia emissions) and climate change (through emissions of methane, nitrous oxide and CO_2). Air pollutants such as NO_X, VOCs, CO and CH_4 (precursors of ozone) and aerosols/fine particulates not only affect air quality but also contribute to global warming (Box 2.2.8).

Box 2.2.6 The 'CAPACT' project

Air pollution, particularly from the energy and transport sectors, is a significant problem in Central Asia. Pollution levels in urban areas are high and have a significant impact on the health of the population and the environment.

UNECE and UNESCAP have developed a project: Capacity Building for Air Quality Management and the Application of Clean Coal Combustion Technologies in Central Asia (CAPACT) in collaboration with energy and environmental authorities in Central Asia. Funding comes from the UN Development Account. The project will help to identify appropriate technologies for a cleaner use of coal, and aim to raise the capacity of air quality management within the institutions of Central Asia. The project deals specifically with implementation of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP). The project duration is three years starting from mid-2004. Countries eligible to participate in the project are: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan (UNECE, 2004b).

Box 2.2.7 Hemispheric transport of air pollution

While local and regional emissions sources are the main cause of air pollution problems worldwide, there is increasing evidence that many air pollutants are transported on a hemispheric or global scale. Observations and model predictions show the potential for intercontinental transport of ozone and its precursors, fine particles, acidifying substances, mercury and persistent organic pollutants.

In the northern hemisphere, these flows may be important for understanding air pollution problems in population centres and impacts on remote areas. To develop a fuller understanding of this growing body of scientific evidence, the Executive Body of the UNECE CLRTAP has established a Task Force on Hemispheric Transport of Air Pollution. The task force will also estimate the hemispheric transport of specific air pollutants for the use in reviews of protocols to the Convention (http://www.unece.org/env/tfhtap/).

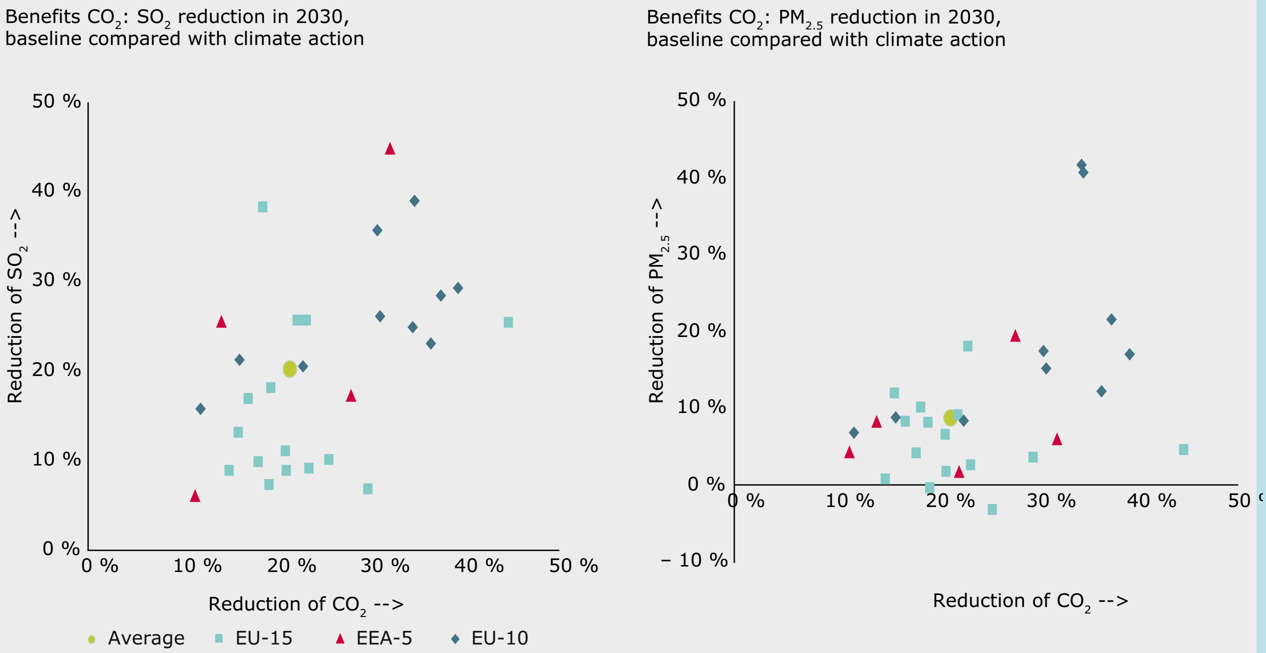
Box 2.2.8 Positive side effect of climate change policies on air quality

A recent study (EEA, 2006c) showed that EU efforts to meet its long-term climate change objectives could make a substantial contribution to reducing air pollution. In particular, benefits of climate change policies would lie in:

- a reduction in the costs of controlling air pollutant emissions: reducing greenhouse gas emissions, by burning smaller amounts of fossil fuels, will mean less air pollution. As a result the cost of tackling air pollution will be cut significantly (by about EUR 10 billion per year);
- less damage to public health and ecosystems: the reduction of greenhouse gases as a result of climate change policies would lead to a fall in air pollutants from fossil-fuel combustion (most notably oxides of nitrogen, sulphur dioxide, and particulates (Figure 2.2.7) and their associated health effects (more than 20 000 fewer premature deaths per year);
- such benefits are expected to be more significant in 2030 than in 2020 since a longer period of time will be available for implementing measures and for changes in the energy system. Nevertheless, climate change policies, if successful, will reduce the overall cost of the air pollution abatement measures needed to meet the objectives of the Thematic Strategy on Air Pollution by 2020.

However, the report also states that in order to meet the EU long-term objectives for air pollution, significantly greater efforts will still be needed in the form of further targeted air pollution abatement measures. For example, reductions in emissions from non land-based sources, especially shipping, would be necessary to reduce health effects to the target levels (see also Chapter 3, Climate change).

Figure 2.2.7 Benefits of climate policy



Note: EEA-5: Bulgaria, Norway, Romania, Turkey and Switzerland.

Source: EEA, 2006c.

Table 2.2.3 Maximum allowable concentrations in EECCA countries, EU air quality limits/targets for the protection of public health, and WHO air quality guideline values

		EECCA µg/m³	EU µg/m³	WHO (15) µg/m³
Sulphur dioxide, SO_2	20 minutes	500		500 (16)
	1-hour mean		350 not to be exceeded > 24 times per year	
	24-hour mean	50 (17)	125 not to be exceeded > 4 times per year	20
Nitrogen dioxide, NO_2	20 minutes	85 (18)		
	1-hour mean		200 not to be exceeded > 18 times per year	200
	24-hour mean	40 (19)		
	Annual mean			40
Particulate matter, PM_{10}	Hourly			
	24-hour mean		50 not to be exceeded > 36 times per year	50
	Annual mean		40	20
Particulate matter, $PM_{2.5}$	24-hour mean			25
	Annual mean		25 (20)	10
Total suspended particles, TSP	20 minutes	500		
	24-hour mean	150		
Carbon monoxide, CO	20 minutes	5 000		
	1-hour mean			30 000
	8-hour mean		10 000	10 000
	24-hour mean	3 000		
Ozone, O_3	20 minutes	160		
	1-hour mean			
	8-hour mean		120, target value not to be exceeded > 25, average over three years	100
	24-hour mean	30		
Benzene, C_6H_6	20 minutes	1 500 (21)		
	24-hour mean	100		
	Annual		5 (22)	
Lead, Pb	20 minutes	1		
	24-hour mean	0.3		
	3-month mean			
	Annual		0.5	0.5
Benzo(a)pyrene	24-hour mean	0.001		
	Annual		0.001	

(15) WHO air quality guidelines global update 2005. Report on a Working Group meeting, Bonn, Germany 18–20 October 2005.
(16) 10-minute exposure.
(17) In Belarus — 200 µg/m³.
(18) The revised MAC is 250 µg/m³ in Belarus and 200 µg/m³ in the Russian Federation.
(19) In Belarus — 100 µg/m³.
(20) Concentration cap suggested by the proposed directive on 'Ambient Air Quality and Cleaner Air for Europe'.
(21) In Belarus and the Russian Federation — 300 µg/m³.
(22) As of 1 January 2010.

2.3 Inland waters

Photo: Danube river © George Buttner

Key messages

- In many EECCA and SEE countries there was a significant decline in the monitoring of water quality during the 1990s. Since then, improvements have been observed but in several countries water monitoring is still inadequate if a clear picture of the status and trend in water resources is to be obtained.
- More than 100 million people in the pan-European region still do not have access to safe drinking water and adequate sanitation. While there is generally continuous access to good quality drinking water in WCE, the supply in EECCA and SEE is often intermittent and of poor quality and the quality of water supply and sanitation services has deteriorated continuously over the past 15 years.
- Unsafe water, sanitation and hygiene results in 18 000 premature deaths, mostly of children, each year in the pan-European region, mainly in EECCA and SEE.
- The rural population in the EECCA and SEE countries suffers more than urban citizens from deficient water supply and sanitation infrastructures.
- One-third of the pan-European population lives in countries where water resources are under substantial pressure (water stress).
- Total water abstraction in the region has decreased by more than 20 % over the last 15 years. Most of the decrease occurred in EECCA and the EU-10. Since the late 1990s, the annual water use by agriculture, industry and cooling for power production have remained nearly constant.
- High leakage losses in water distribution systems, poor management and maintenance of irrigation systems, and unsustainable cropping patterns are all exacerbating the impacts of droughts.
- The latest climate change scenarios suggest significant summer drying across many parts of Europe, in particular in the southern part.
- Both in EECCA and SEE the daily switching on and off of the water supply network allows pollutants to contaminate the network and increases the wear of the infrastructure. Leaks allow for cross contamination between water and sanitation networks.
- Most of the urban population's housing in the region is now connected to sewers, but wastewater in some EECCA and SEE countries is still discharged directly to the environment.
- The available data suggests an improvement of water quality in rivers in recent years, but some large rivers and many smaller watercourses remain severely polluted.
- In the last five years, the pan-European region has suffered more than 100 major floods. Inappropriate river management, soil sealing and deforestation all exacerbate the risk of flooding.

2.3.1 Introduction

The hydrological cycle may be the ultimate form of recycling but the volume of freshwater available to humankind is finite, and because all life and health on Earth depends on water, it is a precious resource, and one with which we tamper at our peril. The amount available to us today is no different from that which was available to our ancestors; only, there are more of us than ever before, making more calls on this finite resource, and expecting more of it — its availability, its cleanliness, and its ability to wash away our waste.

Currently, precipitation — the hydrological cycle's method of renewing freshwater resources — is highest in the north-western part of Europe and in mountainous areas such as the Alps and the Pamir Mountains. But climate patterns are changing, and with them patterns of rainfall. Generally it is expected that as Europe warms, so precipitation will generally increase in the north, but decrease further south — emphasising the current inequities of freshwater distribution, while raising the risks of floods and droughts.

With water becoming more limited on a per capita basis, our husbandry of this vital resource increases in importance. Some of our uses of it, such as over-use for irrigation, are profligate and remove water from its cycle of renewal for a long while; the same is true of wastage from water delivery systems. Other major uses return it more quickly, but add pollutants, making it unfit for other uses, potentially damaging human health, the biology of water courses, and ultimately the marine environment. Yet others, like water used as a coolant in the generation of energy, do return water to the hydrological cycle rapidly, but, by changing its medium from liquid to vapour, can deprive people downstream of drinking water and water needed to maintain their livelihoods.

Much has been done across Europe — through efficiency and innovation — to maintain the availability of water for all and to improve its quality, both for human consumption and for the wider environment. Yet, as this sections shows, there is more that can be done, and more that needs doing since, like precipitation and ready access to clean fresh water, achievements and standards are unequally shared across Europe.

2.3.2 Water resources and use

Water availability

Overall, Europe uses a relatively small portion of its total renewable water resources each year: total water abstraction is about 524 km^3/year, or around 7 % of the long-term annual average (LTAA) available freshwater resource of 7 400 km^3. However, because available water resources and people are unevenly distributed, the amount of water available per capita varies widely. Such countries as Iceland and Norway have plentiful supplies, while the Mediterranean islands of Cyprus and Malta, some of the densely populated central EU-25 Member States including Germany, Italy, Poland, Spain and southern United Kingdom, and some of the Central Asian countries have the least available water per capita.

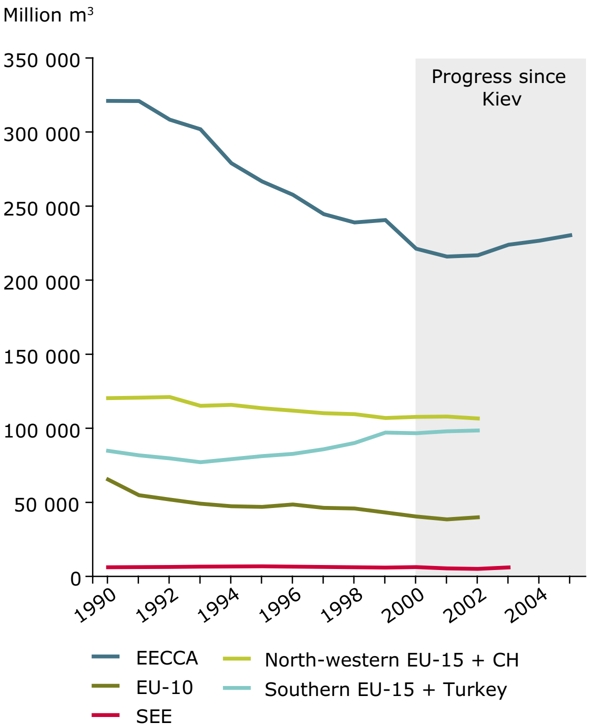
Europe's reservoirs have a total capacity of about 1 400 km^3 or 20 % of the overall LTAA. Six relatively water-short countries, Azerbaijan, Kazakhstan, Kyrgyzstan, Romania, Spain, and Turkey, are able to store more than 40 % of their LTAA, and another six countries, Cyprus, Bulgaria, Ukraine, Sweden, Czech Republic and Tajikistan, have smaller, but still significant storage capacities. Although such huge structures are beneficial for securing supply, they can adversely affect the regional water cycle and sediment transport, and act as barriers for migrating fish, including salmon and sturgeon.

Water abstraction

Total water abstraction has remained largely constant since 1998, but a 15 year perspective reveals a 20 % reduction (Figure 2.3.1) with a rapid decline from 1991 to 1997. The largest reductions, 35–40 %, were in EECCA and SEE. By contrast, in southern Europe, abstraction increased by more than 15 %, particularly in Turkey. In the SEE, it has remained almost constant and is low when compared to other regions.

Water stress can be defined by the water exploitation index (WEI) which divides the total water abstraction by the LTAA resource (Figure 2.3.2).

Figure 2.3.1 Change in total water abstraction in the period 1990–2005



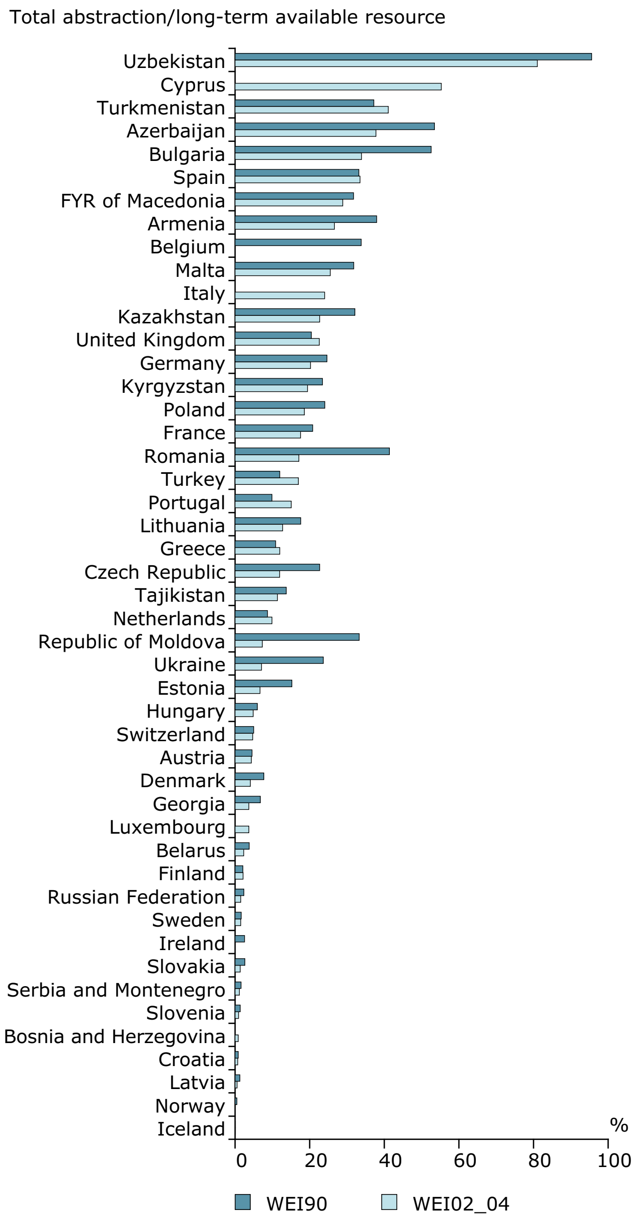
Note: North-western EU-15 + CH : DE, DK, FR, NL, AT, FI, SE, CH, England and Wales;
EU-10: CZ, EE, LV, LT, HU, PL, SL, SK, BG, RO; Southern EU-15 + TR: ES, GR, PT, TR;
SEE: HR, MK, RS.

Sources: EEA CSI18; UN Statistics Division, 2006; CISSTAT, 2006.

The warning threshold, which distinguishes a non-stressed from a stressed region, is around 20 %, with severe water stress occurring where the WEI exceeds 40 %.

Twelve countries can be considered water-stressed, Uzbekistan, Cyprus, Turkmenistan, Bulgaria, Belgium, Spain, Azerbaijan, Malta, Former Yugoslav Republic of Macedonia, Italy, the United Kingdom ([1]), and Germany, representing a third of the region's population, but only in Uzbekistan, Cyprus and Turkmenistan does the WEI exceed 40 %. Most of the countries with high WEI have high abstraction for irrigated agriculture, although some countries have high abstraction rates for cooling water particularly in Germany, the United Kingdom, Bulgaria and Belgium.

Figure 2.3.2 Water exploitation index (WEI) (total water abstraction per year as percentage of long-term freshwater resources in 1990 and 2002/2004)



Sources: EEA CSI18; UN Statistics Division, 2006; CISSTAT, 2006.

The WEI decreased in 28 out of 37 countries included in Figure 2.3.2 during the period 1990 to 2002, most markedly in EECCA and EU-10, while in six countries — the Netherlands, the United Kingdom, Greece, Portugal, Turkey and Turkmenistan — WEI increased.

([1]) England and Wales.

Water use

Across Europe, 45 % of total water abstraction in the region is used for agriculture, 40 % for industry and energy generation (cooling in power plants), and 15 % for public water supply. However, this masks considerable regional differences.

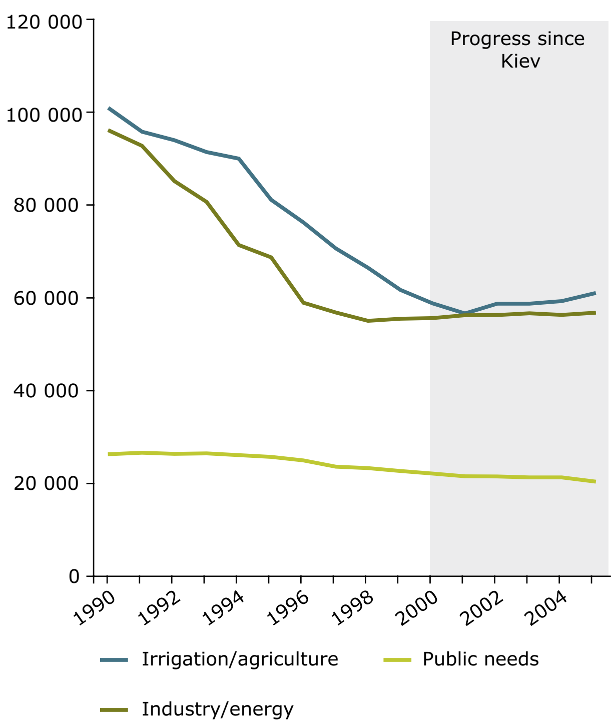
In some Mediterranean countries, the public water supply accounts for a higher than average proportion, for example 34 % in Cyprus and 87 % in Malta (UNEP/MAP, Blue Plan, 2005), with seasonal demands varying considerably to cope with the inflow of tourists in summer.

In the EECCA countries, agriculture and industry and energy generation are still the dominant water users in spite of a fall of more than 40 % during the 1990s (Figure 2.3.3). In the mid-1990s there was also a 20 % reduction in water use for public needs (households and service sector). However, there is a risk that the reduction in water use in the EECCA countries is over-estimated due to omission of water abstractions by private agriculture and industry in national statistics.

In WCE and SEE (Figure 2.3.4) irrigation and energy cooling each account for around a third of the water abstraction while public water supply and the manufacturing industry account for 18 % and 12 % respectively of water abstraction.

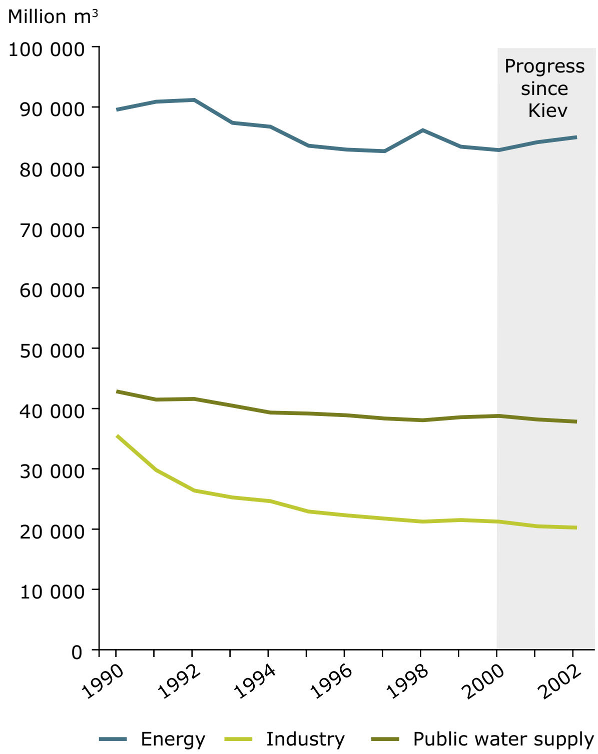
Despite the introduction of more efficient cooling technologies only a minor reduction in the use of water in energy generation has been achieved between 1990 and 2002, with many of the WCE countries still using more than half of their abstracted water in power plants. Over the same period, industrial abstraction in WCE and SEE fell by more than 40 %, with a 75 % reduction in EU-10, but only 25 % in the EU-15.

Figure 2.3.3 Trend in water use by sectors in the EECCA countries, 1990 to 2005



Sources: EEA CSI18; UN Statistics Division, 2006; CISSTAT, 2006.

Figure 2.3.4 Trend in water abstraction for sectors in selected WCE and SEE countries



Note: Energy cooling: CZ, EE, HU, PL, BG, RO, DE, ES, FR, NL, AT, FI, England and Wales;
Industry: CZ, LV, HU, PL, SI, SK, BG, RO, DK, ES, FR, NL, AT, FI, SE, England and Wales, DE;
Public water supply: CZ, HU, PL, SI, SK, BG, RO, BE, DK, DE, ES, FR, NL, AT, FI, SE, UK, IS, NO, CH.

Source: EEA CSI18.

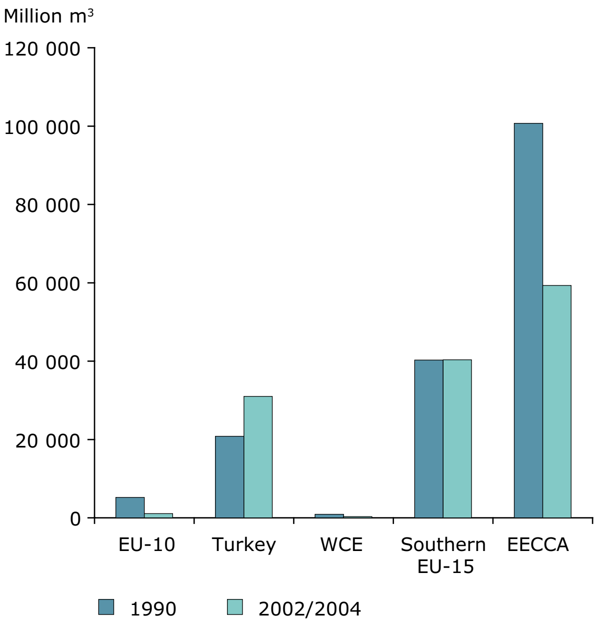
In WCE and SEE there has been a general downward trend in the public water use, most pronounced in EU-10 (– 30 %). In these countries, economic restructuring led to water companies increasing prices and installing water meters: as a result, both people and industry used less water. Nevertheless, in most EU-10 Member States, the supply network is obsolete and losses in distribution systems require high abstraction volumes to maintain supply (see Section 2.3.3). Abstraction for agriculture (Figure 2.3.5) is highest in arid regions including the Mediterranean, southern EECCA and Turkey, irrigation accounts for more than 60 % of water use (see also Section 7.1, Agriculture).

The decrease of agricultural activities in EECCA and central and eastern European countries during the transition period led to marked decreases in water use. In contrast, Turkey's withdrawals for irrigation has recently increased by 35 % as a result of major new irrigation projects over an area of more than 7 million hectares within the basins of the Tigris and Euphrates.

Impacts of water abstraction

Water availability problems generally occur in areas of low rainfall and high population density, and those with intensive agricultural or industrial activity. Apart from the problems of providing water to users, over-exploitation has led to the lowering of groundwater levels, the drying-out of water courses and wetland areas in Europe, and to salt-water intrusion in aquifers — a particular problem in large areas along the Mediterranean coastline (EEA, 2003). High irrigation water use may also lead to salinisation of the soil (see Section 2.1).

Figure 2.3.5 Water use for irrigation in European regions



Sources: EEA CSI18; UN Statistics Division, 2006; CISSTAT, 2006.

In Central Asia, groundwater levels have changed significantly as a result of abstraction for agriculture. Declining water levels in the region's rivers and the Aral Sea have affected their ability to recharge groundwater supplies, resulting in a lowering of the water table by up to 50 cm per year on non-irrigated territories and in some regions by as much as 10–15 m in total. On irrigated land, however, groundwater levels have risen with consequential flooding of centres of population. For example, in Uzbekistan, groundwater levels have increased by up to 1.5 m in 70 % of the total area of the Khorezm region and over 50 % in the lower reaches of the Zeravshan river, respectively (GIWA, 2005).

Some EU-25 Member States are also suffering the results of overexploitation most often associated with irrigation but in some places also with tourism (see Section 7.4 on Tourism). In Spain, more than half of the total abstracted groundwater volume is obtained from areas facing overexploitation problems (MIMAM, 2000); groundwater levels of the Milan aquifer have decreased between 25 m and 40 m over the last 80 years; and on Greece's Argolid plain it is common to find 400 m deep boreholes contaminated by sea-water intrusion (UNEP/MAP, Blue Plan, 2005).

Promoting sustainable use

Most countries have water resource management plans that address both supply and demand. Indeed the EU Water Framework Directive (European Parliament and Council, 2000) acknowledges that modern water management needs to take account of ecological, economic — including pricing — and social functions throughout an entire river basin, while the EECCA Environment Strategy includes integrated water management programmes based on similar river basin principles.

Over the past ten years, many governments, NGOs, municipalities, water companies and international organisations have focused on providing an increasing amount of information on sustainable and water-wise farming, gardening and household practices, often through dedicated websites but also through such mechanisms as water-efficiency labelling on household appliances.

Water pricing is another of the strategies that is being employed to encourage sustainable use. The EU's Water Framework Directive requires Member States, by 2010, to recover the cost of water services that impact the environment — such as damming, channelling and pumping — from users including farmers, hydropower generators, riverine transporters and ordinary household consumers, splitting the costs by sector on the polluter-pays principle.

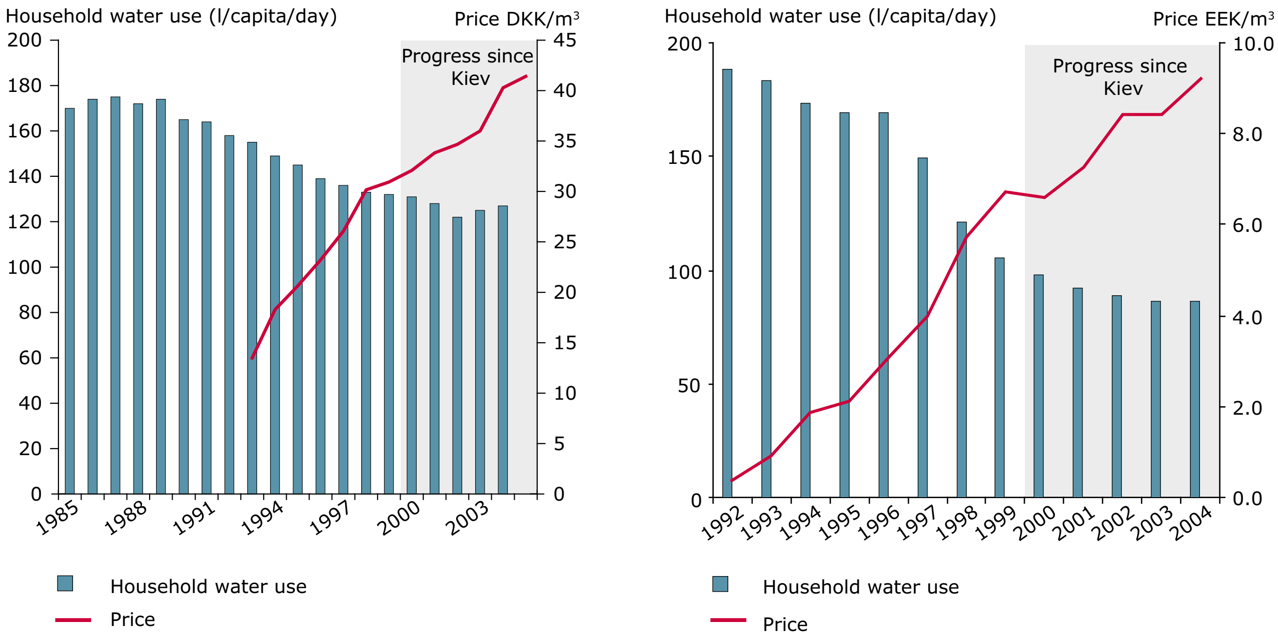
There is a risk that if Member States only include drinking water and wastewater treatment infrastructures in their economic analyses, the entire economic burden of improving water bodies by 2015 would fall on ordinary citizens who already pay high prices for their water services.

Although there are wide variations in water charges across Europe because of, for example, different attitudes to cost recovery, in real terms water prices have tended to rise over the past 20 years. In several countries, exemplified by Denmark and Estonia, rising water prices have significantly lowered household water use (Figure 2.3.6). In Estonia, where, in common with other eastern European and EECCA countries, water prices were heavily subsidised before 1990, increased prices together with the introduction of more advanced sanitation devices have led to more than a 50 % reduction in use.

Charges linked to water metering have proved to provide a high incentive to save water, and indeed experience shows that households with water meters generally use less water than those without them. Many of the WCE countries already meter the majority of water uses, but metering elsewhere, particularly for agriculture, is still in its infancy.

Both the EU and the governments of EECCA countries recognise the need to find a balance between water charges and their citizens' ability to maintain levels of health and personal hygiene. To

Figure 2.3.6 Water pricing and household water use in Denmark, 1990–2005 (left) and Estonia, 1992–2004 (right)



Source: DEPA, 2004 updated by EEA.

Source: Estonian Environment Information Centre, 2006.

this end the EU Water Framework Directive seeks to guarantee an affordable basic level of domestic water (Article 12a) while the EECCA Environment Strategy includes subsidies for low-income households to secure their access to water services.

2.3.3 Drinking water

Most people in WCE have continuous access to clean drinking water, and take that for granted, while their counterparts in EECCA and SEE are likely only to have access to poor quality water, and in some places even the supply of that is intermittent. Indeed, the World Health Organization (WHO) estimates that more than 100 million Europeans do not have access to safe drinking water and adequate sanitation, making them vulnerable to water-related diseases (WHO, Europe). Furthermore, WHO reports that unsafe water and poor sanitation result annually in around 18 000 premature deaths, 736 000 disability-adjusted life years (DALYs) and the loss of 1.18 million years of life (WHO, 2004), many of which would be preventable, were cleaner water and adequate sanitation available. The majority of deaths are of children and most of the deaths and DALYs occur in the EECCA and SEE countries.

Improved water sources and connection to supply networks
In 2000 the UN member states adopted eight Millennium Development Goals (MDGs), the seventh of which aims to 'halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation'.

One of the objectives of the EECCA Environment Strategy is to 'improve the management of municipal water supply and sanitation infrastructure'. This includes the improvement of institutional and regulatory frameworks to ensure financial viability of utilities, to provide access of the poor to water services, to safeguard public health, and to protect the environment.

Although the two policies both aim to improve access to sufficient drinking water of good quality, it is important to understand the differences between the indicators used to assess the achievement of the objectives:

- the focus of the MDG 'access to an improved water source' means access to a source of at least 20 litres per person per day within 1 km of their home, be it piped water, a public standpipe, a protected well or a spring;
- the EECCA Environment Strategy focuses on management of municipal water supply and sanitation infrastructure, that is service from a centralised or piped water supply, sewerage networks and wastewater treatment.

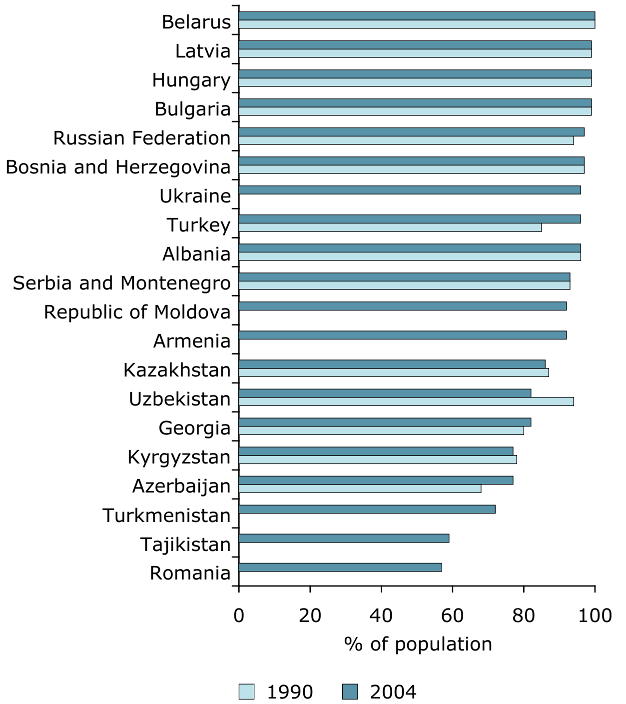
Access to an improved water source
In 2005, the World Bank reported on the status of the seventh MDG in Europe and Central Asia based on data from the WHO-UNICEF Joint Monitoring Programme (World Bank, 2005). Overall, 91 % of people within these regions have access to an improved water source. However, a more detailed look at EECCA and SEE countries (Figure 2.3.7) reveals that the situation has not progressed since 1990, with some of the Central Asian countries and Romania still having a higher proportion of the population without access to an improved water source.

Urban-rural disparities are also significant. The regional averages show that 98 % urban and 79 % rural people have improved drinking water. However, between 1990 and 2004 access to improved drinking water in rural areas deteriorated with 4 million people losing access. As a whole, Europe is not making progress towards the MDG, but there are some improvements; both Azerbaijan and Turkey are on track to meeting the target (UNICEF, 2006).

Centralised water supply (piped water)
Coverage by centralised water supply and sanitation services in urban areas of EECCA and SEE is generally high (OECD, 2005), for example 90 % in the Russian Federation, Belarus and Ukraine, but water supply systems serve less than 60 % of the urban population in Central Asia (Figure 2.3.8). In rural areas connectivity is generally much lower with people having to rely on water from wells, rivers, canals or springs.

Almost all, 90–100 %, of the urban population in SEE countries are connected to piped water, but here, too, the rate among rural populations is much

Figure 2.3.7 Population with access to an improved water source (household connection, public standpipe, protected wells and springs) (selected countries, 1990 and 2004, %)



Notes: All of the population of AD, AT, BG, CH, CY, DE, DK, FI, IS, LU, MT, NL, NO, SE, SK have access to improved water supply.
No information from BE, EE, FR, GR, IE, IT, LV, MC, PL, PT, ES, UK.

Source: UN Statistics Division, 2007.

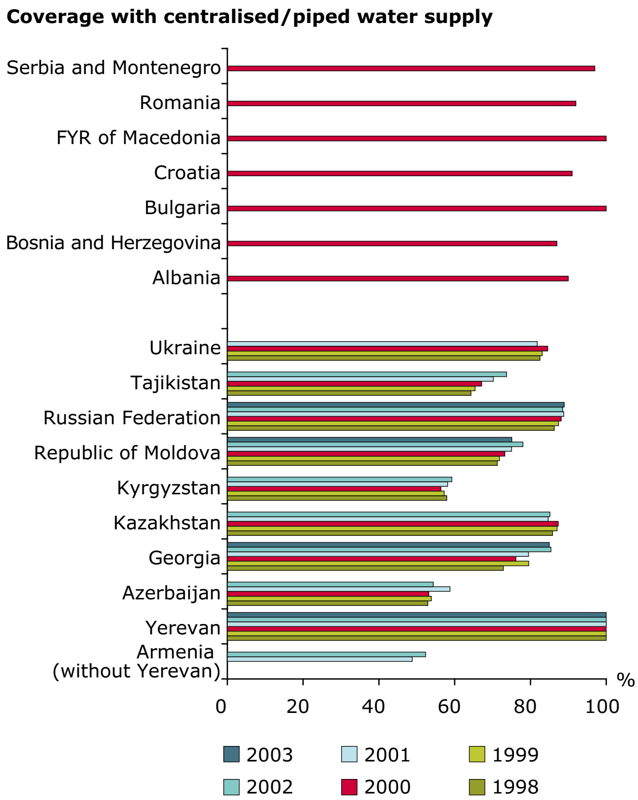
lower, with, in some countries, less than one third of these people having access to piped water. Many rural populations mostly rely on open wells, many of which are unprotected from pollution including chemical pollution from wastewater discharges, from agriculture and urban area run-off, and from landfills.

Connectivity in most urban areas is one thing, the quality of water supply and sanitation services delivered to clients is another, and this has deteriorated over the last 15 years. Hence, while the vast majority of urban populations may have access to water utility services, the quality of the services is increasingly weak. Two indicators demonstrate this situation particularly well.

The amount of water that is produced, but which is either lost through leakage or stolen from the distribution network, has remained at very high levels in all EECCA countries (Figure 2.3.9 left), and has steadily increased in some of them. For instance, the proportion of unaccounted-for water in Georgia, the Republic of Moldova and Uzbekistan rose from about 30 % to 45 % and it remained at 50–60 % in Armenia and Kyrgyzstan. Losses are also substantial in some Mediterranean countries, for example: Albania, up to 75 %; Croatia, 30–60 %; Czech Republic, 20–30 %; France, 30 %; and Spain, 24–34 % (EUWIMED, 2006).

In some European countries including the United Kingdom and Denmark there has been a focus on reducing losses from public water supply systems. In Denmark, these were reduced from around 10–12 % in the 1980s to 6 % in 2004, while in England and Wales losses have decreased from around 30 % at the beginning of the 1990s to 23 % in 2004 (Figure 2.3.9 right).

Figure 2.3.8 Urban population with centralised/piped water supply (EECCA and SEE countries, 1998–2003, %)



Sources: OECD, 2005; Speck, 2005.

Both in the EECCA and the SEE countries the continuity of water supply has been deteriorating. In EECCA, apart from the Russian Federation and Belarus, users in all countries surveyed currently receive water for less than 24 hours per day (Figure 2.3.10). Generally water is available for fewer than 20 hours a day, but in Armenia and Azerbaijan it can be as low as five to seven hours, tempting people to leave taps open so that they can collect a few buckets of water when it comes. To make matters worse, in some cities the pressure is only sufficient to provide water to the lowest floors of buildings. The daily switching on and off of the network, in many places several times per day, allows micro-biological and other pollution to contaminate the network, diminishing the quality of the water supplied, and increasing the deterioration of the infrastructure.

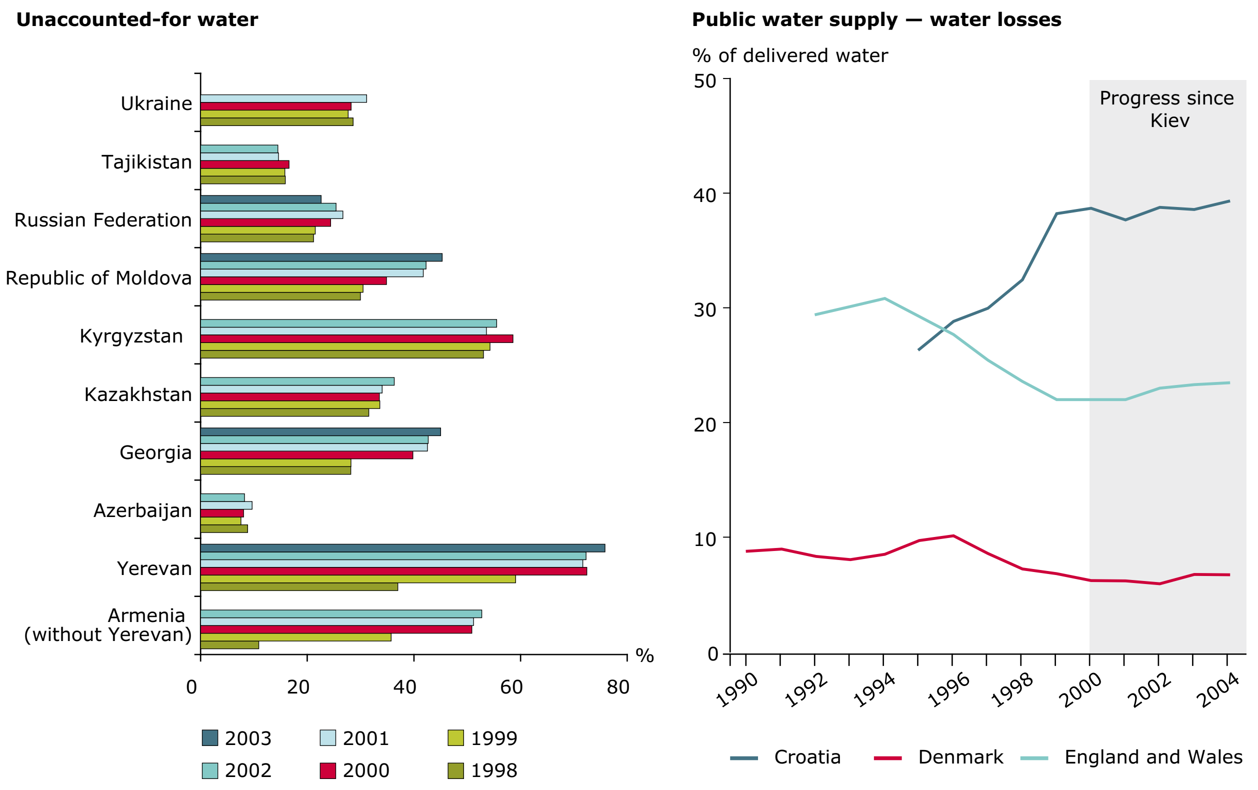
In SEE countries, the water availability can regularly be interrupted or restricted to several hours per day as it is in Albania, where it has been reported that water is generally only available for three to four hours per day, with some areas only receiving supplies once in three days (Rohde *et al.*, 2004).

Drinking water quality

While most people in WCE have access to drinking water of good quality, in the EECCA and SEE countries quality frequently does not meet basic biological and chemical standards. A recent World Bank study of five countries — Armenia, Kazakhstan, Kyrgyzstan, the Republic of Moldova, and Serbia and Montenegro — found that water quality had deteriorated in all cases and was of particular concern in Kazakhstan and the Republic of Moldova (World Bank, 2005).

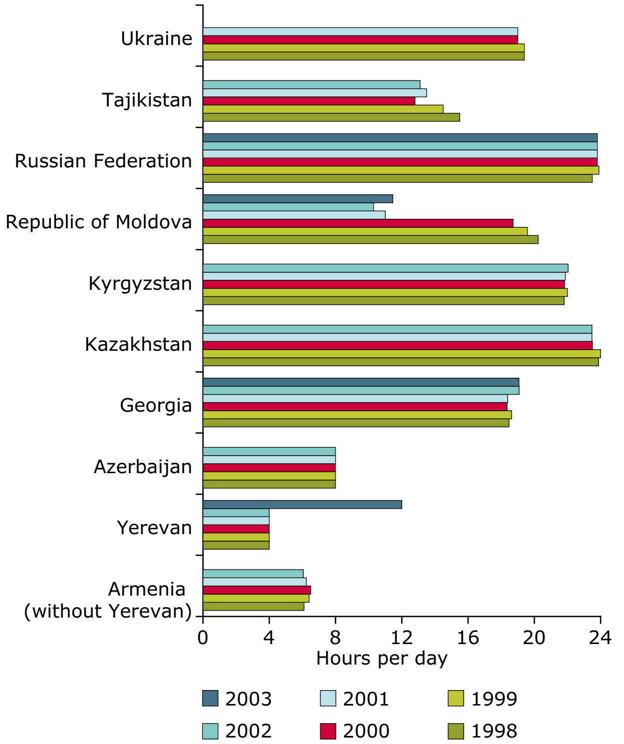
Microbial contamination has been recognised as the prime concern throughout the region (WHO,

Figure 2.3.9 Unaccounted-for water in EECCA countries (%) (left); Water lost from public water supply systems in Croatia, Denmark, and England and Wales (1990–2004, % of delivery) (right)



Sources: OECD, 2005a; CROSTAT, 2006; Statistics Denmark, 2006; DEFRA, 2005b.

Figure 2.3.10 Continuity of supply (hours per day)



Source: OECD, 2005.

Europe), with chemical pollution more localised but where it exists it can also have a significant impact on health. New and emerging protozoan pathogens, such as Giardia and Cryptosporidium and some chemicals, pose additional challenges in the short term (see also Section 2.5, Hazardous chemicals).

In the European countries of EECCA, chemical pollution is the more immediate problem, while in the Central Asian countries microbiological pollution of drinking water is more important (WHO, 2004). However, a paucity of adequate data on drinking water combined with incompatible reporting systems makes it difficult to produce adequate analyses beyond the country level.

- In rural areas of the Republic of Moldova, where most of the population draws its drinking water from underground sources and only 17 % of families use central supply sources, bad water quality has a direct impact on health, causing increased morbidity and generating additional health-related expenditures for the state budget and economy (UNECE, 2005).
- In Uzbekistan in 2004 and 2005, 16.3 % and 18.9 % of the studies of the public water systems and 14.6 % and 11.6 % of tests of the official water pipes did not correspond to national standards (National contribution received during Belgrade review process. http://belgrade-consultation.ewindows.eu.org/reports/rep285401).

Drinking water quality in SEE often does not meet standards:

- in Albania urban water rarely has even preliminary treatment as a result of the lack of adequate treatment and disinfection facilities and the unreliable supply of chemicals. The water situation in rural areas is even worse. With no piped water supply, rural householders dig their own wells, in some cases on the banks of heavily polluted rivers whose waters are unsuitable for human consumption. Additionally, a lack of sanitary protection zones is causing contamination of groundwater sources;
- in Bosnia and Herzegovina only 32 % of the urban population is supplied with safe, treated drinking water and indeed some 42 % of laboratory-tested water samples were deemed to be unsafe and microbiological analyses show that 32.5 % of all water samples were unsafe. It is likely that significantly more than 68 % of the rural population is exposed to unsafe drinking water;
- deterioration of the water supply infrastructure in Serbia and Montenegro, including the chlorination systems, has contributed to a decline in the quality of piped drinking water. The problems with contaminated water supplies are prominent in Serbia where 29 % of samples from piped systems in 2001 did not meet the physical/chemical or bacteriological standards (World Bank, 2003).

It is clearly the poor and rural populations that are most affected by deteriorating water supplies. In Tajikistan, for example, less than one-tenth of the poorest 40 % of the population has access to piped water at home, compared to more than three-quarters of the richest 20 %. Further, water taken directly from shallow wells, ponds and irrigation canals, and frequently contaminated with untreated domestic wastewater, is all that is available for these people, exposing them to diarrhoea, dysentery and hepatitis.

Policies to ensure safe water

The 1999 UNECE Protocol on Water and Health to the Convention on the Protection and Use of Transboundary Watercourses and Lakes was the first international agreement to provide a basis for a reasonable and equitable management of water resources that serves the needs of ecosystems, agriculture, industry and human health.

The protocol, which entered into force in August 2005, calls on the parties to:

- strengthen their health systems and address future health risks;
- improve planning for and management of water resources;
- improve the quality of water supply and sanitation services; and
- ensure safe recreational water environments.

The EU Water Initiative — EECCA component (EUWI-EECCA) is a partnership that seeks to improve the management of water resources in the region. The partnership was established between EU and the EECCA countries at the World Summit for Sustainable Development in 2002.

The partnership is intended to build on and reinforce existing partnerships and bilateral and regional programmes by bringing partners with related water activities together within a common framework. It is open to all stakeholders and draws together government, inter-governmental organisations, civil society, private sector, NGOs and academia.

From a stock-taking exercise on country performance in late 2005 carried out by the EU on the EUWI-EECCA component, it is clear that there is a long way to go before the provision of access to safe drinking water and basic sanitation to all in the EECCA countries becomes a reality. For each of the countries examined, the underlying problems are the same, but vary in intensity. The problems are:

- worn-out water and sewerage networks;
- continued deterioration of water utilities;
- lack of skilled staff — due to low pay and low status of the water sector, and;
- poor chemical and biological quality of raw water and water supplied.

Urgent action is needed to address these issues and improve urban and rural water supplies across EECCA. Improved coordination of river basin management of water bodies, including transboundary rivers, a strengthening of the legal and regulatory framework, and the attraction of foreign investments will all be needed.

2.3.4 Climate impacts on water

Rising temperatures worldwide are likely to intensify the global hydrological cycle. Annual precipitation trends indicate that northern Europe, over the last century, has become wetter by 10–40 %, whereas southern Europe has become up to 20 % drier (Chapter 3, Climate change; Klein Tank *et al.*, 2002). Over the same period, annual river discharges have increased in some regions in northern Europe, while they have fallen in others, particularly in southern Europe (EEA, 2004). Further, predicted increases in temperature are very likely to bring with them unpredictable shifts in precipitation and snow cover, which may reduce the availability of groundwater, together with more extreme weather events leading to an increase in the frequency and severity of flooding and droughts (Eisenreich, 2005).

Climate change may also markedly change the seasonal variation in river flow. Higher temperatures will push the snow limit upwards both in northern Europe and in mountainous regions and this, in conjunction with less precipitation falling as snow, will result in higher winter run-off in northern European, Central Asian and mountain-fed rivers such as the Rhine, the Danube and the Syr Darya. Moreover, earlier spring melts will lead to a shift in peak flow levels. As a result of the declining snow reservoir and decreasing glaciers, there will be less water to compensate for the low flow rates in summer.

Higher water temperature

Higher air temperatures lead to higher water temperatures, as evidenced by an increase of 1–3 °C in European rivers and lakes over the last century (Figure 2.3.11). In particular, one-third of the 3 °C increase in temperature of the Rhine is believed to be the result of climate change and the remaining two-thirds of more cooling water being returned to the river in Germany (MNP, 2006).

Increases in water temperature reduce the oxygen content and increase biological respiration rates and thus may result in lower dissolved oxygen concentrations, particularly in summer low-flow periods.

Fish, for example salmonids, and other aquatic organisms have specific temperature preferences which determine their spatial distribution along a river or at a regional scale. Warming could lead to the extinction of some aquatic species or at least to modifying their distribution in a river or move their distribution northwards in Europe.

Increased water temperature also affects ice formation, and there are several examples from the northern part of the region where the duration of ice cover, and its extent and thickness in lakes and rivers, have decreased. For example, the ice break-up in Russian rivers currently happens 15–20 days earlier than in the 1950s, and a shift towards a longer annual ice-free period and earlier ice break-up has been observed for many Nordic lakes. Such effects may, in turn, have ecological impacts on the biology of lakes, causing shifts in the composition of plankton communities and changes in the timing of phytoplankton blooms.

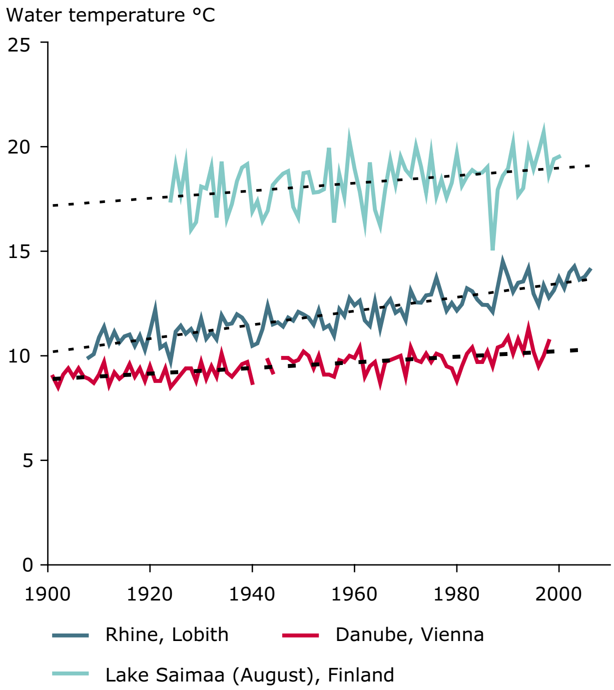
Changing river discharges

Water flowing out of rivers 'freshens' seawater, making it less salty. Changes in the freshening of the Arctic Ocean, the result of increased river discharge and melting of sea ice, including Greenland's ice sheet, could have major implications for the global climate by altering the large-scale ocean currents such as the Gulf Stream (see Chapters 3 and 5). A major source of freshwater out-flows into the Arctic Ocean are the Eurasian rivers, the six largest of which have increased their discharge by 7 % over the past 70 years (Peterson *et al.*, 2002; Hadley Centre, 2005; Richter-Menge *et al.*, 2006).

Changes in average water availability in most European river basins are likely to be relatively small over the next 30 years (EEA, 2005b). However, over the longer term (see Figure 3.6) most climate change scenarios predict that northern and eastern Europe will see an increase in annual average river flows and water availability (IPCC, 2001; Arnell, 1999; Arnell 2004). In contrast, average run-off from southern European rivers is expected to decrease; particularly some river basins in the Mediterranean and southern parts of EECCA, which already face water stress, may see marked decreases in water availability.

Changes in flow regimes and annual availability as well as in the biological and chemical characteristics of Europe's water resources will have far-reaching economic effects, particularly on such activities as irrigated agriculture, hydropower generation and use of cooling water. Moreover, wetlands and aquatic ecosystems are threatened,

Figure 2.3.11 Trend in annual water temperature in the Rhine (1909–2006), the Danube (1901–1990) and average water temperatures in August in Lake Saimaa, Finland (1924–2000)



Sources: River Rhine: Rijkswaterstaat; River Danube: Hohensinner, 2006; and Lake Saimaa: Korhonen J., 2002.

affecting those sectors that depend on the goods and services they provide. Reduced raw water quality will affect drinking water supplies and those industries that depend on high water quality, including tourism, and may in the worst case impact human health.

Climate change and European water policies
The integration of adaptation provisions into European policies is just beginning. In 2005 an extensive assessment of the potential impacts of climate change on water resources was carried out at the request of EU Member States (Eisenreich, 2005), resulting in the European Commission launching the second phase of its climate change programme, focusing on impacts and adaptation, including water management. Additionally, the EEA prepared a summary of best adaptation practices in the water sector (EEA, 2007) and in February 2007 the EU German Presidency organised a symposium to discuss climate change and the European water dimension (http://www.climate-water-adaptation-berlin2007.org). All these activities provided input to the Green Paper from the Commission of June 2007.

Climate change is one of the key issues being considered as EU-25 Member States undertake an initial assessment of flood risks and draw up the risk management plans as part of a proposed directive on flood risk management (see next section). Similarly, climate change will be taken into account in relation to water management planning, droughts and water scarcity.

2.3.5 Droughts and floods

Droughts
Conflicts between human requirements and ecological needs for water are on the increase, and these intensify during severe and extensive droughts. While the primary cause of droughts is a deficiency in rainfall, rising human demand for water is an important factor. The main impacts include water supply problems, shortages and deterioration of water quality, intrusion of saline water in groundwater bodies, and increased pollution of receiving water bodies as a result of there being less water to dilute pollutants, and drops in groundwater levels.

Recent severe and prolonged droughts (see Box 2.3.1) have highlighted Europe's vulnerability to shortages of water, and alerted the public, governments and operational agencies to the need for drought mitigation measures. Policies are needed to encourage demand management that increases water use efficiency, rather than supply-side approaches such as dams, reservoirs and large-scale water transfers. Measures could include the use of economic instruments, water-reuse and recycling, increased efficiency of domestic, agricultural and industrial water use, and water-saving campaigns supported by public education programmes tuned to local and national circumstances (see also section on education for sustainable development in Chapter 1).

The latest climate change scenarios suggest significant summer drying across many parts of Europe in particular in the south, lower rainfall in other seasons, and increased variability (see previous section). Combining these patterns leads to an assertion that, over the coming decades, Europe is likely to suffer more frequent meteorological droughts, potentially further exacerbated by generally elevated temperatures increasing the demand for water.

In recognition of the seriousness of these challenges, the European Commission is undertaking an in-depth assessment of the situation, and will present its findings during 2007.

Floods
Floods endanger lives and inflict heavy economic losses, but in addition they can have severe environmental consequences, for example when installations holding large quantities of toxic chemicals are inundated. The coming decades are likely to see a higher flood risk in Europe with increasing economic damage.

Over the last five years, Europe suffered over 100 major floods, including those along the Danube and Elbe rivers in summer 2002, in the northern Caucasus in July and August 2002, in the Alps in summer 2005, and along the Danube in the spring 2006. In all, since 2000 floods in Europe have caused at least 700 deaths, the displacement of about half a million people and at least EUR 25 billion in insured economic losses (Table 2.3.1).

Box 2.3.1 Recent drought events in the pan-European region

In 2000 and 2001, parts of Central Asia were hit by a severe drought. In 2000 it was called the 'worst in 95 years', but the second year was even more devastating, at least in Tajikistan and Uzbekistan's districts of Khorezm and Karakalpakstan close to the Aral Sea, where much rice, cotton and fodder was lost. The impact of the drought was exacerbated by poor water management and poor maintenance of the irrigation system as well as unsustainable cropping (Wegerich, 2001; UNECE, 2001).

The SEE countries are increasingly facing long periods of drought creating economic problems. Bulgaria, for example, has experienced several summer droughts since the mid-1980s: in the summer droughts of 1993, crop losses were estimated at 2 % of GDP, while in 1996 and 2000, annual maize and wheat production fell to around half of the average achieved in 1961–1990. From 1982 to 2000, Romania suffered from droughts which affected the river basin in the southern part of the country, reducing run-off by 50–70 % of the long-term average. There were shortages in the supply of drinking water, energy generation was adversely affected, and in some areas agricultural production fell by 40–60 % (World Bank, 2003).

During the 2003 heatwave and drought much of southern and central Europe experienced a substantial drop in crop yields — the strongest negative deviation from the long-term trend in Europe in the last 43 years (UNEP, 2004).

In 2005 and 2006, Spain and Portugal have suffered from water shortages. The hot dry summer in 2005 followed a period of winter drought in 2004–2005. In Portugal, 97 % of the land area was afflicted with severe to extreme drought — the most severe conditions since the 1940s, and a contributing factor to the forest fires which caused widespread destruction.

Some areas are more affected than others (Map 2.3.1). Between 1998 and 2005 north-western Romania, south-eastern France, central and southern Germany, northern Italy, and the east of England experienced the highest concentration of repeated flooding.

Unwise river basin management also plays a significant role in the occurrence of floods. In converting land for agriculture by preventing it from flooding, rivers have been deepened, culverted and straightened, and dykes have been built. Further, the natural retention capacity of floodplains has been destroyed by urbanisation, increasing the risk of floods through the sealing of soil, resulting in the rapid run-off of storm water to the river. Deforestation of upstream mountainous areas, too, accelerates run-off. Unless future river basin management makes space for water, floods are likely to become even more devastating as the climate changes bring more intense rainfall.

Although establishing clear links between climate change and increased flooding is difficult, the magnitude and frequency of extreme weather events are expected to increase with hydrological extremes, including floods, likely to be more frequent and severe. In particular, the number of sudden, localised but severe floods — flash floods — are expected to rise, increasing the likelihood of casualties. However, to properly assess the climate impacts on the occurrence of floods, further study of the complexity of other driving forces of flooding needs to be undertaken.

In order to improve flood protection, the European Commission presented its draft Floods Directive in January 2006, laying down a series of steps to be implemented by Member States — but subject to change. The first step calls for preliminary flood risk assessments of their river basins and their associated coastal zones; the second step involves drafting flood risk maps. These will be followed by a final phase involving the creation of integrated flood risk management plans for each flood zone.

The management plans will:

- include measures to reduce the probability of flooding and its consequences;
- address all phases of the flood risk management cycle, focusing particularly on preventing damage by avoiding the location of houses and industries in present and future flood-prone areas and by adapting future development to the risk of flooding;

- support measures to reduce the likelihood of floods and/or their impact in a specific location such as by restoring flood plains and wetlands;
- improve preparedness such as providing instructions to the public on how to react in the event of flooding.

Since many of Europe's river basins are shared by more than one country, concerted action at European level should result in the better management of flood risks. Furthermore, countries should exchange information, coordinate their risk assessments, flood maps and preventative efforts, and make action plans publicly available. And they should encourage active public participation in the drafting and updating of flood risk management plans specifically by those citizens and businesses directly 'in the line of fire'.

2.3.6 Pollution and water quality

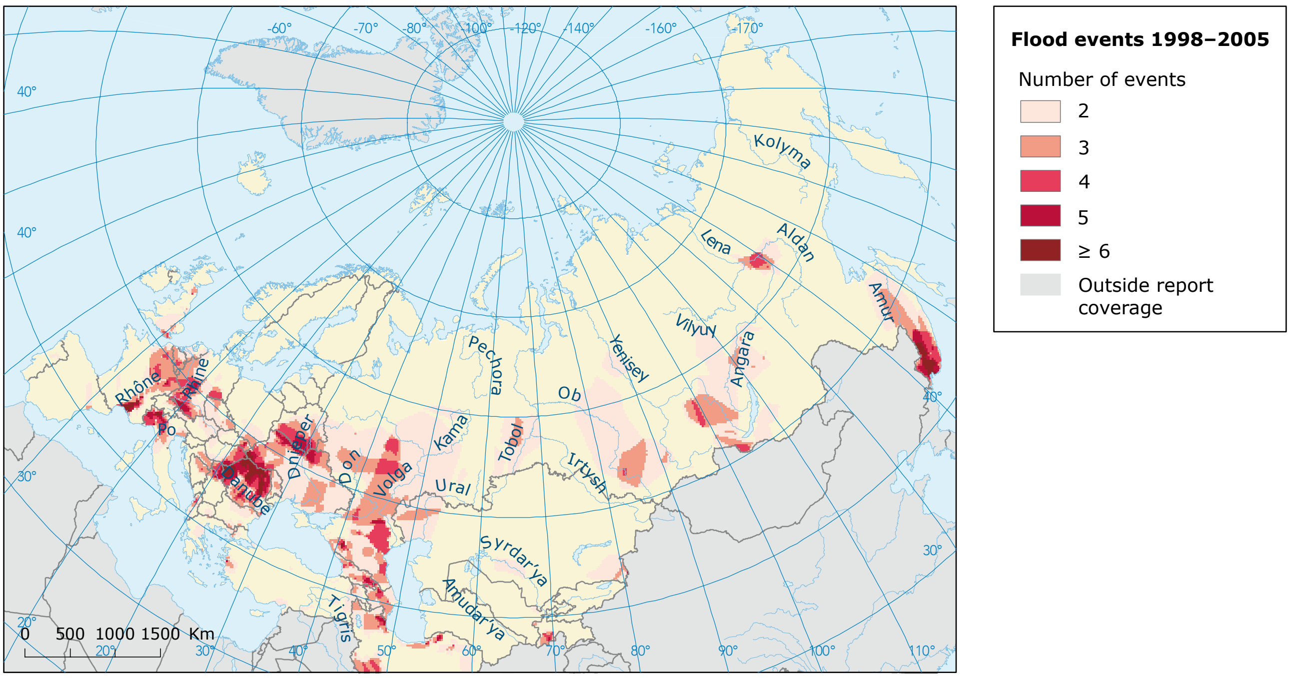
The main drivers of pollution discharges and the deterioration of water quality are industrial production, intensive agriculture and population growth. The extent to which wastewater from population and industry is discharged into waters is dependent on the condition of the sewage collection system and the treatment facilities available. While, in many areas, considerable investment and change has been made to counteract point sources of water pollution, discharges from diffuse sources, in particular agriculture, are much more difficult to control.

Sanitation

Improved sanitation, an important public health measure essential for the prevention of disease, refers to the number of people with access to public sewer connection, septic system connection, pour-flush latrines, simple pit latrines, or ventilated improved pit latrines (WHO/UNICEF Joint Monitoring Programme).

In 2004 around 90 % of the population in the EECCA and SEE countries had access to improved sanitation (Figure 2.3.12). Six countries, Bosnia and Herzegovina, Bulgaria, Croatia, Turkey, Ukraine and

Map 2.3.1 River catchments affected by flooding (1998–2005)



Source: EEA, based on Global Active Archive of Large Flood Events, Dartmouth Flood Observatory — EMDAT.

Table 2.3.1 Major floods in the pan-European region during 2005 and 2006

2006	
•	Spain and Portugal, October–November 2006: 155 300 km² affected.
•	Greece, October 2006: Thessaloniki received more rain in 24 hours than it usually does during the entire month of October. Worst floods in 50 years in Volos. 100 000 hectares crops damaged. EUR 4.5 million damage to roads and infrastructure. Hundreds of homes flooded.
•	Romania, Bulgaria, Ukraine, April–May 2006: 144 600 km² affected. Highest level of the Danube in Romania and Bulgaria since 1895.
2005	
•	Romania and Bulgaria, September 2005: 10 deaths. 29 370 km² affected.
•	Switzerland, Austria, Germany, August 2005: USD 790 million damage. 44 900 km² affected. 12 deaths. Worst flood in central Europe for a century.
•	Romania, Republic of Moldova, Hungary and Bulgaria, August 2005: USD 625 million damage, 34 deaths. 68 750 km² affected by this record flood which lasted for 20 days.
•	Romania, July 2005: USD 800 million damage. 13 000 displaced. 23 deaths. 40 040 km² affected. Worst flood in 30 years.
•	Tajikistan, Kyrgyzstan and Afghanistan, June 2005: USD 50 million damage, 103 000 km² affected. 11 000 people displaced and 39 died in this flooding that lasted for 37 days.
•	Bulgaria, May 2005: USD 10 million damage, six deaths and 71 250 km² affected. Caused by the heaviest rainfall in more than 50 years.
•	Russian Federation, May 2005: Lasted a month. Nearly 500 houses flooded but only one fatality. 279 300 km² affected after the Amur river rose to its highest level in 30 years.
•	Finland, May 2005: Worst spring flooding since 1981. Damage running into millions of euro, 24 900 km² affected, and 400 people displaced.
•	Poland, Romania, Hungary, Czech Republic, Slovakia, March 2005: Melting snow and continuous rainfall caused flooding that killed four people and affected 673 500 km². Lasted for 26 days.
•	Kazakhstan and Uzbekistan, February 2005: A dam broke as snow melted causing flooding over 135 400 km² and displacing 30 000 people. Lasted for 28 days.
•	United Kingdom, January 2005: Over 3 000 homes flooded leaving thousands homeless and three dead. Millions of pounds damage.

Source: EEA, based on Global Active Archive of Large Flood Events, Dartmouth Flood Observatory — EMDAT.

Uzbekistan, are on track to meet the MDG target of 'halving, by 2015, the proportion of people without sustainable access to … basic sanitation', but in some countries, mainly in rural parts of Central Asian countries sanitation is still very deficient with more than one-third of the population living without improved sanitation (UNICEF, 2006) — a situation that has essentially remained the same since 1990.

Wastewater treatment

With increasing urbanisation and development around Europe, households and industries are generally connected to sewers. Connection to a collection system, however, does not guarantee that the water is adequately treated. Indeed, the sewerage connection rates in EECCA and SEE countries cannot be used as an indicator for the amount of wastewater actually being treated before its discharge into open waters. Despite the rather high connection rate, the wastewater is in many cases not treated, either because there is no wastewater treatment plant or the plant does not function properly (Box 2.3.2).

Before 1990, large volumes of effluent were discharged into surface water bodies from municipal, industrial and agriculture sources, causing pollution of both surface and groundwaters. This diminished in the early 1990s, not generally as the result of the introduction of pollution control technologies such as improved wastewater treatment but rather because of the collapse of many industries and reduced agricultural activities. Moreover, a number of polluting activities still exist, notably mining, metallurgical and chemical industries. In rural areas connectivity to sewers and wastewater treatment is generally very low, resulting in most of the wastewater being discharged untreated.

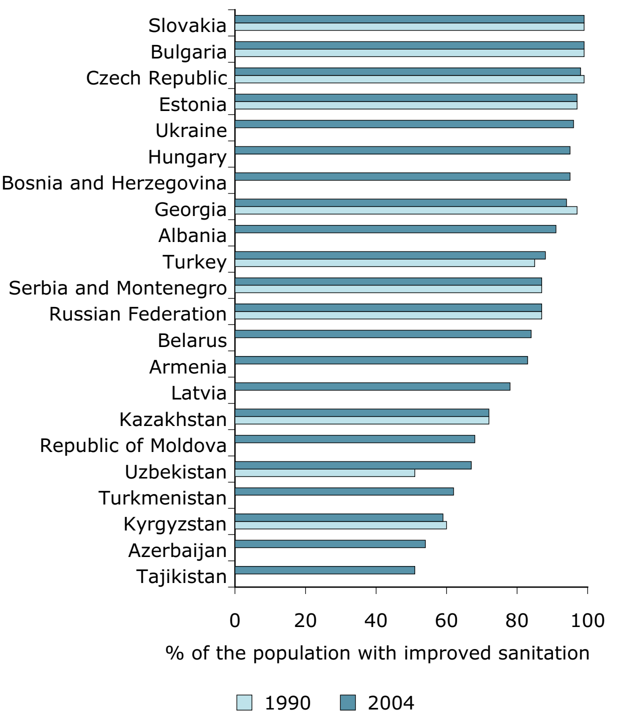
Across the EU-25 in 2002, 90 % of the population were connected to sewerage networks (Eurostat, 2006). However, some wastewater is discharged without or with only limited treatment. Some regional differences exist: in the northern and central European countries generally more than 90 % of the population is connected to wastewater treatment plants. In southern Europe and the EU-10 connection varies between 50–80 %. In 2002 there were still some large cities that discharged their wastewater nearly untreated, such as Cork, Barcelona, Brighton, Milan (European Commission, 2004), and Bucharest (National contribution received during Belgrade review process. http://belgrade-consultation.ewindows.eu.org/reports/rep285401).

The last twenty years have seen marked increases in the proportion of the population whose housing is connected to wastewater treatment and in improvements in wastewater treatment technology. In the northern and central countries most of the wastewater now receives tertiary treatment — i.e. nutrients are removed — while in the southern countries and the EU-10 most wastewater receives secondary treatment — primarily removal of organic matter.

In Turkey, the percentage of people connected to sewers increased from 52 % in 1994 to 66 % in 2004. This period of economic development saw a near doubling in the amount of wastewater discharged (Figure 2.3.13), a quadrupling in the number of wastewater treatment plants from 41 to 165, and by 2004 more than half of the country's wastewater received some kind of treatment.

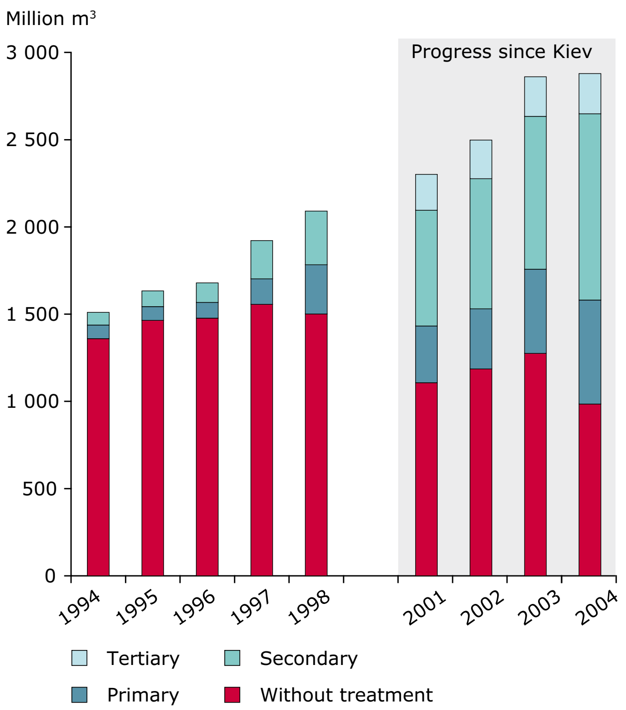
As a result of the economic recession in the 1990s, the amount of wastewater and pollutants discharged in the EECCA, SEE and new EU-10 decreased markedly mainly as a result of the decline in highly polluting industry. Although many of these economies have since improved and industrial output has increased, there has been a shift towards less polluting industries in the EU-10, with several

Figure 2.3.12 Total population with access to improved sanitation, selected countries (%, 1990 and 2004)



Source: UN Statistics Division, 2007.

Figure 2.3.13 Wastewater treatment in Turkey



Source: Turkey Statistical Yearbook.

Box 2.3.2 Examples of poor and deteriorating sewerage networks and wastewater treatment in EECCA and SEE countries

In Albania, the wastewater collection and treatment infrastructure has neither been maintained nor developed quickly enough to cope with the increasing flow of pollution. No new wastewater infrastructure has been built to keep pace with the increasing population in the major cities of Tirana and Durrës (UNECE, 2002).

The condition of wastewater facilities in Azerbaijan is generally very poor. Lack of maintenance for more than a decade, excessive leakage and infiltration, and a low standard of construction, including materials, are the main causes. Discharges of insufficiently pre-treated harmful industrial wastewater into the municipal sewer systems impair the efficiency of the wastewater treatment plants not designed to deal with these loads (UNECE, 2003).

In Bosnia and Herzegovina's urban areas, the connection rate for households is 56 %, but in villages and rural areas a maximum of 10 % of the households are connected to sewerage systems. Due to the lack of resources, the sewerage systems are on the whole poorly maintained and in many cases may not even have been completed. At the time of the civil war 1992–1995, only seven municipal wastewater treatment plants were in operation, and although since then many of the plants were returned to operation, more than 95 % of the municipal wastewater is still discharged, untreated, into water bodies (UNECE, 2004a).

In Georgia only one of 30 municipal wastewater treatment plants is functional (national information).

In the Republic of Moldova wastewater discharged from residential and industrial areas is a major pollution contributor to surface waters as most of the treatment plants are not operational. Out of the 580 plants built before the early 1990s, only 104 were still in use in 2003. As a result, since 2000 the quantity of untreated or insufficiently treated wastewater has risen dramatically (UNECE, 2005).

In Tajikistan many wastewater treatment plants are obsolete and only 20 % still work. Other than in the capital, Dushanbe, there is no biological treatment either because the plants never had the capability or because the cost of electricity needed for their operation is too high (UNECE, 2004b).

In Serbia and Montenegro ten years of little maintenance and no investment has resulted in most municipal and industrial wastewater being discharged largely untreated. It is estimated that only 13 % of treatment plants work satisfactorily and that only about 12 % of municipal wastewater is treated. Lack of access to water and sanitation is a public health issue for some populations, particularly those living in urban slums (World Bank, 2003).

new wastewater treatment plants helping to reduce pollution further.

Despite huge investment in better wastewater treatment eutrophication caused by large inputs of nutrients, mainly nitrogen and phosphorus, is still a major environmental problem across Europe, affecting all types of waters. Diffuse source run-off from agricultural land is the principal source of nitrogen pollution, typically contributing 50–80 % of the total load (EEA, 2005a), while households and industry point sources still tend to be the more significant sources of phosphorus, though the input from agriculture is far from negligible.

In general, discharges of both nitrogen and phosphorus from point sources — industries and people — have decreased significantly over the past 30 years, whereas the losses from diffuse sources — mainly agriculture — have generally remained constant. The changes in point-source discharges are mainly due to improved treatment of urban wastewater — particularly in WCE countries where treatment is now very effective — the lowered phosphate content of detergents, and reduced industrial discharges. However, measures to reduce the nitrogen surplus from agricultural land have only had limited success so far, but are now slowly beginning to show results in terms of a reduction in diffuse losses.

The state of water quality

In addition to the water quality assessment below, an in-depth report on the status of transboundary rivers, groundwater and lakes in the UNECE region under the auspices of the UNECE Transboundary Watercourse and International Lakes Convention (see Box 2.3.3) was presented at the 2007 Belgrade

Conference. Other initiatives such as those of the World Water Assessment Programme and its 2006 report (Unesco, 2006) and UNEP Global Environment Monitoring System (GEMS Water) add to an understanding of the status of global and regional water bodies.

Most European countries have water quality monitoring programmes for groundwater, rivers, and lakes. In the EU, this is currently being harmonised and strengthened by the implementation of the Water Framework Directive.

Generally, in EECCA and SEE countries, although several institutions such as hydro-meteorological services, environmental inspectorates and regional authorities are involved in water monitoring, there is limited coordination. In the Volga basin, for example, many private enterprises carry out monitoring and, as they are the main owners of updated environmental information, charge for access to their data.

Such non-coordinated systems can easily lead to the use of different methods for sampling and measuring, resulting in low comparability of data, which in turn does not allow a clear picture of the status of water resources to be established. Some countries, however, including Belarus and Ukraine, have recognised the necessity of better coordination in order to improve water management.

In much of the EECCA and SEE, water monitoring declined during the era of economic restructuring in the 1990s. Monitoring was generally focused on larger rivers, with an emphasis on waters upstream and downstream of major cities, while the monitoring of lakes, reservoirs, smaller rivers and groundwater was extremely limited, and only a few countries showed any interest in diffuse sources of pollution.

However, there are now widespread indications of improvement in both EECCA and SEE countries, particularly since 2003, as a result of increased funding and the extension of monitoring networks. Funding has multiplied seven-fold in the Russian Federation (OECD, 2007), Croatia and Serbia and Montenegro show progress towards compliance with the Water Framework Directive monitoring, while Armenia, Azerbaijan and Uzbekistan have developed, or are in the process of developing monitoring plans.

Water quality in EECCA and SEE countries

As data on the quality of the surface waters are very limited, the following assessment has been based on a review of the latest national state of the environment reports, UNECE Environmental Performance Reviews (EPRs) and World Bank Country Water Notes.

Analysis of available data indicates an improvement in the water quality of the EECCA and SEE rivers in recent years. The large southern and western EECCA rivers generally show a moderate level of pollution, while the pollution levels are low around large EECCA rivers running north through sparsely populated lands. Some large rivers including the Kura, Amu Darya, Syr Darya and Volga are polluted; while other large rivers have hot spots downstream of large cities which discharge insufficiently treated wastewater. The pollution of many small water courses remains severe.

According to their own national standards, most Russian rivers and lakes can be characterised as moderately polluted. Almost all reservoirs, too, are significantly polluted, and their water quality a cause for concern.

- The Volga, one of Europe's largest rivers, flows through one of the Russian Federation's most important economic regions. This concentration of people and industry has resulted in heavy environmental pollution, with, in 2002, the Volga and its tributaries receiving 8.5 km^3 of polluted wastewater, the majority from household and industrial discharges (43 % of all polluted discharges in the Russian Federation) 0.76 km^3 of which had not been treated at all (Demin, 2005). As a result, most sections of the Volga are classified as polluted and 22 % of sections as dirty: the water of Volga's tributaries also vary from polluted to extremely polluted.
- In 2004, 30 % of analysed samples of Ukraine's surface water for agricultural use showed contamination by nitrates, and more than a

Box 2.3.3 UNECE transboundary water bodies assessment

Under the 1992 UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, the parties take measures to prevent, control and reduce water pollution that has transboundary impacts. Under the auspices of the Convention's Working Group on Monitoring and Assessment, with Finland as lead country, a comprehensive assessment was drawn up as a contribution to the 2007 Belgrade Ministerial Conference 'Environment for Europe'. The report analysed pressures on water bodies and provided information on trends in their ecological and chemical status. It also shed light on the effectiveness of measures taken, and culminated in a set of measures to prevent further degradation of transboundary waters and achieve their long-term health.

The report covers the entire UNECE region, with the exception of northern America. Special attention was given to EECCA countries as they face the biggest challenge in reducing transboundary impacts. Although some 20 % of the rivers in the Caucasus and Central Asia, including most of the transboundary rivers in mountain areas, are still in 'high and good status', some of these water bodies show signs of increasing pollution or are potentially threatened by mining and ore processing. The majority of the rivers in EECCA fall into the category 'water bodies with moderate pollution'. Rivers, which take up their pollution load in lowland areas and/or foothills with intensive industrial and agricultural activities, are deemed 'polluted'. Insufficiently treated wastewaters add to this pollution load. This and the subsequent pollution of drinking water sources have resulted in an increase in water-related diseases in the region; indeed many of the area's rivers have become practically unfit for the supply of drinking water. Ever increasing eutrophication remains the worst phenomenon affecting transboundary lakes.

Improving the status of waters in EECCA will first and foremost require investments in largely outdated municipal sewage treatment facilities, which often also receive wastewater from small and medium-sized enterprises. Apart from sewage, manufacturing waste and general waste management are challenging. This includes waste storage ponds containing hazardous waste from mining, metal processing and chemical industry; illegal waste disposal along rivers; and old and often uncontrolled waste disposal sites which will generate increasing amounts of pollution if they are not properly handled. Additionally, strategies are needed for the better integration of policies to control diffuse pollution from agriculture and to adapt to climate change.

The effective management of transboundary water bodies is of particular importance in SEE since 90 % of the territory falls within transboundary river basins: there are more than 12 large transboundary rivers and four transboundary lakes in the area. Major challenges for the management of transboundary water resources in the SEE region include:

- **Water quantity management**. In several cases, one-sided exploitation of water resources by upstream parties causes critical deficiencies in the water supply to downstream users and affects the natural water cycle in wetlands and aquifers.
- **Water quality management**. Water in some shared water bodies is unfit as drinking water, or even for bathing, without extensive treatment — with, in most cases, water quality still in decline. Shared water bodies have been used as convenient sinks for urban and industrial wastewater, with unsustainable agricultural practices further adding to the problem. Investments in municipal wastewater treatment and regulation of both industrial effluents and agricultural run-off have been introduced in several cases, but still only address a small part of the problem.
- **Flood management**. All rivers in the SEE region are subject to irregular flooding and it is likely that annual flood damage will increase, given prevailing unsustainable management practices at national level and limited investment in flood mitigation.

The Petersberg Process Phase II/Athens Declaration aims to build capacity and share experience among key partners in the countries of the SEE region on Integrated Water Resources Management (IWRM) of transboundary water bodies. It provides the framework for exchange of information and experience, in support to future investments. The process is a joint effort of the German Ministry for Environment, Nature Conservation and Nuclear Safety, the Hellenic Ministry of Foreign Affairs and the World Bank.

Although there is an increasing consensus that the available water must be shared amongst individuals, economic sectors, intrastate jurisdictions and sovereign nations — transcending political and administrative boundaries — there are still numerous obstacles to achieving this aim. The main obstacles derive from the interdependencies and conflicting interests among different uses — fisheries, agriculture, hydropower generation, water supply, tourism, etc. — coupled with different levels of infrastructure, legal and institutional frameworks, policies, priorities and interests of each country exacerbated by entrenched positions over issues including historical rights, cultural values and political persuasions.

Sources: UNECE Water http://unece.org/env/water/welcome.html; Petersberg Process http://www.bmu.de/english/water_management/current/doc/36213.php; Transboundary Waters Information Exchange Network for South Eastern Europe: http://www.watersee.net/.

further 1 % by pesticides. Further, in 2005 national data showed that 25–30 % of all the country's natural water bodies did not meet its sanitary standards, with the smaller Ukrainian tributaries being more heavily polluted, mainly by agricultural run-off, than the main rivers. Nonetheless, there are many unspoiled water bodies in Ukraine, particularly in the mountainous areas. In the Republic of Moldova, the main rivers Dniester and Prut are moderately polluted, while smaller rivers like the Reut and Bicu are more polluted (UNECE, 2006).

- The quality of the Dniepr is a major concern because the river is Ukraine's main water body, making up 80 % of the country's total resources and providing water for 32 million people. In the 1990s, the water was made undrinkable in many areas by discharges of a number of pollutants from various sources. While substantial progress has been made since then, much remains to be done (UNECE, 2006).
- During the time of economic transition, pollution of Caucasian surface waters decreased, and the scarce data available indicates that there has been an improvement of water quality in Armenian rivers in recent years. In Georgia ambient water quality has also improved somewhat during the last 15 years, not from the introduction of pollution control technologies but from drastic reductions in industrial production and therefore wastewater discharges.
- The transboundary Kura river system is polluted by the discharge of poorly treated or untreated wastewater from the 11 million people living in its catchment area. About 70 % of the population of Azerbaijan uses its water for drinking and household purposes. Due to the collapse of many industries in the early 1990s, pollution has decreased; nonetheless, a number of polluting activities still exist, most notably the mining, metallurgical and chemical industries which produce heavy metals, ammonia and nitrates.
- The waters of the downstream sections of the rivers in Central Asia and the Aral Sea as well as the Aral Sea itself are heavily polluted by salts and chemical pollutants discharged by agriculture and other industries (GIWA, 2005; CA REAP, 2006). On their way towards the Aral Sea, the clean freshwaters of Amu Darya and Syr Darya, the two of the main water resources of Central Asia, are turned brackish by the return of waters used for land-washing and irrigation making it unpalatable during low-flow periods (Crosa *et al.*, 2006; Murray-Rust *et al.*, 2003).
- At present Kazakhstan's water bodies are intensively polluted by the country's mining, metallurgical and chemical industries and city utilities which are a serious ecological threat. Most polluted of all are the Irtysh, Nura, Syr Darya, and Ili rivers, and the Balkhash Lake.
- Kyrgyzstan's water is particularly pure in the upper stretches of such rivers as the Naryn, Amu-Darya, and others flowing from the mountain. However, in the vicinity of urban, agricultural and industrial centres, the water quality deteriorates, with pollution hot spots found in the densely populated Chu river basin.

Many SEE water bodies are polluted and have poor quality water.

- Albanian surface waters are heavily contaminated from two major sources: urban wastewater directly discharged into surface water bodies, and pollution by industry, though the latter has lessened during the economic crisis. Many Albanian rivers, including the Ishem, Tirane, Erzeni, Shkumbini, and the Semani, show a deficit of dissolved oxygen, with high chemical (COD) and biochemical (BOD) oxygen demand values, which indicate pollution by organic matter, generally of domestic origin. The Alb Gjanika and Semani rivers, in which wastewater from oil extraction and processing is discharged, are among the most polluted in the country.
- The quality of surface water in Bosnia and Herzegovina varies from relatively clean to poor primarily because of an insufficient number of adequate urban/industrial wastewater treatment plants and diffuse agricultural pollution primarily from pesticides and fertilisers.
- In the Former Yugoslav Republic of Macedonia groundwater and surface waters are relatively clean in their upper courses, but rapidly deteriorate along their middle and lower courses. The major polluters are discharges

of municipal or industrial wastewater but in the agricultural north-east, there is significant pollution from livestock waste and food industries. In general, polluted wastes are discharged directly into receiving water bodies without any treatment. In recent years the country's water quality has somewhat improved because of industrial decline.

- The discharge of untreated municipal and industrial wastewater within Serbia and Montenegro has resulted in the significant pollution of the water resources. River stretches downstream of major settlements show a marked decline in water quality as the result of untreated municipal and industrial discharges.

Water quality in WCE

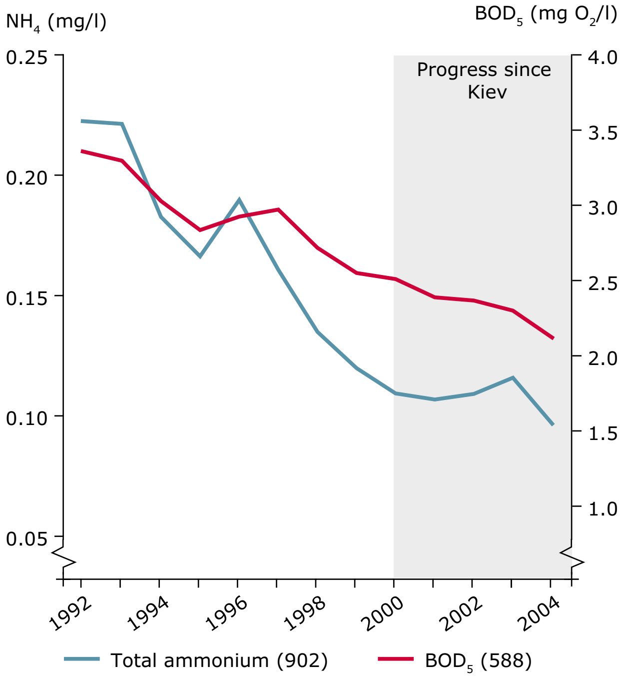
Water data for WCE are plentiful and consistent and reflect developments over considerable time. Collected by individual countries, the data are designed to provide representative assessments for the countries themselves, and for the region as a whole. Collected annually from more than 3 500 river stations in 32 countries, more than 1 500 lake stations, and around 1 100 groundwater bodies, the data are stored within the EEA's Waterbase, to which the European Commission and national and regional bodies all have access. The overreaching indications from Waterbase are that while, in comparison to some areas, the quality of water in WCE is enviably good, there remain areas of concern and areas in which improvement is both possible and desirable.

Concentrations of organic matter (as biochemical oxygen demand over 5 days (BOD_5)) and total ammonium (NH_4) have generally decreased in rivers in the EEA member countries in the period 1992 to 2004, reflecting the general improvement in wastewater treatment over this period. The decrease is mainly due to improved sewage treatment as a result of the EU's Urban Waste Water Directive, but also to a decline in polluting manufacturers after the economic recession of the 1990s.

BOD and ammonium concentrations are highest in some central countries and lowest in northern European countries, with EU-10 Member States showing the greatest declines (Figure 2.3.14).

Concentrations of phosphorus have also generally decreased in rivers, and to a lesser extent lakes, in the WCE area since the 1990s, reflecting the general improvement in wastewater treatment. Overall, there has also been a minor decrease in nitrate concentrations in European rivers over the same period, but indicators suggest little or no change in nitrate concentrations in Europe's groundwaters and lakes (Figure 2.3.15).

Figure 2.3.14 Trend in total ammonium (NH_4) concentrations and BOD_5 in selected WCE rivers (1992–2004)

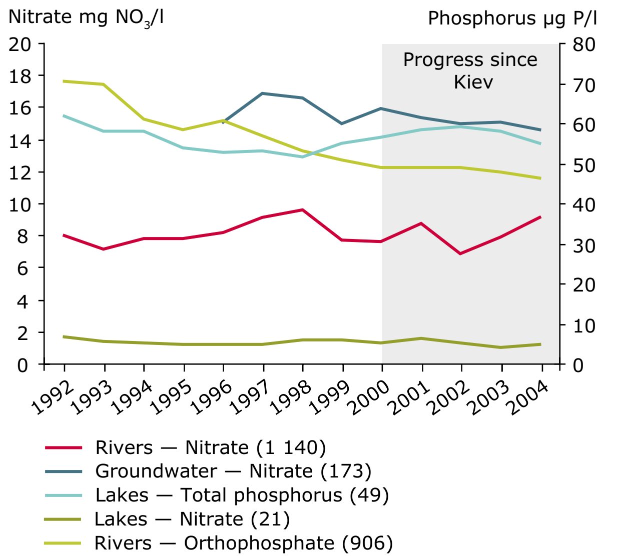


Notes: Numbers of river monitoring stations in brackets. Total ammonium data from AT, BE, BG, DK, ET, FI, FR, DE, HU, LV, LT, PL, SL, SE. BOD_5 data from AT, BE, BG, CZ, DK, FR, HU, LV, LT, SK, SL, UK.

Source: EEA CSI19.

There have been significant decreases in river nitrate concentrations in some countries (Figure 2.3.16). Denmark and Germany had the highest proportion of river stations reporting decreasing trends, indicating that national and EU measures introduced to reduce nitrate pollution, such as those in the Nitrates Directive, are taking

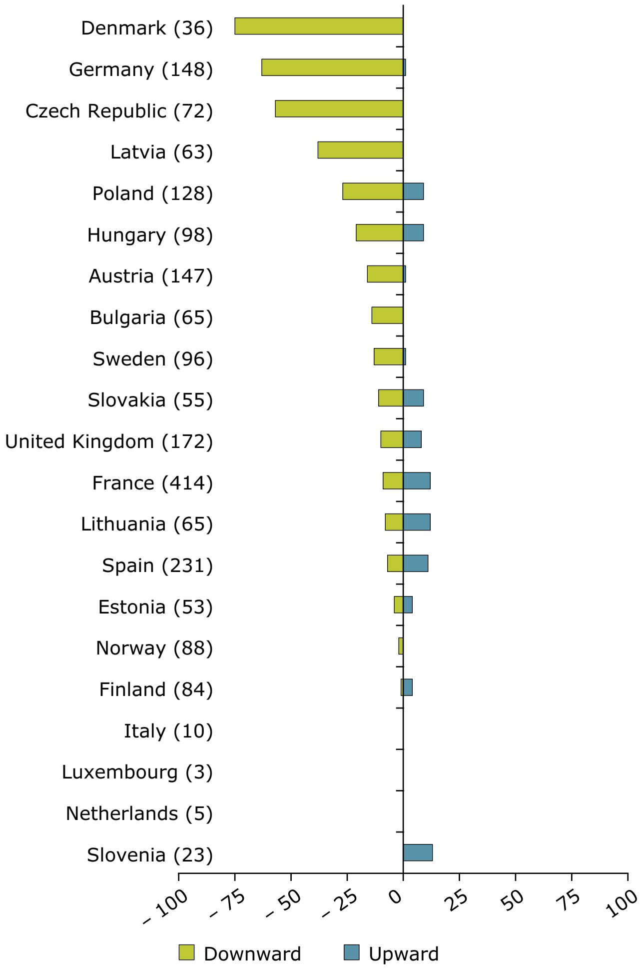
Figure 2.3.15 Nitrate and phosphorus concentrations in selected WCE freshwater bodies (1992–2004)



Note: Numbers of groundwater bodies, lake and river monitoring stations in brackets.
Lakes: nitrate data from Estonia (4 stations on 1 lake), Finland (6 stations on 6 lakes), Germany (5 stations on 5 lakes), Hungary (15 stations on 6 lakes), Latvia (1 station on 1 lake) and Slovenia (4 stations on 2 lakes).
Total phosphorus data from Austria (5 stations on 5 lakes), Denmark (19 stations on 19 lakes), Estonia (4 stations on 1 lake), Finland (11 stations on 11 lakes), Germany (5 stations on 5 lakes), Hungary (11 stations on 2 lakes), Latvia (1 station on 1 lake), Sweden (3 stations on 3 lakes) and Slovenia (4 stations on 2 lakes).
Groundwater bodies: 147 groundwater bodies with data from Austria, Bulgaria, Denmark, Estonia, Finland, Germany, Lithuania, the Netherlands, Norway, Portugal, Slovakia, Slovenia and the United Kingdom.
Rivers: data from Austria, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Sweden and the United Kingdom.
Concentrations are expressed as median of annual average concentrations for groundwater, rivers and lakes.
Data are from representative river and lake stations.
Stations that have no designation of type are assumed to be representative and are included in the analysis.

Source: EEA CSI20.

Figure 2.3.16 Percentage of river monitoring stations per country reporting increasing (upward) or decreasing (downward) trends in nitrate concentrations (1992 to 2004)



Note: Negative values on 'y' axis equate to decreasing trends, positive values increasing trends.
Analysis based on representative river monitoring stations except for Norway where flux monitoring stations were used.

Source: EEA CSI20.

effect. The Czech Republic, Latvia, Hungary and Poland, also had a high proportion of river stations reporting decreasing levels of nitrates. These are likely to be related to the decrease in agricultural activities that has been occurring in these countries during their transition to a market-oriented economy (see Section 7.1, Agriculture).

Key policies to improve the aquatic environment

Pollution control has been high on the political agenda for almost 50 years, and several national and EU initiatives, for example the Directives on Nitrates, Urban Waste Water and Drinking Water, supplemented by international marine conventions, the UNECE Convention on Transboundary Rivers and Lakes and the EECCA's Environment Strategy, have been agreed and implemented by countries to varying degrees. The last two political frameworks and the EU Water Framework Directive of 2000 clearly recognise that traditional end-of-pipe solutions, targeted at solving water quality issues originating from one specific source, have not proved adequate to re-establish clean rivers and lakes supporting healthy aquatic ecosystems.

As a consequence, the concept of transboundary and integrated river basin management has been introduced taking account of the fact that sustainable water resources management should not only result in better water quality but also ensure that aquatic habitats and their biological communities are protected and restored.

There are tremendous challenges ahead if this concept is to be successful across Europe, and there is a need to define clear and measurable targets for the achievement of the goal, which, in Europe, is the establishment of good ecological potential for surface water bodies by 2015. Across the wider region, a strengthening of water monitoring and information management is badly needed to assess whether any progress is being made.

2.4 Soil

Photo: Soil, a life-supporting system © Erika Michéli

Key messages

- Since the Kiev conference, progress has been made both in terms of policy development and the availability of information. However, 'soil work' is still at too early a stage for any marked improvements in the status of the soil resources to be recorded.

- Soil legislation is evolving. The recently adopted EU Soil Thematic Strategy (2006) includes the proposal for a soil framework directive addressing the issues in a holistic and integrated way. This progress was facilitated both by increased knowledge and by positive developments in national legislation.

- Soil is a resource of global concern. Some problems associated with its management, such as erosion and its transportation in floods and by wind, may have transboundary effects. Others, including desertification, are common to a number of areas in Europe, while yet others, such as the effects of soil degradation on the carbon cycle, can potentially worsen global warming.

- Although the ecological and socio-economic functions provided by soil are essential to social and economic well-being, soil is still a relatively neglected natural resource across the pan-European region. This is evidenced by a lack of information available to analyse known threats, by the relative paucity of budgets allocated to tackling soil problems, particularly when compared to those available for the other environmental media air and water, and for the piecemeal character of soil policy actions across the pan-European region.

- The importance and the complexity of analysing current risks, especially climate change, emphasise the need for new thinking on mechanisms to ensure that the evidence base for soil meets future policy challenges. For example, the exchange of best practices, between countries and regions with similar soil conditions could reduce remediation costs across many soil threats and provide valuable areas for cross-border cooperation.

- Uncontrolled soil sealing — the urban sprawl that is widespread across Europe — may result in the unnecessary loss of good quality soil. Detailed and sound information about soil is required as a core element of integrated planning, if the goal of sustainable urban development is to be achieved.

- In the SEE and EECCA regions, particularly in rural areas, soil degradation is exacerbated by socio-economic factors such as weak or recovering economies with limited budgets for environmental protection, poverty, political tensions, insufficient environmental regulation or implementation, limited public participation, and restricted access to cleaner technology and environmental information.

- In these regions, the consequences of soil degradation include the loss of livelihoods leading to unemployment and poverty, health problems, land abandonment and depopulation of rural areas. Further, this last factor can, of itself, cause increased population pressure in other areas.

- In WCE and some SEE countries, soil polluting activities are estimated to have occurred at nearly three million sites. Thorough investigations carried out up to 2005 identified more than 1 800 000 potentially contaminated sites, of which 240 000 are in need of remedial treatment. One positive aspect of this is that it indicates an increased awareness of soil contamination issues.
- Large sums of public money are needed to fund remediation activities, typically 35 % of the remediation costs. This is because many of the legally responsible polluters either are insolvent, no longer exist, cannot be identified, or cannot be made liable. Remediation of about 80 000 sites across Europe is complete. In spite of these considerable efforts, it will take decades to clean up the legacy of contamination.

2.4.1 Introduction

Well-functioning soil is essential for the maintenance of the socio-economic and ecological systems which support our livelihoods and underpin our society. It not only supplies most of our food, raw materials and ecosystem services — it also forms the basis for the development of human settlements: the building of homes and infrastructure, recreation facilities, and waste disposal. Soil conserves the remains of our past, is a reservoir for genes, and hosts a wide range of biodiversity. It is itself a relevant part of our cultural heritage through its underpinning of landscapes. Due to these many values, the distribution and the use of soil have influenced the growth and collapse of entire civilisations (Diamond, 2005). However, we still seem not to fully realise its importance. Soil's resilience to natural and anthropogenic pressures, and the long time it takes to show changes in its status, are perhaps the reasons why we take it for granted. Its buffering capacity and its capability to filter and absorb contaminants mean that damage is not perceived until it is far advanced. It is a limited resource that needs to be managed in a sustainable way (EEA/UNEP, 2000).

This assessment is mainly concerned with various aspects of soil degradation in SEE and EECCA, since this is seen as a priority. WCE countries are only partially covered, with particular reference to soil contamination and soil sealing, as a broader overview of the current status of soil in the EU is included in the EEA's report *The European environment — State and outlook 2005* (EEA, 2005).

The partial coverage of geographical areas and soil threats in this section also reflects gaps in scientific knowledge, and the lack of up-to-date and comparable data and information.

The state of soil in Europe is influenced by its diversity, distribution and specific vulnerabilities across the region, as well as the diversity of climate, topography and the availability of other natural resources. Soil conditions are also determined by the spatial distribution and intensity of economic activities, together with the underlying social, political, legislative, financial, scientific and institutional frameworks within individual countries.

Soil should also be considered as a transboundary concern. Some problems associated with its management cross borders, for example erosion and the transportation of soil in floods and by wind. Others are common to a number of areas, including desertification — a phenomenon in both Central Asian and Mediterranean countries, while yet others can be attributed and contribute to problems outside the areas directly affected, such as the melting of permafrost due to climate change, with the consequent release of CO_2 and CH_4, potentially worsening global warming.

The sharing of information and knowledge across borders is essential if these inter-relationships are to be addressed. Joint action programmes between neighbouring countries and across Europe would help to convert an improved understanding into practical action. International programmes, such as the UN Convention to Combat Desertification

(UNCCD), have fostered action to combat land degradation in affected countries in Europe through the implementation of national, sub-regional and regional action programmes ([1]). The implementation of regional programmes, particularly those addressing transboundary issues, such as the Regional Environmental Reconstruction Programme (REReP) for the Balkans, and the Regional Environmental Action Programme for Central Asia (CA REAP) should provide a basis for further progress (REC, 2006; UNEP, 2006).

The major threats to soil have not changed in the past decades. They still include physical degradation — erosion, sealing and large-scale land movements, contamination, salinisation, loss of organic matter — and a decline in soil biodiversity. Urbanisation, tourism, transport, agriculture and industry are all sectors that apply particular pressures on soil. In southern, central and eastern Europe, after decades of economic development based on the heavy exploitation of natural resources, the economic crises which followed conflicts and the collapse of the centrally-planned economies have in general lowered some of these pressures. But several soil problems, such as erosion and historical contamination, have intensified as a result of deficits in national budgets, an inability to maintain physical and institutional infrastructures, poverty and environmental security issues (OECD, 2005; UNEP, 2003, 2005) (see Chapter 1, Europe's environment in an age of transition).

In the EECCA and SEE regions, institutional infrastructures, legislative frameworks and funding for soil protection are generally adequate neither to cope with the extent of the existing problems nor to prevent further degradation. Additionally, there is a general lack of awareness on the part of both soil users and policy-makers of the effects of their actions. The situation has been made worse by limited access to efficient equipment and cleaner technologies, together with a paucity of adequate knowledge (OECD, UNECE EPRs). However, the wider implementation of proven best practices and the introduction of measures similar to those required by current EU legislation are expected to improve the capacity of the administrations to respond effectively.

Despite the fact that a wide range of activities rely on soil and contribute to the depletion of soil resources, there is no specific EU legislation on soil protection. Unlike water and air, the protection of soil is addressed indirectly through measures primarily aimed at the protection of other media such as groundwater, or developed within sectoral policies. However, some progress has been registered since the Kiev conference, both in terms of policy development and the availability of information. For example, the EU Thematic Strategy on Soil, which focuses on its protection as an essential of sustainable development, has marked an important first step in EU soil policy. This strategy was adopted in September 2006 and includes a legislative proposal (European Commission, 2006a) ([2]).

More information has been progressively made available to cover specific issues, such as soil contamination, and for more countries, especially in the SEE and EECCA regions. Nevertheless, much work still has to be done to register an improvement in the state of soil resources across the pan-European region.

2.4.2 Soil in urban and industrial areas

Contamination and soil sealing are the main soil problems in urban and industrial areas.

Contamination can be a legacy stretching back many decades or centuries. As a consequence, the responsibilities for pollution and, therefore, remediation are often difficult to identify because the polluters are often no longer in business. This in turn contributes to making it difficult, time-consuming and costly on the public purse to manage contaminated sites.

([1]) Two regional implementation annexes (Annex IV, Northern Mediterranean and Annex V, Central and Eastern Europe) and a sub-regional action plan (Central Asia) are in place.
([2]) Detailed information on the Soil Thematic Strategy is available on the European Commission website on EU soil policy: http://ec.europa.eu/environment/soil/index.htm. Last accessed January 2007.

Uncontrolled urban expansion — the urban sprawl that is widespread across Europe — may result in the unnecessary loss of good quality soil. The Community Strategic Guidelines on Cohesion 2007–2013 states that the redevelopment of brownfields (3) and the rehabilitation of the physical environment are important measures to improve the competitiveness of European urban areas. The regeneration of public spaces and industrial sites can play an important role in helping to create the infrastructures necessary for sustainable economic development (European Council, 2006). In western Europe the low price of agricultural land — in most cases good agricultural land — compared to that of already urbanised or derelict land — brownfield sites — is an important factor underlying urban sprawl. In many development projects, the cost of acquiring agricultural land is low relative to using already urbanised land, allowing for better profits to be made. Two factors are at work here: a failure to take into account the value of the future agricultural use of land and demographic patterns together with changing social and economic aspirations that encourage farming families to sell off their land cheaply. The maintenance of artificially low prices for good agricultural land in western Europe is also reinforced by the use of expropriation tools (EEA, 2005).

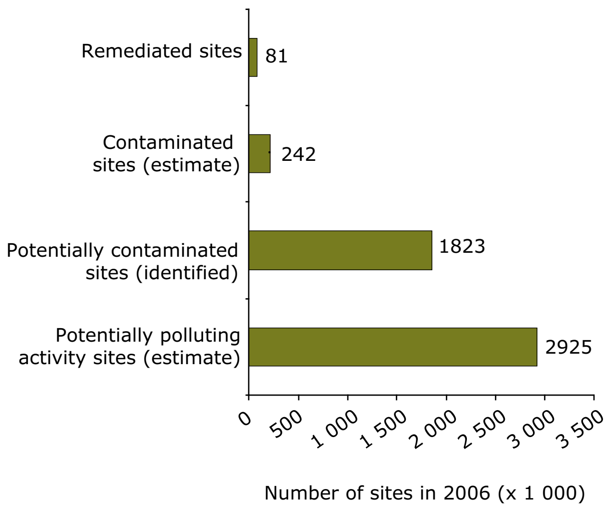
Soil contamination

Contamination from local sources and air deposition of traffic and industrial effluents affect soil and groundwater quality throughout the pan-European region. Soil contamination can have serious effects on human health through direct contact and by the ingestion of contaminated soil, for example through drinking water from sources that flow through contaminated areas, through the food chain, and even by children in playgrounds.

In WCE and some SEE countries, potentially polluting activities are estimated to have occurred at nearly three million sites and investigation is needed to establish where remediation is required (EEA, 2007). Thorough investigations carried out up to 2005, leading to registration and eventually remediation, identified more than 1 800 000 potentially contaminated sites, of which 240 000 are in need of remedial treatment (Figure 2.4.1).

These estimates have increased considerably over the past years, due to progress in investigation, monitoring and data collection, and are expected to continue to rise in the future. According to projections based on the analysis of changes observed in the last five years, the total number of contaminated sites identified as being in need of remediation could increase by more than 50 % by 2025. In those countries for which remediation data

Figure 2.4.1 Overview of progress in management of soil contamination in WCE and some SEE countries



Note: The graph shows an overview of the status in the management of contaminated sites in EEA member countries.
Data coverage: AT, BE (Flanders and the Brussels region), BG, HR, CZ, DK, EE, FI, FR, DE, GR, HU, IS, IE, IT, LV, LI, LT, LU, MK, MT, NL, NO, RO, RS, SK, SI, ES, ES, CH, TR, UK (England and Wales). Time reference: FI, FR, GR, LV, LT, NO, TR: 2006; HR, DK, NL, ES: 2004; IS: 2002; SI: 2001; LI: 2000; other countries: 2005.

Sources: Eionet priority data flows on contaminated sites; Turkey: NATO/CCMS-Turkey, 2006; United Kingdom: Environment Agency, 2005.

(3) In this report, brownfields are sites:
- of formerly industrial or commercial used land, now derelict or underused;
- have been affected by former uses of the site or surrounding land;
- require intervention to go back to beneficial use; and
- may have effective or suspected contamination problems.

Source: Cabernet (website: http://www.cabernet.org.uk/index.asp?c=1134. Last accessed April 2007).

are available, about 80 000 sites have been cleaned up in the last 30 years (EEA, 2007).

In most SEE and EECCA countries the real extent of contamination is unknown because systematic inventories do not exist or cover only specific sites — for example mining or waste disposal sites — and some specific regions, such as those affected by the Chernobyl accident: activities to rectify this are only at an early stage of development. However, some progress has been observed recently, especially in SEE (EEA, 2007; results of the OECD EECCA questionnaire 2006 summarised in OECD, 2007) where Croatia, the Former Yugoslav Republic of Macedonia and Serbia have reported the establishment of centralised inventories. In these countries, soil in urban and industrial areas that has been subjected to regular monitoring is reported to be contaminated with heavy metals, hydrocarbons and organic chemicals (SOER-RF, 2005; UNECE, 2006) (see also Section 2.5, Hazardous chemicals).

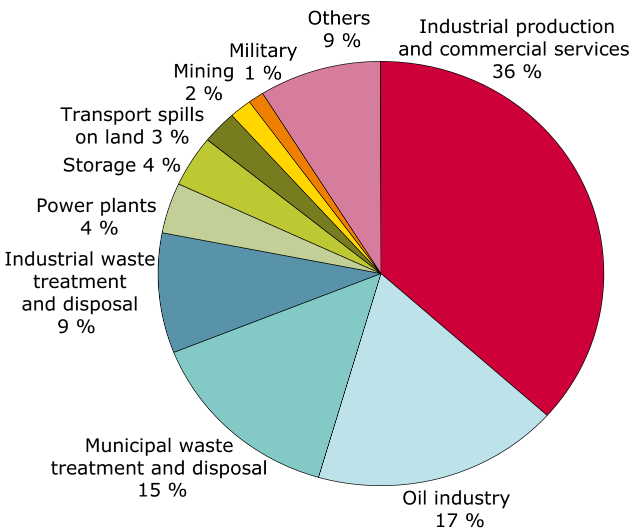
In the EECCA region, large areas are heavily contaminated as a result of poor practices and accidents in various sectors including agriculture, mining (especially for uranium and metal ore), oil and gas extraction, nuclear power generation, waste disposal and recycling, the storage of hazardous chemicals, and at research and military installations, such as nuclear testing, bio-chemical research and rocket launching sites. Many industrial, military and mining installations are now abandoned, reducing some of the pressures on the environment, but leaving a large number of sites unattended (UNECE, 2000; RLNP, 2002; UNEP/GRID, 2006).

Parts of Belarus, the Russian Federation and Ukraine are still heavily contaminated with radionuclides as a result of the Chernobyl accident. Health and lifeexpectancy have decreased markedly in the contaminated areas and thousands of people living in the high-risk zones have been relocated. The most affected areas have been removed from economic use and cannot be restored to pre-existing conditions (UNECE, 2005) (see also Section 2.1, Environment and health perspective).

If soil contamination is common across the pan-European region, the activities causing contamination vary. In general, industrial and commercial activities, and the treatment and disposal of waste are the most significant in the EEA countries (Figure 2.4.2). At industrial and commercial sites handling losses, leakages from tanks and pipelines, and accidents are the most frequent causes of soil and groundwater contamination, with the chemical and metal working industries, energy production, and the oil industry the greatest contributors (EEA, 2007).

Within SEE, the inappropriate disposal and treatment of waste from municipal and industrial sources, and regular industrial activities, including inadequate storage of chemicals, are the major sources of contamination. Adequate waste management systems do not exist in most countries and illegal dumping is widespread, more so in rural than in urban areas. In Turkey, municipal, industrial and illegal waste disposal sites account for 80 % of all sources of contamination, with other industrial facilities and mining tailings providing

Figure 2.4.2 Overview of economic activities causing soil contamination in some WCE and SEE countries (% of investigated sites)



Note: The graph shows the main sources of soil contamination in Europe as percentage of the number of sites where preliminary investigations have been completed. European shares have been calculated as a weighted average over 22 EEA member countries, using the total number of investigated sites as weights.
Data coverage: AT, BE (Flanders and the Brussels region), HR, CZ, EE, FI, MK, GR, IT, LT, LU, MT, RO, SK, ES, SE, CH.
Time coverage: 2006; BE, HR; 2004; ES: 2002.

Source: Eionet priority data flows on contaminated sites, 2006.

the remainder (Source NATO/CCMS-Turkey, 2006). In Croatia, about 200 landfills and 3 000 illegal waste deposits have been targeted for remediation (National Environmental Action Plan adopted in 2003). In Bulgaria, the storage of obsolete chemicals is predominant; while in the Former Yugoslav Republic of Macedonia, mining sites represent 27 % of all sources of contamination.

Management of contaminated sites

Although many countries in WCE have legislative instruments that apply the 'polluter-pays' principle for the management of contaminated sites, large sums of public money are also provided to fund remediation activities (EEA, 2007). This is due to limitations on the application of the principle for the remediation of historical contamination since many of the legally responsible polluters either no longer exist, cannot be identified or made liable, or are insolvent. On average, more than 35 % of total remediation expenditures in the surveyed countries derive from public budgets, with a maximum of 100 % of public funds employed in the Czech Republic, the Former Yugoslav Republic of Macedonia and Spain, and a minimum of about 7 % in France, where a large share of the funding comes from the private sector. However, it should be noted that while information on public expenditures is widely available, information on private expenditures is scarce.

In WCE and some SEE countries, progress can be observed in the remediation of sites. In the countries for which comparable figures are available, the average number of cleaned-up sites increased by more than 150 % between 2001 and 2006, with increases in individual countries ranging from about 30 % in Austria and Italy to around 600 % in Belgium and Norway. The total number of sites awaiting remediation has grown on average by about 40 % over the same period, while estimates on the number of sites where potentially polluting activities have taken place have more than doubled (EEA, 2007). One positive aspect of these outcomes is that they indicate an increased awareness of soil contamination issues.

In EECCA, although some remediation has been carried out by both the public and private sectors — for example, the oil companies — concerted regional action is currently far from satisfactory. Inventories of contaminated sites have only been made by four countries in Central Asia, while national clean-up programmes have been established in just three. Further, these may cover only specific sites, such as tailing and mining waste sites in Kyrgyzstan (according to the results of the OECD EECCA questionnaire 2006 summarised in OECD, 2007). Clean-up is expensive — for example, for a single mining site in Kazakhstan an estimated EUR 62 million are needed, while the annual funding for containment to avoid further contamination amounts to about EUR 2 million (UNEP/GRID, 2006). Such costs are frequently beyond the scope of the public purse in countries where the polluters often cannot be made liable.

Soil sealing

Estimates, based on the analysis of Corine land cover data which covers most WCE and some SEE countries, show that the extent of built-up areas has increased by more than 5 % between 1990 and 2000. These trends are most pronounced around existing urban centres and along the coast (EEA, 2006).

The sealing of soil, often without the necessary planning permission, is common in and around urban and coastal areas. Such uncontrolled urbanisation is often the result of rapid economic growth and the expansion of tourism, leading to internal rural-to-urban migration, and facilitated by a lack of spatial planning and a limited capacity of the public administration to enforce building regulations.

Sealing also increases pressures on agricultural land, as urban expansion usually takes place at the expense of good soil. In most EECCA and SEE countries, there are no coherent national strategies for spatial development, and building regulations are rarely enforced. Across Europe there is a general lack of national programmes for promoting the rehabilitation of brownfield sites. Above all, such programmes could contribute to the improvement of the urban environment and a reduction in the unnecessary consumption of productive agricultural land. It could also contribute to economic development and employment — in Ireland, for example, urban renewal has provided an estimated 80 000 net additional jobs in city and town centre locations in the period 1986–1996 (EPA, 2005).

Box 2.4.1 Brownfields — illegal building and human exposure to soil contaminants

The sealing of the soil by building and infrastructure construction, often without any planning permit, is common in the vicinity of urban and coastal areas in some countries. Previously developed land or brownfields may be reused, sometime without prior remedial action. For example, in Albania, the construction of houses in abandoned industrial sites has been reported and nearly one-third of the population live in illegal settlements. The use of former industrial sites for residential purposes increases the exposure of the population to hazardous substances which are left in the soil by past activities. This might result in significant risks to human health, especially for the children, who may come in direct contact with contaminated soil and, due to the 'hand to mouth' activity, may ingest particles of contaminated soil.

Photo: Former industrial site close to residential areas in Albania © Gordon McInnes, 2003

In the United Kingdom, targets have been established to minimise the consumption of agricultural land and the recycling of previously developed land is regularly monitored. The percentage of new building on previously developed land exceeded 60 % in 2003, while the share of new dwellings converted from existing buildings on previously developed areas increased from 54 % to 73 % in the period 1990–2005. In Germany, where almost 34 000 ha were lost to development in 2003 — 80 % for human settlements — targets have been set to reduce the conversion of greenfields ([4]) by more than 65 % or to 30 ha/day by 2020 (Thornton, G. *et al.*, 2006). However, as data on the redevelopment of urban areas are patchy and not really comparable, partly as the result of the lack of common definitions — for example of brownfields, it is difficult to draw pan-European conclusions (EEA, 2007; Cabernet, 2004).

If, on the one hand, brownfield redevelopment provides many opportunities for improving the quality of life in urban areas, on the other it presents many challenges. In Ireland, for example, brownfield redevelopment is reported to be the cause of a recent increase in the volume of hazardous waste: contaminated soil was the largest single hazardous waste type generated in 2004, accounting for more than 45 % of total reported volumes (EPA, 2006). This reflects the fact that contaminated soil is frequently treated as waste to be disposed of, rather than as a valuable resource that can be cleaned and reused. Again, in Albania the enforced destruction of illegal buildings has created huge amounts of construction waste that may contain toxic material, such as asbestos, in a country that has no capacity for its treatment.

To increase the uptake of both contaminated and non-contaminated brownfield sites for redevelopment, there is a need for the implementation of a complete package of measures, including economic, legal and fiscal incentives (Thornton, G. *et al.*, 2006). In the period 2000–2006, the EU structural funds for the EU-25 included EUR 2.25 billion for the rehabilitation of industrial sites and about EUR 2 billion for the rehabilitation of urban areas (ENEA, 2006). This has been translated into national operational programmes — in Italy, for example, in the same period, expenditure from EU structural funds, together with other public and private sources, were targeted to finance the clean-up of 17 out of the 54 contaminated areas, the remediation of which was identified as being in the national interest. The total estimated cost of this programme was EUR 770 million (ISS, 2005).

([4]) The term 'greenfields' indicates land — agricultural or other land — which is undeveloped, as opposed to brownfields.

2.4.3 Soil in rural areas

The soil threats analysed here for EECCA and SEE countries are diffuse contamination by the agricultural sector, and air depositions, physical degradation as a result of erosion or compaction, salinisation, and the impacts of wars.

The major problems causing degradation of soil in rural areas of SEE are poor agricultural practices, especially inefficient irrigation schemes, the overuse and stockpiling of chemical fertilizers and pesticides, and mining operations (UNEP, 2003). In EECCA, the main causes are the over-use of agrochemicals, especially organic pesticides (see also Sections 2.5, Hazardous chemicals; and 7.1, Agriculture), large-scale irrigation and drainage schemes, irrigation with waste water that contains industrial and livestock farm effluents, salinisation and water logging, and the uncontrolled storage of mineral fertilisers. Water and wind erosion, compaction and degradation of the permafrost layer in the northern latitudes are additional main factors in play. New legislative instruments and programmes aimed at reducing and preventing soil degradation are being put in place, some of which have been devised within the frameworks of international conventions such as UNCCD. However, these often lack explicit financial support, hampering their implementation.

In the Caucasus and Central Asia, the harsh climate and topography, coupled with the pressures caused by the concentration of population in certain areas, make the soil particularly vulnerable. Transboundary environmental problems are particularly important around the Aral and Caspian seas, while parts of the territory are still affected by conflicts (UNEP/GRID, 2006; UNEP, 2005). The situation is made worse by the recurrence of natural phenomena such as earthquakes, landslides, floods, droughts and extreme weather events, which can aid the spread of contaminants, even to remote areas. To help solve these problems, some action is being taken through the Regional Environmental Action Programme for Central Asia (CA REAP), which identifies land degradation as one of the main environmental priorities for the region (UNEP, 2006).

Chemicals and unexploded ordinance

Deposits of obsolete pesticides and pharmaceuticals pose risks in most SEE and EECCA countries, with the IHPA ([5]) estimating that stockpiles of obsolete pesticides may exceed 60 000 and 180 000 tonnes respectively in the two regions (IHPA, 2006; see Sections 2.5, Hazardous chemicals; 2.3, Inland waters; and Chapter 6, Sustainable consumption and production for more details). Measures have been taken to improve the storage of agrochemicals, but these are insufficient to cope with the problem, so in the Republic of Moldova, for example, a project funded by the World Bank is expected to eliminate 1 150 tonnes of obsolete pesticides in the period 2006–2007 (see also Section 2.5, Hazardous chemicals).

In Belarus, radionuclides from Chernobyl have contaminated nearly 4.5 million ha, almost 40 % of which is agricultural land, and more than 20 % of the country's area (Ministry of Natural Resources and Environmental Protection, 2006). The total cost of the damage resulting from the loss of productivity of agricultural land, forests and mineral deposits is likely to reach USD 235 billion by 2015 (UNECE, 2005).

In Ukraine, fallout has affected more than 6 million ha, contaminating large areas of forest and agricultural land, including highly fertile soils (Ministry of Environment of Ukraine, 2007). Some 5–7 % of the Ukrainian annual state budget is being used to alleviate the consequences of the disaster, with nearly USD 7.5 billion having been spent in the period 1991–2005 (UNECE, 2006).

In Bosnia and Herzegovina, the European country worst affected by land mines, minefields extend to over 4 % of the land area, rendering some 10 000 hectares of agricultural land and 20 % of the forests unusable (ICBL, 2005). In Croatia 2 % of the land area, inhabited by about 1 million people, is still mined (ICBL, 2006). Clearance is difficult, slow and costly, and is likely to take many years, but annual budgets are persistent. In Croatia, for

([5]) International Hexachlorocyclohexane and Pesticide Association.

Box 2.4.2 Flooding — export/import of 'brown water'

The extreme floods of recent years are a reminder that water takes everything. Additional to the loss of human life and the economic impacts, floods transport large amounts of soil downstream. Ecosystems close to the river are affected, upstream by erosion and downstream by sedimentation, but little is yet known about the composition of the transported material. However, the expected consequences of climate change and changing precipitation patterns are likely to make full analyses of the process more important in the near future.

The transboundary nature of this challenge is obvious. It shows the requirement to address soil issues in the context of river catchments for which a clear understanding of the soil conditions in different catchments, through an increase exchange of information and experience, will be needed. An example of future EU instruments to address this issue is the proposed directive on the assessment and management of floods in which soil is mentioned as a relevant aspect of flood risk management.

Source: European Commission, 2006b.

Photo: Flooding in the area of river Regen, Bavaria © www.agroluftbild.de

example, EUR 250 million were spent between 1998 and 2005, while total de-mining costs are estimated to eventually run to EUR 1.5 billion (ICBL, 2006).

Water and wind erosion

In SEE, soil erosion caused by water and, to a lesser extent, by wind is both severe and widespread. The abandonment of agricultural areas and their subsequent reversal to permanent vegetation may have contributed to a reduction of erosion in some places, but in mountain areas, which cover a large part of the region, the lack of maintenance of terraces may actually have increased erosion. In some countries the whole area under risk may extend to 80–90 % of the national territory, as in Albania, Bosnia and Herzegovina, Croatia, Serbia and Montenegro, and Turkey (SOVEUR, 2000). Large parts of the territory are already irreversibly degraded — in some areas, such as the Croatian karstic region, the soil layer has completely disappeared. Structural changes in land ownership, with increases in the number of larger farms, are expected to intensify the risk of future erosion.

Effects include the loss of soil fertility, land abandonment and increased hydro-geological risks. In Bosnia and Herzegovina, half the arable land was not used in 2001, while annual losses, caused by mismanagement, expansion of the karstic area and forest fires, amounted to an annual average of 10 000 ha in 2002–2003. Hydro-geological risks — flooding and soil mass movements — concern large portions of the region; indeed several disastrous events have occurred as a result of extreme weather or accidents, with important social and economic impacts (see Section 2.3, Inland waters).

Considerable efforts to deal with erosion have been made in some countries. In Turkey, for example, 1.2 million ha were restored between 1992 and 2004 (MEF-T, 2006). Further progress is expected with the implementation of the 2005 law on soil protection and land use.

In the western part of EECCA, water erosion affects more than 35 % of the Republic of Moldova and 30 % of Ukraine. Wind erosion is worst in

Belarus, where nearly 20 % of the total area is impacted, and in the drier areas in the southeast European part of Russia and Ukraine (SOVEUR, 2000; UNECE, 2006; Ministry of Natural Resources and Environmental Protection, 2006; Ministry of Environment of Ukraine, 2007).

The impacts of erosion, such as the transfer of contaminants, can be severe. These include economic losses: in 1998 in Ukraine these amounted to nearly EUR 1.5 billion (TACIS, 1998a) and between EUR 35–43 million in the Republic of Moldova, while the benefits of soil conservation measures were valued ten times higher (TACIS, 1998b). Although these data are old, they remain the best currently available.

Soil erosion is most severe in those parts of Central Asia and the Caucasus with steep slopes, a harsh climate and strong winds, and where inadequate land management practices have accelerated the process. These include farming on land with steep slopes and fragile, shallow soils; overgrazing; deforestation; and inefficient irrigation. To make matters worse, energy shortages have dramatically increased demands for fuel wood resulting in deforestation. Other drivers of erosion include land privatisation when private owners do not have the means to maintain anti-erosion measures or apply other environmentally friendly practices; flooding; and rising levels of water bodies, contributing to the erosion of coasts and river banks, especially in the Caspian coastal areas.

Erosion is perceived as an environmental priority in all countries of Central Asia and the Caucasus due to its serious effects on agriculture, food security and livelihoods, and its links to desertification. Crop yields can be seriously impacted, as in Armenia where losses in grain production due to erosion have been estimated to amount to 50 000—60 000 tonnes per year (UNECE, 2000). This, in turn, contributes not only to food shortages but to the loss of livelihoods in countries such as Tajikistan, where agriculture employs large parts of the population.

Salinisation and water logging

Salinisation and waterlogging alter soil quality and reduce crop yields, thereby reducing an area's capacity to produce food, which in turn has severe socio-economic implications.

According to conservative estimates gathered from various sources, salinisation affects nearly 50 % of the total irrigated land area — 15 % of all arable land in Central Asia. The worst situation is found in the region around the Aral Sea where up to 95 % of the territory is affected. Salinisation is also reported in the lowlands of the southern Caucasus, where it covers nearly 1 million ha, corresponding to 40 % of the total irrigated land or about 30 % of the total arable land (World Bank, 2003). Economic losses can reach 40–60 % of the yield in moderately salinised areas, with peaks of 80 % in severely salinised ones (World Bank, 2003). In Turkmenistan, for example, the direct economic damage of yield losses was estimated to be well over USD 140 million, while the cost of the rehabilitation of salinised land amounted, in 2001, to about USD 65 million (UNEP, 2006).

Salinisation and waterlogging are also found in the western part of the EECCA region. In Ukraine, they are estimated to affect about 3 % and 12 % of the total land area respectively — 9 million ha in total (Ministry of Environment of Ukraine, 2007). Although in the Russian Federation these problems cover a smaller part of the territory, they nonetheless have severe impacts (IIASA, 2002; SOVEUR, 2000).

Most remediation projects at the local level focus on improving irrigation systems and the efficiency of water use, and maintaining drainage systems. Many of these projects are linked to programmes to combat desertification and other international programmes and are mainly funded by international sources.

Compaction and permafrost

Compaction — mainly caused by bad agricultural practices and in particular the use of heavy machinery, more common in the past but still used today as a result of the inability of farmers to acquire new equipment — is the most widespread form of degradation in the cultivated areas of the western part of the EECCA region, especially in the Republic of Moldova, the Russian Federation and Ukraine, and it is often found in combination with surface crusting. In Ukraine, for example, it affects

Box 2.4.3 Frozen ground

Permafrost is ground that is at or below the freezing point for water for two or more years. This definition only depends on temperature and not on the soil moisture content, the nature of the ground or its location. Permafrost may consist of mineral or organic soil (Cryosols), rock or ice and can occur on land or under offshore artic continental shelves. Its thickness may range between less than one metre to more than one kilometre.

Source: National Snow and Ice Data Center internet: http://nsidc.org/sotc/permafrost.html. Last accessed May 2007.

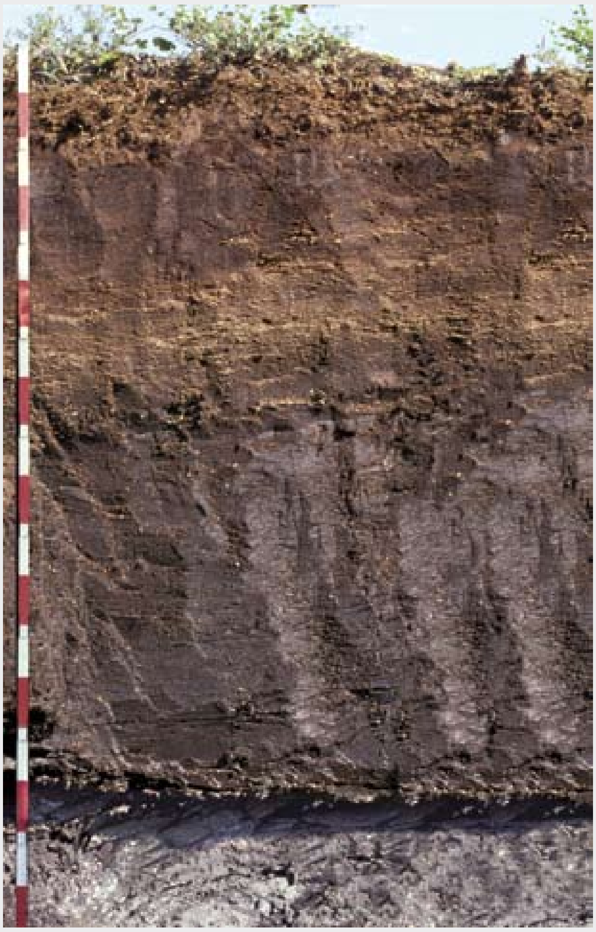


Photo: A frozen, organic-rich soil (Cryic Histosol) located to the west of the Ural mountains in northern Russia. The photograph clearly shows both the frozen soil and the ice layer at the base. © Andreas Lehmann, 2004

nearly 40 % of the total land (SOVEUR, 2000), while in the Russian Federation, it covers more than a quarter of the agricultural land (IIASA, 2002).

About 65 % of the land area of the Russian Federation is covered with permafrost (IIASA, 2002) ([6]) , the top layers of which are very sensitive to temperature increases and disturbance. Its degradation is due to both natural seasonal changes in temperature and human-induced climate change. The melting of permafrost increases the risk of flooding and of surface mass movements, such as landslides and the slow flowing of soil down-slope over an impermeable layer, a degradation process known as 'thermokarst'. Many ecosystems in northern latitudes depend on permafrost conditions and thermokarst can have major impacts, such as replacing boreal forests with wetlands (in the case of 'wet thermokarst') and replacing boreal forests by steppe-like habitats (in the case of 'dry thermokarst').

Moreover, as the permafrost melts, the decomposition of organic material in the soil provokes the release of large quantities of CO_2 and CH_4, powerful greenhouse gases, thus in turn potentially contributing to global warming. Western Siberia has warmed by up to around 3 °C in the last 40 years or so (Pavlov *et al.*, 2004). Impacts on the permafrost include melting of the world's largest frozen peat bog which could unleash billions of tonnes of trapped CH_4 into the atmosphere and at the same time dramatically alter valuable landscape and ecosystem characteristics (see also Chapter 3, Climate change).

2.4.4 The way forward

The ecological and socio-economic functions provided by soil are essential to the social and economic well-being of Europe and as such deserve to be addressed more fully both in scientific and policy terms. These functions include soil as a source of biomass and support to food production, as a filter and buffer that reduces the harmful effects of pollution, as a home for a wide range of biodiversity, as support to human settlements, as a source of

([6]) OECD EPR, 1999 reports a 40 % coverage of permafrost.

raw materials, and as a store for carbon and other elements. The latter function in particular could become much more important in the context of future climate change risks.

In the SEE and the EECCA regions, the direct causes of soil degradation are exacerbated by socio-economic factors such as limited budgets for protection and restricted access to cleaner technology, and natural factors such as high seismic, hydro-geological or climatic risks. Together these can trigger consequences such as the loss of livelihoods, unemployment and poverty leading to mass migration and land abandonment.

The transboundary effects of soil contamination are worsened by differing national regulations and environmental standards, suggesting that concerted regional initiatives are necessary — some programmes, such as the Regional Environmental Reconstruction Programme (REReP), are reported to have generated good results (REC, 2006). Nonetheless, the relationship between the reduction of degradation and progress in policy in the regions cannot be analysed sufficiently due to gaps in existing data.

Many countries across Europe do not have specific legislation covering the management of contaminated sites: rather issues are often addressed within general environmental, waste management or water regulations. The adoption of measures to prevent new contamination and introduce risk-based management options for tackling historical soil contamination would help greatly in countries lacking specific legislation. In particular, efficient permit systems to prevent new contamination and promote best practices in the management of existing contamination are measures that have been shown to work.

The establishment of systematic inventories of contaminated land, use of appropriate technologies and techniques for clean-ups, and the establishment of specific funds and economic instruments are other measures to be considered. In WCE environmental permit and risk management systems, together with national and EU legislation and the application of the polluter-pays principle, have contributed to a substantial improvement.

Consideration should also be given to minimising the pressures on the environment associated with agricultural production. These include measures to minimise erosion and increase the efficiency of irrigation systems, implementation of good farming practices, introduction of sustainable farming systems, organisation of services providing advice, training and support to farmers, and increased investments in environmental measures (see also Section 7.1, Agriculture).

The keys to progress towards sustainable use of soil across Europe remain better integration of soil protection into sectoral, local and regional policies, and spatial planning instruments in particular, implementation of preventive measures, and widespread introduction of proven best practices. Further progress on the implementation of international conventions such as the UNCCD could provide opportunities and important additional resources, especially for those countries which are not directly involved in the EU accession processes.

Although existing monitoring and modelling activities on soil produce a wealth of data, their varied formats and poor targeting in terms of policy priorities and future risks make these wholly inadequate as a basis for enabling organisations, such as the EEA and UNEP, to undertake assessments that are robust enough to support the monitoring of the impacts of policy actions. To make matters worse, there are increasing pressures on national budgets for soil monitoring and modelling, and in many countries soil studies are being given lower priority, with the result that, in future years, there is likely to be a shortage of qualified personnel to undertake monitoring and modelling activities in parts of Europe.

The importance and complexity of analysing current risks, especially climate change, emphasise the need for new thinking on mechanisms to ensure that the evidence base for soil meets future policy challenges. The UN Intergovernmental Panel on Climate Change (IPCC) and the proposed mechanism under the EU biodiversity communication (European Commission, 2006c) to provide independent, authoritative, research-based advice to policy-makers are the types of mechanisms that could be considered in the area of soil.

2.5 Hazardous chemicals

Photo: Vaskh obsolete pesticide storage sites, Tajikistan
© ENVSEC Ferghana Valley Programme, 2006

Key messages

- The chemical industry has been growing worldwide and is economically significant in Europe, especially in the EU, Switzerland and the Russian Federation. The production of toxic chemicals has increased at almost the same rate as the total chemical production, and both have grown faster than the GDP. Since the Kiev conference, about one billion tonnes of toxic chemicals have been produced in the EU. Demand for chemicals is now increasing across EECCA and SEE countries, leading to rising imports.

- Past accident and other sites, sometimes contaminated with obsolete chemicals, continue to have environmental impacts.

- New problems are appearing, resulting from exposures to low levels of an increasing number of chemicals, often in complex mixtures. New risks from 'old' pollutants are also becoming evident in the light of increased scientific knowledge and new uses.

- There is still a lack of data on inherent properties — hazards — and on exposures, sources of releases, hot spots, and associated risks. Only 14 % of more than 2 000 high production volume chemicals (HPVCs) had basic toxicity information in 1999 and there has been little improvement since then.

- The economic cost of late action — both in terms of remediation of contaminated sites and health impacts — can be high. Implementation of the new EU legislation on the Registration, Evaluation and Authorisation of Chemicals (REACH) is estimated to result in benefits 2 to 50 times higher than the costs.

- Globalisation is resulting in a shift of environmental burdens to developing countries, and the re-importation of hazards via transboundary pollution and contaminated products.

- The lack of relevant data and information covering the whole region means that it is not possible to conclude whether serious threats from chemicals to human health and the environment have been reduced since the Kiev report.

- The past few years have seen important new agreements and legislation, both in Europe and globally, that address the safer handling and management of chemicals to protect both human health and the environment. Successful implementation of these agreements, which is being urgently called for, requires that they be linked to other environmental policies and fully incorporated in the social and economic development strategies of countries in the UNECE region.

2.5.1 Introduction

'The sound management of chemicals is essential for the protection of human health and the environment, and [for] sustainable development. It is consequently important for the Millennium Development Goals and the World Summit on Sustainable Development (WSSD) Johannesburg Plan of Implementation goal that by 2020 chemicals are used and produced in ways that lead to the minimization of significant adverse effects on human health and the environment.'

Source: IOMC, 2006.

Significant progress has been made on the policy front with regard to the sustainable management of chemicals since the Kiev assessment. At EU level, this includes the Registration, Evaluation and Authorisation of Chemicals (REACH) legislation, and the integrated pollution prevention and control (IPPC). The global harmonised system on classification and labelling (GHS) was agreed and two major conventions entered into force, the Stockholm Convention on Persistent Organic Pollutants (POPs) and the Rotterdam Convention on Prior Informed Consent (PIC). The Strategic Approach to International Chemical Management (SAICM), adopted by the UN International Conference on Chemicals Management and the Global Ministerial Environmental Forum (Dubai, 2006) renewed the United Nations Conference on Environment and Development (UNCED, Rio, 1992) target of global implementation of the sound management of chemicals, 'so that, by 2020, chemicals are used and produced in ways that lead to the minimization of significant adverse effects on human health and the environment' (IOMC, 2006). An EU goal in the Sixth Environment Action Programme (6EAP) strengthens this commitment.

Nonetheless, it has not been possible to conclude whether significant threats to human health and the environment are declining because of a lack of comparable and systematic data on emissions, environmental concentrations and the impacts of hazardous chemicals. The decreasing environmental loads and human-body burdens of some regulated chemicals clearly show that risk reduction measures can be successful. However, the identification of new risks may require adapted or additional measures, as in the case of heavy metals and chemicals of emerging concern. Overall, progress in bringing the problems under control is slow, especially for persistent chemicals that have been produced in large quantities.

This section examines the latest trends in chemical production, and potential environmental and human exposures. It focuses on recent information about both well-known chemicals and emerging issues; describes potential exposures from consumer products, contaminated sites, obsolete chemicals, and industrial accidents; and discusses recent progress in policy responses for the sound management of chemicals.

2.5.2 Trends in production of hazardous chemicals

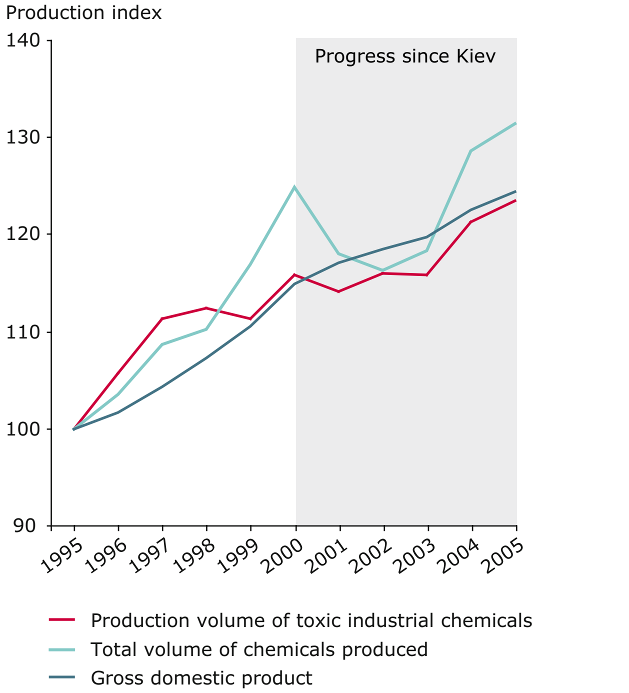
The increasing production, trade, and use of manufactured goods — electronics, clothing, cars, etc. — account for most of the flows of chemicals in today's society, and thereby increasing exposure to them of people and the environment (ASEF, 2006).

European countries contribute significantly to the global trade in chemicals, which increased by an average of 14 % a year between 2000 and 2005 (WTO, 2006a). The EU-25 and Switzerland together have a 59 % share of world exports and 48.4 % of world imports. Although EECCA accounts for just 1.8 % of world exports and 2.1 % of imports (WTO, 2006a), the Russian Federation's exports grew by 13 % from 2000 and in 2005 its trade in chemicals was valued at USD 13.2 billion. Exports from Belarus, Kazakhstan and Ukraine are also increasing, while the trade in chemicals in Armenia, Azerbaijan, Georgia, Kyrgyzstan and the Republic of Moldova is characterised by higher imports than exports, with demand increasing, for example for agrochemicals and consumer products (WTO, 2006a; 2006b). In SEE there is a similar trend, with increasing imports and, to a lesser extent, exports between 2001 and 2005 (WTO, 2006b).

The EU chemical industry has grown faster than gross domestic product (GDP) over the past ten years, with the production of industrial chemicals increasing by 31 % and GDP by 25 % between 1995 and 2005. Production of toxic chemicals ([1]) increased by 23.5 % and that of the most dangerous — carcinogenic, mutagenic and repro-toxic chemicals (CMR) by 22 % (Eurostat, 2006).

The annual production of toxic industrial chemicals in the EU-25 in 2005, as registered in the Prodcom database, was 212 million tonnes (see Figures 2.5.1 and 2.5.2), of which 9.3 % was in new EU Member States. In all, since the Kiev conference, about one billion (1 000 million) tonnes of toxic chemicals have been produced in the EU. Comparable information is not currently available for EECCA countries.

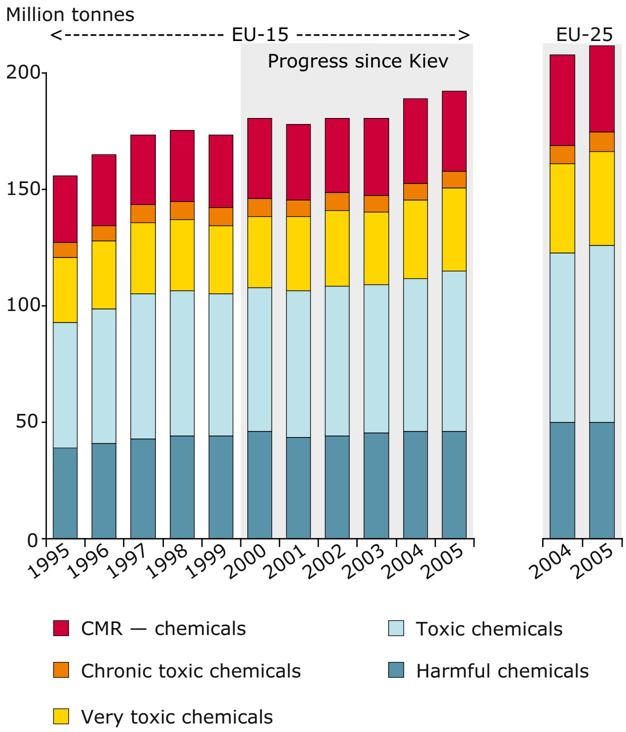
Figure 2.5.1 Production volumes of industrial chemicals relative to GDP for EU-15 Member States 1995–2005



Note: The indicator of total production of toxic chemicals is compiled for 168 toxic chemicals using production quantities collected under the 'Prodcom Regulation' (Council Regulation (EEC) No 3924/91 on the establishment of a Community survey of industrial production). The toxicity classes have been assigned according to the classification and labelling system ('risk phrases' or R-Phrases) designated for the individual substances in Annex VI to the 'Dangerous Substances Directive' 67/548/EEC as amended (Eurostat, 2005; 2006; for further details on the methodology, see Eurostat, 2006a).

Source: Eurostat, 2006 derived from production statistics.

Figure 2.5.2 Production of toxic chemicals in the European Union *



Note: * = Confidential data have been excluded, but make no significant difference to the result.

Source: Eurostat, 2006, derived from production statistics.

The chemical industry has been a leading innovator in environmental technologies compared with other industries and organisations (Arduini and Cesaroni, 2004; European Commission, 2005). Driven by environmental regulation and economic interests, the number of patent applications by chemical companies, for example, have been higher for clean technologies — one of the 12 principles of green chemistry (Anastas, 1998) — than for end-of-pipe solutions.

2.5.3 Some chemicals of concern

The lack of sufficient information about inherent properties and environmental monitoring data for

([1]) Those classified as toxic according to the EU legislation, Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances.

chemicals have long been identified as problems that seriously impair the analysis, evaluation and assessment of potential threats to humans and the environment (European Commission, 2001; EEA, 2003; UNEP, 2003).

A study by the European Chemicals Bureau (ECB) on data availability in 1999 showed that base-set (2) data were only available for 14 % of more than 2 000 EU high production volume chemicals (HPVCs); for 65 % there was less than base-set data, and 21 % had no data at all (Allanou *et al.*, 1999). This situation had not changed significantly by 2006 (ECB, 2006).

The International Council of Chemical Industries Associations (ICCA) initiative on high-production-volume chemicals (HPVCs), launched in 1998 to bring the data sets for more than 1 300 HPVCs to the level of the OECD SIDS (3) data package, itself comparable to the EU base set, by 2004 has only partly reached its target. By October 2005, a total of 334 ICCA chemicals had been assessed, and the ICCA list had been extended to 1 428 HPVCs (ICCA, 2006) (4).

Emissions and releases of chemicals can occur during every stage of their lifecycles, from production and processing, through manufacturing, their use in downstream production sectors and by the general public, to disposal. Any of these can lead to localised pollution, for example from poorly managed industries, contaminated sites, or accidents, and to diffuse releases causing long-term exposure to low levels of individual or mixtures of chemicals. For chemicals used in long-life articles — such as construction materials — emissions related to their disposal can occur several decades after their production and processing. This is one reason why some chemicals are still found in the environment or in human tissue long after they have been withdrawn from use.

Public information about industrial emissions in the EU has been available via the European Pollutant Emission Register (EPER) since 2004. This is the first register of industrial emissions to air and water, and gives access to information on annual emissions from about 12 000 industrial facilities in the EU-25 and Norway (5) (see also Section 2.5.4, Policy responses for sound management of chemicals). The European Pollutant Emission Register (EPER) review report 2004 reveals that about two-thirds of the 50 air and water industrial pollutants have been decreasing. These include nitrogen pollutants released into water bodies (– 14.5 %), the various types of phosphorus (– 12 %), and the emissions of dioxins/furans (– 22.5 %) into the atmosphere. An upward trend can be observed in emissions of certain pollutants, such as carbon dioxide which increased by 5.7 % between 2001 and 2004. In 2004, key tools to control carbon dioxide emissions such as the Emissions Trading Scheme (ETS) were not yet in place (European Commission, 2007; EEA, 2007).

There are increasing concerns about environmental and health effects of diffuse chemical releases arising from consumer products and unintentional by-products, such as PAHs and dioxins from industrial or traffic-related combustion (see also Section 2.1, Environment and health perspective). The United Kingdom Royal Commission on Environmental Pollution concluded that diffuse pollution from products is 'more pervasive and more difficult to detect and correlate with adverse effects on the environment and human health' than that released accidentally during the production process (RCEP, 2003).

One way of signalling the extent to which consumer products pose a risk to human health is through the EU rapid alert systems. These include the Rapid Alert Systems for Food and Feed (RASFF) and the Community Rapid Information System (RAPEX) for non-food consumer products — cosmetics, clothes, toys, jewellery, etc. Through these two indices the system records the number of health risks reported for consumer products (Box 2.5.1).

(2) The base set is the information requirement defined in Annex VIIa of Directive 67/548. It is comparable to the OECD Screening Information Data Set and includes physico-chemical properties, results of environmental fate testing, results of environmental effects testing, and results of health effects testing.
(3) Screening Information Data Set (OECD).
(4) http://www.cefic.org/activities/hse/mgt/hpv/progress.htm. Accessed 30 January 2007.
(5) http://www.eper.ec.europa.eu/.

Box 2.5.1 The EU rapid alert system for consumer products

- The rapid alert system for consumer products gives a rough indication of the number and character of risks posed to human health. It has two components:
  - a system for food/feed products (RASFF) — includes risk categories such as pathogenic micro-organisms, heavy metals, residues of veterinary medicinal products, and chemical contamination;
  - a system for non-food consumer products (RAPEX) — includes risk categories such as allergies, cancer, chemical risk injuries, electric shock, and fire risk.
- This notification system allows EU Member States to take immediate action once a risk from a consumer product has been reported through a quick information-exchange system.
- Under the RASFF system for food/feed products, 386 out of 3 228 risk notifications in 2005 were for chemical risks, including from heavy metals and residues of veterinary medicines. The main notification categories were mycotoxins (31 %) and pathogenic micro-organisms (27 %).
- In 2005, the vast majority of RASFF notifications arose from border or market controls while only 71 out of the total of 3 228 resulted from a company's own checks. There was 22 % increase in notifications in 2005.
- Under the RAPEX system for non-food consumer products, 95 out of 1 051 risk notifications in 2006 were for chemical risks. The main categories included injuries (25 %), electric shock (24 %) and fire risk (18 %).

Source: European Commission, 2006; 2007.

In 2005 the RASFF registered a significant increase in hazards arising from materials which are in contact with food, such as the migration of lead from ceramic ware, the migration of chromium and nickel from metal ware, or the migration of isopropyl thioxanthone from carton packages — notified for the first time. In case of plastic materials and articles, rapid alerts of primary aromatic amines (PAA), suspected human carcinogens, were in most cases related to migration from kitchen utensils made of nylon imported from China (European Commission, 2006).

As the People's Republic of China is rapidly becoming one of the largest exporters of consumer products to Europe and was indicated in 48 % of all notifications under the RAPEX system, the EC signed a Memorandum of Understanding with the Chinese authorities in 2006 to enhance the safety of a wide range of products as well as a specific roadmap for safer toys (European Commission 2006; 2007).

Old problems and new concerns

New uses, improved analytical methods, and increased knowledge of hazardous properties have led to environmental concerns about chemicals that had not previously been regarded as problematic. Nonetheless, other compounds, such as heavy metals, polyaromatic hydrocarbons, dioxins and PCBs that have been regulated and monitored for a long time, continue to pose problems because of their persistence, their use in new technologies including nanotechnology, newly identified exposure routes such as the case of acrylamide in food (ECB, 2002); or other concerns, for example pesticide spraying leading to chemical exposure of people living nearby or passing fields (RCEP, 2005).

Contaminated sites and obsolete substances

Industrial and agricultural activities in countries where disposal of waste has been unsustainable have created a legacy of environmental and economic impacts. The storage and disposal of obsolete chemicals, including pesticides, have been identified as major environmental problems in many EECCA and SEE countries — and are still relevant in EU Member States (UNEP, 2006; BauA, 2000; see Chapter 6, Sustainable production and consumption).

Environmental hazards from stocks of obsolete chemicals include leakage to soil and groundwater, volatilisation or dispersal to air of pesticide dusts on contaminated soil particles, and contamination of vegetation. This can lead to direct or indirect acute and chronic toxic effects in humans, livestock and wildlife resulting from environmental contamination or via the food chain (see also Section 2.4, Soil).

Box 2.5.2 Reducing the burden of the past: soil clean-up activities in Albania

Former chemical plant in Bishti I Palles, Durres

The storage areas of this factory in Bishti I Palles contained 106 tonnes of carbon disulphide, 56 tonnes of dimethylamine, 10 tonnes of ethylenedieamine and 9 tonnes of trimethylamine in metal drums, as well as 400–500 tonnes of HCH isomers in plastic bags. The site has been cleaned up with support from the Dutch government, which provided about EUR 2 million for clean-up, repackaging and removing the hazardous substances for treatment outside Albania. The project was successfully finalised in 2006, and most indicators for groundwater, surface water and air are now within the limits.

Former Lindane and Dichromate factory in Porto-Romano, Durres

The former Lindane and dichromate factory and a nearby dumpsite are located some 6.5 km north of Durres city. After clean-up activities were completed, monitoring results still demonstrated very high levels of persistent and toxic substances. For example, the level of HCH isomers in milk was approximately 50–100 times the German limit of concern and the measured level of chlorobenzene in drinking water was more than 4 000 times the German limit of concern.

Former Soda-Polyvinylchloride (PVC) Plant in Vlora

In PVC production, elemental mercury (Hg) is used as a catalyst. On about 11 hectares of the plant, near the electrolysis building, mercury concentrations in the top 250 mm of soil are between 10 mg and 100 mg/kg with hot spots showing up to 20 000 mg/kg. In the air, the concentration of mercury was far above the quality limit of 50 ng/m^3: 30 000 ng/m^3 around the electrolysis building and near the vinyl chloride station; and 10 000 ng/m^3 in the area of the sludge depository.

Marine deposits at the sewerage outlet contain 2 010 µg Hg/kg, and levels are still 50 µg Hg/kg 550 m from the shore. High mercury concentrations have also been detected in Vlora Bay water: 22.5 ng Hg/l compared with 2.8–6.8 ng Hg/l in the Adriatic Sea, and in sediment: 0.34 mg/kg compared with 0.05–0.1 mg/kg in other areas of the Mediterranean sea. Mercury concentrations in Vlora Bay mussel samples are 0.29 mg/kg, higher than those in other areas on the Albanian shoreline (0.02–0.04 mg/kg).

Photo: Bor mining complex, Albania © ENVSEC Ferghana Valley Programme (2006)

Source: NRC Chemicals, Albania.

Although much uncertainty is associated with the stock-taking of obsolete chemicals, the International HCH and Pesticides Association (IHPA) has put a lot of effort into providing up-to-date estimates of known stockpiles. The historical use of hexachlorocyclohexane (HCH) and the production of the pesticide Lindane (gamma-HCH), for instance, have led to an estimated total of 1 600 000–1 900 000 tonnes of HCH wastes worldwide, including 150 000–500 000 tonnes in eastern Europe (IHPA, 2006).

Since the Kiev assessment, total quantities of identified stocks of obsolete chemicals have increased due to IHPA efforts. However, many clean-up activities have been initiated with some having been successfully finalised (Box 2.5.2). In the Republic of Moldova, the removal of 1 150 tonnes of obsolete pesticides, financed by the World Bank, should be completed by the end of 2007. In Romania, through the EU Phare project, the Ministry of Agriculture, Forest and Regional Development was able to remove 2 300 tonnes of obsolete pesticides in 2006 (see also Section 2.4, Soil; and Chapter 6, Sustainable consumption and production).

Persistent organic pollutants and heavy metals

Heavy metals, such as mercury, lead and cadmium (see Box 2.5.3), and persistent organic pollutants (POPs), which include dioxins, polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB), are examples of chemicals that continue to occur in the environment at levels that are close to (eco)toxicological effect levels, despite restrictions on their production and use. After controlling emissions from industrial point sources, diffuse sources of these persistent and cumulative compounds are causing more and more concern.

For example, dioxins, a group of substances covered by the Stockholm Convention (see Section 2.5.4, Policy responses for sound management of chemicals) are not produced, but result from several industrial and combustion processes. Significant emissions are also found in connection with private burning of household waste (BUWAL, 2004). As dioxin releases from industry are heavily controlled, levels in biota, including food and human samples, have generally been decreasing (Van Leeuwen and Malisch, 2002), although high levels are still found in 'sinks' such as the Baltic Sea. However, such findings as a recent report from the environmental health biomonitoring programme in Flanders that demonstrated a significant association between exposure to dioxin-like compounds, PCBs or HCB, and fertility problems (Schoeters *et al.*, 2006; see also Section 2.1, Environment and health perspective) supported the introduction of new EU measures establishing stricter maximum levels for the sum of dioxins, furans and dioxin-like PCBs in

Box 2.5.3 Potential toxic effects of mercury, lead and cadmium

Mercury

Mercury compounds may affect human health in several ways. Of the highest concern is organic mercury — methylmercury — which is particularly harmful to the developing brain of the foetus and young child. Mercury persists in the environment and bioaccumulates in fish and other aquatic species, and can therefore be hazardous to humans through the consumption of contaminated food. Although the beneficial effects of eating fish normally outweigh possible hazards from contamination, for vulnerable groups, including pregnant women and young children, several EU Member States have already issued specific advice on limiting the frequency of consumption and volume of particular predatory fish, such as swordfish, marlin, pike and tuna. Also, in 2004, the European Commission issued targeted consumer advice on methylmercury in fish and fishery products, based on the scientific opinion of the European Food Safety Authority (Watanabe *et al.*, 1996; Clarkson *et al.*, 2003; European Commission, 2004).

Photo: Haidarkan Mercury plant, Kyrgyzstan
© ENVSEC Ferghana Valley Programme (2006)

Lead

The greatest concern for lead is its effects on the central nervous system in young children. Blood levels of lead in the population have been shown to drop quickly in response to reduced exposure as a result, for example, of phasing out leaded petrol (see Section 2.1, Environment and health perspective). However, in recent years adverse impacts of lead on the intellectual development of young children have been found at levels below those previously assumed to be safe — 100 µg/litre (Lanphear *et al.,* 2000; Canfield *et al.*, 2003; Fewtrell *et al.,* 2004).

Cadmium

Cadmium, a metal that is cumulatively toxic to plants, animals and micro-organisms, can be transferred from contaminated soil to crops and animals, and through food, on to people where it may affect kidneys and bones (ECB, 2003; UNEP, 2006a).

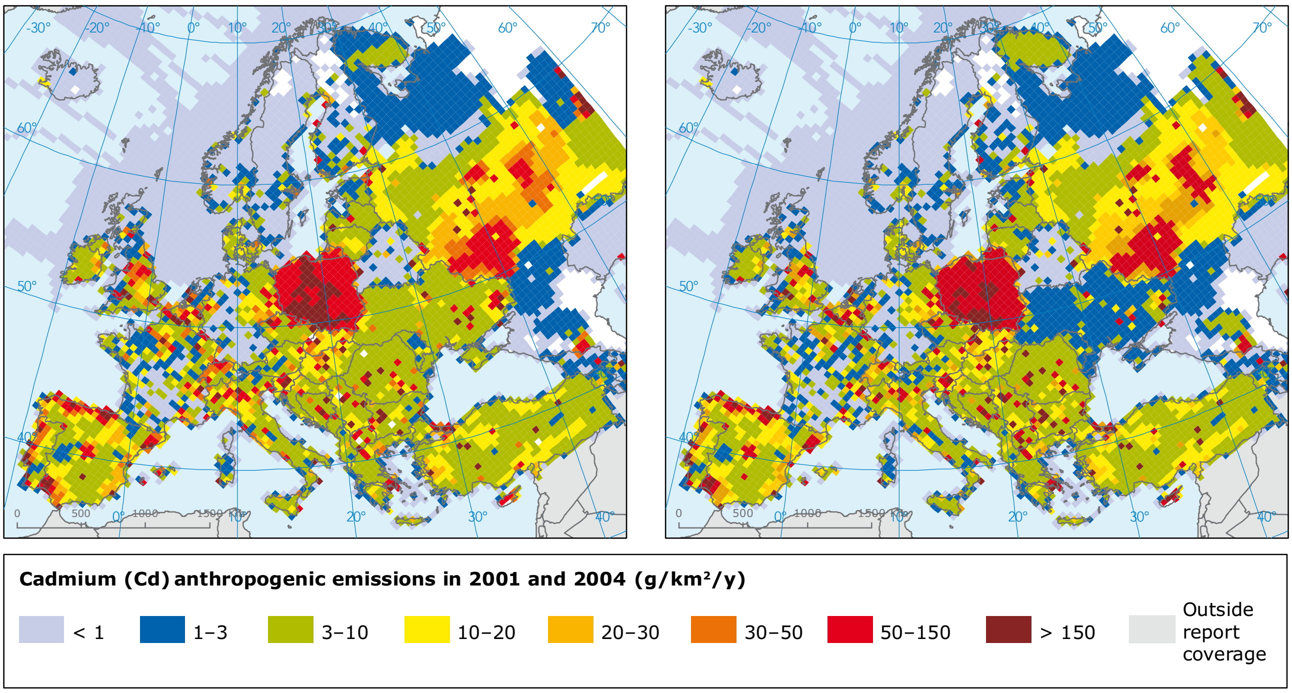
feed and food products, applicable from November 2006 (European Commission, 2006).

In EECCA countries, POPs contamination is also a problem, as confirmed by the national implementation plans provided by several countries under the Stockholm Convention. In Armenia, for example, the energy sector is one of the main sources of pollution with PCBs, present in oils used in electrical equipment. Residual amounts of DDT continue to be detected in environmental media — soil, surface water, and water from Lake Sevan, for example — foodstuffs and human organism. The monitoring data indicate the presence of Lindane and DDE in 87 % to 97 % samples of human breast milk from feeding mothers in rural regions of Armenia. Based on the assessment of 2000–2001, uncontrolled burning of wastes is the main source (58–92 %) of unintentional generation and emission of dibenzo-p-dioxins and dibenzofurans (PCDD/DF) to the air (Republic of Armenia, 2005).

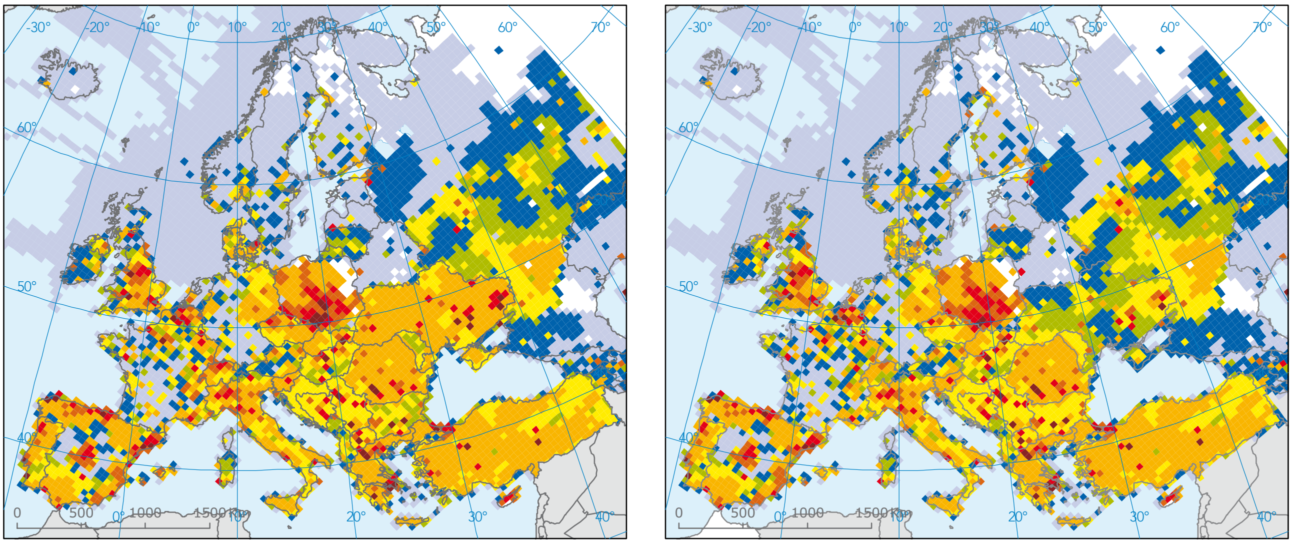
Mercury is a recognised global pollutant (UNEP, 2002) and is the subject of international and regional action plans, including those developed by the United Nations Environment Programme (UNEP), the Arctic Council and the EU (European Commission, 2005). In February 2007, UNEP's Governing Council concluded that current efforts to reduce the risks from mercury were not sufficient to address the global challenges and recommended further long-term international action (UNEP, 2007). With regard to lead and cadmium, it was agreed to complete the reviews of scientific information and report back to the Governing Council in 2009. These reviews will focus especially on long-range environmental transport in order to inform discussions on the need for global action.

Map 2.5.1 shows the spatial distribution of anthropogenic emissions of mercury, cadmium, and lead in the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) area in 2004 compared with 2001 (EMEP, 2005). High mercury deposition levels are characteristic of countries with high emission levels and also of the Arctic regions of Finland, Norway, the Russian Federation and Sweden, due to atmospheric and marine transportation processes known as 'the grasshopper effect' and 'mercury depletion' of the atmosphere in high latitudes causing preferential deposition in the Arctic (Environment Canada, 2004; EMEP, 2003).

Map 2.5.1 Anthropogenic emissions of heavy metals in the EMEP region

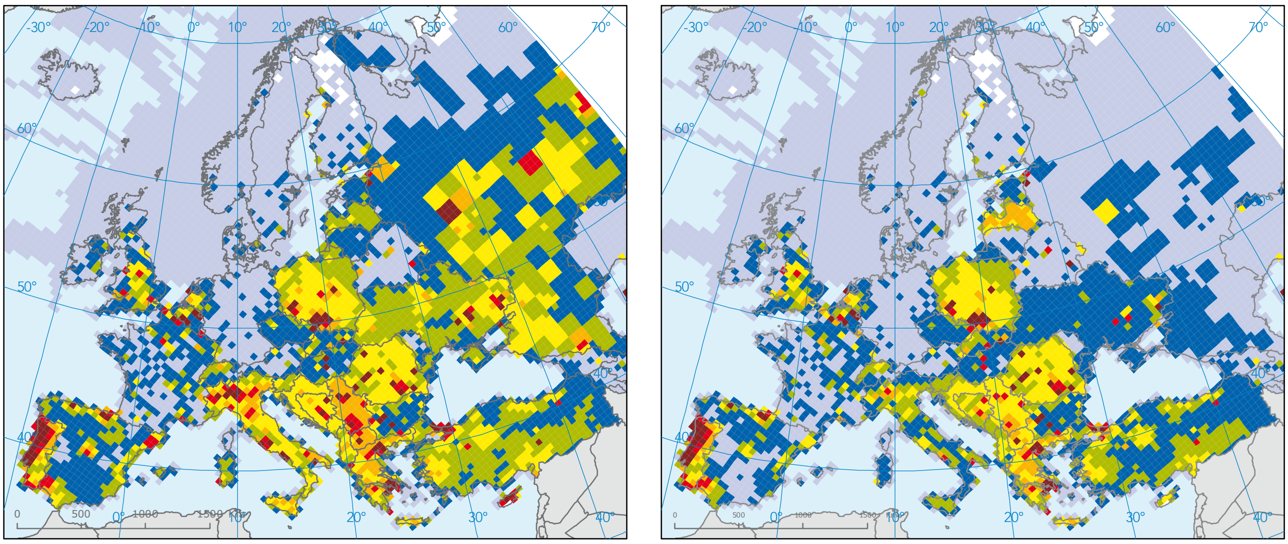


Map 2.5.1 Anthropogenic emissions of heavy metals in the EMEP region (cont.)



Mercury (Hg) anthropogenic emissions in 2001 and 2004 (g/km²/y)

< 1 | 1–3 | 3–5 | 5–10 | 10–50 | 50–100 | 100–300 | > 300 | Outside report coverage



Lead (Pb) anthropogenic emissions in 2001 and 2004 (g/km²/y)

< 0.1 | 0.1–0.5 | 0.5–1 | 1–2 | 2–3 | 3–5 | > 5 | Outside report coverage

Source: MSC-East, 2007.

Emerging chemicals

In the past, emerging chemicals often have only been detected by accident or as a result of research projects. The EU Water Framework Directive (WFD) (see also Section 2.3, Inland waters) now requires EU Member States to conduct investigative monitoring as well as regular surveillance controls. Criteria for the selection of substances for these surveys include high production volume, toxicity, bioaccumulation potential and persistence causing environmental degradation. The surveys provide information for setting priorities and the efficient focusing of further monitoring. Some countries have already implemented screening programmes:

Box 2.5.4 Emerging chemicals — are these the new POPs?

Brominated flame retardants (BFR)

BFR, which are used in many products including electronic equipment, upholstered furniture and car seats, are found everywhere in the environment: in European lakes (Kohler *et al.*, 2005), in deep ocean waters (de Boer *et al.*, 1998); in the Arctic environment; in humans worldwide, including in breast milk samples (Birnbaum and Staskal, 2004; Vieth *et al.*, 2005), and in the eggs of seabirds in northern Norway (Knudsen *et al.*, 2005). Recycling of redundant electric and electronic equipment has been identified as an activity with a high potential for BFR emissions (Morf *et al.*, 2005).

Geographic trends of BFR in polar bears, whales, ringed seals and seabirds are similar to those for PCB, which suggests that these chemicals are transported to the Arctic and accumulate by the same pathways (AMAP, 2005; ACAP, 2005). Uses of pentaBDE and octaBDE, both BFR, have been strictly limited in the EU, and these substances are candidates for inclusion in the Stockholm Convention (ENDS Europe, 2006) (see Section 2.5.4).

Perflourinated organic compounds (PFC)

This is a group of compounds widely used in fluoropolymers, elastomers — especially perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) — which are components in industrial and consumer products including metal plating, fire-fighting foams (OECD, 2005; OECD, 2006), textiles, packaging material, and cleaning products (Caliebe *et al.*, 2004).

PFC that are widely found in the environment, particularly in wildlife including marine mammals, and human tissues (Olsen *et al.*, 2005; LGL, 2006; Kannan *et al.*, 2004; So *et al.*, 2006; BfR, 2006) are transported to the Arctic by ocean currents (Prevedouros *et al.*, 2006). PFOS and PFOA have also been detected in human umbilical cord blood, which means that they are able to pass through the placental barrier and enter foetal circulation (Inoue *et al.*, 2004; Greenpeace and WWF, 2005). This gives special cause for concern as PFOS and PFOA have been found to be toxic to reproduction in animal experiments. Map 2.5.2 illustrates some recent monitoring results from the North Sea.

PFOS is currently being discussed as a candidate for inclusion in the Stockholm Convention. At the EU level, legislation has been adopted to restrict the marketing and use of PFOS from 27 June 2007 (European Commission, 2006). In early 2006, the US Environmental Protection Agency invited producers to participate in a voluntary PFOA Global Stewardship Programme. Participating companies have committed themselves to achieving, no later than 2010, a 95 % reduction in emissions and content in products compared with a 2000 baseline, and to work towards the elimination of PFOA by 2015 (US EPA, 2006).

Platinum group elements (PGE)

PGE are increasingly released into the environment, raising concern over ecological and human health risks (WHO, 2000; LAI, 2002). In Europe, the main anthropogenic source is emissions from automobile catalytic converters that contain platinum or palladium and rhodium. Other sources are dental alloys, electronics, anti-cancer drugs and catalysts in various industrial applications. PGE are found in airborne particles and road and river sediments, but their dispersion and transformation in the environment is still largely unknown (Sure *et al.*, 2002). A recent study on PGE in the river Rhine and its tributaries found concentrations that were low but still could not be entirely explained by direct discharges. The authors postulate that indirect discharges as well atmospheric deposition could be responsible. This hypothesis is supported by measurements in rain, fog and dust (IWW, 2004).

PGE have been associated with aquatic toxicity and several human health effects (Ravindra *et al.*, 2004). These are mainly attributed to the soluble forms, especially halogenated salts, while the metallic form is relatively inert (Moldovan *et al.*, 2002; IPCS, 2002; WHO, 2000). The relevance of these hazards at the low concentrations found in the environment is still under debate. However, the potential of PGE to accumulate in the environment and in biological material, their presence in remote areas, such as Greenland ice and the Alps (Barbante *et al.*, 2001), indicating the potential for long-range transport, give cause for concern (see also Chapter 6, Box 6.5 for environmental impacts of PGE mining).

indeed, Nordic countries have been screening the environment systematically for potentially hazardous substances since 2001 (IVL, 2005).

Four examples of emerging chemicals are highlighted here, due to their widespread and increasing use or their persistence and/or potential for bioaccumulation in the environment. These are brominated flame retardants (BFR), platinum group elements, perfluorinated organic compounds and pharmaceuticals (Boxes 2.5.4 and 2.5.5).

Box 2.5.5 Emerging chemicals — pharmaceuticals

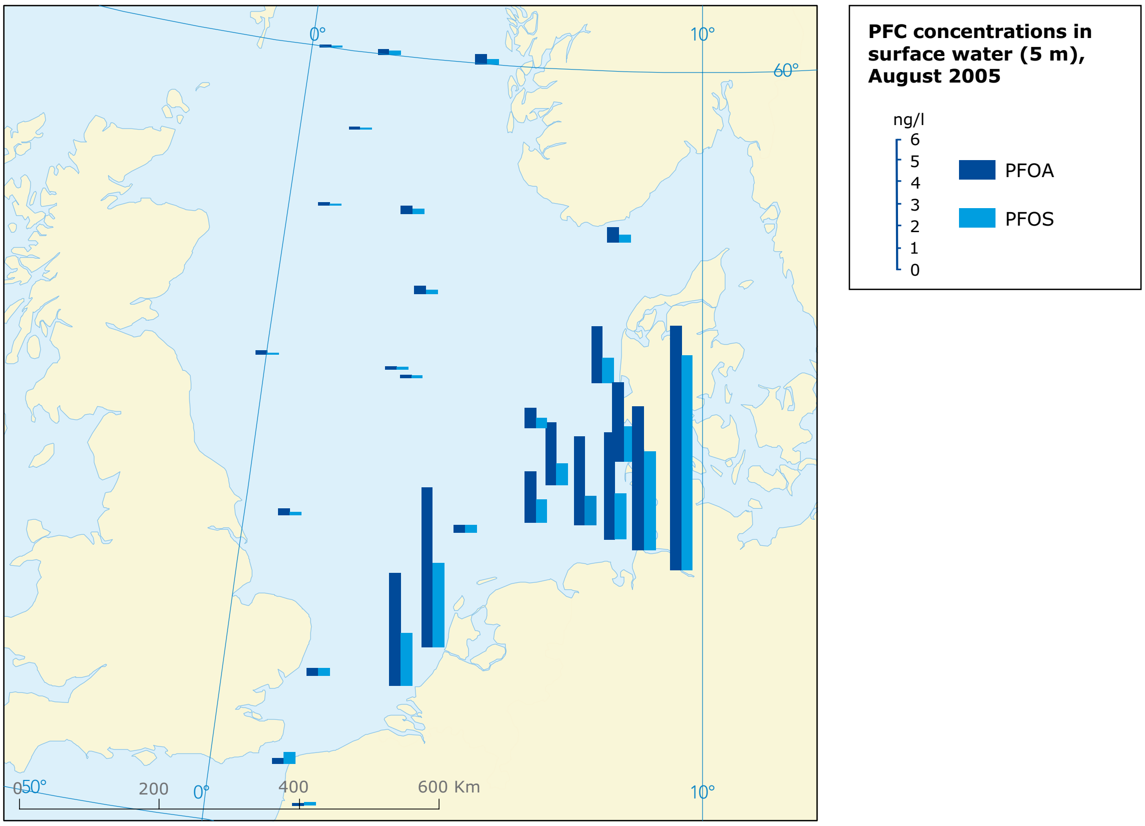
There has been increased concern since the Kiev conference about diffuse sources of pharmaceuticals in the environment (Apoteket, 2006; NORMAN, 2007). Potential hazards arise from threats to ecosystems, species, and the efficacy of drugs as a result of increased resistance from very low but widespread contamination of water and soils. There seem to be no direct threats to health from the trace amounts detected in drinking water. However, there is little research on this issue, and the focus of pharmaceutical companies and regulatory agencies is largely on drug efficacy and acute environmental impacts while it is the health and environmental hazards from long-term, sub-therapeutic exposures that are of main concern (Jones *et al.*, 2005; Sachverständigenrat für Umweltfragen, 2007). Recent data indicate the scale of the problem.

In a study of 159 drug substances by Stockholm County Council, 157 were found to be persistent or lacked data about their biodegradability, 54 were bioaccumulative and 97 were of high or very high eco-toxicity (Miljöklassificerade läkemedel, 2005).

At the Gothenborg sewerage plant, 26 substances were measured as part of an EU research project, REMPHARMAWATER (Andreozzi *et al.*, 2003). Fourteen drugs could be detected in concentrations that ranged from nanograms to milligrams per litre — a widely used anti-inflammatory and analgesic drug, ibuprofen, was detected at the highest concentration, 7 mg/L.

Sweden has pioneered a simple drug hazard categorisation tool based on a weighting of persistence, bioaccumulation, and toxicity which is the basis of information provided to patients, doctors and other specialists (Wennmalm and Gunnarsson, 2005). Proposals for drug research that gives more weight to environmental impacts have been made (Jjemba, 2005). There is very little data on this issue in EU, EECCA, and SEE countries, but pharmaceutical hazards are of increasing concern due to the rising use of drugs. Early use of screening tools, like those developed in Sweden, in all European countries, and 'take-back' measures, as in Sweden and Germany for example, would be useful and precautionary measures.

Map 2.5.2 PFC concentrations in surface water (5 m) in the North Sea, August 2005



Source: Theobald *et al.*, 2006; N. Theobald, pers. comm., BSH, 2007.

Distant impacts of chemical pollution in the pan-European region

Persistence, increasing concentrations up the food chain — bioaccumulation, and the atmospheric and marine transportation of chemicals over long distances may result in environmental and human exposure in areas far from where the chemicals were released. For example, there are serious concerns about the Arctic region being a global sink for mercury and other persistent chemicals, impacting not only the human population but other mammals, fish and plant life. The Baltic Sea is affected by historic and current contamination with POPs and other toxic compounds. Further, POPs are found in high-altitude mountain areas, such as the Alps, which serve as cold condensers for POPs (Kallenborn, 2006; Kallenborn and DiGuardo, 2006) (Box 2.5.6). Global action to deal with this problem is taken under the frame of the Stockholm Convention (see Section 2.5.4).

Industrial accidents, transboundary pollution and effects of globalisation

In some countries, accidental chemical spills significantly affect both the environment and human health. Their impact may be regional as well as local, and in some cases may even have transboundary effects. Mining, a major economic activity, is one of the sectors in which there have been major accidents, often associated with the release of large amounts of toxic substances (EEA, 2003).

In recent years, globalisation has led to the outsourcing of chemical production from rapidly developing regions — for example, according to their own website, 14 of the 16 European companies that belong to the 'world majors' (Cefic, 2005) have business relationships in China, where, according to UNEP, chemical spills have led to major releases of chemicals to the environment, leading to transboundary pollution (UNEP, 2005). For example, the Songhua River spill in November 2005 affected the water supply of thousands of people in the Russian Federation. The positive consequence of this particular event was a formal agreement, signed on 21 February 2006, between the Russian Federation and China to jointly monitor cross-border rivers to ensure water quality (Environment News Service, 21 February 2006).

Considering the number of major chemical accidents with linked transboundary pollution issues in China, harmonisation around the European standards would help reduce overall risks of importing chemical hazards, not only into China, but also into Europe via transboundary pollution or from the use of consumer products made in China. International companies have an important role to play in exporting EU safety standards, in line with the 'Responsible Care Global Charter' and 'Global Product Stewardship' launched by the International Council of Chemical Associations (ICCA) in February 2006.

2.5.4 Policy responses for sound management of chemicals

There has been substantial progress in the evolution of policy to promote sound chemicals management since the Kiev conference. Across pan-Europe, countries have developed or are in the process of developing national implementation plans for both EU and global policies, such as REACH; the Globally harmonised system for classification and labelling (GHS); the Strategic Approach to International Chemicals Management (SAICM); the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals, which entered into force 24 February 2004; the Stockholm Convention on Persistent Organic Pollutants, which entered into force on 17 May 2004 (see Box 2.5.7); and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). However, not all countries have ratified the relevant international conventions (see Annex 1, Legal instruments).

Although the formal effectiveness evaluation is a rare feature of global conventions, the effectiveness of the Stockholm Convention has to be evaluated regularly, starting four years after its entry into force. In anticipating this requirement, the secretariat has requested parties to identify existing monitoring programmes that could be used in its Global Monitoring Programme (GMP). A link between those concerned with policy and scientific experts is very important to ensure the input of information on and from existing monitoring programmes on regional and national levels (further details can be

Box 2.5.6 Regional case studies

The Arctic — a sink for pollutants from distant sources

POPs and other hazardous contaminants, such as mercury, are not produced or used in the Arctic. They are mostly transported by rivers, air and ocean currents from industrialised areas in the south.

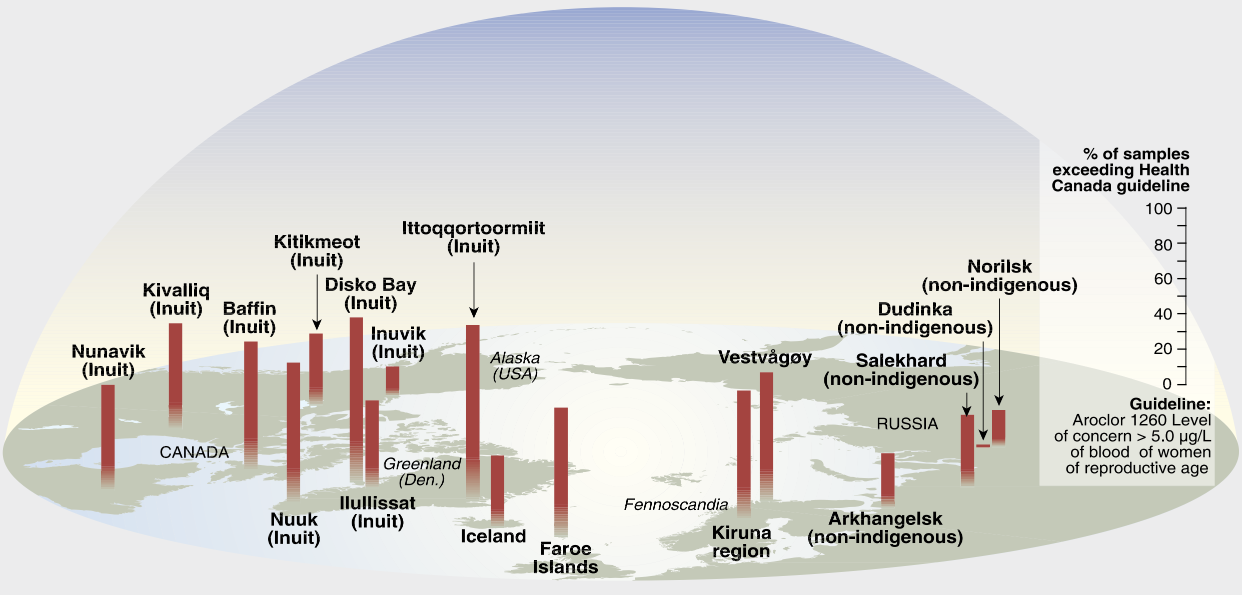
Accumulation of POPs in the food web can result in high exposures to wildlife and humans. Arctic animals need large deposits of blubber to survive when food is scarce. This makes them particularly susceptible to POPs that can bind to fat. When fat deposits are used, chemicals stored in them are remobilised and can affect organs and functions vital to survival and reproduction, such as hormons, vitamins, the immune and enzyme systems. Although understanding of what happens in the organism is limited, it is likely that populations of Arctic animals at the top of the marine food chain such as polar bear, arctic fox, killer whale and glaucus gull are negatively affected. Low temperatures that slow the breakdown of chemicals are another reason why the Arctic is vulnerable to chemicals.

People in the Arctic, living on traditional diets with a high blubber and fat content are also affected. Inuits in Canada and Greenland have higher levels of PCBs, HCB, chlordanes and mercury in their blood than in other circumpolar countries (see Figure 2.5.3). On the Faroe Islands, exposure to methylmercury and/or PCBs during foetal development was associated with adverse neurological and behavioural effects in children. Traditional diets are easily accessible, cheap, have high cultural significance and protect better against cardio-vascular diseases than imported food. Arctic peoples therefore find themselves in a dilemma where cautious dietary advice is needed.

Photo: A female glaucus gull dies after brooding and hatching her chicks. Every year since 1986, scientists have found glaucus gulls dead or dying in convulsions near the bird colonies on Bear Island in the Barents Sea. Very high levels of POPs have been found in the liver and brain of such birds, and their fat deposits are usually depleted

Sources: Burko and Kallenborn, 2000; AMAP, 2002; 2004.

Figure 2.5.3 Levels of PCBs in the blood of people in the Arctic (the most widespread contaminant in this area)



Source: Arctic Monitoring and Assessment Programme (AMAP), 2003. AMAP Assessment 2002: Human Health in the Arctic.

Box 2.5.6 Regional case studies (cont.)

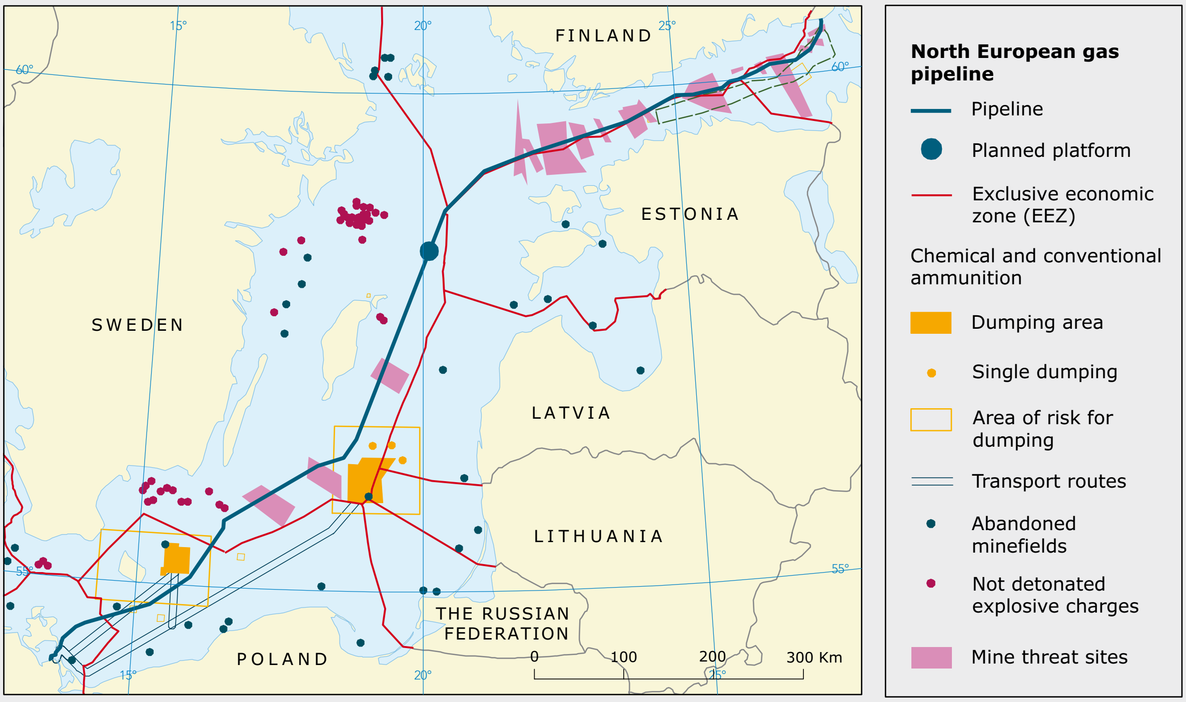
The Baltic Sea — toxic burdens of the past and present problems

The Baltic Sea is a sink for many persistent and toxic substances (Nordic Council of Ministers, 2005). Levels of heavy metals in blue mussels have been decreasing, but concentrations of some contaminants are still up to 20 times higher than in the northern Atlantic. POPs, such as dioxins and PCBs, continue to cause concern (see also Chapter 5, Marine and coastal environment) with Baltic seafood being found to strongly influence human body burdens of PFCs (Falandysz *et al.*, 2006).

In the past, the area has also been a dump for various waste including toxic substances, dredged spoils containing considerable quantities of heavy metals, and conventional and chemical munitions. Swedish cartographers recently discovered 30 barrels containing 9 000 kg of mercury, that had, like 21 000 other containers containing toxics, been dumped legally during the 1950s and 1960s (Spiegel on-line, 22 August 2006). After World War II at least 100 000 tonnes of traditional munitions (Nehring, 2005) and about 40 000 tonnes of chemical munitions, containing some 13 000 tonnes of chemical warfare agents, were dumped in the Baltic, mainly to the south-east of Gotland, east of Bornholm and south of the Little Belt (HELCOM, 2003).

Very little is known about the migration and impacts of toxic agents associated with chemical munitions in the marine environment (OSPAR, 2006; HELCOM, 2003). To date the advice has been that, if left undisturbed on the seabed, dumped conventional and chemical munitions pose no risk to humans. If disturbed, however, they represent a risk to fishermen and seafarers, and, if washed ashore, to the general public. Remediation of marine dumpsites of chemical weapons and munitions is technically challenging (OSPAR, 2006). Most recently this problem became newsworthy in relation to 'Nord Stream' — formerly called the North European gas pipeline, a planned offshore pipeline through the Baltic Sea to transport gas from the Russian Federation to western Europe (Germany and the United Kingdom) (see Map 2.5.3). According to the project information document, military practice areas and dumping sites may well require additional large-scale field surveys to identify and assess areas with suspected ammunition. These could be followed by mitigation measures such as the re-routing of pipelines; sub-sea risk reduction measures on site including the moving dumps on the sea bottom; or the removal of the ammunition (Nord Stream, 2006). The documents were provided for the Baltic region countries in November 2006 in voluntary fulfilment of the requirements under the Espoo Convention (UNECE Convention on Environmental Impact Assessment in a Transboundary Context) (See Annex 1, Legal instruments).

Map 2.5.3 North European gas pipeline



Source: Nord Stream, 2006.

Box 2.5.6 Regional case studies (cont.)

The Alps — monitoring persistent and other organic pollutants in the Alps — MONARPOP network

There is justified concern that mountain ranges are meteorological traps for POPs, but little is known about their loads in the Alps compared with other remote European regions. Pesticide concentrations in needles and humus were found to increase with altitude, and sediments in remote alpine lakes show unexpectedly high levels of certain POPs — despite the absence of nearby sources. Accumulating local evidence gave rise to the first large-scale transnational inventory of POPs pollution in the Alps — MONARPOP (Monitoring Network in the Alpine Region for Persistent and other Organic Pollutants). The project measures the pollutant levels in mountain vegetation and soil, across the Alps and along selected altitude profiles, where biochemical methods are used to reveal the biological effects. MONARPOP, part of the UNEP Master List of Actions to reduce or eliminate the release of POPs, focuses on POPs regulated under the Stockholm Convention, but also includes a number of other toxic organic compounds.

Sources: MONARPOP, www.monarpop.at.

found at www.pops.int). Human milk has been identified as a preferred matrix for monitoring (UNEP, 2003). The next round, the fourth, of the World Health Organization (WHO) coordinated studies on exposure levels of POPs in human milk will be adjusted to provide monitoring data useful for the effectiveness evaluation (Malisch *et al.*, 2006), the first of which will be completed at the fourth meeting of the Conference of the Parties (COP 4) in 2009.

The third Conference of the Parties (COP 3), held in May 2007, agreed to establish a global monitoring plan to study the impact of the convention on POP levels, and adopted a 'dioxin toolkit' for governments, setting out rules for estimating the emissions of dioxins from anthropogenic and natural sources. However, the delegates failed to reach an agreement on a compliance regime for the convention. The meeting also adopted guidelines on Best Available Technology (BAT) and Best Environmental Practice (BEP) for reducing POPs emitted as by-products of industrial processes, — mainly dioxins, but also furans, PCBs, and hexachlorobenzene (ENDS Europe, 2007).

The Strategic Approach to International Chemicals Management (SAICM) was adopted by the International Conference on Chemicals Management (ICCM) in Dubai on 6 February 2006. SAICM was developed by a multi-stakeholder Preparatory Committee, co-convened by UNEP, the Intergovernmental Forum on Chemical Safety and the Inter-Organization Programme for the Sound Management of Chemicals. It provides a policy framework to support the achievement of the goal, agreed at the 2002 Johannesburg World Summit on Sustainable Development (WSSD), of ensuring that by 2020, chemicals are produced and used in ways that minimise significant adverse impacts on the environment and human health.

The overarching policy strategy, which sets out the scope of SAICM, identifies objectives for risk reduction, knowledge and information, governance, capacity-building and technical cooperation, illegal international traffic, as well as underlying principles and financial and institutional arrangements. Proposed work areas and activities for implementation of the strategic approach are defined in a global plan of action.

Since the first ICCM session, more than hundred governments have nominated SAICM national focal points. Regional focal points for the five United Nations regions as well as non-governmental and intergovernmental organisations have also been nominated. Regional meetings have been held to initiate SAICM implementation, and a quick-start programme has been launched to support activities to enable initial capacity building and implementation activities in developing countries.

In 2004 the OECD, responding to the request by WSSD, initiated the development of a global portal to information on chemical substances, eChemPortal TM, to improve availability and access to information on chemicals. The portal, which is planned to be operational in 2008, is under preparation in cooperation between several OECD member countries, the European Commission, the International Council of Chemical Industry Associations, the International Programme on Chemical Safety, UNEP Chemicals and environmental NGOs.

In addition, many countries are preparing to implement the Globally Harmonized System (GHS) for classifying and labelling hazardous chemicals, with a target date of 2008, agreed at WSSD. The system aims to ensure that information on physical hazards and toxicity will be available in order to enhance the protection of human health and the environment during the handling, transport and use of chemicals.

In the EU, after many years of debate and negotiation, new chemicals legislation on the Registration, Evaluation and Authorisation of Chemicals (REACH) was adopted by the European Parliament and the Council, and entered into force on 1 June 2007. REACH is seen as the European contribution to SAICM. Its key elements are:

- equal requirements for new and existing substances — for example, toxicity testing and information;
- shifting the burden of proof from competent authorities to manufacturers and importers;
- involvement of downstream users;
- better risk communication via chemical safety reports.

REACH is expected to have an impact far beyond the EU, as its requirements are applicable to substances that are imported into the EU. Indeed, some countries are already developing their own national legislation along the lines of REACH.

Emissions of hazardous chemicals from industrial installations and agricultural activities are regulated in the EU through the Integrated Pollution Prevention and Control (IPPC) Directive (European Council, 1996), by applying an integrated approach, best available techniques, flexibility, and public participation. The first round of 31 best available technique reference documents (BREFs) under the IPPC Directive was completed in December 2006.

Under the IPPC Directive, details of industrial emissions have to be reported to the European Pollutant Emission Register (EPER) and made publicly available on a website hosted by the EEA. The EPER, launched in early 2004, gives access to information on annual emissions from about 9 200 industrial facilities in the EU-15, Norway and Hungary — mostly for 2001, and about 12 000 facilities in the EU-25 and Norway for 2004. The EPER will be replaced by the European Pollutant Release and Transfer Register (European PRTR), as laid down in Regulation (EC) No 166/2006 adopted on 18 January 2006. The European PRTR implements the UNECE PRTR Protocol, signed in May 2003 in Kiev. The first edition of PRTR is expected in autumn 2009 and will include data for the first reporting year, 2007.

The Seveso II Directive, adopted in 1996 replaced the original Seveso Directive of 1982, developed following the accidental dioxin release in Seveso in 1976. The Seveso II Directive was broader in scope and introduced new requirements for safety management systems, emergency and land-use planning, and reinforced the provisions on inspections by Member States to prevent risks to the environment and human health from industrial chemical accidents. In 2003, in the light of serious industrial accidents, the Directive was extended to cover risks arising from storage and processing activities in mining — the case of cyanide spill in Baia Mare, 2000; from pyrotechnic and explosive substances — the case of Enschede fireworks accident, 2001; and from the storage of ammonium nitrate and ammonium nitrate based fertilisers — the case of the explosion in a fertiliser plant in Toulouse, 2001 (European Parliament and Council, 2003). The Member States were to comply with the extended Directive by mid-2005.

There is no comprehensive overview available on the status of chemicals management in EECCA, although some countries — Armenia, Belarus, Kazakhstan, Kyrgyzstan, and the Russian Federation — have published national profiles to assess their national infrastructure for the sound management of chemicals, under SAICM. An analysis of the existing chemicals management system in the Russian Federation, elaborated in the framework of a cooperative project between the Russian Federation, the Nordic Council of Ministers, Sweden and Finland, is therefore used as an illustrative example (Box 2.5.7).

Policy challenges

The safe management of chemicals requires the cooperation of many stakeholders in different sectors and a range of different tools (for an overview of the status of ratification and implementation of international conventions see Annex 1, Legal instruments). Producers and manufacturers have special responsibilities to which they can respond not only by fulfilling their legal obligations but also by applying the principles of Green Chemistry, (Global) Responsible Care, and (Global) Product Stewardship (Anastas, 1998; Green Chemistry Network, 2006). But legislation on chemicals and legislative tools that ensure environmental quality or health protection from hazardous chemicals are often developed and executed by different authorities, which leaves gaps and results in a need to improve interlinkages and cooperation between these authorities.

An integrated approach to sound chemicals management would contain the following elements:

- the substitution principle, to ensure that hazardous chemicals, products and processes are replaced by safe alternatives;
- the 'polluter pays' principle and economic responsibility for damage and negative impacts on the environment and human health, including corporate liability and compensation;
- the precautionary principle.

Although the benefits of chemical production and use are clearly reflected in rising sales of chemicals, the benefits of reductions in chemical hazards are much more difficult to quantify because of their diffuse, long-term, and mostly qualitative nature. Unlike the transport and energy industries, there have been no comprehensive quantitative studies of the external costs of chemical production and use. However, retrospective analyses can help illustrate the large potential costs of inaction on harmful chemical exposures, as indicated by the EEA report *Late lessons from early warnings: the precautionary principle 1896–2000* (EEA, 2002) for chemicals such as PCBs, CFCs, TBT, and the Great Lakes' pollutants.

A recent retrospective analysis of the cost to the EU-25 of the failure to act on PCB exposures when the first early warnings arose in the 1930s, or the 1960s with the first indications of environmental damage, shows that the remediation and site clean-up costs alone — excluding health and ecosystem damage costs — between 1971 and 2018, will be at least EUR 15 billion (TemaNord, 2004). Meanwhile, a summary of 36 studies on the future costs and benefits of REACH concluded that the costs of better controls would be around EUR 4 billion, while the benefits are estimated at between EUR 10 and EUR 200 billion.

Box 2.5.7 EECCA: chemicals management in transition

The Russian Federation's legislation on chemicals is in transition. The framework for this legal development is laid down in the strategic document 'the foundations of the state policy for ensuring chemical and biological safety of the Russian Federation for the period up to 2010 and the longer term', approved by the President on 4 December 2003.

A system has been in place since 1992 for the registration of hazardous substances, based on available information, and since 1994 for safety data sheets (SDS). However, enforcement is poor and the legal status of SDS is unclear. Further, there are no uniform requirements for labelling or common classification criteria such as those in the present EU system and GHS. Instead, standards depend on the product category, and labelling on expert knowledge in interpreting test results. There is no unified approach for testing, other than for pesticides, and tests do not necessarily follow OECD methods. One of the major challenges will be harmonisation with the provisions of international law, international treaties and agreements of which the Russian Federation is part. GHS and REACH are of particularly of interest for the development of the Russian systems for classification, labelling and registration.

Sources: Ruut and Simanovska, 2005.

Some of the economic benefits expected from more eco-efficient management of chemicals include the stimulation of eco-innovation, for example green chemistry; greater energy efficiency; and less energy import dependence. Furthermore, environmental technology industries and smarter use of existing laws such as the IPPC Directive, where future performance standards could complement best currently available technologies, are likely to stimulate an increase in the number of jobs and the volume of exports as a result of increased demand from the wider chemicals sector.

The distribution of costs and benefits is often neglected in conventional cost benefit analysis: between different social groups — producer interests and societal interests; between geographically disparate groups — for example, Arctic and European citizens; and across generations. Equity issues are therefore important, for example, what discount rate, if any, should be used to estimate the present value or future costs and benefits of persistent chemicals. Such an approach requires public participation.

The focus on integration and wider involvement has been strengthened and now needs to be put into practice: IPPC provides an integrated approach to protecting all environmental media and disseminating better technologies, SAICM encourages countries to set up inter-ministerial or inter-institutional arrangements for chemical management, and REACH will actively involve both downstream users and producers in reducing chemical hazards.

These new frameworks for sustainable management of chemicals will contribute to reaching the goals of the United Nations Conference on Environment and Development.