

Module 10

Water Protection

Summary

This module consists of 2 parts:

A. Water protection in general

B. Groundwater protection zones

In many areas, groundwater is used directly as drinking water – this counts for up to 80% in Europe and Russia. It is the most reliable of all fresh-water resources. Possibilities for its abstraction and quality vary greatly from place to place. The lack of preventative measures against anthropogenic (man-made) water pollution contributes to unsafe drinking water. Polluted groundwater results in unsafe drinking water. High investments for treatment can lead to safe drinking water. In more extreme cases, a complete abandonment of drinking water abstraction may be the only solution.

Part A. Water protection in general, gives an overview of the groundwater pollution's most common sources of. Regulations on the prevention of water contamination are also discussed, and some examples on policies and measures to prevent water pollution are described.

Part B. Groundwater protection zones, defines different water protection zones and the restriction on human activities in these zones. Some examples on good water protection measures are stated.

Objectives

The pupils can describe the most common sources of water pollution and are aware of water protection strategies. They can describe the different groundwater protection zones of a water catchment area and understand the aim of the different zones.

Key words and terms

Water pollution, anthropogenic, water protection, directives, agriculture, communal wastewater, animal waste; Water Protection Zones, sanitary zones, catchment area, water quality, hydrogeological conditions

Preparation/materials

Materials	Preparation
Map of the village, map of the sanitary zones	Communication with mayor/water supplier
Risk assessment check lists (protection zones)	Available in module 18
Related national/local guidelines or regulations on water protection	Communication with mayor/water supplier Research on the Internet
National guidelines on the establishment of water protection zones within the drinking water catchment areas	Communication with mayor/water supplier, eventual internet research on the Internet
Guidelines on the restrictions within the different water protection zones	Communication with mayor/water supplier, eventual research on the Internet

Water Protection

10A. Water protection in general

Introduction

In most areas, groundwater is cleaner than surface water. Groundwater is usually protected against contamination from the surface by the soil and rock covering layers. However, depending on geological and hydrological conditions and on rock covering layers, groundwater can get severely contaminated, in particular with microorganisms, nitrate and pesticides. Polluted groundwater results in unsafe drinking water with high investments for treatment. In extreme cases, a complete abandonment for drinking water abstraction may be the only solution. The discharge of untreated or poorly treated wastewater, as well as infiltration of animal manure, strongly affects the quality of water sources and human life.

A constant decline of ground- and surface water quality has been observed in countries with intensive livestock farming (chicken, pigs), intensive crop growing, involving the use of chemical weed-killers (herbicides), and over-fertilisation. The runoff and leakages of nitrates, pesticides and phosphorus from agricultural land during rainfall is only one cause of water-pollution. However, regions with small-scale farming lacking safe management of animal manure, and other organic waste and households' wastewater, often contribute to water pollution.



Slopes and soil characteristics, erosion, deforestation, farmers' land-use, crop choices and production techniques all contribute to the quality of waters.

Besides man-made pollution, natural geological substances, such as fluorine, arsenic or salts, can also negatively affect water and restrict its use. In this manual, the focus is set on explaining anthropogenic water pollution by agricultural practices and mismanagement of human and animal excreta.

1. What can be done and on which levels?

Often, water pollution is man-made, and therefore, can be minimised by people.

Experiences from many countries show that water protection policies are attractive and sustainable from an environmental and economic point of view for the long term. In many cases, costly groundwater treatment for providing safe drinking water could be avoided. In addition, safe recreational and bathing water are treasures to all people, where untreated wastewater should not be present.

In many countries, local, regional or national regulations are established, targeting industries, communities or farmers in order to protect the water sources and basins, intended to deliver drinking water to the citizens. For implementation of the protection measures, stakeholders on all levels (national, regional and local) need to be involved.



A variety of pollution prevention and control measures are needed because water pollution can originate from many different sources.

1.1. Policies and agriculture

For many decades, discharges of nitrogen and pesticide compounds from agricultural activities have posed a problem for groundwater quality not only across Europe, but the world. Nitrogen is a substance needed for the vegetation of all plants and is found in mineral fertilisers, manure and slurry. However, only a small proportion of the applied fertiliser actually reaches the crops and is taken away with the harvest. A large proportion accumulates in the environment as a surplus, for example in the form of ammonia or laughing gas. The rest remains in the soil or seeps into the groundwater in the form of nitrate. Nutrients are not the only substances that contaminate our waters, but also heavy metals and pesticides. Around 20 to 40 % of heavy metal discharge into surface waters, originating from erosion or drainage outflows, are from agricultural land.

The bulk of pesticide pollution originates from agriculture, from the application of fields to the cleaning of sprayers and other machinery. Pesticides from the *triazin* chemical group, for example the herbicides *atrazin* and *simazin*, are substances frequently found in ground- and surface waters. Other pesticides with a high potential to pollute the groundwater are *diuron* or *bentazon*. Many countries have a pesticide list (active ingredients) with potential groundwater polluting properties. In Germany, around 40 active ingredients were identified with a high importance for water protection.

The legal framework stipulates the following for example:

- Obligations of the national, regional and local institutions and wastewater/water utilities
- Quality of groundwater and/or surface water
- Monitoring of water quality and quantity
- Type of waste and wastewater treatment
- Adapting and supporting the most sustainable and suitable sanitation systems
- Measures on the restoration and protection of water bodies
- Human rights regarding access to safe water and sanitation
- Transparency and access to information and public participation

In order to decrease water pollution in the European Union (EU), political actions, particularly in the area of agriculture, were needed and several water-related directives or guidance were developed and published.

European Water Framework Directive (2000/60/EC)

The purpose of the European Water Framework Directive of 2000 is to establish a framework for the protection of inland surface water, transitional water, coastal waters and groundwaters (see also Module 14). The Water Framework Directive (WFD) explains that further deterioration should be prevented, and promotes sustainable water use based on long-term protection of available water resources. Member States are expected to protect and enhance all artificial and heavily modified bodies of water with the aim of achieving a good ecological potential, a good chemical status, and ensure a balance between abstraction and recharge of groundwater.

European Nitrate Directive (91/676/EEC)

In 1991, the EU published the Nitrate Directive, concerning the protection of water from pollution caused by nitrates from agricultural sources. This directive tries to control the amount and timeframe of fertiliser application for crops and grasslands, as well the usage of manure from livestock. Also, it requires Member States to designate “vulnerable zones”, which are areas of land that are likely to contribute to nitrate levels exceeding 50 milligrams per litre (mg/l). (See module 14 for further information.)

European directive on the protection of groundwater against pollution and deterioration (EC Groundwater directive) (2006/118/EC)

Measures to prevent and control groundwater pollution are stipulated in this directive and should be adopted. Quality standards for nitrates, plant protection products and biocides should be set as community criteria for the assessment of groundwater bodies’ chemical status. Together with the nitrate directive consistency, the EC Groundwater Directive should be ensured also related to human and animal waste. The EC Groundwater Directive sets EU-wide binding limits. (See module 14 for further information.)

1.2. Domestic wastewater

Worldwide, many rural villages rely on decentral water and wastewater systems for the collection of wastewater, such as dug wells, boreholes, standpipes, pit latrines and/or septic tanks. These mechanisms usually result in unprotected sources and mismanagement of human waste. The treatment of communal wastewater or individual wastewater is an essential requirement for long and short-term preservation of water resources. Communal wastewater and/or excreta from pit latrines or septic tanks have to be treated and sanitised before being released into the environment. See also module 8.

Even in regions without a centralised wastewater collection and treatment system, an appropriate wastewater treatment or human excreta treatment can be practiced. Modern sustainable and decentral approaches, such as urine diverting dry toilets, constructed wetlands or wastewater ponds, contributes to the protection of water resources. Communities should be informed about the relation between communal and domestic wastewater management and pollution of water resources. They need to select the most appropriate solution, taking the available financial and human resources into consideration. Approaches on the management of wastewater should be investigated and adopted to the local environmental, social and economical conditions. Planning work and implementation of a wastewater management system should take a holistic approach to wastewater discharge, treatment and re-use.



Particularly in high-density communities without a sewage connection or without a wastewater treatment system, the infiltration of untreated human excreta in soil or the discharge of improperly treated wastewater into surface waters should be avoided.

A guidance on decentralised treatment of wastewater is delivered by the European Union: “Guide on extensive wastewater treatment processes, adapted to small and medium sized communities (500 to 5 000 population equivalent -p.e.)”. This guidance document is an addition to the Council Directive decreed on 21 May 1991 concerning urban wastewater treatment (91/271/EEC), which is one of the key parts in the European Union's environmental policy. One of the main measures in this text is the obligation for agglomerations with more

than 10 000 or more than 2,000 p.e. that discharge their wastewater into a sensitive area, have to set up a system for collecting wastewater which is connected with a wastewater treatment plant.



A urine diverting toilet has two outlets and two collection systems, one for urine and one for the faeces, in order to keep these excreta fractions separate. Urine and faeces are collected in separate containers, stored or treated, and finally used in crop production.



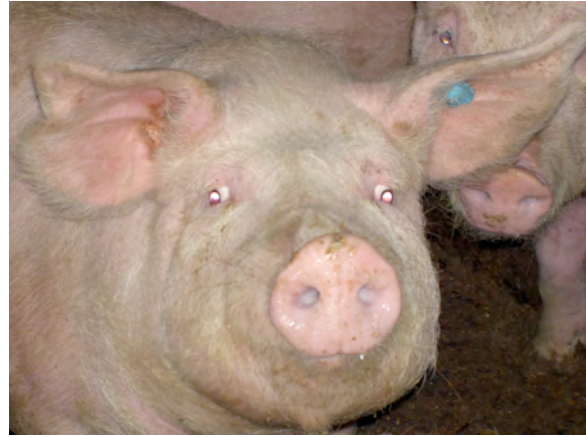
Constructed wetland used for a decentralised treatment of wastewater (Photo Andrea Albold).

1.3. Animal manure

In many rural villages, it is rather common that families have some cattle for their own consumption or for commercial purposes. Depending on the culture, solid animal waste is mostly collected and stored outside on a heap, where the soil is in direct contact with the manure. Rainwater will partly washout the nutrients and finally infiltrate into the groundwater.

Livestock is often kept in stables, where the conditions are not suitable for collecting the liquids, resulting in runoff into the soil. In order to avoid leakages of the animal manure into the soil, the manure produced in the stable should be collected and stored in a closed concrete platform with borders, such as small walls from which liquid manure can flow into a reservoir or pit. A watertight layer under the manure heap (manure platform), a covered watertight basin, or tanks for the slurry/liquid manure should avoid uncontrolled leakages into the groundwater.

In some EU Member States (e.g. Austria, Germany, Netherlands) regulations on handling animal manure are established and promoted.



An often neglected aspect of sustainable water protection is the safe storage of animal manure.

To assure runoff of the leaking liquid, the platform must have a slope of 3-5 %, and a gutter where the liquid is collected and stored in the reservoir. A storage capacity of at least 6 months should be available, in order to ensure a timely and targeted use of the slurry or manure. The application of the manure should be according to the needs of the plants. In general, the animal-stocking rate should be related to the size of the available fields and in balance with the cultivation of crops.



Manure should be stored on a closed concrete platform with borders.

Table 1. Overview of common Sources of Potential Water Contamination
 Source: EPA United States Environmental Protection Agency

Category	Contaminant Source
Agricultural	<ul style="list-style-type: none"> • Fertilizer storage/use • Pesticide storage/use • Manure spreading areas/pits, lagoons • Animal burial areas • Drainage fields/wells • Animal feedlots and storage • Irrigation sites
Commercial	<ul style="list-style-type: none"> • Metal industry, photography establishments • Auto repair shops, Car washes/gas stations • Laundromats, Paint production/shops • Medical institutions/laboratories • Construction areas, Railroad tracks and yards • Wastewater drainage, storage tanks, landfills
Industrial	<ul style="list-style-type: none"> • Asphalt plants, wood preserving facilities • Petroleum production/storage • Mining, drainage • Chemical manufacture/storage • Toxic and hazardous spills • Electronic/metal manufacture • Wastewater drainage, pipelines • Wastewater sludge, septic cesspools
Residential	<ul style="list-style-type: none"> • Sewer lines, septic tank and pit latrines • Household hazardous products/detergents, • Pharmaceutical, fuel, oil • Fertiliser/pesticides in households and gardens • Manure leakages and spreading
Other	<ul style="list-style-type: none"> • Hazardous waste landfills • Cemeteries • Recycling/reduction facilities • Municipal incinerators and landfills • Road de-icing operations • Road maintenance depots • Municipal sewer lines • Storm water drains/basins/wells • Open burning sites • Transfer stations • Salt water intrusion

2. Exercises and Questions

- What are the main reasons why water should generally be protected?
- Which regulations on water protection are known and what do they imply?
- On which levels (local, regional, international) can something be done towards water protection?

WSP related activities

- Concerning the assessment of human and animal waste management, a list of possible sources of water pollution in the local village can be made.
- Interviewing the mayor or water authorities on the management of the communal wastewater about what they want to explain about water regulations is advisable.
- How is the wastewater in private households managed? (Is wastewater deposited in a septic tank, in the sewer or infiltrated in a pit?)
- Interviewing the family and neighbours on the management of animal manure, fertilisers and pesticides can reveal interesting aspects. Interviews with farmers about the usage of pesticides and fertilisers (and about knowledge about the Nitrate Directive) may be very helpful.
- The “road” of the participants’ wastewater should be drawn from the point of usage to its release into the environment.
- The most intensive sources of pollution in villages, and in the local village on-site, generally can be inserted into a map.

3. Text sources and further reading

Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Available from <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991L0676:EN:NOT>

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Water Protection

10B. Groundwater protection zones

Introduction

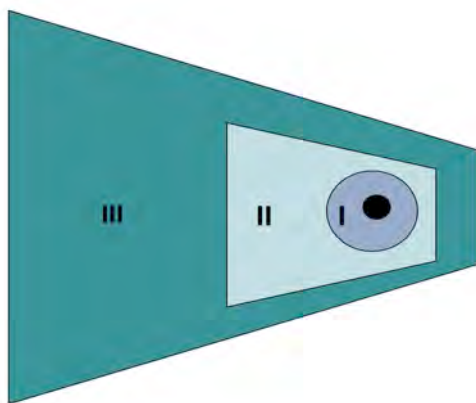
For more intensive protection of groundwater sources, many countries established national or regional regulations on the protection of water sources intended for abstraction of drinking water. Generally, the water protection area is divided into several Water Protection Zones (WPZ) with more or less intensive restrictions addressing diffused water pollution from agricultural activities for example. Activities in the WPZ, which cause or could cause damage or pollution of the groundwater, are prohibited.

1. How are groundwater protection zones defined?

The shape and size of a protection zone or sanitary zone depends on the condition and properties of the soil layers, the infiltration of rain or river water and the movement of the groundwater (from which side does the groundwater stream). Hydro-geological studies define the properties of the ground and the groundwater. For example, the type of soil and its permeability are analysed as well as the velocity of the groundwater stream.

The division of several zones can vary slightly from country to country. In general, the protection zones should include at least the so-called 50 or 60 days zone. In this zone, the groundwater needs 50 or 60 days to travel from any point below the water table to the abstraction point. During this timeframe, it should be able to minimise bacteria. However, within the mentioned time, chemical contaminants will hardly be reduced, and up to 3 or 4 protection zones are necessary for preventing chemical pollution. Those zones should be identified by hydro-geological investigation.

The drinking water protection area should consist of the entire subterranean catchment area of a water abstraction point; sometimes, the surface catchment area needs to be considered as well. However, due to many reasons, most water suppliers or communities are not aware of this requirement.



Scheme showing water protection zones I-III.

- *Well-field protection (Zone I)*
- *Inner protection zone (Zone II)*
- *Outer protection zone (Zone III)*

1.1. Overview of the divided protection zones

- Zone I, or well-field zone, must ensure the protection of the water abstraction point and its immediate environment from all types of contamination and impairment. Depending on the regulations, the radius can be established at least 10 meters around the point of abstraction and be surrounded by a stable fence.
- Zone II, or inner protection zone, must ensure protection from contamination via pathogenic microorganisms (e.g. bacteria, viruses, parasites and worm eggs), as well as other impairments posing a hazard due to the presence of short flow paths and short flow durations to the water abstraction point.

This zone can have a minimum radius of 50 metres.

- Zone III-A, or outer protection zone, should ensure protection from far-reaching impairments, especially from contamination with chemical or radioactive substances that are either resistant or non-degradable. For some countries, Zone III-A is defined by a 400-day travel time from the point below the water table.
- Zone III-B, or source catchment protection zone, is defined as the area around the source within which all groundwater recharge is presumed to be discharged at the source.

1.2. Groundwater protection zones and restrictions

In the following table examples of restrictions for different sanitary zones are presented.

	Examples of Restrictions
Zone I	Unauthorised entrance, any kind of agriculture or other usage
Zone II	Setting up of construction sites; Designation of new construction areas; Building new traffic routes; Infiltration of sewage; Fertilisation with solid and liquid manure and mineral fertilisers; Application of pesticides; Deforestation; Discharge of waste for recycling purposes; Handling of substances hazardous to water; Exploitation of minerals; Animal preserves and permanent grazing; Building, extension and operation of industrial facilities handling extremely large quantities of substances that may be harmful to water (e.g. refineries, metallurgical plants, chemical plants, power plants);
Zone III-A	Designation of new industrial estates; Discharge of waste for recycling purposes; Handling of substances hazardous to water; Exploitation of minerals; Building, extension and operation of facilities for the treatment, storage and deposition of waste, residues and mining refuse; Building, extension and operation of industrial facilities handling extremely large quantities of substances that may be harmful to water (e.g. refineries, metallurgical plants, chemical plants, power plants) Usage of mineral fertilizer and water-soluble pesticides;
Zone III-B	Building, extension and operation of facilities for the treatment, storage and deposition of waste, residues and mining refuse; Building, extension and operation of industrial facilities handling extremely large quantities of substances that may be harmful to water (e.g. refineries, metallurgical plants, chemical plants, power plants);

Table 1. Overview of the water protection zones and examples of restriction.

Source: According to Deutscher Verein des Gas- und Wasserfaches e.V., DVGW



Sign for a water protection zone in Germany

2. Barriers and mechanisms for implementing the restrictions

Adequate regulations on water protection strategies do not necessarily guarantee the implementation of the regulations. If land properties located in the protection zones are not communal, or do not belong to the water supplier, problems may arise with the implementation of restrictions. Also, lacking geological and hydrological information about the catchment zones or monitoring practices of the groundwater quality contribute to inadequate water protection. Land-users lacking awareness about *do's* and *don't's* in the protection zones contributes to groundwater pollution. Successful water protection strategies are carried out in cooperation with the relevant stakeholders, such as farmers and citizens. Mechanisms like forestation, raising awareness, intensive farmer consultation and disincentive taxes for polluting practices have all been proven to be effective to improve water quality.

In principle, experience has shown that water protection can only succeed WITH agriculture, not AGAINST it. Expertise and competent advice to farmers is an important element of this approach.



Groundwater quality is prone to contamination by e.g. the intensive cultivation of maize. Pesticides and synthetic fertiliser were applied on the field in this picture.

There are some ways of reducing water pollution by adopting modified approaches to farm and land management:

- 1) Nutrient balance assessment and fertiliser management
- 2) Crop rotation, appropriate land use, riparian buffer strips
- 3) Organic farming – restricted amount of livestock per hectare

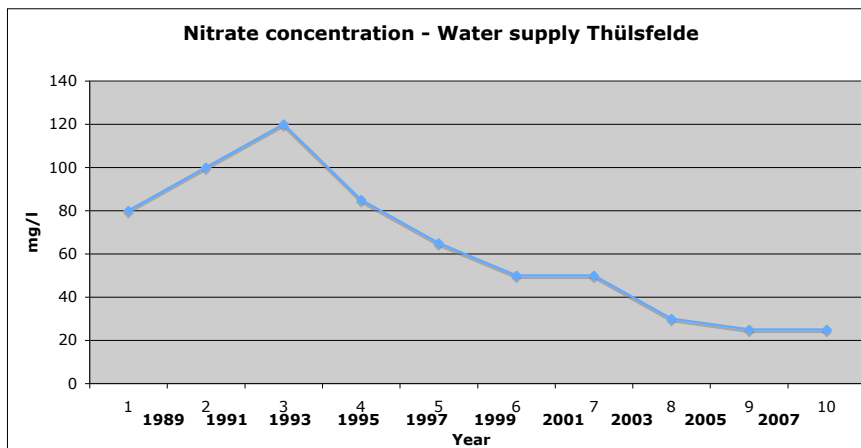
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- 4) Elimination or restricted usage of synthetic nitrogen fertiliser and pesticides
 - 5) Forestation, termination of ploughing of grassland

2.1. Examples of good water protection policy

Since the foundation of the Munich waterworks in Germany around 1900, forest management has been focused on ensuring good water quality. However, in spite of the existing regulation within the water protection zones, a slow but constant decrease in water quality had been observed. In 1992, the waterworks decided to cooperate more intensively with the farmers. Organic farming was promoted, and farmers were subsidised for not using synthetic fertilisers or pesticides for working according to the rules of organic farming. Citizens were informed and stimulated to consume the organic grown products from the catchment area.

Currently an area of 4 200 hectare (ha) is managed primarily to maintain water quality: 1 500 ha is forest and an additional area of 2 700 ha is bound to long-term contracts of about 100 local farmers, who have committed to certified ecological/organic agriculture. Due to its strict prevention policy, the Munich water works deliver excellent drinking water without any treatment to their consumers. Since some years, the water has been free of pesticides. The nitrate concentration remains on the natural level of less than 10mg/l. Financial experts calculated this prevention policy, including consulting and subsidising the farmers, which is less expensive than water treatment.

The following example shows the water supply in Thülsfelde, in North-Germany. Due to the intensive livestock-activity in the water catchment area, the nitrate concentration in the shallow groundwater, which was used for the water supply, exceeded the limit of 50 mg/l more and more. In 1993, the water supplier promoted organic farming in the water catchment areas in close cooperation with the farmers. For marketing the organic-grown products and food processing firms, supermarkets and consumers were mobilised as well. As the graphic shows (Graphic 1), the nitrate concentration was decreased to the limit of 50mg/l after 6 years of organic farming.



Graphic 1: In 1993, the water supplier promoted and realised organic farming in the water catchment areas in close cooperation with the farmers in Thülsfelde, North-Germany. Source: Data according OOWV, PowerPoint Grundwasserbewirtschaftung, Egon Harms

2.2. Water protection by households and citizens

Communities are also often located in a catchment area from where drinking water is extracted and delivered by a centralised system or individual water sources to the households. Certainly, consumers and households can also contribute to a contamination of ground and surface waters. For example, car wash runoff flows into rivers, or the oil contaminated wash water infiltrates into the groundwater. Other examples include: pesticides and too much fertiliser used for gardening, manure of livestock and human excreta that are not adequately managed, and left overs of painting or medicines released in the environment or in the toilet. Therefore, water protection starts at the household level and everybody can contribute to keep the water clean. Campaigns

sensibility of water sources and the risks and causes of water pollution can be an effective measure for raising citizen's awareness of the effects of their water handling.

3. Exercises and Questions

- Which properties are important in defining a water protection zone?
- Name the different protection zones and the appropriate restrictions.
- Which barriers could occur when implementing water protection regulations? An interview with the mayor or water authorities should be informative because they speak from own experience.
- Research on the Internet about geological-hydrological conditions in areas of water sources, e.g. type of soil: sandy, loamy, rocks, and on the direction of the groundwater streams and the groundwater level.
- Name a good practise example of water protection policy.

WSP related activities:

- Detailed research on the Internet may give information about regulations on water protection zones in the local area.
- Make a map of the different protection zones in the local area (in cooperation with the expert).
- Farmers of households located nearby the drinking water sources should be interviewed e.g. about the usage of pesticides and fertilisers and about the knowledge of managing water protection zones.
- An excursion to the WPZ can be organised to identify possible sources of groundwater pollution: how should the situation be and what is the practice currently?
- Land-users in the protection zones should be interviewed concerning the management of animal manure, usage of fertilisers and pesticides, or other possible pollutants of e.g. industry-processing firms.
- Are there firms, industries or households releasing substances or liquids into the environment which endanger the water quality?
- The drinking water provider should be interviewed concerning: quality and quantity of the abstracted water, water analyses and other monitoring (water level) results, challenges and opportunities in the catchment area, a system of subsidy for good practices of farmers.

4. Text sources and further reading

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Directive 2006/11/EC of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community.

OOWV-Water4All (2005). Sustainable Groundwater Management; Handbook of best practice to reduce agricultural impacts on groundwater quality. Available from http://www.wise-rtd.info/sites/default/files/d-2008-07-02-w4a_Handbuch.pdf