

ENVIRONMENTAL PROPERTIES OF THE SOIL

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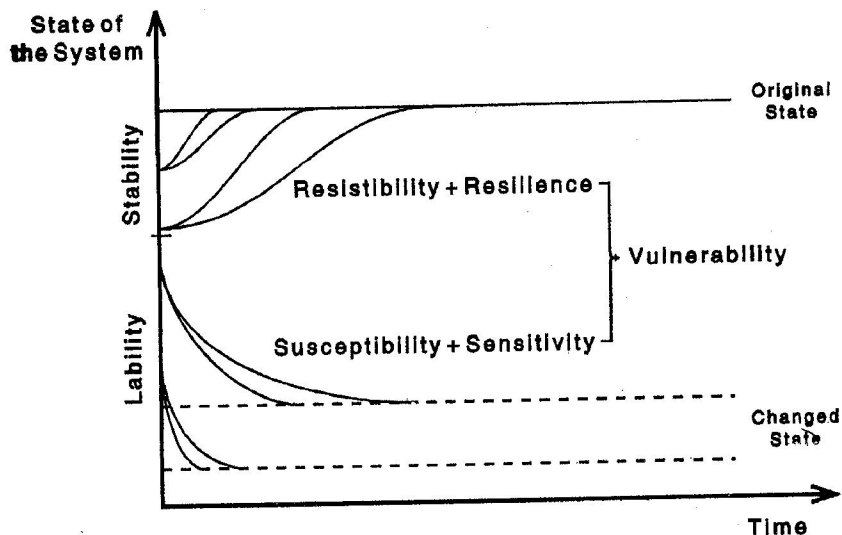
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Environmental properties (stability, resistibility, resilience, lability, susceptibility, sensitivity, and vulnerability) of soils indicate the evaluation of soil from the viewpoint of environmental conservation, characterize soils as special system which can react differently to changes of natural factors (including the anthropogenic ones). The presented concept unifies their use and makes their definitions more precise.

DEFINITIONS AND PRINCIPLES

According to the Act No. 127/1994 of the Slovak National Council, also parallelly elaborated in several works by Kozová, Drdoš et al. (1992), Kozová, Pavličková (1993), Kozová (1993), the assessment of anthropogenic influences on the environment needs an evaluation of susceptibility and vulnerability of soils. These are considered among the environmental properties of soils (Fig.1), the most important of which are:

Fig.1 Schematic presentation of the concept of Enviromental properties.



Stability represents the ability of an ecosystem to keep the original state through its internal dynamics. Stability relates to reversible changes and includes resistibility and resilience. Reversible damage includes (van Lynden 1993): contamination by some organic compounds from air emissions and agricultural sources, and soil compaction, though some examples of irreversible damage through deterioration of soil structure are also known.

Resistibility is the ability to resist the inclination from the original state under the influence of some disturbing factor. It depends on the extent of inclination.

Resilience is the ability to return to the original state which depends on the rate of change.

Typical examples are compaction and loosening of soils. Sandy soils are more resistant to compaction than clayey soils. But we can have two clayey soils which have the same resistibility, but they differ in intensity of bioturbation and consequently in resilience too.

Lability represents the inability of an ecosystem to return to the original state due to irreversible changes (it is the opposite of stability). It includes susceptibility and sensitivity. The following impact of soil degradation may be considered to be irreversible (Blum 1988): soil losses through sealing, stripping, mining and erosion, soil contamination by heavy metals from air emissions and agricultural inputs and by radioactive compounds with long half-time periods, and when through acidification an advanced stage of decay of soil constituents is reached.

Susceptibility is the inability to counter the irreversible changes and depends on the extent of these changes.

Sensitivity depends on the rate of the irreversible changes in soil properties due to the influence of natural factors (including the anthropogenic ones).

As typical example could be wind erosion of soils. Sandy soils are more susceptible to wind erosion than clayey soils. On the other hand structured and non-structured sandy soils may have the same susceptibility, but they differ in sensitivity to wind erosion.

Vulnerability represents the way and extent of ecosystem response on anthropogenic influence. It is a measure of the cost (energy) required for soil reclamation. It results from stability (resistibility, resilience) and lability (susceptibility, sensitivity). Batjes and Bridges (1991) have defined vulnerability in a different sense - as the "capability for the soil system to be harmed in one or more of its ecological functions".

Environmental properties of soils indicate the evaluation of soil from the viewpoint of environmental conservation and characterize soils as special systems which can react differently to changes of natural factors. Some of these terms are frequently used in literature (Batjes and Bridges 1991, Feodoroff 1987, Glazovskaya 1990, Lal 1993, Michal 1992, Tomášek 1985, Várallyay et al. 1989) but not always in the sense of this concept. The presented concept unifies their use and makes the definitions more precise.

According to the Appendices No.2 and 3 of the mentioned Act, it is necessary to elaborate the present state of the environment and express it by ecological carrying capacity and degree of ecological stability of the landscape. Hence it is also necessary to elaborate the susceptibility and vulnerability of soil against the mechanical, chemical, and biological degradation.

Susceptibility as a measure of deterioration of the environment under the influence of different factors was mentioned by Canters et al. (1991). Susceptibility of the pedon toward radical changes of properties is given by its physical, chemical, and biological state. Susceptibility measurement is expressed, either by the extent of the irreversible changes in different soils which are conditioned by the same factors of equal intensity, or by different intensity of factors which cause equal changes in the state of a soil system.

In this sense clayey soils are more susceptible to waterlogging under the influence of raising groundwater level than sandy soils. Raising the groundwater level 1m leads to stronger reducing processes in clayey soil than in sandy soil. In other words clayey soil is about 4 times more susceptible to waterlogging than sandy soil, because capillary raising in clayey soils is 4 times higher than in sandy soils (Benetin et al. 1978). Susceptibility toward pollution is higher in sandy soils relative to clayey soils, because the addition of only small amounts of toxic materials may exceed the threshold values. Dry warm sandy regosols are more susceptible toward mineralization of humus than wet cold clayey gleysols. Susceptibility to salinization of wet gleysols in the arid regions with mineralized groundwaters is very common. On the other hand, salinization is much less common in sands and usually does not lead to the formation of saline soils. Mechanical susceptibility is indicated for example by erosion as a result of deforestation. Chemical susceptibility is expressed by soil acidification under the influence of incineration. Biological susceptibility is indicated by infection in places used for grazing cattle.

For simple processing, the assessment in a three-degree scale (weak, medium, strong) is enough, while in a complex evaluation a more detailed five-degree scale of soil susceptibility to degradation should be used: very weak, weak, medium, strong, very strong.

In the case of evaluating soils with: 1. sandy regosols, 2. sandy fluvisols, 3. loamy cambisol, 4. loamy phaeozem, and 5. clayey phaeozem to mechanical degradation it is enough to divide them into weak susceptible soils (No.1 and 2), medium (3 and 4), and strong (5). However, in the complex evaluation these five soils indicate the five-degree scale of soil susceptibility to the mechanical degradation. Different types of susceptibility could be determined according to the character of anthropogenic activity and structure of soil cover.

Vulnerability is a special environmental property of the different components of nature and consequently of soils. Under this term it is necessary to understand the way and measure of reactions against the anthropogenic influence. Distinction of territory vulnerability in an intensively used landscape is needed because of required exact identification of these influences on the nature. In a more vulnerable region the same influencing factor causes more extensive and intensive degradation than in a less vulnerable region. This approach represents an important criterion for determining influences of actual or intended projects and activities on the quality of the environment. In this work we endorse the concept of the UN document which introduces examples of landscape vulnerability in Finland and Hungary (Kozová, Drdoš, et al. 1992), for the necessity of its application on soils in Slovakia through EIA.

We evaluate soil vulnerability by means of different degrees, the principle of which was partially taken from the five-degree sensitivity of landscape according to Roberts (1991). Extent of soil degradation and the possible costs necessary for remediation are evaluated by these degrees. It could be better for scientific purposes to express vulnerability by energy units (J).

Degree of vulnerability is characterized as:

1. Least. Very weak soil degradation. It is not necessary to devote any costs (energy) for its remediation. Soil itself can handle the anthropogenic influences. Example: soil compaction (bioturbation).
2. Slight. Weaker deterioration of soils due to short-term influence by less harmful factors. Return to original state require low costs (energy), and simple, usually agrotechnical measures. Example: loss of nutrients (fertilization).

3. Moderate. Strong to very strong degradation of soil character and functions which can be quickly reclaimed with reasonable costs (energy) using agrotechnical and simple land reclamation measures. Example: acidification (fertilization and liming).

4. Very. Total deterioration of soil environmental properties and functions which requires high costs (energy) for their reclamation. Enhancement and reclamation of the basic soil functions usually require land reclamation measures. Example: waterlogging (drainage).

5. Critical. Total deterioration of soil. It is practically impossible to bring soils to their original state. Possible reclamation needs a creation of new soil - man-made soil by recultivation. Example: total soil denudation (creation of a new soil).

Different pedons can be classified into different degrees of vulnerability according to the type of degradation processes involved.

CONCLUSIONS

It would be useful in the future to elaborate the detailed methodology for determination of the soil susceptibility degree on soil degradation (mechanical, chemical, and biological) and the soil vulnerability to estimate the anthropogenic influences on the environment (according to the Act No. 127/1994).

Furthermore to determine physical, chemical and biological parameters of the environmental properties of soil: stability, resistibility, resilience, lability, susceptibility, sensitivity, vulnerability, etc. Soil classification and its division into classes according to the environmental properties of soils.

An additional part of the future project could be the elaboration of soil maps of the Slovak Rep. (1:500000) according to the importance of the environmental properties of soils.

The described approach of soil environmental characteristics could also be applied to other components of nature.

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SÚHRN

Pri posudzovaní antropických vplyvov na životné prostredie sa majú podľa zákona Slovenskej národnej rady č. 127/1994 Zb. vyhodnocovať náchylnosť a zraniteľnosť pôdy. Tieto vlastnosti radíme medzi environmentálne vlastnosti pôdy, z ktorých najvýznamnejšie sú: Stabilita, tj. schopnosť ekosystému udržiavať vlastnou dynamickou rovnováhou určitý svoj stav. Stabilita sa vzťahuje na reverzibilné zmeny a zahrnuje odolnosť a pružnosť.

Odolnosť je schopnosť odolávať vychýleniu z pôvodného stavu pri pôsobení niektorého rušivého faktoru a závisí od rozsahu zmien.

Pružnosť je schopnosť vrátiť sa do pôvodného stavu, ktorá závisí od rýchlosti zmien.

Labilita predstavuje neschopnosť ekosystému vrátiť sa do pôvodného stavu v dôsledku ireverzibilných zmien. Labilita zahrnuje náchylnosť a citlivosť.

Náchylnosť je neschopnosť čeliť nevratnému narušeniu dynamickej rovnováhy a závisí od rozsahu zmien.

Citlivosť odráža rýchlosť nevratných zmien pôdných vlastností a funkcií, ku ktorým dochádza vplyvom prírodných (vrátane antropogénnych) faktorov.

Zraniteľnosť predstavuje spôsob a mieru reakcií ekosystému na vplyv človeka. Je to miera nákladov (energie), ktoré treba vynaložiť na obnovenie najdôležitejších vlastností a funkcií pôdy, ktoré boli zhoršené degradačnou činnosťou človeka. Vychádza pritom zo stability (odolnosti, pružnosti) aj lability (náchylnosti, citlivosti), ktoré premieta do vratnej aj nevratnej miery jej poškodenia antropickou činnosťou.

Environmentálne vlastnosti pôdy vyjadrujú jej hodnotenie z hľadiska ochrany prírody. Charakterizujú pôdu ako osobitný prírodný systém, ktorý je schopný rôznych reakcií na zmeny prírodných, vrátane antropogénnych faktorov.