# PRESSURE FACTORS





In all types of groundwater settings, it is logical to think of the likelihood of pollution occurring as the interaction between the pollutant load that is applied or might be applied to the subsurface environment as a result of human activities, and the vulnerability of this environment to pollution. Taking the latter first, vulnerability is determined by the characteristics of the strata separating an aquifer from the land surface, in terms of how easily pollutants can reach the aquifer from the ground surface, and what capacity there is in the soil and geological strata to attenuate the pollutants. Karstic aquifers, with their lack of soil cover and rapid flowpaths leaving little time for attenuation, are almost invariably classified as highly vulnerable. Alluvial aquifers are also likely to be considered as vulnerable, unless they contain a high proportion of clay-rich material to reduce their permeability, are overlain by a protective confining layer of clays and/or the water table is relatively deep. The transboundary groundwaters of SEE are likely, therefore, to be highly vulnerable to pollution if the pressure factors outlined below produce significant loadings of mobile and persistent pollutants. The only exception would be the deeper confined groundwaters of the thick alluvial sequences, particularly those shared by Hungary, Serbia and Romania.

## AGRICULTURE

Globally, agricultural activities provide some of the major pressures on freshwater systems in terms of both quantity and quality. Some 70% of total global water use is for agriculture. Within Europe, 44% of water abstraction is for irrigation,[1] although this is clearly greater in the dry southern countries than in the north and west of the region. Where this heavy usage depends on abstraction of groundwater, severe and sometimes irreversible problems can result.[2] Moreover, intensive cultivation, both with and without irrigation, uses heavy applications of fertilizers and pesticides. Intensive cultivation and animal production can produce increased levels of nutrients and pesticides in groundwaters from infiltrating surface run-off from agricultural land, leaching from the soil through the unsaturated zone, and sometimes from return waters from irrigation schemes. The consequent pollution of freshwater systems is well documented from many parts of the world, and in Europe has been one of the main factors behind the adoption by the EU of the Water Framework Directive and Groundwater Directive.[3]

Agriculture is indeed an important pressure factor within SEE. As mentioned above, many aquifers, especially some of the larger alluvial ones, are used to support irrigated agriculture. This also implies application of fertilizers and pesticides, but it is likely that the recent conflicts and political changes and economic difficulties in the region have suppressed both the usage of water for irrigation and the application of fertilizers and pesticides. Deterioration of the operation and maintenance of irrigation schemes since the late 1980s and a sharp decline in the area under irrigation has decreased the use of water for this purpose.[4] Water abstraction has indeed been stable or declined slightly in SEE in the past decade.[5] With the expected economic growth and the need to increase crop production, agricultural pressure factors are expected to become more important.

Livestock watering is reported as a minor but widespread water use in both karstic and alluvial areas. Animal production, however, may take radically different forms in the two: intensive livestock production facilities in the major plains and valleys and distributed grazing in the mountainous areas. Confirmation of these pressures may come from local pollution of groundwater by pathogens and nitrogen.

## INDUSTRY

Overall, industrial pressure factors for transboundary groundwaters in the region appear to be rather limited. Groundwater usage by industry is modest, and even where mentioned is usually less than 25% of the total. The presence in groundwater of heavy metals and organic compounds from industries was reported, including pyrallene from the aluminium processing plant close to Podgorica. The close linkages between surface water and groundwater were illustrated when, in December 1983, high phenol concentrations were observed in the Ibar and Zapadna Morava Rivers. The source was identified as the coal gasification plant at the Obilic mine on the Sitnica tributary in Kosovo. The associated alluvial aquifer was found to be locally polluted and the municipal supply to Kraljevo was threatened for a considerable time,[6] although there was no transboundary impact. As for agriculture, the recent political changes and difficult economic situation have resulted in the decline of industrial activities and the closure of manufacturing plants. In some cases these former industrial plants which are not working at the present could represent potential pollution hot spots.

Where groundwater pollution problems do occur, they are likely to be localized and originate from dispersed small and medium-sized industries, rather than from large sites or complexes of large undertakings. The latter are in any case more likely to be capable of installing pollution abatement technologies and controlling pollution at the source. In addition, these larger enterprises voluntarily carry out self-monitoring in an attempt to demonstrate their compliance with environmental standards. Smaller and medium-sized industries are less able to do this and, where they have been closed and abandoned, it may be difficult to apportion responsibility for monitoring and management of the legacy of pollution of sites and the underlying groundwater.

[1] European Environment Agency. Europe's environment: the fourth assessment, 2007.
[2] Foster S S D and Chilton P J. 2003. Groundwater, the processes and global significance of aquifer degradation. Phil. Trans. R. Soc. London B, 358, 1957–1972.
[3] Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration.
[4] World Bank 2003. Water Resources Management in South Eastern Europe, Volume I, Issues and Directions, Volume II, Country Water Notes and Water Fact Sheets.
[5] European Environment Agency. Europe's environment: the fourth assessment, 2007.
[6] Filipovic B, Vujasinovic S and Stevanovic Z. 1994. Some general aspects of groundwater protection in Yugoslavia – Symposium, Impact of Industrial Activities on Groundwater Quality, Constanza, 196–204.

## SEWERAGE AND WASTE DISPOSAL

Disposal of municipal and domestic wastewater is a pressure factor for groundwater where (a) the wastewater is disposed of directly into the ground by septic tank systems; (b) where collected, untreated wastewater and/or stormwater drainage is disposed of directly into the ground; or (c) where such wastewater carried by surface water systems infiltrates into the underlying groundwater. All three scenarios are likely to occur in the region, and could lead to pollution of groundwater by pathogens, organic compounds and nutrients.

Septic tanks systems are an important or even dominant method of domestic effluent disposal for dispersed rural populations and small villages and towns throughout the region. These installations provide local point sources of pollution with pathogens, chloride and nutrients and, where the population is dense, can provide measurable impacts on groundwater quality. They are, however, unlikely by themselves to produce transboundary impacts.

## MINING

Mining activity needs economically viable and technically feasible mineral deposits provided by the underlying geological strata. In general, valuable mineral deposits are rarer in karstic areas than other rock types and also not common in the alluvial sediments of major river basins, and pressures from mining were not, therefore, anticipated to be a regional problem. Near Podgorica in Montenegro, the large aluminium plant referred to above contributes to an increase of aluminium in Skadar Lake (a Ramsar site) and possibly also in the karst and alluvial groundwater. The tailings pond accident in January 2000 at Baia Mare in north west Romania released 100,000 $m^3$ of cyanide-rich tailings waste into the nearby river system and thence into the Somes, Tisza and finally the Danube. The tailings contained 50-100 tons of cyanide as well heavy metals, disrupting drinking water supplies at 24 locations for 2.5 million people, and causing major fish kills.[7] Some shallow private groundwater supplies close to the spill were seriously affected, but deeper municipal supplies drawing from the confined aquifers were largely unaffected and transboundary groundwater impacts have not been observed. Quarrying for limestone is likely to be a localised pressure factor in the karstic areas, and open pit gravel extraction, with subsequent use of the water-filled pits for recreational purposes, was reported as a pressure factor in Hungary and Croatia.

## SOLID WASTE DISPOSAL

Disposal of solid municipal and industrial waste was not widely reported as a pressure factor, although occasionally mentioned as a source of heavy metals and organic pollutants. Landfills generally provide local pressure factors, and may be important in the narrow coastal plain of Croatia.

## TOURISM AND RECREATION

Parts of the region have long been recreational and tourist destinations for visitors from Eastern Europe and the countries of the former Soviet Union. Following the recent political changes, closer links with Western Europe, and for some countries of the region membership of the EU, are likely to greatly broaden the area from which visitors will come to enjoy the sights of the region. This is already being seen in major winter sports and summer recreation developments in Romania, Bulgaria, Slovenia and Serbia, by widespread reconstruction, and by new development, for example on the Bulgarian and Croatian coasts. The use of mountain areas (the recharge areas of many transboundary groundwaters) and their watercourses for recreational purposes is increasing. The impact of recreation on mountain ecosystems, especially rivers and lakes but also karstic groundwater systems needs to be monitored and managed. National Park areas are especially vulnerable to such pressures, and may need specific protection in this respect. One which is particularly vulnerable to pollution is the National Park of Mali Thate/Galicica which separates the Ohrid and Prespa Lakes and is shared by Albania, Greece and The former Yugoslav Republic of Macedonia.

## RIVER REGULATION

Management of surface water discharges by river regulation is normally thought of as a pressure factor for surface waters. However, the construction of dams for hydroelectric power schemes or major structures for

[7] Regional Environmental Centre for Central and Eastern Europe 2000. The cyanide spill at Baia Mare, Romania. UNEP/WWF.

flood control, irrigation diversions or to facilitate river transport can modify river flows and river bed morphology sufficiently to affect groundwater flow, discharge and recharge. The silting up of reservoirs can also impact on downstream aquifers. Although outside the region, the Gabcikovo scheme on the Danube between Slovakia and Hungary has a major impact on groundwater, and through this on nearby wetland ecosystems supported by the adjacent alluvial aquifers. Major upstream reservoir construction in one country can create pressures on groundwater further down the surface water catchment where the aquifer is not itself transboundary. The Mesta/Nestos River basin between Bulgaria and Greece is a case where major reservoir construction has modified the hydrological and sedimentation regime so much that it has a major negative impact on the downstream alluvial aquifer of the delta, although there is no actual transboundary groundwater.