UDK 911.3

GEOCHEMICAL ANALYSIS OF SNOW COVER WITHIN THE ROAD LANDSCAPE ENGINEERING SYSTEM KIEV – ODESSA

Ruslana Didura
Vinnytsa Mykhailo Kotsiubynskyi State Pedagogical University

The problem of study of snow cover pollution by chemical elements of the road landscape engineering system of Kyiv – Odesa has been considered; the previous experience of researches of domestic and foreign scientists has been analyzed, the characteristics of the climatic conditions of the Kyiv – Odesa highway has been given. Three natural areas for taking snow samples have been selected: the first is near the city of Bila Tserkva (Kyiv region); the second natural area is located in the surrounding of the city of Uman on the fork "Clover leaf" (Cherkasy region), where the road of international importance Stryi – Ternopil – Kropyvnytskyi – Znamyanka crosses with M – 05 highway; the third area is located near the urban village of Kryve Ozero on the fork "Clover's leaf" where the M-05 highway and the P-75 road of regional significance (Slobidka – Balta – Kryve Ozero – Pervomaisk – Domanika – Oleksandrivka) are crossed. The analyses were performed in Uman City-District Department of Public Institution "Cherkasy Regional Laboratory Centre of the Ministry of Health of Ukraine" using the following methods: turbidimetric, photo-color-metric, titrimetric, gravimetric, direct potentiometry, atomic absorption spectrometry according to MVV 31-497058-015-2003. The conducted studies have shown that there are such chemical elements in the snow cover of the road landscape engineering system of Kyiv – Odesa as: heavy metals, calcium, magnesium, chlorides, sulfates, ammonia, nitrates, fluorides, nitrites and manganese. Nitrites, fluorides, ammonia, petroleum products of phenol are within the normal range and do not exceed the maximum permissible concentration (MPC). Indicators of some chemical elements exceed the maximum permissible concentration: chloride ions are increased at areas 2 and 3; the sulphate index is the largest in the second background area of Uman city; the nitrate index is the highest near the urban village of Kryve Ozero; the lowest pH environment is near Uman city, the highest pH - in the urban village of Kryve Ozero, and it is close to the alkaline medium. Geochemical studies of the snow cover of the road landscape engineering system of Kyiv – Odesa were not carried out before, however, they are urgent.

Key words: Kyiv – Odesa highway, road landscape, road side, heavy metals, snow cover, copper, cadmium, zinc, distribution, concentration.

Topicality and novelty of the research

The highest indicators of environmental pollution with the harmful substances are observed in the XXI century. However, most of them are always confirmed by field studies. The snow cover has been taken as an example, which made it possible to investigate the concentration of harmful elements from different sources of pollution. Pollution of the snow cover occurs in two stages. The first stage involves the formation of snowflakes and their combination with harmful elements within the cloud, and the actual snowfall is already with the polluted components. The second stage is the direct impact of the surrounding factors on relatively clean snow such as road transport, ferrous and nonferrous metallurgy enterprises, anti-icing agents, and so on. All these factors enrich the snow with chemical elements. The Ukrainian legislation lacks the state standards for the content of chemicals, as well as heavy metals in snow cover that is exposed to external factors. Therefore, one of the main highways of Ukraine, Kyiv – Odesa, which is related to the roads of I category, was selected for the research. The topicality of the research is that such studies were not carried out within the highway, but they are necessary for the further rational use of not only the existing road landscape engineering system, but also the surrounding landscapes.

Analysis of recent publications on the research topic.

The research of snow cover was carried out by domestic and foreign scientists: O. R. Akimova, I. M. Andrusyshyna, A. M. Valchuk-Orkusha, O. G. Golub, V. F. Demchenko, G. I. Denysyk, R. V Didura, S. A. Kuralap, I. V. Kuraiev, V. I. Kozlovskyi, O. R. Lempeka, L. Yu. Matviychuk, O. G. Melnykova, T. I. Porozhyna, V. A. Yurchenkova , M.V. Yanchyk and others [8,5].

T. I. Pozhoryna and S. A. Kuralap in the process of environmental-geochemical researches of Voronezh city determined the influence of urban environment on accumulation of heavy metals in the snow cover [5, p.121-126]. The content of chemical elements in the snow cover in the Kyiv region was studied by V.F. Demchenko, I. M. Andrusyshyna, O. I. Golub, O. R. Lampeka. O.M. Valchuk-Orkusha together with G.I. Denysyk partially studied the geochemical properties of the road landscapes of Podillya [1]. In the most publications, particular attention is paid to heavy met-

als in the snow cover near major cities and industrial sites (ferrous and nonferrous metallurgy plants). The content of heavy metals in the snow in the road landscape engineering systems is studied a little. In 2017, we conducted a research on the detection of heavy metals in the road landscape engineering system of Kyiv – Odesa, but the snow cover was not used at the same time.

Methodology and methods of research: In the analysis of melting snow, it is possible to use techniques that are equated with water quality. The main regulatory document in the research is SanPin 4630-88 sanitary rules and norms of surface water from pollution [7]. GOST (state standards) 4011-72 clause 2 was used for determination of heavy metals; GOST 4245-72 cl.2 – for chlorides; GOST 4389-72 cl.3 – for sulfates; GOST 4192-82 cl. 3 – for ammonia; GOST 18826-73 cl.3 - for nitrates; GOST 4386-89 variant a - for fluoride; GOST 4192-82 cl. 4 – for nitrites; GOST 4388-72 cl.2 – for copper; GOST 7974-72 cl.3 - for manganese; GOST 3351-74 cl.5 – for turbidity and sediment; GOST 1164-72 - for dry residue; calcium, magnesium, petroleum products and phenols were investigated according to Yu. V. Novikov's methodology "Methods of studying water in reservoirs" [4]

Different methods have been applied to determine the chemical elements in the snow cover: sulfates were determined by turbidimetric; color, nitrates, nitrites, ammonia and turbidity – photo-color-metric; the content of chlorides, oxygen and alkalinity was determined by titrimetric; suspended matter - gravimetric; pH medium - direct potentiometry method; heavy metals have been investigated by the atomic absorption spectrometry method according to the MVV 31-497058-015-2003 [6, 2].

Goal of the research: to carry out a geochemical analysis of the content of chemical elements in the snow cover of the road landscape engineering system of Kyiv – Odesa.

Presentation of the main material.

The Kyiv – Odesa highway connects the central part of Ukraine with the North Black Sea coast and extends for 453.8 km. The road landscape engineering system is located within two physical and geographical zones: Forest-Steppe and Steppe. Such a spatial location contributes to a variety of climatic indicators, including those affecting the formation of the snow cover of the road landscape engineering system of Kyiv-Odesa. Snow cover in some years can be formed from 20-30 to 130-160 days; the average duration of snow cover is 60-70 days with a height of 12-15 cm [3, 159-169]. During this period there is accumulation of chemical elements on the surface of snow, and at above-zero temperature the snow dissolves with the pollutants and falls into the soil where there is an exchange in the system: snow – water – soil – plant.

3 natural areas which adjoined directly to the Kyiv - Odesa highway are selected to study the chemical elements in the snow cover. The first local area is near the city of Bila Tserkva (Kyiv region); the second - in the surrounding of the city of Uman on the fork "Clover leaf" (Cherkasy region), where the road of international importance Stryi – Ternopil – Kropyvnytskyi – Znamyanka crosses with M – 05 highway; the third area is located near the urban village of Kryve Ozero on the fork "Clover's leaf" where the M – 05 highway and the P – 75 road of regional significance (Slobidka – Balta – Kryve Ozero – Pervomaisk – Domanika – Oleksandrivka) are crossed. Samples of the snow were taken at a depth of 0-10 cm with a fivefold repeat in a glass container with signed labels at a distance of 5-10 m from the roadbed of the highway. The analyses were performed in Uman City-District Department of Public Institution "Cherkasy Regional Laboratory Centre of the Ministry of Health of Ukraine". The general location of the studied areas at a distance of 120 km from each other made it possible to record the changes in accumulation of heavy metals in the snow cover and allowed to monitor the quality of snow at various parts of the Kyiv – Odesa road. The winter during the study was snowy and frosty, which made it possible to collect snow samples in the second half of February. According to the results of the research on the chemical composition of water in the samples, the following elements were found: heavy metals (Cu, Mg and Fe), calcium (Ca), magnesium (Mg), chlorides (Cl-), sulfates (SO_{4-2}), ammonia (NH_3), nitrates (NO_{3-}), fluorides, nitrites (NO_{2-}) and manganese (Mn).

Heavy metals (HM) include a group of chemical elements that are heavier than iron (at 2.0 to 3.7 times by atomic weight and 1.1 to 1.7 times by density). HMs are divided into four groups of toxicity: very high level of toxicity (Cd, Hg, Pb, Cu, Thi, Sn, Cr, Ag, Sb); high degree of danger (Bi, U, Mo, Ba, Mn, Ti, Se, Te); the average degree of danger (Rb, As, W) and low degree of danger (Sr, Nb, Zr). The snow cover was represented by such heavy metals as: zinc, copper and iron. The research found chemical elements of heavy metals, which belong to the first and second classes of danger and are one of the main environmental pollutants.

Table 1

Results of iron content determination

Sample number	Date of selection	Content of Fe, mg/dm^3 MPC – 0,3 mg/dm^3
1	24.02.2017	< 0,1
2	24.02.2017	< 0,1
3	24.02.2017	< 0,1

The results showed that the amount of iron in the snow cover in the background areas is small enough and is within the limits of the MPC norm (Table 1).

Table 2

Results of magnesium content determination (Mg)

Sample number	Date of selection	Content of Mg, mg/dm^3 MPC – 20 mg/dm^3
1	24.02.2017	1,2
2	24.02.2017	1,2
3	24.02.2017	1,2

The content of magnesium in the snow cover on all background areas is within the normal range, and does not exceed the MPC (Table 2).

Table 3

Results of calcium content determination (Ca)

Sample number	Date of selection	Content of Ca, mg/dm^3 MPC – 3,5 mg/dm^3
1	24.02.2017	8,0
2	24.02.2017	2,0
3	24.02.2017	4,0

Calcium in the snow cover changes its indexes from 8.0 to 2.0 mg / dm^3 (Table 3). The largest index is in the Kyiv region near the city of Bila Tserkva. This is due to the fact that on the outskirts of this city there is a plant in production of tires and rubber products. All spent chemical elements from the plant are moved by air masses and settled in the suburban area. Also, the exhaust gases of vehicles influence the calcium increase in the snow cover.

Table 4

Results of chlorides content determination (Cl-)

Sample number	Date of selection	Content of Cl-, mg/dm^3 MPC – 350 mg/dm^3
1	24.02.2017	7,0
2	24.02.2017	12,0
3	24.02.2017	15,0

A significant amount of chlorine ions in all areas of the study is due to the use of anti-icing agents in winter time, such as sand and salt mixture – (15% of salt and 85% of sand, with residue). Since the areas 2 and 3 are located at the junction of highways of international and regional importance, the requirements are increased for the roadway in winter period, and the road services strew the roads with a road mixture of greater quantities (Table 4).

Table 5

Results of sulfate content determination (SO$_{4-2}$)

Sample number	Date of selection	Content of SO$_{4-2}$, mg/dm^3 MPC – 500 mg/dm^3
1	24.02.2017	4,8
2	24.02.2017	12,0
3	24.02.2017	0,9

A considerable amount of acid residues is found in Uman city at the fork "Clover leaf" (Table 5). The high content of SO$_{4-2}$ is explained by the fact that the traffic flow goes not only along the highway M – 05 and M – 12, but there is an entrance to the city where there is an upgrade. Besides there is a traffic police checkpoint as well, where a minimum speed of 50 km/h is established, and the amount of harmful substances from the car increases when braking and accelerating of a car. The smallest number is observed on the fork "Clover leaf " of the M – 05 highway and the R – 06 road near the town of Kryve Ozero. This is due to the fact that the traffic is not only intense, but continuous and the emissions from the car are much less than when going up or accelerating of a car.

Table 6

The chemical composition of the snow cover of the M - 05 highway

Sample number	pH	Hanging materials, mg/dm^3	Main ions, mg-eq /dm^3					
			SO$_{4-2}$	Cu	Ca	Mg	Cl-	NO$_{3-}$
1	8,45	0,61	4,8	0,002	8,0	1,2	7,0	2,25
2	7,34	0,50	6,5	0,002	2,0	1,2	12,0	2,39
3	7,76	0,55	0,9	0,002	4,0	1,2	15,0	2,25

As we can see from table 6, the most polluted section of the highway is located in the city of Uman. The load with vehicles is double at the junction of Kyiv – Odesa, where the road of international significance Stryi – Ternopil – Kropyvnytskyi – Znamyanka and the M – 05 highway are crossed. Indexes of ammonia, nitrites, manganese phenols, petroleum products are within the norm in accordance with the MPC. The medium is neutral in all snow samples. Only the medium of the first area is close to alkaline medium.

Conclusions. The content of heavy metals, ammonia, nitrites, manganese phenols, petroleum products on all areas of the study is within the

normal range and does not exceed the MPC., there is the high chloride content due to the use of substances - against icing on the area near the city of Uman on the fork "Clover leaf", where the road of international importance Stryi – Ternopil – Kropyvnytskyi – Znamyanka crosses with M – 05 highway, and near the urban village of Kryve Ozero on the fork "Clover's leaf" where the Kyiv – Odesa highway and the P-75 road (Slobidka – Balta – Kryve Ozero – Pervomaisk – Domanika – Oleksandrivka) are crossed. Also, the following chemical elements in the snow of the road landscape engineering system of Kyiv – Odesa have been found as: Cu, Mg, Fe Ca, Mg, chlorides, sulfates, ammonia, nitrates, fluorides, nitrites and manganese. The pH medium was studied; the overall hardness was given and weighed materials for each area of the study were determined.

The comparative characteristic for objective assessment of the content of chemical elements in the snow cover of the roadside areas of the Kyiv – Odesa highway can be taken as the basis with the background indicator, but it does not exist. Therefore, the normative documents of the relevant state standards and methodology of Yu. V. Novikova, K. O. Lastochkina and Z.N. Boldina on the research of water quality in reservoirs were selected. The comparative analysis was carried out on the basis of this methodology, which in our opinion is successful, and promising for the further rational use of the road landscape engineering system of Kyiv – Odesa.

References

1. Denisik G. Valchuk O. (2005) Analysis of road landscapes of Podillya. Vinnitsa: Tezis.
2. Lviv B. (1966) Atomic absorption. Moscow: Science, 1966.
3. Marinych O. (2005) "Physical Geography of Ukraine" In : O. Marinych & P. Shishchenko. Kyiv: Knowledge, .pp 159–169.
4. Novikov Yu. (1990) "Methods for studying the water quality of reservoirs" In: K. Lastochkina & A.Shitskova. Moscow: Science, 1990. 400 p.
5. Porozhina T. (2015) Ecological and geochemical diagnostics of the state of the urban environment due to the snow cover of the city of Voronezh. Samara Scientific Journal. 4. pp. 121–126.
6. Ukraine Parliament (2011) State standard of Ukraine ISO 5667-6-2001. Water quality. Sampling Guidelines for sampling water from rivers and other watercourses. (Act of Parliament)
7. USSR MINISTRY OF HEALTH (1988) Sanitary rules and standards of protection surface water from pollution. SanPiN 4630-88.
8. Voloshin I., Lepky M., Matviychuk L. (2005) Features of contamination of forest and roadside plantations of highways of national importance of Volyn region. Scientific herald of Volyn State University named after. Lesia Ukrainka. 7 pp.162-167.

Руслана Дідура. Геохімічний аналіз снігового покриву у межах дорожньої ландшафтно-інженерної системи Київ – Одеса. Розглянуто вміст хімічних елементів у відносно чистому сніговому покриві, під впливом навколишніх чинників, на прикладі придорожньої смуги автодороги Київ – Одеса. Проаналізовано подібні дослідження закордонних та вітчизняних вчених. Проведено геохімічні аналізи на трьох натурних ділянках: перша поблизу м. Біла Церква (Київська обл.); друга натурна ділянка зосереджена в околицях м. Умань на розвилці «Лист конюшини» (Черкаська обл.), де перетинається дорога міжнародного значення Стрий – Тернопіль – Кропивницький – Знам'янка із автотрасою М – 05; третя ділянка розташована поблизу смт Криве Озеро на розвилці «Лист конюшини» де перетинаються автотраса М–05 із автодорогою регіонального значення Р –75 (Слобідка – Балта – Криве Озеро – Первомайськ – Доманіка – Олександрівка). Забір снігу відбувався у другій половині лютого на відстані 10 м від полотна автодороги на глибині 0 – 10 см, із п'ятикратною повторюваністю. Аналізи виконували в Уманському міськрайонному відділі ДУ «Черкаський ОЛЦ МОЗ України». Проведені дослідження показали, що у сніговому покриві присутні такі важкі хімічні елементи: кальцій, магній, хлориди, сульфати, аміак, нітрати, фториди, нітрити та марганець. Нітрити, фторити, аміак, нафтопродукти феноли знаходяться у межах норми та не перевищують ГДК. Однак деякі показники виходять за гранично допустиму концентрацію: іони хлориду підвищені на ділянках 2 та 3; показник сульфатів найбільший у другій фоновій ділянці; показник нітратів найвищий у третій ділянці; найнижче pH середовище у межах другої ділянки, найвищий показник pH у третій і наближений він до лужного середовища. Геохімічні дослідження снігового покриву дорожньої ландшафтно-інженерної системи Київ – Одеса раніше не проводили, однак це є актуальною проблемою сьогодення.

Ключові слова: автомагістраль Київ – Одеса, дорожній ландшафт, примагістральна смуга, важкі метали, сніговий покрив, мідь, кадмій, цинк, розповсюдження, концентрація.

Руслана Дидура. Геохимический анализ снежного покрова в пределах дорожной ландшафтно-инженерной системы Киев – Одесса. Рассмотрены содержание химических элементов в относительно чистом снежном покрове, под влиянием окружающих факторов, на примере придорожной полосы автодороги Киев - Одесса. Проанализированы подобные исследования зарубежных и отечественных ученых. Проведено геохимические анализы на трех натурных участках: первая вблизи г.Белая Церковь (Киевская обл.) вторая натурная точка сосредоточена в окрестностях г. Умань на развилке «Лист клевера» (Черкасская обл.), где пересекается дорога международного значения Стрый - Тернополь - Кропивницкий - Знаменка с автотрассой М - 05; третий участок расположен вблизи пгт Кривое Озеро на развилке «Лист клевера», где пересекаются автотрасса М-05 с автодорогой регионального значения Р-75 (Слободка - Балта - Кривое Озеро - Первомайск - Доманика - Александровка). Забор снега происходил во второй половине февраля на расстоянии 10 м от полотна автодороги на глубине 0 - 10 см, с пятикратной повторяемостью. Анализы выполняли в Уманском районном отделе ГУ «Черкасский ОЛЦ МОЗ Украины». Проведенные исследования показали, что в снежном покрове присутствуют такие тяжелые химические элементы: кальций, магний, хлориды, сульфаты, аммиак, нитраты, фториды, нитриты и марганец. Нитриты, фториты, аммиак, нефтепродукты фенолы находятся в пределах нормы и не превышают ПДК. Однако некоторые показатели выходят за предельно допустимую концентрацию: ионы хлорида повышены на участках 2 и 3; показатель сульфатов крупнейший в второй фоновой области; показатель нитратов высокий в третьем участке; низкое рН среды в пределах второго участка, самый высокий показатель рН в третьей и приближен он к нейтральной среды. Геохимические исследования снежного покрова дорожной ландшафтно-инженерной системы Киев - Одесса ранее не проводили, однако это является актуальной проблемой современности.

Ключевые слова: автомагистраль Киев - Одесса, дорожный ландшафт, примагистральная полоса, тяжелые металлы, снежный покров, медь, кадмий, цинк, распространение, концентрация.