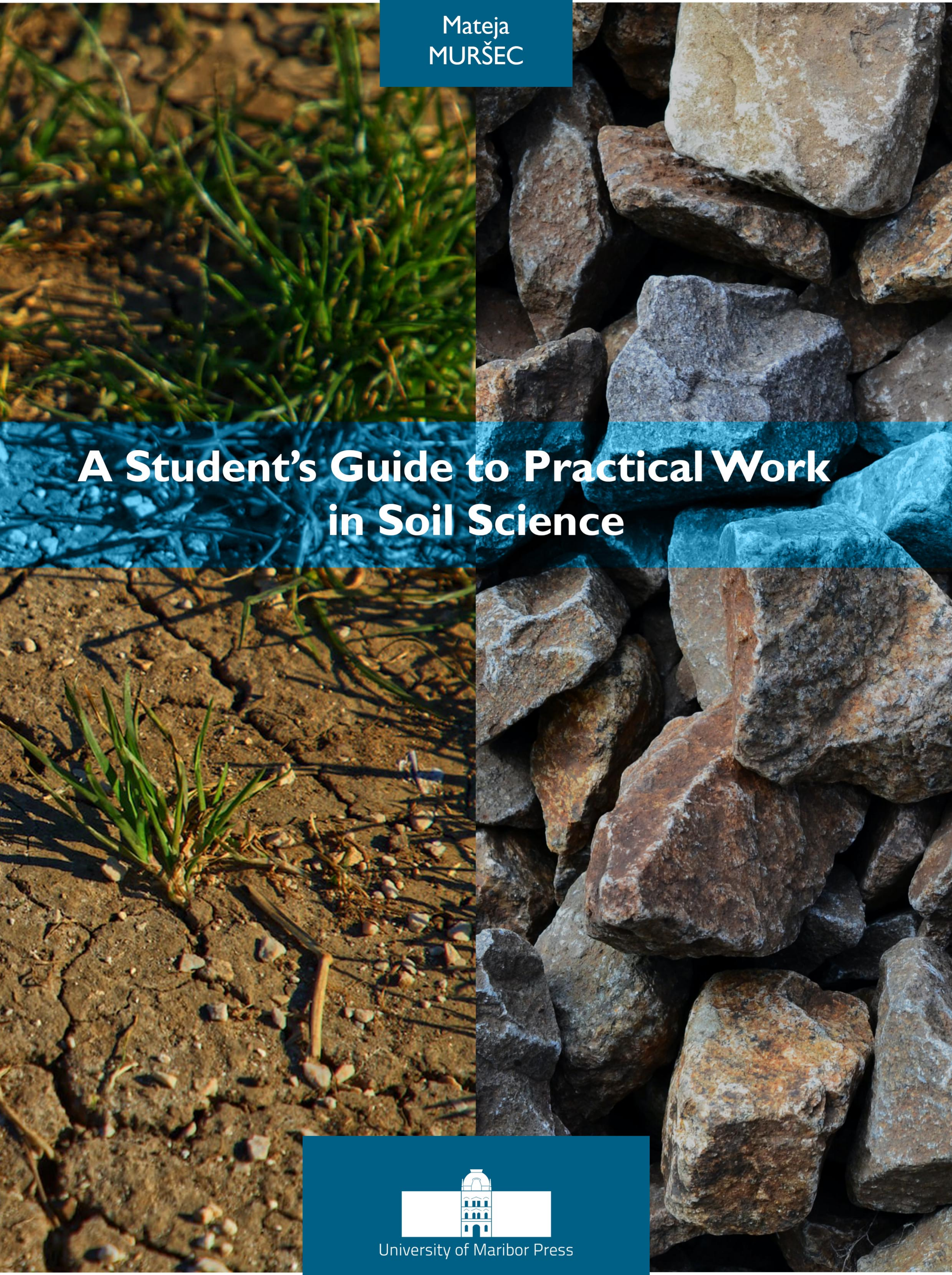

Mateja
MURŠEC

A Student's Guide to Practical Work in Soil Science

University of Maribor Press

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Faculty of Agriculture
and Life Sciences

A Student's Guide to Practical Work in Soil Science

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Part one:

GEOLOGY

THE ROCK CYCLE

The lithosphere is the solid, outer part of the Earth. It includes the brittle upper portion of the mantle and the crust. The crust consists of two types of tectonic plates:

a) The oceanic plate (denser, but thinner than the continental plate – a few km thick)
b) The continental plate (thicker than the oceanic plate – from a few ten km, to more than 200 km thick)

The lithosphere with the tectonic plates are composed from different kinds of rocks . Rock divisions occur in three major families based on how they are formed: igneous, sedimentary, and metamorphic. Rocks are naturally occurring aggregates of one or more minerals. Minerals are solid natural occurring compounds with define chemical composition and certain physical characteristics.

Further watching:

Tectonics of the Planet Earth [educational video]

Types of Rocks and the Rock Cycle: Igneous, Sedimentary, Metamorphic [educational video]

Rock Cycle [educational video]

TASKS

Try to explain the rock cycle in the simplest way by using the web site!

Which mechanism is responsible for the recycling of rock materials?

Try to find the geological map of your country (on the web site).

IGNEOUS ROCKS

Igneous rocks originate from magma, which is situated at least few kilometres under the Earth's crust. Magma are melted rocks, who changed their state due to very high temperature (more than 1500 °C). Because magma is liquid and usually less dense than the surrounding solid rock, it moves upward to cooler regions of the Earth.

According to its origin, there are two groups of igneous rocks:

a) **Intrusive**, or plutonic, igneous rocks form when magma cools slowly and crystallizes below the Earth's surface or it intrudes older rocks. Most intrusive rocks have a grained structure with large or small, well-formed crystals.

b) **Extrusive** igneous rocks form when magma quickly cools on the Earth's surface, where it has erupted from a volcano. Most extrusive (volcanic) rocks have a porphyritic structure (partly cristallined rocks), few of them also have a glassy, vesicular or massive structure (with small crystals).

The composition of magma is limited to eight common elements of the Earth's crust: *the most common chemical elements in the crust are:*

1) *Oxygen (46.6%)*
2) *Silicon (27.7%)*
3) *Aluminium (8.1%)*

4) *Iron (5.0%)*
5) *Calcium (3.6%)*
6) *Potassium (2.8%)*
7) *Sodium (2.6%)*
8) *Magnesium (2.1%)*

These elements combine within a melt to form silicate minerals, the most common minerals of igneous rocks. These silicate minerals include feldspars (plagioclase feldspar, potassium feldspar), quartz, micas (muscovite, biotite), pyroxenes (augite), amphiboles (hornblende), and olivine [educational link]. These minerals make up over 95 % of the volume of the common igneous rocks.

The colour of an igneous rock is related to the colours of the minerals present:

a) Rocks that are usually of a rich composition in silica with considerable amounts of quartz and light-coloured feldspar - felsic/sialic composition.

b) Rocks rich in magnesium (Mg) and iron (Fe) tend to contain olivine, pyroxene, amphibole, and biotite - mafic composition. These minerals tend to be strongly (dark) coloured.

Basic igneous rocks classification by their origin and by mineral composition is presented in *Tab. 1*.

Table 1: Igneous rock classification

(Monroe et al., 2007; Kočevar and Jaecks Vidic, 1998)

IGNEOUS ROCKS CLASSIFICATION		
	INTRUSIVE	EXTRUSIVE
	Structure	
Mineral composition	***Grained***	***Porphyritic*** (glassy, vesicular, massive)
Felsic (> 65 % silica; K, Na-feldspars; < 15 % dark minerals)	granite, granodiorite, syenite	obsidian, pumice, rhyolite, paleorhyolite
Intermediate (53-65 % silica; Na, Ca-feldspars; 15-40% dark minerals)	diorite, tonalite	andesite
Mafic (45-52 % silica; Ca-feldspars; > 40 % dark minerals)	gabbro (chislakite)	basalt, diabase
Ultramafic (< 45% silica, nearly 100% dark minerals-FeMg silicates)	peridotite	kymberlite

Further watching:

Igneous rocks: [educational video]

Introduction to Igneous Rocks [educational video]

TASKS

Do you know any igneous rocks?

What are the most intrusive and extrusive rocks worldwide?

Which igneous rocks can you find in your country and where?

How will you recognize intrusive and extrusive igneous rocks?

How will you distinguish igneous rocks by mineral compositon?

SEDIMENTARY ROCKS

Sedimentary rocks can originate from any kind of previously existing rock (igneous, sedimentary or metamorphic), which are exposed at the Earth's surface. Because they were formed under very different conditions compared to the Earth's surface (lower temperatures, pressure, forces of wind, rain, snow, and ice, sun light), they begin to weather. Some transport media (running water, glaciers, wind, gravitation etc.) carry away (transport) solid or dissolved products of weathering to other destinations. These particles eventually come to rest (deposited) and become hard rock (lithified)

According to its origin, there are two groups of sedimentary rocks:

a) **Clastic** sedimentary rocks form via the weathering processes which breaks rocks down into gravel, sand or clay particles by exposure to wind, ice, and water. Clastic sedimentary rocks are named according to the grain size of the sediment particles. Pyroclastic sediment rocks are composed of pyroclastic material of different sizes (volcanic ash, rocks).

b) **Nonclastic** (chemical and biochemical) sedimentary rocks form from chemical (or biochemical) reactions, chiefly in the ocean.

According to mineral composition, for agronomists mostly three groups are important:

a) Carbonate (including minerals calcite/dolomite)
b) Silicate (including minerals quartz/mica/clay minerals)

c) Carbonate-silicate (mixed)
d) Others (oxides, haloids sulphates etc.)

Basic sedimentary rocks classification by their origin is presented in *Tab. 2*.

Table 2: Sediment rock classification

(Monroe et al., 2007; Kočevar and Jaecks Vidic, 1998)

	SEDIMENTARY ROCKS CLASSIFICATION		
Particle size (mm)	*Clastic*	*Pyroclastic*	*Chemical/biochemical*
> 2 (gravel: rounded, angular grains)	conglomerate breccia	vulcanic breccia	limestone dolostone chalk tufa chert evaporites (gypsium, halite)
2-0.063 (sand)	sandstone	tuffite	
0.063-0.002 (silt)	siltstone		
<2 (mud, clay)	mudstone claystone marl	tuff	

TASKS

What are the main processes of sedimentary rock formation (in the right order)?

In which clastic rocks can you see the particles with your naked eyes?

Where can you find rounded gravel and why?

What is marl? How will you recognise it?

Which sediment rocks contain mineral calcite and how can you recognise its presence?

How will you recognise the presence of quartz?

In which sediment rocks can we find fossils?

Which sediment rocks can you find in your country and where?

Why are sediment rocks important?

Further watching:

Introduction of Sedimentary rocks: [educational video]

Sedimentary rocks: [educational video]

METAMORPHIC ROCKS

The term "metamorphic" means "to change form." Any rock (igneous, sedimentary, or metamorphic) can become a metamorphic rock. If rocks are buried deep in the Earth at high temperatures and pressures, they form new minerals and textures - all without melting. Changes in the temperature and pressure conditions cause the minerals in the rock to become unstable so they either reorient themselves into layers (foliation) or recrystallize into larger crystals, all without undergoing melting. The presence of volatile compounds (as steam water and some gases) can promote metamorphic processes.

If melting occurs, magma is formed, starting the rock cycle all over again.
By so-called regional metamorphosis, two groups of rocks are distinguished according to pressure direction:

a) **Foliated** metamorphic rocks are formed within the Earth's interior under extremely high pressures that are unequal, occurring when the pressure is greater in one direction than in the others (directed pressure). This causes the minerals in the original rock to reorient themselves with the long and flat minerals aligning perpendicular to the greatest pressure direction. This reduces the overall pressure on the rock and gives it a stripped look.

Foliated metamorphic rocks are somewhat related in process of metamorphosis: each of them presents a particular degree of metamorphism (from low to high) - according to the temperature and pressure they were exposed to:

slate → phyllite → schist → gneiss → migmatite.
They have a very similar mineral (silicate) composition: Na or K-feldspars, mica and quartz - in different ratios.

b) **Nonfoliated** metamorphic rocks are formed around igneous intrusions where the temperatures are high but the pressures are relatively low and equal in all directions (confining geostatic pressure). The original minerals within the rock recrystallize into larger sizes and the atoms become more tightly packed, increasing the density of the rock.

Basic metamorphic rocks classification by type of metamorphosis is presented in Tab. 3.

Table 3: Metamorphic rock classification
(Monroe et al., 2007; Kočevar and Jaecks Vidic, 1998)

METAMORPHIC ROCKS CLASSIFICATION	
Regional methamorphism	
Foliated	*Non-foliated*
slate	marble
phyllite	quartzite
schist	greenstone
gneiss	serpentinite
migmatite	amphybolite
(amphybolite)	

TASKS

How do you recognise marble? How can it be distinguished from limestone?

How do you recognise quartzite?

Fill the potential originate rocks into the following table:

Gneiss

Greenstone

Marble

Amphybolite

Quartzite

Slate

Which metamorphic rocks can you find in your country and where?

Further watching:

Metamorphic rocks video: [educational video]

Metamorphic rocks: [educational video]

CONCLUSIONS

TASKS

What type of parent material dominates in Slovenia (igneous, sediment or metamorphic rocks) and in which part?

By using the geological map of Slovenia, try to find which parent mateial is the oldest and wich is the youngest in Slovenia?

oldest	**youngest**

What types of rock can you find in your extended living area? What is the land use there - are there any kinds of agricultural land? Is the soil quality good?

Are there any active or extinct vulcanos in your country? What kind of material do/did they emit?

Are there any other geological activities or specialities in your country?

Is there a mining industry in your country and where?

Compare the parent materials from your country to the ones in Slovenia. Shortly discribe the differences between them.

Part two

SOIL SCIENCE

SOIL SAMPLING

In agriculture, proper soil sampling is a good base for further analytical work and fertliser recommendations. Correct fertilizer nutrient use can result in an increased yield, in reduction in costs and potential water pollution.

For soil sampling, further facts are important:

- Purpose of sampling (chemical, physical, microbial analyses)
- Way of sampling (disturbed, undisturbed samples)
- Depth of sampling (depends on the most developed roots)
- Time of sampling (in the field after harvest)
- Marking a sample (date, location, soil depth, soil use, name of the worker, parcel number, name of the land owner)
- Packing and transport of samples (plastic bags or containers)

a) Disturbed soil samples for (mostly) chemical analysis

This is the ordinary way of soil sampling for agricultural research in nutrient status in soils, mostly used for chemical analysis (soil pH, organic mater content, carbonate content, nutrients content and availability etc.) and some physical analysis (soil texture and gravimetrical water content).

Fields must be devided into uniform areas before soil samples are collected (according to soil type, slope, hydrology crops etc). From the field, a representative soil sample is recommmended to be taken (a mixture of 20–30 subsamples, evently taken from the field – depends of soil homogenity and surface area). Odd areas in the field (eroded spots, turn rows, abandoned farmsteads etc.) must be avoided. Soil sampling can be done at random in the sample area or in different patterns: in a grid pattern or in a pattern of choosen letter (X, Y, Z, W) etc. [educational link].

Samples are taken by using a soil-sampling probe, an auger, and a spade or shovel. Tools should be either stainless steel or chrome-plated. If a shovel or a spade is used, digging a V-shaped hole to sample depth is recommended with cutting a thin slice as shown on the [educational link].

Sampling should be done at proper sampling depth (according to the depth of the highest rooth density):

- 0-5 and 5-10 cm from the pasture, grassland
- 0-(20)30 cm in the field (arable land)
- 0-30 cm in the orchard/vineyard

Soil samples should be collected in clean, plastic buckets and mixed thoroughly. The representative sample is taken as the mixture from the bucket in about 0.5 – 1 kg and transported into plastic bags or containers.

b) Undisturbed soil samples for physical analysis

Undisturbed soil samples are samples that are cut, removed and packed with the least possible disturbance. In this case, all agreggates and void ratio and moisture content should be kept the same way it was in the field (without pressing and squeezing). This way of sampling is needed for some special physical measurements: bulk density, porosity, volumetric water content.

For taking undisturbed soil samples, a special tool is needed: a stainless steel rings of a known volume (100 cm^3) with cover lids, sampling head, hammer, knife, solid box for transporting, marker pen, and meter.

The place intended for sampling should be in its natural state as much as possible (do not step on it!). The soil core should be taken at the appropriate moisture conditions (not too wet or too dry). Don't affect the sampled soil during the sampling. At least 4 to 5 soil core samples should be taken from the same spot to ensure representativeness.

Beside classical soil sampling, where soil samples are bulked and subsampled to give a representative value of a soil property; sampling could be also analysed separately, in a similar manner to the characterisation of a horizon in a soil pit, to obtain information about the nature of spatial variability of that property.

Further watching:

Soil Sampling, Bulk Density, and Water Content: [educational video]

Soil Bulk Density test: [educational video]

How to take a soil sample: [educational video]

Soil and its dynamic: [educational video]

TASKS

Take a disturbed soil sample from field/orchards/pasture/garden from an appropriate depth according to a land use and developing plant roots. Air dry it. Mark the sample with all the important informations and pack it into plastic bag.

Take three undisturbed soil samples with special device (metal cilinders with 100 cm^3 volume) from:

- forest (0-5 and 20-25 cm depth)
- grassland (0-5 cm)
- parking place (0-5 cm)

NOTES

SOIL TEXTURE

Soil texture is one of the most important physical soil parameters. It has a great impact on water management, aeration, plant growth and fertility management. It means a relative proportions of different sized soil particles (sand, silt and clay). Soil texture is determined with the three major group sizes of soil particles (according to the American texture classification system):

SAND: 2 – 0.063 mm (coarse sand: 0.063 – 0.2 mm, fine sand: 0.2 – 0.05 mm)
SILT: 0.063 – 0.002 mm (coarse silt: 0.05 – 0.02 mm, fine silt: 0.02 – 0.002 mm)
CLAY: < 0.002 mm

Each of these size particles has its special physical or chemical impact on the soils (larger particles with lower surface area have more physical, smaller particles with higher surface area have more chemical impact).

According to different relative proportions of the mentioned particle size fractions, soil texture (according to the American texture classification system) distinguish twelve major textural classes (see Texture triangle). The soil texture triangle is a common means of determining the soil texture classes.

Some terms often used to describe the various textural classes are simplified bellow:

- clayey or fine textural classes with 'heavy texture': clay, silty clay, clay loam, silty clay loam and sandy clay;
- loamy or medium textural classes with 'medium heavy texture': loam, sandy clay loam, silt loam and silt.
- sandy or coarse textural classes with 'light' texture: sand, loamy sand and sandy loam.

Generally speaking, sandy soils tend to be low in organic matter content and native fertility, low in ability to retain moisture and nutrients, low in cation exchange capacity (CEC) and buffer capacities and rapidly permeable, well aerated and warm soils.

As the relative percentage of fine particles (silt/clay) become greater, properties of soils are increasingly affected in a way where the fertility increases, organic matter content increases, cation exchange capacity (CEC) and buffer capacities increase, ability to retain moisture and nutrients increases and there is a weaker movement of air and water.

Determining soil texture

There are several methods for determining soil texture classes, from very simple ones in the field, to sophisticated laboratory techniques for accurate determination of particle size distribution.

a) *Field method*

In the field, the percentage of sand, silt and clay in a soil is estimated by feel: the soil is rubbed between the fingers and the thumb and estimated of the amount of the various size fractions by their characteristics. In case of dry soil, it should be sufficiently moisten. This process requires skill and experience. By this simple method we can distinguish six basic textural classes only (out of twelve): clay, loamy clay, loam, loamy silt, loamy sand, sand.

b) *Lab method*

Some of the lab method are based on the principle of Stoke's law (Eq. 1). In brief, Stoke's law shows a relationship between particle size and the amount of time for a particle to settle down (sediment) in standing water. The large the particle (sand), the faster it will settle down in standing water. The smaller particles (clay) take a relatively long time to settle.

Eq. 1: Calculation of settling velocity of particles in standing water by Stoke's law

$$\boldsymbol{v} = \frac{\mathbf{2} * \left(\boldsymbol{\rho}_{\mathbf{p}} - \boldsymbol{\rho}\mathbf{f}\right) * \boldsymbol{R}^{\mathbf{2}} * \mathbf{g}}{\mathbf{9}\boldsymbol{\eta}}$$

v = settling velocity of particles (m/s)
ρ_p = mass density of the particles (2.6 kg/m^3)
ρf = mass density of the fluid (1.0 kg/m^3)
R = diameter of the particle (m)
η = dynamic viscosity (kg/m*s)
g = the gravitational acceleration (m/s^2)

Further watching:

Soil texture calculator: [educational link]

Soil Texture Triangle Tutorial: [educational video]

Texture by feel procedure: [educational video]

Soil texture by feel: [educational video]

Sediment deposition and Stoke's law: [educational video]

TASKS

What is the most optimal textural class for crop production and why?

Try to determine texture class of your soil sample with a simplified field method. Help yourself with the following descriptions of basic textural classes (by Plaster, 1997):

- Sand: each particle can be easily seen; sands feel gritty to the touch, they are not sticky, they do not form a stabile cast when squeezed.
- Loamy Sand: it resembles sands in that that it is loose and single grained, most individual grains can be seen and felt. Because it contains some more silt and clay this sand, is slightly cohesive when moist and fragile cast can be formed more readily with them than with sand.
- Loam: it feels as though it contains a relatively even mixture of sand, silt and clay; it has a slightly gritty feel, yet is fairly smooth and slightly sticky and plastic when moist. Loam tends to be rather soft and friable. Cast can be formed and handled quite freely without breaking.
- Clay Loam: it feels as though it possesses more clay than silt or sand; sticky and plastic when wet. Firm casts can be formed when moist and hard when dry. The moist soil will form a thin ribbon when squeezed between the thumb and fingers.
- Silty Loam: produces a soft and floury feeling; casts can be formed freely without breaking. By squeezing it between the fingers, moist soil feels soft and smooth, but it will break into small bits (not form a thin ribbon).
- Clay: it forms extremely hard clods when dry and it is extremely sticky and plastic when wet; moist soil can be ribboned out by squeezing it between thumb and forefinger and may be rolled into a very thin and long wire.

Determine the soil textural class with the following data: 25% clay, 53% silt? How much sand does contain this textural class?

How much sand, silt and clay contain the following textural classes?

- Silty clay:
- Sandy loam:
- Loam:
- Loamy sand:

NOTES

SOIL STRUCTURE

Soil structure is a fundamental property which makes soil a porous medium. A number of physical (erosion, runoff, infiltration, drainage, aeration), chemical (nutrient leaching, ion exchange, gas movement, mineralisation, immobilisation) biological (root and microbial turnover, decomposition, respiration, humification, organic matter accumulation) processes are affected by soil structure.

Structure development is a result of climate, soil organisms and soil management (man acting on the soil). Expansion and contraction of soils through freezing, thawing, wetting, drying along with soil organisms (earthworms, plant roots, moles, microbes) working through the soil are involved in structure development. Soil organic matter represents one of the most important glues to hold soil particles in larger aggregates! Good structure depends not only on organic matter, but also on calcium (and iron) and the clay content in the soil. Organic fertilising, liming (in acidic soil only!), proper usage of mechanisation or pasture are recommended for better soil structure.

Soil structure is the arrangement of soil particles into larger aggregates or peds. These peds are characterized and classified on the basis of shape, size and strength.

Soil structure types are:

- granular (< 1 cm)
- subangular blocky (< 5 cm)
- angular blocky (< 5 cm)

- prismatic (< 10 cm)
- columnar (< 10 cm)
- platy/lamellar (few mm)

A soil exhibits only one structure per soil horizon, but different horizons within a soil profile may exhibit different structures. All of the soil-forming factors, especially climate, influence the type of structure that develops at each depth. Granular structures are usually located at the soil surface in the A horizon. The subsoil, predominantly the B horizon, has a subangular blocky, blocky, columnar or prismatic structure. Platy structure can be found in the surface or subsoil while single grain and structureless structures are most often associated with the C horizon.

Determining Structural stability

- *By Field method*

In the field, structural stability can be determined via a simple and quick method. Firstly, evenly distribute ten undisturbed aggregates on a beaker and carefully pour distilled water over them, so that the aggregates are completely immersed.
Wait for ten minutes. In the meantime, you can gently circle the water covered aggregates with a baker once or twice. After ten minutes, count the number of stable soil aggregates and classify the soil sample by using the following criteria of structural stability grade (from 1 to 6, Tab. 4).

Table 4: Structural stability grades
(by Sekera and Brunner, 1943)

1	Peds are mostly stable
2	< 50% peds sre disturbed/unstable
3	50% peds are disturbed/unstable
4	> 50% peds are disturbed/unstable
5	Mostly peds are disturbed/unstable
6	All of peds are disturbed/unstable

Further watching:

Soil structure: [educational link]

Soil structure: [educational video]

TASKS

What is the most optimal structural type for crop production and why?

Try to determine the structural type of your soil sample.

Determine the stability of soil aggregates by field method!

Why is structural stability so important?

SOIL DENSITY

a) Bulk density (D_b)

Soil bulk density is a soil property largely used in agriculture, mainly for soil and water management practices. It depends on the nature, dimensions and arrangement of soil particles. Sampling should be done carefully (see sampling of undisturbed soil samples).

Definition:

The relation between the mass of a soil sample dried at 105°C and the total soil volume (sum of volumes occupied by soil particles and pores) can be defined as the soil bulk density (Eq. 2).

Eq. 2: Calculation of soil bulk density

$$\boldsymbol{D_b = \frac{M_s}{V_{total}}}\ [\mathrm{g/cm^3}]$$

D_b = soil bulk density
M_s = mass of dried (at 105°C) soil sample
V_{total} = total soil volume (volume of metal ring)

The bulk density of mineral soils commonly ranges from 1.1 to 1.5 g/cm^3 in the surface horizons. It increases with depth and tends to be higher in compacted horizons and lower with soils with more organic matter.

To get the mass of the oven-dried sample, undisturbed soil samples (in metal rings) should be dried at 105°C for 24 hours and weight on a balance scale. The volume of the metal ring is actually the total soil volume (solids + pores).

b) Particle density (D_p)

Definition:

Particle density is the volumetric mass of the solid soil (Eq. 3). It differs from bulk density because the volume used does not include pore spaces.

Eq. 3: Calculation of soil particle density

$$\boldsymbol{D_p = \frac{M_s}{V_{solids}}}\ [\mathrm{g/cm^3}]$$

D_p = particle soil density
M_s = mass of dried (at 105°C) soil sample
V_{solid} = volume of soil solids (volume of remain water in biretta)

Particle density represents the average density of all the minerals composing the soil. For most soils, this value is very near to 2.65 g/cm^3 because quartz has a density of 2.65 g/cm^3 and quartz is usually the dominant mineral. Particle density varies little between minerals and has little practical significance except in the calculation of pore space. The presence of solid organic materials in the soil decreases the value.

The way to measure the solid phase volume (V_{solid}) is based on evaluating the volume of the solid part of a sample (after being oven-dried) displaced by water (or another fluid).

SOIL POROSITY

Definition:

Soil porosity represents a fraction of the volume of pores (voids) over the total volume (Eq. 4), between 0 and 1, or as a percentage between 0 and 100%.

The soil system is composed of three phases:

- solid (mineral + organic)
- liquid (water)
- gas (air)

Total soil volume represent the sum of all three phases together [educational link]. Soil pores are commonly filled with water and air. Soil porosity mostly depends on soil texture, structure and organic matter content.

Eq. 4: Basic calculation of soil porosity

$$\boldsymbol{P = \frac{V_{pores}}{V_{total}}}\ \mathbf{[\%]}$$

P = porosity
V_{pores} = volume of pores (voids)
V_{total} = total soil volume

Because soil pore volume can't be measurred directly, soil porosity is calculated via bulk density and particle soil density. Porosity is inversely related to bulk density.

Eq. 5: Calculation of soil porosity regard to soil bulk density and particle density

$$\boldsymbol{P = \left(1 - \frac{D_b}{D_p}\right) . 100} \ \ [\%]$$

P = porosity
D_b = bulk density
D_p = particle density

Soil porosity depends on a soil texture, soil structure, organic matter content and soil management.

NOTES

SOIL WATER CONTENT

Generally, soil water content or soil moisture content is the water that is held in the spaces between soil particles. It can be expressed as a volumetric or mass (gravimetric) basis.

Soil moisture is a highly variable property. It can change in a time frame between minutes to years. However, most soil properties are more stable, and should be referenced to dry soil weight.

a) Gravimetric water content (W)

W is expressed by mass (weight) as follows (Eq. 6):

Eq. 6: Calculation of gravimetric water content in soil, expressed in g/g

$$\boldsymbol{W = \frac{M_{water}}{M_s}} \quad \left[\frac{g}{g}\right]$$

W = gravimetric water content
M_{water} = mass of soil water
M_s = mass of dry soils

Gravimetric water content can also be expressed in percentage (%), Eq. 7:

Eq. 7: Calculation of gravimetric water content in soil, expressed in percentage

$$W = \frac{M_{water}}{M_s} * 100 \ [\%]$$

b) Volumetric water content (θ)

θ is defined mathematically as (Eq. 8 and Eq. 10: Calculation of volumetric water content regard to gravimetric water content):

Eq. 8: Calculation of volumetric water content in soil, expressed in ml/ml

$$\theta = \frac{V_{water}}{V_{total}} \left[\frac{ml}{ml}\right]$$

θ = volumetric water content
V_{water} = volume of soil water
$V_{dry\ soils}$ = total soil volume

Volumetric water content can also be expressed in percentage (%), Eq. 9: and Eq. 10.

Eq. 9: Calculation of volumetric water content in soil, expressed in percentage

$$\theta = \frac{V_{water}}{V_{total}} * 100 \ [\%]$$

Eq. 10: Calculation of volumetric water content regard to gravimetric water content

$$\theta = W.D_b$$

θ = volumetric water content
W = gravimetric water content
D_b = bulk density

Further watching:

Water movement in soil: [educational video]

Porosity and permeability: [educational video]

Soil moisture calculations: [educational link]

TASKS

Determine bulk density:

- Collected undisturbed samples (without lids) dry at 105°C for 24 hours on ALU foil saucers.
- After drying, let them cool and weigh them on a balance scale (including metal rings and ALU foil saucer).

Determine particle soil density:

- First, remove the oven-dried soils from the metal rings and crush them in a mortar.
- Weight 20 (or 10) g of dry and crushed soil and put it in a 50 mL volumetric flask.
- Fill biretta with distilled water up to the 50 mL mark.
- Slowly transmit the distilled water from the biretta to a volumetric flask up to the 50 mL mark.
- Check the remaining quantity of distilled water in the biretta, which presents the volume of the solid part of the sample in a volumetric flask.

Calculate bulk density, particle soil density, porosity, and soil moisture (fill table with figures) and explain the differences among measurement from different spots.

Location of the Sample/ Spot	**Soil depth (cm)**	**Mass of metal ring (g)**	**Mass of ALU foil (g)**	**Mass of metal ring + ALU foil + fresh sample (g)**	**Mass of fresh sample (g)**	**Mass of metal ring + ALU foil + dry sample (g)**	**Mass of dry sample (g)**	**D_b (g/cm^3)**	**W (%)**	**Θ (%)**	**V_{solid} (ml)**	**D_p (g/cm^3)**	**P (%)**

SOIL COLOUR

Colour can be a useful indicator of some of the general properties of a soil, as well as some of the chemical processes that are occurring beneath the surface.

Soil colour gives visual information on:

- organic matter content (dark brown or black)
- parent material (depends on mineral type and age)
- presence and chemical reactions of some minerals (mostly iron)
- moisture content (red from oxidized Fe and Al oxides, grey from reduced Fe, etc....).

Soil colour is described by using a Munsell colour book, which specifies soil colours based on three colour dimensions:

- hue
- value (lightness)
- chroma (colour purity)

For example: 10YR 6/4 is the colour of a soil having a hue of 10YR, a value of 6, and a chroma of 4.

Further watching:

Soil colour: [educational link]

TASKS

Describe the colour of your soil sample using the Munsell colour book.

SOIL ACIDITY

Soil acidity (alkalinity) is one of the fundamental soil properties and impacts on the physical, chemical and biological processes. The most important influences are on nutrient availability, microbe activity and mobility of some harmful substances in a soil.

Soil acidity is a result of many different factors: parent material, climate, organic matter decomposition, live organisms activity, weathering of minerals and pollution from human activities.

Soil acidity is expressed as a pH value (Eq. 11).

Eq. 11: Calculation of soil pH

$$pH = -\log[H^+]$$

pH is a negative concentration of H^+ ions. As the pH scale is logarithmic, the concentration of H^+ ions increases ten-fold for each unit decreased in pH.

Soil pH can range from 2 to 10, and each soils has a narrow specific range. The optimal pH for arable crops in humid temperate regions is between 5 and 7 (Tab. 5). Soil pH does not fluctuate widely in normal, unamended soils. For agricultural purposes, soil pH has been altered by liming acidic soils for some decades.

Two soil acidity types are distinguished:

a) Active acidity: the activity of H^+ ions in the aqueous phase of soil (reagent is distilled water).

b) Potential acidity: concentration of H^+ ions, which are adsorbed on the colloids' surface (reagent is $CaCl_2$ or KCl solution).

Both acidity types are in chemical equilibrium. The potential acidity is about one unit lower than the active acidity, while a concentration of H^+ ions on the sorptive part of the soil is from 1,000 to 10,000 higher than in a soil solution. During the year, the active acidity varies more than the potential one.

Soil pH classification in agricultural soils is presented in Tab. 5.

Table 5: Soil acidity classification

(pH in 0.01 M $CaCl_2$ by Mihelič et al., 2010)

Soil acidity	pH
Alkalic	> 7.2
Neutral	6.8 – 7.2
Moderate acid	5.6 – 6.7
Acid	4.5 – 5.5
Very acid	< 4.5

Further watching:

Soil pH test: [educational video]

Soil pH: [educational video]

TASKS

Measure the active and potential acidity.

- Mix dry and sieved (< 2 mm) a soil sample (a) with a distilled water and (b) with 0.01 M $CaCl_2$ solution in a 1:5 ratio (10 mg soil + 50 ml water/solution).
- Shake (or mix with a glass stick) the soil suspensions for five minutes and leave them for (at least) one hour.
- Measure the soil pH in both soil solutions by using:
  a) pH meter (electrometric)

b) paper or liquid pH indicators (colorimetric)

Compare the pH measurements in distilled water and in $CaCl_2$ solution – which result is lower and why?

Classify soil pH with the table. Does your soil need some melioration according to soil acodity? What are your recommendations?

Why is the soil acidity such an important information?

SOIL ORGANIC MATTER CONTENT

Soil organic matter content (SOM) is very important part of the soil, affecting many physical, chemical and biological soil properties and activities. Despite the fact that it presents only a few percentages in soils, organic matter contributes to better soil structure, porosity, aeration, water holding capacity, cation exchange capacity, nutrient status, buffer capacity, soil temperature, microbial activity etc. Organic matter content is one of the basic soil quality indicators. For this reason, organic fertilising cannot be replaced with mineral fertilising!

SOM consists of living and dead plant material, living organisms, products derived from microbial and faunal metabolism and humus (stabilised complex organic material). Plant residues are composed of soluble components, hemicellulose, cellulose, lignin, ach and nitrogen compounds (proteins). The decomposition rate of these materials has the following trend: sugars, starches, simple proteins > crude proteins > cellulose > hemicellulose > fats, waxes > lignin.

Soil organic matter decomposition:

- MINERALISATION (70 - 90%): easily decomposed soil organic matters are readily decomposed by soil biota to simple inorganic compounds (nutrients-ions, water, CO_2)

- HUMIFICATION (10 - 30%): the product is humus, composed of complex organic compounds (humin, humic and fulvic acids)

Agricultural soils is classified in a few classes according to organic matter content (Tab. 6).
2 to 4% SOM are recommended in agricultural soils (in organic farming from 3 to 4%).

Table 6: Agricultural soil classification according to organic matter content
(by Mihelič et al., 2010)

% SOM	Class
< 1	Very low organic soil
1 – 2	Low organic soil
2 – 4	Organic soil
4 – 8	Highly organic soil
8 – 15	Very highly organic soil

Determining soil organic matter content

Soil organic matter content can be determined by different analyses, in Slovenia, the Walkley-Black method is commonly used.

Basic principle of the method: it is a moist oxidation for determining the most active parts of SOM (dead plant material at different steps of decomposition + humus).

$K_2Cr_2O_7$ in a sulphur acid solution oxidates with the carbon from the soil organic compounds and becomes a form of CO_2. With adding phosphoric acid and therefore developing strong complexes, oxidation of indicators is prevented.

$$3C^{\circ} + 2\ K_2Cr_2O_7 + 8\ H_2SO_4 = 3\ CO_2 + 2\ Cr_2(SO_4)_3 + 2\ K_2SO_4 + 8\ H_2O$$

Cr^{6+} is reduced in v Cr^{3+}. The remaining quantity of dichromate Cr^{6+} is titrated via Mohr salt (feroammonium sulphate). For a more visible colour skip from orange to green, a diphenylamine indicator is added.

Further watching:

Soil Organic Matter Accumulation and Oxidation: [educational video]

Formation of soil organic matter via biochemical and physical pathways of litter mass loss: [educational video]

TASKS

Try to evaluate the content of SOM by colour.

Determine the SOM content by using the Walkley-Black method and classify soils using Tab. 6.

Procedure:

- Weight 0.5 – 2.0 g of an air dried and sieved (< 2 mm) soil sample.
- Put it into a 250 ml Erlenmeyer bottle and add 10 ml of $K_2Cr_2O_7$ solution.
- Slowly add 15 ml of conc. H_2SO_4.
- For total oxidation, a heating at 120 °C - 130 °C is necessary.
- Cool the suspension and add 65 ml of distilled water and 5 ml of phosphoric acid.
- Add 1 ml of diphenylamine solution and titrate with a solution of Fe (II) sulphate from dark blue to green colour.

Use the same procedure for a blind sample (without soil).

Calculation:

Eq. 12: Calculation of soil organic carbon content (C_{org})

$$\% \, C_{org} = \frac{\mathbf{0.3} * (\mathbf{a} - \frac{\mathbf{a} * \mathbf{c}}{\mathbf{b}})}{Z}$$

a = added amount of $K_2Cr_2O_7$ solution (ml)
b = consumption of Fe (II) sulphate solution for a blind sample (ml)
c = consumption of Fe (II) sulphate solution for a soil sample (ml)
Z = weight of soil sample (g)

The percentage of soil organic matter is calculated based on the fact that the percentage of Corg in SOM is relatively constant (58%),

Eq. 13: Calculation of soil organic matter content (SOM)

$\%\ C_{org} = \%\ SOM * 0.58$

$$\boldsymbol{\%\ \mathrm{SOM} = \%\ C_{org} * 1.724}$$

SOIL NITROGEN

Forms in soils

Nitrogen (N) in the soil system exists in many forms and changes (transforms) very easily form one form to another. The most of soil nitrogen is bounded in organic compounds (cca > 95%), where it is not available for plants. The rest of soil nitrogen (a few percent) exists in mineral forms as ammonium, nitrates or nitrites. Organic bounded nitrogen becomes available to plants after the finalisation mineralisation process as ammonium ions (NH_4^+). Beside ammonium form, plants can also absorb nitrogen in nitrate form (NO_3^-), which is the product of the nitrification process. During the nitrification process, a mid-product is also nitrite (NO_2^-), but it is toxic for plants. Nitrate, nitrite and ammonium forms are so-called mineral (inorganic) forms of nitrogen. The nitrogen cycle is very dynamic one, mostly driven by microbes .

Role for plant growth

Nitrogen is an integral part of all proteins, and is one of the main chemical elements required for plant growth and photosynthesis. In most agricultural conditions, availability of usable nitrogen is the most limiting factor of high growth. Plants absorb nitrogen in either ammonium or nitrate form.

The mineralisation and immobilisation are regulated by the C/N ratio in soils:

- If $C/N > 25$ → immobilisation (organisms need to take in nitrogen from the soil solution for growth)
- If $C/N < 25$ → mineralisation (when N is in excess, it is excreted by microbes)

Soil nitrogen determination

1. *Determining total (organic) soil nitrogen via the Kjeldahl method – basic principle*

The Kjeldahl method is a means of determining the nitrogen content of organic and inorganic substances. For determining total nitrogen, dried and sieved (< 2 mm) soil samples should be prepared.

The Kjeldahl method may be broken down into three main steps:

a) Digestion - the decomposition of nitrogen in organic samples utilizing a concentrated acid solution. This is accomplished by boiling a homogeneous sample in concentrated sulfuric acid. The end result is an ammonium sulphate solution. A general equation for the digestion of an organic sample is shown below as one basic example:

$$\text{Organic N} + H_2SO_4 \rightarrow (NH_4)_2SO_4 + H_2O + CO_2 + \text{other sample matrix by-products}$$

b) Distillation - adding excess base to the acid digestion mixture to convert NH_4^+ to NH_3, followed by boiling and condensation of the NH_3 gas in a receiving solution. The acid digestion mixture is diluted and made strongly alkaline with NaOH, liberating NH_3 as follows:

$$(NH_4)_2SO_4 + 2NaOH \xrightarrow{\text{heat}} 2NH_3\uparrow + Na_2SO_4 + 2H_2O$$

c) Titration - to quantify the amount of ammonia in the receiving solution.

$$(NH_4)_2SO_4 + H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + (NH_4)_2SO_4 + 2H_2O$$

The amount of nitrogen in a sample can be calculated from the quantified amount of ammonia ions in the receiving solution.
Soil nitrogen is expressed and calculated in percentage (%).

2. Determining mineral forms of soil nitrogen – basic principle

For determining mineral nitrogen, fresh soil samples should be prepared (sampled from three different soil depths, frozen). Usually, nitrate and ammonium forms are determined (nitrite form is commonly negligible).

Fresh samples are extracted via a $CaCl_2$ solution with preceded shaking for one hour and filtrated suspension. Concentrations of ammonium and nitrate are determined via molecular absorb spectrometry (MAS) with measuring the absorbance of coloured solutions.

Results are expressed in mg/kg of fresh soil sample.

Further watching:

Nitrogen cycle: [educational video]

What is the Nitrogen cycle: [educational video]

TASKS

Observe the demonstration of the basic procedures of soil nitrogen determination.

Shortly describe the following processes in the nitrogen cycle:

- Fixation by clay: NH_4^+

- Ammonification and mineralisation: R-NH_2 → NH_3 → NH_4^+ (organic N à ammonia à ammonium)

- Nitrification: NH_4^+ (ammonium) → NO_2^- (nitrite) → NO_3^- (nitrate)

- Volatisation: $CO(NH_2)_2$ (urea) → NH_4^+ (ammonium) → NH_3 (ammonia)

- Denitrification: NO_3^- (nitrate) → NO_2^- (nitrite) → NO (nitric oxide gas) → N_2O (nitrous oxide gas) → N_2 (dinitrogen gas)

- Immobilisation: NH_4^+ (ammonium) and NO_3^- (nitrate) → R-NH_2 (organic N)

- Leaching: NO_3^- (nitrate)

- Plant uptake: NO_3^- (nitrate), NH_4^+ (ammonium)

- Symbiotic fixation: $N_2 \rightarrow NH_3 \rightarrow R\text{-}NH_2 \rightarrow$ amino acids → proteins

Think over which facts are important for N fertilisation?

How often do we perform N fertilisation during the year?

Describe losses of nitrogen from the soil. Which factors influence these losses?

What are the mineral (inorganic) forms of nitrogen? Which of them are important for plant nutrition and which are subjected to leaching and why?

SOIL PHOSPHORUS AND POTASSIUM

A. **SOIL PHOSPHORUS**

Role in plant growth

Phosphorus (P) is an essential element classified as a macronutrient because of the relatively large amounts of P required by plants. One of the main roles of P in living organisms is in the transfer of energy. Organic compounds that contain P are used to transfer energy from one reaction to drive another reaction within cells. Adequate P availability for plants stimulates early plant growth and promotes maturity. In plants, phosphorus is important as a structure element of ADP and ATP molecules (energetic molecules in biochemical processes) and DNA and RNA (genetic material). It has a significant role in plant production: photosynthesis processes, nitrogen fixation, harvesting (blooming, insemination, seed formation), roots developing, stem stability at cereals, and plant quality.

Forms in soils

Although P is widely distributed in nature, P is not found by itself in elemental form. In natural systems like soil and water, P exists as phosphates. Orthophosphate, the simplest phosphate, has the chemical formula PO_4^{-3}. In water, orthophosphate mostly exists as H_2PO_4- in acidic conditions or as HPO_4^{2-} in alkaline conditions - these are plant available phosphate forms.

Much of the phosphate used by living organisms becomes incorporated into organic compounds. When plant materials are returned to the soil, this **organic phosphate** is slowly released as inorganic phosphate or incorporated into more stable organic materials. The release of inorganic phosphate from organic phosphates is called **mineralization** and is caused by microorganisms breaking down organic compounds. The activity of microorganisms is highly influenced by the the soil's pH, temperature and soil moisture. The process is most rapid when the soil is warm and moist but well drained.

Another source of inorganic phosphorus is mineral weathering (apatite).

Phosphate can potentially be lost through soil eutrophication and to a lesser extent to water running over or through the soil.

Generally, in soils phosphorus may exist in many different forms in three 'pools':

- solution P (very small concentration in soil solution, directly plant available)
- active P (adsorbed phosphorus on soil colloids; main source for available P - indirectly plant available)
- fixed P (insoluble inorganic phosphorus and resistant organic compounds; not available to plants)

Soil pH mostly impacts phosphorus mobility, bounding and availability! Beside soil acidity, there are also some other factors, which influence phosphorus forms, like clay content, type of clay minerals, presence of Fe, Al, Mn, Ca, amount of soil organic matter and its decomposition rate, and microbe activity.

Danger of adding phosphorus

Although P is essential for plant growth, mismanagement of soil P can pose a threat to water quality. The concentration of P is usually sufficiently low in fresh water so that algae growth is limited. When lakes and rivers are polluted with P, excessive growth of algae is often the results (eutrophication). High levels of algae reduce the water clarity and can lead to decreases in available dissolved oxygen as the algae decays, and there are conditions that can be very detrimental to fish populations.

Fertilising

For fertilising analyses, the amount of available phosphorus in the soil is expressed in mg P_2O_5/100g (Tab. 7), although this form does not represent an available form and is not present in fertilisers.

Table 7: Soil stock of phosphorus
(by Leskošek, 1993)

Grade of P stock in soil	P_2O_5/100g	Stock
A	< 6	Poor
B	6-12	Middle poor
C	13-25	Good - Optimum
D	26-40	Too much
E	> 40	Extremely

B. **SOIL POTASSIUM**

Role in plant growth

Potassium (K) is an essential element classified as a macronutrient because of the relatively large amounts of K required by plants. The exact function of K in plant growth has not been clearly defined. Potassium is associated with the movement of water, nutrients, and carbohydrates in plant tissue. Various research efforts have shown that potassium stimulates early growth, increases protein production, improves the efficiency of water use, is vital for standing persistence, longevity, and improves the resistance to diseases and insects. These roles or functions are general; but all are important to profitable crop production. If K is deficient or not supplied in adequate amounts, plant growth is stunted and yields are reduced.

Forms in soil

The total potassium amount in soil varies from 1 to 3.5% (1.5% in average). The amount of soil potassium is significantly higher than soil phosphorus (0.06%). Nearly all of this potassium is in the structural component of soil minerals (K-feldspars, clay minerals, micas) and is not available for plant growth. The main K source in the soil is the mineral part, where K is released from soil minerals after the weathering process, while organic matter is an almost negligible source of K [educational link].

Three forms of K (unavailable, slowly available or fixed, readily available or exchangeable) exist in soils. All three forms are in specific reciprocal relationship:

slowly available K ↔ exchangeable K ↔ water-soluble K

The rate of conversion is affected by such factors as root uptake, applied K-fertilizer, soil moisture, and soil temperature

Unavailable Potassium: approximately 90 - 98 % of total soil K is found in this form (depending on soil type). Feldspars and micas are minerals that contain most of the K. Plants cannot use the K in this crystalline-insoluble form. Over long periods of time, these minerals weather (break down) and K is released. This process, however, is too slow to supply the full K needs of field crops. After weathering, some K moves to the slowly available pool or moves to the readily available pool.

Slowly Available Potassium: This form of K is trapped between layers of clay minerals and is frequently being fixed. Growing plants cannot use much of the slowly available K during a single growing season. The amount of K fixed in the slowly available form varies with the type of clay that dominates in the soil. These clays fix K when soils become dry because K is trapped between the layers in the clay mineral. This K, however, it can be released (or not) when the soil becomes wet.

Readily Available Potassium: K that is dissolved in soil water (water soluble) and is attached to the exchange sites on the surface of clay particles (exchangeable K) is considered readily available for plant growth. This is the form of K measured by the routine soil testing procedure.

Fertilising

For fertilising analyses, the amount of available potassium in soil is expressed in mg K_2O/100g (Tab. 8), although this form does not represent the available form and is not present in fertilisers.

Soil Potassium stock depends mostly on soil texture.

Table 8: Soil stock of potassium

(by Leskošek, 1993)

	K_2O/100g	
Grade of P stock in soil	Coarse to mid-course soil texture	Fine texture
A	< 10	< 12
B	10 – 19	12 – 22
C	20 – 30	23 – 33
D	31 – 40	34 – 45
E	> 40	> 45

Further watching:

Potassium cycle: [educational video]

Soil Potassium, Ag Nutrient Management: [educational video]

The Phosphorus cycling: [educational video]

Phosphorus cycle: [educational video]

TASKS

Think about what is important for P and K fertilisation?

How often do we perform P or K fertilisation?

Which forms of soil P and K are plant available?

____

____

____

____

Determine the available P and K by following the procedure of AL-method and estimate their stock in soil.

Determining available soil P and K via the AL method (by Egner-Riehm-Domingo, 1960)

Principle:

The first part (extraction) is the same for P and K. For this purpose, an Al-solution (ammonium sulphate) is used. The measurements of available P and K forms are different: P conc. is measured via MAS (molecular ascorbic spectrometry), while K conc. is measured via (AES=atomic emission spectrometry).

In an acidic medium, PO_4^{3-} ions form a complex compound with ammonium molybdate, which is reduced after adding a reductive solution (ascorbic acid and stannous chloride) and develops a characteristic blue colour. The absorbance of the blue coloured complex compound, a measure of concentration of Phosphorus in the test sample is read on a colorimeter at a wavelength of 659 nm.

Extraction of P and K ions:

1. Mix 5 g of air dried soil sample with 100 ml AL-extraction solution.
2. Shake soil suspension for two hours on a horizontal shaker.
3. Filtrate the suspension.
4. Use clean solution for P and K determination.

A. Phosphorus

Preparation of Standards P solutions:

a) Solutions for standard curve;

1. Pipette 5 ml of Al-solution into five 50-ml flasks. For each series, add 0, 2, 4, 8 and 10 ml standard solution into each flask (0.01 mg P_2O_5/ml).
2. Add 20 ml of distilled water and 2 ml of ammonium molybdate solution into each flask.
3. Mix the solutions well!
4. After five minutes add five drops of a reductive solution and mix well again.
5. Solutions with further concentrations are prepared: 0, 0.4, 0.8, 1.6 and 2.0 µg P_2O_5 /ml.

b) Soil solutions;

1. Pipette 5 ml of soil extract into 50-ml flask and add the same quantity of reagents in the same order as for the previous solutions for standard curve.
2. Wait for thirty minutes until it develops a blue colour and measure the absorbance at a wavelength of 659 nm via the molecular ascorbic spectrometer.
3. Continue measuring. The spectrometer draws the standard curve of P absorbance in the soil samples.

In an acidic medium, PO_4^{3-} ions form a complex compound with ammonium molybdate, which is reduced after adding a reductive solution (ascorbic acid and stannous chloride) and develops a characteristic blue colour. The absorbance of the blue coloured complex compound, a measure of concentration of Phosphorus in the test sample, is read via a colorimeter at a wavelength of 659 nm.

Calculation of available P:

Phosphorus conc. is expressed in mg P_2O_5/100 g soil. In calculation, soil weight (5 g) and dilution (5 g/100 ml and 5 ml/50 ml) are taken into consider.

Eq. 14: Calculation of available soil phosphorus

$$\textbf{mg } P_2O_5/100g = \textbf{reading on apparatus} * 20$$

B. Potassium

Preparation of Standards K solutions:

c) Solutions for standard curve;

1. The basic standard K solution is 1 mg/ml.
2. Prepare a standard solution with different K concentrations: 5, 10, 20, and 30 µg K/ml.
3. K concentrations are measured directly in the sample extract by atomic emission spectrometry.

Calculation of available K:

Available Potassium is expressed in mg K_2O/100 g soil. The readings on the apparatus are expressed in µg K/ml, and this is the reason why the calculation in mg K_2O/100 g is necessary: K content in soil extract (in µg K/ml), volume of extraction solution (in ml), correcting factors for K→ K_2O (1.2) and soil weight from 1 to 100 g soil (100) are taken into consideration (Eq. 15 and Eq. 16).

Eq. 15: Calculation of available soil potassium 1

$$mg\ K_2O/\ 100g\ = \frac{c(K) * V * 1.2 * 100}{m * 1000}$$

Eq. 16: Calculation of available soil potassium 2

$$mg\ K_2O/\ 100g = c(K) * 2.4$$

W(k) = potassium content in soil sample (mg K_2O/100 g)
C(k) = potassium content in extractied soil sample (µg K/ml)
1.2 = transorming factor, pretvorbeni faktor
100 = transforming factor (1 g in 100 g)
M = weight of soil sample
1000 = transforming factor (µg in mg)

SOIL PROFILE DESCRIPTION

The soil profile is a vertical section of the soil that depicts all of its horizons. The soil profile extends from the soil surface to the parent rock material. The soil profile is an important tool in mechanical, nutrient and water management. Soil profile descriptions are valuable for deciding how the soil might be used and/or predicting how the soil might react to its intended use. Technical descriptions of the soil are not only useful for farmers, but for scientists, ecologists, soil engineers, hydrologists and land use planners.

Before the soil profile description, a representative spot (location) should be choosen according to the parent material, topography, hydrology, vegetation, land use, etc. (a topography, geologic and some other maps or aerophoto pictures are helpful). For describing a soil profile, a pit is commonly excavated down to the parent material (that depends on the purpose, topography, soil depth, stoniness etc).

Description of master soil horizons:

O: The O horizon is a surface horizon that is comprised of organic material (>20%) at various stages of decomposition. It is most prominent in forested areas where there is an accumulation of debris falling from trees.

A: The A horizon is a surface horizon that largely consists of minerals (sand, silt, and clay) and with appreciable amounts of organic matter. This horizon is predominantly the surface layer of many soils in grasslands and agricultural lands.

E: The E horizon is a subsurface horizon that is heavily leached. Leaching is a process in which soluble nutrients, clay, organic matter, carbonates or sesquioxides are increased in the soil due to precipitation or irrigation. The horizon is typically light in colour. It is generally found beneath the O horizon.

B: The B horizon is a subsurface horizon. B horizons form below an O, A, or E horizon and they have undergone sufficient enough changes during soil genesis, that the properties of their original parent material are no longer discernible. In humid regions, B horizons are the layers of accumulation of materials such as silicate clays, sesquioxides (iron and aluminium oxides), and organic material. These materials typically accumulate through a process called illuviation, wherein the materials gradually wash in from the overlying horizons. B horizons can develop a stronger colour than the overlying horizons.

C: The C horizon, also known as the saprolite, is a subsurface horizon. It is the least weathered horizon. It is unconsolidated, loose parent material.

R: Hard bedrock underlying the soil.

Further watching:

Soil horizons [educational video]

Soil horizons [educational video]

TASKS

Describe general site information:

Name of location	
GPS coordinates, elevation	
Date	
Authors(s)	

Parent material	Rock type, bedrock
Macrorelief	Plane, valley, depression, plateau, river terrase, hills, mountain, carst field, carst plateau
Microrelief	Plane, crest, foothills or middle part of the crest, plateau, bottom of valley, sink-hole, terasse
Form of microreliefa and inclination (%)	Without crest, uniform, concave, convex, terassed, irregular
Stoniness; **Gravel form**	Dominant (>80%), predominant (40-80%), frequent (15-40 %), moderate (5-15%), rare (2-5%), negligible (<2%), unstony; rounded, angular, mixed
Rockyness	Dominant (>80%), predominant (40-80%), frequent (15-40 %), moderate (5-15%), rare (2-5%), negligible (<2%), unrocky
Exposition of microrelief	N, S, E, W, NE, NW, SE, SW
Hydrology	The type and nearness of standing or running water
Vegetation	The type of pravailing vegatation, eventual specialities
Roots' depth	Very shallow (<30 cm), shallow (30-50 cm), mid-shallow (50-100 cm), deep (100-150 cm), very deep (>150 cm)
Land use	Field, pasture, orchard, wineyard, hope-field, forest, park, garden, bush, reeds, land deposit, barrenness

Excavate a soil pit.

Needed tools: spade/showel, metter, knife, pH meter or indicators, tube-glasses and petri dish (petri dish), 10% HCl, distilled water, Munsell colour book, magnifier lens, description paper-form.

Some recommendations about exavating a pit and preparing the pit face for describing a soil profile:

- The upper soil layer should be put on one side of the pit, while the deeeper layers should go on the other side;
- the pit face (front, verical site in the pit) should be undisturbed for better soil description;

- the opposite part of the pit face should be arranged by steps for easier movement in and out of the pit;
- the size of the pit should be big enough for a good observation of the soil characteristics;
- the pit face should be gently cleaned off with a knife (considering natural breaking by clods or structural aggregates);
- according to morphological soil properties, mark (with a knife) the border lines between different soil horizons;
- measure the depth of the horizons;
- make a sketch of the soil profile;
- dig out the bottom of the pit to expose the parent material;
- describe the morphological properties of each horizon and try to name it (fill the following table);
- according to sequence and presence of soil horizons, try to determine the soil type [educational link]:.

Make a sketch of the profile:

- mark depths and type of horizons
- colour the horizons
- present and density of roots
- sketch soil structure (mark shape and size-type)
- present stone/rock presence (shape, size and density)
- present the special occurences, if present

Provide a describtion of the soil profile:

Horizon	**Depth (cm)**	**Structure**		**Texture (L, CL, SL, SL, C, S)**	**Consistence (plastic, loose, friable, firm etc.)**	**Moisture (dry, moderate wet, wet)**	**Colour**	**Organic matter (mineral, low OM, moderate OM, high OM)**	**Roots distribution**		**Gravel**			**pH (CaCl2)**
		aggregate type (spherical, angular, laminar, prismatic)	Aggregate stability (unstable, low, moderate and high stability)						Depth	Density	Shape (rounded, angular)	Size	%	

Define the soil type:____

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A STUDENT'S GUIDE TO PRACTICAL WORK IN SOIL SCIENCE

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Abstract The student's guide is intended for foreign students choosing Soil science subject at UM. It contains the basics of the geological composition of the lithosphere, classification, mineral composition, and recognition of various rocks. Students are guided through the use of proper equipment and methods of sampling, transportation, preservation, and sample preparation prior to further analysis. Field work and laboratory procedures for determining various physical (soil structure, texture, bulk density, porosity, soil moisture, soil colour) and chemical (soil reaction, organic matter content, nitrogen, phosphorus, and potassium content) characteristics of soil quality are described. Finally, it helps students to describe the soil profile with an accurate description of the general soil horizons and the determination of the soil type.

Keywords:
rocks,
soil quality,
field work,
laboratory methods,
soil profile

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