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A. LISNYAK[*], E. MICHAELI[**], M. BOLTIŽIAR[***], J. VILČEK[****], V. SOLAR[**]

[*] *V. N. Karazin Kharkiv National University, ecological faculty, Ukraine, laa.79@mail.ru*
[**]*Department of Geography and Applied Geoinformatics Faculty of Humanities and Natural Sciences, University of Prešov, 17. Novembra 1, 081 16 Prešov, Slovak Republic*
[***]*Department of Geography and Regional Development, Faculty of Natural Sciences, Constantine the Philosopher University in Nitra, Tr. A. Hlinku 1, 949 01 Nitra, Slovak Republic*
[****]*National Agriculture and Food Centre - Soil Science and Conservation Research Institute, Regional workplace Prešov, Raymanova 1, 080 01 Prešov, Slovak Republic*

THE LANDFILL OF INDUSTRIAL WASTE FROM NICKEL PRODUCTION AND ITS IMPACT ON THE LANDSCAPE (CASE STUDY FROM SEREĎ IN SLOVAK REPUBLIC)

The landfill of waste from nickel production is situated to the south of Sereď in Slovak Republic. The landfill area covers around 50 ha. Volume is in present day 5.5 - 6.5 mil. [t] and in 1993 it was about 9 mil.[t]. The landfill was formed during 30 years of manufacturing process, which was stopped due to the economic and ecological reasons in 1993. The pollution of base rocks, underground waters, soils and air pollution was noticed during production in the Nickel smelting plant and continues up to the present days. In this paper we focused on the current structure on the landfill of waste from nickel production and its impact on the environment. Physical and chemical properties of the waste are responsible for the creation of a specific ecosystem, not peculiar to the natural landscape, which negatively affects the quality of the environment. It is proposed to reduce waste using microwave vitrification method, although it is very expensive, but the most effective, because procedure in converting waste glass provides high chemical stability and water resistance.

Keywords: waste, nickel production, metallic dust, contamination, Sereď, Slovak Republic

Лисняк А., Михаэли Е., Болтизиар М., Вилчек Й., Солар В. СВАЛКА ПРОМЫШЛЕННЫХ ОТХОДОВ ОТ ПРОИЗВОДСТВА НИКЕЛЯ И ЕЁ ВЛИЯНИЕ НА ЛАНДШАФТ (НА ПРИМЕРЕ Г. СЕРЕД В СЛОВАЦКОЙ РЕСПУБЛИКЕ)

Свалка отходов от производства никеля, расположена к югу от г. Серед в Словацкой Республике. Полигон занимает площадь около 50 га. В настоящее время объем свалки составляет 5,5-6,5 миллион тонн, а в 1993 году был около 9 миллион тонн. Свалка образовалась за 30 лет производства, которое было остановлено из-за экономических и экологических причин в 1993 году. Во время производственной деятельности никелевого завода на свалке было обнаружено загрязнение подстилающих пород, грунтовых вод, почв и воздуха, которое продолжается и в настоящее время. В работе исследована текущая структура полигона с отходами от производства никеля и его влияние на окружающую среду. Физические и химические свойства отходов являются причиной создания специфической экосистемы, не свойственной природным ландшафтам, которая негативно влияет на качество окружающей среды. Предлагается для сокращения отходов использовать метод микроволновой витрификации, хотя это очень дорого, но наиболее эффективно, т.к. процедура стеклования в преобразовании отходов обеспечивает высокую химическую стабильность и сопротивление воды.

Ключевые слова: отходы, производство никеля, металлическая пыль, загрязнение, микроволновая ветрификация, г. Серед, Словацкая Республика

Лісняк А., Міхаелі Є., Болтізіар М., Вілчек Й., Солар В. ЗВАЛИЩЕ ПРОМИСЛОВИХ ВІДХОДІВ ВІД ВИРОБНИЦТВА НІКЕЛЮ І ЙОГО ВПЛИВ НА ЛАНДШАФТ (НА ПРИКЛАДІ М. СЕРЕД У СЛОВАЦЬКІЙ РЕСПУБЛІЦІ)

Звалище відходів від виробництва нікелю, розташоване на південь від м Серед у Словацькій Республіці. Полігон займає площу близько 50 га. В даний час обсяг звалища становить 5,5-6,5 мільйон тонн, а в 1993 році був близько 9 мільйон тонн. Звалище утворилася за 30 років виробництва, яке було зупинено через економічні та екологічні причини в 1993 році. Під час виробництва нікелевого заводу на звалищі були помічені забруднення підстилаючих порід, підґрунтових вод, ґрунтів та повітря, яке продовжується і до наших днів. У роботі здосліджено поточна структура полігону з відходами від виробництва нікелю і на його вплив на навколишнє середовище. Фізичні та хімічні властивості відхлдів є причиною утворення

специфічної екосистеми що невластива природним ландшафтам, яка негативно апливає на якість довкілля. Пропонується для скорочення відходів використати метод мікрохвилевої витріфікації, хоча це дорого але ефективно тому що процедура склування перетворення відходів забезпечує високу хімічну стабільність та опір води

Ключові слова: відходи, виробництво нікелю, металевий пил, забруднення, м. Серед, Словацька Республіка

Introduction

The landfill of industrial conglomerate waste (the waste from production of nickel to origin from the treatment of iron-nickel laterite ore from Albania with 1 % nickel in one ton of ore) is located on the Danubian plane at an altitude of 125 m. It is from aspect of the environment the heavily disturbed space [8], which is not resolved of ecologically and was left on a self-cleaning ability of the natural landscape. The aim of this paper is to highlight the current structure on the landfill of lúženec that has evolved over the last 30 years (after the ending production of nickel) under influence of anthropogenic processes and natural processes in moderate climate zone.

The area of the Danube plane [12] near the Sereď is built by fluvial sediments (Pleistocene and Holocene). Regarding the anthropogenic sediments there is a significant landfill of metallurgical waste from nickel production. It is a homogeneous formation from the petrographic point of view. The material is granulometric very fine (97 % faction is smaller 0.1 mm), black colour, originated by grinding and washing Albanian laterite iron-nickel ore. The permeability of this mass is very high, so the rainfalls can reach its bottom layers very quickly. The landfill is classified as an industrial, fireproof, surface, convex, accumulating anthropogenic landforms [10, 18], anthropogenic terraced plateau with wide surface and steep slopes (declination of slopes is 10° – 45°). Landfill is the subject of recent fast natural erosive geomorphological and anthropogenic processes as well (rain wash, creep, deflation and mining). Deflation occurs on the dry and vegetation free part of landfill, mostly on the places, where the landfill plane is destroyed by mining processes. The investigated area is warm and dry with very mild winter and a rainfall shortage is from 100 to 150 mm per year [11]. In the region are rich collectors the underground waters (in the depth of 2 – 3.5 m under the surface of floodplain (river Váh). The vegetation is metahemerobic, with minimal biogenic processes [2] and soils are represented by Spolic Technosols on the material of technogenic origin [17]. Animals are concentrated on reclaiming part of the landfill.

Material and methods

Methodology is oriented towards the research of the primary geoecological structure of the landfill. Secondary landscape structure according to the corresponding categories of land use, were identified by using the interpretation of high-resolution orthophotos from 2013. Digitalization of spatial data were processed manually by method on screen using software ArcView GIS 3.1 The identified landscape elements were consequently categorized into the purposefully arranged legend according to their content characteristics. The obtained results were verified in the terrain research.

Results and discussion

The presented contribution was focused on the character of the primary and secondary landscape structure and especially on the impact of the landfill to environment. The attention was given to floristic composition of plants communities on the landfill of waste (lúženec). Physical and chemical characteristics waste conditioned the emergence of a very specific ecosystem, which cannot be found in any natural landscape.

The vegetation on the landfill is specific and its differentiation and composition is not identical with others landfills. The highest number of plant species grows from its foothill to the height approximately 2 metres. Vegetation which is concentrated in the tufts is covering sporadically only upper part of the landfill slope, which is formed on the pure waste (lúženec) without additives of sludge from sugar factory. The continuous vegetation cover

can be seen mostly in the oldest landfill parts, where is the arboreal vegetation mostly with *Populus canescens.* More than as half of the landfill is covering the formations of grass - phytocoenosis of *Calamagrostis epigejos* and *Artemisia absinthium*. About 40 % of the landfill area has no vegetation cover (Fig. 1).

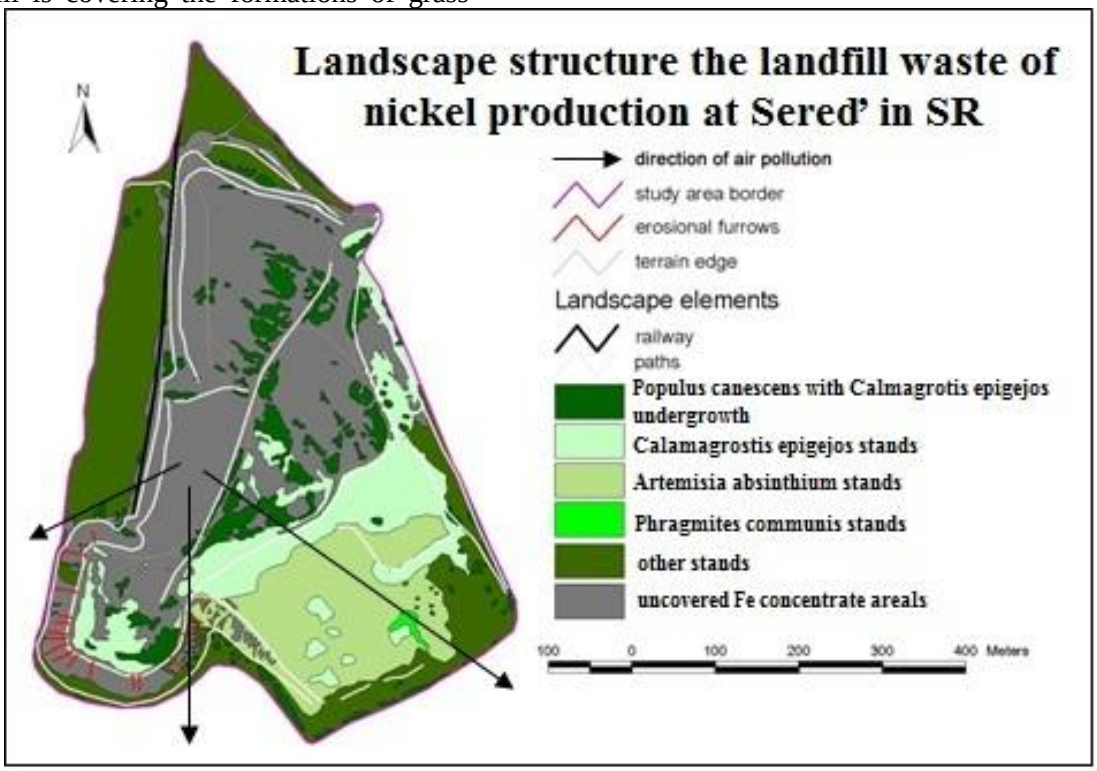

Fig. 1 – Landscape structure the landfill of waste from nickel production in 2013

The area of landfill with its surroundings is strongly degraded. According to the regionalization of Ministry of Environment of the Slovak Republic [8] the territory belongs pursuant to the environmental quality into strongly disturbed area. The situation is more important as it concerns the region with the oldest settlement of the lowland landscape in Slovakia with the most productive, highly and very productive soils [16]. Production of nickel (in Nickel smelter in Sereď) per year was 3000 t Ni and 60 t of Co and 300 000 t of waste (lúženec). The waste of nickel production – lúženec shows high content of various metal oxides and other substances. The content of iron – Fe is highest (Table 1, 2). The waste is a medium rich Fe - concentrate [3]. Despite of this, its use in metallurgy is highly limited.

Table 1

Production of metal in [t], waste in [t], Chemical composition of lúženec in %, Annual consumption of chemicals in [t]

Annual production of metal in [t], % of waste	Annual production of waste in t, for 30 years	Chemical composition of waste in %	Annual consumption of chemikals in [t]
3000 [t] Ni, 60 [t] Co, 1,02 % of waste	300 000 t waste, 9 000 000 mil. [t] waste	50 - 80 % Fe, 2,5 – 3,5 % Cr_2O_3, 6 – 8 % SiO_2, 6 – 8 % Al_2O_3, 2.5 – 3.5 % CaO, 0.17 % Ni, 0.6 – 0.18 % P_2O_3	2 800 [t] NH_4OH, 1 200 [t] Na_2S, 611 [t] HCl, 1 013 [t] H_2SO_4

Source: Kalebáč, Souček, Had 1987

Table 2

Chemical analysis the pure waste

Measurand	Unit	Horizon	Method
Depth [m]		0.4	
pH (H_2O)		8.50	E
TOC	[%]	0.05	HTO
C	[%]	0.74	EA
N	[%]	0.05	EA
Fe_2O_3 T. content	[%]	78	RFS
Al_2O_3	[%]	3.27	RFS
Ni	[mg/kg]	2 920	RFS
Cr	[mg/kg]	24 300	RFS
Cu	[mg/kg]	49.0	RFS
Zn	[mg/kg]	300.0	RFS
Fraction ≤ 0.01	[%]	11.1	AS

Source: ŠGÚŠ, Geoanalytical laboratories, ASL STN EN ISO/IEC, Spišská Nová Ves, SR, Analysis in 2011

From the aspect of negative impact of the landfill on environment in present days we identified these:

In the lowland scenery the landfill, with its physiognomic shape, represents a significant allochthonous barrier element.

Its integration in to the landscape, mainly regarding the length of a human life, could be considered as incontrovertible phenomenon.

According to the present mining rate and export of waste (lúženec) it is possible to liquidate the landfill in approximately 600 years.

From the beginning of depositing in 1963 till the present days the landfill has been the source metallic dust, which escapes in to the landscape (air, waters, soils, vegetation cover) to the distance of 50 km.

There is no monitoring station of the air pollution and therefore the data concerning pollution of dust and other emissions are missing. According to the long-lasting observations of the state observing system the worst water quality is measured in the Váh (river) near Sereď. Water contamination was caused by technological water release until the cessation of manufacturing process in 1993, without any cleaning the release was directed to the inundation area of the Váh (river) and directly into the river. The pollution in the river influenced the underground water quality, where the increased contents of heavy metals, nitrogen, chlorides and disulphate compounds were measured. High concentration exceeded border limit of the state standards. On the basis of micro-pollutants content the water on this part of the river belongs to the IV.th class of quality (extremely polluted).

Nickel is considered as hazardous element for soil. The landfill of lúženec and area of former Nickel smelter represents anthropogenic Ni sources. This is evident in the floodplain of the Váh (river), where Ni has been dispersed from this industrial sources by air transport (dust) and migration of underground waters to the distance of 40 to 50 km (about 1500 ha of agricultural soils contains Ni – risk element). In organic matter in the soils is high concentration of Ni and secondary oxides of Fe [1]. Regional median values of Ni content is from 35 mg to 40 mg. kg $^{-1}$ of soil [15]. The risk of the contamination of plant production with heavy metals is so high, that the territory is recommended only for grassing.

The liquidation the landfill of waste from nickel production (lúženec) and elimination the impact on the environment at Sereď went since 1994 several directions, but so far was not successful none of them except the partial reclaiming.

The first: mining the waste from nickel production and its use as a material for the production of low-alloy steel [9] and ferroalloys e. g. ferrochrome. Experimental metallurgical research has demonstrated that this form of use is not economical [3].

The second: the use this material as an admixture in cement – it is prohibited by EU

legislation for the content of chromium (it is a health damaging).

The third: the use material to prewashing of brown coal – this form is of insignificant in the relation to its quantity.

The fourth: the redevelopment of the dump to the greening - for that possibility was realized experimental research which designated the ability the selected plant species to grow on the toxic waste. The research results showed that reclaimed to the greening is possible, but only with the 10% admixture of sludge from sugar factory into material (lúženec) for improving its properties (Banásová, Hajduk, 1984). The reclaiming was performed on 8 ha of the landfill.

The fifth: the protection against the spread of metallic dust into the air - the sprinkling the landfill with water – is ineffective as the equipment built for this process is dysfunctional, not working. Creating of the green zone for the remediation to prevent the impact of the landfill on the environment was not created.

The sixth: The elimination of groundwater pollution through the construction of the hydraulic membrane and the amelioration channels has not been implemented due to high costs to investing and to operating. Elimination the impact of the landfill on groundwater until today has not been made. The planned 50-years the groundwater monitoring has not been also performed. The all possibilities the remediation and liquidation of impact the dump on the environment have been processed into the projects, but have not been performed.

Project documentation was elaborated for each direction of liquidation the waste (lúženec), but all these suggestions remained on the level of projects and pollution elimination, mainly of underground and surface waters, was left to the self-cleaning ability of natural structure. The pollution continues up to the present days and is the key problem for foreign investors and is an obstruction for modern trends in agriculture development.

Conclusions

In this paper we focused on the current structure on the landfill of waste from nickel production and its impact on the environment. Physical and chemical properties of waste (lúženec) were the cause creating of a very specific ecosystem that does not equivalent in the natural landscape. Significantly affecting the quality of the environment and they are a key problem in the city Sereď and its wider surroundings. The liquidation the landfill by the mining is an ineffective. Large amounts of waste excludes use the method of phytosanation [6]. The method of microwave vitrification even though it is very costly [14], but the most effective. The essence of vitrification procedure is transformation the lúženec on the vitrite, which has a high chemical stability and water resistance. The method can be used on the large masses especially industrial wastes and it is important from aspect of waste reduction. It is a very perspective method. Remediation of the landfill is not currently possible, because it is private property.

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Ю. Г. МАСІКЕВИЧ, д-р біол.наук, проф.
Буковинський державний медичний університет,
Чернівецький факультет Національного технічного університету «ХПІ»,
yumasik@meta.ua

А. Ю. МАСІКЕВИЧ, канд.техн.наук, доц.
Чернівецький факультет Національного технічного університету «ХПІ»,
ecolawkhpi@meta.ua

ГІГІЄНІЧНА ЯКІСТЬ ВОДИ В РІЧКАХ БУКОВИНСЬКИХ КАРПАТ ЯК ПОКАЗНИК ЕКОЛОГІЧНОЇ БЕЗПЕКИ РЕГІОНУ

Досліджено показники гігієнічної якості води басейну ріки Білий Черемош, одного з лісогосподарських районів Буковинських Карпат. Отримані результати свідчать про зростання величини показників БСК від витоків і до гирла р. Білий Черемош. Вниз за течією ріки має місце забруднення річкових вод змивами органічної природи з прибережної та водоохоронної зони, які розкладаються з використанням розчиненого у воді кисню. Зазначена тенденція істотно посилюється в період переходу від зимово-весняного до літнього сезону.Обговорюється практичний підхід підвищення рівня екологічної безпеки гірських екосистем шляхом утилізації відходів деревини.

Ключові слова: гігієнічна якість водних ресурсів, лісогосподарський регіон, гірська екосистема, екологічна безпека

Масикевич Ю. Г., Масикевич А. Ю. ГИГИЕНИЧЕСКОЕ КАЧЕСТВО ВОДЫ В РЕЧКАХ БУКОВИНСКИХ КАРПАТ КАК ПОКАЗАТЕЛЬ ЭКОЛОГИЧЕСКОЙ БЕЗОПАСНОСТИ РЕГИОНА
Исследованы показатели гигиенического качества воды реки Белый Черемош, одного из лесохозяйственных районов Буковинских Карпат. Полученные результаты свидетельствуют о росте величины показателей БПК от истоков и до устья р. Белый Черемош. Вниз по течению реки имеет место загрязнение