SOIL POLLUTION

KNOWLEDGE ABOUT SOIL

CONCEPT OF SOIL,
KEY FEATURES

CONCEPT OF SOIL

The top fertile layer of the earth's crust, a three-phase disperse system.

EVOLUTION OF THE SOIL

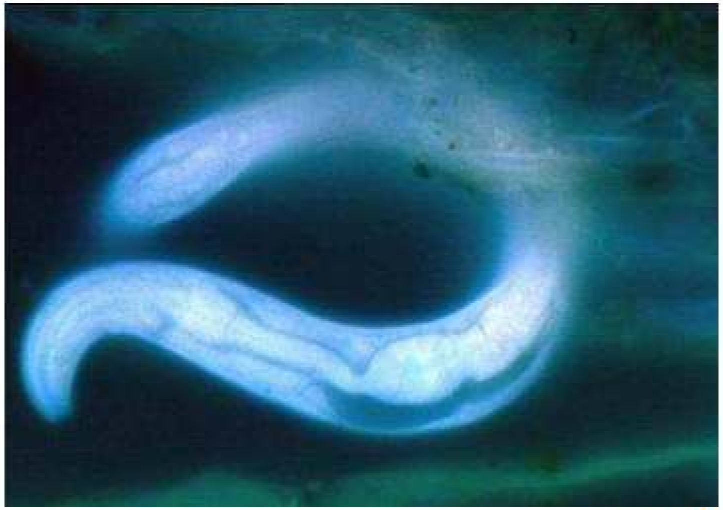
- **FIRST STEP: physical weathering** of bedrock, that is, the fragmentation of rocks due to temperature, wind and water.

- **SECOND STEP: chemical weathering**, in which the rocks are dissolved in water-soluble minerals and nutrients. Clay, as the main soil composition is formed.

- **THIRD STEP: biological phase of soil formation**. lower and higher organisms settlle in the physical and chemical detritus and after decomposing create the mold..

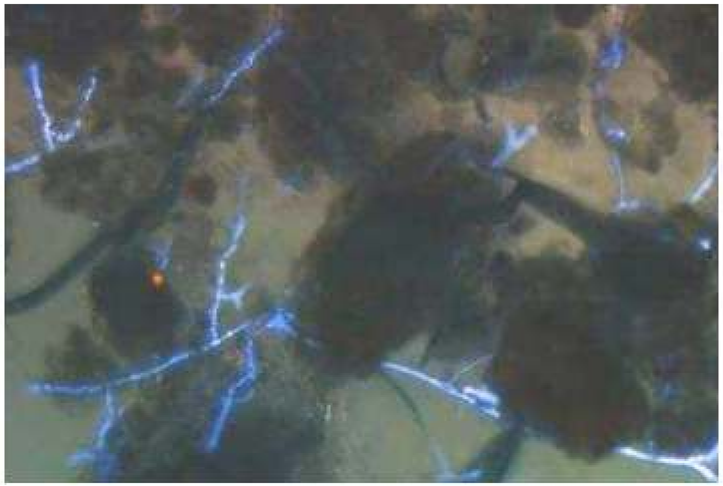
BIOLOGICAL SOIL FORMATION

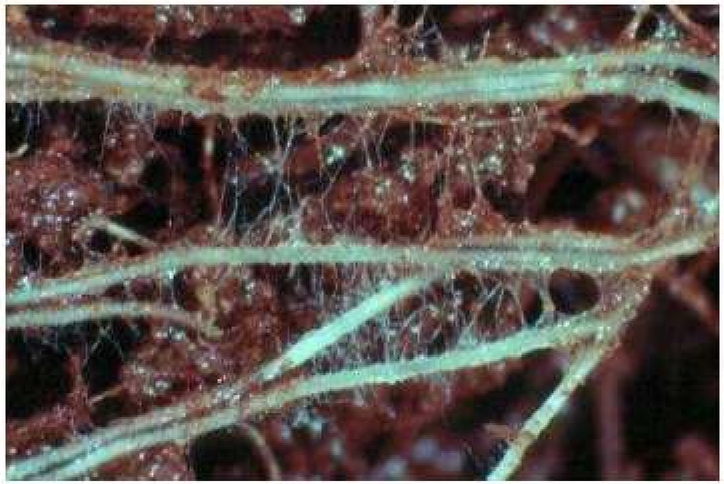
Guinea worm



Earthworm

hyphae





FACTORS OF SOIL FORMATION (1)

According DOKUCSAJEV, *five soil forming factors are distinguished:*

- *geological factors,*
- *climatic factors,*
- *topography,*
- *biological factors,*
- *age of soils.*

They together, form the soil, they can not replace each other, and some may only temporary and locally dominate.

Human activities, such as a modifying factor also a contribute to soil formation.

FACTORS OF SOIL FORMATION (2)

1. Soil forming rocks:

- The raw material for soil formation is provided by the rocks.

2. Climatic factors:

- **Temperature**: **indicates how much energy comes to the surface**, and to what extent and for how long physical and chemical processes assist in the formation of the soil, and determines to what plants can live in the soil.

- **Rainfall**: **determines the amount and form of water coming to the surface** and thus indirectly the weathering conditions, as well as affects the plants on the surface.

- **Wind**: **indirect effect is increasing of evaporation and transpiration**, while the **direct effect of deflation, namely soil degradation caused by the wind**.

FACTORS OF SOIL FORMATION (3)

3. Topography:

- Determine the surface and subsurface water movements, material and energy flow processes. They play a role in modifying the impact of climatic and geological factors.
  - e.g. **with increasing altitude temperature decreases**, while **rainfall increases**;
  - it affects the **erosion**, i.e. **soil degradation caused by water**;

4. Biological factors:

- involves activities of surface and soil organisms. This biological weathering.

5. Age of soils:

- Physical, chemical and biological processes take time.

FACTORS OF SOIL FORMATION (4)

+ Human activities:

- Human activities alter the impact of the natural factors prevailing in soil formation.

  - **correctly applied interventions:** increases fertility,
  - **faulty management:** may reduce, or even ruin the soil,

    (e.g. environmental pollution: $\rightarrow$ soil acidification, releases, etc.)

MATERIAL AND ENERGY TRANSFORMATION PROCESSES IN THE SOIL (1)

Process association:

- ✓ involves material- and energy-conversion processes during and following the formation of the soil;
- ✓ serve as a basis of soil sampling;

Process couples in the soil:

- ➢ accumulation of organic matter - the decomposition of organic material;
- ➢ wetting of the soil - drying out of the soil;
- ➢ leaching - salt accumulation;
- ➢ clay formation - clay disintegration (podzol formation)
- ➢ clay migration – clay precipitation;
- ➢ oxidation – reduction;
- ➢ acidification - alkalinization;
- ➢ structure formation - structural deterioration;
- ➢ soil erosion - soil cover (sedimentation);

MATERIAL AND ENERGY TRANSFORMATION PROCESSES IN THE SOIL (2)

- **Degradation:**
  - ✓ decomposition is carried out by micro-organisms (bacteria, fungi);
  - ✓ outcome: inorganic materials, salts (ions in solution) that are plant nutrients;
- **Adsorption**:

  on the surface of soil colloids (clay and humus) many pollutants are bound;
- **Filtering the solid phase**:

  soil is also filter, reducing the amount of contaminants getting into ground water;
- **Material intake of the plants**:

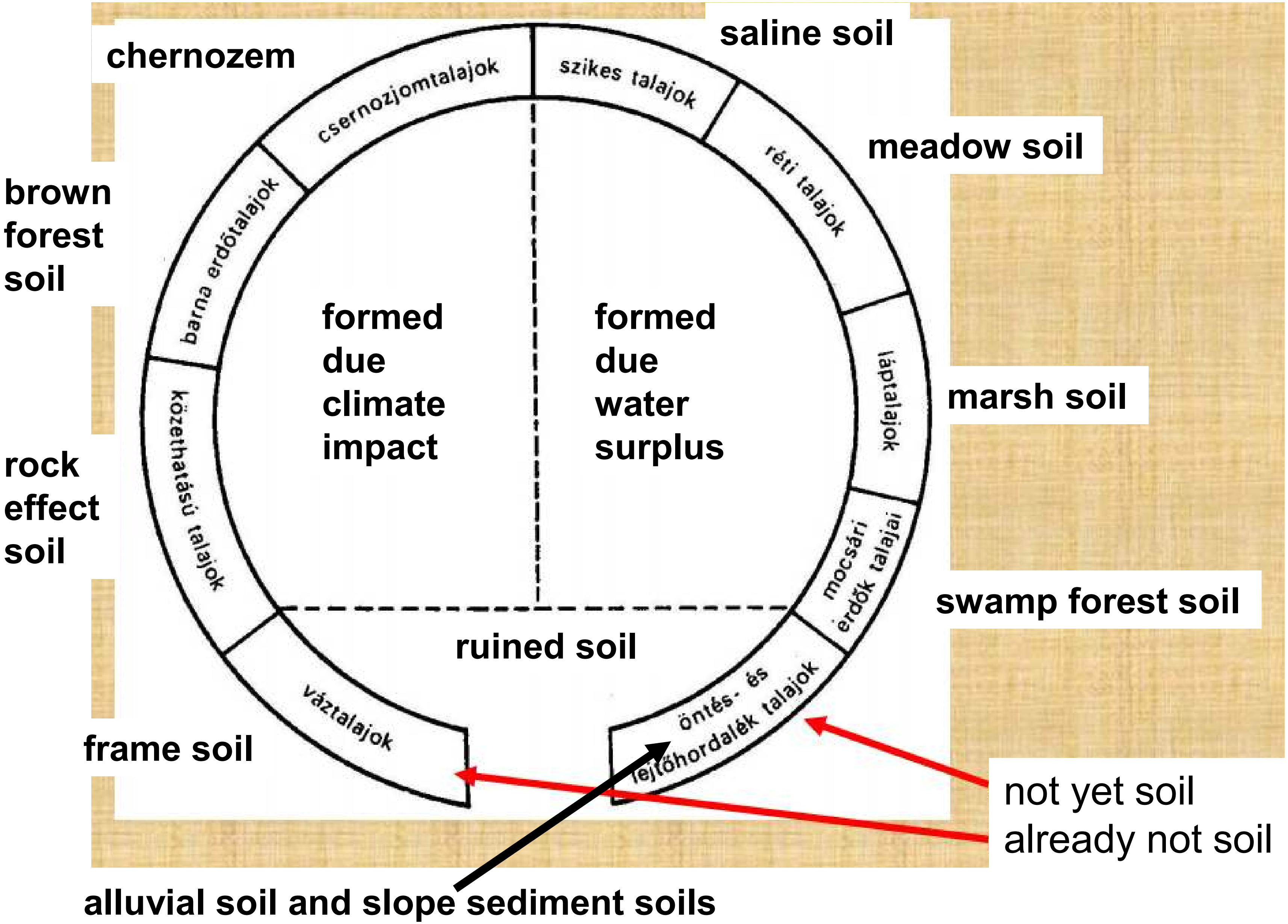
  they mainly intake pollutants of plant nutrient, thus occur purification in soil;

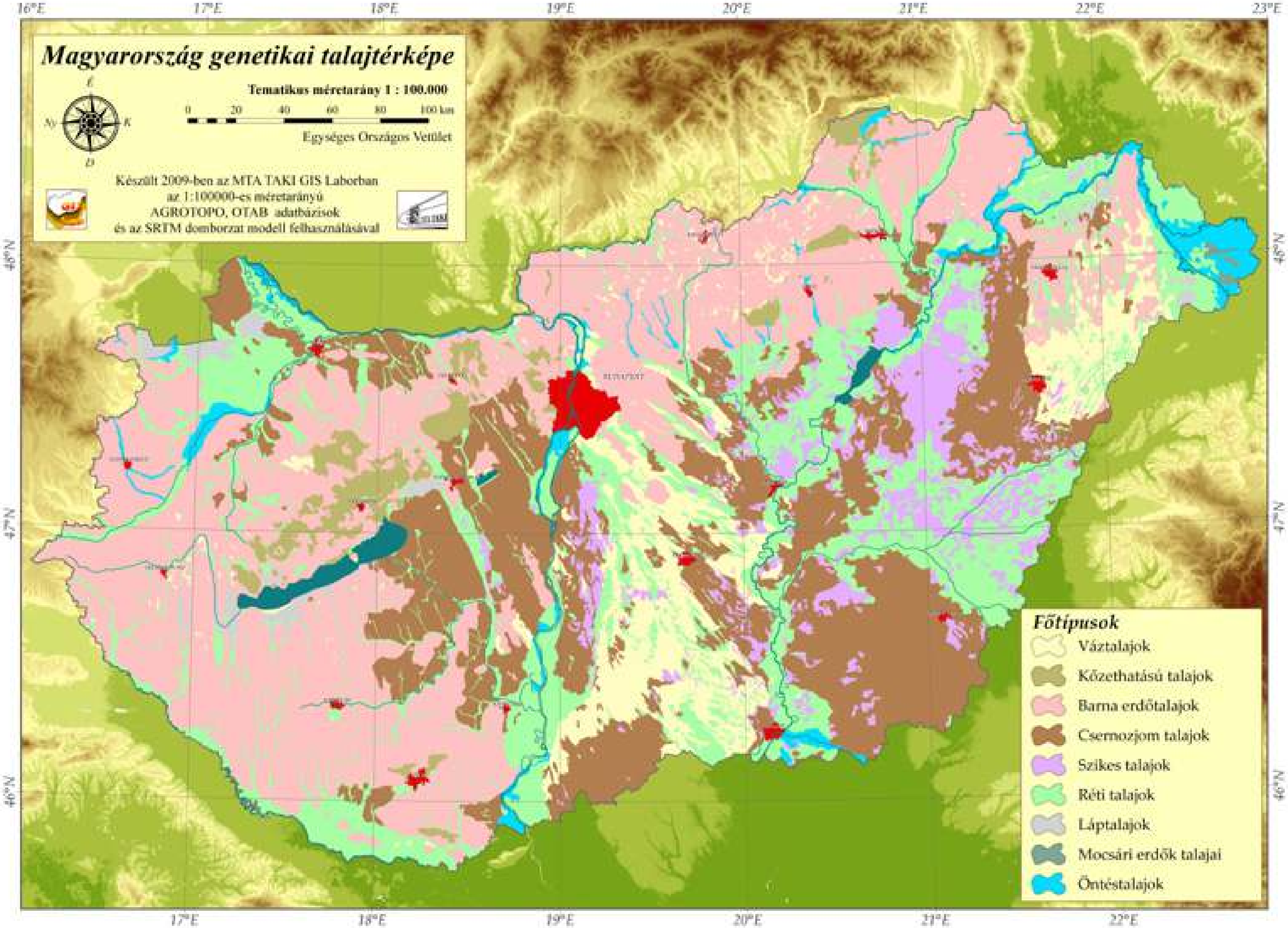
CLASSIFICATION OF SOILS

- **Soil geographic:**
  classifies into main types on geographic regularities;

- **Genetic**:
  examines the soils on their development; individual stages, the types form the units of the classification;

GENETIC SOIL TYPES

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és az SRTM domborzat modell felhasználásával
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Főtípusok
Váztalajok
Kőzethatású talajok
Barna erdőtalajok
Csernozjom talajok
Szikes talajok
Réti talajok
Láptalajok
Mocsári erdők talajai
Öntéstalajok

PHYSICAL PROPERTIES OF THE SOILS (1)

1. Grain composition:

In order to know physical properties of the soils, particle classification is used;

It occurs mostly by screening and drizzling;

2. Mechanical features

2/1. Hygroscopicity of the soils (hy %):

It is one of the main characteristics of water management. Moisture bound from the atmosphere is called hygroscopic water.

2/2. Arany bondage of soils:

It expresses water absorption capacity of the soil; it characterizes water management of the soils.

2/3. 5-hour capillary water rasing of the soil:

It is important for the soils of relatively high soil water level. One of its essential elements is the humus content of the soil layer by layer.

PHYSICAL PROPERTIES OF THE SOILS (2)

3. Structure of the soil:

Greater or lesser elements of the soil occur partially stuck together partly with humus or other binders stuck.

Most frequent soil structure forms:

- sandy;
- dusty;
- crumbly (like a porous sponge form);
- coarsely crumble or rough (dense, saturated with calcium, but not bound with humus);
- laminar (parallel layer structure);
- polyhedral (rich in mud, moist, during airless conditions);
- columns (typical for neutral saline);
- walnut (rounded edges and corners nuggets on the effect of tree roots);

CHEMICAL PROPERTIES OF THE SOILS (1)

1. Colour:

- ✓ iron 3+ content: gives a tan colour;
- ✓ iron 2+ content : gives a bluish, greenish-grayish colour;
- ✓ Mn 3+ content: gives a purplish colour;
- ✓ $CaCO_3$: gives a ligth colour;
- ✓ humus: dark stains in the soil;

2. pH:

- ✓ expresses H+ concentration;
- ✓ neutral: between 6,8-7,2; above this alkaline, below this acidic;

Average pH value of the most common solutions in everyday life

Material	pH-value	Chemical character
battery acid: H_2SO_4	1	
Hydrochloric acid (stomach acid - an empty stomach)	1,0–1,5	
citric acid	2,4	
Coca Cola	2,0–3,0	
acid	2,5	
juice (cherry)	2,7	
orange juice and apple juice	3,5	
wine	4	
sour milk	4,5	acidic
beer	4,5–5,0	
acid rain	< 5,0	
coffee	5,0	
tea	5,5	
rain	5,6	
mineral water	6,0	
milk	6,5	
water (depending on water hardness)	6,0–8,5	
human saliva	6,5–7,4	near neutral
blood	7,4	
sea water	7,5–8,4	
pancreatic secretion (intestinal)	8,3	
soap	9,0–10,0	
household ammonia	11,5	alkaline
slaked lime $Ca(OH)_2$	12,4	
hypo - bleach	12,5	
concrete	12,6	
washing soda - NaOH	13,5–14	

CHEMICAL PORPERTIES OF THE SOILS (2)

3. $CaCO_3$ content:

An important ingredient in agricultural point of view.

If lime content is high, it can be detrimental, causing nutrient uptake difficulties in the dry season.

Examination: 10% hydrochloric acid is dropped into the soil and lime content is concluded from the effervescence strength and its duration.

4. Soda alcalinity:

Harmful chemical properties of saline and salinating soils.

It is poisonous for plants, and worsen soil water management conditions.

CHEMICAL PORPERTIES OF THE SOILS (3)

5. All the salinity of the soil soluble in water:

The soluble sodium salts are the most harmful. The more salt soluble in water, the more likely the soil salinization.

6. Hydrolytic acidity :

It serves for characterizing acid soils.

It provides more accurate data on the hydrogen state of a soil solution than pH measurements.

7. Exchange acidity:

A The increased soil acidification is caused by aluminum. Water and nutrient management of the soil is getting bad. Its improvement occurs with liming.

CHEMICAL PORPERTIES OF THE SOILS (4)

8. Adsorption capacity (T):

Amount of cations in mg per 100 g soil.

9. Soil saturation (S):

Exchangeable cations bound on the surface of soil colloids are originated partly from base and partly from H+. Base comprise the amount of the total adsorption capacity. **Saturation (S) is given in mg per 100 g soil.**

10. Soil unsaturation (T-S):

It is used to indicate H+ bound by the soil.

Knowing S, and T saturation percentage (V, %) is important. In practice, **it is used to characterize soil acidity**. It shows that how much is the base among the exchangeable cations in percentage of the total adsorption capacity.

$$V\% = (S:T) \cdot 100$$

SOIL

- the top, fertile and loose blanket of the earth's crust
- rocks + dead organic residues

↓

weathering processes

- the most valuable part: humus
- features:

  graininess, pore size, water absorption, temperature, pH, water and air quantity, etc.

SOIL DEGRADATION

- processes that
  - reduce soil fertility or
  - lead to complete destruction of the soil.

    - ➢ salinization;
    - ➢ Soil acidification;
    - ➢ deterioration of soil structure;
    - ➢ erosion;
    - ➢ pollution (quantity and quality problems);

SOIL DEGRADATION SOIL POLLUTION

The role of soil:

- A component of the ecosystem;
- receives material and energy flows and stores some of them;

Soil:

- stationary;
- transmission does not occur;
- there is no cycle → not the cycle reduces the consequences of a polluting effect;
- Self-cleaning capacity: microorganisms, aerobic (O_2, irradiance), anaerobic processes;

SOIL DEGRADATION

erosion (water-wind)

- fertility

varies with soil depth

non-eroded: 100

heavily eroded: 30

- vegetation drowning on landfill site

deflation – wind speed > 4 m/s

- crop decline

SOIL DEGRADATION

Reasons:

- ✓ windl
- ✓ water
- ✓ deforestation
- ✓ acidification

Depends on:

- ✓ wind speed;
- ✓ feature of the vegetation;

Prevention

SOIL ACIDIFICATION

result of agricultural activities

Effects:

- ✓ loose topsoil;
- ✓ limited production capacity;

Prevention

DEFORESTATION

= destruction of native forests;

Reasons:

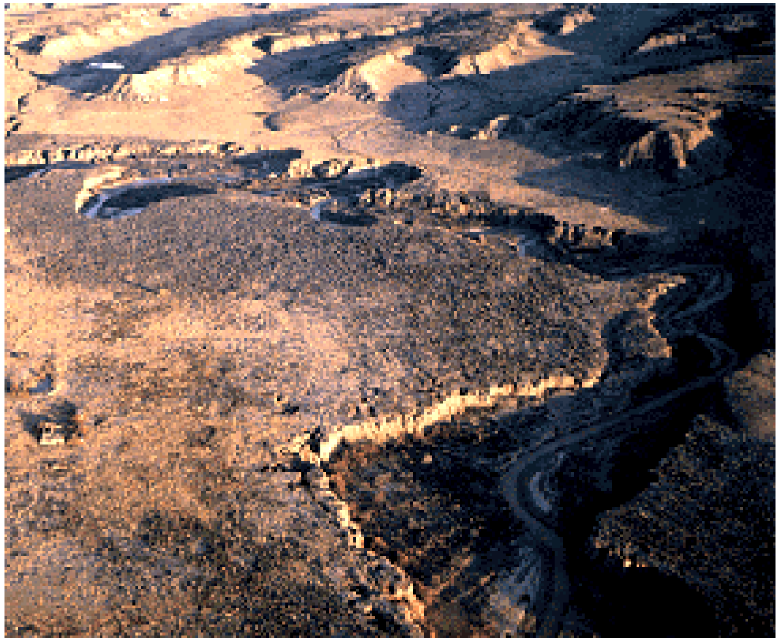
- agricultural cultivating of former forest areas;
- use of wood as fuel and construction purposes;

Consequences:

- changes in carbon and water cycle;
- soil erosion;
- evaporation of water resources;
- extinction of species;
- **desertification**;

DESERTIFICATION

= degradation of former arable lands;



Reasons:

- population explosion;
- climate change;
- deforestation;

Prevention:

- tree planting;
- use of existing water resources;

SALINIZATION

= accumulation of soluble salts in the soil;

Reasons:

- presence of soluble salts;
- high water resources;
- high evaporation rate;
- little rain;

Aral Sea

Indications:

- Early indications;
- subsequent signals;

Prevention:

- maintenance management;
- relief actions;

3500 BC – 1800 BC: at the Tigris and Euphrates region the effectiveness of the Sumerian agriculture was worsening ⇒ grain harvest reduced;

Reason: the soil became salty;

← irrigation water increases the level of the ground water;

if excess water does not flow down in channels ⇒ the soil will be soaked with water ⇒ dissolved salts contained therein will be precipitated on the surface ⇒ they form a coherent crust (Sumerians: *„the soil surface turned white"*);

The water used for irrigation made the soils completely alkaline ⇒ the area became increasingly unfit for agricultural production;

⇒ the Sumerian culture gradually declined (Markham, 1994; Mészáros, 2002).

Salt steppes,
Hortobágy

Sodic soil profiles

Saline grass
on sodic soil

Soil degradation processes in Hungary

- loss in soil and surface habitat;
- disruptions in normal functions of the soil;
- adverse changes in the metabolic processes of the soil;
- loss in soil fertility;
- harder agricultural utilization, rising costs of production;
- shorter time to carry out energy-saving agro-technical operations in a timely and appropriate quality (higher demand for machinery, decreasing opportunities fro applying associated machine lines, increasing energy demand);
- increasing requirement for irrigation and drainage;
- Higher need for fertilizer (bigger losses in fertilizer, lower fertilizer utilization);

Soil degradation processes in Hungary

Harmful environmental side effects:

- increased sensitivity to drought;
- extension of inland waters and stagnant wetlands; siltation of reservoirs and canals;
- increase of runoff – increasing risk of flooding;
- increasing pollution of surface and groundwater resources;
- landscape degradation;
- disintegration of ecological cycles;
- accumulation of hazardous substances and their release in food (food security);
- contamination of natural waters and drinking water;
- deterioration of living conditions on the land;

Fighr against erosion and deflation

1. Plant cover

Good protective effect:

closed forest;
autumn sowings;
associating crops;

Bad protective effect:

spring sowings;
maize;
sugar beet;

2. Technical facilities

- ✓ terrace,
- ✓ windbreak,
- ✓ shelter forest belt

Soil pollution (1)

Industry:

- sulphur dioxide, nitrogen oxides

→ pH decrease (Scandinavia)

(acidifying effect of a significant soil degradation and fertilization)

soil degradation – 100 kg/ha, fertilizer – 360 kg/ha, acid rain – 10 kg/ha $CaCO_3$)

- soot, ash, dust (cement factories)
- aluminum smelters: F_2
- dumps: fertility impairing substances

Soil pollution (2)

Urbanization: waste;

Traffic:
- exhaust gases;
- spills;
- salting roads;

Soil pollution (3)

Agriculture:

- tillage (structural deterioration may occur);
- fertilization;
- irrigation;

Nutrient supplementation of the soils

- **Purpose: nutrient supplementation of depleted soils for higher crop yields;**

  CO_2 – from the atmosphere, from the remaining soils;

  macroelements – NKPS,

  microelements - Ca, Mg, Fe, Mn, Cu, B, Zn, Mo ...

- **Solutions:**
  - **rest;**
  - **organic fertilizer;**
  - **fertilizer;**

Comparison of fertilizer and organic fertilizer

Fertilizer

- Easily utilized;
  ⇒ improves the crop yields
  in the current year;
- its dispersion to the soil is well mechanized;
- **increases the production intensely:**
  1 kg N-fertilizer ≈ +100 kg grass;

Organic fertilizer

- difficult to store;
- it exerts its effect over a longer period (3-4 years);
- it is difficult to disperse it to the soil;
- **it is less intensive to increase the production:**
  100 kg farmyard manure ≈ +31 kg grass;
- replaces trace elements;

Beneficial effects of fertilization

Beneficial effects occur in case of proper fertilization, and especially in short term;

- better use of natural conditions;
- greater assimilation surface;
- lower specific water consumption;
- mass of the resulting humic substances increases (root);
- favourable effect of accompanying materilas and additives (Ca, micro-nutrients);
- favourable change in chemical composition of the plants (protein- and micronutrient content increases);

Negative effects of fertilization: (1)

Adverese reactions occur in case of improper fertilization and long term;

- rapid depletion of nutrient stocks (unilateral fertilization);
- leached N and P → eutrophication of surface water;
  → deterioration in the quality of drinking water wells;
- increase of salt concentration

  sulphate → difficult to dissolve;

  chloride → readily soluble (not bound);

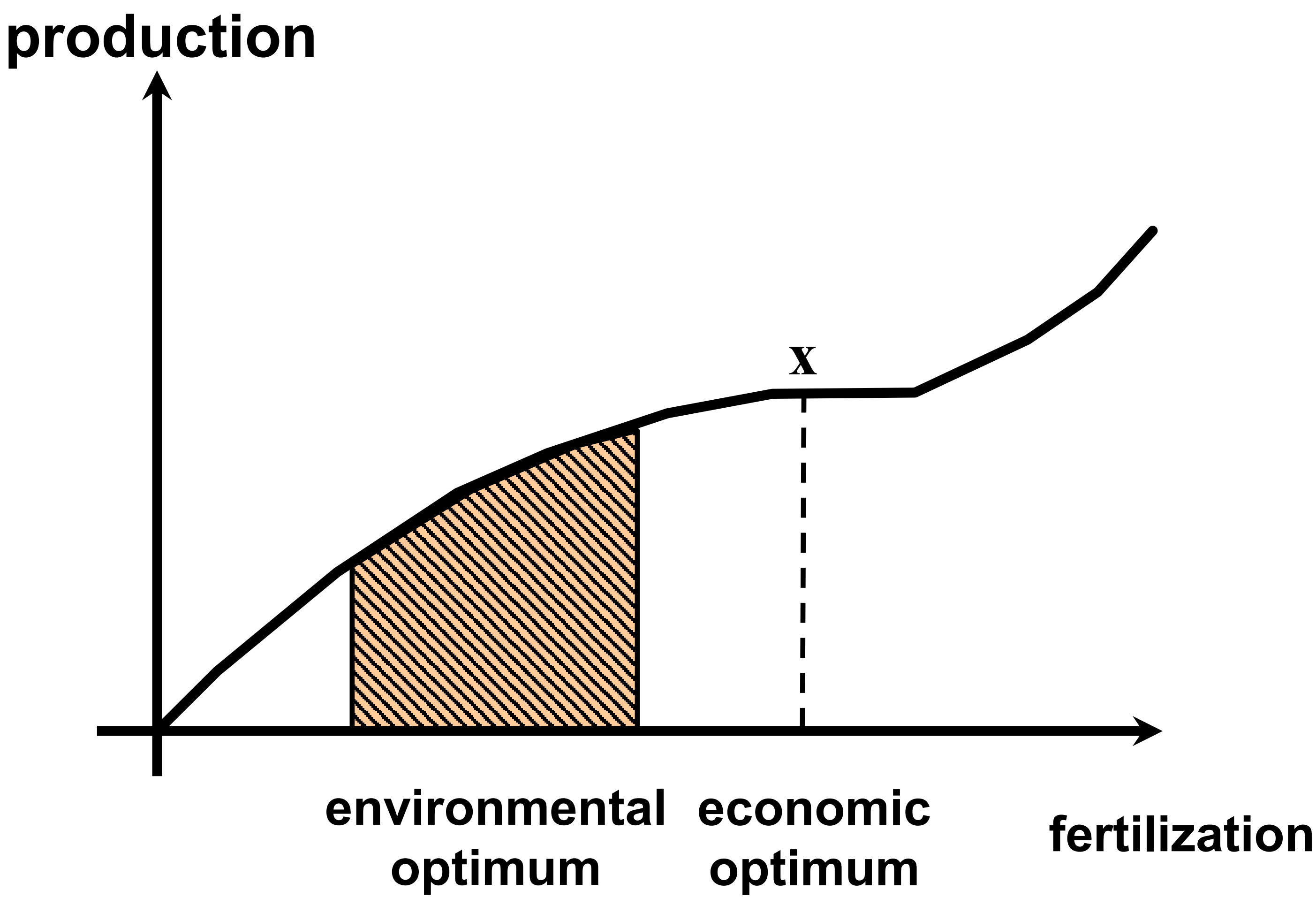
Negative effects of fertilization: (1)

- **changes in the nutrient content of the plants**

  (lettuce, spinach – nitrate: possible loss of quality over 150 ppm)

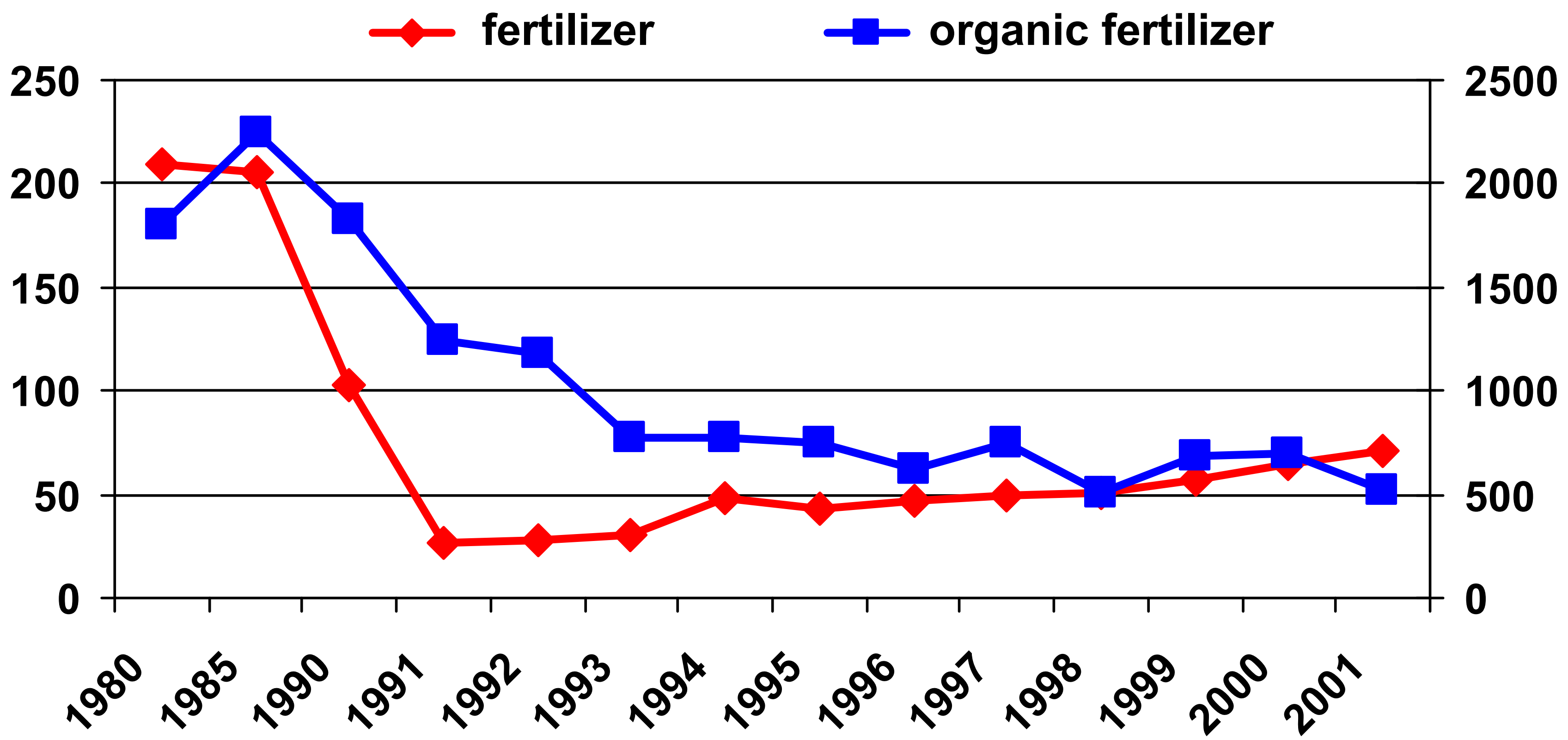
- **resistance of the plants deteriorates;**
- **increases green material production of both weeds and natural vegetation; the demand for weed control increases;**

Ecological and economic optimum of fertilization



- **environmental optimum:**
  - **as complete uptake of nutrients as possible;**
  - Liebig law (1840): the development of a plant is a function of the factor that is the lowest rate available;

Consumption of fertilizer and organic fertilizer in Hungary, 1980-2001 (volume per hectare, expressed in active material, kg)



Source: Magyarország környezeti mutatói (Environmental indicators of Hungary), 2002

Effect of irrigation

- structural deterioration;
- nutrient leaching;
- becoming meadow soil, marsh;
- rise of groundwater level;

  (above 60 cm: destruction of orchards)
- secondary salinisation;

The impact of human activities on the quality of the soil

- fertilization;
- irrigation;
- soil pollution;

Possibilities for increasing soil nutrients

- fertilizers;
- Crop residues, manure, compost, sewage sludge;
- bio-products;
- liming;
- Micronuótrient supplies with leaf fertilizer;

The most commonly used nutritional supplementation is fertilization!

Duration experiments have shown that higher doses of fertilizer (N_{135} P_{90} K_{90}) significantly increase the soil fertility.

Soil chemical effects of fertilization

- Modifies pH of the soil
  regular and abundant use of acidific fertilization incresaes unsaturation of the soils and can lead to **soil acidification;**
- abundant use of fertilization **can increase soil salinity;**
- **oxidation-reduction conditions can shift in the soil;**
- **Appropriate nutrient supply accelerates the mobilization of nutrients in the soil.**

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Irrigation

Components of interaction of the soil and irrigation water:

- quantity and quality of irrigation water;
- location movement and chemical composition of the ground water;
- az öntözés módja és gyakorisága;

Regular irrigation exerts impact to:

- water balance of the soil;
- physical properties of the soil;
- chemical properties (nutrient, salt balance and salt composition);
- direction and intensity of soil formation;

Major impacts of irrigation on soils

Positive impacts

- ✓ better water supply for the plant;
- ✓ increased nutrient uptake;
- ✓ leaching of harmful salts;
- ✓ soil protective effect against erosion and deflation;

Adverse effects

- ✓ structural destruction, deterioration in water management;
- ✓ leaching of nutrients;
- ✓ harmful consequences of over-watering;
- ✓ salinisation, salinity growth;
- ✓ soils become soggy;

Water quality parameters

1. **Salinity of irrigation water;**
   units can be: mg/l, g/l, mS/cm
   c mg/l = 640 EC (electrical conductivity)
   Salt concentration of irrigation water cannot exceed 500 mg/l, namely 0.781 mS/cm (mS/cm = SI unit of conductivity);
2. **It cannot contain soda;**
   soda (or residue sodium carbonate) equivalent: Sz_e(mgee/l);
   $Sz_e=(HCO_3^- + CO_3^{2-}) – (Ca^{2+} + Mg^{2+})$
3. **Effective Ca + Mg concentration;**
   $(Ca^{2+} + Mg^{2+})$effective $=(Ca^{2+} + Mg^{2+})$measured $– 0,25(HCO_3^- + CO_3^{2-})$
4. **Relative Na-content of irrigation water;**
   Na(%) max. can be 40-45%;
5. **Sodium Adsorption Ratio (SAR);**
6. **Magnesium (%)**
   if higher than 40-50%, you cannot use it as irrigation water;

- Cation composition of the irrigation water is favourable if it includes little Na-ion.

- Regarding salinisation effect of the water, not he absolute amount of sodium ions, but their proportion to the remaining cation is determinative.

- If sodium is in equilibrium with hydrocarbons ⇒ value of Na(%) may be 35%.

- If sodium is in equilibrium with other anions ⇒ maximum value of Na(%) can be 40-45%.

- If the amount of Mg(%) (in percentage of the joint amount of a Ca and Mg) larger than 40-50% ⇒ water can not be used for irrigation water.

- Most often, the salinisation effect is expressed by the ratio of Na(%) and Na adsorption ratio (SAR).

Soil pollution

Industrial and technological development, as well as urbanization has significantly increased the amounts of contaminants in the air, the soil and the surface water.

The effect of different pollutants depends on the following factors:

- chemical properties, solubility and availability of ion / compounds;
- duration of the impact and the concentration of the toxic substance (dose) came to the body);
- the status of living organism, adaptability (age, level of development, etc.).
- presence or absence of other harmful materials.

- Toxic compounds absorbed in large quantities within a short time may cause **acute illness** or destruction;

- Low concentration of toxic substances can also be harmful if the effect is sustained and regular (dosage, toxicity);

- **Persistence** is resistance of the of toxic substances to natural degradation;

- The **persistent** of a **compound**, the greater the danger that after accumulation **it is getting to the a living organism** (chlorinated hydrocarbons, polycyclic aromatic hydrocarbons, etc.);

Sources of the geologic environment / soil pollution

A non-uniform classification of **potential threatening activities / areas**:

- **Older landfills:**
  unofficial landfills, slag heaps;
- **Potential polluting activities:**
  industrial and utility areas, chemical plants, coke ovens, tar processing, gas plants, agrochemical centres, petrol stations, fuel storage facilities, rail transfer sites, etc;
- **Areas of large-scale soil pollution:**
  - ✓ polluted areas through large-scale transport or immission (e.g. heavy metals, radioactivity);
  - ✓ polluted areas through flooding;
  - ✓ improper land use (e.g. sewage, sludge, manure);
- **War remains, military areas:**
  destroyed factories, ordnance, ammunition, propellant stations, shooting ranges, buried ammunition;

Classification of pollutants

A. Micropollutants

- inorganic pollutants:
  toxic heavy metals (Pb, Cd, Ni, Hg, Cr, stb.);
- organic micropollutants:
  - pesticides
  - other organic pollutants
    - ✓ chlorinated aliphatic hydrocarbons;
    - ✓ aromatic hydrocarbons;
    - ✓ mono-aromatic hydrocarbons;
    - ✓ polycyclic aromatic hydrocarbons(PAH);
    - ✓ polychlorinated biphenyls (PCB) and other derivatives;

B. Macropollutants

- inorganic (large amount of nitrogen fertilizers);
- organic (mineral oil and petroleum products);

Concept of soil pollution

If substances (contaminants) reducing productive capacity get into the soil either directly or mediating by air and water, furthermore **their quantity and secondary materials derived from them exceed soil decomposing ability,** then we speak of soil pollution.

Contaminants wiil not remain in the topsoil, they **can go beyond the physical / geometric borders of the topsoil**. Then we are talking about the **pollution of the geological environment / lithosphere**.

The impact of these chemicals on the crops will depend on the following factors:

(a) the quality of the pollutants in the soil;

(b) the amount of pollutants accessible to the root the amount of pollutants accessible to the root;

Inorganic pollutants

TOXIC HEAVY METALS

They can occur in the soil:

- **in liquid phase:**
  - ✓ as hydrated ions,
  - ✓ in the form of soluble organic and inorganic complex;
  - ✓ as an ingredients of colloids;
- **in solid phase:**
  - ✓ in insoluble in precipitation;
  - ✓ on the surface organic and inorganic colloids in exchangeable form;
  - ✓ in crystal lattice of silicate;

A **dynamic equilibrium** is established between the various forms. Heavy metal compounds that are insoluble in the original state of soil, can be mobilized due to acidification and hence may cause severe environmental damage.

To understand the environmental impact of soil contamination we should know:

- ✓ the properties of the soil;
- ✓ the total amount of the toxic metal;
- ✓ the mobile set;

Minerals

- Minerals can get into the soil either directly, or from the air by settling, or by leaching through the precipitation;
- The most harmful are heavy metal ions (Pb, Cd, Cu, Cr, Hg, stb.) and the pH-altering and acids or bases;
- Heavy metal contamination of soils (mg/kg dry matter) (or ppm):

Soil	Cd	Pb	Zn	Cu	Cr	Hg	As
normal area	0-1	1-20	3-50	1-20	2-50	0.1-1	2-20
landfill	0-50	0-16000	0-9500	0-11000	0-28	0-39	40-150
city garden	0.9-2.1	300-700	140-600	1-97	-	0.4-1.1	2-20
junkyard	110-1550	20000-30700	7900-15000	7080-10000	-	3.5-9	0-40
wastewater irrigated area	16-144	2470-7200	1435-7600	182-5600	0-8400	0-6.5	0-59
EU guidelines	1-3	50-300	150-300	50-140	-	1-1.5	-

Lead (Pb)

In terms of human and animal health, it is a highly toxic element.

Main sources of lead pollution :

- ✓ leaded fuel;
- ✓ coal combustion;
- ✓ smelteries;
- ✓ lead processing;
- ✓ sewage, etc.

Voncentration of lead

- over unpolluted areas : 2-20 $mg \cdot kg^{-1}$;
- along high-traffic roads : 500-600 $mg \cdot kg^{-1}$;
- close to lead processing: 3000 $mg \cdot kg^{-1}$;

Binding and behavior of lead in the soil :

Lead is the most strongly bound metal in organic complexes. It is bound through specific adsorption processes, its leaching is very little.

Cadmium (Cd)

In humans and animals is toxic even in very little concentration (it causes bone shrinkage, kidney damage, lung damage).

Main sources of cadmium pollution:

- ✓ ore mining;
- ✓ metal processing;
- ✓ waste incineration;
- ✓ sewage sludge;
- ✓ transport;

Cadmium concentration

- over uncontaminated areas: < 1 $mg \cdot kg^{-1}$
- along high-traffic roads : 3 $mg \cdot kg^{-1}$
- in metropolitan parks : 0,5-5 $mg \cdot kg^{-1}$

Binding of cadmium and its behaviour in the soil:

- ❑ in neutral and alkaline soils specifically adsorbed proportion of Cd is significant;
- ❑ if pH < 6.5, ⇒ nonspecific adsorption takes over;
- ❑ if pH < 5 ⇒ 30% of all Cd is available for the plants;

Mercury (Hg)

Its steam and soluble compounds are highly toxic.

Main sources of mercury pollution:

- ✓ wood and metal processing industries;
- ✓ sludge;
- ✓ composted municipal waste;
- ✓ fungicides containing mercury;
- ✓ burning oil;

Concentration of mercury

- over uncontaminated areas: < 0,1 $mg \cdot kg^{-1}$ (ppm)
- over industrial and urban areas: 0,1-0,4 $mg \cdot kg^{-1}$ (ppm)
- over contaminated areas : 7-10 $mg \cdot kg^{-1}$ (ppm)

Binding of mercury and its behaviour in the soil:

- ❑ Depending on the redox conditions, mercury appears in the different oxidation stages; mineral and organic colloids strongly adsorb in the Hg^{2+} ions and mercury vapour.
- ❑ Due to the extremely weak mobility of mercury, the crops can withdraw it only slightly from the ground, so their Hg content is low (< 0,04 $mg \cdot kg^{-1}$).

Organic pollutants

Organic pollutants occur in liquid, solid and gas phase of the soil, as well.

The majority of organic contaminants are toxic both for humans and animals,

→ **oral, inhaled,**

→ **absorbed through the skin.**

Toxic organic substances entering to the ground in small quantities (pesticides, polycyclic aromatic hydrocarbons, polychlorinated biphenyls) are called in total organic **micro-pollutants**.

Polycyclic aromatic hydrocarbons (PAH)

Hydrophobic, resistant materials containing three or more fused aromatic rings, (anthracene, phenanthrene, pyrene, benzo (a) pyrene, etc.).

Occurrence:

- ✓ during the formation of crude oil;
- ✓ oil refineries;
- ✓ gas works area;
- ✓ during fuel combustion;
- ✓ during forests burning;
- ✓ moorlands combustion;
- ✓ flue gases;
- ✓ cigarette smoke;
- ✓ exhaust of motor vehicles;

Carcinogenic effect of several members of the group of PAH compounds – i.e. BaP - is proven.

Getting into the soil, humic substances adsorb them.

Persistence of PAH compounds are small, they decompose over less than six months.

- **benzo (a) pyrene (BaP):** procarcinogenic (carcinogenic substance); ingested → BaP epoxy-diol; → it is bound to guanine, a component of the DNA molecule, ⇒ disrupts the structure of the DNA double helix; ⇒ transcription errors, mutations → **cancer**;

- Do develop polycyclic aromatic hydrocarbons **during roasting coffee, peanuts, almonds**, etc? Yes, but their amount is not significant.

Dangerous Foods: burnt toast, grilled meat over an open fire (barbicue), smoked food, etc;

- **BaP** is found in a high proportion
  - **in tobacco smoke,**
  - **in the exhaust gases and**
  - **in wood burning in smoke;**

Polychlorinated biphenyls (PCB) and their derivatives

They are exclusively of industrial origin (due to their high viscosity, thermal and chemical stability, they are used in hydraulic fluids, as well as in insulating and cooling fluids), water insoluble hydrophobic materials.

Getting into the soil, they are bound with hydrophobic adsorption by humic substances.

When getting into the body, they are accumulated in fat tissue and attack the nervous system, as well as bodies responsible metabolism.

Pesticides

Pesticides used in agriculture:

- herbicides,
- insecticides,
- fungicides.

The average persistence of pesticides in soil:

- small (< 3 months), pl. 2,4-D, MCPA, etc.
- medium (3-12 months), pl. atrazin, simazin, linuron, etc.
- large (1-3 years), heptaklór, lindán, etc.
- very high (>3 years), DDT, dieldrin.

Detergents (surfactants)

- **Detergent are surfactants, produced synthetically.** Detergents may be anionic and cationic.

- In Germany, since 1964 only the so-called soft, anionic detergents should be sold that are 80% biodegradable when biological waste water treatment.

- Detergents can get to the soil over areas (1) without sewerage, (2) sewage infiltration and (3) receiving industrial waste.

- They are adsorbed in the soil in 2-3 cm thickness, and if this layer is saturated, they may get into the ground water. The groundwater they cause deterioration of flavours and smells, even **cause foaming**. They facilitate migration of flavor constituents, minerals, oils, and toxic materials in the soil and ground water, as well.

Organic macro-pollutant, crude oil

Most important source of the organic macro-pollutants are mineral oils;

- Their yield worldwide: 2800-3500 million tons/year

- source of pollution:
  - ✓ mining;
  - ✓ transport;
  - ✓ filling;
  - ✓ cleaning;
  - ✓ distillation, etc.

- pollute:
  - ✓ soils;
  - ✓ freshwaters and salty waters, and
  - ✓ air;

- **Prevailing long-term toxicity is one of the most dangerous environmental hazards;**

"The oil spill age"

- **0.5% of crude oil transported by sea (more than 12 million tons/year) get to the seas;**
- its impact to the marine ecosystem:
  - **mutagenic;**
  - **carcinogenic;**
  - **contains growth-inhibiting materials,** in 5-100 g/litre concentration destroys even offspring of marine algae and other organisms;
  - inhibit the degradation of natural materials;
- 600 thousands tons/years gets to the Earth surface from the atmosphere;
- rivers, lakes get much more;

- direct pollution input
  - ✓ usually of anthropogenic origin;
  - ✓ local in nature;

- pollution input through the atmospheric and water cycle in association with natural and anthropogenic processes
  - ✓ regional;
  - ✓ hemispheric;

- Soil degradation $\longleftrightarrow$ pollution;
  pollution is not limited to the surface of the earth's crust detectable directly, or by instruments;
  $\Rightarrow$ its **degree** of space, nature and time **can only be detected after a certain level of development** of existing **contamination**;

- contamination of the soil is regular and continuous;
- hazard potential of many soil pollution is not known;
- detection of soil pollution has not been too much in practice;
- clearing of soil pollution is the most costly per unit;

The limit

- **For the load of a given medium standards, policies, laws and regulations** determine the numeric value, but they do not refer to the given or polluted area;

- **Limits** covering the vast majority of the potential pollutants are recorded in the **joint regulation of 10/2000 (IV.2.) Ministry of Environment, Ministry of Health", "Ministry of Agriculture and KHVM**; for the soil to the concentration: mg/kg;

- ⇒ **polluted soil, if** the concentration of the given pollutant **exceeds the limit** laid down by the Regulation;

Exploration, delineation and evalation of the polluted area

- The first step in the preparation work of **collecting and recording the status** is required to assess the potential hazard;

- The first assessment may comprise extreme statements;

- **Research strategies:**
  - ✓ **hierarchical:** pollutant characteristics will be known at the end of the research;
  - ✓ **targeted:**
  - ✓ **combination of both:** preliminary and detailed research in two stages;

The impact of crude oil and petroleum products in the soil (1)

- Crude oil is a mixture of aliphatic and aromatic hydrocarbon.
- The oil in the soil reduces self-purification capacity of the soil, while in ground water it induces destructive effect for taste and odour.
- Lower boiling compounds evaporate (destructive effect for odour).
- **Biodegradation of the oil can take place**
  - **naturally**, **through auto-oxidation**: on the effect of sunlight, sulfur compounds and organic metals;
  - **biological way: through bacteria in the soil** (Aeromonus, Pseudomonas, Arthobacter), depleting effect of which are promoted by N and P content of fertilizers (this process is also used to artificially break down oily sludge, spread out on the soil surface with doses of fertilizer);

The impact of crude oil and petroleum products in the soil (2)

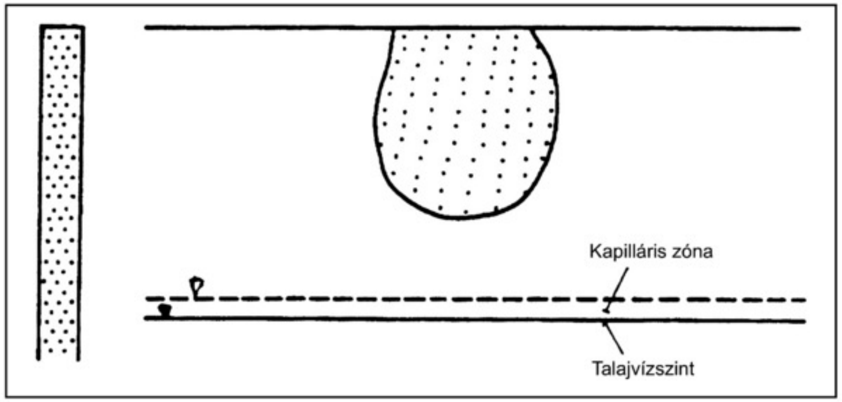
- blocks the pores of the soil, water and air balance of the soil is upset, the plants destroy;
- functioning and composition of the soil microbial communities damage;
- olajlencse alakulhat ki a talajvízszinten;

Treatment of oil pollution in the soil

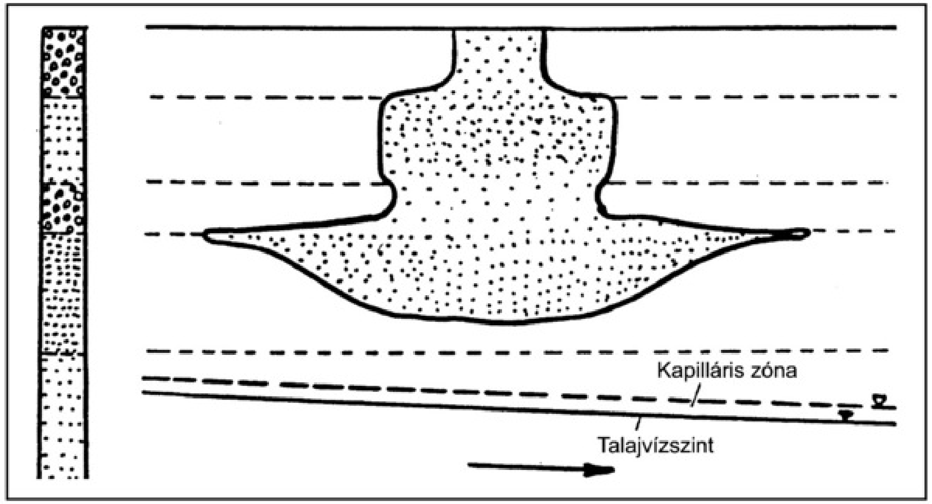
- **with oil-guzzling bacteria:** in case of little oil pollution;
- **with in situ, ex situ remediation process** (expensive procedures);
  - **in situ soil treatment:** without soil extraction, purification on site (e.g. aeration, soil washing, biological degradation, etc.);
  - **ex situ soil treatment:** the soil is excavated, transported and cleaned (i.e. aeration, washing, burning, etc.);
    - In case of large quantities, the polluted soil can be placed on hazardous waste site;

Mineral oil pollution of the soil

Oil movement in the soil (1)

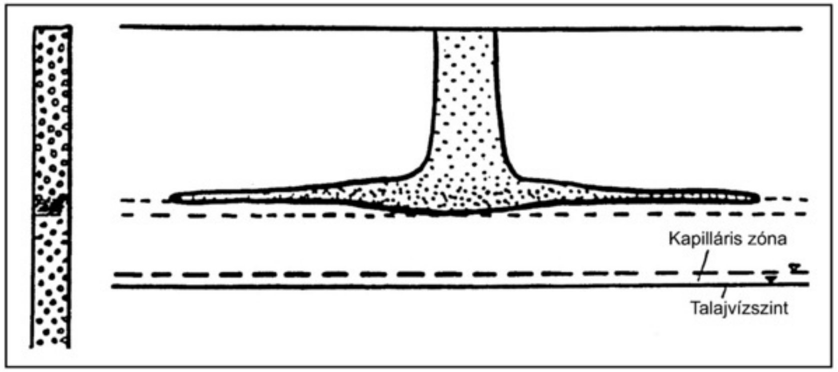


Shape of the oil body in a homogeneous soil

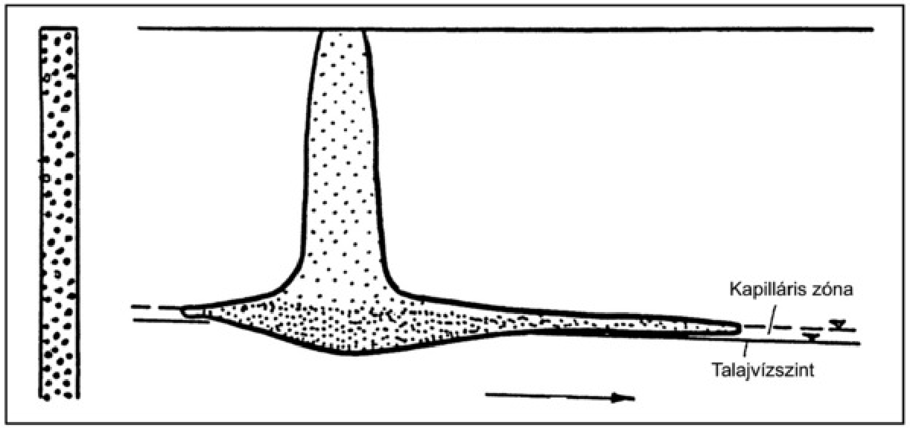


Shape of the oil body in different soil permeability

Oil movement in the soil (2)



Location of the oil body when the oil-through-impermeable ground ends.



The oil body reaches the groundwater level

Soil contamination of mechanical engineering

The most common soil pollutants of mechanical engineering:

- heavy metals
- oils
- acids, alkalis

Basic principles of damage control

- Sub-tasks of selecting remediation technologies relating to polluted soil:
  - clarification of future use;
  - assessment of risk caused by the pollution;
  - to determine the magnitude of residual spill tolerated;
  - selection of remediation technologies;
  - implementation;

There is no 100% used method. The results obtained are to be determined on the basis of the respective technical / legal / economic aspects.

Damage control

Damage control – according to its result - can be divided into three target states - with no clear boundaries:

- **1st target:** to prevent the spill from spreading, the so-called **localization;**
- **2nd target: partial exemption,** for example, extraction of the oil phase (oil lens);
- **3rd** – and enviromentally correct – **target:** a **full disposal of the site**;

Possibilities

- To **leave** the polluted soil **on the site, use restricted**.
- **Cover** or encapsulate a watertight manner.
- **To keep** the highlighted polluted block **in waste containers**, subject to regulated conditions.
- **To clean** the polluted space portion, in situ, as off site.
- **To bring pollutant concentrations below the thresholds** during cleaning.

Always look on the bright side of things!

We finished for today, goodbye!

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өнөөдөртөө ингээд дуусгацгаая, баяртай

让我们总是从光明的一面来看待事物吧！

今天的课程到此结束，谢谢！

الأشياء! دعونا ننظر دائما إلى الجانب المشرق من

انتهينا لهذا اليوم، وداعا!