WATENV – Water, Soil and Vegetation

Lecture 2 (April 23rd, 2012)

2. Groundwater

- **Groundwater** is „sub-surface water completely filling pore spaces. Its movement is caused by gravity and its own force of friction" (DIN 4049)
- **Technical terms:** Aquifer, unconfined aquifer, confined aquifer, aquitard, aquiclude, bore, artesian bore
- Due to a lack of primary energy, groundwater is not forming independent habitats. However, groundwater is influenced by vegetation:
- By extraction of nutrients in the vadose zone
- By leaf fall and related mineralization processes
- Groundwater and spring water show only minimal changes in ionic composition and have a constant temperature between 6 and 10°C
- Exception: **karst springs**
- **Plant communities** serving as **indicators** like *Cochleario pyrenaicae-Cratoneuretum commutati* (Pyrenäen-Löffelkraut-Community) are solely related to habitats directly influenced by spring water and/or ground water with constant temperature and oxygen levels

2.1. Consistency of groundwater and seepage water

- **Petrographic characteristics**, e.g. solubility, of rocks in the related catchment area that either form the aquifer or are in contact with it influence groundwater consistency
- Furthermore, the **dissolved contents of seepage water** influence all characteristics of groundwater, depending on soil and vegetation as well as antrophogenic land use.
- Decomposition or accumulation of toxic groundwater contents are controlled by residence time, physical and chemical features and the availability of oxygen.

2.2. Groundwater pollution

- **Pollution hazards** are caused by both infiltrated surface water and seeping precipitation water
- **Seepage water as transporting medium**: the water is polluted by surface processes (e.g. the use of fertilizers) or wet and dry atmospheric deposition
- All nutrients and pollutants that are not degraded in the aquifer can re-enter the surface with spring water

2.3. Groundwater consistency and water vegetation

Solution contents	Type of groundwater
Primary, geogenic	Soft, base-poor groundwaters in siliceous catchement areas (sand, sandstone, granite) with softwater vegetation Hard, carbonatic groundwaters from limestone areas respectively sulfatic from gypsum areas with hardwater vegetation Chloridic (salinar) groundwaters in areas near coasts or in combination with inland salt deposits with salt respectively brackish vegetation
Secondary, biogenic respectively anthropogenic	Nutrient or pollution-rich groundwaters with different origins and catchment areas

The groundwater type (e.g. carbonatic, chloridic, sulfate-rich) controls the vegetation.

- **Hard water** and **soft water** differ in carbon availability, thus different types of plants occur

2.4. Chemical and transport processes

Starting situation	Reaction	Effects
NO3		Decrease of CO2
Few to no CO2	$(C,H,O) + NO_3^- + H^+ \longrightarrow CO_2 + H_2O + N_2$	Increase of CO2
Organic compounds		Increase of pH

Denitrification: at anaerobic conditions or at low oxygen levels, nitrate is reduced and thus removed from the nutrient cycle. The consumption of protons leads to a pH rise

- The presence of pyrite (FeS_2) in the aquifer can cause an **autolithotrophic denitrification** by *Thiobacillus denitrificans*. It oxidizes sulfide to sulfate and reduces nitrate to elementary nitrogen
- $FeS_2 + NO_3^- + H^+ \rightarrow Fe_2^+ + SO_4^{2-} + H_2O + N_2 \uparrow$
- Eutrophication, pollution and acidification of groundwater can have serious consequences
- Below pH 5.0, heavy metals and toxic aluminium ions are mobilized in high amounts in groundwater and seepage water

3. Formation of surface waters

- Studies of pollen and fossilized/ sub-fossilized plant pieces using carbon isotope dating provide information about the forming of these biotopes since the last ice age in Central Europe

- **Lake and swamp sediments** serve as archives for the temporal reconstruction.

3.1. Formation of stream systems

- **Stream flows** formed as primary drainage systems of the continents' water surplusses that can not be stored flow into the oceans
- The Lena flows into the Laptew Sea, a marginal sea of the Arctic Ocean
- **Anthropogenic water systems**, like artificial waterways (e.g. the Nord-Ostsee-Kanal, a canal linking the North Sea and the Baltic Sea, Germany) and canals for irrigation, like the California Aqueduct

3.1.1. Origin of Central European streams

- The strongest impacts of the Quaternary glaciations in Germany are the moraine sediments in the Northern German lowlands and in the basins north of the Alps.
- Due to the permafrost and the huge sediment load, **braided river systems** existed adjacent to the ice caps.
- They consist of interlinked, shallow stream channels that can still be found in arctic and alpine regions today