Module 4

Drinking Water Sources and Extraction

Summary

The supply of drinking water comprises many components and tasks, starting at the catchment area. This module introduces methods of selection of different sources for water supply and their qualities. Water extraction is also discussed.

Objectives

The module puts teachers and pupils in the position to understand the selection of water sources like groundwater, springs or rivers for a drinking water supply. They will be able to make a rough appraisal of the conditions of the water sources for their water supply, their advantages and disadvantages.

Keywords and terms

Catchment area, water source, surface water, well, borehole, spring, water extraction

Preparation/material

Materials	Preparation
Questionnaire	Making copies, eventual revising and adding more relevant questions
Excursion to water sources	
Paper, pencils	

Drinking water sources and extraction

Introduction

In comparison with other European countries, Bulgaria is a water-poor country. Hence, a constant and reliable water supply to the public is a challenge. In 2003, around 372 m^3 of freshwater were abstracted, whereof 65% were from surface waters or bank filtrates and 35% were from groundwater. 98% of the households are connected to a central water supply. 50% of the freshwater used is good quality, thus further improvements are desired and EU-standards have to be fulfilled (EU Drinking Water Directive). Draughts and water shortages are challenges, as are water losses up to 60% through broken piping systems.

A successfully working water supply, which delivers tasty and healthy drinking water all day, is not self-evident. The following pages give an overview on how supply of public water works and what kind of equipment is used to fulfil regulations and customer demands.

1. Source selection and catchment area

The selection of water sources to establish a water supply depends largely on the hydrological and geological conditions and (local) precipitation in the catchment area. An advanced mapping of the hydrological, geological and land use conditions is very helpful for proper planning and implementation. The management of the catchment area can be essential to minimising problems in water quality and in the treatment of the water. A higher quality of water is assured through accurate land use management (see also module 2 and 10). This can reduce technical and financial investment by already removing unwanted water contaminants like fertiliser, pesticides, other chemicals or pathogens. A good example is the work of the Munich Water Works (www.swm.de/english.html). Ecological agricultural practise within the catchment area and regional marketing of the products were established. Water suppliers are able to deliver drinking water without nearly any treatment.

1.1. Surface water

Rivers (e.g. Danube), canals or lakes (natural or artificial) are a frequently used source of water, but they are vulnerable to pollution by man and wildlife. Agriculture (pesticides, fertiliser, grazing cattle) industry and wastewater discharge cause a volatile water quality with higher concentrations of chemicals and pathogenic microorganisms. Nutrient-rich water can be affected by algae and their toxins too. Furthermore, droppings of wildlife in surface waters are un-avoidable; on account of this, surface waters without treatment are not safe for drinking purposes. Depending on the catchment area, different measures of preventing hazardous risks have to be undertaken. Because of the potential risk of pollution, surface waters are only considered if other sources (especially groundwater) are not available.

Water from an upland catchment area, without agricultural activities and with an acceptable pH, usually shows good chemical quality, but does not necessarily have a good microbiological status! Finally, microorganisms are the main cause of diseases when unsafe water is consumed. Small rivers are often affected by local human activities and show poor water quality. The community and local administration have the power to change the conditions. Lowland streams are expected to have the worst water quality, and the local influence to change water quality is at a very low level. In general, this water can change very quickly in its properties, like turbidity (rainfall) or colour (seasons). Natural variability of water quality is common for surface waters, but man-made pollution should be as low as possible..

The Danube is a source
for drinking water for many villages and cities

If possible water should be collected from the ground in the immediate vicinity of the stream and riverbank. Further, the intake should be situated at a point with low turbulence, during e.g. high rainfalls. If surface water is selected as a source for the drinking water supply, a lot of technical and financial effort has to be made to deliver safe and proper drinking water to the public. At least a minimum of filtration and disinfection is required. May be lakes are more uniform in their water quality, but not less vulnerable to contamination as mentioned above for rivers.

1.2. Springs

The quantity and quality of water from a spring can vary depending on its source. Springs fed by a deeper aquifer are more reliable and constant, whereas those issued by a perched water table or covered by fissured limestone or granite may dry up. The treatment of spring water is normally less intense because the suspended matter is lower. However, water is not protected against contaminants from agriculture or wastewater from households or communities in many areas. In certain circumstances microorganisms and chemicals can contaminate shallow ground and the spring's waters. Soil layers have a certain capacity on adsorbing and filtering pollutants. Hence, deep-water layers are better protected against infiltration than shallow ones in general. As mentioned in module 3, the composition of the soil layers has a huge influence on the water quality and content. Water passing the soil layers dissolves and transports minerals from the soil into the groundwater. Depending on these layers and the geology, groundwaters and springs can contain a varying mixture of several minerals, which can cause technical or health risks. Building a water collection chamber can protect the abstraction point of the spring. The collection chamber can protect the source from pollution, entrance of vermin and debris, and can provide storage for times of higher demand.

1.3. Groundwater

Boreholes and wells are used to explore groundwater of different depths and quality. The quantity of water, which can be extracted, depends on the characteristics of the aquifer. It can be helpful to test it after construction by pumping. Shallow wells and boreholes are more at risk to be contaminated than deeper ones, but if sited correctly, they can deliver good quality drinking water. As for springs, the water content and quality is strongly related to the soil layers above the aquifer. Water abstracted from deep wells and boreholes can originate from catchments many kilometres away. Hence, it is important for the water supplier to know the properties and characteristics of the catchment area (see also module 10 – water protection). Most groundwater (aquifers) are renewed naturally by infiltration of water from rain or snow in the recharge area; which, as mentioned above, may be many kilometres away from the extraction point. However, the water table will subside if the water abstraction for water supply or for irrigation exceeds the natural recharge capacity of the groundwater layer (water mining).

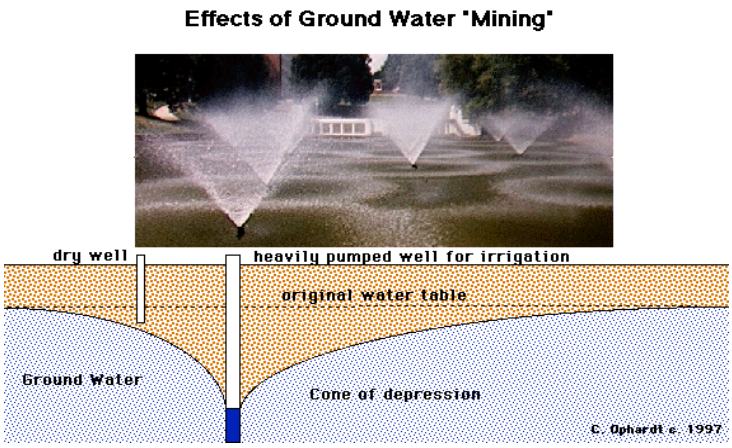

Figure 2: Overexploitation of a groundwater layer
Source: http://www.elmhurst.edu/~chm/vchembook/301groundwater.html

In this case, wells may get dry, water could be sucked from the upper soil layers into the aquifer or coastal salty water could infiltrate into the aquifer depending on the depth. Overexploitation of the groundwater source has to be avoided!

The water quality is a matter of type of water source and changes according to geological, land use and weather conditions. The following table gives a rough idea of expected raw water content. For example adequate extracted groundwater will contain no particles, but springs or surface water can contain many particles after heavy rainfalls. In contrary, the groundwater can have high levels of calcium, magnesium and salts depending on the geological conditions. Surface water is less vulnerable for those elements.

Contaminant in raw water	**Ground water**	**Artesian water**	**Spring**	**Surface water**	**Most frequent source**
Microorganism	+	-	++	++	Wastewater, agriculture
Nitrate	++	-	++	-	Wastewater, agriculture
Calcium/magnesium	++	++	+	-	Natural
Sulphate	+	+	+	-	Natural
Iron/manganese	++	++	+	-	Natural
Fluoride	+	+	-	-	Natural
Sodium/potassium (Salts)	++	++	+	-	Natural, infiltration of sea water, inadequate irrigation practice
Particles (sand/loam)	-	-	++	++	Erosion, weather events (rain)
Contaminant during distribution					
Microorganisms	++	++	++	++	Leakages in pipes and connections
Metals: lead, copper	+	+	+	+	Lead or copper pipes, Corrosion
Chlorine-compounds/halogens	+	+	+	+	Chlorination
Phosphates	+	+	+	+	Treatment with phosphates
Salts	+	+	+		Treatment by ion exchanger at household level

Table 1: Different types of raw water and vulnerability for possible natural and anthropogenic contaminants. - Low vulnerability; +Vulnerable; ++ High vulnerability

2. Water extraction

The technical realisation of water extraction is different for each type of source and geological condition. Descriptions are held simple to be clear and comprehensible.

Boreholes/wells

Boreholes have a small diameter, may vary in depth and are drilled by specialists. Even deeper aquifers are accessible. They are mostly favoured if no other water supply is provided and water is needed in high quantities (e.g. irrigation). Legal aspects have to be taken into consideration. In contrast to boreholes, wells are dug by hand, have a larger diameter of about 1 meter or more, and are in most cases not deeper than 20m.

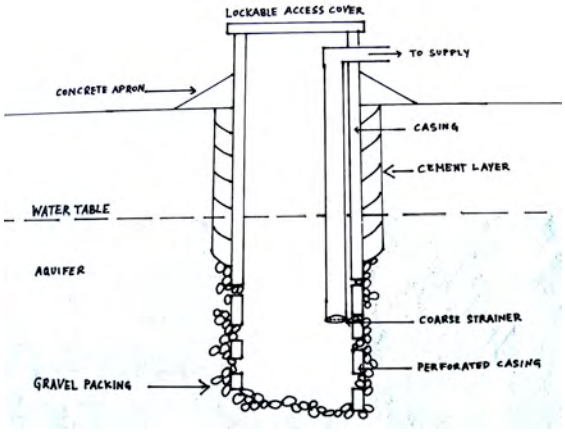

Figure 1: Schematic overview of a well or borehole source
According to Source: DWI: http://dwi.defra.gov.uk/research/completed-research/reports/DWI70_2_137_manual.pdf

Springs

Tapping of a water source can be established where groundwater occurs at the surface or is in less depth water layers. The source is exposed by a dredger or by hand. A filter pipe (PVC pipe with slots) is installed crosswise at the level the water flows. This is covered with silt and gravel. The water collected in the pipe is lead to a small chamber or basin from where it goes to the water treatment or straight to the consumer. Springs are protected from pollution and can provide storage for times of higher demand.

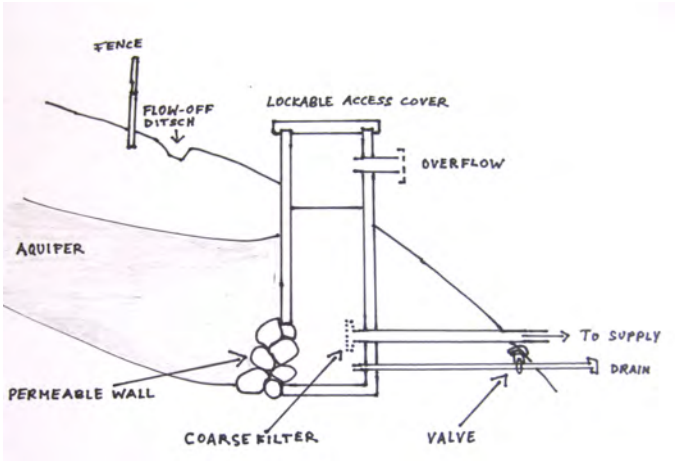

Figure 2: Schematic overview of a spring source
According to Source: DWI: http://dwi.defra.gov.uk/research/completed-research/reports/DWI70_2_137_manual.pdf

Entrance of a spring catchment

Photo source: Bayerisches Landesamt für Umwelt (Bavarian State ofice for Environment); (http://www.lfu.bayern.de/wasser/merkblattsammlung/teil2_gewaesserkundlicher_dienst/doc/nr_219_anlage6.pdf

Water collection of a spring in Bavaria. Tapping of the spring can be carried out with several drainage pipes. The basin should be covered and ferment proof.

Photo source: Bayerisches Landesamt für Umwelt (Bavarian State ofice for Environment); (http://www.lfu.bayern.de/wasser/merkblattsammlung/teil2_gewaesserkundlicher_dienst/doc/nr_219_anlage6.pdf

Rivers and lakes

Rivers and lakes can serve as drinking water supply; however, they always have to be treated before consumption. Surface waters are easily polluted by wildlife and infiltration by contaminants from wastewater and agricultural activities. Further natural variations of water quality, such as turbidity through water turbulences, are likely in rivers and streams. If possible, water should not be collected from the surface in the immediate vicinity of the stream and riverbank. The intake should be situated at a point with low turbulence.

3. Exercises and questions

- Pupils collect information about the available water sources and their catchment areas; e.g. from the water supplier or and hydro-geologist.
- In which way did water usage develop during the last 20-30 years in the pupil's communities? Pupils could do some research on this topic. Pupils ask their parents or grandparents about their observations of the level of the groundwater (of the wells) or the water yield of local springs.
- Pupils measure and observe the water flow of one or more springs (if available) over a given time.
- Plan excursions to the local water sources and ask the pupils to discuss from which direction the groundwater flows.

WSP related activities

Pupils identify the sources used for the local drinking water supply and the related catchment area:

- Pupils should make a map of the water sources used for water supply.
- Pupils interview the drinking water supplier about the quantity and quality of the used drinking water sources
- Pupils should discuss which sources they would choose if they would be a water supplier looking for the best circumstances for introducing a water safety plan in their environment.
- Pupils write an essay on the most appropriate water sources for their drinking water supply. They can involve experts to support.

4. Text Sources and further reading

Drinking Water Inspectorate (DWI), (2001). Manual on Treatment for Small Water Supply Systems. Available from http://dwi.defra.gov.uk/research/completed-research/reports/DWI70_2_137_manual.pdf

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