Environmental load of the Slovak landscape as a result of the negative impact of human activities

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Abstract: *The aim of the paper is to assess the negative effects of human activities in landscape. Human activities with negative effects in the scientific literature are called stress factors. Stress factors negatively influence natural ecosystems, natural resources, human environment, biodiversity, and landscape stability. The negative effects of human activities in landscape cause destruction of the natural ecosystem due to the construction of artificial elements and pose a threat to the quality of the living conditions of natural ecosystems. The paper evaluates human activities as stress factors in landscape and describes the environmental load of the Slovak landscape caused by stress factors.*

Key words: stress factors, human activities, environmental load of landscape, Slovakia

Introduction

Almost every human activity is accompanied by production of undesirable materials in solid, liquid or gaseous form. In the landscape they are the xenobiotic substances causing the load of the landscape and its components and their contamination (air, water, soil, geological environment etc.) as well as the disturbance of natural processes taking place in landscape. Single landscape forming components are interrelated what causes the transfer of single xenobiotic elements from one substance to the other. For example, air pollutants get into the forest ecosystems by acid rains and they penetrate the soil by precipitation. Similarly, xenobiotic substances from soil get into cultivated crops by cycling of water and nutrients within ecosystem, etc. Cycling of xenobiotic substances in landscape is permanent. The consequences of these materials are the negative phenomena as global warming, greenhouse effect and other climatic changes (Izakovičová, Oszlányi, 2013).

The functional structures used for dwelling, recreation, industry, agriculture etc. are potential sources of negative factors. All these manifestations of human activities of material character as well as their accompanying phenomena of non-material character appear in landscape as foreign, endangering materials often referred to in literature as stress factors. The term "stress factors" was used for the first time in medicine and represents any kind of material or energy that has a negative influence on living organisms. In this paper "stress factor" is defined from the point of view of landscape ecology that studies landscape as a geosystem (Selye, 1966; Charvát, 1969; Michal, 1992) and it is any kind of material or energy that has a negative impact on evolution of the natural landscape ecosystems.

Material and methodology

At present, there are several approaches to the definition of the notion of "landscape load". Many authors (Scharpf, 1980; Schemel,1978; Swoboda, 1989; Hrnčiarová et al., 1997; Drdoš,

1997, Kozová, Izakovičová, Pauditšová, 1998) define the load as the difference between the given and the desired situation in the environment. Scharpf (1980) defines the load as the real existing environmental state regarded as an unfavourable change as the result of real or expected activity. This unfavourable change is perceived as a conflict in landscape utilization. By means of generalizing different definitions we can define the landscape load as the load of negative effects of human activities in natural environment. Human activities operate in landscape as stress factors, it means environmental factors causing stress, which either directly (primary stress factors) or indirectly (secondary stress factors) reduce and devastate landscape. The load of landscape by stress factors is interpreted as a set of unsubstantial influences, which negatively act in landscape and life environment and instigate various chemical, physical, bacteriological and other changes in landscape. According to exposure to stress factors can be divided into two basic groups:

Primary stress factors are represented by the physical occupation of the territory and alteration of natural ecosystem. The group includes any semi-natural and artificial anthropogenic elements (industrial and agricultural facilities, transport areas and lines, areas of intensive farming and forestry, areas of housing, and recreation). All these primary stress factors can be specified according to the occupied area. Their positions in landscape cause changes of land-use and landscape structure and prevent living organisms from migration (Bürgi, M., Hersperger, A. H., Schneeberger, N., 2004, Csorba, 1996, Conway, T. M., Lathrop, R. G., 2005, Jensen, J. R., 2000, Mander, Ü., Murka, M., 2003. Turner, M. G., Gardner, R. H., O'Neil, R. V., 2001).

Secondary stress factors represent negative effects caused by human activities that cannot be specified only according to their scope. Secondary stress factors disturb and endanger the evolution of natural ecosystems. The following are the secondary stress factors (Izakovičová, Oszlányi, 2013):

- *contamination of rock environment* represents natural (abiotic and biotic) and anthropic accumulation of components exceeding the background amount for the given lithotype. It is necessary to observe areas with contamination of the rock environment in terms of landscape load,
- *air pollution by heterogeneous substances* - areas in which pollutants exceed the limit (emission, immision and deposit limits). Air pollution is nonpoint or diffused pollution it means immissions coming from various sources of pollution spread by the transfer. It can be also result of point pollution sources - emissions, which are responsible for the local air pollution in terms of the environmental load.
- *noise load of the environment* - environments in which the noise level exceeds acceptable levels. Noise load of the environment exists in industrial centres, along lines of communication, flight routes and airport air cones, noise in mining areas, etc.,
- *odour load of the environment* - a phenomenon which can be objectively measured only with difficulties and is mostly subjective,
- *vegetation damage* – is the damage done to its natural development, as a result of abiotic (wind, hailstone, floods, snow, frost, drought and other), biotic (re-reproducing of offenders) or anthropogenic factors (immissions, crude oil spill and other). It is very important to know that a lot of the natural risks and hazards are caused by humans and their activities. Damaged areas of vegetation should be assessed according to the degree of damage.

- *water pollution* - water with excessive content of heterogeneous substances. Quality of surface waters is assessed according to the following basic parameters: parameter of oxygen regime, basic chemical parameters, comprehensive chemical parameters, heavy metals content, biological and microbiological parameters, parameters of radioactivity,
- *soil degradation* - soil with damaged physical, chemical or biological characteristics. The most important demonstrations of soil degradation are soil contamination, salting of soil, one-side nutrient depletion of soil, soil weariness and overall loss of soil fertility, etc.
- *protective belts* - belts of hygienic protection around individual anthropogenic objects for the protection of the environment against adverse influences. These belts of hygienic protection represent supposed zones of negative influences of individual objects.

The anthropogenic stress factors are primarily the results of socio-economic activities. Realization of interests of production industries is mainly manifested in landscape by its occupation or by the negative impact on single landscape-creating particles. It means that human activities in landscape often operate as stress factors.

The methodological procedure of evaluation the assessment consists of two main blocks (Izakovičová, Oszlányi, 2013).

A) Assessment of the environment load through primary stress factors

The main negative manifestation of the primary stress factors is the anthropization of the environment as a result of taking over the natural ecosystems for building purposes. In order to establish the degree of influence on the given area the structure coefficient reflecting the surface proportion of individual landscape components and their landscape-environmental importance can be used. This indicator represents the degree of anthropogenic change (load) in landscape. Thus the structure coefficient reflects the landscape load due to the primary stress factors.

In theory, the structure coefficient can be in the range of $\langle 0, 1 \rangle$. The value being 0, the whole territory would be covered by building areas or dumps. If the value of 1 was achieved, the whole area would be covered by natural ecosystems. It is not possible to achieve these peripheral values in a civilized society. In reality, the values in Slovakia range from 0.17 to 0.83. The lower the structure coefficient, the higher the proportion of artificial ecosystems. Thus with a decreasing value of the given coefficient the primary stress load is increasing.

B) Assessment of the environmental load through secondary stress factors

Through secondary stress factors the environment load indicates the extent of the impact on the environment by accompanying phenomena of human activity in landscape. Their negative influence is manifested in endangering and damage (anthropization) of natural resources. Methodological procedures of the assessment consist of the following steps:

I. ***Analyses*** - selection and organization of stress factors resulting from the development of individual industries in a given territory. The scope of the mapped phenomena is getting wider when passing to a lower hierarchical level (for example from a regional to a local level). The result of this is the cartographical demonstration of the analytical indicators of secondary stress factors.

II. ***Syntheses*** - superposition of spatial demonstration of analytical indicators. The result is identification of points of contact and formation of complexes with a combination of stress factors differing according to the type and intensity of their negative influence.

III. ***Evaluation*** - the evaluation of points of contact with a cumulative influence of stress factors, the result of which is the hierarchical structure of landscape load - identification of the type and degree of landscape load.

IV. ***Proposition*** - a proposal for landscape utilization resulting in environmental optimisation with regard to the present landscape load - the assessment of problem solving in overloaded regions, the possibilities for the development of unloaded regions, etc.

Application of the methodological procedure in the territory of Slovakia

Methodical procedure was applied in the territory of Slovakia. The assessment was divided into two basic groups:

A) Assessment of the environmental load through primary stress factors

It was carried out for each settlement. Proportion of artificial and natural areas within each cadastral territory was assessed. The assessment revealed that most loaded are the great settlements – towns with high concentration of human activities. From the spatial point of view, the mountainous settlements with the high rate of natural ecosystems are the regions with the top ecological quality and high rate of original natural ecosystems. On the contrary, the least favourable ecological quality of spatial structures is in lowland areas, such as the Podunajská rovina Flatland, Podunajská pahorkatina Hill Land, Východoslovenská rovina Flatland, Juhoslovenské kotliny Basins etc., where the large–area ploughed land or urbanized areas are the dominant elements of land use. The negative ecological quality of spatial structures is also typical for basin regions (Zvolenská, Turčianska, Žilinská, Žiarska, Pliešovská Basins, etc.), where the rate of eco-stabilizing components does not exceed 30% of the total area.

B) Assessment of the environmental load through secondary stress factors

Air pollution

Air quality of the SR is affected by different pollutants. They are produced by the industry, urbanisation, transports and agriculture. Among the most important harmful substances at present are sulphur, nitrogen oxides, carbon monoxide, carbohydrates, organic substances and dust particles. The trend in emissions of basic pollutants is a long-term (1993-2011) decrease. A rapid drop was observed in connection with the society's transition when many industrial plants were closed. Installation of devices reducing escape of pollutants, upgraded technology in plants producing pollutants also contributed to the improvement of air quality. The biggest producers of pollutants escaping to the air (primary pollution) in the SR are still energy, transports, metallurgical engineering, and chemical industries. The principal sources of pollution in the rural area are the individual heating systems/hearths. The most loaded areas in terms of the spatial air quality assessment are mostly around big industrial centres such as Bratislava, Košice – Prešov, Dolné Považie (Trnava, Sereď, Šaľa, Galanta, Nové Zámky), Horné Považie (Trenčín, Púchov, Považská Bystrica), Central Spiš (Krompachy, Spišská Nová Ves), Horná Nitra (Prievidza, Handlová, Partizánske), Pohronie (Žiar nad Hronom, Banská Bystrica, Zvolen), Zemplín (Vojany, Strážske, Vranov nad Topľou, Snina, Humenné), Žilinská Basin (Žilina), Turčianska Basin (Martin), Popradská Basin (Poprad) and the like.

Water pollution

Although positive trends are apparent in the water quality in the territory of Slovakia, the situation is not at all satisfactory. Monitoring of surface waters carried out in partial basins show that all monitored points complied with the limits for the selected general indicators and those of radioactivity. Nevertheless, limits were exceeded in the area of synthetic and non-synthetic substances, hydro-biological and microbiological indicators. In the last quoted, limits of enterococci were exceeded in partial basins of the Rivers Morava, Váh, Slaná, Bodrog, Hornád, and Bodva; thermotolerant coliform bacteria and coliform bacteria overstepped limits in some parts of basins of the Rivers Morava, Váh, Slaná, Bodrog, Hornád, Bodva, and Poprad.

An often-exceeded pollutant in all partial basins is the nitrogen of nitrates. The principal polluting sources of surface water are wastewaters from industry, urbanisation, farming, etc. released into water streams. Since 2000 a progressive diminution of released wastewaters is observed.

Basic monitoring of groundwater quality in 2012 has been accomplished in the territory of Slovakia in 171 points. It shows bad results in oxidation-reducing situation including frequent excesses in admissible concentration of overall Mn (58-fold), Fe (61-fold) and NH4+ (13-fold). As far as trace elements are concerned, increased concentration of Al (twice), As (10-fold), Sb (4-fold), Pb (twice), and Hg (once) were observed. Specific organic substance pollution is only of local nature. Bad situation was recorded in 17.3% of total 101 groundwater localities (Ministry of Environment of the SR, 2014).

Factors causing contamination of groundwater are varied. They are mostly consequences of the development in industry, agriculture, urbanisation and transports. In-filtering rainwater containing foreign substances from the polluted air are considered secondary pollution sources.

From the spatial point of view, the most contaminated is the groundwater released from pits. They contain over limit amounts of Al, As, Cd, Cu, and Hg. Groundwater in lowlands and basins with high concentration of economic activities both agricultural and industrial is also heavily contaminated. Multiples of admissible concentrations of sulphates, chlorides, nitrates, phosphates, potassium, iron, manganese, aggressive carbon dioxide and many metals, first of all copper, zinc and cadmium, were found there.

Degradation of soil resources

Soil is subject to chemical and/or physical degradation. A severe type of the chemical soil degradation is contamination by heavy metals, organic pollutants, acidification, but also accumulation of sodium or salinisation.

Soil contamination in the territory of Slovakia is monitored in regular intervals. Results of monitoring show that over limit concentrations were found for Cd and Pb in Fluvisols especially in the lower reaches of some rivers. Contamination, which took place in the past, perseveres. Examples of such load are the regions of Spišsko-gemerské Rudohorie with the over limit occurrence of Cu, Pb, Zn, Hg, As, Bi, Be and Co, area of the Low Tatry Mts. with over limit occurrence of Sb, As, W and Cu, that of Kremnické Mts., the Štiavnické Mts. with over limit occurrence of Pb, Zn, Cu, As, Cs, and the Little Carpathian region with over limits of As, Sb, Pb, Zn, and Ba. Increased concentration of the quoted elements is mostly the legacy of old environmental loads in quoted areas.

Adverse effect of mining activity is also obvious in the alluvial soils in the basin of the River Hron, Štiavnický Brook, Rivers Slaná, Hornád, Pezinský and Smolnícky Brooks. Negative consequence of coal mining and the following development of the energy industry showed in soil contamination by increased contents of As, Ba, Cs and Hg in the area of Horná Nitra.

Industrial production significantly participates in contamination of soil. Increased contents of some elements associated with local production processes were found in industrial zones, for example increased content of fluorine in the Žiarska Basin due to aluminium production or increased content of chromium next to the ferroalloy plants in Dolná Orava, and the like.

Along with industry, agricultural production also contributes to soil contamination. Soils in vine growing and horticultural areas contain increased concentrations of Cu, Zn, and F while typical for the intensively exploited agricultural soils are the increased contents of P and F and partially also Cd. Local load by increased contents of Pb, Cr, Cu, Zn and Hg has been found in environs of big urban settlements. Increased concentrations As, Cd, Pb, Hg, Bi and Mo in forest soils in the consequence of trans-boundary transport of exhalations were measured in the boundary arch of the Carpathians. Nowadays, there are in total 1.4% of contaminated and 0.4% of severely contaminated soils in Slovakia (Ministry of Environment of the SR, 2014).

Physical degradation of soils in the territory of Slovakia manifests itself by the hazard of soil erosion, avalanches and landslides. Almost 39% of farmland is potentially threatened by water erosion and the most susceptible to water erosion hazard are the soils of mountain and sub-mountain areas of the High Tatras, Low Tatras, the mountain ranges of Veľká Fatra, Malá Fatra, Eastern Carpathians, etc. The lowland areas are the least threatened by water erosion (Ministry of Environment of the SR, 2014).

Wind erosion is not a serious problem in the SR. It afflicts about 5.5 % of the agricultural soil pool where only 1.3% is extremely threatened. They are mostly lighter soils with low content of organic mass which are prone to desiccation (thereby to wind erosion) especially in seasons when they are not covered by vegetation (Ministry of Environment of the SR, 2014). Territorially speaking, the most threatened are the open, intensively ventilated lowlands: Záhorská, Podunajská and Východoslovenská. Wind erosion hazard for the Juhoslovenská Basin and some other low situated areas of the country has been classified as moderate.

Physical soil degradation is aggravated by slope processes. Size of the territory with the detected slope stability defects is about 1,500 km^2, which equals approximately to 3% of total area of the SR. These defects are caused by slope gravitation movements prevailingly in mountainous parts of Slovakia, less in basins and hill land.

Avalanche hazard is typical, like in case of water erosion and landslides, for mountain areas. It threatens first of all our highest mountain ranges, the High Tatras, Low Tatras, Veľká Fatra, and Malá Fatra.

A part of our agricultural soil pool is threatened by *compaction*. At present, 457 thousand ha of land is potentially threatened by compaction processes and 19 thousand ha of farmland is already compacted (Ministry of Environment of the SR, 2014). The most endangered soil types are the loamy soils (Luvisols) probably due to their intensive use. The causes are attributable to inappropriate management especially use of heavy mechanisms.

Loading and damage to vegetation

Systematic monitoring of the load and damage to vegetation in the territory of Slovakia is carried out for the forest ecosystems. Forest ecosystems are threatened by several abiotic, biotic and anthropogenic factors. Due to abiotic factors, first of all the harmful action of wind, snow, rime, and draught 1,272.5 thousand m^3 of wood matter was damaged, while more than 79.4% of damage was attributed to the wind in 2012. Among the damaging biotic agents in forest growths, the spruce bark and wood boring insects lead followed by the leaf-eating and sucking insects, putrefaction, tracheomycoses, and game.

The most important biotic agent was the spruce bark beetle (*Ips typographus*) with more than 89% share in total wood matter attacked by insects and spruce trees are the most afflicted species (99.6 %).

The gravest anthropogenic factors which threaten the forest systems include excessive logging and substitute of original forest growths by monocultures, shrinkage of forest ecosystems in favour of the expanding technosphere, development of recreation activities and effects of immisions. Forest growths weakened and damaged by immisions (especially spruce, fir and beech woods) are more susceptible to damage by abiotic and biotic agents. As much as 73% of anthropogenic factors are immisions (Ministry of Environment of the SR, 2014). The most damaged wood species are oak, locust, fir and spruce and the least damaged are beech and hornbeam trees. Spatially speaking, the most threatened are the ecosystems in the area of Spiš and the Tatras, Kysuce, and Orava.

As far as protection of the biotopes of the European significance is concerned, it is unsatisfactory or bad in 60 % of forest biotopes. Bad situation is also in a half of shrub biotopes, in 70% of permanent grassland biotopes, and in 70% of fresh water biotopes. Likewise, based on the assessment of protection for the species of the European importance, the situation is not good. Unsatisfactory or bad is the protection of a half of assessed vascular plants, half of mammal species, 70% of reptiles and 90% of amphibians (Ministry of Environment of the SR, 2014).

Synthesis – load of the landscape

The synthesised assessment of overall environmental situation shows that speaking about concentration of foreign substances, the most loaded are the industrial or old mining areas of Slovakia: the karst territory of Spiš-Gemer, Horná Nitra, Žiarska Basin, the area of Strážske-Humenné-Vranov nad Topľou and those around urban industrial centres: Bratislava, Košice, Prešov, Žilina, Banská Bystrica, Ružomberok, etc. Increased concentration of selected elements in soils is evident in the area of the Little Carpathians, Low Tatras, Kremnické Mts., Štiavnické Mts., etc. Higher levels of groundwater contamination and increased contents of phosphorus, fluorine, and partially cadmium were detected in lowlands with intensive farming. At the same time there is an increased level of hazard and damage to soil pool due to erosion, accumulation, and slope processes.

Conclusion

Assessment of the environmental load in landscape is in the centre of attention as the accumulated environmental problems become existential. The main initiator of these environmental problems is the unbearable environmental load resulting from anthropogenic activities operating as stress factors. The extent of the problem depends on the range, length

and intensity of the stress factors. The aim of the permanently sustainable development is to minimize the environmental problems resulting from unbearable environmental load caused by human activities. However, the starting point of the permanently sustainable development is the awareness of the present state of the environmental load.

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