Journal of Geology, Geography and Geoecology

Journal home page: geology-dnu.dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ. Geol. Geograph. Geology, 31(4), 591-600.

doi:10.15421/112255

Ecozones of road landscape-engineer systems: structure, typology, significance

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Received 09.01.2022;
Received in revised form 16.02.2022;
Accepted 13.07.2022

Abstract. We analyzed one of the inseparable components of road landscapes of Ukraine, their ecozones. As noted, road landscapes are divided into three categories: road landscape-engineer systems (RLESs), road landscape-technogenic systems (RLTSs) and road landscapes proper (RLP). Depending on those categories of road landscapes, there form respective road ecozones. Most distinctively, they become structured and developed over the process of constructing and functioning of RLESs. Therefore, the objectives of our research were the structure, typology, properties and significance of ecozones, mostly those of road landscape-engineer systems for the purpose of their rational exploitation. The objects of the research were RLESs of Ternopil-Khemelnytskyi-Vinnytsia-Uman-Kropyvnytskyi (M-12) and Kyiv-Odesa (M-5). The research was carried out using the basic principles of landscape science – emergence, cause and effect relationships, history, comparability; methods of analysis, synthesis, modeling, mapping, GIS-technologies using the software: graphic editors CorelDRAW and Adobe Photoshop, and also open-source network of satellite images Google Earth and other. The notion of road ecozone is considered as a complex ecological structure that is formed and developed over the process of functioning of road landscapes. In more details, we have analyzed the ecozones of modern road landscape-engineer systems M-12 and M-5 which have long been actively operating. Field landscape-science-oriented and ecological studies of ecozones of those RLESs over the period of 2019-2021 made it possible to distinguish and substantiate ten microecozones in their structure. Their specific features are conditioned by specifics of the structure and ecologic condition of previous landscape complexes – the fundamentals of modern RLESs; spatial-temporal specifics of the formation; «linear» spread; dependence on the functioning of one type of transport (automobile) and purpose. The features of microecozones are conditioned by land allocated to roads, technical impact, chemical contamination, contamination of soil, aquatic and air contaminations, acoustic and lighting impacts, and esthetic and landscape contaminations. Over the process of further studies, it is possible to distinguish other microecozones, specifically those of biotic and geological impacts, and also uniting certain microecozones into groups. We analyzed one of typical features of road ecozones – their asymmetry. We distinguished and characterized three types of asymmetry of road ecozones – wind-caused, orographic and landscape asymmetries. Not always do their vectors of development coincide. We should note that over the process of functioning of RLTSs and SRLs, there also develop roadside ecozones with respective set of microecozones, though they need additional studies. Further study of ecozones in road landscapes would allow for more thorough planning and forming of their structure, functioning, impact on human health and environment. Road landscapes of any category need to be re-constructed into a system of complex purpose – transport, scientific, recreational and esthetic.

Keywords: road landscape, road landscape-engineering system, ecozone, microecozone, road asymmetry, rational exploitation.

Екозони дорожніх ландшафтно-інженерних систем: структура, типологія, значимість

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Анотація. Розглянуто одну із невід'ємних складових дорожніх ландшафтів України, їх екозони. Зазначено, що дорожні ландшафти поділено на три категорії: дорожні ландшафтно-інженерні системи (ДЛІС), дорожні ландшафтно-техногенні системи (ДЛТС) і власне дорожні ландшафти (ВДЛ). У залежності від цих категорій дорожніх ландшафтів формуються й відповіді дорожні екозони. Найбільш чітко вони структуруються і розвиваються у процесі розбудови і функціонування ДЛІС. У зв'язку з цим, метою дослідження є пізнання структури, типологія, властивості та значимість екозон, переважно, дорожніх ландшафтно-інженерних систем для цілей їх раціонального використання. Об'єкт дослідження ДЛІС Тернопіль-Хмельницький-Вінниця-Умань-Кропивницький (М-12) та Київ-Одеса (М-5). Дослідження проведено із використанням базових ландшафтознавчих принципів емерджентності, причинно-наслідкових взаємозв'язків, історичності, сумісництва; методів – аналізу, синтезу, моделювання, картографування, ГІС-технологій із застосуванням програм: графічних редакторів CorelDRAW і Adobe Photoshop, а також відкриті мережі космічних знімків Землі Google Earth та інші. Зазначено, що поняття дорожня екозона – це складна екологічна структура, яка формується і розвивається у процесі функціонування дорожніх ландшафтів. Детальніше розглянуто екозони сучасних дорожніх ландшафтно-інженерних систем М-12 і М-5 тривалий час і активно функціонуючих. Польові ландшафтознавчі та екологічні дослідження екозон цих ДЛІС упродовж 2019-2021 років дали можливість виокремити й обґрунтувати у їх структурі десять мікроекроекозон. Їх специфічні ознаки зумовлені: особливостями структури та екологічним станом попередніх ландшафтних комплексів – основи сучасних ДЛІС; просторо-часовими особливостями формування; «лінійним» розповсюдження; залежності від функціонування одного виду транспорту (автомобільного) та призначення. Серед мікроекозон: дорожнього відводу, технічного впливу, хімічного забруднення, забруднення ґрунтового покриву, водного і повітряного забруднення, акустичного і світового впливу, естетичного і ландшафтного забруднення. У процесі подальших досліджень можливе виокремлення інших мікроекозон, зокрема біотичного і геологічного впливів, а також об'єднання окремих мікроекозон в групи. Розглянуто одну із характерних ознак дорожніх екозон – їх асиметричність. Виділено і зхарактеризовано три види асиметрії дорожніх екозон – вітрову, орографічну й ландшафтну. Їх вектори розвитку не завжди співпадають. Зазначено, що у процесі функціонування ДЛТС і ВДЛ теж формуються дорожні екозони з відповідним набором мікроекозон, однак вони потребують додаткових досліджень. Подальші пізнання екозон дорожніх ландшафтів дадуть можливість реальніше планувати й формувати їх структуру, функціонування, вплив на здоров'я людей та довкілля. Дорожні ландшафти будь-якої категорії необхідно перебудовувати у системи комплексного призначення – транспортного, наукового, рекреаційного й естетичного.

Ключі слова: дорожній ландшафт, дорожня ландшафтно-інженерна система, екозона, мікроекозона, дорожня асиметрія, раціональне використання.

Introduction

In the structure of modern landscapes, specialists of various scientific spheres (from construction engineers to designers) pay sufficient attention to roads (Babkov, 1980; Biliatynskyi, 1998; Elektronnyi resurs, 2012; H.I. Denysyk, Sytnyk, Chyzh, Bezlatnia, B.H. Denysyk, & Voina, 2020; Derzhavni budivelni normy Ukrainy, 2000; Kotsenko, 1986). Somewhat less interest was paid to road landscapes – complex systems of anthropogenic (mostly technogenic) origin, structure and functional specifics of which are determined by roads proper and their infrastructure – various constructions and points of services, roadside windbreaks, etc (Valchuk, 2002; Denysyk, Braslavska, Volovyk, Valchuk-Orkusha, Buriak-Habrys, & Stefankov, 2021; Denysyk, Didura, 2019). The functioning of road landscapes and their paradynamic interrelations with the environment result into development of peculiar, still poorly studied road ecozones, which are spatially much larger than the road landscapes (Valchuk, 2002; Didura, 2019; Denysyk, Didura, 2019). Road landscapes have been, are and will be the «central place» of genesis, development and functioning of road ecozones. They form the main properties and features of road ecozones, determine their borders and the pattern of unfavorable and favorable processes that develop in them. Road, road landscape and road ecozone are triune structure, unified first of all by internal interrelations, the pattern of development of which often depends on the external influence. Studying only one component of this triune structure would not provide the complete knowledge about its functioning and would obviously limit the possibility of developing measures regarding its rational exploitation.

Absence of results of complex researches of ecozones of road landscapes is due to a number of factors, the main being low number of specialists in landscape ecology, especially those who are studying modern landscape-engineer systems, to which road landscapes are classified to (Denysyk, Valchuk, 2005; Denysyk, et al., 2020; Denysyk, Didura, 2019; Usmanova, Melnyk, 2010); prevalence of isolated landscape and ecological studies of road landscapes, which reflect only specifc problems (Babkov, 1980; Butovskyi, 1987; Mylkov, 1973; Khodan, 2012); expensiveness of conducting studies of road ecozones which would characterize properties, particularly geochemical, geophysical, etc.

In Ukraine, *studies of ecological condition of roads* and their impact on adjacent landscape complexes, and then the road landscapes in general have become active in the late 20th-early 21st century. At first, those were ecological-geochemical studies of individual geocomponents in areas of highways of state and inter-oblast significances which were most loaded (interchanges, intersections, steep slopes of roads) by vehicles. They focused on heavy-metal contamination of forest and road structures (Voloshyn, Lepkyi, & Matviichuk, 2005; Voloshyn, 2009; Khodan, 2012; Halahan, 1993, 2013, 2014), agrocenoses adjacent to highways (Hrabovskyi, 2002; Eskov, Eskova, & Seraia, 2012), industrially urbanized territories (Bryhadyrenko, Chernysh, 2003; Eskov, et al., 2012); soil cover in the zones of highways' impacts (Denysyk, Valchuk, 2005; Usmanova, Melnyk, 2010); snow and groundwater (Yurchenko, Melnykova, & Yachnyk, 2014; Andrusyshyna, Holub, & Lampeka, 2015). Those studies have partially considered the issue of impact the highways impose on zoocenoses of adjacent territories (Hrabovskyi, 2002; Denysyk, Valchuk, 2005; Halahan, 2014), and have also touched upon the problem of complex research of ecologic condition of road landscapes (Denysyk, Valchuk, 2005; Halahan, 2014). The available materials of ecological-geochemical studies of roadside territories of highways and their analysis as complex road landscape-technical systems (Denysyk, 1998; Denysyk, Valchuk, 2005; Denysyk, 2014) allowed distinguishing specific roadside zones of ecologic disaster within the road landscapes (Valchuk, 2002), and later analyze them in more details in the monograph «Road landscapes of Podilia» (Denysyk, Valchuk, 2005). Further, the road ecozones have been receiving little attention, and gradually the number of ecological-geochemical studies of road landscapes has been decreasing (Didura, 2016, 2019). This is due not only to high cost of geochemical geophysical, ecological and other studies of road landscapes, but also because during their active development over the recent 5-7 years, priority was the roads (kilometers) rather than formation of road landscapes with respective ecozones.

Therefore, the objective of the study was ecozones of modern roadside landscapes, their structure, classification and rational construction.

Materials and methods

Over the process of our study of ecozones of road landscapes, we used the basic principles of landscape science – emergence, which is a property of landscapes as an integrity; cause and effect interrelations between individual geocomponents, history, comparability. Besides the field landscape-science methods, we utilized generally accepted (analysis, synthesis, comparison, modeling, mathematical) and geographical (historical-geographical, cartographic, genetic, geochemical, periodization) methods of research. To store and recreate the visual data, we used GIS technologies and computer modeling using the following software: graphic editors CorelDRAW and Adobe Photoshop, and also open network of satellite images Google Earth and others. We researched the roadside ecozones that have formed over the process of construction and explotation of highways of National significance Ternopil-Khmelnytskyi-Vinnytsia-Uman-Kropyvnytskyi (M-12) and Kyiv-Uman-Odesa (M-05).

Results of the research

Notion of roadside ecozone has not been formulated clearly. In our opinion, it is a complex ecological structure that is formed in the process of functioning of a road landscape. Road landscape is a system of technogenic origin, structure and functioning pattern of which are determined by road proper and its infrastructure – engineer constructions, service points, roadside windbreaks, etc (Denysyk, Valchuk, 2005). We distinguished and substantiated three categories of road landscapes: road landscape-engineer systems (RLES) – modern three-block (nature, equipment, management), actively functioning road landscapes; road landscape-technogenic systems (RLTSs) are RLESs that are out of active functional use, which have no management complex and the technical complex is only partly functioning; road landscapes proper (RLPs) –out-of-use road landscapes that develop following the natural patterns (Denysyk, 1998).

Depending on those categories of road landscapes, there form respective road ecozones. Most clearly they manifest, develop and become structured during the process of functioning of road landscape-engineer systems.

Ecozones of RLESs are complex natural-economic formations. Specific peculiarities of development of their structure and functioning are conditioned by:

- specifics of the structure and properties of previous (natural, nature-anthropogenic and anthropogenic) landscapes – fundamentals of modern road landscape-engineer systems;
- Historical peculiarities of the formation (ways of construction, materials, equipment) and functioning;
- «linear» spatial spread on large distances;
- Dependence on specifics of functioning of one type of transport – automobile.
- Field studies of highways Ternopil-Khmelnytsky-Vinnytsia-Uman-Kropyvnytskyi (M-12) and Kyiv-Uman-Odesa (M-05) in 2019-2021 revealed that ecozones of those road landscape-engineer systems are complex formations. In their structure, we distinguished microecozones (Fig. 1, 2).

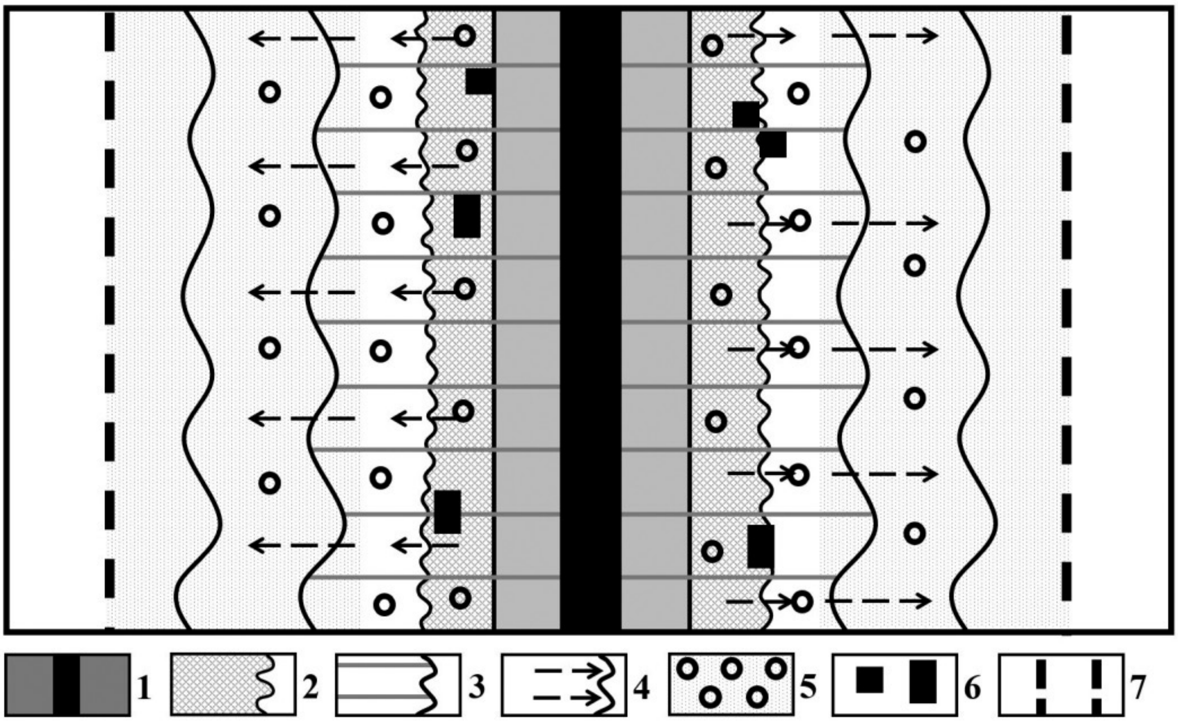

Fig. 1. Structure of ecozones of road landscape-engineer system
Microecozones: 1 – land allocated to road; technical impact; 3 – chemical contamination; 4 – acoustic impact; 5 – atmospheric contamination; 6 – esthetic contamination; 7 – landscape contamination.

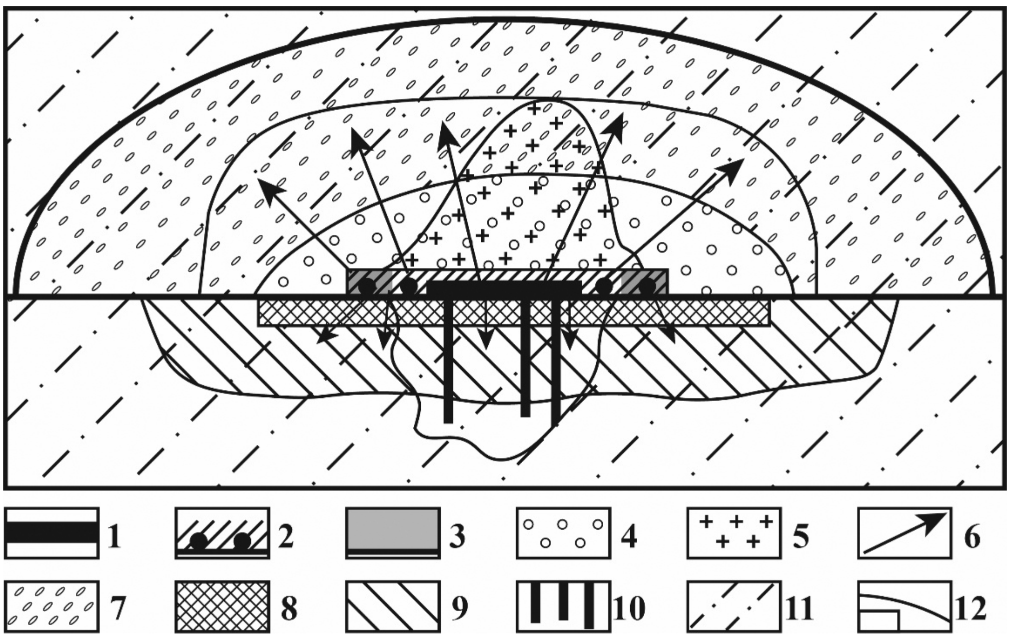

Fig. 2. Generalized profile of ecozone of road landscapes
Microecozones: 1 – land allocated to road; 2 – technical impact; 3 – esthetic contamination; 4 – chemical contamination; 5 – lighting impact; 6 – acoustic impact; 7 – atmospheric contamination; 8 – destruction and contamination of soil; 9 – aquatic contamination; 10 – possible geological impact; 11 – landscape contamination. Borders: 12 – microzones.

Microecozone of land allocated to road (MeLAR) is the central part, the «stem» of ecozone of road landscape-engineer system. It is mostly symmetric, the width corresponds to projected roadway zone and could be 3-5 m (single-track earth road) to 50-100 m (modern highways). Microecozone of land allocated to road includes road proper, ditches and roadside protective windbreak. According to the European standards, the area of highways should be as follows: 4-track – 4.6 ha per 1 km of road length and

6-track – 7.7 if flat; and 6.6 and 11.1 ha/km if hilly (Kucheriavyi, 2001). This microecozone is the source of contaminants. The specifics of its structure and functioning are the factors the ecological condition of other road microecozones depends on.

Microecozone of technogenic impact (MeTI) includes areas adjacent to the road which have been involved during construction and thereby affected by equipment and are used in the period of exploitation. This microecozone includes cut slopes, mound and terraced slopes, quarries and storages, various embankments and ditches, areas and driveways to gas stations, car services, etc. They create no entire line and are located along the road as individual plots or occupy small areas (quarries, cut terraces, etc). However, this microecozone plays important role in the functioning of the entire road ecozone as a provider of necessary substances and supports the MeTI in proper exploitable condition. The width of MeTI of M-12 highway ranges 16 – 32 to 150 m. The microecozone of technogenic impact is the place where road infrastructure is constructed.

Microecozone of chemical contamination (MeCC) is often determining in ecological aspect. This microecozone is where chemical elements, particularly heavy metals, actively accumulate, migrate and spread. Width of microecozone of geochemical contamination of the highway (M-21) ranges 20-50 to 200-500 m. Parameters (especially width and saturation by chemical elements) of the microecozone depends directly on type of road and transport loading. Most often, on rural roads and roads of inter-district conjunction, the width of geochemical contamination zones is no more than 20-35 m, it is 120-160 m on inter-oblast highways (Vinnytsia-Mohyliv-Podilsky; Khmelnytsky-Kamianets-Podilskyi), and 200-250 m on state highways (Ternopil-Khmelnytskyi-Vinnytsia-Uman-Kropyvnytskyi).

Spatially, contamination of those microecozones by chemical elements, especially heavy metals, is not uniform. This allowed distinguishing landscape-geochemical sections, nodes and plots within its borders (Denysyk, Valchuk, 2005). The most geochemically impactful on the environment and the most harmful were geochemical nodes formed in places where large highways, road junctions, etc cross. Methods of studying them have been thoroughly developed (Halahan, 2014; Denysyk, Valchuk, 2005; Khodan, 2012). However, spread and accumulation of chemical elements and, especially, heavy metals in geochemical nodes of road landscapes are mostly from-center-oriented and uniform at first. Further, the ranges of contamination, in particular such of soil cover, have spotted pattern. Spotted pattern of spread of chemical elements is observed within the borders of road «sections», though is not a characteristic feature. This peculiarity of geochemical abnormalities depends not only on structure of microecozones of geochemical contamination, but is also conditioned by mosaic pattern of landscape where road landscape-engineer systems are functioning.

Microecozone of contamination (destruction) of soil cover (MeDS) covers MeRR, partly MeTI and MeCC. They are formed as a result of destruction of soils or paving soils by asphalt concrete, their chemical contamination, drying (presence of thermally abnormal areas and freed energy), waterlogging of engineer constructions, disposal or spill of gasoline, diesel fuel, oils, etc. Its width is 50-200 m. Contamination of soil cover of landscape-engineer systems by chemical elements, especially heavy metals (Hg, Cd, Pb, Zn, Fe, Co, Ni, Mn and other) often coincides with their overall geochemical contamination. At the same time, it is important to distinguish areas of soil contamination where concentration of heavy metals exceeds the allowable norms. So far, the number of such plots has been low. In Kyiv-Odesa highway, four such zones were fund: Bila Tserkva (the crossing of roads and road fork), Pykovets village (the crossing of E 95 road and Internatsionalna St., Uman), the city of Uman (the Clover Leaf fork); Khadzhybeyskyi Lyman (heavy concentration of transport at the entrance to the city of Odesa) (Fig. 3a, b, c). The most threatening concentration of heavy metals in soils was found at the crossing of highways M-05 and M-12 on the outskirts of the city of Uman (the Clover Leaf fork). There, heavy metals 2.4-fold exceed the norms of the threshold values (Denysyk, Didura, 2019).

Microecozone of aquatic contamination (MeAC) covers surface waters and groundwater, which are subject (experience contamination) to functioning of road landscapes. Contaminations are not only such of water bodies or ground water as a result of disposal or leakage of gasoline, car oil and other substances, but also runoff of contaminated water from the road surface, contamination of water by chemical elements through atmosphere, etc. The area of MeAC significantly increases in places where the roads cross rivers, ponds, lakes, wetlands, or when they are confined to floodplain areas. The borders of this microecozone are sometimes hard to determine, especially regarding contamination of groundwater, particularly in districts of karst spread (Ternopil-Khmelnytskyi).

Microecozone of atmospheric contamination (MeAC) occupies significant areas. It manifests clearer in earth roads and roads with coating of transmission

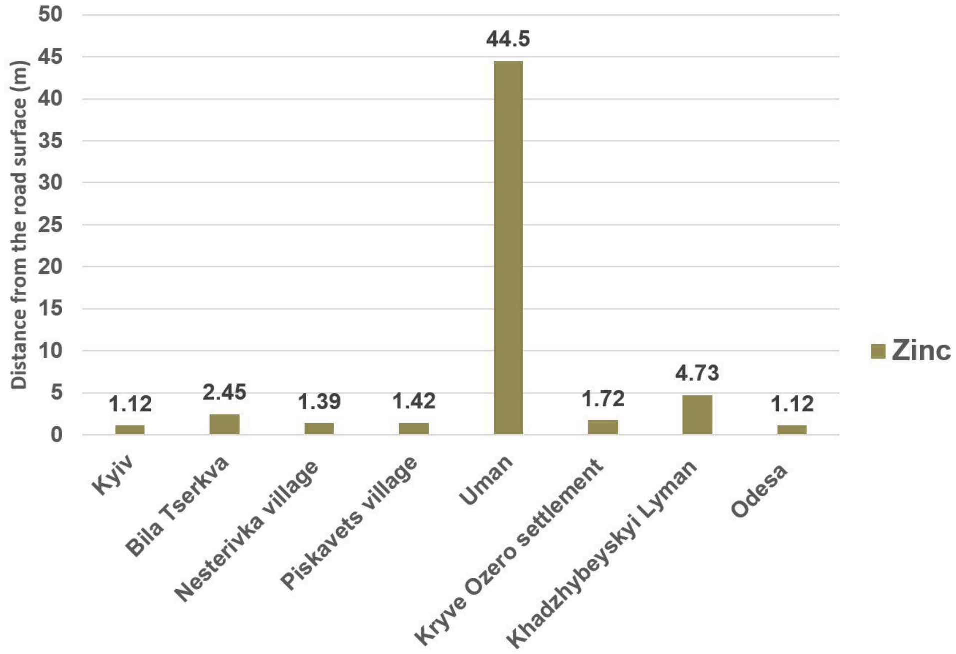

Fig. 3a. Concentration of zinc in roadside soil of the RLES of Kyiv-Odesa
Distance from roadbed / Zinc
Kyiv Bila Tserkva Nesterivka village Pikivets village Uman Kryve Ozero settlement Khadzhybeyskyi Lyman Odesa

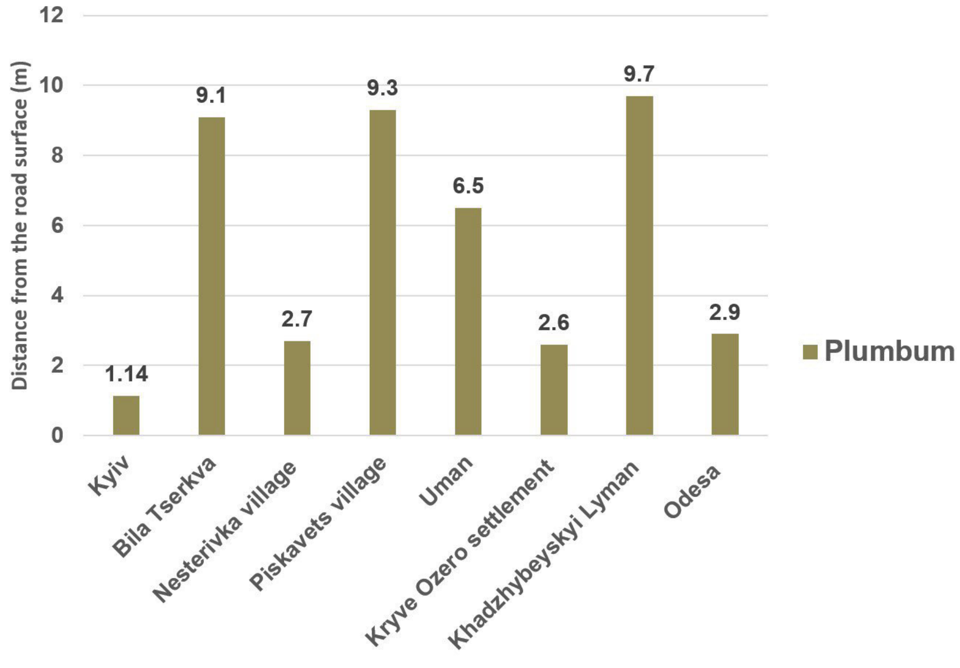

Fig. 3b. Concentration of lead in roadside soil of the RLES of Kyiv-Odesa
Distance from roadbed / Lead
Kyiv Bila Tserkva Nesterivka village Pikivets village Uman Kryve Ozero settlement Khadzhybeyskyi Lyman Odesa

types which border with highways or run across them. Besides air contamination by chemical elements, especially significant is dust. Dust from roads spreads across kilometers, forming a 30 and more meters high «dome» right above roads and adjacent environments. Over the process of field studies of Kyiv-Odesa road landscape-engineer system, we determined that air contamination increases in «enclosed» areas of highways – at crossings of forest structures, presence of unventilated roadside windbreaks, development of roads in hollows, etc. In similar areas of highways, the concentration of chemical elements in air increases as well (Denysyk, Valchuk, 2005; Khodan, 2012), which increases contamination of MeCCs, MeDSs, MeACs,

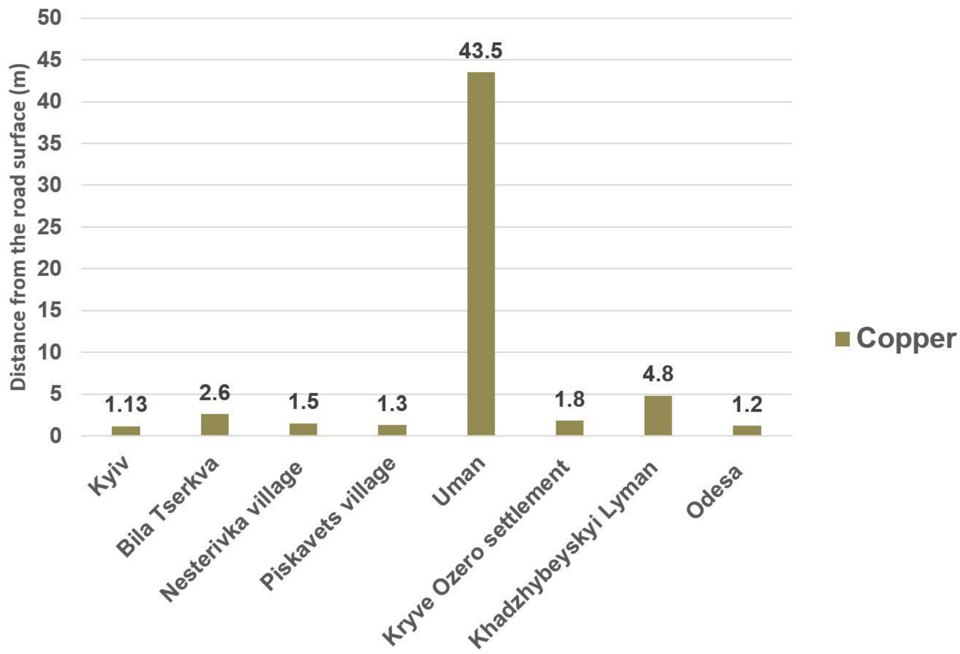

Fig. 3c. Concentration of copper in roadside soil of the RLES of Kyiv-Odesa

and the entire ecozone of roadside landscape-engineer systems in general.

Microecozone of acoustic impact (MeAI). Its formation is recognized as spread of energy of various frequencies in road ecozones (from thousandth of Hz to tenths of Hz). The sources of the impact are fluctuations occurring at hits, friction, sliding of solid details, leakage of fluids and gases (noise, vibration), generation, transmission and use of electric energy, etc. In microecozones of acoustic impact, noise-sound contamination is prominent and determines its borders. Noise is understood as any unfavorable sound or a number of sounds that unfavorably impact the human organism (the range of 20 to 20,000 Hz). In road ecozones, the total of various noise-sound sources forms the so-called sound fields. The zone of their impact depends on the number and type of auto transport, structure of roadside windbreaks, weather, etc, and has borders from 0.2 to 3-4 km.

Microecozone of lighting impact (MeLI) is formed and functions in the structure of road ecozones only during dark. The effect is taken not only on the pattern of functioning of MeRR and activity of people, but also on life of biota of road landscapes. Illumination of road landscapes causes the largest (70-76 % of overall number) losses of insects, birds, amphibians and vertebrate animals. Ecological consequences of negative impact of this microecozone have so far been studied insufficiently, though their harmfulness is obvious.

Microecozone of esthetic contamination (MeEC). Its distinctive features are construction of inappropriate structures, especially linear objects; unoriginality of objects of transport purpose; typical architecture even of service objects, which over the recent years has tended to change for the better; not always esthetically designed «roadside» bazaars, camping and even road signs, posters, architecture memorials, places of worship, etc.

Microecozone of landscape contamination (MeLC) is the result of overall functioning of above-characterized microecozones. In microecozone of landscape contamination, there is seen deterioration in regeneration ability of natural or close-to-roads (agrarian, forest anthropogenic, etc) landscapes, destruction of living locations of living organisms. At the same time, deterioration can occur in the natural environment, when components of the biosphere can self-regulate and restore.

The distinguished microecozones are not isolated one from another; they closely interact with each other, thereby forming one ecozone of road-landscape-engineer systems. Some microecozones are so closely interconnected, that they could be united, for example, MeRR, MeTI and MeDS into microecozone of direct technogenic impact; MeEC, MeAC, MeLI – into microecozone of atmospheric contamination, etc. To develop ecological measures to decrease the negative impact of roads, road landscapes on people and environment, such unification would not practical. Practice needs detailed research and distinguishing microecozones regarding each component of corresponding factor.

Analysis of available literature-cartographic and our own materials of field studies of microecozones of road landscape-engineer systems allowed us to distinguish such a peculiar feature that all microecozones, other than MeRR, and partly MeTI, MeDS, are asymmetric. Asymmetry is also characteristic for ecozones of RLES in general. It is conditioned by:

- spatial location of road landscape-engineer systems in relation to dominating winds – *wind asymmetry*. It is clearly manifested in the RLES Kyiv-Odesa, because of its perpendicular position toward western winds that dominate in the area. Wind asymmetry promotes asymmetry not only of microecozone of wind contamination, but also partly of MeAC, MeCC, MeDS, MeAI and MeLC in general.
- confinement of RLESs to respective forms of Earth's surface – *orographic asymmetry*. It is characteristic for MeTIs, MeACs and MeDCs. In the M-12RLES, it could be clearly seen in the section of Ternopil-Khmelnytskyi highway, especially where it runs across the Podilski Tovtry National Nature Park and Vinnytsia-Nemyriv, where the RLES has been constructed on a complex valley-ravine terrain (Denysyk et al., 2021). In Kyiv-Odesa road landscape-engineer system, the orographic asymmetry is appreciable in the area of Uman-Odesa, particularly where it runs across the southern spurs of the Podilia highland;
- The structure of road landscape-engineer systems – *landscape asymmetry* is formed by all microecozones, is clearly represented by MeECs and MeLCs. The study of landscape asymmetry of ecozones of RLESs have only just begun (Denysyk, Valchuk, 2005; Didura, 2019). Complexity of its study is due to active construction of road landscape-engineer systems of Ukraine. Even in such a RLES as Kyiv-Odesa, the landscape asymmetry of its ecozone is at the stage of formation.

Development vectors of the mentioned types of asymmetry of road landscape-engineer systems can coincide and not coincide. Correlations mostly occur in evened areas of road landscapes (terraces, water divides, etc) and have opposite vector in hilly and canyon-like areas, where the general slope of the surface is clearly manifested or in riverside areas of road ecozones.

Over the process of functioning of road landscape-technogenic (RLTS) and road landscapes proper (RLP), there also form road ecozones with respective set of microecozones. Their number is lower than in road landscape-engineer systems and development of microecozones of RLTSs and RLPs takes place without active impact of equipment and road infrastructure. In particular, geochemical, geophysical and other contaminations significantly decrease in the structure of RLTS ecozone, microecozones of land allocated to road and technical impact go out of control of human and equipment. Ecozones of road landscape-technogenic systems and road landscapes proper need separate study and were not analyzed in this article.

Conclusions

Active construction of road landscape-engineer systems in Ukraine began in early 21st century. Their still insufficiently studied specifics of functioning in already existing, mostly balanced structure of landscape complexes are significantly activated by paradynamic and paragenetic interrelations. They mostly manifest through negative geological-geomorphological, hydroclimatic, biochemical and landscape processes. As a result of development of those processes, there form road ecozones.

Ecozones of road landscape-engineer systems are complex natural-economic formations with specific ecological (geochemical, geophysical, esthetic and other) properties. In their structure, 10 microecozones were distinguished: land allocated to road, technical impact, chemical contamination, contamination of soil cover, aquatic and air contaminations, acoustic and lighting impacts, esthetic and landscape contaminations. Further, it is possible to distinguish other (biological, geological impacts) microecozones, and unify them into separate groups. However, when unifying those microecozones into certain groups reduces depth to which they are studied, which is not practical when designing measures to mitigate negative impact of road landscape-engineer systems on the environment. This is especially relevant for development of projects of wildlife crossings, which are so far absent in the structure of the RLESs of Ukraine.

Studying asymmetry of ecozones of road landscape-engineer systems of Ukraine allows more detailed planning and formation of the structure of roadside protective windbreaks, determining places for construction of wildlife crossings, decreasing geochemical and geophysical impact of the RLESs on the environment and rationally using landscape complexes that are adjacent to them.

Similarly to all other anthropogenic systems, the studied RLESs M-12 and M-5 need measures to be designed not only for their normal and safe functioning, but also for protection and preservation of some objects and territories within their borders. To such, it would be rational to classify: museums of RLESs, protected areas (tracts) of abandoned roads, architectural objects and places of worship, places for recreation and visiting of unique natural objects located in territories adjacent to the RLESs. Those objects and territories would significantly improve functioning of ecozones of road landscape-engineer systems and promote their gradual transition from only transport system to system of complex use – for transport, scientific, recreational and esthetic purposes.

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