



## E2 - Prevention of Aquifer Pollution

**Author:** Kerstin Mechlem

**Scope:** This class familiarizes participants with the legal mechanisms used in domestic and international law to prevent, control and abate aquifer pollution. It explains the specific vulnerability of aquifers and looks at the different causes of pollution ranging from unsuitable abstraction practices to point- and non-point source pollution.

The class highlights how quantity and quality control of groundwater are interrelated because unsuitable abstraction practices can mobilize naturally occurring pollutants such as arsenic or fluoride or induce saline intrusion or the migration of lower quality or brackish waters. Therefore, rules on regulating drilling and abstraction will be covered.

It will also set out how point-source pollution is addressed by absolute prohibitions or limitations on emitting certain substances and how polluting activities may be made conditional upon a wastewater or pollution discharge permit, prior treatment of the substance and/or compliance with effluent standards.

With respect to non-point source or diffuse-source pollution prevention measures, the class will discuss how the whole array of actors involved in land-use and pollution management has to be involved in groundwater quality protection and included in the scope of relevant legislation. Measures to reduce non-point pollution include prohibiting or limiting certain polluting or water-using activities, such as limiting the use of fertilizers and pesticides, restricting certain cropping patterns, reducing animal-grazing intensity, and regulating land reclamation and drainage.

The class will also discuss the use of land surface zoning and the creation of protected areas, which are often used for critical areas of high vulnerability such as recharge areas or the capture zones of the main areas of potable water-supply abstraction. In addition, it will introduce the concept of managed aquifer recharge with specific regard to water quality control. Finally, with respect to international law, the linkages with the obligation not to cause significant harm will be analyzed.

**Purpose:** The objective of this class is to raise awareness of the specific vulnerability of aquifers to pollution and to familiarize participants with well-established as well as emerging regulatory answers to the challenge of aquifer pollution. It will enable participants to critically review and assess the strengths and weaknesses of pollution provisions in water legislation and international legal instruments.

**Methodology:** First, the participants will be familiarized with the topic in an overview lecture, which is supported by a briefing note. In the second section of the class they will apply the information presented in two group exercises. In one exercise the participants will be asked to strengthen the groundwater pollution provisions in a fictitious domestic context. In the second exercise they will assume the role of negotiators of the groundwater quality provisions of a bilateral aquifer agreement.

Site: UNITED NATIONS INFORMATION PORTAL ON MULTILATERAL ENVIRONMENTAL AGREEMENTS

Course: The "Greening" of Water Law: Implementing Environment-Friendly Principles in Contemporary Water Law

Book: E2 - Prevention of Aquifer Pollution

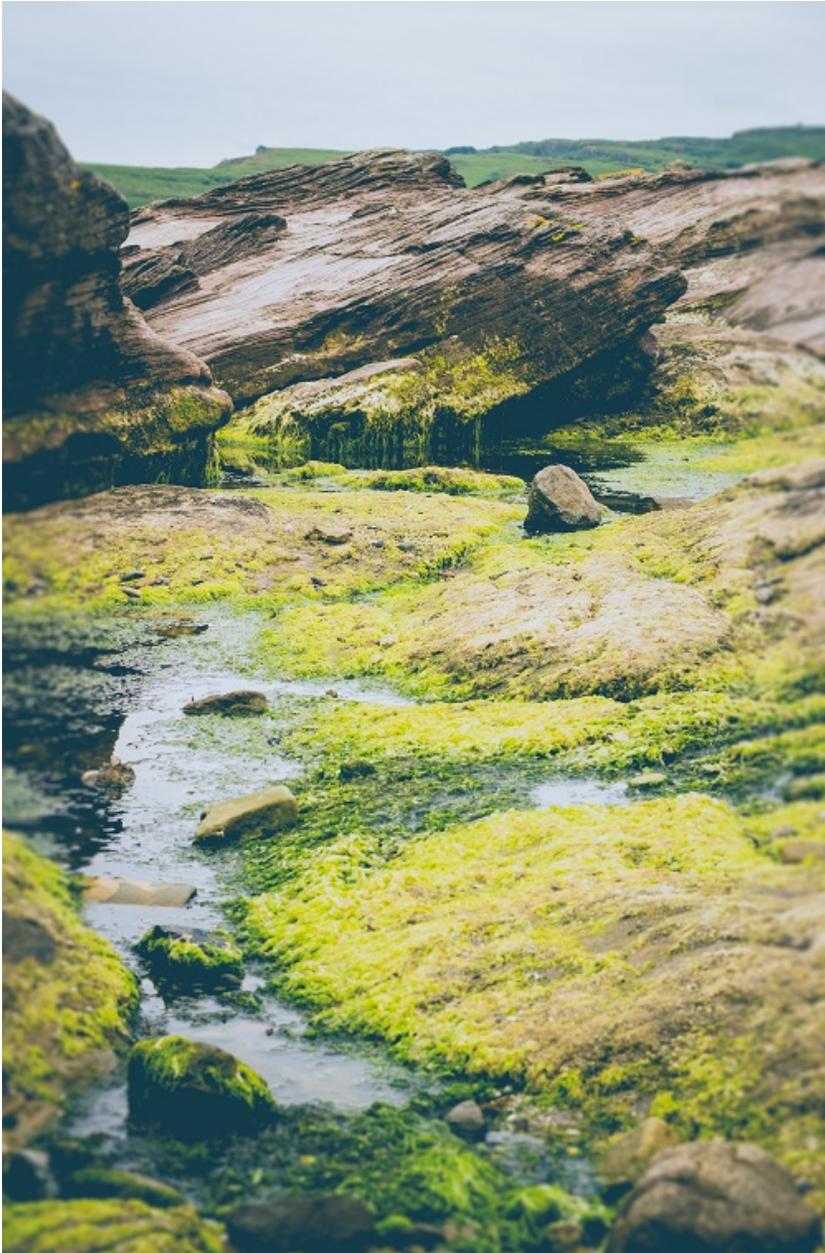
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# 1. Key points

- The protection of groundwater against pollution is a complex challenge: A large number of actors, which are often not groundwater users, cause groundwater pollution in a multitude of ways. It is costly and technically demanding to assess the magnitude and extent of groundwater pollution. There may be long time delays between a polluting incident and the time its effects are felt.
- Domestic legislation has developed legal responses to each of type of polluting event, i.e. to pollution caused by groundwater exploration and abstraction, point-source pollution, diffuse pollution, and groundwater pollution caused by polluted surface water.
- Additional legal mechanisms address groundwater pollution more generally. Examples are the establishment of water quality criteria, the creation of protection zones and managed aquifer recharge.
- In international law, the protection of groundwater against pollution is addressed in a patchy manner. The UN Draft Articles on Transboundary Aquifers (2008) and the UNECE Model Provisions on Transboundary Groundwaters (2012) both contain provision on the prevention, reduction and control of pollution. Out of the very few aquifer-related agreements that have been concluded, even fewer address groundwater quality.

2. Introduction and Overview



## 2.1. Groundwater Pollution: the Challenge

The protection of groundwater from pollution is a complex challenge. A large number of actors may cause pollution in a wide variety of ways. There are difficulties in assessing the magnitude and extent of the occurrence of pollution and long time delays may exist between a polluting incident and the time its effects are felt, which may render the attribution of legal responsibility and liability difficult.

## 2.2. Definition

The definition of pollution used in this class, based on the UN Watercourses Convention and other sources, is as follows:  
“Pollution” ... means any detrimental alteration in the composition or quality of ... waters that results directly or indirectly from human conduct” (Art. 21 UN Watercourses Convention).

### 2.3. Objectives of Groundwater Pollution Prevention

The overarching goal of groundwater pollution provisions in domestic and international law is to preserve as far as possible the natural quality of groundwater with a view to satisfying human water needs (drinking water, domestic uses), protecting public health and meeting economic and social needs (agriculture, industry, recreation etc.), as well protecting groundwater-dependent ecosystems in order to meet environmental needs and to maintain ecosystem services.

## 2.4. Causes of Low Groundwater Quality

The main causes of groundwater quality degradation are pollution caused by inappropriate exploration and abstraction, point-source pollution (mainly from urban sources such as municipal sewage treatment plants, waste disposal and industry effluents), diffuse/non-point pollution (mainly from agriculture), and pollution caused by polluted surface water. In addition, groundwater may show natural water quality deficiencies such as naturally occurring salinity or high levels of solutes (sulphate, fluoride, arsenic etc.), which may render the water unfit for certain purposes.

### 3. The Protection and Control of Groundwater Pollution in Domestic Legislation



### 3.1. Legal Responses According to Type of Pollution

#### *1. Legal and Policy Areas Implicated in Groundwater Pollution Prevention and Control*

Groundwater pollution has to be addressed in an integrated way by measures from different fields of law and policy, including water, agriculture, mining, health, land use and environment. This requires mutually supportive legislative frameworks and institutional cooperation in planning and licencing procedures.

#### *2. Groundwater Quality Degradation caused by Exploration and Abstraction*

Poorly performed drilling operations, inadequate well construction and maintenance and poor well-casing may result in contamination from the well or inter-aquifer leakage and groundwater degradation by mixing water from different aquifers or layers of aquifers of different quality. Abstraction may also induce migration of substances already present in the water or subsoil (e.g. arsenic or fluoride). In coastal areas sinking groundwater tables due to over abstraction may cause ingress of seawater or enhance surface water infiltration. Inappropriate abstraction may mobilize groundwater from deeper and more brackish or saline layers and may also cause land subsidence. To address these issues, domestic water laws tend to regulate the profession of well drillers. Groundwater exploration and borehole drilling tend to be subject to prior notification, a permit or registration as demonstrated by legislation from countries as diverse as Kenya, Kyrgyzstan, Namibia, the Northern Territory of Australia, Oman, the Philippines or Costa Rica (with a piece of special purpose legislation).

In addition, there are rules on borehole construction, well maintenance and the sealing of abandoned wells. The obligation to obtain a permit before abstracting groundwater and permit conditions as to quantity, drilling depths and drilling locations may protect groundwater quality, while simultaneously meeting their primary purpose of groundwater quantity management. The environmental impact assessments (EIA) required for large-scale abstractions also address water quality concerns.

## 3.2. Legal Responses According to Type of Pollution (Contd)

### 3. *Point-Source Pollution*

Point-source pollution is pollution whose entry point into an aquifer can be established with sufficient certainty. Prime examples are waste disposal sites, landfills, septic tanks, inadequate sub-surface storage of dangerous substances, industrial accidents, mines, fracking or highways. An array of measures is taken to address the different uses of point-source pollution. For certain substances absolute prohibitions or strict regulations to prevent or limit their release into groundwater are used. This approach is taken in Art. 4 (1) (b) (i) of the EU Water Framework Directive and Art. 6 of the EU Groundwater Directive.

Polluting activities may also be made conditional upon a wastewater or pollution discharge permit, prior treatment of the substance and compliance with effluent standards/emission limits (on the basis of best available technologies). Economic measures such as water pollution charges may provide incentives to avoid effluent in line with the polluter-pays principle.

For landfills, regulations on siting, operation, monitoring and inspections of the landfill area and storage tanks apply. EIA are included in the procedures for wastewater discharge, waste disposal and other impacting activities. In the field of oil and gas exploration and production, State oil and gas regulations protect groundwater resources through the application of specific programmatic elements such as permitting and regulations on well construction, well plugging, and temporary abandonment requirements as are mandated in the US.

### 3.3. Legal Responses According to Type of Pollution (Contd)

#### 4. *Diffuse Pollution*

Diffuse or non-point pollution is pollution originating from diffuse or indistinct sources, often spread over relatively large areas, whose origin, entry point into groundwater and impact are difficult to impossible to determine with accuracy. The prime cause of diffuse pollution is agricultural use of pesticides/herbicides and fertilizers, resulting in high levels of nitrates and phosphorus in soils. Stormwater runoff in urban areas and airborne pollution transmitted by precipitation (acid rain) also play a role.

To prevent, control and reduce groundwater pollution from diffuse sources, it is necessary to regulate land uses and especially to limit the use of pesticides, herbicides and nitrogen and phosphorus fertilizers and to prescribe the use of best agricultural and environmental practices. The whole array of actors involved in land use and pollution management, including agricultural and environmental agencies seeking to regulate the application of fertilizers and pesticides, must be involved in groundwater quality protection and must be included in the scope of relevant legislation.

In the EU, the 1991 Nitrates Directive, which is now an integral part of the Water Framework Directive, is one of the earliest pieces of EU legislation aimed at controlling pollution and improving water quality by preventing nitrates from agricultural sources from polluting ground and surface waters. It requires the identification of water polluted by nitrates or at risk of pollution, the designation of nitrate vulnerable zones, the establishment of codes of Good Agricultural Practice, the establishment of action programmes and monitoring and reporting.

### 3.4. Legal Responses According to Type of Pollution (Contd)

#### *5. Groundwater Quality Degradation caused by Surface Water*

Groundwater quality can degrade when sea water ingresses in coastal areas due to rising marine levels caused by climate change and when over-abstraction from an aquifer creates a vacuum that allows infusion of seawater. Further, polluted river or lake water may seep into an aquifer through natural processes or as a consequence of sinking groundwater tables. Partially treated wastewater that is used for irrigation may result in groundwater pollution where that water recharges an aquifer. Once contaminated, an aquifer is extremely difficult, if not impossible, to remediate.

Domestic legislation responds by regulating technical measures such as the artificial recharge of coastal aquifers in order to create hydraulic barriers to marine water ingression, by regulating surface water pollution, and by setting quality standards for irrigation water.

### 3.5. Further Legal Measures

#### *1. Water Quality Objectives and Criteria*

Water quality objectives and threshold values are often developed by domestic legislation to serve as benchmarks. These objectives and values are established in relation to various water needs, i.e., different criteria have to be met depending on the intended use of the water. For drinking water the most stringent guidelines are developed. An important guidance document in this field can be found in the WHO Guidelines for Drinking-water Quality.

Water quality objectives and criteria can also serve to measure trends in pollution development and they can be combined with target dates for more aggressive management (e.g. EU Water Framework Directive and Groundwater Directive).

#### *2. Protection Zones*

Protection zones, especially around drinking water abstraction points, are a means to protect groundwater from pollution. For instance, section 1428 of the US Safe Drinking Water Act (1974, amended in 1986 and 1996) requires each State to determine wellhead protection areas based on reasonably available hydrogeological information on groundwater flow, recharge, discharge and other information the State deems necessary to adequately determine the wellhead protection area. Another example can be found in the detailed provisions of the 2011 Draft Groundwater Model Bill of India (sections 11 – 13).

Several levels of protection zones (typically 2-4) can be created around drinking water abstraction sources, including a wellhead protection zone, an inner protection zone, an outer protection zone and a zone covering the recharge area. For each zone different levels of restrictions apply. To demarcate the zones several methods can be used, e.g. with reference to distance or the travel time of groundwater.

### 3.6. Further Legal Measures (Contd)

#### *3. Managed Aquifer Recharge*

The technique of managed aquifer recharge, also known as enhanced recharge, water banking and sustainable underground storage, serves mainly to replenish aquifers in order to elevate the water table and to store water for drought and emergency supplies. Managed recharge can also be used to treat polluted water via aquifer recharge by benefitting from the natural filtering and clean-up capacity of certain types of soils for subsequent recovery (in case of surface spreading techniques, called "soil aquifer treatment" - SAT) and to improve groundwater quality by diluting polluted groundwater with water of better quality. Replenished aquifers can also provide a hydraulic barrier against saltwater intrusion in coastal areas.

#### *4. Supporting Legal Measures*

Laws and regulations on establishing inventories of polluting sources, monitoring and enforcement of permits, aquifer mapping, monitoring and periodic testing of groundwater quality at a sufficient number of representative sampling points (which involves high costs) and the development of aquifer management plans as independent plans or as part of a wider basin management plan are measures that support the prevention, control and reduction of groundwater pollution.

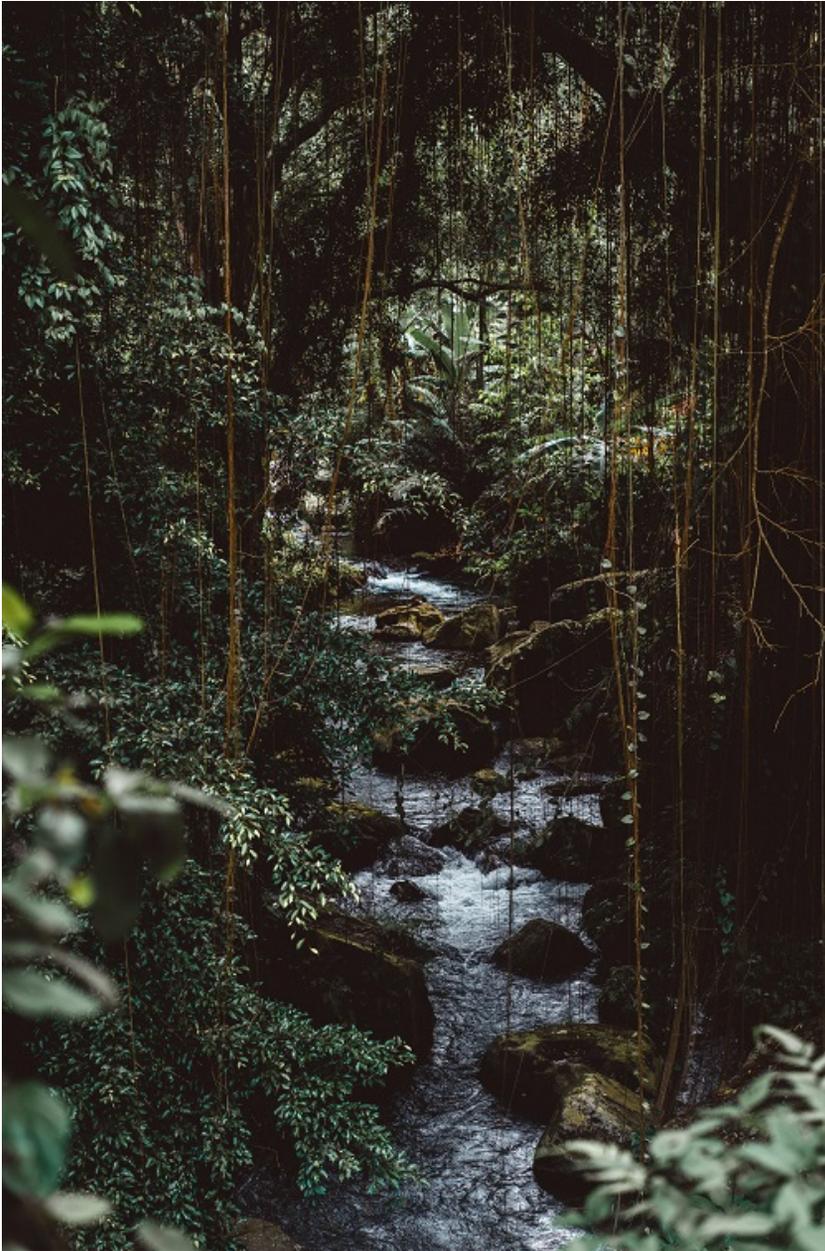
### 3.7. Institutions

Groundwater quality governance requires multilevel governance structures from the ministerial level to groundwater user groups involving stakeholders and institutional cooperation in law and policy-making, including in planning and licencing procedures between the institutions in charge of all relevant sectors.

### 3.8. Constraints to Effective Groundwater Pollution Prevention and Control

Effective groundwater pollution prevention, reduction and control often suffer from constraints such as lack of awareness of groundwater, gaps in knowledge and monitoring, financial limitations, unfavourable socio-economic conditions and institutional barriers. With respect to new polluting activities (e.g. fracking) and new pollutants (e.g. pharmaceuticals), current regulations, quality standards and testing methods may be insufficient to address the changed circumstances.

4. Groundwater Pollution in International Law



## 4.1. Introduction

International groundwater law complements domestic legislative frameworks for the more than 590 transboundary aquifers (including transboundary groundwater bodies as defined in the EU Water Framework Directive). Coverage of transboundary aquifers in international law is still at an early stage, and only a few global or regional legal instruments address transboundary aquifers. Even fewer agreements have been concluded for specific aquifers, and only some of those address groundwater quality issues. Groundwater is often included, directly or indirectly, in the scope of surface water agreements but with no detailed attention to the specific characteristics of aquifers, including their particular vulnerability to pollution.

Where groundwater quality is addressed, legal instruments typically contain an obligation to prevent, reduce and control groundwater pollution – with various degrees of detail provided. As transboundary pollution and its consequences can constitute a form of transboundary harm, the obligation to prevent, reduce and control pollution is closely related to the obligation not to cause significant harm, one of the core obligations of international water law, and the precautionary principle.

## 4.2. UN Draft Articles on Transboundary Aquifers (2008)

The most detailed guidance on pollution prevention is found in the provisions of the 2008 UN Draft Articles on Transboundary Aquifers (Art. 12) and the 2012 UNECE Model Provisions on Transboundary Groundwaters (Provision 5).

The 2008 UN Draft Articles on Transboundary Aquifers were developed by the International Law Commission of the United Nations and endorsed by the UN General Assembly in Resolution 63/124. They are non-binding but still provide important guidance because they are the first official instrument that codifies rules of international law for the management and protection of the world's underground freshwater resources. Article 12 of the Draft Articles on Transboundary Aquifers on Prevention, Reduction and Control of pollution states that:

*“Aquifer States shall, individually and, where appropriate, jointly, prevent, reduce and control pollution of their transboundary aquifers or aquifer systems, including through the recharge process, that may cause significant harm to other aquifer States. Aquifer States shall take a precautionary approach in view of uncertainty about the nature and extent of a transboundary aquifer or aquifer system and of its vulnerability to pollution.”*

### 4.3. UNECE Model Provisions on Transboundary Groundwaters (2012)

The UNECE Model Provisions on Transboundary Groundwaters are a detailed official interpretation of the binding provisions of UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, which has now been opened to global membership. Its Provision 5 states that

*“The Parties shall take appropriate measures to prevent, control and reduce the pollution of transboundary groundwaters, especially those reserved for drinking water supply. In this context, they shall follow the precautionary principle in view of the vulnerability of groundwater to pollution, particularly in cases of possible uncertainty about the nature and extent of transboundary groundwaters.”*

*2. Such measures shall include, inter alia, the following:*

- (a) The establishment of protection zones, in particular in the most vulnerable/critical parts of the recharge area of groundwaters, especially of groundwaters used or intended to be used for the provision of drinking water;*
- (b) The adoption of measures to prevent or limit the release of pollutants into groundwaters, such as negative influences on groundwater from point sources;*
- (c) The regulation of land uses, including intensive agricultural practices, to combat pollution of groundwater from nitrates and plant protection agents;*
- (d) The definition of objectives and the adoption of groundwater quality criteria.*

#### 4.4. Pollution Provisions in Agreements for Specific Aquifers

For specific aquifers only a few legal agreements exist and among those even fewer address groundwater pollution, namely only those for the Al-Sag/Al-Disi aquifer (2015), the Guaraní aquifer (2009), the Nubian Sandstone aquifer system (2000), and the Iullemeden (2009) and Iullemeden, Toudeni/Tanezrouft aquifer system (2014). To date, the agreements for the Guaraní aquifer, the Iullemeden aquifer and Iullemeden, Toudeni/Tanezrouft aquifer system have not been fully ratified and thus are not yet in force.

#### 4.5. Groundwater Pollution in Other Sources of International Law

Much more strict and detailed are the groundwater pollution provisions in the EC Water Framework Directive and Groundwater Directive. These directives are instruments of a supranational character, which have to be transposed into domestic law in the EU and accession countries. Eventually their content becomes part of national legislation and applies to all groundwaters (domestic and transboundary) of the respective countries. In addition to legal instruments on groundwater, some treaties that mainly address surface water basins also contain explicit obligations to protect groundwater against pollution. A significant number of such basin treaties apply (at least formally) to surface and groundwater alike so that their provisions on the protection of basin waters against pollution likewise cover groundwater.

#### 4.6. Constraints to Effective Pollution Prevention and Control

The constraints that limit effective prevention, control and reduction of groundwater pollution domestically apply equally to transboundary groundwater resources -- lack of awareness of groundwater, gaps in knowledge and monitoring, financial limitations, unfavourable socio-economic conditions and institutional barriers. In addition, uncertainty about the transboundary nature of some aquifers, misguided ideas of perceived exclusive sovereignty or limited interstate cooperation in general may limit incentives to cooperate, especially given the dearth of successful examples of interstate groundwater cooperation.

## 5. Conclusions

Groundwater pollution is caused by a multitude of actors in a large number of ways, and pollution sources, scenarios and risks are highly diverse. Addressing the prevention, control and reduction of groundwater pollution requires a variety of legal measures in a number of sectors, including water resources, land use and agriculture, and also requires institutional coordination, cooperation. Since clean-up of an aquifer is difficult to impossible, pollution prevention and reduction should take priority. Changes in lifestyle, living standards, population size and distribution and land-use will have impacts on groundwater quality that have to be taken into account in groundwater planning and management.

International groundwater law is still patchy and incomplete with respect to the prevention, reduction and control of pollution of transboundary aquifers. Only a few examples of inter-state cooperation over those resources exist, and only some of the few agreements that have been concluded address groundwater quality issues. More bi- and multilateral cooperation over transboundary aquifers, including the exchange of data and information, is necessary to effectively address transboundary groundwater pollution.