Erasmus Intensive Programme
Soil & Water

Organigram IP "Soil & Water
second cycle: 01/09/2013 - 14/09/2013
in Tartu

ulm university universität uulm

Input:
Soil science
Root ecology
Wetland ecology
Soil zoology
Soil food chain and soil animals
Effects of soil degradation on soil organisms

Eesti Maaülikool
EMU Estonian University of Life Sciences

Input:
Plant stress ecophysiology
Soil-plant-atmosphere continuum
Soil degradation
Protection and sustainable use of soils

SOIL & WATER

Aix*Marseille université

Input:
Functional ecology
Terrestrial and aquatic Mediterranean environment
Gas exchange between the atmosphere and plants
Global change
Plants under drought

UNIVERSITY OF SOUTH BOHEMIA
in České Budějovice

Input:
Ecosystem Biology
Microbial processes in different soil types
Use of stable isotopes in soil C and N transformations
Hydrobiology

Tartu, Estonia

Summer school - September 1st - 14th 2013

DE-2013-ERA/MOBIP-1-29900-1-33

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Summary

Objectives

This Erasmus IP (Intensive Programme) "Soil & Water" consists of an interdisciplinary international teaching course for students from four EU countries. Thematically it unifies the expertise from the following fields: soil science and ecology, plant sciences and zoology. The activity will foster student's knowledge and competence regarding interactions between soils, plants and soil organisms with special emphasis on soil processes and effects of drought and flooding on plants and soil organisms. It will also define major risks of soil degradation. The structure of the IP will be able to establish a link between soil functions and societal needs and expectations.

Target groups

Target groups of this IP are students from advanced undergraduate and graduate levels having teaching curricula focussed on biology and environmental sciences. The IP "Soil & Water" was set up by the Ulm University, which is also the coordinating institution. Besides students from Germany, also participants from the Czech Republic, Estonia and France will be involved.

Main activities

There are several teaching instruments applied in this programme. Teaching courses will be provided by experts from partner universities, who will cover specific fields (i.e. soil development and degradation, soil microbiology, plant-soil interactions, etc.). Field trips and on-site teaching will demonstrate key system elements and main processes related to soil environment and its effects on plants and soil organisms. Seminars elaborated and presented by students will prepare the participants for these subjects and reflect the knowledge gained.

Learning outcome

Students will gain an interdisciplinary insight in different areas of soil science and plant ecology. Participants will obtain 9 ECTS after finishing this course.

Expected outputs

Teaching material created during the IP will be provided via internet and will be available also for succeeding courses. Various dissemination activities are planned and will cover a central web page, an e-learning platform with teaching materials and a discussion forum, a field site guide and a final student report.

Description

Main objectives of the Erasmus sub-programme

This Erasmus IP was designed as an interdisciplinary international teaching course for students. Through its 30 student participants from four EU countries it will substantially increase the volume of student mobility compared to individual exchange. In the perspective of this IP for a total of three years it will significantly contribute to the student mobility in the involved universities from Germany, Czech Republic, Estonia and France. Such enhanced international mobility of bachelor and master students of participating universities will also enhance interests for international exchange grants given by national funding agencies.

The topic of the IP combining soil science, plant sciences, zoology and ecology assures an interdisciplinary character of this activity. Moreover, the applied aspects taught cover also effects of drought and flooding on plants and soil organisms as well as soil degradation. The field trips and involvement of local experts bring about a link to socio-cultural aspects such as human impact and current development under different land use.

The target groups are students from undergraduate and graduate levels. All partner universities have study curricula which are prerequisite for understanding of the study material and lecture content. Mostly, students from biology and environmental sciences will participate in this IP “Soil & water” and contribute from their specific background. Academic personnel involved in the teaching and developing the curricula for this IP established an interdisciplinary network which can sustain beyond this educational cooperation. This activity brings together broad academic competences and will have substantial value for subsequent teaching activities on all sides. Follow-up research activities will also profit from formal and informal contacts between students and academic personnel, as well as from the interdisciplinary level of this IP.

The lectures by participating scientists (see the preliminary programme) will provide an outstanding interdisciplinary overview and process-based knowledge related to soil processes combining soils, plants and soil organisms in relation to environmental problems. The multidisciplinary approach on these subjects including various climatic zones and human effects on an European level is the innovative aspect of this Erasmus Intensive Programme.

Project objectives

Soils provide the basis for plant production and provide numerous ecosystem services ranging from water storage and purification to carbon sequestration. There are continuous interactions between soils and the soil-related biota such as plants, microorganisms and soil fauna. Plant roots fulfil major exchange functions with the biotic and abiotic soil environment. Root systems are designed to secure plant anchoring in the soil and exposed to competitive interactions.

Anthropogenic activities are affecting the below-ground conditions producing several constraints for plant growth. Especially soil compaction increases the soil bulk density and alters soil physical properties such as water permeability and gas exchange. Humans provoke fire hazards, and manipulation of the water table results in changes in soil salinity. In the view of environmental change, extreme weather events, such as drought and flooding are expected to increase in frequency and intensity on the global scale (IPCC 2007); the functioning of soil-related process are bound to be impaired more regularly and severly, therefore impacting on plant productivity.

On this background, the Erasmus Intensive Programme “Soil & Water” aims to provide an interdisciplinary international course for students from four countries to bring together expertise from different geographical and climatic locations in Europe together with different land-use and land-history patterns. The activity has the following objectives in order to foster student's knowledge specifically to a wide range of European environments, and to transmit the state-of-the-art competences in general terms and particular ‘hot’ topics:

- to highlight the interactions between soils, plants and soil organisms
- to provide interdisciplinary insights into soil processes
- to increase the knowledge in relation to plant, with emphasis on elucidating effects of drought and flooding on plants and soil organisms
- to outline major (anthropogenic and natural) threats for soil degradation and its mitigation
- to establish a link between soil functions and societal needs and expectations

In order to fulfil these aims, our Erasmus Intensive Programme will be held in locations of contrasting climatic conditions across Europe. The IP “Soil & Water” will start in Ceske Budejovice, Czech Republic, an appropriate location to demonstrate various sites, ecosystems and interactions in Central Europe. For 2013, this IP is scheduled to take place in Estonia, a country with wet and cold climate on the north-eastern margin of the EU. Finally in 2014, France will host this activity and provide insight on soil topics in relation to the seasonally hot and dry Mediterranean climate.

The establishment of such broad international cooperation will promote general academic competences and has substantial value for subsequent teaching activities on all sides. Academic personnel will get insight into teaching structure and contents at the hosting university. The lectures provided will go beyond the usual range and content of courses in the participating institutions. The lectures can be linked to existing study programmes in biology, environmental sciences and in other curricula at the participating universities.

Research activities will profit from formal and informal contacts between students and academic personnel. The IP has a strong potential to foster co-operation of biological sciences in relation to landscape management, agriculture and forestry, and to transmit this spirit to a generation of young upcoming scientists. Students will gain insight in the relevant curricula and open the opportunity to participate in already existing Erasmus exchange programmes. The IP contributes to the international mobility of bachelor and master students of participating universities and therefore provides them a better international visibility of open positions. Further, exchange experience enhances the chance to qualify for international exchange grants given by national funding bodies such as DAAD.

The proposed lectures by participating scientists will introduce specific topics and provide an outstanding interdisciplinary overview of the process-based knowledge. The programme is unique in the sense of relating soils, plants and soil organisms across a wide range of climate zones and of environmental problems essential to Europe. This is the innovative and multidisciplinary approach of this Erasmus Intensive Programme application.

Daily Report - Monday September 2nd, 2013

Anna Hohnheiser, Theresa Hilber, Maarius Utso

Introduction to soil-water relations (Kadza)

In the morning we had an introducing lecture about soil water relations.
First of all we heard something about the three soil phases:
There is a solid, a liquid and a gaseous phase.
The solid phase contains inorganic material, for example skeleton and fine soil (sand, silt, clay), as well as organic material like humus, plant roots, soil organisms, soil microorganisms and fungi.
The liquid phase consists of water with ions and DOC (Dissolved organic carbon).
The gaseous phase contains N_2, O_2, CO_2 and H_2O vapor in changing proportions.
Between the different phases, there are some interactions like exchange of ions and DOC.

In soil there is not the same concentration of the different gases like in the air: there is less O_2 because microorganisms breathe O_2 and produce CO_2.
If soil is saturated, there is a lack of oxygen and a higher amount of carbon dioxide what can lead to anaerobe conditions.

The soil water can be measured with the pressure head which is also called water potential Ψ what can be measured with a device called Tensiometer.

Here are some important states of soil moisture (in cm water column):

0 = saturated conditions

-340 = field capacity

<-15000 = wilting point (Water is unavailable to plants)

The water holding capacity of soils and also the plant available water depends also on the pore-size of the different structures.
Soil is a mixture of different particles:

Gravel: > 2 mm

Sand: 2 – 0,063 mm

Silt: 0,063 – 0,002 mm

Clay: > 0,002 mm

Clay plays an important role in soil structure, water retention and cation exchange. About 30% of clay water cannot be extracted by plants.

Water supply to plant roots

Plant roots percolate many layers of soil and play a huge role in the soil-water-plant interactions. The main functions of plant roots are:

-water uptake

-nutrient uptake

-anchoring the plant in soil

-interaction with biotic and abiotic soil environment

There are a lot of interactions between the roots, the soil-water solution and the solid phase of soil, what is summarized in the following:

Root	**Soil solution**	**Solid soil phases**
← Ion uptake	← ion exchange →	
→ H^+/OH- release	→ pH acid/base reactions →	
↔ respiration	← redox reactions →	
→ ligand	ligand exchange	
→ enzyme →		
↔		

The last topic of this lecture was the root turn over, the root distribution and architecture and finally the natural distribution of resources like light and CO_2. There are a lot of complex mechanisms and correlations between the root distribution, availability of resources and architecture of roots.

Functions of root turnover:

- renewing the fine roots
- carbon and nutrient cycling
- most important for absorption characteristics of the rooting system
- balance between fine rooting system and mortality
- fine roots construction costs 25-33% of total C invested under ground to the roots.

Natural distribution of resources:

- distribution of light and CO_2 concentration in the above ground space according to predictable gradient

- heterogeneously distributed resources
- vertical distribution: vertical gradients in soil, organic matter and infiltration of precipitation

architecture: clusters of available nutrient accompanied by preferential uptake of the seepage water
root clustering: a rule in natural soils for optimised exploitation of aggregated resources

<u>Taking samples for practical work (afternoon)</u>

After lunch break we went out on the campus to collect samples for the practical work in the following days and take a closer look on the typical flora of these locations.
At first we collected samples of uncompacted and compacted mineral soil, then we went to other place where we found organic soil and at last we took samples of sandy soil near the river Emajõgi. On our way to this river we walked through grasslands (*Cirsium oleraceum*), which were used for recreational activities (Frisbee etc.).

On the riverbanks of the slow-flowing Emajõgi we saw old trees of willow species:
Salix alba
Salix pentandra
Salix viminalis
Salix phylicifolia

Whereas on the sandy beach we found species as:
Glyceria maxima
Butomus umbellatus
Iris pseudacorus
Thypha latifolia
Sium erectum

The high nutrient level in the water could be recognized with the presence of:
Potamogeton perfoiliatus
Phragmites australis
Nuphar lutea

Student presentations (afternoon)

1) General information about Estonia

In the first presentation we got general facts about Estonia and an overview about the typical Estonian landscape and geography, fauna, flora and climate.
Estonia is a small country in the North-East of Europe and counts about 1.4 million inhabitants. It is a very flat country with a typical hemiboreal flora. You can find about 64 mammal species including the moose. There are also about 329 bird species, especially the barn swallow, what is national bird of Estonia.

2) Vegetation zones and their sections in north western Europe

The second student presentation was a summary of a paper of Teuvo Ahti, Leena Hämet-Ahti & Jaako Jalas which was published in Acta Botanica Fennica 5 in 1968.
According to this paper, north-western Europe can be divided in three different vegetation zones:

Temperate Zone: deciduous forest consisting of e.g. beech, ash, oak, hornbeam and basswood
Hemiboreal Zone: Spruce, pine, beech, hornbeam, mountain oak, British oak, hazel etc.
Boreal Zone: Coniferous wood and frost resistant deciduous wood like meadow, birch, alder etc.
Furthermore we heard some facts about the climate, the distribution of coniferous and deciduous forests and the distribution of the forest landscape types in Estonia.

3) Rhizosphere geometry and heterogeneity arising from root-mediated physical and chemical processes

This review article, which was published in 2005 by Philippe Hinsinger *et al.* in the New Phytologist, deals with the processes which influence the rhizosphere and the soil microorganisms. It also deals with processes which are responsible for spatial and temporal heterogeneity of the soil. The article says that the rhizosphere is different from bulk soil due to biochemical, chemical and physical processes, what is a consequence of e.g. nutrient and water uptake, root growth, deposition and respiration. These processes are quite complex and are influenced by plants and microorganisms and also by the soil constituents.

4) Effects of rooting volume and nutrient availability as an alternative explanation for root self/ non-self discrimination

The next presentation was also based on an article, which was written by Linde, Hess and Hans de Kroon. It was published in the Journal of Ecology in 2007.

The article deals with three hypotheses, questioning the root mass, plant growth and root biomass production according to its dependency of the available rooting volume or to the total amount of available nutrients.

Tuesday, September 3rd, 2013

Students gathered approximately 8.30 in the classroom.

At 8.30 Endla Reintam, Estonian soils and nature

The presentation was about Estonian soils, relief and climate. The beginning of the presentation was a global approach about Estonian landscape and geology, which are from Vendian, Cambrian, Ordovician and Devonian sediments.

The best soils in Estonia are in the middle of Estonia. In Estonia there is a diversity of the soils like: Leptosols, Rendzinas, Cambisols, Luvisols, Stagnosols, Planosols, Podzolic soils, Podzols, Gleysols, Histosols etc. For example the Cambisols are the best soils for agricultural purpose and also have a very thick humus layer and are about 10% of the cultivated area. The soils can be differentiated by the number and the type of the horizons. Most of the soils have an A horizon on the upper surface which correspond to humus layer. For example, the exceptions are the Podzols which have an O-horizon on the top which correspond to organic horizon. Each type of the soils has a different property about pH, humus concentration, texture etc.

At 10.30 Alar Astover, Protection and sustainable use of soils

Alar Astover gave a theoretical presentation, how to sustain a soil and protect it. In the beginning of the presentation was mentioned, that sustainability of the soils can be defined in many different ways. Overall sustainability means an agriculture that indefinitely maintains productivity. In the presentation it was pointed out that the area of arable land per capita has decreased continuously worldwide. But still the crop production should be doubled by 2050. Various soil functions and qualities were pointed out and it was showed how their properties change in time.

At 12.00 Lunch

At 13.00 Endla Reintam, Soil degradation

In the second presentation, Mrs. Reintam pointed out several threats which affect soils. For example erosion, decline in organic matter, contamination, soil sealing, floods, landslides etc. 17 % of land area is affected on water erosion. Thus soil loss in Europe every year is quite significant. In addition there is also a damage done to the soil organisms because of the impacts of soil degradation like pollution with heavy metals, toxic substances like pesticides or soil compaction. Especially for soil organic matter decrease there are general factors like: cultivation, deep ploughing, overgrazing, erosion and forest fires.

At 14.30 Endla Reintam and Alar Astover, Practical work related to soil description and classification

The students gathered in front of the university. The group was divided into two smaller groups. One group went to the laboratory and second group went to a field to do a practical work. The digging was conducted in Tartu, Tähtvere (N58.39583°, E26.68431°). To properly describe soil features, a 1 m deep hole was necessary to dig 8 (figure 1).

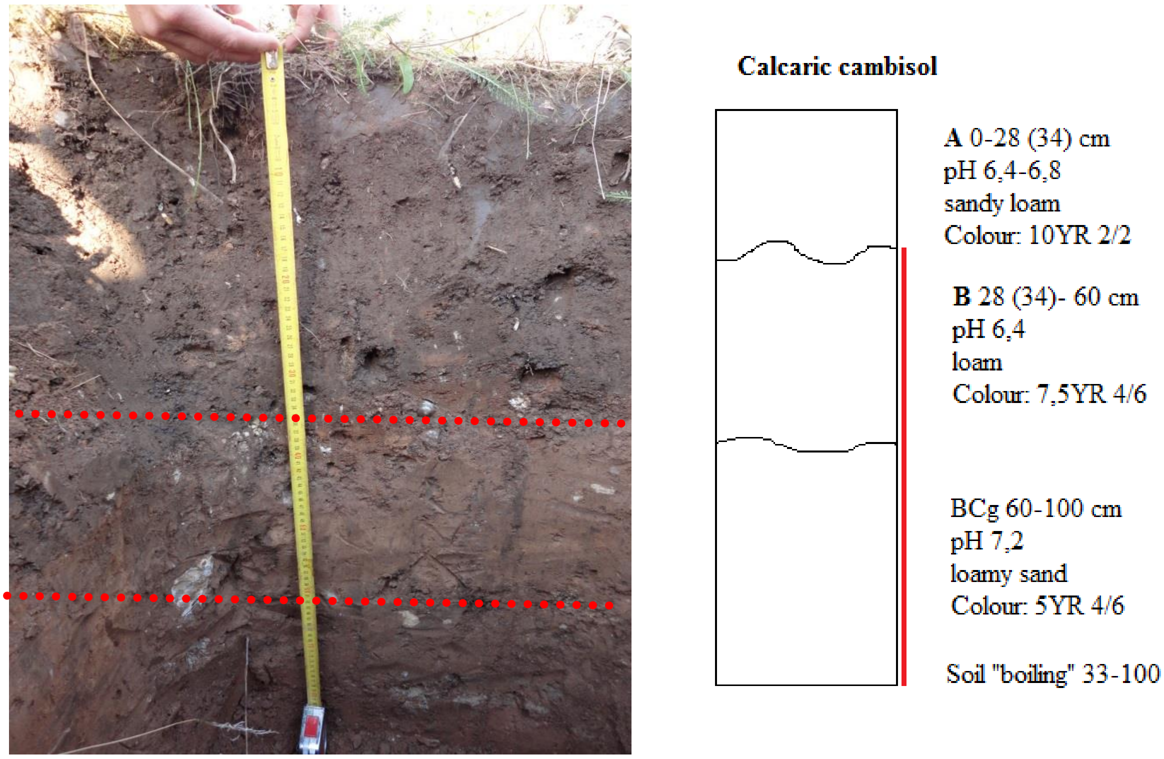


Figure 1: Horizons of a Calcaric Cambisol soil (the scheme on the right is slightly displaced)

Then we made a couple of rough property tests. More detailed tests were made in laboratory. The Characteristics are shown in the following list.

1- Color

The specific color of each horizon was compared to a special reference book (Munsell Color Charts) with color-codes. The humus horizon was darker than the others (Figure 1) because it contains more organic residues.

2- “Boiling”-reaction

At 33 cm depth, we observed the starting of the reaction of the soil with 10% HCl solution (bubbles appeared). That means we had more calcium-carbonate matter (Figure 2).

Figure 2: “Boiling”-test by tipping HCl solution down the several horizons

3- pH

We visualized the acidity of the soil of different horizons with an universal indicator. Results are summarized in Figure 1. The deeper the sample the more alkaline it was (Figure 1). (The layers above were more yellow to green thus more acidic.

Figure 3: Showing the color change range of universal indicator. As soil itself was alkaline, the acid was added to the dish to get red reaction.

4- material content

We formed a ring with hands out of the soil samples and checked the rifts and cracks of it. It represents proportion of the sand, silt and clay particles.

5- porosity

We had a look at the structure of some soil samples. The amount of pores and the size related to the entire volume correspond to the porosity.

6- water content

The water content was measured with a Percometer device developed by the Estonian engineer Tiit Plakk. It measures the dielectric constants and specific conductivity of the soil. This two parameters are related to the water amount in the soil and hence to concentration of salts including beneficial nutrients.

The other group did similar work the next day (Wednesday, September 4th, 2013) but in consideration of another kind of soil type. This soil type is called Luvisol and was characterized by a special E-horizon in comparison to the Calcaric Cambisol. In the following two figures one can see the scheme and a picture of the Luvisol soil profile. In the German soil systematic it is called Parabraunerde.

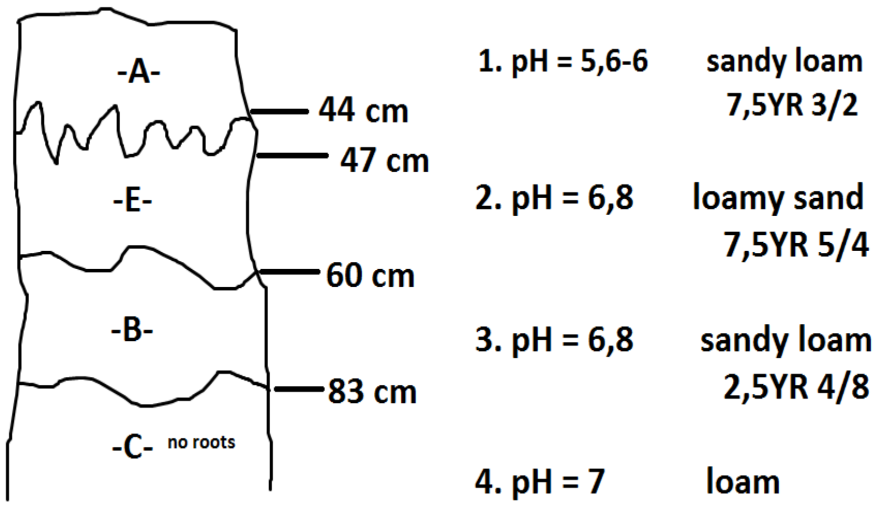


Figure 4: Scheme of the Luvisol observed on the field near the Estonian University of Life Sciences (at address Kreutzwaldi 64).

In the figure above are shown the features und properties. The change from sandy loam to loamy sand and the other way around is distinctive. The pH approaches to the neutral point till the fourth horizon (C-horizon). In contrast to the calcareous Cambisol there was no chemical bicarbonate reaction with the HCl solution.

Figure 5: Picture of the investigated Luvisol

The A-horizon was well structured and uncompacted. The E-horizon had a clayey washed out appearance. B-horizon is similar to the first and the C-horizon consists of the parent material.

Report: 04.09.2013

(Anne Lotter, Gloria Gessinger, Olivie Parthiot)

Shear Strength

To determine the shear strength of our soil samples we used the shear strength apparatus applying a vertical force of 300 kPa. The apparatus shears the upper layer and the lower layer 1.5 cm against each other and measures the force needed (Figure 1). The further the layers are sheared against each other the higher force needed. Different soil textures have different shear strengths. At one point sand reaches maximum shear strength and remains on this plateau whereas the shear strength of humus declines after the maximum is reached. Moreover the apparatus measures the soil water content and the settlement of the particles in the sample.

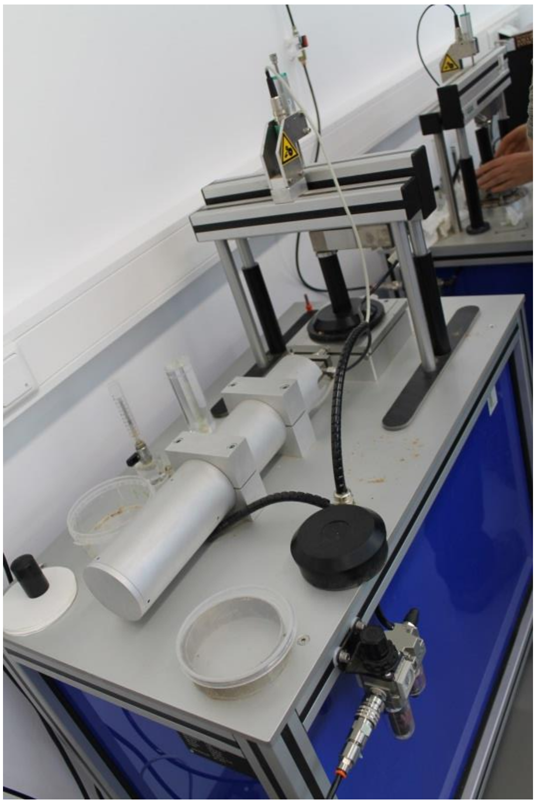


Figure 1: Device to measure the shear strength.

Compaction Ability

The compaction ability is measured with the compression apparatus (Figure 2). A vertical force is gradually applied on the soil sample and the compression depth noted. Humus can be compacted almost ten times as much as sand and has a higher precompression rate. For the precompression rate depends on both the soil water content and structure, more water aspirers from the humus sample.

Both methods above are used in agricultural contexts to determine the soil resistance against mechanical forces such as heavy machines.

Figure 2: Device to measure the soil compaction.

Soil Water Capacity

Soil samples of different textures have different soil water capacities and therefore contain different amounts of water. These can be measured by weighing the fresh sample and subtracting the dry weight (Figure 3). Analogously the total soil water capacity can be measured after previous saturation of the sample.

Figure 3: Scale used to weigh the soil samples.

Field Capacity

The field capacity is the soil water content of a sample after drainage of full saturated sample by gravity only. The samples are put on top of a sand body for two days preventing evapotration and due to capillarity and gravity most of the water is sucked out. The remaining water, held back by the soil with adhesion and cohesion, is called field capacity. Therefore sand has for example a lower field capacity than humus.

Plant available Water

Gravimetric soil water content does not tell much about water availability. Therefore, a pressure box is used to measure how much plant non-available water remains in a certain type of soil under given pressure. From this data, pF curves are constructed elucidating the relationship between soil water and soil water potential, the later a measure of plant water availability.

At highly negative water potentials, plants will die even though there is technically sill water remaining in the soil. This water is called the plant non-available water and is strongly bound to the soil particles by physical forces, for example adhesion.

Soil Permeability

Soil permeability is the ability of a porous material to allow fluids to pass through it. To measure the permeability of the soil the sample is saturated overnight first. After that it is put into a fixation device and a water flux through the sample is generated (Figure 4). Measuring the volume of water passing through the soil over a certain time, the speed of the water flux can be determined. This leads to a value which allows a comparison of different soil types.

Figure 4: Device to measure the soil permeability.

Soil Profile

<u>Location:</u> Estonian University of Life Sciences, Kreuzwaldi 64, close to Laboratory Building (The red lightning in Figure 5 indicates the sampling location)

<u>Site:</u> meadow, Devonian sediments, high vegetation cover (100%), old field succession, nitrogen rich (Indicator: *Urtica dioica*) (Figure 6)

Plant species: *Urtica dioica, Artemisia vulgaris, Cirsium arvense, Tanacetum vulgare, Trifolium pratense, Agropyron cristatum, Anthriscus sylvestris, Vicia cracca, Lamium album, Sonchus sp., Achillea millefolium*

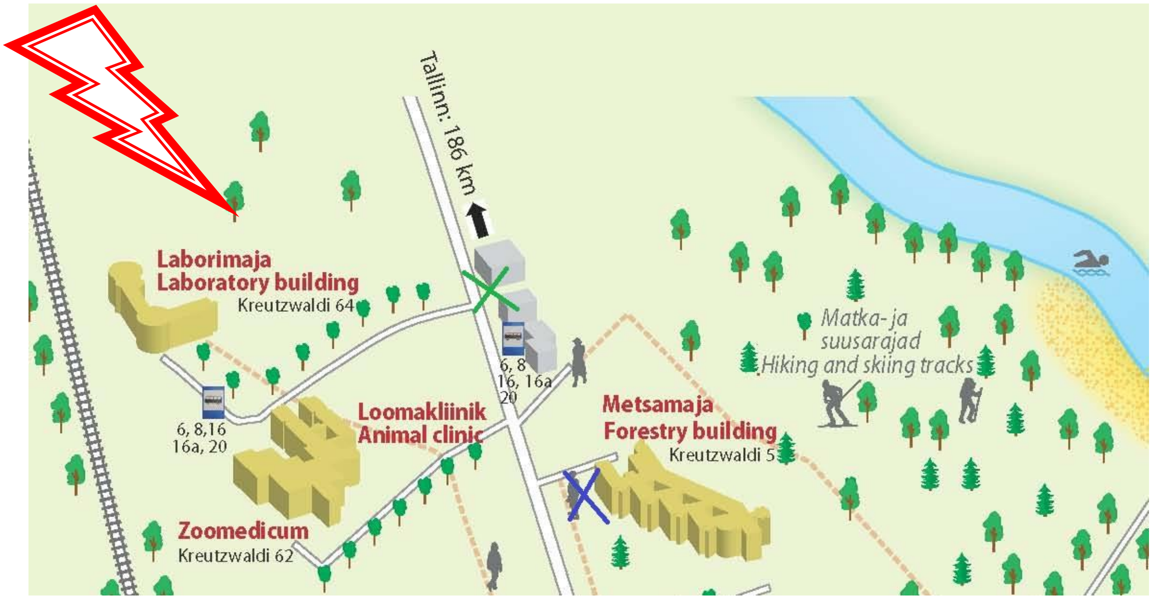


Figure 5: Map of Estonian University of Life Sciences. The red lightning indicates the sampling location.

Figure 6: Sampling site with vegetation cover including two international students digging a hole.

To show the profile of a certain soil we dug a hole measuring 0.5 x 0.5 x 1 m. Using a key we distinguished the texture of the different soil layers. The color was matched with the Munsell color chart for each soil layer (Figure 8). We also determined the pH using universal indicator (Figure 9). The lime content can be shown by spilling HCl on the soil. If lime is contained it leads to bubbles. Our soil profile did not show a reaction (Figure 10). This led to the following soil profile which is classified as Luvisol (Table 1, Figure 7).

Table 1: Soil profile including the depth, texture, pH, and color of the different soil horizons.

depth [cm]		texture	pH	color
0 - 43	A-horizon	L_S	5.6	7 5YR 3/2
43 - 56	E-horizon	S_L	6.8	7 5YR 5/4
56 - 83	B-horizon	L_S	6.8	2 5YR 4/8
83 - 100	C-horizon	L	7.0	5YR 4/6

Figure 7: Soil profile.

Figure 8: Munsell color chart.


Figure 9: pH measurement with universal indicator. **Figure 10: HCl test for lime content.**

Soil Compaction

To detect the degree of soil compaction in the different layers we used the Eijkelkamp Penetrologger seen in Figure 11. It is inserted in the ground using virility. The strength needed is displayed and a compaction profile is evaluated.

Figure 11: Device to measure the soil compaction.

Soil Water Content – Percometer

The percometer is used for measuring the water content and salt content of a soil. It detects the electric conductivity by sending electrical signals in the ground (Figure 12).

Figure 12: Percometer used to measure the soil water content and salt content.

Lectures

<u>Soil compaction (Reintam)</u>

Definition: Compaction of the mineral and organic matter in soil reducing pore sizes, particles pressed together

Causes:

- natural: raindrops impact
- anthropogenic: tillage compaction in agriculture => heavy soil compaction
  Wheel traffic => major cause of soil compaction

Consequences:

- It reduces the capacity to save water
- Effect on soil bulk density
- On compacted soils, there is no effect of using fertilizer
- Difficulties for plants to take root and spread its root system in the soil
- Affect soil organisms, e.g. decline of the amount of earthworms

⇨ The best protection of the soil are the plants

Plant stress biology (Kazda)

Def: Stress

- **In human biology**: reaction to a change that requires a physical, mental or emotional adjustment
- **Plant stress**: State in which increasing demands made upon a plant lead to an initial destabilisation of functions.

Plant and their environment:

Abiotic factors	**Biotic factors**
Temperature	Competition
Water	Herbivory
CO_2, O_2	Pollination & dispersal
Nutrients	Parasitism
Soil properties	Symbiosis
Chemicals	Allelopathy
Human-induced	Microbial interactions

Most common plant stress factors

- Drought
- Temperature
- Flooding
- Excess of salts or heavy metals
- Deficiency or excess in nutrients
- Mechanical stress: wind, snow
- Soil compaction
- Herbivory

Adaptations

- Hardening

Focus on drought stress:

Reasons for insufficient water supply:

- Climatic: ratio precipitation/evaporation, predictability of precipitation
- Site specific: aspect, water storage capacity in soil

Conditions:

- water shortage: low water potential often accompanied by increasing osmolarity of the soil solution
- Slow water transports to the roots
- Higher soil temperature

- Impaired mineralisation of soil nutrients
- Changes in cost/benefit ratio of the fine roots

Growth conditions under drought

- Dry air (high water vapour pressure deficit)
- High radiation
- High air temperatures
- High leaf temperatures
- Low soil availability
- Ionic imbalances
- Often low oxygen supply to the roots

Salt stress:

- Dehydration
- Ionic stress
- Alkalisation

Interactions between soil and plants (Astover)

Plant growth is precondition for soil formation

Soil forming factors are: - Time
- Climate
- Organisms
- Plants!

Plants are:

- Initial source of organic matter (CNPS cycling, “feed” for soil biomass, raw material for humification)
- Soil miners

What plants need from soil

- water
- mineral nutrients
- suitable conditions for root development

The main interaction zone is the rhizosphere

Root architecture – nutrient/water location, but also physical constraints

Mechanisms of nutrient uptake

- Diffusion (high concentrations => low concentrations)
- Mass flow (with water, longer distances) (Root interception)
- Foliar uptake: plants can take water and minerals from the air through le leaves
- Mycorrhiza (up to 80% of higher plants species, up to 90% of P…)

Nutrient mobility in soil:

- very mobile: NO_3^-, sulphate, S, B
- Moderately mobile: NH_4^+, K^+, Ca_2^+, Mg_2^+…
- Immobile: P, Cu, Fe, Mn, Zn

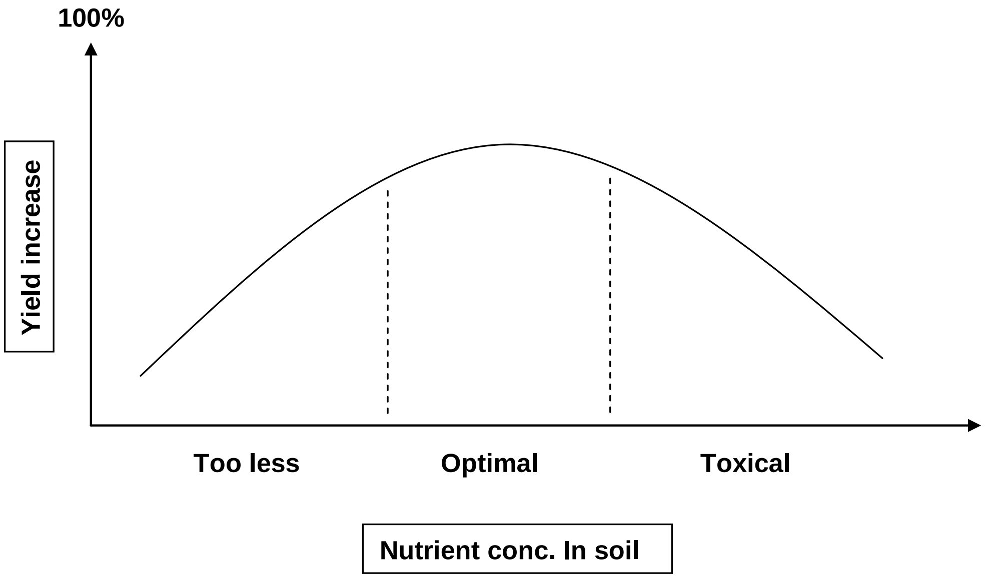
Nutrient availability depends on pH!

Example: Hydrangea (Hortensia)

Some species of this genera change their colours depending on soil pH

=> acidic = blue, neutral = pink

Optimal nutrient concentration:



Soil is quite resistant:

- soil is like a bank

⇨ "you get money very easy but when you don't pay it back, you'll probably get into trouble."

Final comment: Plants are good indicators of soil quality!

Daily Report – Thursday, 5th September 2013

Depature 8.05 from Tartu

On the Way to Järvselja Mr. Miguel Portillo Estrada repeated some information about Estonia and told us some facts about Järvselja forest or measurements like gas exchange in ecosystems and soil respiration.

Arrival 9.25 in Järvselja

We started a half day excursion to Järvselja to visit the ICOS (Integrated Carbon Observation System) project on European soil. The main topic of this excursion was the eddy covariance method. The project at this station began in 2008. With the eddy covariance method you can measure the vertical turbulent fluxes between the surface boundary layer and the atmosphere. We learned something about the measurement of wind speed, gas concentration, especially of carbon dioxide, temperature, humidity and the pressure, which are measured on many points of the tower. Through the wind speed and the concentration of particles in the air, it is possible to reconstruct the place of origin. The aim why measurements are taken is to find out the boundary layer resistance. At night there is much carbon dioxide respiration in the soil which the plants can use for photosynthesis and growing. During the day the plants need water to transpire oxygen.

The measure system of an eddy-tower is composed of a 3D Sonic Anemometer, which measures the wind speed, a portable photosynthesis measurement and a thermometer.

Beside the wind speed measured by the 3D Sonic Anemometer the Porometer measures the gas exchange on leave level of carbon dioxide and water vapour.
At this place there are many interesting plants like *Anemone hepatica*, *Asarum europaeum*, *Oxalis*, *Paris quadrifolia* and *Filipendula ulmaria*. Especially the plants *Aegopodium podagraria*, *Crepis paludosa* and *Lamium galeobdolon* are indicators for nitrogen and humus-rich soil, and *Climacium dendroides* is an indicator of eutrophic and wet soil.

After a short trip we arrived at the second place. We walked to the next stop; there we saw the new station with a tower of 130 m in height. The tower that has a foundation of 4-5 tons was built during the last winter because the soil was frozen. This took only about 6 weeks. This new building will accomodate automatic devices for climate variables and gas concentrations.

After that we saw a Primary Forest, this is a forest which hasn´t been touched by silviculture for almost 100 years. The tallest tree is the Picea abies with a height of 43.1 m and a diameter of 71.7 cm and an age of 250 years.

We drive back to Tartu at 12.35.

Arrival at Tartu 13.30

At 14.35 Marian Kazda began the lecture on the topic "Plant growth in wetlands". He spoke on plant stress under flooding and also under hypoxia. He told us that most growing processes stop when plants are under stress. The plant stress under flooding has three big negative effects: oxygen shortage (hypoxia and anoxia), chemical changes of soil properties and post-anoxic oxidative stress.

Mr. Kazda showed us an example of a tomato plant under hypoxia and a tomato plant without hypoxia. The normal plant had normal gibberellic acid and cytokine concentrations while the concentrations in the plant under hypoxia were reduced. In contrast, the abscisic acid concentration in the tomato plant under hypoxia is increased which results in stomata closing the stomata. In the normal tomato plant the abscisic acid concentration is low and the stomata are open. Also the ethylene concentration in the plant under hypoxia is increased in comparison to the normal plant. Moreover the leaves of the tomato plant under hypoxia are curved.

We also learned that the consequence of a low oxygen supply is a shortage of energy. To understand how serious the consequence of a low oxygen supply is, Mr. Kazda gave us an example: a plant under normal conditions makes 38 ATP, a plant with a low oxygen supply makes only 2-3 ATP, because of the different ways of energy-production. Another effect of a low oxygen supply is a low root growth.

Later he told us some effects of hypoxia and anoxia on soil properties like that redox potential falls and that there are more reduced cations in the soil solution such as Fe^{2+} and Mn^{2+}. After that we learned what plants can do to protect themselves. Plants can cover root issues to protect themselves of ions. He explained us that plants can release oxygen out of the roots that there is a tiny oxygenic space around the roots which microorganisms which can use oxygen to transform reduced ions. Then Marian Kazda explained us how plants adapt to low oxygen levels in the substrate. Plants can guide oxygen through plant aerenchyma due to processes humidity-induced pressurisation, thermoosmotic ventilation and Venturi-effects. We learned that the gas diffusion of oxygen is possible

through porous-membrane within the leaf, enabling gas diffusion but preventing the mass flow.
After that we got some information on radial oxygen loss and the carbon cycle. The roots release oxygen and organic carbons, through aerobic respiration of microorganism the organic carbons transfers to carbon dioxide which the soil respires in the atmosphere. Roots are associated with methane-oxidation bacteria to oxidize methane to carbon dioxide, which they can use for photosynthesis. He explained us that in wetland plants the supply of the rhizosphere with oxygen is highly important for methane oxidation.
At the end of his presentation he gave us a short summary. He repeated that the supply of the rhizosphere with oxygen by wetland plants is highly important for methane oxidation and the methanotrophic methane-oxidation provides carbon dioxide for plant photosynthesis. He also repeated that the fluctuation in internal oxygen concentrations indicates complex interactions between aeration and oxygen consumption.

Zuzana Urbanova gave a summary of "wetland and carbon fluxes". She began with some attributes of wetlands: a transitional ecosystem between aquatic and terrestrial systems, which is permanently or periodically waterlogged or flooded, hydrotropic vegetation and the substrate is saturated with water. The definition of the Ramsar Convention is "... wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters." The Ramsar convention is of international importance, especially as a waterflow habitat. It is an international treaty for the conservation and sustainable utilization of wetlands, to stop loss of wetlands, to recognize the fundamental ecological functions of wetlands and their economic, cultural, scientific and recreational value.
Wetlands make only 6% of the earth surface. The ecological function of wetlands is complex; the wetlands are the most biologically productive and biologically diverse ecosystem, with living filters and element cycling (e.g.

accumulation, transformation and transport). Wetlands influence atmosphere and hydrosphere, further the flood control, shoreline stability and they host many species of plants and animals.

Later she presented us the main factors affecting wetlands: the hydrology and climate, the trophic status and oxic vs. anoxic conditions. Especially wetland biotopes are determined mostly by hydrology, e.g the source of water (precipitation, groundwater, surface water), the water depth and its fluctuation, the flow rate, the timing and duration of flooding and the hydrology influences of chemical and physical traits, e.g. soil anaerobiosis, nutrient cycles and their availability and organic matter accumulation, which influences plant species composition. Wetlands can be classified in marine and coastal wetlands, inland wetlands and human-made wetlands. Typical for the marine and coastal wetlands are shallow marine waters, coral reefs, rock and sandy shores, intertidal zones, salt marshes, lagoones and estuarine waters. The characteristic for the inland wetlands are riverine, like river deltas, rivers, creek, streams and floodplains, the lacustrine, e.g lakes (freshwater, salt periodic ...) and the palustrine like marshes, swamps, wet grasslands, fens, bogs, springs and oases. At last the human-made wetlands are classified through ponds, rice paddies, water reservoirs, sand and stone pits, constructed wetlands, ditches, canals and drains. Then we learned something about carbon in wetlands, particularly that carbon is the basic element of life forms. Carbon is needed for the photosynthesis and the respiration in the aerobic system. The major reservoir of carbon is not the atmosphere with 735 Pg but the soil with 2100-2500 Pg, especially the wetlands contributed with 450-700 Pg (Pg = 10^{15} g). She gave us some information about the carbon cycling in wetlands. The ecosystem absorbs carbon through photosynthesis and loses it through autotrophic respiration, heterotrophic respiration and leaching. Carbon accumulates when immobilisation in humus and/peat exceeds carbon losses. The result of the carbon cycling is the ecosystem carbon balance. Carbon accumulation exists in wetlands because of slower decomposition. The decomposition rate is controlled by the hydrological regime, the content of oxygen, the temperature, the quality and quantity of organic material, the microbial activity, the pH, nutrient content, water quality and so on. The result of carbon accumulation varies between wetland types and in time.

The variability of carbon fluxes was a short chapter in her lecture. Both, photosynthesis (GPP) and ecosystem respiration (Re) are controlled by many factors, which can change gradually: the climate (radiation, temperature, and precipitation), the plant species composition (quality and quantity of organic matter, root exudates ...) and the hydrology. These three points are all in interaction with each other. The carbon fluxes vary over the years.

The next topic is the wetlands as a methane source and the factors influencing methane production and emission are an important point of this topic. Wetlands are one of the largest natural sources of methane to the atmosphere. Particularly methane has a 25 times stronger global warming potential than carbon dioxide. As a result wetlands have dual impact on climate, the sink of carbon dioxide and the source of methane. Methane is an end product of anaerobic decomposition under the most reduced condition, when other electron acceptors (Oxygen, Nitrate, Iron, Manganese, Sulfate) are depleted. Methane is produced by methanorganic Archaea and they use as a substrate e.g. acetate, carbon dioxide and hydrogen or methyl compounds. The transport from the methane to the atmosphere happened via plants (aerenchym), diffusion and ebullition. Aerobic methanotrophic bacteria are responsible for the methane oxidation. The next point are the factors, which influence the methane production and emissions e.g. hydrology (aerobic/anaerobic conditions), the trophic status (nutrients, pH, substrate availability ...), the plant species composition (oxygen transport through aerenchyma, quality of organic matter, exudates ...) and the temperature. Analogical to the carbon accumulation, the methane production and emissions vary also in time and between wetland types.

At the end of her presentation she showed us something about the feedback mechanism of wetlands and climate. The carbon dioxide sequestration represents the cooling effect and the methane emissions the warming effect. Global warming potential (GWP) is a measure of the relative effect of a given substance compared to carbon dioxide. Methane has more effective thermal absorption and has increased in methane concentration over the last 200 years from 0.7 to 1.8 ppm.

The last question was: "What will be the impact of climate change to wetlands?" The sea level rises, especially at the coastal wetlands, the higher temperatures e.g. increase in photosynthesis, respiration, biomass production, decomposition, methane emissions, changes in plant composition and so on, and the changes in precipitation with hydrology, plant composition, biogeochemical process and so on. The climate change is projected to be the most severe at the high latitudes where most peatlands are situated, and the permafrost melting in the tundra.

Jana Rieckmann & Carolin Sommer

Friday, 6th September 2013

Today we made a full day excursion. At first we stopped at “Meenikunno” bog. This bog is in the Nature Park “Meenikunno”. More than 8000 years ago the bog was built as a result of swamping of dry and sandy land. Underneath the water saturated peats of the bog is a dry layer, and even deeper is the groundwater – typical for a high land bog. It is fed by precipitation (= ombrotrophic) which is absorbed by mosses. The peat mosses form a thick vegetation carpet so that precipitation gathers on top of the mosses and builds lakes. The bog is poor in minerals, soil and water are acidic. Acidity and brown colour derive from decomposed organic matter. Its pH is 4 because organic acids are washed out into the lake.

Fig. 1: Testing the pH value with universal indicator.

This means that in a bog like this extreme conditions of living are dominating.

There are a lot of species of peat mosses with different colours: green, yellow and reddish. We saw the red *Sphagnum rubellum* and the green *Sphagnum dusenii*.

Fig.2: Sphagnum dusenii

Fig. 3: *Sphagnum rubellum*

In "Meenikunno" bog grow many pines that are very small because of continuously growing peat mosses. Due to this fact a big part of the trunks are burried under *Sphagnum* mosses.

Carnivorous plants trap insects. As the soil is poor in minerals and proteins carnivorous plants obtain proteins from digested insects. We could see many individuals of *Drosera rotundifolia*.

Fig. 4 + 5: *Drosera rotundifolia*

In this bog are three lakes. A wooden path leads to the shore of the biggest lake where we tested pH value. The lake covers an area of 4.7 hectares and it is 2 to 3 metres deep.

Fig. 6: The bright blue colour is an optical deceit – it's a reflection of the blue sky, the water actually is brown from humic acids.

Many plants have adapted to the extreme conditions in a bog. We found a lot of them:

- *Calluna vulgaris*
- *Chamaedaphne calyculata*
- *Rhododentron tonnentasum*
- *Drosera rotundifolia*
- *Vaccinum macrocarpun*
- *Pinus sylvestris*
- *Calla palustris*
- *Ramalina pollinaria*
- *Cladonia stellaris*
- *Scheuchzeria palustris*
- *Sphagnum rubellum*
- *Sphagnum dusenii*
- *Sphagnum fuscum*
- *Sphagnum palustre*
- *Sphagnum magellanicum*

Fig 7: *Calla palustris*

Fig.8: Meenikunno Nature Park with typical lichen *Cladonia stellaris* .

Second stop at 13.30 – arrival to the Nature Reserve of Piusa Caves (nutrient–poor sandy soils, main tree species - pine)

Fig. 9

- Here we met our local guide Kaire.

First she introduced us the Piusa Caves Visitor Centre

- It has been opened since 2010.
- The purpose of the visitor centre is to contribute to the protection of the Piusa caves and protected species by the year-round coordination and planned developing of tourism, also to provide the safety of the tourists visiting Piusa caves.
- Piusa Caves Visitor Center has a interesting shape, it is designed like a bat.

Fig. 10: The colour of glass depends on utilized kind of sand.

Next we moved to the Piusa Caves

- Which have emerged as a result of manual mining of glass durning 1922-1970.
- Deeper layers of sand are better for glass manufacturing, because of their mineral composition.
- All the cave systems together are about 20 kilometers long.
- Temperature in the caves is about 8°C all year round.
- The Nature Reserve of Piusa Caves was formed to protect the sandstone caves in Piusa, which are the largest hibernating area for bats not only in Estonia, but also anywhere in the Baltics.
- The caves become a protected area in 1981.

- In addition to bats, this territory contains habitats suitable also for other protected species, such as the great crested newt (Triturus cristatus) inhabiting the quarry ponds next to the caves.

Fig. 11: Inside Piusa caves.

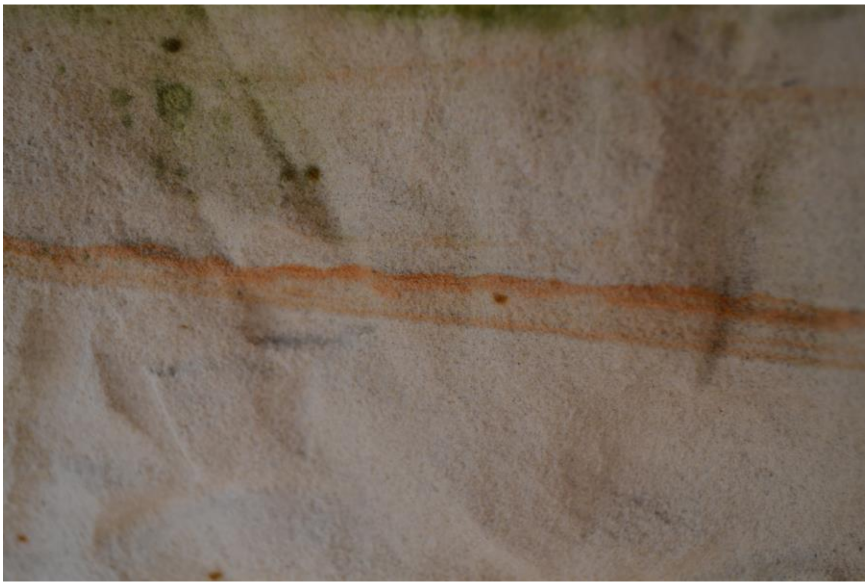


Fig. 12: Red layer in the sandstone indicates iron; white sand was exploited for glass production.

14.45 – lunch – place called “Kolme Sõsara Hõrgutised“ (The Tree Sisters Delicatessen)

- We were served zucchini soup, homemade bread and pear cake. It was very delicious.

After the lunch, there was a short movie about Nature Reserve of Piusa Cave habitats and its species

Cave-hibernating: five species of bats and some species of butterflies:

- Pond bat (*Myotis dasycneme*)
- Daubenton’s bat (*Myotis daubentonii*)
- Brandt’s bat (*Myotis brandtii*)
- Brown long-eared bat (*Plecotus auritus*)
- Northern bat (*Eptesicus nilssonii*)
- The Herald (*Scoliopteryx libatrix*)
- The European Peacock (*Inachis io*)
- Tissue moths (genus *Triphosa*)
- Mosquitoes

Inhabiting the quarry ponds:

- Great crested newt (*Triturus cristatus*)
- Smooth newt (*Lissotriton vulgaris*)
- Pool Frog (*Pelophylax lessonae*)

Walk to the Piusa quarry where Dr. Muhle gave us a short speech about plants that are characteristic to nutrient-poor sandy soils and its ponds. Some of the species we saw:

- *Corynephorus canescens*
- *Cyperus esculentus*
- *Lycopodiella inundata*
- *Centaurium*

Fig. 13:Piusa quarry.

16.15 – back in bus, departure from Nature Reserve of Piusa Caves

Our last stop was the “Ahja river valley landscape” in southeast Estonia. The Ahja river ancient valley nature park is located in one of the oldest landscape protection areas and was formed in 1957. The river has its source in Lake Erastvere and leads into Lake Emajõgi. It has a downhill gradient of about 87 kilometres and in its lower part the Ahja river is navigable. It is one of the richest rivers in fish and other species in Estonia. Among many others you can find rainbow trouts (*Oncorhynchus mykiss*), grayling (*Thymallus thymallus*) and northern pikes (*Esox Lucius*). 34 plant species have been attested. Towering sandstone outcrops can be seen along the river, the forest growing on the sides of the valley.

Fig. 14: The most famous of the outcrops is Suur-Taevaskoja, which is 150 meters long and 24 meters high. Dark coniferous forest grows on the backdrop of the cliff.

Fig. 15: Nest holes in the sandstone. Many bird species feel at home in this valley like brightly kingfishers (*Alcedo atthis*) which are an indicator species for a good water quality and white-throated dippers (*Cinclus cinclus*).

Due to the water capacity of the valley grow specific plants there. Some of them we've seen:

- *Maianthemum*
- *Betula*
- *Pteridium aquilinum*
- *Corylus avellana*

In the nature park different soils can be found thus plant communities change in their assortment and common plants as the following can also be found:

- *Pinus sylvestris*
- *Urtica sp.*
- *Impatiens parviflora*

Daily Report - 7th September 2013

(Vardo Lund, Miriam Tschaffon, Madlen Prang)

8:30 – 10:00: Experimental climate change (Dr. Ilja Reiter)

The day started at 8:30 am and first presentation was about Experimental climate change.
That is Global Change and climate change: Global Change encompasses population, climate, economy, land use, urbanization, carbon cycle and more however climate change is distribution of weather patterns over periods ranging from decades to thousands years.
Definition about climate change: steady state (stable), dynamic equilibrium and Pseudo-steady-state.
In climate change models you can predict what is coming up in future. Models show that temperature increase should range from the 0.3-6.0°C. A warming of 0.3-6.0°C increases significantly the rate of soil respiration, the net N mineralization and the aboveground plant productivity. In future there should be more research, especially long term experiments, whole ecosystem warming and gradient studies for the southern hemisphere.
Global carbon dioxide in atmosphere is reached over 400 ppm (parts per million), carbon dioxide has a big impact to climate change. At the beginning of industrialisation the concentration of CO_2 was just 280 ppm.
A good research on climate change is hard to do because there are many factors. You need to know components to understand how it affects the climate.
Climate change is multifactorial.

10:30 – 12:00: Soils and Ecosystem Dynamics I (Dr. Tomáš Picek)

This presentation was about the biogeochemistry of wetlands.

Wetlands used by people

- rice (25% of the world's population is fed by rice)
- fishing
- wastewater treatment (constructed wetlands)
- hunting
- water for drinking, irrigation

Importance of wetlands

Wetlands protect from global warming because of the carbon sink.

Tropical raised mire (Indonesia)

- forest, river
- water from precipitation
- organic matter: peat
- mixed silt and clays
- production of coal

CO_2

Oxygen transport to soil

- agar-dissolution in water (by heating)
- bubbling with N_2 – anoxic conditions
- adding of $FeSO_4$
- after cooling: put plants into the agar
- paraffin on the surface of the medium (inhibition of diffusion of oxygen)

→ observation of redox reactions:

$FeSO_4$: Fe(II) (reduced form, blue)
Fe + O_2 → Fe(III) (oxidized form, red)

Results after several days of incubation:

red colour around the roots of the wetland plant
→ it was able to oxidise the iron by O_2 from the air transported to the roots

- also Na_2S: black colour

→ after 1 day, the agar was becoming transparent around the roots of the rice plant
→ after 4 days, the transparent medium became larger, a reddish colour appeared around the roots (from oxidized Fe)

Redox pairs

- redox pairs have different redox potentials:

high: oxidized, negative: reduced

- most reduced compound: CH_2O

→ microorganisms gain much energy by oxidizing it with O_2

Oxidation-Reduction-Reaction:

An Oxidation-Reduction-Reaction is a reaction in which one substance loses electrons (is oxidized) and another substance gains electrons (is reduced).

General formula for Oxidation-Reduction-Reactions:

aOx + bB + ne → cRed + dD

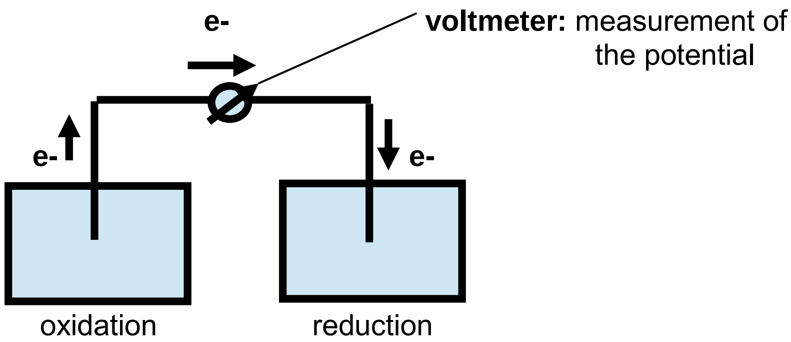
Ox: oxidizing agent (electron acceptor)
Red: reducing agent (electron donator)
ne: number of electrons
B, D: general substances taking part in the reaction

Redox Potential E°:

The Redox Potential is the tendency of a substance undergoing oxidation to give up electrons and of a substance undergoing reduction to gain electrons.

- calculated by Nernst equation
- units: V or mV, sometimes log E (pE) is used

Electrochemical Cell



When can water / soil be anoxic?

→ when soil is flooded (waterlogged) and there is consumption of oxygen
e. g. when algae are on the top and organisms in the water consume the oxygen by respiration

Experiment with *Scripus validus*

- measurement of redox potential close to the root

→ around the root you can find oxygen, after 1 mm there is almost no oxygen

- redox potential is decreasing away from the root

- light → photosynthesis → stomata are opened → oxygen diffuses to the roots

→ positive redox potential at day, negative potential at night

→ **oxygen microenvironments**

13:00 – 13:45: Soils and Ecosystem Dynamics II (Dr. Tomáš Picek)

In his second presentation Dr. Picek told something about constructed wetlands.

- substrate: can be mineral (sand...)
  but also organic (humus)

example: Wayland, Australia

- can also be directed to buildings in a city
- some are constructed for farming

What are Constructed Wetlands?

- systems constructed by men
- biotechnology
- used for (waste) water treatment

What are they used for?

→ treatment of polluted water

- landfill leachate
- mine leachate
- farmyard runoff
- highway runoff
- industrial waste water
- municipal waste water

History

- natural wetlands used for waste water treatment in middle ages
- first experiments with constructed wetlands in 20th century
- now there are many constructed wetlands in Europe

Types of Constructed Wetlands:

surface flow:

- emergent plants
- submerged plants
- free floating area
- floating-leaved plants

sub-surface flow:

- most of the newest wetlands
- filled with sand, water goes through substrate

Important parameters:

- Person Equivalent (PE)

- Removal Efficiency

→ percentage of pollutant removed in constructed wetlands

- Total Suspended Solids (TSS)
- COD = Chemical Oxygen Demand
- BOD = Biological Oxygen Demand

Hydrology

- Hydraulic Residence Time (HRT)

→ average time that water remains in the wetland

- Hydraulic Loading Rate (HLR)

A simple water balance equation for constructed wetlands:

$$S = Q + R + I - O - ET$$

S: net change in storage
R: contribution rate
I: net infiltration
O: surface outflow
ET: loss due to evapotranspiration

Substrate

- gravel
- crushed rock
- sand in size of 0.5 cm to several centimetres

Treatment processes

1) settling of suspended particulate matter
2) filtration and chemical precipitation through
3) contact of the water with the substrate and litter
4) chemical transformation … etc.

Inflow → screens → Imhoff septic tank → inflow into the beds → bed 1 / 2 → outflow

Pretreatment:

- screens
- sand trap
- septic tank

Treatment bed

Constructed wetland with horizontal subsurface flow

→ mostly goes out as gasses like CO_2

→ nitrogen is also removed as gas

- tubes: plastic tubes with holes

Plant species used for constructed wetlands:

Plants like Typha, Phragmites, Phalaris, Iris and Glyceria.

Advantages of these systems:

- the best for discontinuous waste water inflow and for waste waters with low concentrations of pollutants
- low maintenance costs
- no need of electricity (or very low)
- no need of professional staff
- natural system – part of the landscape

→ can be biotope for frogs, birds, mosquitoes

- cooling system for landscape
- can survive floods usually without any problems

Disadvantages:

- need large space
- variable efficiency for N and P removal
- cost can be little bit higher than for traditional plants

In the end, Dr. Picek presented some examples of different wetlands, e. g. Anne Valley, Ireland, Klosterenga, Oslo, or Heglig in Sudan.

14:15 – 16:45: Taxonomy and ecology of wetland organisms (Dr. Hermann Muhle)

Dr. Muhle's presentation was the last one today. He began with general information to wetlands, especially bogs and afterwards he started with the wetlands in Germany and continued with the ones in Estonia. He also described the plants which are growing on theses wetlands.

In Estonia the most common form of vegetation are boreal spruce- and pine forests. In the centre of wetlands, were the wetlands are actively growing, the pines were smaller than at the edge of the wetlands. In the German "Pfrunger-Burgweiler Ried" the pine (*Pinus montana*- group) is also the dominating species. The peat past has to be restored in the "Pfrunger-Burgweiler Ried", therefore the drainage has to stop and the water has to be re-injected, so that *Sphagnum magellanicum* has the possibility to grow again and produce biomass. To reach this goal the farmers have to be convinced and involved, because naturally they are the biggest obstacle. Because in the wetlands the soil can't be easily tilled, there has to be another possibility to use these wetlands. One of these possibilities are the permission of grazing animals like the heck cattle (*Bos taurus*). It's important to rewater the drained bogs in Germany, because only than the typical bog species like Sph*agnum russowii* can grow again. In Germany there are many bogs, which were drained but now there are reconstruction measures like in the “Murnauer Moos”, the “Großes Moor (Vechta-Diepholz)” or the “Kendlmühlfilze“, so that nowadays cottongras species (*Eriophorum)* can grow again.

The effects of agriculture on wetlands are various, so the human drain used the litter-meadow and changed the structure of the bogs; they also take the peat out, so of several species, there are only 1-2 species left. After decades there are only forest left, caused to drainage the birches and other species can grow on the dried land. To restore bogs, which were used to peat- production for horticulture, there are only problems in re-watering if the water level is not still high, when the water is gone, there are problems in re-watering, and the process lasts longer. When the water is out of the bogs, it also goes out of the dead cells, *Sphagnum* species bleach out and they get pale.

Pedicularis sceptrum-carolinum also called Moor-king Lousewort is a member of the family of Orobanchaceae, which is distributed in the area of foothills of the Alps.

Sphagnum magellanicum is a big red member of mosses species, which make up the highest amount of new peat. Whereas *Sphagnum papillosum*, with a brown colour only appears in western areas, like western Europe and northern America, *Sphagnum rubellum*, with a red colour can also be found in the bog we visited yesterday. *Sphagnum balticum* offers in Germany a very rare sight, whereas in Estonia it's commonly seen, also *Sphagnum pulchrum* and *Helodium blandowii* are nearly gone in Germany.

For the *Sphagnum* species and other bog plants the re-watering of the peatlands is very important and in some bogs in Germany the processes of reconstruction have already started.

Monday, September 9th, 2013 – daily report

Introduction to soil zoology – apl. Prof. Dr. M.

Wanner Based on the script provided by M. Wanner

Definition of soil

The soil is a natural body consisting of layers that are composed of minerals mixed with organic matter. It forms a structure filled with pore spaces, which could be changed by physical, chemical and biological processes. The soil is an abiotic and biotic habitat for a lot of organisms, as bacteria, fungi, protists, animals, and plants (Fig. 1).

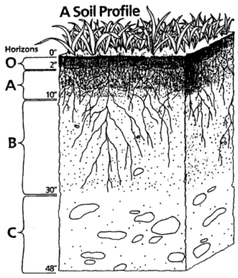


Figure 1: soil profile with the different layers. o-horizion=organic matter, a= top layer; humus b=subsoil, mineral layer, c=parent rock

Functions of soil

The basic functions of soil are regulating the water and the nutrient cycle. The soil is used as source of raw materials, like mineral resources. It is the livelihood for plants and animals.

The organisms of soil

In the soil are living a lot of different organisms. From microorganisms to vertebrates, a huge range can be found in a little area in the soil. The organisms are classified in microflora, microfauna, macrofauna, megafauna. (Fig. 2)

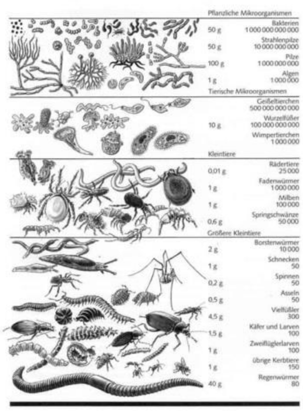


Figure 2: Residents of the soil and the abundance of species

Soil organisms reveal the highest abundance in the upper soil layers, as e.g. bacteria and fungi (microflora), protozoa and nematodes (microfauna, and larger soil animals (meso- and megafauna) (Fig. 2).

Classification of soil organisms

The part of the microflora includes bacteria, fungi and algae. Furthermore the classification of the microfauna (protists and animals) includes protists, rotifers and tartigrades. The animal kingdom involves e.g. the earthworms, snails, arthropods and vertebrates. Including this classification is also the size of the animals. The microfauna are with its protozoa the smallest unit in the animal classification. Thereupon in the mesofauna can be found bigger animals like springtails or mites. In the macrofauna there are earthworms and ground beetles and the largest size classification is called the megafauna, including big snails and earthworms.

Soil animal location

The animals are mostly restricted in the upper layer of the soil. The location can be classified in different areas:

- Edaphon: organisms living in the soil without the roots
- Edaphic: animals living on the soil surface
- Euedaphic: animals living inside the soil
- Hemiedaphic/anecic: animals living in the "transition zone"

Habitat

There are different types of habitats, where also different organisms live in. First there is the aquatic habitat, mostly for the microfauna. In the terrestrical habitat are macro-, meso- and megafauna.

Diet

There are different types of feed in the habitat of soil. Saphrophagus feed on dead organic matter, Microphytophagus feed on bacteria and fungi, the Zoophagus feed on living animals and Phytophagus feed on plants.

Why are soil organisms so important?

Soil organisms have a positive impact on the structure of soil, but also they are very important for the soil fertility. Those organisms are often bio-indicators for a success control of the soil and in which state the soil moves. Additionally they are used as management measures. The protection of soil is more and more debated, and in that case the soil organisms serves for better understanding, if a specific area in a landscape have to be protected or not. Hence with the existing of macro- and microfauna politicians get a better understanding for protection and the biodiversity of the soil, because there is no effective soil-management without knowledge of the soil animals.

Ecosystem services

Ecosystem services are one of the most important functions of soil organisms because they have such a huge impact on e.g. the soil formation. Additionally is the decomposition an example for the importance for soil fertility. Furthermore there are the bioturbation, organic matter or primary source of carbohydrates and nutrients for soil life. Of course there are more functions of the ecosystem services which are needed for the balance of life in the soil.

Decomposition of organic matter – litter breakdown enhanced by soil fauna

Biotic decomposition is a process where living organisms support the disaggregation of organic material with its dispersions and decomposition products. There is a directly decomposition by fragmentation of organic matter and the indirectly composition by feeding on microbes. Decomposition is one of the most important functions of organisms in the soil and receives the life cycle in the soil and the food web.

Problems with studying soil organisms

Studying soil organisms is not that easy as some people imagine. Including this studies there are a lot of problems. First of all soil is not homogenous, it is a variable, heterogeneous medium which changes a lot of times and it is a mixture of solid, liquid and gaseous environments. You never find a soil which is only one type of bedrock. The population of soil organisms can be extremely high and is quite diverse. Additionally the processes between the organisms and their environment are much important for the ecosystem. Therefore different methods are needs to investigate the soil.

Prokaryotes in Their Environments

Prokaryotes are very important in element cycling and the decomposition, because these organisms are able to fix nitrogen and because of this, they prevent the accumulation of toxic levels of nitrogen in lakes and oceans. Including this organisms, one of the oldest are *Cyanobacteria.* They can change earth by generating atmospheric O_2.

Protozoa

Protozoa are microscopic unicellular eukaryotic organisms and they are find in almost every possible habitat. Protozoa are very old animals, in fact they can be found in fossils in sedimentary rocks of pre-cambium era. Also they have a polyphyletic and paraphyletic origin.

Soil protozoa

Those protozoa feed mainly bacteria, but also fungi, algae and organic matter and because of that they have an important function to the decomposition in the soil and for the food and energy turnover. The length is 5 to 500 µm and they live actively in water-filled soil pores. They are responsible for 40 % of the Nitrogen mineralization and contribute 30 % to faunal biomass and 70 % to respiration.

Habitat of earthworms

There are three groups of species, the epigeic species are living nearly under the surface and they are high pigmented, because they are more often exposed to the sunlight. On the other hand there are the anecic species, which living deeper in the soil and they are able to construct burrows that are stable.

Soil arthropods

Another important class of animals in the soil are the arthropods. Here you can find species of Aranae, Pseudoscorpions, and Diplopoda.

Soil degradation, disturbance and organismic succession – apl. Prof. Dr. M. Wanner

Based on the script from M. Wanner

Definition of Soil degradation

Soil or land degradation is the decline of ecosystem services of the soil up to the point of the loss of these services. The main processes of degradation are water and wind erosion, the excess of salts and chemical degradation. Furthermore there are the physical degradation e.g. structure loss, sealing or crusting and biological degradation like biodiversity loss.

Disturbance or catastrophe

A catastrophe is an extreme tragedy with terrible consequences, in the ecology also called XXL-disturbance. A catastrophe includes e.g. an earthquake or a hurricane and after such events the ecosystem is much damaged and many organisms lost their habitat, the complete balance of the ecosystems is destroyed. Such an event is limited and it is not a regular component of the ecosystem. On the other hand a disturbance is an alteration of a regular process. As a consequence of a disturbance, there are often created niches and this event increase the biodiversity.

There are two mechanisms to increase biodiversity. The first one is the landscape diversity, which is linked to biodiversity. A change in the landscape generates a change in biodiversity. The second one is the decrease in local competition results and as a result of this there is an increase of the local biodiversity. This is called the intermediate disturbance hypothesis. On the other hand there is the metapopulation theory, which means, that a metapopulation considered consisting of several distinct populations together with areas of suitable habitat. The population is often stable because immigrants can re-colonize the habitat.

The characteristics of today‘s landscapes in Europe

There are different kind of factors which forms the landscapes. Most of them are effected by human like fragmentation in form of traffic and highways. Additionally there are the sealing, the intensive agricultural and forestal exploitation. Those changes include consequences for biodiversity. Genetic isolation is a result for fragmentation and soil degradation a result for sealing. With every change in landscape follows a change in biodiversity.

What is "natural"?

To call something natural you have to know what implies natural. The forests in Germany were cleared in the 18th century and now more than 98 % of the German forests are of "artificial" origin. 2000y ago Germany was covered with oak and beech forests. The lakes are strongly influenced by human, the rivers in Germany are to 98 % regulated and meadows resulted from agricultural use. As a result of this, all our landscapes are created by human and cannot be called as "natural" anymore.

Secondary habitats for endangered species: Post-mining landscapes & military training areas?

These areas are large, unfragmented, the soil is not sealed and there is no agricultural use. The soil is nutrient poor and there are highly dynamic conditions. Such habitats could be important for endangered species. For an example there is the Open-cast-Mining Site Berzdorf Rutschung. Here can be found very good conditions for early plant successional stages and it is a shelter from strong winds. The most important fact of this area is, that there is no public access and the ecosystem can develop as natural as possible. This area is quite important for dragonflies, amphibians, birds and vascular plants. The military areas are also small hotspots for amoebae, because these landscapes are not used anymore and the organisms could expand without human influences.

Soils under drought - Dr. Virginie Baldy

Soil can be considered as a medium for plant growth, as a recycling system, as a water supply and purification, as a habitat, as an engineering medium, etc.

Among the different horizons present within the soil profile, organic horizons occupy the upper layers of it. These organic horizons constitute the humus layers. Therefore from top to bottom it is possible to find different organic soil horizons: non-fragmented leaves (OL), organic layer including faunal faeces (OH), organo-mineral layer (E or A). These superficial horizons are the most active in a food web and flow of energy perspective. Soil quality and fertility depend from the decomposition process. This leaf litter decomposition is a key process for ecosystem functioning, and it's mainly a biological process.

There is a lack of data about the C sequestration in humus.

Fragmentations and mixing of the horizons create physical and chemical modifications. As a result, humification and mineralization processes occur.

This decomposition process is carried out by different groups including fungi, bacteria, insects, arthropods, etc. According to their respective size, it is possible to distinguish among: microfauna (<0.2 mm, nematodes and protozoa), mesofauna (0.2-4 mm, microarthropods and others), macrofauna (> 4mm).

Leaf litter decomposition is controlled by:

a) Leaf litter chemistry (structure and defense compounds, nutrients)

b) Environmental conditions (i.e. water content)

For studying litter decomposition, litter bags in situ approach method is used. With mesh size depending on the fauna we wanted to study. We put a certain amount of litter in net bags. Some of the litter bags were retrieved from the field at regular intervals. We determine leaf mass loss during decomposition, and decomposers associated to decomposed leaves, by means of biomass and diversity measurements.

Methods for studying the mesofauna:

• Berlese funnel mesofauna extraction. Based on the principle that mesofauna escapes from dry litter and falls down to an alcohol solution. After extraction, organisms are counted and identified.

• Ergosterol is a fungal biomass indicator: extraction, purification and quantification by HPLC

• Microbial catabolic profiles associated to decomposed leaves (based in color changed related to degradation capacity) are also used due to optical density is proportional to degradation capacity of the organism.

• Litter secondary metabolites dynamics: terpenoids and phenolics extraction (chromatography and spectrometry).

Do stress and disturbance affect leaf litter decomposition?

Mediterranean terrestrial ecosystem is characterized by a climate with a hot and dry summer, low annual rainfall, violent rainy and windy events, recurrent fires, sols often shallow, and an old anthropogenic pressure. These ecosystems are colonized by plants adapted to these stressed conditions, with special morphology (as scleprophyllous plants are dominant) and special physiology as these plants are producing large amount and diversity of secondary compounds.

Water stress affects litter decomposition: during dry periods fungal biomass development is almost stopped and therefore decomposition is almost stopped. There is a positive linear relation between litter humidity and litter fungal biomass, and this is also visible in the number of individuals of mesofauna which is increased in humid seasons. Mesofauna colonization occurs later than fungi colonization since mesofauna needs fungi to start the process. In the temperate forest, we observed a continuous dynamics for leaf mass loss and decomposers. On the opposite, in the shrubland, we observed a discontinuous dynamics, depending on drought periods.

Compost amendment on Mediterranean soils is a suitable technique for accelerating the natural recovery process of soils degraded by recurrent fires, by increasing soil fertility. Although, sludge compost contains high quantity of P which can represent an environmental problem. Compost amendment increases leaf nutrients content but does not affect litter decomposition, fungal biomass and abundance of microarthropods associated with litter. It helps the plants to survive during dry period because it contains more water than soil.

In the French Mediterranean region you can see a land use change after an abandonment of agriculture. This abandoned land is colonized by Aleppo pine (*Pinus halepensis* Mill.) which is an expansionist species. In 1980, 180 000 ha were colonized by this species, compared to 36000 ha at the end of the XIXth century. *Pinus halepensis* is a plant species which produces a high amount of Plant Secondary Metabolites (PSM). There are three ways of release of PSMs: i) volatilization and this way of release is involved in biosphere-atmosphere relationship; ii) leachates and roots exudates and then participate to biotic interactions; iii) leaf litter decomposition and then participate to biogeochemical cycles. We compared the dynamics of PSM amount and diversity during needle decomposition in three successional stages of *P. halepensis*: colonization stage (~10 years old), stabilization stage (~30 years old) and mature stage (>60 years old, mixed forest).

The chemical diversity of *P. halepensis* varied according to organs like roots or needles and successional stage, especially between colonization and mature stages. We performed a leaf litter decomposition experiment during 30 months in the three pine forests, and we determined leaf litter mass loss, phenolics and terpenoids litter contents, microbial and micrarthropods dynamics. We sampled litter bags every 6 months after rain.

We observed a quick leaching or/and decomposition of phenolics during decomposition but for the colonization stage phenolics remained stable longer compared to stabilization and mature stages. We observed a slower decomposition of litter terpenoids compared to the phenolics, and a lower amount of terpenoids in litter from colonization stage forest compared to the two others stages. Dynamics of decomposers: We observed an increase of abundance of microarthropods during the process whatever the stage, and fewer organisms associated to decomposed leaves for colonization stage. We observed a negative correlation between fungal biomass and phenolic index during decomposition. The more phenols, the fewer fungi associated to leaves. Leaf mass loss was less important for colonization stage. In conclusion we observed more phenolics, less terpenoids, less decomposers and a lower decomposition rate for the colonization stage, due to phenolics.

Secondary Metabolism of Plants – Importance and functions – Prof. Dr. Catherine Fernandez

Based on the script of Prof. Dr. Catherine Fernandez

Primary metabolites are essential for growth and development and have genes with high stringency controlling essential functions. The secondary metabolism is essential for the survival of the individual and those genes are with a high plasticity controlling functions that are under selection pressure of a continuously changing environment. They are unique, diverse and adaptive. The primary and secondary metabolites serve the producing organisms by improving their survival fitness. A further attribute is the high diversity of these metabolites. The most important blocks employed in the biosynthesis of secondary metabolites are derived e.g. from Acetyl-CoA.

There are different types of secondary metabolites, e.g. Phenolic compounds, terpenoids and alkaloids. Terpenoids are formed by the polymerization of units of 5 carbons and are generally lipophilic and because of that they can be found in essential oils. Another example are the alkaloids and they are a group that contain mostly basic nitrogen atoms. They have a great biological activity and pharmacological effect and are often used as medications. Phenols or phenolics are a class of chemical compounds consisting of a hydroxyl bonded directly to an aromatic hydrocarbon group. The hydrophilic compounds are biosynthetized is in the cytosol, alkaloids and terpenoids are synthesized in the plastides, but also some alkaloids are produced in the mitochondria. The lipophilic compounds are produced in the endoplasmic reticulum. Furthermore the production of the secondary metabolites varies according to several parameters e.g. physiological like age, season and organs. Some varies in the genetic factors also influence the production of these metabolites. Biotic interactions (e.g. herbivory) and environmental parameters and have also impact on secondary metabolite production. For example, the effects of water have an impact of the production, because drought increases PSM production. In plants there can be found a different location of metabolites like in leafs, rod or fruits.

Secondary metabolites are also necessary for surviving of the organisms, because of that there are some theories on defense production and resources. For example the Carbon nutrient balance hypothesis (CNBH). This hypothesis proposes that the degree of resource availability in the habitat determines plant carbohydrate status which determines the nature of chemical defenses. Another hypothesis is the so called Growth-Differentiation Balance Hypothesis. It relies on an assumed negative correlation between defense and growth. Growth is here dominant under favorable conditions and differentiation dominates when conditions are suboptimal for growth. The role of plant secondary metabolites concerns defense against abiotic factors (e.g. drought, high temperature, ozone), biotic factors (e.g. herbivory, pathogens or plants via allelopathy).

Secondary metabolites are released in the environment by four pathways: volatilization leaves leachates, roots exudates, decomposition of leaf litter. The compounds could act in allelopathy processes. Allelopathy is defined by Rice (1984) as "Any direct or indirect effect by one plant, including micro-organisms, on another through the production of chemical compounds that escape into the environment and subsequently influence the growth and development of neighboring plants includes both inhibitory and stimulative reciprocal biochemical interactions" and by Inderjit (2011) as « Suppression of the growth and/or establishment of neighboring plants by chemicals released from a plant or plant parts ». Allelochemicals: the secretions of plants are the chemical substances which can affect the growth, behavior and population biology of other live beings. Currently, allelopathy research focusses on the interaction between:

- Plants – plants,
- Plants – microorganisms,
- Microorganisms – microorganisms.
- Allelopathy include also autotoxicity

In allelopathy there is donor plant and target plant or microorganism. Allelopathy plays a role in plant succession as in the secondary succession in Mediterranean region (with *Pinus halepensis* as donor plant). This process is also important in the context of plant invasion, with the Novel Weapons hypothesis (Callaway & Aschehoug, 2000). Microbes are important in allelopathy as targets and as mediators of allelopathy in plants. They can enhance plant allelopathy effect (degradation of toxic compounds could create more toxic products; Mycorrhizal networks could facilitate the transfer of allelochemicals from donor to target plant). However, microbes also can detoxify allelochemicals through degradation and limit allelochemical impact.

Seminar by Lukas Griesinger und Jakob Gerber

<u>Protozoa as bioindicators in agroecosystems, with emphasis on farming practices, biocides, and biodiversity (W. Foissner, Agriculture Ecosystems & Environment, 1997 Universität Salzburg)</u>

Introduction: Soil Protozoology

- Unicellular animal-like eukaryots
- Mostly asexual reproduction (fission)
- Sometimes sexual

- Important part in the soil food web (feeding on bacteria)
- Moist conditions required
- Can form cysts
- Most frequent in the upper 15 cm of soil

Protozoa classification

- Testacea (pseudopods and a shell)
- Naked amoebae (pseudopods and no shell cover)
- Flagellates (whip-like flagella)
- Ciliates (hair-like cilia)

Groups of protozoa

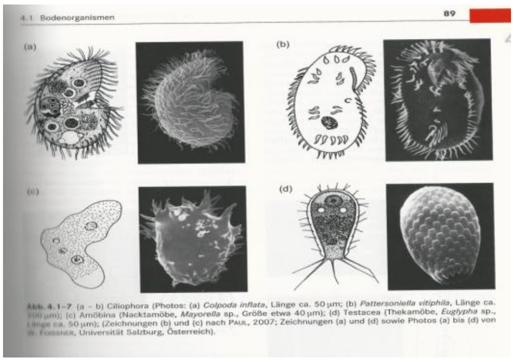


Figure 3: Picture of each group (Lehrbuch der Bodenkunde, Scheffer/Schachtschabel)

Importance of protozoans in the food web

- Enhancing the growth of others due to excretion of 60% of ingested nutrients (Bardgett and Griffiths 1997)
- They make nitrogen (also phosphorus) available by feeding on bacteria and release it for others like plants
- They regulate and stimulate bacterial communities by grazing on them
- Eventually there is an increase of the decomposition rate and soil fertility
- In general the presence of protozoans is valuable and necessary for a good soil quality

Conventional Farming and ecofarming effects on soil fauna

Ecofarming method: main aim is to protect and stimulate soil life, as well as maintain soil fertility and resource regeneration if it is possible

Conventional farming method: main concern is more an economic profitable approach in order to farm just efficient

- Significant differences between the two farming types considering a wheat field and a vineyard

→ there is more biomass on the ecofarming site

- Soil zoological factors of ecofarmed and conventionally farmed grasslands and meadows are not really different

Results:

1. Many zoological parameters are statistically not different between the two farming plots
2. No distinct differences in composition of ciliates and testate amoebae between ecofarmed and conventionally farmed fields
3. Nevertheless there is a higher biological activity in ecofarmed sites also accompanied by higher humus content and less soil compaction
4. In semiarid regions conventional farming does more damage to soil fauna than in Atlantic regions
5. Agricultural ecosystems are more sensitive to conventional farming than ecofarming
6. Soil life is distinctly richer in ecofarmed variants (Pfiffner et al. 1990), depending on investigation methods
7. Potential of nitrogen mineralization and also microbial and parasitoid abundance and diversity is higher in organic farms
8. Still there are sometimes no significantly differences for any of the investigated parameters

→ to sum up it is best according to present knowledge to prefer farming methods which conserve soil life and biodiversity of communities! (But also further research has to be done)

Effects of biocides on soil protozoa

Well-designed field studies are rare.

For the most commonly biocides there are studies.

BUT the testate amoebas have been mostly ignored.

Even though pesticides and their metabolites are bound in humus
=> a main source of food for amoeba

5 Conclusions

1. Reaction of soil protozoa to biocide stress is the same as of other organism
2. Protozoans are just as sensitive to pesticides as other test organisms
3. Insecticides are more toxic than herbicides
4. Insecticides disturb soil protozoa critically
5. Fungicides very likely do not disturb soil protozoa critically

Comments on the paper

- It is more of a review and summary
- Many cites
- Criticism and hints that literature and efforts in this field of biology have to be improved

Seminar by Anne Lotter and Gloria Gessinger

Dynamics of initial ecosystem Development at the artificial catchment Chicken Creek, Lusatia, Germany (Michael Elmer • Werner Gerwin • Wolfgang Schaaf • Markus K. Zaplata • Karin Hohberg • Rossen Nenov • Oliver Bens • Reinhard F. Hüttl)

Aim of the environmental monitoring program

- ecosystem development:
  - increase of complexity of structures and their interactions
- determine evolving properties and functions
- ➢ fundamental approach and essential requirement to untangle the complex web of processes
- ➢ better understanding of both ecosystem functioning as well as ecosystem reactions to alterations of structural properties.
- During ecosystem development both the complexity of structures and their interactions increases as additional patterns (e.g., surface and subsurface flow paths, humus layers and soil horizons, rooting channels and worm burrows) and processes (e.g., erosion and sedimentation, C-accumulation and pedogenesis, effects of biota) appear.
- These initial processes determine and control evolving properties and functions of the system
- Thus, the analysis of young ecosystems in their initial stage of development seems to be a fundamental approach and essential requirement to disentangle the complex

web of processes, and help in better understanding both ecosystem functioning as well as ecosystem reactions to alterations of structural properties.

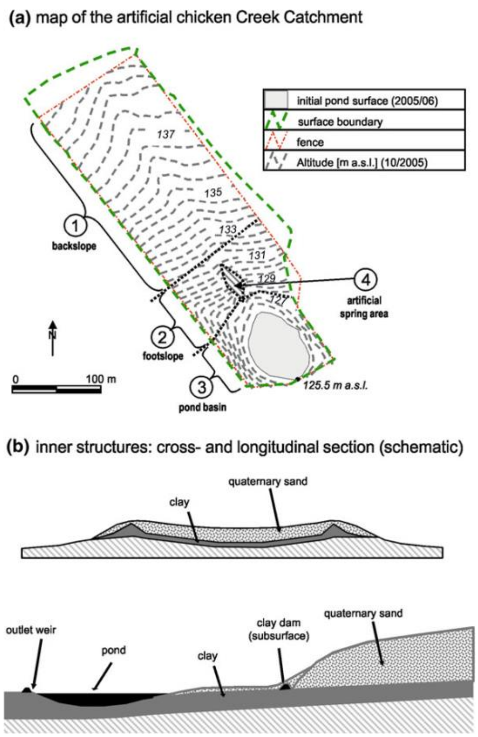


Figure 4: Map of the artificial catchment (a) and schematic profiles showing inner structures of the site (b)

- two-layer system
  - clay layer
  - overlying sandy layer
- watershed covered sand area of 6 ha
- unrestricted and unmanaged succession
- the site can be divided into three major sections:
  - backslope area
  - footslope
  - pond basin
- subsurface clay dam

  ➢ barrier for groundwater fluxes

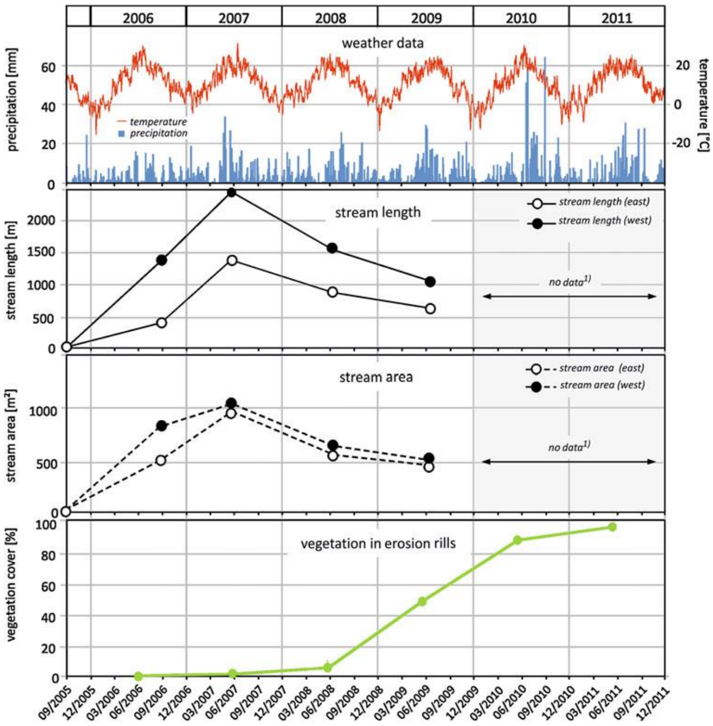


Figure 5: Geomorphic development of the Chicken Creek catchment since autumn 2005

- dominated by intensive surface runoff processes
  - ➢ intense sheet and gully erosion
- length and area of active streambeds within erosion rills increased
- Biological colonization obvious in 2009
  - ➢ changed geomorphic development
  - ➢ length and area of eroding rills decreased

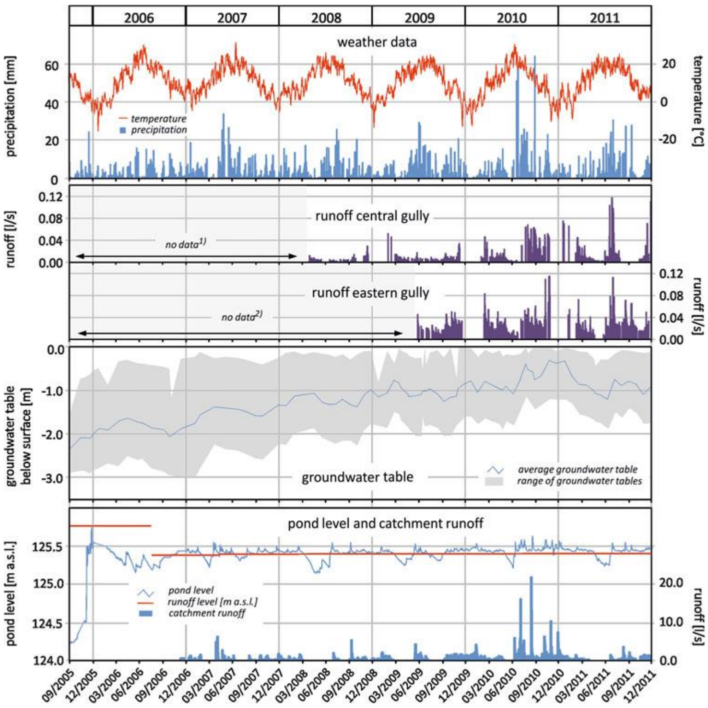


Figure 6: Hydrologic development of the Chicken Creek catchment since autumn 2005

- establishment of a groundwater body proceeded over several years
- completed in 2009, only the seasonal fluctuations remained
- high amounts of rainfall in 2010
  - ➢ temporary increase in groundwater levels up to the surface
- close relationship between the temporal patterns of rainfall and discharge at the pond weir

  = initial conditions of the catchment
- sudden, complete filling of the pond basin in winter 2005/06
  - ➢ specific meteorological conditions, bare sediment surface und physical soil crusting

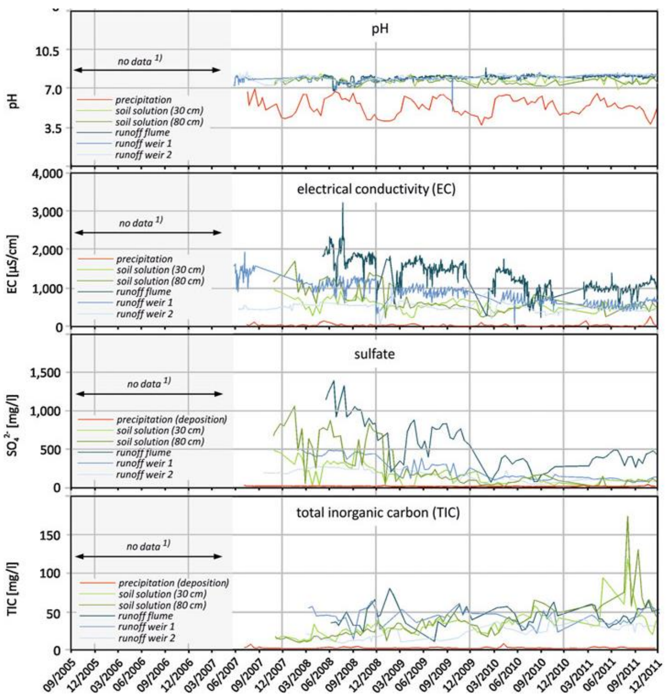


Figure 7: Chemical development of the Chicken Creek catchment since autumn 2005

- concentrations and EC values of the soil solution corresponded to the chemistry of runoff water
- mean pH values varied between 7.0 and 8.4
- decreases of SO_4, Ca^{2+} and Mg^{2+}
  - ➢ electrical conductivity
  - ➢ traces of gypsum

    = source for both Ca^{2+} and SO_4
  - ➢ gypsum was dissolved and mobilized within a few years
- increasing vegetation cover and litter input to the soil
  - ➢ increasing inorganic carbon (TIC) concentrations

→ strong source for calcium, magnesium, sulfur and inorganic carbon

→ strong sink for nitrogen

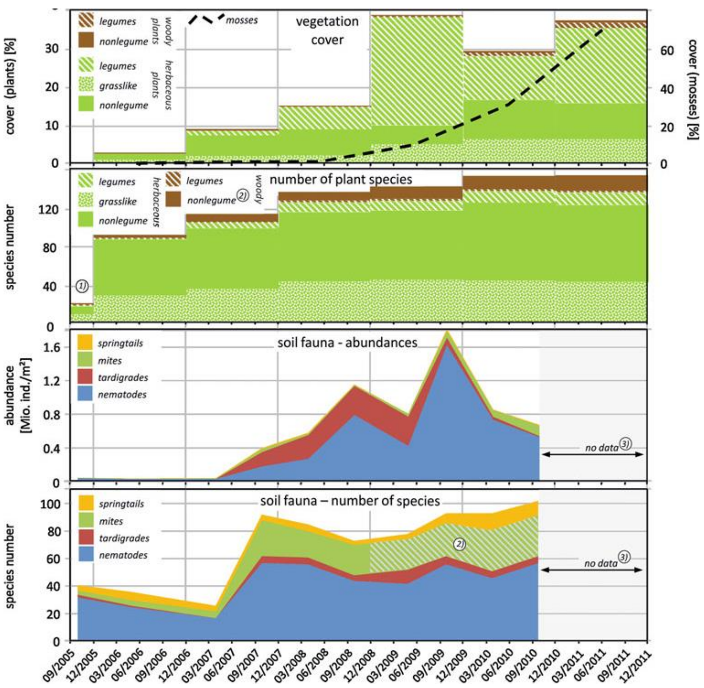


Figure 8: Biological development of the Chicken Creek catchment since autumn 2005

- patterning of species composition
- first dominating plant species *Conyza canadensis*
- Total plant cover increased and reached a preliminary maximum in 2009
  - ➢ groundwater reached its maximum level
- A general decline in vegetation cover was then observed in 2010
  - ➢ decreasing cover of the dominant species *Trifolium arvense*
  - ➢ unfavorable weather conditions
    - – harsh winter season 2009/2010
    - – high rainfall amounts during summer 2010
- importance of woody plants is increasing
  - e.g. leguminous tree species *Robinia pseudoacacia*
    = major component of the establishing vegetation
- increase of bryophytes (mosses) since 2009/2010
  - ➢ favored by the wet weather conditions in 2010
- increase in total species numbers has slowed down
- numbers of soil animals were low during the first 2 years
- densities steadily increased since 2007
- None of the soil faunal groups under investigation have yet reached their usual species numbers

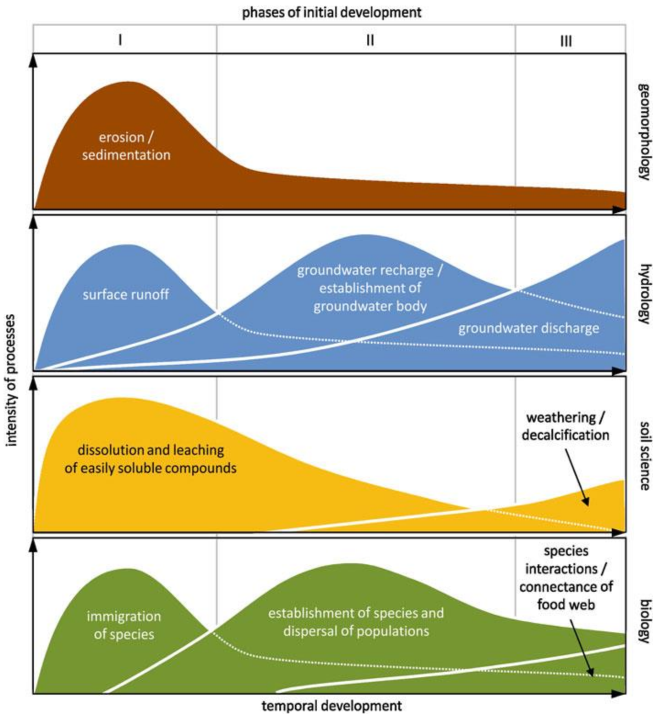


Figure 9: Intensity of geomorphic, hydrologic, pedogenic and biologic processes and their temporal development during the initial ecosystem stage

I: Geophase

Sandy substrate with low organic matter

- ➢ Erosion and Sedimentation
- ➢ formation of new structures
- ➢ high surface runoff due to a lack of surface cover

pioneering biota:

1. agricultural: lucerne
2. from forests: black locus, pine, oak

scattered populations e.g. near the water rills

II: Geo-hydrophase

- Less erosion because of biological soil crust
    - ➢ higher stability, e.g. mosses
- Ion transport into groundwater, e.g. gypsum
- decalcification
- Initial groundwater recharge through infiltration
- Infiltration increases because of the biotic soil crust

- fewer runoff

Phase III:

- Biotic interactions:
  - vascular plants replacing moss crust
- increasing soil fauna and complexity of soil food web
- Groundwater discharge because of higher evapo-transpiration rate
- Increased heterogeneity for:
  - water availability
  - nutrient availability

<u>Conclusion:</u>

- highly dynamic development
- three phases of ecosystem development can be distinguished
- soil fauna still low
- few feedback mechanisms

→ Chicken Creek catchment still in a very early, initial state

Expectations for future development:

1. quantitative increase of biomass
2. higher connectivity
3. qualitative growth: energetically more efficient patterns
4. increasing feedback mechanisms

→ investigation of interactions between the different compartments is needed

Daily report 10.9.2013 Erasmus IP „Soil & Water“, Estonia

Martina Balzarova – University of South Bohemia, photo: Martina Balzarova (www.balzarova.cz)

Yvonne Mayer – Ulm University

We were leaving the grounds of Tartu University early in the morning.

Our first stop was at **lake Peipsi** in town Mustvee (population around 1,610) in Jogevamaa county. And actually it is one of three parts of Lake Peipus – north L. Peipsi, south L. Pihkva and Lake Lämmijärv is connecting these two previous parts. The total area of the Lake Peipus is 3555 km^2. Mean depth of the lake is 8.3 m. Around 30 rivers and streams are entering the lake, the biggest are Emajõgi and the Velikaya River, the water from the lake is being taken out by River Narva. The lake is located on the border between Estonia and Russia which goes almost in the middle of the lake. According to scientific classification the lake is unstratified eutrophic lake with mesotrophic features. The total annual nutrient load is 15.57 tons N/km^2, 327 kg P/km^2 with more than 70% of N and around 40% of P originating from agriculture. Average pH is 8.14. Because of the shallow depth of the lake it warms up and cools quickly, average temperature in summer is around 25-26°C and the lake is frozen during winter months.

Water balance of Lake Peipus:

	Water balance	Volume
Inflow	Precipitation	560 mm (1.9 km^3)
	Surface and groundwater	3150 mm (11.2 km^3)
Outflow	Streamflow	3390 mm (12 km^3)
	Evaporation	320 mm (1.1 km^3)

← Satelite image of the lake from Google map

The main use of the lake is industrial and recreational fishing, even in winter time and of course tourism and sport activities. There are 36 species of fish recorded. Most common fish species are berch (*Perca fluviatilis*), bream (*Abramis brama*), pike-perch (genus *Sander*), roach (genus *Rutilus*), European smelt (*Osmerus eperlanus*).

One of the biggest problems of the lake is high rate of pollution that came from Russian site of the lake to the Estonian shoreline. In same seasons there is a problem of high fish mortality due to the pollution and high algae cover (lack of oxygen).

We observed several organisms out of 115 species of vascular plants being recorded in the Lake Peipsi. From plants we were able to see different species of Potamogeon, from family

Potamogetonaceae. These freshwater plants can vary in size. Sometimes they are annual but often perennial. They can produce rhizomes which are the common over-wintering form. Some species can produce other specialised overwintering buds, these are called turions which may be borne on the rhizome, on the stem or on stolons from the rhizome. The leaves of this genus are alternate, which is in contrast to closely related genuses and therefore a good identification characteristic. We have seen these species in particular: *P. perfoliatus, P. cristatus, P. natans, P. trichoides, P. pussilus*

Other interesting plants that can be seen here: Ribbon-leaved water-plantain (*Alisma gramineum*), creeping spearwort (*Ranunculus reptans*), needle spikerush (*Eleocharis acicularis*) and common spike-rush (*E. palustris*), waterawlwort (*Subularia aquatica*), eight-stemmed waterwort (*Elatine hydripiper*), spring quillwort (*Isoetes echinospora*), *Sparganium gramineum,* arrowhead (*Sagittaria sagittifolia*), *Cladophora* spp.

Rumex maritimus is annual wetland plant species, 10-70 cm height. Family Polygonacea.

Invasive plant Canadian Waterweed (*Elodea canadensis*, Kanada vesikatk in Estonian language) was also found on the site. This species is highly invasive thorough Europe. The origin of this water plant

is from North America as the name suggest. It came to Europe via Ireland, firstly reported in 1836. After five years it was already found on island of Great Britain. In Estonia the first record of this species are from 1905 and nowadays it is very common. The plant is commonly used as aquarium species. It belongs to family Hydrocharitaceae. It is dioecious, with male and female flowers on different plants. The Canadian waterweed is very fast growing species and can easily overgrow native water plants. It also can cause a problem for water traffic since it can block water canals, slow moving rivers and ponds.

On shoreline we have seen many shells of Zebra mussel (*Dreissena polymorpha*). Zebra mussel is relatively small with maximum size of 3-5 cm. The shell is triangular in shape and is striped (dark and light pattering). But its population can expand really quickly and cause again many problems in boat traffic (for example they can grow on buoys and their weight just pulls the buoy down, or overgrow walls of the canals). It is native to Aral, Black and Caspian sea. In Estonia as in many other European countries it is an invasive species.

Also widely distributed were shells of Lister´s river snail (). There are many *Viviparus* species but only *V. contectus* acute mud snail lives on the bottom of large lakes. Mud snails are herbivores; they eat plants from the lake's floor. This species of snail is moderately pollution sensitive. Although it is widespread local populations can be threatened by extinction due to destruction of habitat (mostly by pollution). It is native to Estonia and can live up to 13 years.

Our second stop was **Kohtla-Nõmme oil shale underground mining museum**

Oil shale is the most important natural resource in Estonia and geologically related to Middle Ordovician. It is used around the globe, for example in USA, Australia and Russia, but it is not as valuable as mineral oil or coal. It can be used to gain electricity and – after several cleaning processes – to produce mineral oil.

The Kohtla-Nõmme oil shale underground mining museum gave us an impression of the miner's daily underground life. The mine is located in north-east Estonia and was opened in 1937 by Englishmen. It was running till 2001, when it was closed mainly due to decreased productivity and less consumption of oil shale. The released oil shale was used to produce electricity. Altogether the mine produced more than 48 million tons of oil shale when it was shut down.

Generally the miners worked until an age of around 40 or 50 and were supposed to have an honorable job, as it was a difficult and dangerous work. However they suffered from several health problems caused by the working conditions in the mine – the heavy machines and the use of explosives to develop new tunnels were connected to huge noise and dust.

When we actually got underground we got a detailed impression of the working conditions in the mine and how they changed with the industrialization. By the time the miners still worked with men-powered drillers. This number increased after the industrialization heavily due to a machine called "mining combine", which made it possible to gain about 300 tons of oil shale per shift. With that numbers in mind it was quite easy to imagine how fast the exploitation of nature in this area took place and what huge impact must have been left.

Aidu oil shale mining area (open land)

Even before our arrival at the underground museum we could spot from the bus the huge changes to the environment due to the mining activity in this area. As some of the chambers collapsed during time, the water level changed which brought serious problems for agriculture. Another eye-catching aspect was the huge men-made hills due to Estonia normally being rather flat. These hills were not being recultivated and reforestated, but as there is still oil shale and limestone left in it, the hills are "burning from the inside" which also causes problems for the environment as the oxygen enters the deposites.

As an example of the mining area and revitalization of these hills, we visited the Aidu oil shale mining area right next to the underground museum. The mining activity caused a problem in terms of disposing the non-usable materials that were dug out of the earth - this is how the he calcareous hills developed in this area. Generally there are some serious problems for plants cultivated the area such as:

- There is no humus layer so there is no nitrogen
- The water intention is very low
- As for the exposition there is very much sunlight (extreme condition)

- There are adverse chemical conditions
- The pH is very low and may even be down to 1

As for the hill we visited, it was easy to spot the process of primary succession and an increase of biodiversity which was due to the limestone contained in the soil. As limestone is the biggest store of organic carbon found in nature.

We discovered next that Cambium fossils can be found all over this artificial hills. In Cambium about 550 Mio. years ago a huge explosion of biodiversity took place in shallow waters, which is the explanation why you can find marine life in several layers of the soil. The fossils are generally formed by calcite minerals which enrich in buried organisms and slowly fill them with calcium carbonate. As for other properties of this soil, we found sediments of a more brownish colour that indicate clay sediments within the calcareous material. There are also different soil building processes which favour the vegetation growth, too. And as the fossilized organisms were rich in nutrients and then turned into stone without oxygen there is a high biological productivity in the soil.

After a short inventory of the fossilized organisms' variety we discovered that oldest ones we found were corals (*Cnidarians*) of two different types: *Hexacoralia* which are the main reef builders and *Octacoralia*. They were followed in evolution by *Polychaetes* and Sponges, of which we also found lots of fossilized individuals, especially Silica Sponges. We also got hold of lots of shells, barnacles and sea urchins and members of Scaphopoda class (*Dentalium vulgare*, Elefantenzahn in german) which represent the highest evolved organisms we found on this calcareous hill. As typical representatives of the cambium age, we found also lots of fossilized trilobites.

Scaphopoda ←

Bryozoa →

Trilobite ←

Part of belemnite →

Polychaete worm ←

fossil sponge →

Waterfall Valaste in Ontika landscape reserve. The Watarefall is not natural it is manmade drainage. The recorded height of the artificial waterfall is 30 m. You can clearly see that it is artificial because the corridor by which the water come has sharp edges and the limestone is not smoothed by water erosion. Here we could see closed pathway with bridge build in front of the waterfall. This structure was build illegally and was closed because of this issue. The structure is also not very nice and destroys the otherwise beautiful scenic view. In future there is a possibility that it will be demolished. On the cliff we can easily see cross section of different layers: 1) Limestone (white), 2) Glaukonit (blue-green colour), 3) Argilit (dark colour), 4) Obulus sandstone layer which is rich in phosphorus and also contain shells, 5) sandstone, 6) Siltstone and 7) Clay.

The clay was blue in colour and it is the finest clay in Estonia.

The plant cover was very dense, with high trees suggesting presence of rich soil. In upper layer there is leptosols and in deeper layers regosols. Also there is warm area – protection of strong inland winds and warm coming from nearby sea. And plant was especially pointed out - dog's mercury (*Mercurialis perennis*). It is member of family Euphorbiaceae, herbaceous plants often poisonous. Dog's mercury favours alkaline (basic) soils and can be found in abundance in suitable habitats especially in limestone regions.

We than continued our trip to nearby **sea side area** to closely observe this ecosystem. On the sandy coastline there were many big stones that were brought here by glaciers. These stones are called erratic boulders.

In sea we could observe different algae – *Dictyota dichotoma*, members of rhodophyta group, green algae *Enteromorpha* (nutrient indicator algae) that was covering stones.

From animals we have seen different remains of mollusca and crustacea group, mostly their shells but also several living crabs running on the sand. Some barnacles were attached to stones in the sea. We also observed few sea birds especially sea gulls.

Plant covers near the sea consisted of plants able to tolerate high salinity and also are able to attach to sandy soil. Further from the beach where there is more soil the composition of plant cover changed and there was mostly *Phragmites australis*. We also have seen *Calammophila baltica* which is a hybrid between *Ammophila arenaria* and *Calamagrostis epigejos* that both have been also present on the site.

Lathyrus maritimus or in English called Beach Pea is a circumboreal species and can be found along the Pacific coast of North America and throughout parts of Asia and Europe. Fruit is a smooth flat pod.

Sea sandwort (Honckenya peploides) is the only species in the genus Honckenya of the flowering plant family Caryophyllaceae It can be also spelled *Honkenya.* The plant is a succulent perennial growing at the edge of the sea.

The Baltic sea is highly eutrophicated due to pollution. We were in a north- east part of Estonia on the coast of Gulf of Finland which is 400 km long and the maximum width is 130 km. The average depth is around 40 m and the max. depth recorded 115 m. There is large influx of freshwater from several rivers and therefore the salinity is low - between 0.2 and 5.8 ‰ at the surface and 0.3–8.5 ‰ near the bottom. The Neva River (from East) brings 2/3 of all freshwater. The average water temperature is close to 0 °C in winter; during summer it is around 15–17 °C at the surface and 2–3 °C at the bottom of the sea. The gulf is usually frozen from late November to late April.

⟵ Map of Baltic Sea and Gulf of Finland from Wikipedia

In the Gulf of Findland there is significant contamination by ions of mercury and copper, organochlorine pesticides, phenols, petroleum products and polycyclic aromatic hydrocarbons.

Kiviõli ash hill

The Kiviõli ash hill is another example of the large footprint the mining activity in Estonia leaves to nature. The ash hill consist of dark material - the origin of which is burned oil shale and containing limestone – and a bit sandy matter on it. This ash is taken from a nearby powerplant that can be seen from the top of the ash hill. A recent experiment of Tartu University showed that the ash after some years bears no danger to the environment any more due to decomposition. The ash hill is today used for extreme sport and a lookout, as you can see far distances due to the ash hill being very high and Estonia's landscape rather flat. We also noticed some windmills producing energy nearby, but were explained that there aren't many of them in Estonia because their energy is not very lucrative compared to mineral fuels. As for the plants on the ash hill, the area was rather meager, but we did find sea buckthorn (*Hippophae rhamnoides*) and *Sylago*.

Our last stop was in **Moedaku** sport center where we had dinner and spend our night. In the evening we played Disco-Golf on local field, relaxed, talked and later we had a sauna and some singing as well.

Day 11 (Wednesday, September 11th 2013)

After staying at Mõedaku spoordibaas overnight, the excursion day started with a short walk to a nearby forest. Among the floral species found there were hazel (genus *Corylus*), oak (genus *Quercus*), maple (genus *Acer*), spruce (genus *Picea*) and alder (genus *Alnus*).

The richness of the site is due to a good nutrient and water supply. These are essential factors for plant growth and plant health and their present was also indicated by the height of the examined trees (about 25-30 m).

No litter layer could be observed which stands for a high activity of soil animals and therefore a high decomposition rate.

Even though the general condition of the forest was fairly well, dead spruce trees could also be seen. The estimated reason for the death of these trees is a combination of factors – that is – the bark beetle (subfamily *Scolytinae*), a poor tree health because of an ongoing drought and the chance of the bark beetles to produce more generations during one mating period because of good conditions. When bark beetles produce multiple generations during their reproduction season there is also the possibility of them infesting healthy, vital trees.

Looking closer, a lot of different snails could be seen on the ground or on top of leaves. Particularly abundant was the white-lipped snail (*Cepaea hortensis*, Müller, 1774), which is a primary decomposer easily recognized by the white lip at the aperture of the shell of adult specimen that indicates their end of growth.

The pH of the soil was estimated to be between 6 and 6.5 at the top layers, therefore being a bit acidic due to the high decomposition rate and the thereby produced organic acids.

After leaving Mõedaku spoordibaas we drove to Nõmmeveski in the Lahemaa national park. The Lahemaa national park is the largest and oldest national park in Estonia, established in 1971, covering 725 km^2. It was the first national park established in the Soviet Union. About a third of the park is sea and about two thirds is covered by forest. A small part of the park is closed to the public, about 0.1%

There is a canyon about 20 meters high and in the canyon flows the river Valgejõgi, formed of limestone and sand deposits. The canyons top sediment layer is sand, till and gravel with limestone beneath, then there is a layer of glauconite minerals, argillite and at last sandstone.

The Valgejõgi river was dammed in 1898 to produce electricity and was closed around 1970. In the canyon the old concrete channel built to transport water from the dam to the power plant is striking in the environment and big concrete blocks are scattered around the canyon. It is interesting to see the organismic succession on this old infrastructure, with mosses, lichen and even trees growing on the concrete structures. In many places the concrete has acquired a quite thick layer of calcium carbonate,

The canyon is well covered with mostly coniferous spruce and pine but also has among others elm, native maple, hazel, and many kinds of ferns. Horsetails are prominent in the forest floor. The leaf litter transports a big amount of nutrients to the river, and up to 80% of the nutrients of the Valgejõgi river are supplied by leaf litter.

Among curious organisms found at Valgejõgi was a water scorpion, a left-handed snail of the family *Clausiliidae* and many types of Trichoptera larvae. Trichoptera larvae are important for nutrient cycling and processing in aquatic food webs but their adult, terrestrial stage often goes unnoticed because it is usually short. Trichoptera larvae can be used as indicators of water quality by observation of their silk cases. The larvae form the cases to protect themselves from toxic substances in the water and therefore the cases indicate presence of toxins.

After leaving the Valgejõgi canyon our next destination was Palmse manor.

When we were finished with collecting animals we had free time to have a look around the Palmse Manor. The complex was established in the 16th century and renovated in the years 1973-1986. Visitors can learn about the Estonian manor life and architecture here. The manor, which is situated in the nature landscape of Lahemaa National Park, belongs to the biggest baroque mansions in Estonia. The main building, the Manor house, was built up 1720 and nowadays is completely renovated and fully-equipped with furniture from the 19th century. First floor looks very festive with the decoration and high ceilings. Bedrooms were situated on the second floor; wine cellar and the kitchen are in the basement. The Manor house is surrounded by gardens planted with *Cornus alba,* decorative trees such a big-leaf linden (*Tilia platyphyllos)* and other plants. There is a pond with a summer house (rotunda) behind the main house. Other historical buildings are situated in the area – bathhouse, greenhouse and barn, distillery, ice cellar, winter garden etc. There is a possibility to visit the café and the tavern which serves national dishes. Professor Kazda, Muhle and Reintam explained the typical land use mechanisms at the time of feudalism. Mr. Muhle showed many typically garden plants and explained the architecture of the garden, which is orientated on French gardens from these times.

After visiting Palmse Manor we moved by bus to the next location – the fishermen's village of Altja. We went to the local tavern where we had cauliflower-carrot soup, salmon and bread pudding for lunch. After the lunch we went for an excursion in the village and at the coast. Altja is a typical shoreline village with one street surrounded by old wooden fishermen's houses and sheds, which were used to dry fishing nets in. Other structures were used as smoke-houses for preservation the fish for the winter. First known written record comes from the 15th century. Number of old houses has been restored recently. There are no professional fishermen living in the village these days. Most houses are in private property and they are used as summer homes. Tourists can take a hike along the local nature trail. The shoreline is rocky but there is a sandy beach close to the village too. We found again erratic boulders which are transported during the ice-ages from northern regions. Teachers explained the land use of such small villages in older times compared to the previous seen estate of Palmse Manor and compared to today's farming structures.

When we finished exploring the village and the coastline we all together met next to the bus at 18:30 and we took to the road back to Tartu.

Daily Report 12.09.2013

Alena Nostova, Jiří Mastný, Frederick Zittrell

Lecture summaries

Frederick Zittrell

Allelopathy

Functions, Release, Interactions and Current Research Approaches

(Fernandez)

Definition (Inderjit et al., 2011):

Suppression of the growth and/or establishment of neighboring plants by chemicals released from a plant or plant parts.

→ Allelochemicals: Secondary compounds of plant origin that interact with their environment and possess allelopathic activities.

Other definitions also include stimulative effects, reciprocal interactions, for example with microorganisms, and autotoxicity.

Characteristics of allelochemicals

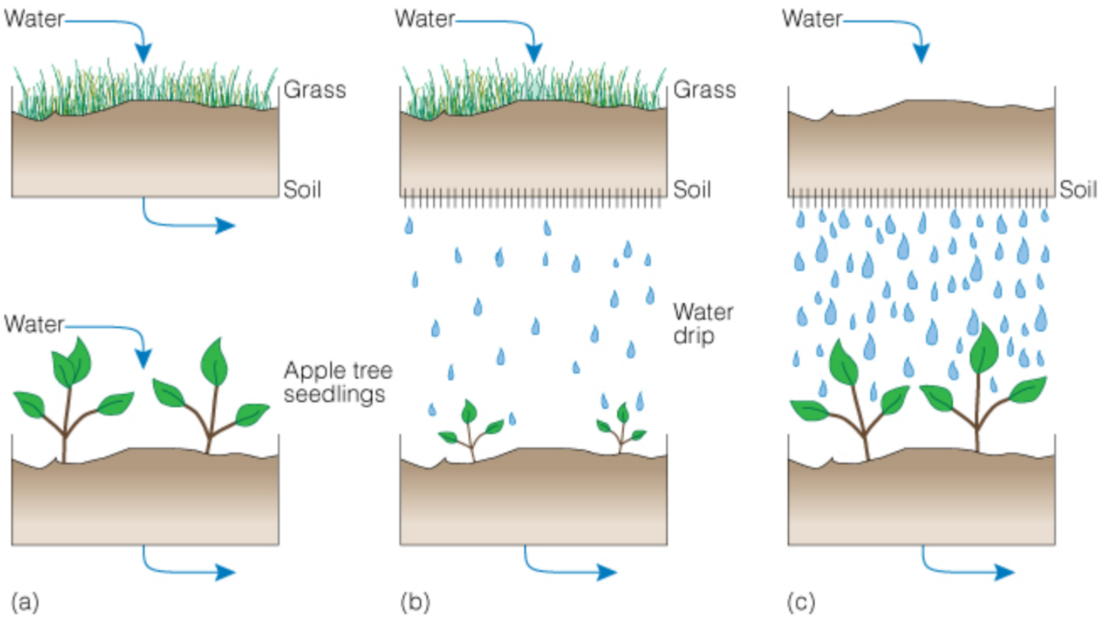
- Present in all organs (root, shoot, leave, flower, fruit)
- Variable in metabolic pathway of production
- Different ways of release: Volatilization (into the air), leaching (solute into the ground), active exudation and decomposition
- Variable basis of detrimental effects on growth (enzyme activity, cell division, growth regulator activity, membrane permeability…)

Methodology of Allelopathy Research

General difficulty: Separation of competition and allelopathic effects.

- Preliminary studies: Identification and characterization of allelochemicals (chemical properties, metabolical and anatomical derivation, way of release, variability in time…)
- Common approach: Filter paper bioassays; addition of macerated, presumably allelochemicals containing organs of a donor plant in different developmental stages and concentrations on seedlings of target species → Detection of allelopathic potentiality of respective plant organ in respective plant community
- Field experiments: Direct addition of suspected substance onto the field

Example 1: Experimental demonstration of allelopathic effects of grass on apple seedlings



Example 2: Allelopathic impact on secondary succession in Mediterranean plant communities; Bioassay approach

1. Application of needle and root macerates of 10, 5 and 2.5% concentration from *Pinus halepensis* of 10, 20 and 30y age on seedlings from 2 herb species.

   Result: Significant decrease of germination rate in any bioassay combination; needles of young pines and roots of old pines inhibit growth.

2. Application of needle macerates of young *P. halepensis* on 15 target species put in natural and sterilized soils.

   Result: Inhibition of twice as many species on sterilized (80%) than on natural (40%) soils → Microorganisms greatly modulate allelopathic potential of young *P. halepensis.*

   Furthermore, macerates promote microbial activity (cause to be investigated).

3. Application of needle and root macerates of old *P. halepensis* on same species' seedlings, put in natural and sterilized soils.

   Result: Decreased germination speed and growth of seedlings → autotoxicity; inhibition of pine regeneration in old pine wood, oaks are not affected

→ *P. halepensis* is a driver of secondary succession

Example 3: Allelopathy in the ecosystem forest

Research on downy oak forest (Mediterranean) with understory of a high cover of *Cotinus coggygria* (smoke tree); biodiversity changes between *C. coggygria* absent and present were observed.

1. Chemical analysis: High diversity of terpenes in smoke tree leaves of all developmental stages, especially in litter
2. Bioassay on plant diversity: Green and senescent leaves decrease growth of seedlings (from more or less sensitive species); increased allelopathic effect in sterilized soil
3. Bioassay on oak regeneration: Young oaks are sensitive to *C. coggygria* allelochemicals

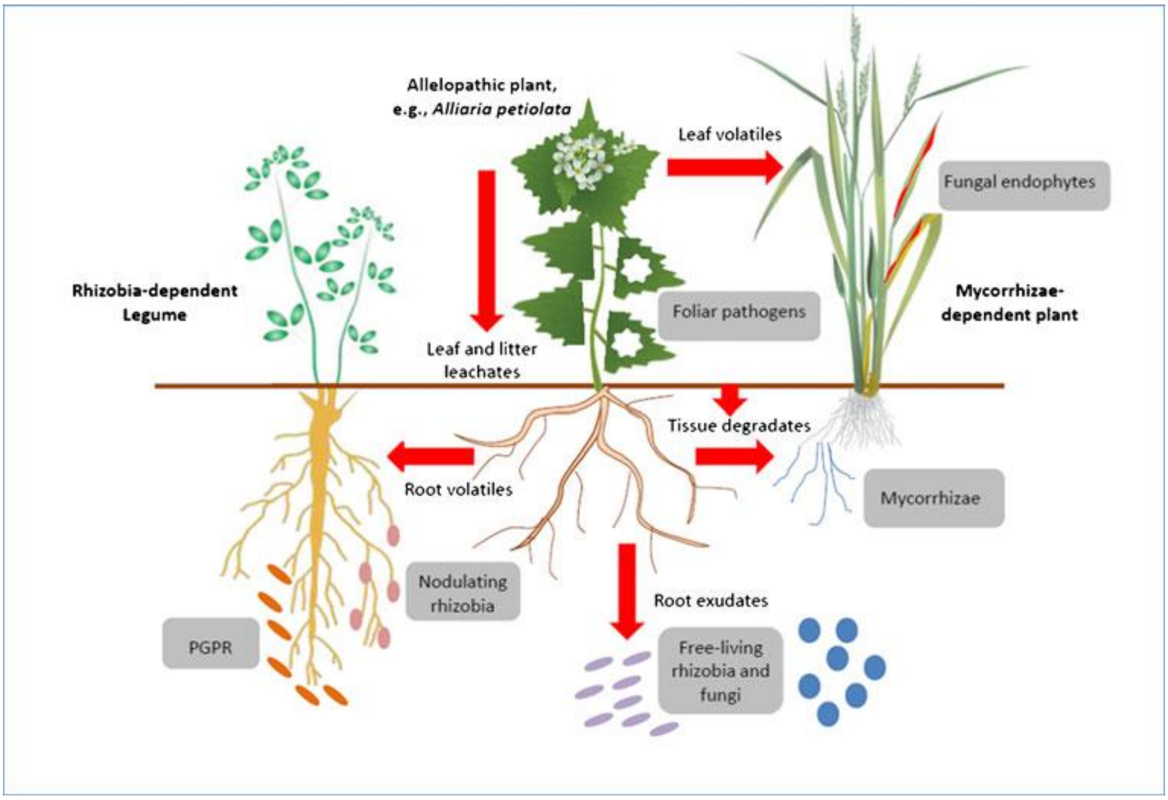
→ *Cotinus coggygria* has a strong allelochemical influence on biodiversity

The "Novel Weapons" Hypothesis

Theory about the success of invasive plants: In natural environment plants co-evolve – defense against allelochemicals develops slowly along with them. If plants invade a very different ecosystem, the native plants have no sufficient defense against the differently evolved allelochemicals, the "novel weapons", and are likely to lose the battle for growth and reproduction.

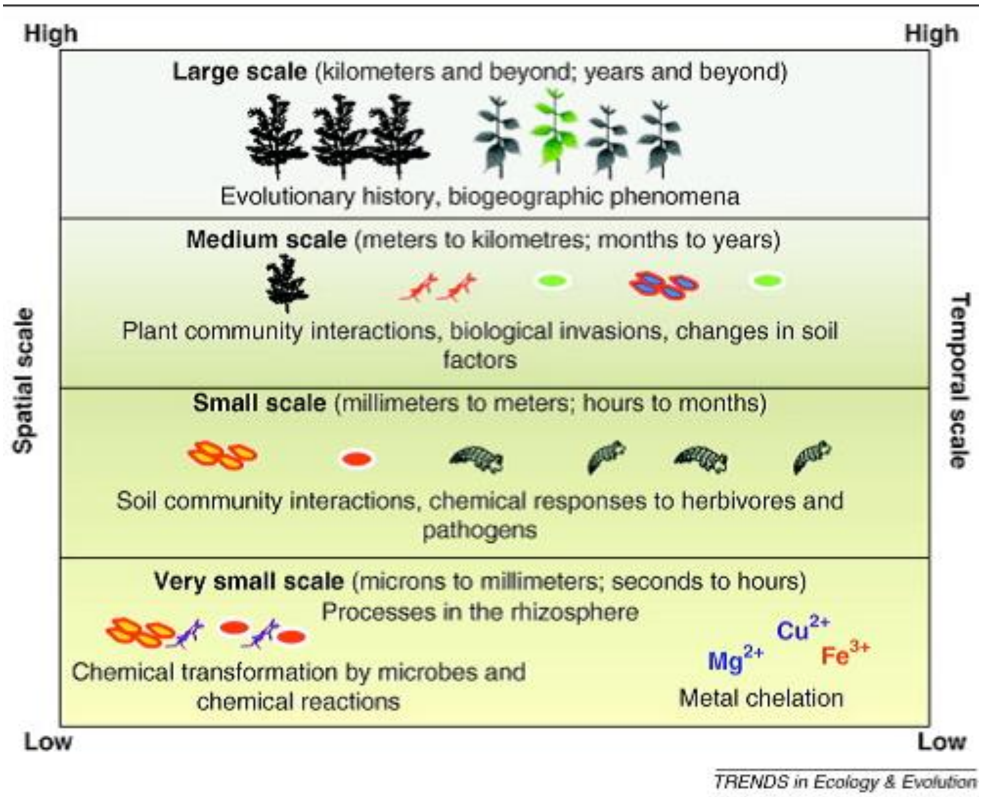
Microorganisms as Targets and Mediators of Allelopathy

For example: *Alliaria petiolata* releases allelochemicals inhibiting mychorrhiza-fungi, thereby decreasing the fitness of plant competitors that rely on mychorrhizae.



Diverse sites of microbial interaction (Cippolini et al., J.Chem Ecol 2012)

Microorganisms play different roles



Inderjit et al., 2011

They can be harmed by allelochemicals, therefore neutralize them. In this process, even more toxic compounds (for plants) could be produced, thus enhancing allelopathic effects on plants. Mychorrhizal networks can facilitate the transfer of allelochemicals.

Impact of Plant Communities Change on Leaf Litter Decomposition

(Baldy)

With the oak observatory in southern France (Mediterranean area), experimental long-term studies on the effect of decreasing rainfall due to climate change on *Quercus* pubescens forest diversity and functioning can be conducted.
Q. pubescens is the dominant tree species in France, the observed oak-forest of 95 hectare, which has not been used for 70 years, is studied using a 40 meters long crossed gateway system on two levels, allowing monitoring from soil to canopy without disturbance of the ecosystem.

Example 1: Impact of climate change
Prognosis till 2100: 30% decrease of rainfall and doubling of the summer dry period
→ increased water stress

Experimental approach: Covering of a part of the forest during rainfall (ongoing study)

Example 2: Litter-mixing effects of decomposition

Hypothesis: Plant diversity↑ → chemical diversity↑ of litter → taxonomic and functional diversity↑ of soil microbes → efficiency↑ of litter decomposition

Experimental approach: One-year decomposition experiment with mixtures of one to four different species (*Acer monspessulanum, Quercus pubescens, Cotinus coggygria, Pinus halepensis*) in litter-cages put on the forest soil.

Results:

- Positive effect of *A. monspessulanum* on decomposition efficiency in any two-species-mixture.
- Positive effect of *P. halepensis* on decomposition efficiency in any mixture, increasing with raising number of other species.
- Oppositional effect of *P. halepensis* mixed with *Q. pubescens*; *Q.* favoring *P.* decomposition, *P.* inhibiting *Q.* decomposition.

→Hypothesis partly certified – biodiversity does not promote litter decomposition per se, but depends on the different species and their combination.

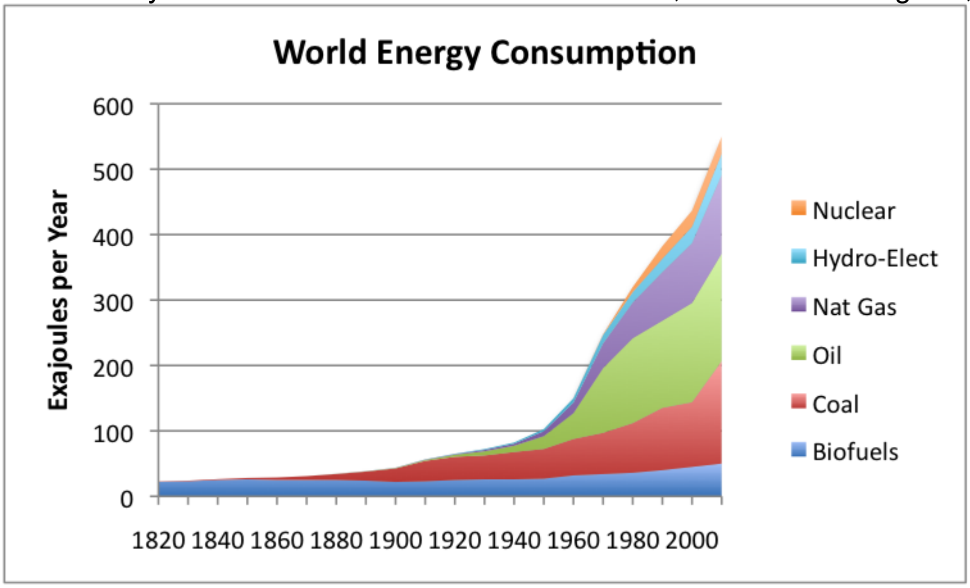
Acidification of Freshwaters and Soils

Causes and Consequences

(Baldy)

19th century: First industrial revolution with coal, steam engines and railway

20th century: Second industrial revolution with oil, combustion engines, motorization etc.



World energy consumption per year (ourfiniteworld.com)

NO_x^{+} and SO_2^{*} emissions:

Natural	Anthropogenic
Volcanic events^{*+}	Industry*
Forest fires*	Transport^{*+}
Decomposition^{*+}	Agriculture^{+}
Oceans^{+}	…
…	

Chemical transformation into strong acids H_2SO_4 and HNO_3
→ **Acidification of soil**

The problem: Acid-cations exchange with nutrient cations bound to soil particles → leaching of nutrients; self-amplifying effect.

Countermeasure: Calco-magnesium liming, leading to changes in soil pH, Ca-Mg-content and humus morphology – but depends on geological substrates: it is beneficial to sandstone, but detrimental to granite.

Botanical practical work; theoretical background

Water potential

Jiří Mastný

Water potential is the chemical potential of water in a specified part of the system, compared with the chemical potential of pure water at the same temperature and atmospheric pressure. Water potential is measured in units of pressure MPa. It was defined, that the water potential of pure, free water at atmospheric pressure and at a temperature of 298 K is 0 MPa.

Plants retain in biomass less than 1% of the water absorbed. Most of the water is lost by transpiration, which is the evaporation of water from plants. This is necessary for photosynthesis, because the stomates, which allow CO_2 to enter the leaf, also caused water loss. There is a gradient in water potential in the plants. Highest (less negative) water potentials occur in the soil and lowest water potentials are usually at the top of the plant. This is water potential in plants during the day in optimal condition. However, there are some changes at night. At night the gradient collapses or gets very small because there is little transpiration.

Water potential response also when are dry conditions in soil. Water potential of leafs decrease at dry conditions in soil. Thus lead to hormonal signals (mainly abscisic acid) and stomata close.

Long distance movement of water in the plant occurs by bulk flow. Water in the xylem is under tension. The source of tension in the xylem is the negative pressure that develops in the walls of mesophyll cells when water evaporates by stomata.

The cell wall is something like a very fine capillary wick soaked with water. Surface tension in the crevices of the wall induces a negative pressure in the water. Thus the motive force for xylem transport of water is generated at the air-water interfaces within the leaf by transpiration.
Protoplasma in cells contain 85-90% water. Live cells must maintain a positive hydrostatic pressure (remain turgid) to be physiologically active. Turgor is needed for cell expansion and structural rigidity of non-lignified organs like leaves.

In roots, water moves by diffusion through cell membranes. The driving force is the difference in water potential. In the xylem water moves by bulk flow and the driving force is the difference in pressure (ψ_p). From the leaf air spaces to the atmosphere near the leaf surface water vapour moves by diffusion (no membrane), so the driving force is only the difference in water vapour concentration.

$$\psi_{\mathrm{W}} = \psi_\pi + \psi_p$$

Water potential in any part of the system is the sum of the osmotic potential (ψ_π) and the hydrostatic pressure (ψ_p)

Hydraulic lift is the movement of water from deep moist soils to drier surface soils through the root system. This occurs primarily at night, when the plant is at equilibrium with root water potential.

CAM plants are adapted to dry condition – these plants have maximum stomatal conductance at night, when is lower air temperature. This also means that hydraulic lift occurs during the day in the CAM plant.

Reference: Lambers H., 2008 Plant Physiological Ecology - Second Edition, Springer ISBN: 978-0-387-78340-6

Plant - Water Relations

Alena Nosova

Although water is the most abundant molecule on the Earth's surface, the availability of water is the factor that most strongly restricts terrestrial plant production on a global scale. Thus, if we want to explain natural patterns of productivity or to increase productivity of agriculture or forestry, it is crucial that we understand the controls over plant water relations and the consequences for plant growth of an inadequate water supply.

The water in the plant cell

The water in the plant cell occurs in several forms:

Water of hydratation (5-10% total cell water) - associated with ions, dissolved organic substances and macromolecules. Because of dipole character, water molecules are able to associate with ions, form several layers of structured water and cover the macromolecules with thin cove of water. Electrostatic forces between ions and water molecules. Most of the water of hydration is bound by capillary forces in the protoplasm and cell wall. The forces holding water on the surface of structural elements in a matrix can be expressed in terms of the matric pressure τ.

Stored water – water in solutions, reserved in specialized cell compartments, most easily translocated. The osmotic pressure π of a solution is given by:

$$\pi^* = n \cdot R \cdot T = 2 \cdot 27 \cdot n \frac{T}{273} \text{ [MPa]}$$

π increases with absolute temperature T and with the number of dissolved particles n. For example, during the conversion of sugars to starch and revers process, plant cell can rapidly alter its osmotic pressure and regulate net water influx.

Interstitial (vascular) water is a transport medium in the spaces between cells and in the conducting elements of the xylem and phloem systems.

The water potential of plant cells

It is the thermodynamic state of the water rather than its total quantity that influences the biochemical activity of protoplasm. The thermodynamic state of the water in a cell can be described as a water potential:

$$\Psi_{cell} = (-)\Psi_{\pi} + (+)\Psi_{P}$$

Water potential is the chemical potential of water in a specified part of the system, compared with the chemical potential of pure water at the same temperature and atmospheric pressure. Water potential is measured in units of pressure MPa. It was defined, that the water potential of pure, free water at atmospheric pressure and at a temperature of 298 K is 0 MPa.

The osmotic potential Ψπ is invariably negative, whereas the pressure potential Ψp can be positive, zero or in exceptional cases even negative. A negative water potential indicates that the cell as a whole is under tension. Despite that matric potential Ψτ is usually small, sometime it is important to include it in calculations of cell water potential.

When water-saturated, the protoplast has attained its greatest volume and exerts the greatest pressure on the call wall. Due to the internal (turgor) pressure the cell wall is maximally distended. Then the resulting wall pressure compensates for the osmotic effect of the of the cell sap so that net water uptake into the cell is stopped. At this point of water saturation Ψcell = 0 and Ψπ = Ψp. Loss of water leads to reduction of the vacuolar volume and a rise in cell sap concentration. Increasingly pressure is exerted on the protoplast by the cell wall, until the cell volume has diminished to a threshold value, beyond which the cell wall can shrink no further (zero turgor point). If the cell is in an aqueous (hypertonic) medium (Fig.1,2) the protoplast begins to pull away from the cell wall, this stage is called incipient plasmolysis (Ψp = 0, Ψcell = Ψπ).

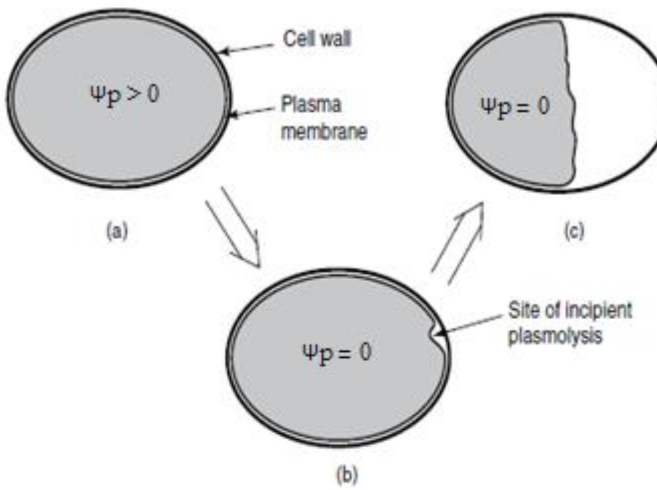


Figure 1. Relative position of the plasma membrane for a plant cell undergoing plasmolysis: (a) turgid cell with the plasma membrane pushing against the cell wall; (b) cell just undergoing plasmolysis, i.e., at incipient plasmolysis; and (c) cell with extensive plasmolysis, as the plasma membrane has pulled away from the cell wall over a large region.

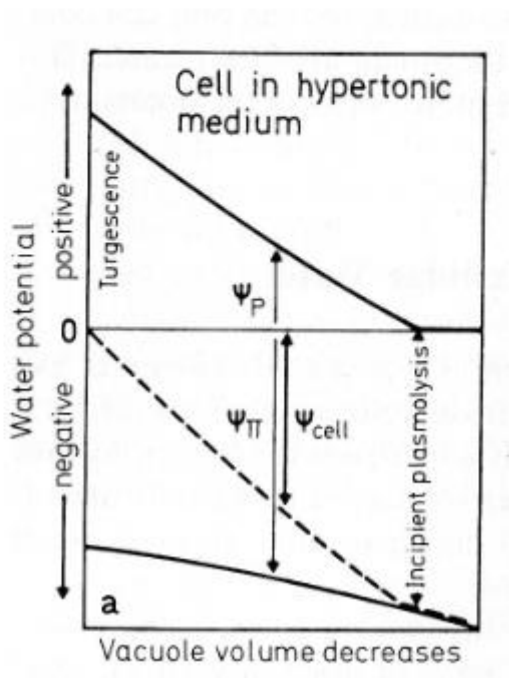


Figure 2. Water-potential diagram for vacuolated cells in a hypertonic medium (a).

Water relations of the whole plant

The shoot of terrestrial plants steadily loses water to the air surrounding it, this water must be replaced from the soil. Transpiration, water uptake and conduction of water from the roots to the transpiring surfaces are inseparably linked processes in water balance.

Water uptake by roots

A plant can withdraw water from the soil only as long as the water potential of its roots is more negative than of soil solution around. The rate of water uptake by roots increases in parallel with increase of absorbing surface of the root system.

Roots usually develop negative water potentials of a few tenths MPa, which is nevertheless quite sufficient to withdraw the greater part of the capillary water from most soils. Plants can obtain more water from the soil by actively lowering their root potential: hygrophytes -1MPa, crop plants from -1 to -2Mpa, mesophytes to -4MPa and xerophytes at most -6 MPa.

During the night, water drawn from the deep, moist soil horizon is conveyed not only to the shoots but also to the roots nearer the surface (Fig.3). If the water potential in the uppermost soil layers is lower than that of these roots the latter lose water to the surrounding soil. This nocturnal hydraulic lift in deep-rooting plants helps other plants with more superficial root systems to survive period of drought.

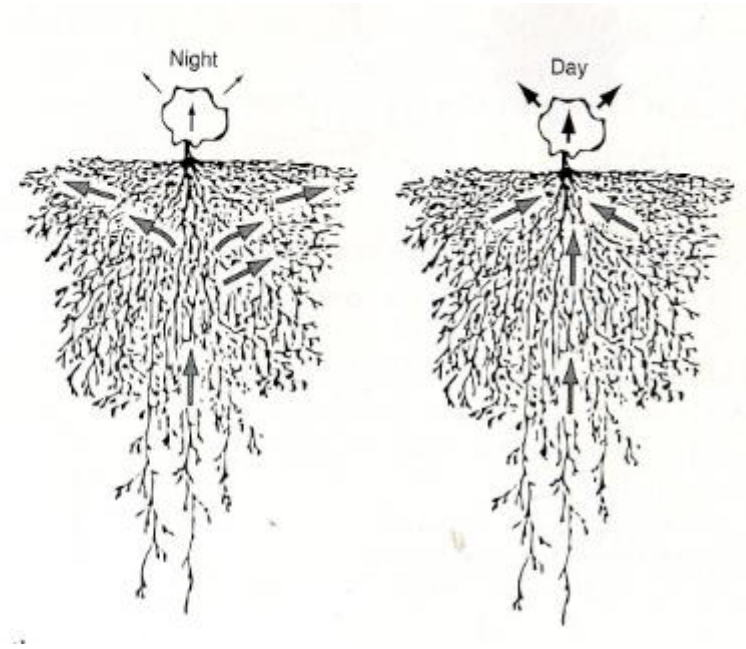


Figure 3. Hydraulic lift in the root system of Artemisia tridentate (Dawson, 1993)

Soil-plant-air gradient of water potential is a basis of water flux inside the plants

The plant bridges the steep water-potential gradient between soil and air (Fig.4). Because the shoot is exposed to the vapour-pressure deficit of the air a flow of water through the plant is set in motion. The steepest water-potential gradient is that between the shoot surface and dry air. Resistance to water transport through soil-plant-air decrease.

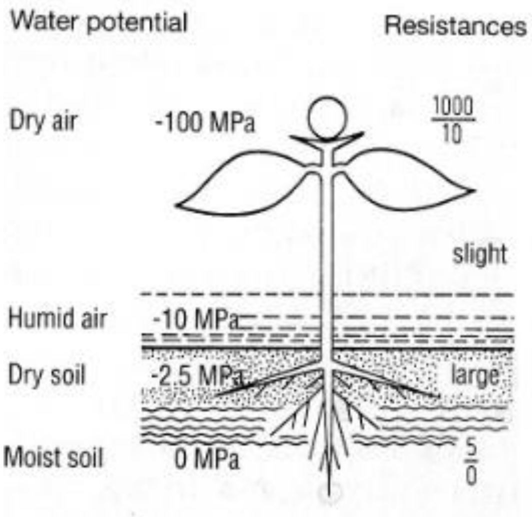


Figure 3 Water-potential gradients and resistances to water transport between soil, plant and atmosphere.

The potential gradient in the soil-plant-atmosphere continuum is the driving force for water transport through the plant. The water potential Ψz at a particular location in the plant is lower, the lower the water potential in the soil, the greater the effect of gravity Ψg, the greater the hydraulic resistances r_j, between the soil and the point of reference z in the shoot, and the more water flowing through the plant (sum of partial fluxes Σ_{ji}):

$$\Psi_z = \Psi_{soil} + \Psi_g + \Sigma_{soil}^{z} j_i \cdot r_i$$

The plant would be expected to exhibit a speed gradient in water potential only when large quantities of water are flowing through it, i.e. when conditions promote intensive transpiration.

The path of water in the plant

Within the plant water moves from cell to cell (short distance transport) and through xylem (long distance transport).

Cell to cell diffusion is based on hydrostatic gradient between the cells and apoplastic translocation.

In the root the water passes parenchyma, endodermus (with blocked by Casparian strips apoplastic transport) and then goes to central stele where the long distance transport takes place.

The rate of sap flow

The amount of water moved through the vascular system in unit time is dependent on the relative conducting area (ratio of xylem conducting area A_{xyl} and the leaf surface area Al or leaf mass of the transpiring parts that are supplied by this conducting tissue) and flow resistances, on the physiological state of the plant and on environmental conditions.

Water Loss from the Plants

Plants lose the water in vapour from by evaporation (transpiration) and in liquid form (guttation, negligible contribution).

Evaporation from the water surface depends on water-vapour content and temperature of air.

Evaporation under conditions of unlimited water supply and unimpeded removal of the water vapour is called the potential evaporation. The actual evaporation from moist surfaces is usually less than potential evaporation, because water is almost never replenished as rapidly as is lost.

Transpiration

Transpiration is an inevitable consequence of photosynthesis; however, it also has important direct effects on the plant because it is a major component of the leaf's energy balance.

Within the organs of the plant, water evaporates from the intercellular air space (liquid-vapour conversion) and escapes through the stomata. After, vapour diffuses into boundary layer and thence into the open air. Transpiration is affected by external factors to the extent to which they alter the steepness of the vapour pressure gradient between the plant surface and air. Dryness and temperature of the air, warming of the leaf surface (by irradiation) also leads the transpiration even with high air humidity. For big leaves wind can remove the vapour-saturated layer and effect on transpiration.

Maximal transpiration

Is a unimpeded intensity of evaporation under regular conditions of evaporation in natural habitat. The rate of maximal transpiration is connected with morphology and life-form of a plant. The highest transpiration intensities have been recorded for tall herbs of the meadows on river banks in Asia and for floating and swamp plants.

Transpiration as a diffusion process, regulation of transpiration

Diffusion of the water through the leaf can be described by resistances (conductances) on the different steps (Fig.5,A):

$$g_{leaf} = g_s + g_{cut}$$

g_s – stomatal conductance is determined by anatomical features, arrangement and density of the stomata.

g_{cut} – cuticular conductance, is so low that it can be ignored in most cases, except when the stomatal conductance is extremely low.

Transpiration is strictly dependent on the physical conditions affecting evaporation only as long as degree of stomatal opening does not change. Plants can regulate stomatal opening and quantitative changes can be determined porometrically. A temporary reduction in the degree of stomatal opening elicited by a decrease in light intensity, dry air, water deficit, extremes temperature and toxic gases. The way stomata respond may differ from one plant species to another and even from one individual to the next within the same species. Even the leaves of a single plant vary quite considerably in this respect, depending on their age, the conditions under which they developed and their positions on the shoot.

The water balance of a plant

The basic processes involved in the water balance of a plant are water uptake, conduction and water loss. The difference between water absorption and transpiration, i.e. water balance indicates the status of water equilibrium in the plant: negative balance means that the uptake is insufficient to meet the requirements of transpiration, and positive values means that transpiration is decreased while uptake is unchanged. Short-term fluctuations (Fig.5) if water balance reflects the interplay of the various water-regulating mechanisms (mostly changes in stomata aperture) and occurs during the day. Long-term (seasonal) fluctuations are based on changes of rainy/dry periods during the year.

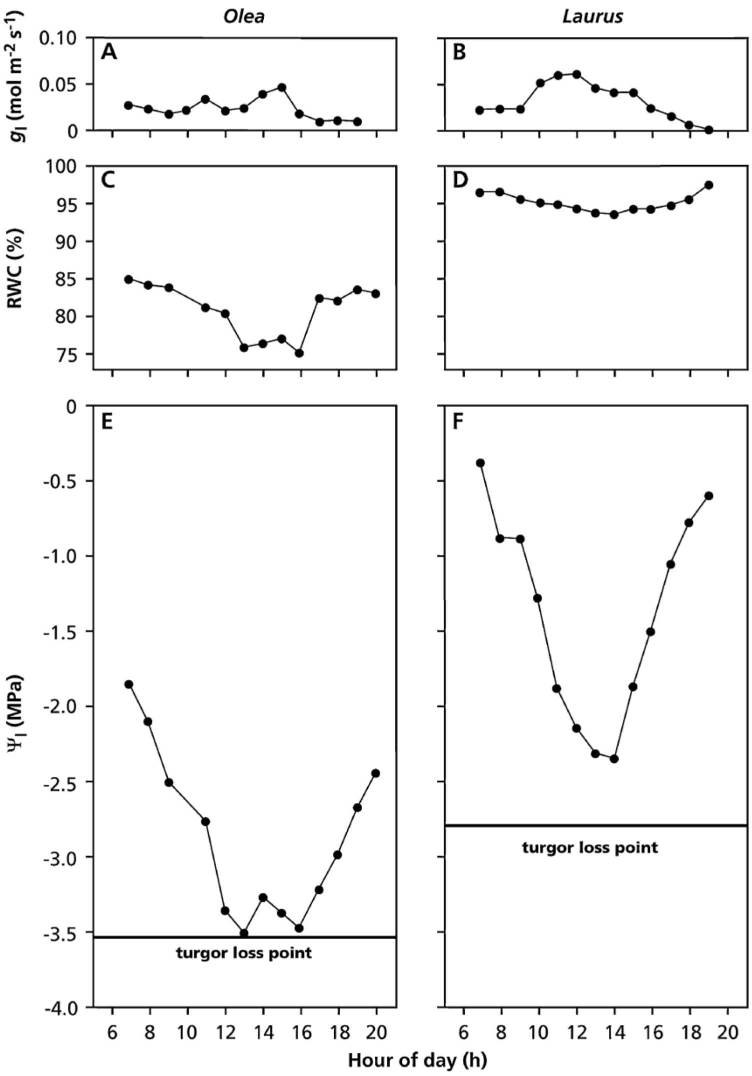


Figure 5. Time course of the leaf conductance to water vapour (A, B), the relative water content (RWC) of the leaves (C, D), and the leaf water potential (E, F) for two Mediterranean tree species, the relatively drought-tolerant Olea oleaster (olive) and the less tolerant Laurus nobilis (laurel). RWC is defined as the amount of water per unit plant mass relative to the amount when the tissue is fully hydrated. Measurements were made in dry season.

Indicators of the state of water balance

Water balance can be computed from quantitative determinations of water uptake and transpiration, therefore it is customary to make an indirect estimate of the water balance through its effect upon the water content or water potential of the plant.

Relative water content (RWC), the water content at any particular time of observation helps to demonstrate the water deficit (Fig.5):

RWC = Wact/Wsat *100%

The actual water content (Wact)

Water content of the leaves under conditions of saturation (Wsat)

Water saturation deficite (WSD) shows the water deficiency:

WSD = (Wsat-Wact)/Wsat *100%

Fluctuations in water content affect the concentration of the cell sap and the turgor of the cells. The osmotic potential rises when the water balance is negative (osmoregulating processes should be taken into account as well). As an indicator for the state of the water balance the actual value of osmotic potential is compared with its optimum value, and the osmotic maximum under conditions of extreme water shortage.

Water relations in the different plant types

Hydrostable plants: shows a great sensitivity of stomata respond; store the water in roots and the wood and bark of the stems or trunks. Include aquatic plants, succulents, sciophytes, certain grasses and trees of humid regions.

Hydrolabile plants can afford to risk quite large losses of water and the consequent rise in cell sap concentration. Such plants can tolerate strong fluctuations in water potential. Many herbs of sunny habitats, steppe grasses, woody plants, pioneer species.

Conclusion

The shoot of terrestrial plants steadily loses water to the air surrounding it, this water must be replaced from the soil. Transpiration, water uptake and conduction of water from the root to the transpiring surfaces are inseparably linked processes in water balance. The vapour-pressure deficit of the air is the driving force for evaporation, and the water in the soil is crucial quantity in water supply. The water balance is maintained by a continuous flow of water, and is thus in a state of dynamic equilibrium.

References:

Larcher W.,1995 Physiological Plant Ecology - Third Edition, p.217-254

Lambers H., 2008 Plant Physiological Ecology - Second Edition, Springer ISBN: 978-0-387-78340-6

Practical work: turgor potential of a potato

Frederick Zittrell

In the first part, students should learn about turgor pressure by conducting a simple experiment.

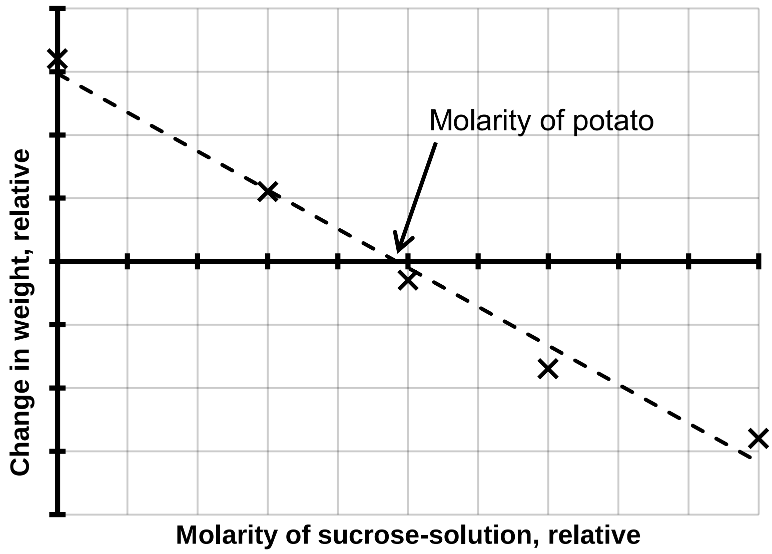
In order to obtain physical stability, plant cells actively store Ions, sugars and other organic compounds in their vacuole, producing high molarity of this solution. The physical pressure of the vacuole is antagonized by the cell wall, leading to high tension against it – this is called turgor; it is the only mechanism for non-lignified plant tissues to produce stability.

Depending on the molarity of the solution in the vacuole and the surrounding solution, turgor pressure can be higher or lower. Students were to determine the turgor potential (the higher the molarity of the vacuole, the lower the potential) of potato parenchyma with a simple experiment.

Small pieces of potato were each put in solutions of different molarity, starting at 0M (distilled water) up to 1M (sucrose solution) for 1 hour. By weighing the pieces before and after accurately, it could be calculated whether they gained or lost weight during the treatment.

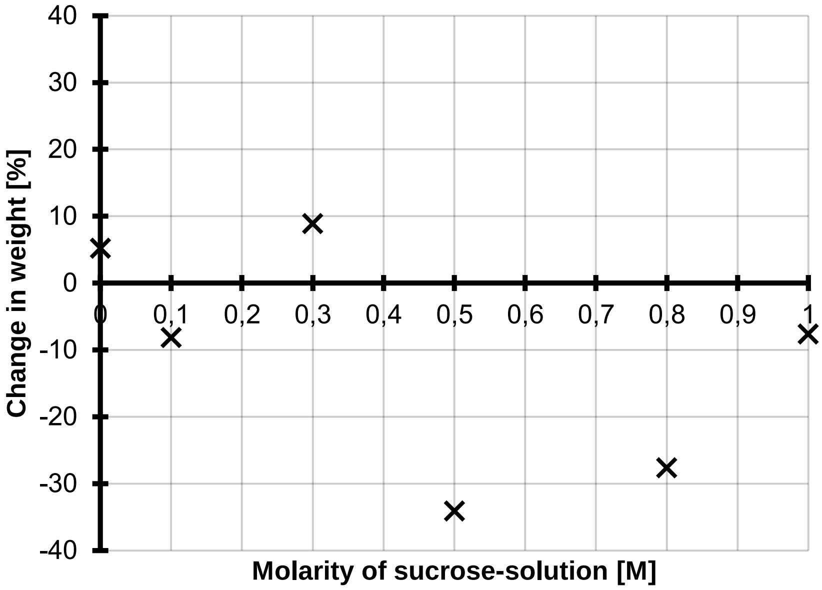
In hypotonic environment (0M), water diffuses into plant cells establishing turgor; vice versa, in hypertonic solutions plant cells lose water.

Thus, a diagram with the measured change in weight in percent depending on the molarity of the solution is expected to look somehow like this:



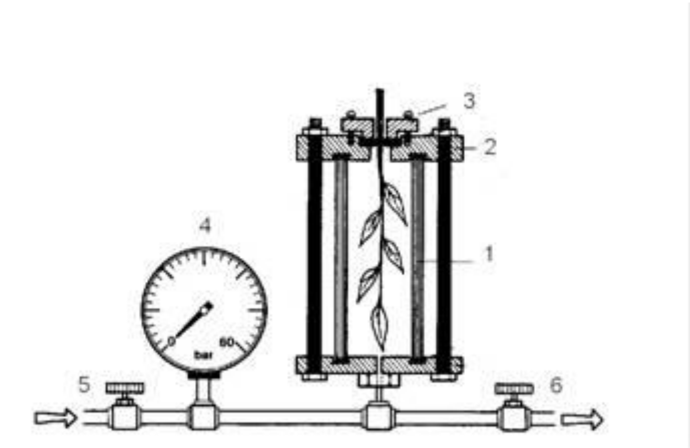
Where the fitted curve and x-axis meet is where one can read the molarity of the tissue because water influx and efflux are equal. The turgor potential equals the water potential of a sucrose solution of this molarity.

However, the obtained diagram looks different:



The values do not follow a linear pattern; a failure of experiment execution is as obvious as it is unbelievable. Fitting a curve is not a reasonable option; the turgor potential cannot be determined.
The experiment was conducted in two steps by two different groups of students; it is probable, yet not reconstructable, that the cups that contained the different solutions got mixed up due to non-comprehensible labeling.

In the second part, students were shown how water potential can be measured. The mode of operation of a common pressure chamber, a schematic shown in the following figure, was professionally explained by a highly qualified supervisor.



Pressure chamber (plantstress.com)

The pressure on the leaves within the chamber rises step-wise. The scientist observes the cut surface of the shoot; when xylem sap leaks out, the negative air pressure in the chamber equals the water potential of the leaves.

Zoology practical work

Jiří Mastný

Zoology practical work started at 10 30. First part of lesson was theoretical. First of all, we discussed what the animals are. We defined animals like multicellular, mobile, heterotrophic organisms and we postulated that unicellular animals are not considered as animals. Then the teacher told to us about body plans and biology of animals and about the evolution.

The practical work was based on determining of insects samples. These samples were collected in May. It was necessary to have some basic knowledge about the biology of these animals, before we started determining of these animals. The teacher talked about general introduction in the biology of animals. We obtained determination key. This determination key was made by famous English author Chinery (1993) and the name of this key is “Collins Field Guide Insects of Britain and Northern Europe”. First step in determining of animals is divining into groups according to the number of legs or pairs of the legs. There are some examples, what we should know, when we wanted to determine arthropods: Arthropods have thorax and abdomen and they have also lens eyes. Scorpions and spiders have 4 pairs of legs. However scorpions are not so important in Estonian region. Also predatory and orepathic (vegetarian) mites have 4 pairs of legs. Woodlays (crustaceans) have 7 pairs of legs. More than 7 pairs of legs have centipedes and millipedes. Hexapods have 3 pairs of legs. Hexapods are divided in 3 groups: Springtails, beetles and bugs. Difference between beetles and bugs is that beetles have chawing mouth part, meanwhile bugs have sucking advice.

Then we obtained our samples. First step was split animals from each other and divided them into groups according to determination key. Sometimes it was difficult because of missing legs or strange shape of animal, but most of the samples was quite easy to determine. My group found quite many spiders, diptera and ants. When we finished our work, we collected data from all groups and gave them to Petr Kotas and Martina Balzarová. Petr and Martina put all data together and found the most abundant groups. They presented their findings later afternoon. These findings were quite similar to results of me group.

There were three presentations which started at 16 00.

Jiří Mastný, Jana Baxová and Zdeněk Žampach had presentation about study made by Zak and Gelbrecht (2007). The theme of this study and also theme of this presentation was „The mobilisation of phosphorus, organic carbon and ammonium in the initial stage of fen rewetting”. In the first part of presentation they explained basic terms and knowledge about peatland. Then they presented introduction to the paper and results of this study. Results of study show that P, OC and ammonium mobilisation processes on the degree of peat decomposition. Conclusion of this paper is that removal of the highly decomposed peat layer is recommended to reduce the high mobilisation. However, students discussed with Tomáš Picek about this conclusion and they disagreed because this study is only short-term study, but peatlands restoration needs long-term time scale for water table stabilization and ecosystem recovery.

Daily report – IP „Soil & Water " 13.9.2013   Tartu – Estonia

Made by: *Petr Kotas (CZE), Jana Baxová (CZE), Lukas Karl Friedrich Griesinger (GER) and Mihkel Are (EST).*

8:30 – 10:00 (Synthesis form Erasmus IP "Soil & Water")

In the last two weeks we had so many lectures from a lot of different topics and this lecture should combine all topics we discussed.
What we have learned:

Soil: methods; soil as a resource that needs protection; soil horizons; interaction between water and plant roots; importance of soil organisms; microorganisms in the soil.

Plants: wetland plants; allelopathical interactions between plants; rhizosphere; adaptions to the environment (climate); water potential; plant roots; mosses and lichens; dependence from pH; litter decomposition; plant stress; PSM (plant secondary metabolites); identification of plants

Drought and Flooding: hypoxia; toxicity of metals; adaption of wetland plants to flooding; NADES as adaption; influence of soil texture for water availability; post anoxic stress; stress under flooding; climate change simulation.

Soil Organisms: adaptation to the life in the soil; pore size in dependence from soil organisms; methods of catching; classification of soil organisms; importance for decomposition; differences between epigeic and endogeic; importance of protozoa; fungi and mycorrhizas.

Soil-Plant-Interactions: nutrient content and cycling; nutrient availability; erosion migration; succession; sustainable crop production; soil as a substrate for plants; invasive species.

Soil degradation and reclamation: acidification; sealing; compaction of soil; salinization; nutrient loss; water and wind erosion; non sustainable use => decline of organic matter; consequences of high biomass production => pesticides.

Environment soils and plants: global climate change; geology of Estonia => soil and plant cover; emissions; organic matter mineralization; complexity of interactions in nature; litter decomposition.

Excursions:

1. **Järvselja:** gas profiles (daily courses); particles in the air; eddy covariance; plant volatiles; wind speed; gas exchange on the leaf level; litter decomposition; boundary layer resistance; managements and history of forests, drainage; managed and unmanaged forests; the tallest tree in tilia forest
2. **Wetlands:**
   Meenikunao bog: different sphagnum moss vegetation; carnivorous species; lake with pH 4; higher plants in bogs (mushrooms and berries); plants on nutrient poor soils
   Piusa sandstone cave: bats; artificial cave; colors of sand; glass color depends on sand quality; new biotopes after mining
   River valley landscape: sandstone outcrops; hydroelectric power plants => destruction of rapids; landslides; erosion in the sandstones
3. **Northern Estonia:**
   Oil shell mining: working conditions in the past (underground); example of mining area; collapsing in the ground; development of stalagmites (and lichens) in the mine; efficiency of energy production; emissions and environmental impact
   Reclamation site and deposits: Devonian fossils; artificial hills and underground fires; primary succession increasing biodiversity => organic matter accumulation; active recultivation; revitalization recreational use; new biotopes

11:00 – 13:00 (Visiting the Botanical Garden of the University of Tartu)

In the Botanical Garden of the University of Tartu students were split into two groups. First, group one went to the greenhouse of Botanical gardens with Dr.Muhle and second group went outside in Botanical gardens for half hour. Then it changed and first group went outside with Prof. Dr. Kazda and the second group went inside with Dr.Muhle for half of hour. They showed around the parts of Botanical gardens and spoke about them.

In greenhouse we saw arocaria´s species from southern Brazil, succulents from Africa etc. There were *Echeveria*´s species, *Agave Americana*, *Opuntia sp.*, *Aloe sp.*, *Welwitschia mirabilis* etc. In section of tropical forest we saw *Ananas commosus*, *Ficus benjamina*, *Cubanola domingensis* (shrub or small tree from Dominican republic), *Pilea involucrata (Urticaceae)* etc.

Succulent plants

Cubanola domingensis

Outside we saw very well selected plants according to their flowering time and the colour of their blossoms. We briefly saw *Asteraceae*, *Brassicaceae*, *Crassulaceae*, *Fabaceae* and *Apinaceae* families.

Botanical gardens outside

Basic information about University of Tartu Botanical gardens and their departments

The Botanical gardens in Tartu were found in 1803. The department of **Plant Taxonomy** was found on the current site, in front of the greenhouses in the year 1870.

Botanical gardens in Tartu are one of the oldest Botanical Gardens in the world. Are situated on the ruins of the ancient city wall and fortifications near the river and ponds. They have over 6500 plant species from all the world´s climatic zones of the world. The Garden´s greenhouse is the biggest in the Baltic. The Botanical Gardens were designed under the supervision of world-famous botanists, Prof Ledebour and Prof Bunge. The Botanical Gardens currently belong to the University of Tartu and they are used as a study base for students.

There is also the area for growing **monocots**. The most rich-in-species groupings comprise the family *Liliaceae* (genera *Tulipa, Allium, Fritillaria, Ornithogalum*); the *Iris* family, the Orchid family, families *Gramineae, Cyperaceae, Araceae*. There are more than 300 species of monocotyledonous plants growing in the area. The plants are situated to the right of the main entrance, according to their plant geographical distribution. The species from Europe and Asia Minor have been planted alongside the pathway, the plants of Eastern Asia are growing at the tropical greenhouse, the plants from Africa and South-America are in the warmest habitat – the bottom of the hollow. Spring-time flowering starts already in March by bulbous irises, crocuses, snowdrops. They are followed by tulips, tuberous irises. Some of the bulbous plants flowering in early spring have been planted to decorate the shores of the great pond, together with day lilies.

Beside monocots, there is area for **dicots**. A total of 800 natural species grow in this area. The herbaceous perennials constitute the majority of them (more then 60%), but there are also annual plants and those surviving the winter. The most rich-in-species is the *Asteraceae* family with 180 species. The decorations of the department are a pool and some granite statues.

The other site is the **Park,** which is located on the top and slopes of the former bastion and covers the biggest area in the Garden. The arboretum contains species of woody plants from different temperate regions of the world. The area of East-Asian woody plants begins immediately behind the greenhouses. Abundant ground vegetation comprises rhododendrons, maples and yews. The woody plants of North America are on the northern bank of the former bastion, in the back and the northernmost part of the garden.

The **perennials** grow in the department of plant taxonomy, in the rock garden and the arboretum.
The plants from the Caucasus have been planted on the western slope. The East-Asian plants grow from here down to the bottom of the valley. The perennials of South-European origin grow on the warmer western slope.

The **annuals** collection varies from year to year, but the average number of taxa is 100 every year. There are two fixed places for exhibiting annuals, first besides the Palm House and second one in the rock garden on a sunny slope where annuals are planted to form a picture.

The department of **alpine plants** is located in the middle of the garden, on the slopes and the valley of the former St. George’s Bastion of the town wall. The plants are selected according to their natural habitats – the upper part of the forest zone of mountainous regions and the alpine zone. Currently 900 taxa of alpine plants grow in the Rock Garden.

The other part of this department is the **talus garden** which reaches the shady slope and is also the site of the turf garden. The ascent, moulded from peat loaves is suitable for plants growing in acid soils.

The **Rose Garden** is located near the river-side edge. The more than 200-cultivar collection of roses provides an overview of the most important modern variety groupings of cultivated roses, their decorative character and suitability to be grown on an open field.

The Department of **Estonian Plants** is located in the western side of the Botanical Garden, beside the Department of Plant Taxonomy.

The **Palm House**, built in 1982 has the height of 22 meters and the floor area of 500 m^2. There are 58 species of palm trees originating from America, Africa, Asia and Europe. On the hot sunny side of the balcony we can find succulent plants. In the middle of the house an epiphyte tree is exposed – a trunk with bromeliads and cacti displaying a typical rainforest habitat. Under the bananas there is a pool with fish and tortoises.

The **subtropical house** displays plants of subtropics from all over the world. First two beds consist of plants from Australia – the most common representative is eucalyptus and with acacia build up 95% of native dendroflora. The ground-covering plant here is *Viola hederacea*. The big fir-like tree is *Araucaria cunninghami* from the Mediterranean region. The representative of Africa is *Harpephyllum caffrum*. The tree with the syringa-like blossoms is *Melia azedarach* from East-Asia. American plants are represented with *Juanulloa mexicana* from genus *Solanacea*.

In the **tropical house** the main goal is to expose the representatives from tropical America. Some of them are grown from seeds and seedlings brought directly from expeditions. The tropical climate zone has no seasons and the changes in the amount of rainfall and temperature are minimal. There also are tropical epiphytes – bromelias and orchids, lianas and trees.

The collection of **succulents** introduces plants that have become adapted to life in dry climate, bright sunlight and strong winds. The homes of such plants, with minor exceptions, are Africa and Central and South America. The collection on 100 m^2 consists of 600 taxa.

The African cactuses are the following – *Aloe*, *Aeonium*, *Crassula*, *Euphorbiaceae*. The representatives of the New World are *Cactacea*, *Agavaceae*.

Resources

http://www.ut.ee/botaed/index.php?module=2&op=&xid=&dok_id=188

http://www.tripadvisor.co.uk/Attraction_Review-g274959-d2665505-Reviews-Tartu_University_Botanical_Garden-Tartu_Tartu_County.html

Photos from Jana Baxová

14:00 – 15:00 (Mobility within Erasmus programmes)

In this part Dr. P. von Wrangell told students the most actual problems what have consider when someone wants do go and study for sometime in a foreign country. The mayor things to consider are:

1. Paperwork maybe takes more than half a year time when someone wants to go as a foreign student;
2. Funding problems;
3. One of the biggest problems is to bring Credit points back to home university;
4. Most want to go as foreign students in England and Ireland, because of the English language, but this is hard because there are so many people how want to study there and for many universities it is hard to get a partner university in the UK.

For the students Dr. P. von Wrangell gave evaluation papers where the students that took part in the Soil & Water course had to give rating for this program and had the opportunity write what from they option was well made and what could have been made better in the next year. The Evaluation was anonymous, but every one had to write the name of their native university on it.

15:00 – 16:30 (Why should you go to … as an Erasmus-student?)

Groups of students from all participating countries (Czech Republic, Estonia, France, Germany) presented a short contribution to introduce their mother country and university in order to motivate the other students for coming there as an Erasmus students. The first presentation of Estonian students was focused mainly on study opportunities and social events organized by students in Tartu. Presentation was completed by two short videos showing activities during two main student events in spring and autumn. All the German students shared presentation advertising the main attractions of Ulm city and their mother University. The presentation was humorously made as a guided trip by „Deutsche Bahn“ company to Ulm. Students from the Czech Republic briefly introduced their country of residence by basic geographical informations (population, capital city, neighboring countries, geomorphology) and continued by description of The South Bohemia University. They described the main social and scientific activities connected with their Institute and continued by a short video showing the main attractions in Czech Republic (i.e. famous places and historical sites, main inventions originated from Czech. Rep., cuisine, products etc.). Then were the other students tested for their new knowledge by a short quiz. Winners were awarded. Last presentation of French students was made as an invitation to Marseille and surroundings. French students showed a lot of their own pictures from the city, main attractions and historical sites together with main natural interests of Marseille county. The presentation was humorously supplemented by short video-dialogues between French and local Estonian students made previous day in the Tartu city centre. The contributors were asked for they knowledge of French culture. Students from all participating countries were often asked by other students for supplementary informations.

Impressions