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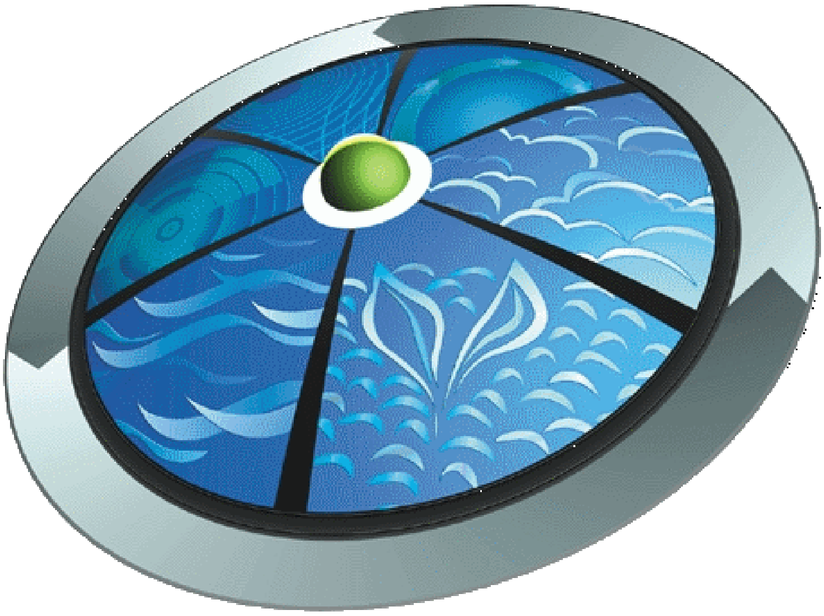

24. volume

SOIL SCIENCE - Ecology - Environmental Remediation

Dr. Andrea Farsang

University of Pannonia – Institute of environmental engineering

This material is made the TAMOP-4.1.2-08/1/A-2009-0021 topic in the frame of University of Pannonia.

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published volumes

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Terms of use:

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4. Glossary

1.	Earth's heat:	The inner energy of the earth's crust.
2.	geothermal energy:	Thermal energy generated and stored in the Earth, which can be utilized for energetic purposes.
3.	geothermal depth-step:	Depth increase per 1 ^{0}C temperature increase.
4.	geothermal gradient:	Earth's temperature increase per depth unit.
5.	thermal water:	Confined ground water with higher temperature than 30 °C.
6.	closed geothermal system:	When used thermal water is repressed to the aquifer.
7.	open geothermal system:	When thermal water after extraction and utilization gets directly to the cistern or the drainage canal.
8.	heating heat pump:	If the higher temperature level's energy output is considered to be the useful energy.
9.	cooling heat pump:	If the lower temperature level's heat extraction is considered to be the useful energy.
10.	COP („coefficient of performance"):	COP is the ratio of the change in heat at the output of the supplied work.
11.	geothermal power plant:	The geothermal power plant transforms the energy of the high temperature and pressure water - stored in the deeper layers of the Earth - into electrical energy.
12.	visible light:	Visible light is the portion of electromagnetic radiation that is visible to the human eye and has a wavelength in a range from 380 to 780 nm.
13.	radiation constant:	The amount of energy in a square meter surface of the Earth' atmosphere in a direction perpendicular to the Sun's radiation.
14.	solar collector system:	Transforms the Sun's energy with a substance into heat energy, which will be utilized by building engineering devices.
15.	collector efficiency:	Collector efficiency is expressed as the ratio of solar energy collected divided by the solar energy available.
16.	flat-plate collector:	Solar collector with flat-plate parts, which absorbs the sun's energy.
17.	evacuated tube collector:	Solar collector with a tube part energy absorber.

18.	solar cell:	Devices that transform the light radiation’s energy directly into DC electrical energy.
19.	solar cell efficiency:	The electricity generated by solar cell power, divided by the incident light performance.
20.	inverter:	Instrument that transforms the solar cell’s DC into AC.
21.	hydropower:	The kinetic and potential energy of the surface water.
22.	water turbine:	Water turbine is a flow machine and on its impeller the energy of constantly moving water is converted into mechanical energy.
23.	drop height	Part of the fluid’s energy flowing through the turbine, which can be recovered as mechanical work on the turbine axis.
24.	axis performance:	Useful performance, which is recoverable on the turbine axis.
25.	turbine efficiency:	The turbine’s axis performance divided by the overall performance of the incoming water.
26.	reaction turbine:	Reaction turbines are acted on by water, which changes pressure as it moves through the turbine and gives up its energy..
27.	impulse turbine:	There is no pressure changing on the impeller during energy transformation.
28.	hydroelectric power plant:	Hydroelectric power plant are facilities that utilize the hydropower of rivers, lakes, seas and feed the electrical energy to the high-voltage system.
29.	waste heat:	Heat that leaves the technologies in the form of loss to the environment.
30.	waste heat index	The waste heat volume per utilized heat unit.

5. Soil's role in the system of environmental compartments

Soil is a special formation at the interface of lithosphere, hydrosphere biosphere and troposphere and its function is closely connected with them. Soil is a dynamic system of physical, chemical and biological interactions. Its significance is multifunctionality: habitat of the plants and partly the animals; storage of heat, water and plant nutrients; high capacity buffer medium, natural filter and detoxification system; conditionally renewable natural resource; human heritage. The soil map of the Earth can be characterized with considerable mosaicity since the soil as landscape ecology subsystem has close functional and structural relation to other subsystems and thus change of any subsystem exerts direct influence on the soil (Keveiné, 1998).

According to Várallyay, the soil is a three-phase, four-dimensional heterogenic polydisperse system. In this complicated system, two subsystems, strongly related and complement each other, can be differentiated: a biotic involving living organisms and an abiotic one comprising inorganic materials (Filep, 1999). The most important feature of the soil is fertility ensured by humus content. The soil - living being system is the main and in many cases the only source of nutrients and raw materials essential for human.

The soil as dynamic system is about to strike the balance against exogenous effects. Some of its natural functions are absorption, dissociation and transformation of some materials (Keveiné, 1998). Mankind also utilizes this latter property disposing waste, sewage sludge and sometimes chemicals into the soil. The soil is a limited source; its territory has progressively been shrinking. Enormous extent of soil surface is used for industrial, municipal, road infrastructural purposes. Inadequate soil utilization and agro-technique (cultivation, fertilization, and plant protection) can cause erosion, soil destruction or pollution. The anthropogenic activities and environmental factors negatively influencing soil can lead to imbalance and gradually depletion of the soil (Tardy et al, 2005). The regeneration takes years, centuries since the soil is formed by slow physical, chemical and biological processes. Consequently, similarly to air and water, the soil also requires protection. In Hungary, the soil is protected by law dually due to its complexity: both environmental and conservational regulations protect the soil along with other spheres.

Act LV of 1994 on arable land declares the aim of soil protection is to **sustain the fertility and quality** of arable land; to prevent the physical, chemical and biological destruction. Soil protection is common task of the **state,** the **land owner**, the investor and the operator but it is the **owner** who **actually realizes it**. The Act on Arable Land differentiates quality (*soil protection*) and quantity (*land protection*) protection of the arable land.

Based on harmonization of land use, cultivation technologies and soil protection guidelines, the **owner is obliged to purse conservation farming** adapting to ecological conditions of the production site. This type of farming has to take into account requirements of conservation-, environment-, water-, public and animal health protection regulated by proper regulation. Furthermore, the owner has to prevent the soil pollution in the given land and save the tilth in the case of for exp. investigation, operation or other utilization.

The duties of the state are:

- registration of soils based on their quality
- monitoring of qualitative change in soil using information monitoring system (TIM 1992-)
- authorities tasks, authorizations concerning soil protection, penalty
- Organization of developmental processes (management of environment friendly, new technologies and projects)

Act LIII of 1995 on „*the* General *Rules of Environmental Protection*" aimed to protect factors and processes in the environment and to ensure environmental conditions of sustainable development. In accordance with this decree, environmental factors are the following: soil, water, air, wildlife and constructed environment by human. This act declares relevant statements about soil protection, in both "Preliminary and Summary Environmental Report". From the viewpoint of soil science, these documents have to contain information hereunder:

- Data on requisition and change in land use of the given area
- Characterization of the soil according to its multifunctionality
- Reconnaissance, liquidation, remediation of the soil pollution from the given activity
- Priority action plans
- Presentation of remediation solutions.

6. Evaluation of our soils in the 21st century: Land evaluation, land valuation

The arable soil, in the agriculture and sylviculture, is such a material and energy system forms and types of which depend on the soils, the climate, the hydrological cycles whereas its value and quality is dependant on the real and potential yield (Dömsödi, 2006).

Criteria of a perfect soil evaluation system are: simple, efficient, usable and understandable. It has to provide enough information on diverse soil types' conditions of each production site in the given country in order that we can objectively compare areas with different natural potentials and agriculture. It is essential expectation from a good system to give authoritative information using as many parameters as possible and to take into consideration the type, specialty of the soils in the given area and their complex soil-forming factors. It needs to pay due respect to economic conditions related to agricultural production and the inner and outer environmental agents influencing them. It is important to emphasis anthropogenic impact causing gradually significant problems nowadays and the degradation degree of these soils in an evaluation system (Kocsis, 2006).

6.1. Hungarian land evaluation system: so called „gold crown" (in hungarian aranykorona) system

The cadastral survey enacted by King Joseph II as the first period of the land registry started in 1786. This temporary cadastre involved 6 agricultural branches and 3-5 land quality classes. The permanent land tax was existence of cadastral registers introduced in 1849 by King Joseph II. After Compromise in 1967, Hungarian economy was prospering and the value of the lands increased; thus it was necessary to qualify the soils in order to impose some tax on them.

The Act VII of 1875 decided on forming a system indicating the land quality by widespread acceptable index and creating the national cadastre. Initially cadastral value of the soils was given in Hungarian "forint"; later in "korona" the then currency of the Austro-Hungarian Monarchy; in wheat equivalent" after inflation, ultimately in "gold crown" (Dömsödi, 1996).

The land tax was determined as follows: at first 20% and later 25% (after modification in 1924) of cadastral income (in corona). According to the definition, *the cadastral net income is the value of mid-yield subtracting all the cultivation expenses.*

At the time of the introduction of this system, "Land evaluation based on sample area" method was generally applied since there were no soil maps. The country was divided into 12 cadastral subparts, which were further separated into small units having similar cultivation conditions: "assessment areas" ("becslőjárás" in hungarian).

The "assessment areas" ("becslőjárás") were very various in size: The smallest one contained only the surroundings of a single village, whereas the largest one consisted of the agricultural area of 51 villages. Their average size was 80000 and 100000 ha (Stefanovits, 1999).

Inside the "assessment areas", 7 cultivation branches could be differentiated: arable land, garden, meadow, pasture, vinery, forest and reed. Quality classes were determined in each cultivation branch (maximum= 8) in every small unit. The extent of every class was the same: 1 cadastral acre viz. 1600 wiener quadrate (= 0.5754 ha).

Designation of these units has based on soil properties but not on scientific principles. Approximately 70000 sample areas were described by scientists in those days determining the maximum yield on them. They could be established for every class how much income can be reached beside average economical level and expenditures (Sipos and Szűcs, 1992).

For example: Arable land class I: 11.10 gold crown/ha – 62.60 gold crown /ha;
Vine class II: 13.90 gold crown /ha – 146.00 gold crown /ha

Yield depended mainly on the soil quality at the beginning of the 20th century. Economical components of the “gold crown” system have not changed since then despite the fact that the economical factors of the production have significantly altered by now. Majority of the soil scientists agrees on disadvantages of this out-of-date system.

The main arguments are as follows:

- ✓ It has not taken into account the results of the soil science
- ✓ It has not allowed national comparison because of the different changes in soil productivity (inducted by cultivation, erosion, acidity, melioration) in the different areas of the country
- ✓ Cultivation methods and yield capacity of the cultivated plants have changed significantly
- ✓ Economical factors are inseparably linked to ecological ones
- ✓ Significance of the transport has increased with the production and specialization, the transport directions has altered. Several market catchment areas were shifted through the Trianon borders
- ✓ It has not taken into account that the land use around cities has changed, the farming became more intensive

In spite of above-mentioned facts, the replacement of the “gold crown” system with a more modern one has failed until now.

6.2. “Hundred point” land evaluation system

The **“Hundred point”** system worked out by Fórizsné, Máté and Stefanovits tries to eliminate all these drawbacks of the “gold crown” system. The advantage of this system emerged in 1970 is that it is based on scientific and soil scientific knowledge. It consists of “evaluation number”, “productivity number”, and “economical factors”.

Whilst “evaluation number” and “productivity number” represent the natural conditions, economical relations are taken into consideration using the economical factors. Real value of a given soil can exclusively be given respecting these factors.

The soil evaluation numbers ranging from 1 to 100 express soil productivity. Besides this number, however, it is relevant to pay respect to even climate, relief and hydrology as natural resources together influencing the soil productivity, giving the productivity number. The soil evaluation number reflects the relative differences in soil productivity on the productivity level of traditional cultivation (stable manure, ploughing with animals). This state is the base productivity level of the soils (Fórizs J.-né, Máté and Stefanovits, 1971).

According to the soil scientists, **each productivity level** evolves over the human activities of various degree and direction.

The **natural productivity** means organic matter mass, biomass produced by natural vegetation (in g/m^2/year) on the one hand; the yield(s) achieved in the first years of cultivation after replacement of natural vegetation on the other hand (Stefanovits et al., 1999).

Base productivity, typical of the 1930s**,** can be characterized with crop rotation cultivation using stable mature as nutrient supplement, swallow or mid-deep ploughing with animals.

Actual productivity is the multi-annual average of real yields as a result of chemical fertilizers regularly used nowadays dependant on the soil types and potential land reclamation in the case of both dry and wet cultivation.

Optimal productivity is the average yield as a consequence of all the economically applicable and essential melioration activities in the given area.

Potential productivity is multi-annual yield average due to all the successful melioration activities in the given area (Stefanovits et al., 1999).

This method determined the potential maximal soil values for each genetic soil types that mean 100 points. Considering the slope angle, the aspect and the climatic properties, these values were refined. Soil evaluation took place regarding the 60% of Hungarian territory with the participation of the personnel of land registries between 1981 and 1988 mainly using “Land evaluation based on sample area” method.

7. Soil properties and their classification in accordance with their temporal variability

More phases of spatial changes in soils can be differentiated: The soil evolves from the rock in the 1st stage during the so-called „soil formation". As a consequence of further stages of different intensity, new soil types appear in a specified order. Ultimately diverse soil types can be observed in Earth. The different processes in soil act closely connected to each other in a well determined order depending on some soil-forming factors. The change in dominant processes and soil process associations typical of every soil result in a new soil type. The modification of processes and soil associations can be caused by one of more soil-forming factors (e.g. land use, natural vegetation, water balance, climate etc.). The dominant soil-forming factors might as well be very diverse within little distance.

Processes in the soil make pairs with their counterparts striking dynamic balance. Such counterparts are the following, for example (Stefanovits et al., 1999):

- organic matter accumulation - organic matter decomposition
- soil drying - soil wetting
- leaching - salt accumulation
- clay formation - clay dispergation
- lessivage - clay aggregation
- oxidation - reduction
- acidification - alkalinization
- structural formation - structural degradation

7.1. Temporal variety of soils

The most significant physical, chemical, biological and morphological soil properties alter spatially and temporally.

Spatial modifications in the soil properties can be the following 3 types:

- periodically changing soil properties (e.g. temperature, CO_2 and nutrient content etc.)
- soil property changing following a trend (e.g. organic matter accumulation, clay formation, lessivage, salt accumulation etc.)
- random changes in soil properties (e.g. pollutions, parameters influenced by human activities etc.)

Temporal modifications in the soil properties can be of different types:

- soil properties changing during some hours (e.g. temperature, soil moisture etc.)
- seasonal (for some months) changing properties (e.g. soil density, biological activities, salt content, pH etc.)
- soil properties changing during some decades (e.g. organic matter, concretions etc.)
- soil properties changing during some centuries (e.g. mineral composition, mechanical soil types, colour etc.)

It is very important to evaluate modifications in the soil properties from the viewpoint of soil protection:

- reversible properties (e.g. pH etc.)
- irreversible properties (e.g. structure degradation etc.)

7.2. Tendencies of spatial and temporal changes in soil properties in Hungary, soil monitoring. Soil Information and Monitoring System

The aim of Soil Information and Monitoring System (TIM) is the temporal monitoring of soil conditions in order to provide information on soil resources in Hungary. The TIM initiated in 1992 takes notice of many parameters: cultivation type, ownership and some limitations based on other viewpoints.

The system is based on altogether 1236 points representing the geographical regions of the country as well as different land use types. After the initially sampling of the soil individual properties are checked with different frequencies ranging from 1 to 6 years. Some soil parameters are measured both considering the given profile and its horizons every year, some others every 3 years or every 6 years, depending on their stability. The monitoring points are selected to be representative the soil resources in Hungary. Out of 1236 points, there are 865 ones in agricultural lands (70%), 182 in forests (15%), 189 special points (15%; **S** points) (Szabóné and Pálmai, 2005).

S points for exp.:

- degradated areas (degradations by environmental and human impacts mainly in agricultural areas, for exp.: erosion, deflation, acidification, salt accumulation, sodification, compaction, soil pollution etc.)
- hydrogeological buffer zone of drinking water resource
- catchment areas of lake and reservoirs
- heavily polluted industrial areas and agglomerations
- agricultural areas with sewage sludge, liquid manure
- areas having busy traffic
- around wastes and hazardous waste deposit plants
- areas with military facilities
- conservation areas
- surface mines, recultivated spoil banks
- sensitive areas from environmental viewpoint (e.g. buffer zone of conservation area)

The measurements can be classified into 4 groups based on monitoring of soil conditions:

- yearly (e.g. pH, nitrate, nitrite)
- every 3 years (e.g. humus content, P, K, Ca, Mg)
- every 6 years (e.g. toxic element content)
- in some cases individually analyzed measurement

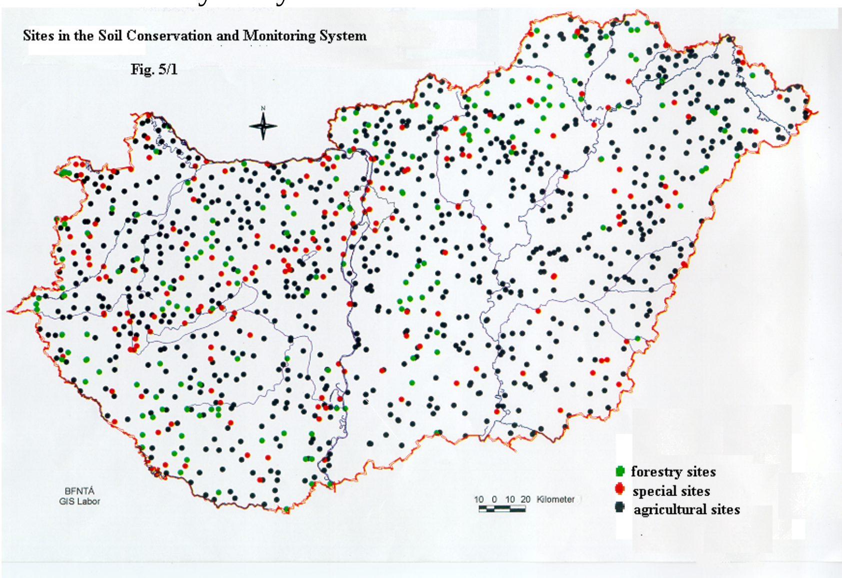

Fig. 7.1 Soil Information and Monitoring System in Hungary (source: Várallyay et al., 2008)

The location of TIM points can be seen in the Fig. 7.1.

The results of the monitoring and the first data series were published in 1997. According to this, following statements can be summarized about the toxic elements:

- Ni is higher than limit value in the 1-2% of the samples
- Cu exceeds the limit value in nearly 1% of the samples
- Pb and Cd content is approaching the limit value in some samples, which unambiguously indicates their anthropogenic origin
- Cr and Co have not exceed the limit value in any samples
- As content is higher in some parts of Hungary, which indicates geochemical enrichment (FM, 1997).

8. Effect of human activities on soil. Soil degradations, qualitative and quantitative deterioration of soil. The physical, chemical and biological degradation of soils

Human activity effecting the soil formation and development is considered to be an modifying soil-forming factor. This impact can generate favourable processes in some cases for exp. sustaining of water balance in the soil; preservation of soil productivity or land protection against soil degradation. The anthropogenic impacts can induce unfavourable processes, too. **The soil degradation is a complex process** that results in *reversible* or *irreversible changes* in soil properties and in *other processes;* reduces soil *productivity*; limits normal *soil functions*. Three types of the soil degradation caused by natural forces or human activities can be told apart (physical, chemical or biological).

The effect of the human activities on soils can be **direct and indirect**. The indirect effect is for exp. the change in chemical composition (CO_2, SO_x, NO_x, CH_4) of soils due to emission of heavy metals and other industrial impurities or aerosols in atmosphere]. This effect can exert influence on the chemical composition of the groundwater by fluctuation in groundwater level. The soil can susceptibly reflect the change in the biosphere (e.g. modification of natural vegetation, deforestation, overgrazing etc.), as well.

The direct effects are for exp. shrinkage of arable land owing to other utilizations, soil pollution or physical, chemical and biological degradation. The most important degradation processes influencing the soils in Hungary:

- Soil erosion, deflation
- Acidification
- Sodification
- Structural degradation, compaction, crusting
- Extreme water conditions: large extent of wet and marshy lands, inland water, drought sensitivity
- Biological degradation: reduction in organic matter, soil biota loss, irreversible change in natural biological activity
- Unfavourable change in biogeochemical cycle of the elements (e.g. alteration of nutrient balance, intensified leaching, biotic-, abiotic immobilization)
- Decrease in soil buffer capacity
- Soil pollution, environmental toxicity

8.1. Soil conditions in Hungary

The conditions of the soils in Hungary can be characterized in accordance with acidification, sodification, physical degradation, extreme water regime, reduction in humus and nutrient content, soil erosion and soil pollution (Table 8.1).

Table 8.1 Location of the main factors inhibiting the productivity of soils in Hungary (The areas with eroded acid rock and surface dense acid rock are marked exclusively in the one case (based on Várallyay)

Main factors limiting the productivity	In percent of the arable land and forest	In percent of Hungary's territory
High sand content	8.9	8.0
Acid reaction	9.3	8.4
Sodification	9.0	8.1

Main factors limiting the productivity	In percent of the arable land and forest	In percent of Hungary's territory
Sodification in deeper soil horizons	2.9	2.6
High clay content	7.5	6.8
Marsh and fen formation	1.9	1.7
Erosion	17.4	15.6
Surface dense rock	2.6	2.3
Total:	59.5	53.5

The most outstanding consequences of the soil degradations:

- reduction in landscape diversity
- decrease in landscape value owing to ecological and technical limits
- decline in soil value, productivity, phytomass production, ecological conditions of plants
- expenditures of decontamination after soil pollution
- soil tilth loss
- disturbance of the normal soil functions, decline in soil multifunctionality
- complicated agricultural utilization, increment in producing and investment costs
    - shorter duration for duly fulfilment of energy-safer agro technical activities in good quality (greater machinery plant demand, limited possibility for use of connected machine line, larger energy requirement);
    - rising watering and draining requirement
    - higher chemical fertilizer requirement (greater chemical fertilizer loss, weaker effects of chemical fertilizer)
- harmful environmental side-effects
    - cumulative drought sensitivity
    - increment in areas with inland and slack water, siltation of reservoirs and canals
    - rising surface run-off, increasing flood hazard
    - cumulative pollution of surface and subsurface waters
    - landscape destruction
- Accumulation of hazardous materials in food (food safety)

As far as the soil **acidification** is concerned it can be claimed that 20%, 18%, 8% of the soils in Hungary are weakly, moderately and strongly acid, respectively.
The main causes of the **soil acidification**:

- acid deposition
- acidification produced by industrial by-products and wastes
- imperfect chemical fertilizer utilization
    - Water solution of some chemical fertilizers is acid: superphosphate, ammonium sulphate
    - The cations of chemical fertilizers are adsorbed on the surface of colloid. During cation exchange protons can get to the soil solution, inducing acidity.
    - Chemical fertilizers can be neutral, acid and alkaline. The cause of it is: the plant takes up electrically charged forms of nutrients. The following materials generate acidity: ammonium sulphate, potassium chloride, potassium sulphate, ammonium chloride. The following materials generate alkalinity: calcium-nitrate, sodium-nitrate.

- Nitrification of the ammonia contributes to soil acidification.

Sodic soils or **secondary salinization** is typical of 10% of Hungary's territory (1 million ha) (Fig. 5). The soil is Solonetz if exchangeable Na ions exceed the 5% of the S value (weakly sodic: 5-10 %, moderately sodic: 10-20 %, strongly sodic: >20 %). The soil is Solonchak if total water soluble salt content is higher than 0.05 %.

The secondary salinization is brought on by improper human activities, mainly incorrect irrigation (inadequate water quality). The adverse effects of sodification or high salt content are:

- weak productivity
- alkaline reaction
- Na^+ dominance in the adsorption surface of soil induces formation of negative physical properties (siltation of sodic soil due to water, decrease in water permeability and water holding capacity)
- damage by inland water, bench formation
- cultivation difficulties both in dry and wet period
- mobilization and dispergation of clay minerals (Solonetz, formation of soloth soil)
- adsorption of phosphor as calcium phosphate
- reduction in activity of the microorganisms
- precipitation of essential microelements as oxide-hydroxide and their getting non-uptakeable for plants

Main objective in the future is to diminish the sodic patch areas in agricultural fields of high productivity; to find other functions for sodic areas impossible to reclaim economically. The conditions of these soils‘ reclamation are: to eliminate the activating and sustaining factors of sodification (shallow sodic groundwater, sodic irrigation and percolation water) with drainage; to facilitate leaching; to decrease the amount of adsorbed Na^+.

Physical soil degradation is a structural deterioration of soil (e.g. compaction, surface siltation, soil cracking, and disaggregation). According to surveys, 23%, 18%, 13% of the soils in Hungary are weakly, moderately, strongly sensitive to structural degradation, compaction, respectively.

Most soils have special structure. The mineral particles of solid phase strongly bind to each other by binding forces and materials, forming aggregates. Basic structural unit are composed of particles > 0.002 mm and organic, mineral colloids (< 0.002 mm) binding them. The most characteristic binding materials are: the organic materials (result in stabile soil structure); the clay minerals (have very important role in the structure building of loamy and clayey soils of poor humus content, result in unsteady soil structure); iron and aluminium hydroxides (e.g. in meadow and brown forest soils) as well as calcium-carbonates (e.g. in chernozems)

Modifying effects of soil structural formation:

- Frostbite – thaw (physical weathering)
- Swelling – shrinking (cracks of different section and depth caused by drying result in less and larger blocks in the soil)
- Root
- Soil cultivation methods (they cause complex effects)
- Exclusively mechanical pressure alone on the soil can not generate waterproof aggregates.

In Hungary, intense compaction could be observed on 50% of the arable lands (1.4 million ha) in 2000 (Birkás et al., 2000).

Activating factors of the compaction:

- Natural factors (e.g. abundant rainfall, inland water)

- Walking on the soggy soil, trampling
- Repetitive cultivation in the same depth (disk pan: 16-20 cm, plough plan: 22-25 cm, 28-32 cm, 38-40 cm).

The degree of compaction (mild, moderate, high) and extent of deformed horizons are dependant on pressure, frequency of deformation and soil moisture. In serious case, the compaction can expend both deeper horizons and the surface (Birkás et al., 2004., Gyuricza, 2001). The compact horizon deeper than 3-4 cm inhibits the plant cultivation.

Symptoms of “plough plan phenomenon” are as follows:

- exclusion of air from soil as three-phase system due to mechanical stress
- rise in bulk volume of the given soil horizon
- reduce in porosity
- decrease in water permeability
- hampered root development
- reduction in yield
- increment in cultivation expenditures.

The other type of soil degradation is the **dissagregation**. The cultivation methods (disk, harrow) in too dry soils disintegrate structural units, causing deflation. Macro-aggregates (>0.25mm) dominate in soils of good structure. The proportion of fine micro-aggregates (dust fraction; <0.25 mm) is increased in soils of degraded structure.

Agronomical conditions, namely the proportion of clod (> 10 mm), crumb (0.25-10 mm), and dust (0.25-10 mm) inform us on processes typical of regularly cultivated soils (Buzás, 1993). The soil is sensitive, degraded if proportion of the fine dust is > 25-30%. The high proportion of the crumb (75-80%) in the soil indicates good climatic stress tolerating ability. The rising dust and clod proportion (e.g. from 10 to 30-40-50%), and decreasing crumb proportion (e.g. from 70 to 50-40%) can be qualified as risky category (Birkás et al., 2010).

After 2 or 3 year-cultivation, topsoil suffering from disaggregation loses

- 10-30% of clay,
- 35-40% of humus matter,
- 35-40% of nitrogen,
- 10-12% of phosphor,
- 8-10% of potassium.

8.2. Soil degradation effects of agricultural activities on soil. Impact of chemicals on soil and groundwater

The elements in the soils can originate from more sources: geogenic, pedogenic and anthropogenic. In some cases (metallipher or serpentine soils close to ore deposits), entirely geogenic elements can exceed the soil limit values in force.

The anthropogenic pollutants can derive from *point* sources for exp.:

- Industrial areas (fuel tanks under surface)
- Communal waste deposit plants
- Accidents (e.g. road accident)

• *Non-point* sources:

- Sewage sludge, compost deposition
- Chemical fertilizers, pesticides
- Traffic
- Animal wastes
- Atmospheric deposition
- Sedimentation

The chemicals are widespread used principally in soil management and plant protection. The chemicals not only substitute nutrients (e.g. organic manure) uptaken by plants but induce their amount. **Nitrogen** run-off from the soils and flow into groundwater can be very **harmful for the environment**: it can cause the eutrophisation of surface waters on the one hand, or enhance the nitrate content of the water and drinking water in the wells on the other hand. Non-uptakeable quantity of **phosphor and potassium fertilizers** can leach and migrate with groundwater and pollute water in the wells, rivers and lakes; whereas the remaining amount can get to surface waters by deflation or soil erosion. Intensive chemical fertilizer use implies high calcium leaching and soil acidification in long run. Both mechanical and chemical plant protection has been intensified because of the significantly risen weed proliferation in the fertilized areas. Despite the foregoing disadvantages, chemical fertilizers can not be ignored over intense food requirements of humankind and consequent trace element and nutrient need of plants (e.g. carbon, hydrogen, oxygen, nitrogen, phosphor, potassium etc.).

The chemical fertilizers can contain different type of heavy metals. Most pollutants as additional material are mainly in superphosphate. The quantity of the pollutants depends on the sites. Disposal of these chemical fertilizers containing heavy metal contamination takes place only in small amount therefore it does not mean significant or potential risk for surface or subsurface waters. Their getting into these waters in considerable amount is possible only by soil erosion.

8.3. Agricultural utilization of the waste sewage sludge

However, the sewage sludge is used by some industrial branches (e.g. construction) but it is the agriculture that utilizes in the most amounts since the sludge having organic and mineral materials induces the soil productivity. Furthermore, it is obvious that agriculture would be the most suitable to utilize the great amount sewage sludge but the disposal can be inhibited by the high concentration of heavy metals (Hackler, 2007).

Quantity limitation in disposal of sewage sludge to the agricultural fields is not rational as based on the experiments, maximum disposable sludge is determined by not hidraulic or dry matter accumulation but the metals and nutrients transported into soil by silt (Vermes, 1997).

Favourable effects of the sludge on the soil properties (Vermes, 1997) are:

- enhances soil moisture, water holding capacity and organic matter in the soil
- reduces the bulk density and compaction of the soil
- induces nutrient content uptakeable for plants
- increases soil cation exchange capacity due to its organic matter, thus the sludge helps in adsorption of heavy metals
- activates microbial activities owing to large number of microorganisms so it contributes to formation and stimulation of soil biota

Majority of phosphor and nitrogen transported into the soil by silt accumulate in the upper cultivated horizons. In accordance with experiments, it can be claimed that nitrate and nitrite content increases even in the deeper horizons owing to the rising sludge. Nitrogen run-off and metal accumulation can be detected parallel to more significant load (Vermes, 1997).

Evaluating experiments on sewage sludge disposal during 10 years, (Juste and Mench, 1992) concluded that heavy metals originated from sludge accumulate in the upper horizons and their mobilization towards the deeper horizons is negligible. Regarding results of the national experiments, it can be established that the sewage sludge in Hungary can contain Zn, Cr, Mn, Pb but metal concentration of harmful amount can not be detected either during long disposal if the sludge disposal guidelines are met (Tamás and Filep, 1995).

In the case of agricultural sludge disposal, the main objective is not the utilization but continuous, safe disposal. Consequently, utilization of sewage sludge is not agricultural task but agriculture can assure relatively economical treatment of the environmental problems (Vermes, 1998). **Government decree** No. 50/2001. (IV. 3) and **40/2008. (II. 26.)** discloses the rules of agricultural utilization and treatment of sewage sludge. The goal of the agricultural utilization of the waste water and sewage sludge is to be a professional and not to exert detrimental influence on environmental spheres, plants, animals, human organisms.

8.4. Soil pollutants of traffic and industrial origin

The environmental compartments (e.g. air, water, soil etc.) of cities and industrial districts are well-known to contain **heavy metals in enriched amount**. The environmental researches have focused on heavy metals recently since these pollutants can biologically not be decomposed, thus, they can **accumulate** in the soil and living organisms.

The investigations more than 30 years ago revealed that some metals could accumulate along the roads with heavy traffic. Nowadays the extensive researches on metals along the roads and their relation to traffic and additives in the fuel are widespread. Several studies aimed at the accumulation depth, adsorption and mobilization forms of the metals in the soil. Furthermore, other researches focused on the question, which plants and plant parts could accumulate the heavy metals and how the metals could enter the soil-plant-animal-human food chain.

Not only toxic elements (e.g. cadmium or lead) can accumulate causing environmental pollutions but essential micro- and macro elements, as well (Szabó, 1998). Even the essential elements can generate toxic symptoms if they accumulate in the given organism higher concentration than the normal one (Láng, 2002). This limit concentration of elements is very variable: some elements have relatively wide range of the optimal concentration (macro elements), whereas the others have very narrow range (micro elements). The non-essential elements below critical limit concentration have not taken effect, but they are toxic above that.

Majority of the investigations have concentrated on **lead pollution** along the road as on the one hand this metal’s toxic character is well-known from the viewpoint of human and animal health, on the other hand lead was used to be added worldwide to petrol as antiknock agent. Consequently, extreme quantity of the lead could be emitted into the atmosphere. Lead salts and metal-lead can accumulate along roads during combustion of typical antiknock agents (tetra-ethyl lead and tetra-methyl lead) in the engine (Árkosi and Buna, 1990). Not only lead but other metals can originate from traffic: **copper, zinc** from brake pads during wear processes of surfaces, **cadmium** from tire wear and wear processes of some metal parts in the car (Csathó, 1994). Therefore, the above-mentioned metals can deposit, precipitate and run-off along the roads so extreme metal concentrations can be detected in the roadside soils or on the hard shoulders. The metal content in the soils and plants has progressively decreased with distance from the road. There is linear relationship between lead content in the roadside soils and vehicular traffic (Árkosi and Buna, 1990). The degree of lead load depends on speed of the vehicles: the more the speed, the more significant the fuel consumption (Fiedler and Rösler, 1993). However, the lead concentration in the environment mainly depends on the amount of fuel additive. Consequently, MOL Hungarian Oil and Gas Company (MOL Plc.) put into the market the unleaded petrol of octane number 95 and 98 in 1996 and 1997, respectively. Ultimately, the sale of the leaded fuel was banned in 1999 (Naszradi et al., 2003).

9. Assessment of soil pollution based on soil properties. Limit value systems

A material (elements, compounds, organic compound) **is considered to be toxic** if it has harmful effect on the soil, plant, animal or human. The toxic – essential character of the given element, the degree of the given soil or water pollution is concentration-dependant.

Effect and toxicity of the given element might be modified and mitigated by other element/material. Some elements, the so called **antagonist elements** prevailing among other ones inhibit their absorption (secondary deficiency). One of the most significant antagonist elements is Ca that hampers absoption of Zn, Cu, Mg (other antagonist examples: Cu-S, Se-S, Zn-Cd). The toxicity depends on **exposure time** (long-term or acute load). The **pollutant form** (for exp. methyl mercury compounds are severely poisonous but the HgS is insoluble, neutral material); **oxidation degree** (CrIII is not poisonous, but CrVI is very carcinogenic, strong poison,); **persistence** (the resistance against natural decomposition) are decisive in the assessment of the pollution. The more persistent (e.g. polycyclic aromatic hydrocarbons, chlorinated hydrocarbons) a compound is, the more probably it accumulates in the environmental compartments and finally enter the living organisms. The heavy metals have not degraded at all. It is very relevant to know the way of exposure (ingestion, inhalation, derma contact or else). Last but not least even the environmental factors can modify the effect of the given pollutant.

About 90% of the elements can assign into trace elements the concentration of which is 0.1 by weight (< 1000 g/t, ppm). Majority of heavy metals possessing higher mass density than 5 g/cm^3 (their atomic number: 23-32, 40-51, 57-84 and 87-106) belongs to trace elements. 12 element of them are especially investigated: Cd, Cr, Co, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sn, Zn. Nowadays a wide number of research works regarding Cd, Hg, Ni and Pb as potential pollutants.

Table 9.1 Potential toxicity and physiological significance of some elements in the plant and the animal (Applied abbreviations: E_p = essential for plants, E_a = essential for animals, T_p = toxic for plants, T_a = toxic for animals) (based on Merian, 1984)

	E_p	E_a	T_p	T_a
Al			*	
Cd			*	*
Co		*		
Cu	*	*	*	*
Fe	*	*		
Mn	*	*	*	
Ni		*	*	
Pb			*	*
Zn	*	*	*	

Some of the trace elements are essential for the plant and animals (Table 9.1). An element is essential in the case of the plants (mainly higher plants) if its lack causes abnormal growth or destruction of the given plant. Effect of an essential element can not be substituted by other one;

its supplementation can eliminate the deficiency disease (Kádár, 1991). The above-mentioned criteria can refer to the animals, too. The potential toxicity and physiological significance of some elements can be seen in table 5.1.

Even an essential element can be toxic in super-optimal concentration, and generate destruction in the metabolism of the organs in the plant, animals and human. The optimal concentration can be very narrow in the case of some element (e.g. Mo, B). The non-essential elements below the critical concentration have not had effect, whereas those above that one unambiguously are toxic. The elements were divided into three groups based on their toxicity in 1966 by Bowen (Csathó, 1994):

- High toxic elements have already damaged test plants below 1 mg/l concentration (e.g. Ag, Be, Hg, Sn)
- Moderate toxic elements have already damaged test plants between 1-100 mg/l concentration (e.g. As, Cd, Cr, Fe, Mn, Zn)
- Slightly toxic elements have rarely damaged test plants above as high as 1800 mg/l solution concentration (e.g. Cl, Br, Mg, K).

In most cases, the soil-plant system blocks entering of the toxic elements in the food chain in toxic concentrations. The plant development significantly slows down or stops before these elements can attain such concentration in plant organs that is toxic for the animal tissue. Some soil properties can promote immobilization of the potential toxic elements. Therefore, in the case of soils polluted by heavy metals, it is very important to pay more attention to these properties during establishment of the tolerable limit values (Table 9.2) (Fiedler and Rösler, 1993).

Table 9.2 Tolerable Cd, Zn and Pb content in the soils polluted by metals depending on different soil properties (based on Fiedler and Rösler, 1993)

pH	5				7			
Clay content (%)	10		30		10		30	
Organic matter (%)	1	3	1	3	1	3	1	3
Cd (ppm)	0.3	0.9	0.9	2.7	0.4	1.3	1.3	3.8
Zn (ppm)	30	90	90	270	40	130	130	280
Pb (ppm)	100	300	300	900	140	420	420	1260

In Hungary, limit values in force of the heavy metals is implemented by *KvVM-EüM-FVM joint decree 6/2009. (IV.14) on protection of quality of groundwater and the geologic medium.* The limit values in this decree have to be regarded during the classification of the pollutions on the geologic medium. The following categories can be distinguished in accordance with the government decree 219/2004. (VII. 21) (on protection of groundwater):

- ✖ **Utilization limit value:** “level of discharge to the environment or any natural resources as stipulated in a legal regulation or an official decision that – relying on available scientific data – is likely to cause damage to the environment if exceeded”.
- ✖ **Emission limit value: “**level of emission to the environment or any natural resources as stipulated in a legal regulation or an official decision that – relying on available scientific data – is likely to cause damage to the environment if exceeded”.
- ✖ **Pollution limit value: “**level of pollution of any component of the environment – as stipulated in a legal regulation – that, if exceeded, may, on the basis of the current scientific knowledge, result in environmental damage or health impairment”.

The decree involves limit values and background concentration that has to be considered to be guidelines till real background concentration in the given area had been determined. Definitions can also be found in the annex of this document:

(A) **Background concentration**: is a representative value which expresses the general concentration of particular substances in groundwater or soil under natural or close to natural conditions.

(Ab) **Verified background concentration**: means an actual concentration of a given substance indicated in groundwater or in the geological medium determined by measurements and to be applied instead of background concentration *(A)*, that is specific for the given area and resulted from natural conditions or as a consequence of diffuse pressure, pollution or pressure affecting groundwater or the geological medium throughout surface water, not associated with the pressure under examination. This value is determined by Environmental National Inspectorate for Environment, Nature and Water during the authorization or remediation.

(B) **Pollution limit value** means the concentration of pollutants due to which the groundwater and the geological medium is to be qualified as polluted, taking into consideration drinking water quality standards and the needs of aquatic ecosystems in the case of groundwater, and the multifunctionality of soils and the sensitivity of groundwater to pollution in the case of the geological medium.

Table 9.3 Pollution limit value of the metals and semi-metals in the geologic medium (unit: mg/kg dry material) (A = background concentration; B = pollution limit value; *d = detection limit value)

	A (mg/kg)	**B (mg/kg)**
Cr total	30	75
Cr(VI)	*d	1
Co	15	30
Ni	25	40
Cu	30	75
Zn	100	200
As	10	15
Se	0,8	1
Mo	3	7
Cd	0,5	1
Sn	5	30
Br	150	250
Hg	0,15	0,5
Pb	25	100
Ag	0,3	2

(Ci) **Intervention pollution limit value**: Risk substance concentration level set forth in a special act of legislation. In cases, where this limit is exceeded and no special pollution limit value (E), or remediation limit value (D) applies, the competent environmental authority (inspectorate) is obliged to intervene. (C1 = especially sensitive, C2 = Sensitive, C3 = Less sensitive area).

(D) **Remediation target limit value** means the concentration prescribed in an official ruling to be achieved by remedial actions with the aim of preventing any damage to human health, ecosystem and environmental elements. This value is to be determined on the basis of a complex assessment carried out as part of the remediation procedure, including measurements of pollutant distribution in environmental elements, its behavior, transport and extent as a well as modeling and site-specific quantitative risk assessment carried out with regard to the land uses.

The joint decree 6/2009 (IV.14) on protection of quality of the geologic medium contains the pollution limit values of the heavy metals (Table 5.3).

Some **soil properties** (e.g. pH, clay content and humus content) **are decisive for metal's mobilization** in the soil. One of them, pH is especially relevant parameter since mobile ion concentrations rises due to the soil acidification. It can be rather dangerous in the case of basically polluted soils as insoluble metal compounds can mobilize and cause serious environmental problems owing to acidification (Stefanovits et al., 1999). The organic matter has a very essential property in metal mobilization because of its metal adsorption ability. During the soil pollution's environmental assessment, it is indispensable to have respect for not only the total metal content but the mobile resource and soil properties, as well.

10. Environmental and human health risk of polluted soils

The **risk estimation** is collection, systematization, analyze, integration of scientific data by which the harmful potential effects of chemicals on the environment and human health can be evaluated (Németh, 2001). The **risk** is probability of damage of the health, the environment or material needs considering the character and extent of the damage. In the environmental practice, after a given pollution, it is necessary to assess exactly the extent of the pollution in the given medium (e.g. soil, groundwater) and the degree of risk to other environmental compartments or human. The main objective of **environmental and human health risk estimation** is to assess probability and extent of adverse effects of the chemicals on ecosystem or human using indices. All these provide a base to environmental practice for exp. in the selection of remediation technology to be applied and realization of limit values.

Necessary data to **estimation using risk indices:**

- Environmental concentration
- Environmental effect (given by approximate count)

Most risk estimation **method applies staged (step-by-step)** guidelines. In general, there is qualitative risk estimation before the quantitative one. If further estimation stages are necessary after the former two ones, even the site-specific risk estimation has to be carried out. The risk estimation of the soil and groundwater pollution can be executed according to the following stages:

I. Descriptive, comparative *Qualitative risk estimation* (evaluation of the risk factors in text form)

II. *Quantitative, general risk estimation* is carried out in order to provide limit values as guideline or normalized values, considering standard exposure conditions.

III. *Quantitative site-specific risk estimation*

- The site-specific measurements have to be carried out in order to determine the site-specific remediation target value.
- In the practical viewpoint, calculations can be realized in two different ways. During the “advancing calculation”, degree of the risk of the ultimate bearer is defined starting from pollutions measured in different environmental compartments.
- During the “backward calculation”, the permissible concentration of the dangerous material in the given polluting source is counted starting from permissible risk level of the ultimate bearer (remediation limit value: D value)

The estimation of human health risk can divide into four phases. In the phase the “**data collection and chemical analytic**” (1), the polluted area is described with the determination of concentration and magnitude of hazardous materials in the environmental compartments. In this phase, utilization of the given area and the relevant human bearers of the effects are identified. During the “**identification of exposure”** (2), predictable average daily intake is determined with measured or estimated concentrations considering potential bearers of the effects. During the “**investigation of dose-response relationship”** (3), response by the ultimate bearers of the effects is presented using results of some toxicological experiments on dose of pollutants. Non-toxic doses and describing models of carcinogen risk are given, too. In the end, in the phase of the “**risk estimation**” (4), results of the exposure and dose-response investigations are compared to each other and extent of the risk can be defined (Németh, 2004).

The main question of decision makers and researchers dealing with quality of soil and groundwater is what extent the acceptable risk is during the risk estimation. The environmental risk is separately defined depending on the carcinogen or non-carcinogen character of the chemical. **Health risk quotient** (HRQ) is ratio of the average daily intake (ADI) (assessed exposition of chemicals with deterministic effect) and tolerable daily intake (TDI) of the pollutant (Dankó et al., 2004). **Environmental risk quotient** (ERQ) can be given with the help of the following formula:

ERQ = PEC/PNEC

- PEC (Predicted Environmental Concentration)
- PNEC (Predicted No-Effect Concentration): predictable concentration not damaging the ecosystem

Risk quotient can be classified based on the following Table 10.1:

Table 10.1 Qualification of the health risk quotient (Dankó et al., 2004)

Risk quotient	Qualification
< 0.01	negligible
0.01 - 0.1	low
0.1 - 1	moderate
1 - 10	high
> 10	very high

There is no safe dose of the carcinogenic chemicals since any slight exposure enhances the probability of tumorous diseases. The commonly accepted range of these chemicals' risk is between 1:10.000 and 1:1.000.000-ig (10^{-4} - 10^{-6}). This accepted risk level means that by exposure of a quite large population to pollutant of the given dose 1 lethal cancer case out of 10.000 or 1.000.000 persons occurs. This cancer however can be caused by many other factors (genetic factors, background radiation, other chemicals in the environment, etc.), as well (Dankó et al., 2004).

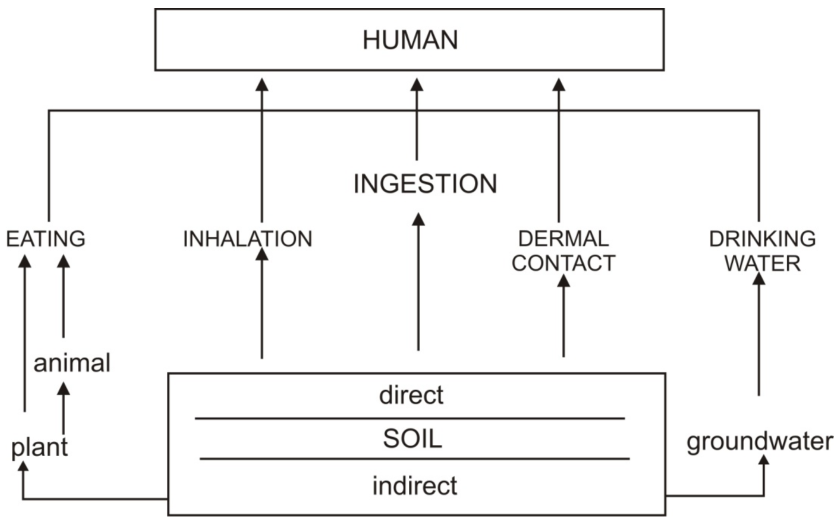

Figure 10.1 Heavy metal load: exposure ways to human

Identification and quantification of the exposure ways play key role in the prevention, control and reduction of the health deterioration and ecosystem damage induced by chemicals. The exposure can be defined as the contact between a chemical and an organization. A target organism can be considered to be exposed if the chemical pass limit between the environment and the organism and get into target point (cell, cell compartment) (Dura et al., 2001). The exposure ways of soil pollution with metals can be seen in the Figure 10.1.

The risk estimation can be executed using some programs of high data requirement, too. These models describe mobilization and migration of chemicals between the different environmental compartments. The input data of risk estimation software can be for exp. identifying and characterizing parameters of the study area; the physical, chemical properties of the pollutants; exactly measured pollution values; information necessary to compute exposure routes (Gondi et al, 2004). **Program RISC 4.0** can be used in risk estimation, in preparing transport models and risk analysis for human health in the case of contaminated area. The methods of this program are based on risk estimation guidelines of US EPA (exposure assessment, toxicity survey, risk estimation) (Risk Assessment Guidance for Superfund - US EPA, 1989). This program can manage the measured pollution data of each environmental media and directly count the risk quotients (www.jaketa.hu).

Main scopes:

- Estimation of human health risk due to the environmental elements (soil, water, air)
- Assessment of the remediation limit values based on risk
- Creation of simple transport models
- Estimation of the potential ecological effects on surface waters and sediments
- Management and storage of the environmental data and the limit values

The each step can be followed with the help of a logically constructed menu system demonstrated in Fig 6.2.

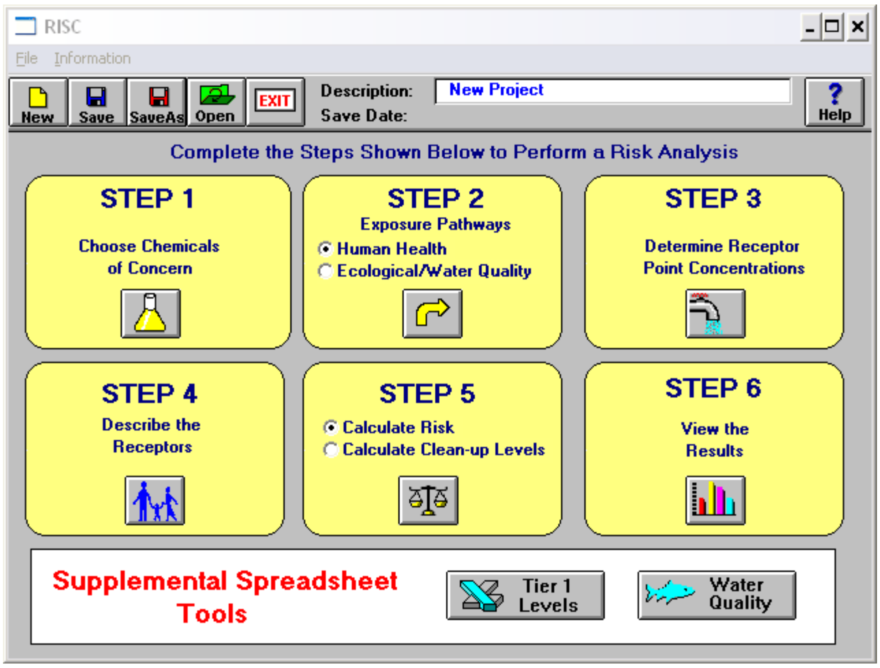

Figure 10.2 Front page of RISK 4.0

Following steps in menu system, the essential chemicals can be selected in step 1 of the (Figure. 10.2). In the RISC we can choose among 86 frequent chemicals the physical, chemical and toxicity data of which are available. The database of the chemicals can be broadened.

Step 2 Definition of exposure pathways.

Exposure scenario can be defined with selection of the pollutants, the transport models (if necessary) and the exposure ways. In this step, ecological or water quality effects can be evaluated, as well.

Step 3 Definition of exposure point concentration.

Receptor-point concentrations can be determined with two types of methods based on the medium given in step 2: the user can give directly point-concentration or source-zone concentrations, then receptor-point concentrations are estimated by the program using transport model.

Step 4 Inputs on surface water and sediment.

The receptors and their typical input parameters have to be chosen. The calculation can be applied to default data or own ones. Data referring to the given area can be input, as well.

Step 5 Calculation of risks and remediation limit values.

The potential carcinogen or non-carcinogen risk indices can be counted using equations given in the risk estimation guidelines of EPA (Risk Assessment Guidance for Superfund - EPA, 1998)

Step 6 View of the results.

The user can give the target risk or risk index for some chemicals or cumulative scenarios representing accumulated risk of the chemicals. The risk, carcinogen indices and input data and their diagram can be observed (www.jaketa.hu).

11. Change in proportion and range of withdrawn land in Hungary

Only 11 percent of land surface of the Earth is arable land. The EU average is nearly 30 percent whilst this value in Hungary is more than 60 percent. Arable land is the most significant renewable natural resource of Hungary, reaching nearly the one third of all renewable resources. Out of the total 9.3 million hectares of Hungary, the potential agricultural area is 7.72 million hectares; while the total cultivated area is around 5.81 million hectares (KSH, 2007). These data also indicate that Hungary is rich in good arable lands.

Due to the unfavorable land policy of recent days, however, the amount of arable land has decreased from 8.24 million hectares (1990) to 7.72 hectares (2007) (KSH 2007). The extent of the withdrawn land has been increasing yearly regarding a longer period. The annual extent of the withdrawn land is 9000 hectares and 15000 hectares between 1950 and 1990 or between 1990 and 2007, respectively.

Soil resources of special importance among natural resources necessitate its rational utilization and protection. Improper utilization depletes not only the soil but the surface and subsurface waters, troposphere and the biota, too. Soils are endangered by degradation processes also naturally, but these processes are enhanced by urbanization, industrial-, infrastructural-, and recreation activities, mining and waste disposal. Former mentioned ways of soil degradation mean physical elimination because these soils can not be reproduced by any pedological method and can not be cultivated any longer (Megyes, 2006).

Many EU documents dealing with soil utilization aimed at the following principles: (1) the soils have to be cultivated regarding the ecological aspects and (2) the soil protection has to be integrated into policy especially in the case of agricultural-, sylvicultural-, mining-, industrial-, touristic-, transport- urban planning- and spatial planning policies.

The first and the most important document in this topic is European Soil Charter ratified by the European Council in 1972 the expanded version of which came into force as Revised Soil Charter in 2003. The aim of Charter is the protection of soils against degradation caused by natural or anthropogenic impacts. Some principles about soil withdrawal established by Charta are as follows:

The section 3 establishes: „Industrial society uses land for agriculture as well as for industrial and other purposes. A regional planning policy must be conceived in terms of the properties of the soil and the needs of today's and tomorrow's society."
This statement expresses the principle of sustainable development.

The most important establishments of section 7 are: „Urban development must be planned so that it causes as little damage as possible to adjoining areas. Towns obliterate the soil upon which they stand and effect neighboring areas as a result of providing the infrastructure necessary to urban life (roads, water supplies etc.) and by producing growing quantities of waste which must be disposed of. Urban development must be concentrated and so planned that it avoids as far as possible taking over good soil and harming or polluting soil in farmland and forest, in nature reserves and recreational areas."

According to section 12: "Governments and those in authority must purposefully plan and administer soil resources. Soil is an essential but limited resource. Therefore, its use must be planned rationally, which means that the competent planning authorities must not only consider immediate needs but also ensure long-term conservation of the soil while increasing or at least maintaining its productive capacity. A proper policy of soil conservation is therefore needed, which implies an appropriate administrative structure necessarily centralised, and properly coordinated at the regional level."

12. Features of technogenic and anthropogenic soils

In the past, research into the physical and chemical properties of soils focused on natural soils; urban soils were almost totally neglected. The investigation of urban soils has only become a focus of scientific research during the past few years. Due to increasing urbanization and industrialization, human activity results in soil contamination, degradation, destruction, and soil formation from anthropogenic parent materials. Consequently, it is necessary to study these modified soils.

The urban soils have soil material having non agricultural man–made surface layer more than 50cm thick that has been produced by mixing, filling or contamination of land surface in urban suburban areas (Bockheim, 1974).

During urbanization and its renewal, the landscape is reshaped, filled, or cut. This modification of the topography creates man-made land in cities (Spirn, 1984). After the land withdrawal different landscaping works are carried out depending on the desired goal. Consequently, various morphological forms (excavated, accumulated plain) can be observed in the citywide (Szabó, 1993). These soils have an urban diagnostic horizon having special characteristics (e.g. poor soil structure, high amount of arefacts) as a surface organo-mineral horizon resulting mixing, filling burial or pollution (Stroganova and Prokofieva, 2002).

Compared to natural soils, the **anthropogenic soils** in the soils can be characterized with horizontal and vertical variability in some properties (e.g. texture, structure, colour, humus content, pH, bulk volume, water holding capacity, productivity etc.). Properties in most natural profiles gradually grade from one horizon to the next lower one, while ones in urban profiles show abrupt changes from one layer to another depending upon the constructional history of the given soil. Consequently, the original multifunctional role of these soils is gradually lost; they are no longer capable to fully fulfill the functions of natural soils. Soil transportation, topsoil scraping (A or sometimes even B horizon) due to landscaping works vertically modify whole the profile, reduce in the soil nutrient supply- and water holding-, buffer capacity, structure stability, and hereby these soil can not achieve the multifunctionality.

Patterson (1976), Craul, Klein (1980) and Simpson (1996) summarized the effects of urbanization and anthropogenic activities on soils:

- Disappearance of soil layers (e.g. sealing, transportation etc.)
- Great vertical and spatial variability
- High amount of artefacts
- Altered soil structure, compaction, physical degradation, decreased amount the pores
- Limitation of water regime, and airing in the soils
- Modification of the organic material decomposition speed and nutrient amount uptakeable by plants; low amount of humus content does not facilitate the aggregation formation
- Various soil chemical properties
- Accumulation of the organic and inorganic pollutants in the soils

13. The soil as to be protected value. The “red book” of the soils

As shown in the previous chapters, it is evident that natural soils have gradually shrinking on Earth, which fact draws our attention to importance of the **soil conservation**. The main task of the soil conservation is to protect the soil values. Consequently, it is necessary to create scientific background (elaboration of evaluation system and National Cadastre of Soil Values, as wide scientific processing as possible) and conservation methods (demonstration of the soil values under national condition, in situ and ex situ conservation).

The **“natural soil types”** belong to the biodiversity similarly to some elements of an ecosystem or the biosphere their conservation is also very relevant and their “obliteration” and “disappearance” are general phenomena.

The soils can be categorized into endangered and non-endangered groups. According to aims of the “red list”, it can be claimed that categorization has not regarded the effects of interventions but provides value of the protection determined by specialty, rarity and functions of the given soil (Bosch, 1988).

The soil conservation came into force **in Great Britain** in the 70s, whereas **in Russia** “Red Book of Soils” was realized in 1989; the goal of which was the scientifically confirmation of the legal protection of the valuable soil formations How could Hungary survey soil values eligible for protection? It is necessary to ***make scientific background*** that means the followings:

- Elaboration of the ***evaluation system***, systematic calculation of the soil values
- Compilation of the ***National Cadastre of Soil Values***
- ***As wide scientific processing as possible*** in the case of the given soil (e.g. monitoring of changes in soil conditions)
- Scientific elaboration of the ***sustaining*** possibilities and methods.

What does “soil value” means?

Special soils*:*

- soils not classifiable into taxonomic categories that are formed by some **special, rare soil-forming processes under natural conditions**
- soils classifiable into taxonomic categories but having **special features thank to some non-soil forming processes** (e.g. cryoturbation)
- **soils originating from former geologic ages** that can provide scientific information on soil processes and environmental conditions of the given age

Typical soils

- ❖ These well-known soil formations can be found in Hungary nowadays. The “tipicity” means that the processes and the environmental conditions creating the formations are characteristic of the given area. Typical formations are less sensitivity to visiting; therefore they are suitable for demonstration and hereby have outstanding educational and training functions, too.

Characteristic soils

- ❖ Peculiar soil in Hungary that either do not occur elsewhere or it do not in this form (e.g. sodic soils)

Rare soils

- ❖ Globally unique soils (e.g. periglacial drop soil in Atkár)

There has not been universal, accepted definition for criteria of soil to be protected in Hungary. The indicators in the “Red List” criteria have to be considered to be as “or criterion” because of the heterogenic basic data and overlapping of evaluation content (e.g. rarity and oligotrophia): if a criterion meets the requirements in the case of a given soil then this soil can be qualified as “red-list soil” (Bosch, 1988).

Rarity

A soil can be considered to be rare if it can be observed only in some areas. Rarity of the soils has to be evaluated individually. There is a list about these soils that helps the evaluation (Bosch, 1988).

Naturalness

(Semi-)Naturalness of a soil can relatively easily be evaluated in accordance with structure of soil profile. Deviation from the natural status can be induced by the following processes:

- Profile deconstruction by erosion
- Covering of the profile by sedimentation or anthropogenic material
- Profile deconstruction by cultivation

Water regime

These hardly utilizable soils having extreme water balance should be put into the “red list” immediately owing to their rarity and high naturalness. Furthermore, special biomes as biotope are entitled to be highly protected. Related to the soil protection, not the characteristics of bioconosis to be protected but the potential of formation of endangered bioconosis is relevant depending on the land use management.

Soil and natural heritage

Soil preserves important information about past human activity, and therefore, it is also part of the cultural heritage. Caused by this fact, it is the duty of heritage conservation and its relevant authorities to protect, also by special legal protection if necessary, this heritage. Therefore, it is terminological question whether the individual soil heritages have to be included into “red list”, or not. This is a reasonable question since these soils are not natural or semi-natural so they might be out of the list from this aspect. However, the “red list” contains such areas where the organic matter types formed during cultivation are not part of the original bioconosis, and thus, the species composition and by this the genetic information of cultural landscape are the values to be protected (Bosch, 1988).

In addition, even the special soil formations can be declared as part of soil heritage. Nowadays, there are lists of these separated individual cases, as well.

Classification of the soils to be protected in accordance with Tardy and colleagues (2005):

Fossil soil profiles are generally located in some excavations (e.g. sand mine) or walls of gullies. The soil processes (soil frost, cryoturbation, frost wedge Kerecsend) in former geologic ages (Holocene, late Pleistocene) or buried soil (e.g. Mende, Basaharc) can be set into this category.

Recent soils and have to be protected not because of their outstanding value or rarity but as the excellent examples of the zonal and azonal soil types situated in Hungary. Thus, it is important to create these objects as a spot of the education. Such excavations can be established where there is possibility to demonstrate the different soil-forming processes, litho- and water effects relating to presentation of the other local conservation values.

Peculiar and spectacular soil profiles for exp. “kovárványos” brown forest, or profiles with calcareous and iron concretions, crotovinas or other features of special soil processes can be exhibited.

The methods of soil values’ conservation
- „in situ” conservation
- „ex situ” conservation (the soil formations of high value in soil monolith collections)
- demonstration of the values under natural conditions, which would support the real conservation

14. Exercises, questions

14.1. **Role of soil in the system of environmental compartments**

1. Which spheres border soil?
2. What means the multifunctionality of the soil?
3. List the functions of the soil.
4. List the tasks of the government in soil conservation in accordance with Land law 1994/LV.
5. What soil conservation duties have to be fulfilled by a land owner based on Land law 1994/LV ?
6. What kind of parts do „Preliminary and Summary Environmental Report" have to contain regarding the *Act 1995 - LIII on the General Rules of* Environmental *Protection*?

14.2. **Evaluation of our soils in the 21st century: Land evaluation, land valuation**

7. What are the criteria of a best land evaluation system?
8. When was the national Hungarian land evaluation system, the so called „gold crown" (in hungarian aranykorona) system created?

A/1700 B/1875 C/1945 D/2001

9. What are the most significant weaknesses of the presently used Hungarian land evaluation ("gold crown") system?
10. Complete the following sentences.

The parts of the **"Hundred point"** land evaluation system are: soil evaluation numbers +…………………….+ economical agents.

11. What does productivity number in "Hundred point" land evaluation system mean?
12. What kinds of productivity levels can be differentiated?
13. Define the following term.

Potential productivity: ………………………………………………………..
Actual productivity:……….……………………………………………………..
Base productivity:………………………………………………………………..
Optimal productivity:……………………………………………………………

14.3. **Soil properties and their classification in accordance with their temporal variability**

14. Processes in the soil make pairs with their counterparts. Complete the following processes with their counterparts.

organic matter accumulation	-	…………………
……………….	-	salt accumulation
……………….	-	clay dispergation
lessivage	-	…………………

……………….	-	reduction
acidification	-	…………………
structural formation	-	…………………

15. Write an example of periodically changing soil properties.
16. Which one is not correct? Soil property changing following a trend is, for example

A/ organic matter accumulation,
B/ clay formation,
C/ soil moisture change,
D/ lessivage,
E/ salt accumulation.

17. Which one is not correct? Soil property changing in some months run (seasonal changing property) is, for example

A/ density,
B/ biological activity,
C/ salt content,
D/ pH,
E/ mineral composition.

18. How long has TIM (Soil Information and Monitory System) been operating in Hungary?

A/1850 B/1992 C/1999 D/2002

19. How many monitoring points does the TIM have?

A/5000 B/1200 C/40 D/400

20. List the S (special) points of TIM.

14.4. Effect of human activities on soils. Soil degradations, qualitative and quantitative deterioration of soil. The physical, chemical and biological degradation of soils

21. Complete the definition.

Soil degradation is a complex process that results in ………… or *irreversible changes* in soil properties and processes in the soil; ………… of soil decreases and restricts the normal………………....

22. List sodification stricken geographical regions of Hungary.
23. List the most significant soil degradation processes.
24. How many percent of Hungary owns soil erosion?

A/1% B/15% C/45% D/5%

25. List the main causes of the soil acidity.
26. Complete the following sentence.

Sodic soils or secondary salinization can be found on …… million hectares of Hungary (……. % of the total country).

27. List the harmful effects of sodification and high salt content.
28. Complete the following sentence.

The soil is Solonetz if exchangeable Na ions exceed the………. % of the S value. The soil is Solonchak if total water soluble salt content is higher than ……. %.

29. What kinds of processes belong to soil degradation?
30. List the most important binding materials in structure formation of the soil.
31. How many percent of Hungary owns soil density according to the estimations?

A/10% B/30% C/50% D/90%

32. Select ones indicating "plough pan phenomenon" of the following sentences.

A/ exclusion of air from soil as three-phase system due to mechanical stress
B/ decrease of the bulk volume in the given horizon
C/ increasing porosity
D/ decreasing water permeability
E/ hampered root development
F/ decrease in yield
G/ increase in cultivation expenditures.

33. Find the mistake in the following statements about soil structure.

Macro-aggregates >10 mm dominate in soils of good structure. The proportion of fine micro-aggregates (dust fraction; < 0.25 mm) is very *low* in soils of degraded structure.

34. List some *point* source of soil pollution.
35. List some *non-point* source of soil pollution.
36. List the potential adverse effects of chemical fertilizers on environment and soils.
37. Which regulation summarizes the rules of the agricultural utilization of sewage sludge?
38. Mark traffic originating elements of soils along streets.

A/Cd B/Pb C/Zn D/Ca E/N F/Cu

14.5. Assessment of soil pollution based on soil properties. Limit value systems

39. What means that the essential - toxic characteristic of the given element is **concentration dependent**? List some examples.
40. List some examples for elements with antagonistic effect.
41. Complete the following text.

……………..characteristic, the persistence has very important role in the assessment of the given pollutant. The persistence means resistance to………………. The more persistence a compound is, the more probably it will………………in the environment and enter the living organisms.

42. Mark the toxic elements both for plants and animals.

A/ Cd B/Pb C/Cu D/Zn E/Ni

43. Complete the following sentence.

About 90% of the elements can assign into trace elements the concentration of which is ………. by weight (<…..g/t, ppm). Majority of heavy metals possessing higher mass density than ………. g/cm^3 belongs to trace elements, as well.

44. Which soil properties exert influence on immobilization of the given toxic element in soils?

A/ pH
B/ depth of tilth
C/ humus content
D/ clay %
E/ colour

45. Which regulation comprises *limit values on protection of quality of groundwater and the geologic medium?*
46. What does *emission limit value* mean in accordance with government decree 219/2004. (VII. 21) (on protection of groundwater)?
47. What does *utilization limit value* mean in accordance with government decree 219/2004. (VII. 21) (on protection of groundwater)?
48. What does *pollution limit value* mean in accordance with government decree 219/2004. (VII. 21) (on protection of groundwater)?

14.6. Environmental and human health risk of polluted soils.

49. List the potential human exposures in the case of metal soil pollution.
50. Delineate staged (step-by-step) guidelines applied during risk estimation of soil and groundwater pollution.
51. Complete the following definition.

The health risk quotient (HRQ) is ratio of the average daily intake (ADI) (assessed exposition of chemicals with deterministic effect) and ……………………... of the pollutant.

52. Environmental risk quotient (ERQ) can be given with the help of the following formula: ERQ = PEC/PNEC**.** What do PEC, PNEC abbreviations mean?
53. How can the risk be classified in accordance with HRQ?
54. Which software can be used for human health risk estimation?

14.7. Withdrawal and other uses of arable lands. Tendencies in Hungary.

55. What guidelines did European Soil Charta introduce in order to mitigate land withdrawal?
56. How much arable land does Hungary have?

A/ 5000 ha B/ 1 million ha C/7.7 million ha D/100 000 ha

57. How many percents of arable land in Hungary is withdrawn land?

A/ 10% B/ 1% C/51% D/17%

14.8. Features of technogenic and anthropogenic soils

58. Complete the following sentences with the right terms.

Compared to natural soils, the anthropogenic ones are characterized with significant changes in their vertical profile. The transition between horizons of the natural soils is ……………..; …………… changes in texture, structure, humus content, pH, bulk volume, water permeability, fertility are typical of anthropogenic soils.

14.9. The soil as to be protected value. The “red book” of the soils.

59. List some special soils.
60. Write some examples of typical and rare soil formations.
61. What are the methods for conservation of soil values?