

THE RESEARCH CURRENT GEOMORPHOLOGICAL PROCESSES AND FORMS OF RELIEF ON THE LANDFILL SITE WASTE FROM NICKEL PRODUCTION

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Abstract

Anthropogenic landforms of relief were created in the landscape by man by the action of exogenous anthropogenic geomorphological processes. Since that all the anthropogenic forms of the relief are located in the current landscape so are influenced today by the natural geomorphological processes. Anthropogenic landforms of relief are directly dependent on the growth of population and on the demands the society for meet their needs (energy, processing of raw materials, agricultural production etc.) which points to the growth of these forms in the future. The variety and number of anthropogenic relief forms will continually expand and their impact on the environment will be greater. Anthropogenic landforms of relief are artificial elements in the landscape and their formation disrupts the dynamic equilibrium of the landscape. In this paper we deal the nature of geomorphological processes and the subsequent forms of relief incurred to the landfill site of metallurgical waste from nickel production over the past three decades. The aim of this paper is to highlight the current geomorphological processes and forms of relief on the example of industrial landfill of lúženec at Sered' in Slovak Republic that has evolved over the last 25 - 30 years (after the ending production of nickel) under influence of anthropogenic geomorphological processes and natural geomorphological processes in moderate climate zone.

Key words: geomorphological processes, creep, sheet erosion, linear erosion, drip pluvial erosion, eolian erosion, deflation

1. INTRODUCTION

Shapes of landforms are the result of a long development. Everyone geomorphological process still consuming some power. The energy of human activity is the youngest form of energy and acts on relief of the earth's surface from the Epiatlantic when there begun significant pressure of humans to structure of the landscape and creating the anthropogenic forms of relief (man-made forms of relief, Szabó 2010). In this article will deal with contemporary active geomorphologic processes and forms of water erosion and deflation on the landfill waste from production of nickel in moderate climatic zone in warm region (Lapin at al. 2002) of Podunajská nížina (lowland). The main objective of the research was to identify geomorphologic processes on the landfill and geomorphological mapping contemporary forms of relief that are formed for the past 30 years by the action of the current exogenous natural and anthropogenic geomorphological processes. Anthropogenic landforms are artificial forms created by man. It is incurred on the basis of exogenous anthropogenic geomorphological processes, whose origin lies in the exponential growth of population and in the demands to meet of needs of human society (energy, processing of raw materials etc.).

Growing demands of human society indicate an increase these shape in the future. The range and quantity of anthropogenic relief forms will continually expand and their impact on the environment and natural processes will be increase. Under their influence is changing the circulation of substances in the landscape and climate, soil, water quality, biota, etc. Anthropogenic landforms are extraneous elements in the landscape and their formation disrupts its dynamic equilibrium (Michaeli & Boltžiar 2009). Development of a new equilibrium cannot be reliably predicted. For the human society and for all the living organisms represent the uncertainty in environmental quality, and occasionally as well

the comprehensive threat. Anthropogenic shapes of relief are the domain of research anthropogenic geomorphology, which includes not only the study of these forms, but well as the processes which created them and monitors their various changes and giving also proposals to eliminate of their harmful effects (Michaeli, Boltžiar & Ivanová 2009).

2. MATERIAL AND METHODS

The methodology is focused on the research and mapping the individual forms of relief and dominant current geomorphological processes to a landfill waste based on field research. Individual elements we identified with using coloured interpretation of satellite orthophotomaps of the year 2012 with high resolution. Digitalisation of spatial data of individual elements was performed "on screen" (directly on the computer screen) under software ArcGIS 10 in scale 1:3 000. The results have undergone verification within a field survey conducted in 2012 - 2013. In field research, we used the classical methods of research in particular relief measure various forms of relief (area, height, depth, width) as well as determining the relative positions of the various forms of relief from the point of action of geomorphological processes, the impact of extracting mechanisms, influence the vegetation cover and other factors. From the other factors we took into account the values of climatic elements, particularly annual precipitation and precipitation in winter and summer half, the temperature especially during the summer half of the year as well as wind conditions.

3. RESULT AND DISCUSSION

Properties and chemical composition of the waste from the production of nickel

Landfill waste from nickel production is located in the lowland landscape of Podunajská nížina (Mazúr & Lukniš 1980) where are active the natural exogenous geomorphological processes which modify the landfill site at present (Mazúr et al. 1980). It was these constitute a hazard to the environment, conservation and quality of life. From this aspect it is necessary to pay increased attention of the anthropogenic forms of relief and subsequently also of geomorphological processes. Our contribution is an attempt to identify those processes and shapes that under their influence on the body of landfill site incurred. Before we will be to characterize exogenous geomorphological processes and forms of relief on the landfill site waste we will present the specific properties of this anthropogenic sediment (Table 1). Lúženec is very fine material according the fractions (powdery sand with share 97% particles 0.1 mm). It is completely black. Material has high throughput and high content of iron. Strongly absorbs solar radiation and is the toxic (Kalebáč, Souček & Had 1987).

Table 1. Production of metal t, waste t, chemicals composition of lúženec in %

Annual production of metal in t, % of waste	Annual production of waste in t, for 30 years	Chemicals composition of lúženec in %
3000 t Ni, 60 t Co, 1,02 % of waste	300 000 t lúženec, 9 000 000 mil. t lúženec	50 - 80 % Fe, 2,5 – 3,5 %Cr ₂ O ₃ , 6 – 8 % SiO ₂ , 6 – 8 % Al ₂ O ₃ , 2,5 – 3,5 % CaO, 0,17 % Ni, 0,6 – 0,18 % P ₂ O ₃

Source: Kalebáč, Souček & Had 1987

According to the classification of anthropogenic relief forms (Zapletal 1969, 1976; Lacika 1999; Čech & Krokusová 2013) include the landfill site waste on the basis of respecting all criterions of the classification into the meso-form of anthropogenic relief. The form of landfill is accumulation of table mountain and is not inflammable is convex in the stage of maturity to old age with a homogeneous material composition (Fig.1).



Fig. 1. Satellite image of the landfill site (© Satellite, 2012)

This form of relief was created depositing the waste from the processing of lateritic iron- nickel ore to the production of nickel and cobalt during 30 years. Through field research of landfill we identified three basic forms of anthropogenic relief (Fig. 2) which were transformed with the natural exogenous geomorphological processes. These basic shapes which constitute the landfill include: plateau of landfill and the slopes both are separated the contour line with value 35 m (terrain edge - cornice). On the basis of field research on the landfill we identified three groups of geomorphological processes associated to medium the water and one process associated with medium the wind (deflation).

Basic Anthropogenic Forms of Relief

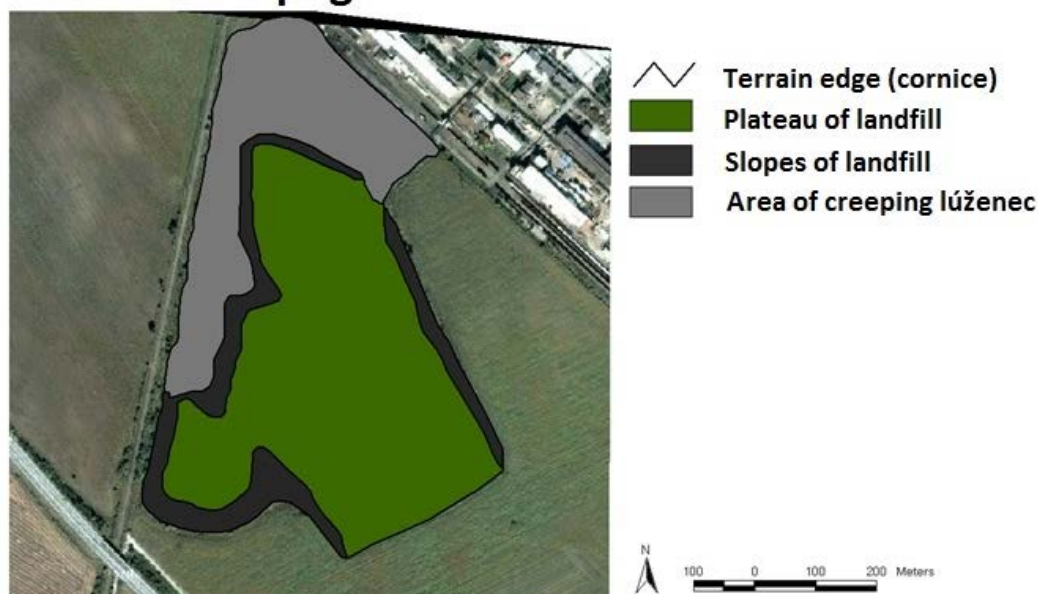


Fig. 2. Basic Anthropogenic Forms of Relief

Gravitational geomorphological processes

Gravitational processes - creep is a slow movement of the material on surface of slopes associated with changes to volume of particles of waste on the basis alternating warming, cooling, wetting and desiccation. When moving is intense gravitational component, because the slopes of landfill are very steep (45°). This process violates too grassed slopes of reclaimed part of the landfill. With the creep of the material is related to sheet-wash of slopes of rainwater, water from melting snow and in our case too from anthropogenic process namely watering water. All processes are situated mainly to the south eastern and western slopes of the landfill. In the upper part of slopes dominated the creeping and in the lower part of the slope is increases the intensity of sheet-wash (Fig. 3).



Fig. 3. Creep and sheet-wash erosion

Geomorphological processes of sheet erosion and linear erosion

The second type of geomorphological processes on the body of landfill and the most important is water erosion. This includes: rain - pluvial drip erosion, sheet drainage erosion and linear drainage erosion, which is divided into the drainage rill and drainage gully erosion and on the anthropogenic erosion of watering water. Watering water is a component of human activity. The force of the component the erosion watering water could not be enough identified in the studied area, mainly due to objective reasons (access to the landfill was limited it is private property). Through the linear water erosion are created on the landfill the rill-marks, rills and gullies. The significant proportion of their genesis has runoff of watering water. During the abundant rainfalls to those processes accedes rain-pluvial drip erosion. Rill-marks and rills (Fig. 4) are initially stages of gully erosion and they occur on plateau and slopes of the landfill. Those forms reaches a depth of several cm to several dm. Water carries away fine material from the landfill and imposes it at the foot of the landfill site and ultimately into its surroundings. Function of watering water which should prevent of deflation is lost thanks to dysfunctional properties (Fig. 5) of spraying system and varies on the processes of water erosion (rill-marks, rills and gullies). The gully erosion developed on the slopes of the landfill. From the aspect of the development stages of these forms belongs among of young form. The vertical erosion participates on the creation of gullies with the rain water and the watering water from the system of sprinkling.



Fig.4. Rill-marks and rills erosion



Fig. 5. Rill-marks and rills erosion of watering water

The depth of gullies is varies and is ranges from 2 m to 2.5 m and somewhere deeper (Fig. 6). They occur on steep southern, south-western and western slopes of the landfill, which are free of vegetation cover. The tops of erosion gullies are usually on the contact zone the plateau and the slopes of the landfill. Some part the gullies has bizzare excavation shapes (Fig. 7).



Fig. 6. Gully erosion



Fig. 7. Gully with bizzare excavation shapes

Wash up material is deposited at the foot of the landfill to forms cones. Their shape and size are difficult to assess. Most of them are overgrown with dense successional vegetation that has spread on the lúženec which is mixed with the original gravel material, which was used as a base for storage of waste. In association with the water erosion is necessary to mention the anthropogenic processes which indirectly support all processes related by water erosion. In the area of mining on the landfill has the watering water and rain water good access to the entrainment of fine particles of the lúženec and forming the relief of landfill by water erosion.

Geomorphological processes eolian erosion (deflation)

Eolic erosion - the activity of the wind is discontinuous and a long-term process. An important condition for the development eolian (wind) erosion is a dry climate, incoherent, respectively no vegetation cover and the substances capable to transmission of the wind. In this type of erosion belong wind deflation, wind corrasion (windcarving) and whirlwind deflation. Lúženec is unpaved fine material. According particle the size of material is called powdery sand and it is eligible on transmission by the wind. According of the fractions belongs to the highly moveable substances. The landfill is located in the territory with the deficit 150 mm of precipitation per year. Area is warm, dry and windy (annual rainfall is 550 mm). From the aspect of eolian (windy) processes on the landfill of lúženec (waste mud from nickel production) predominates eolian (windy) deflation (Fig. 8 and Fig. 9) and transmission of substances in air in the process of dispersion and also accelerated process of this type whirlwind deflation. These processes are bound to 45% area of the surface of the landfill that does not have a vegetal cover. The process of deflation has created the small deflationary forms of relief namely: deflationary grooves - gassi, deflationary witnesses and aerosts (small air dimple). They are located on the slopes of the heap without vegetation. They are unstable forms of micro-relief. An uneven deflation creates on the slopes of landfill site scoops of - deflationary witnesses. The whirlwind deflation on the landfill site is common. Material is transported along the surface of the body of landfill or as dispersed in the air. Eolian geomorphological process is at present one of the most serious environmental problems in the region. The transmitted metallic dust pollutes the air and the dust-fall (SPM) gets into the surface waters and settles on the soils and on the vegetation cover. Metallic dust is a toxic material which, among other elements has high content of chromium and threatens the health of the population. The dust penetrates well into the classical sealed space (e. g. through windows). This state lasts for almost 45 years and a solution is in sight.



Fig. 8. Deflationary dimple (small air dimple)



Fig. 9. Whirlwind erosion

Geomorphological processes of direct anthropogenic erosion

Direct anthropogenic erosion is the result the direct human activities. It is a process that accelerates the landfill all previous geomorphological processes. That includes the mining and adaptation the body of landfill for the mining. This process creates conditions for the transport of material towards the mining machinery. Other anthropogenic forms arise directly of mining. They are deeper round forms of different sizes. Mining machinery on the landfill is not compromised of the subsidence because the landfill is dry area today although the process of production was wet. Landforms of relief incurred by the above process are not stable and they are changing very quickly almost daily (Fig. 10).



Fig. 10. Direct anthropogenic erosion

4. CONCLUSIONS

Our contribution is an attempt to identify anthropogenic processes and shapes of relief which developed on the body of landfill site. Research of anthropogenic forms of relief has in present time increasing importance because their number and acreage in cultural landscape from the aspect of development of human activity is constantly increasing. The nature of these artificial structures in the landscape depends on the material from which they are formed and geomorphological processes that currently underway here (according climate zone). The geomorphological processes are depended mainly of climate zone in which they are located. Both aspects constitute the so-called geomorphological conditions. Geomorphological processes occurring on artificial therefore anthropogenic landforms disrupt balance of the country. They are dangerous the environment, the protected nature, human life and living organisms threatening processes. The research anthropogenic forms of relief are the domain of the anthropogenic geomorphology and it examines too under way anthropogenic and natural geomorphological processes and the changes in their localities and they affected the structure of the surrounding landscape. The anthropogenic geomorphology also suggests as eliminate the harmful effects in the environment and human health.

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