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MONITORING OF THE RADIATION BACKGROUND OF THE CITY OF UMAN: AFTER 10 YEARS

Purpose. Assess the possibility of using radiation background indicators for environmental monitoring.
Methods. Empirical; modeling; comparative.
Results. The main methodological approach is the assumption of the possibility of applying the concept of noospheric ecosystems (in particular, infraecosystems) for monitoring studies. Dangerous impact with a possible increase in the radiation background on the territory of the Uman NUS can be caused by enterprises: extraction and processing of decorative and building stone, limestone, gypsum, chalk and clay shale, sand, gravel, clay and kaolin. This impact can occur mainly through the products used in the improvement of the city of Uman and have a slightly higher radiation background (0.23-0.28 Mzv). Supplementing the database with new information, as well as their comparison using EGIS tools, allowed us to identify certain patterns in the change in radiation background values over the past 10 years (2013-2023): in most medical centers, which are located either in the area of private development or far from busy highways, the overall picture of radiation background values did not change significantly.
Conclusions. Repeated (after 10 years) measurements of the radiation background confirmed the conclusions of previous studies regarding purely natural or purely anthropogenic sources of small doses of radionuclides entering the environment within the city of Uman.
KEY WORDS: *monitoring, radiation background, communication routes, pollution, morbidity, ecological*

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Introduction

Changes in the environment occur under the influence of natural and biosphere factors caused by human activity. Understanding these changes is impossible without distinguishing anthropogenic processes against the background of natural ones. For this purpose, they organize special observations of various parameters of the biosphere, which change as a result of anthropogenic activity [1]. Observing the environment, assessing its actual state and forecasting its development for the future are the essence of monitoring. The dynamics of changes in the radiation background of the city of Uman were also interesting to us because similar studies were conducted at the Department of Ecology and Life Safety of the Uman National University of Science and Technology 10 years ago. And then a fairly significant contribution of the anthropogenic component to the value of the radiation background was established [2].

In fact, most people associate the city of Uman with the Arboretum "Sophiivka" and thereby evoke associations of an ecologically clean area. At the same time, on the territory of

the mentioned arboretum and around it, there are outcrops of Precambrian granites, which have a fairly significant natural radiation background. In previous studies, a close correlation between the values of the natural radiation background and the dynamics of the incidence of neoplasms in the population turned out to be unexpected. Therefore, knowing the values of the radiation background, localized by a certain address binding, it becomes possible to make certain forecasts of the dynamics of morbidity in certain territories. Solving such problems lies within the realm of many Earth sciences - geology, physical geography, medical geography. At the same time, the contribution to the meaning of the radiation background of the anthropogenic component, noted in previous studies, should connect the approaches of social geography and geo-urbanism to our analysis.

The indicated problems do not limit the range of our scientific interests. Actually, environmental monitoring of communication routes, which is the main problem of our research, logically includes problems of environmental quality along the main roads. Surveys of the radiation background were conducted by us directly along the communication routes, but within the limits of the city of Uman. We plan to use the results of these studies as a methodical technique when surveying larger territories (Cherkasia Region).

Actually, the relevance of our research is determined by these problems.

The main goal set by the author is to assess the possibility of using radiation background indicators for environmental monitoring of communication routes (highways).

Therefore, the object of the study is the territory of the city of Uman.

The subject of the research is the comfort of the urban environment, investigated with the help of modern methods of environmental monitoring, in particular through the indicators of the radiation background measured along the communication routes.

Tasks that were set during the research:

- by studying literary sources, justify the need for monitoring the environment at the local level and determine its main tasks, in particular, investigate the dynamics of changes in the radiation background over 10 years;
- to study the conditions, objects and substantiate the research methodology;
- with the help of data from previous publications, carry out a preliminary assessment of possible sources of radiation radiation in the territory of the city of Uman;
- apply the possibilities of modern GIS technologies in monitoring studies of the territory of the city of Uman, in particular, the elementary GIS methodology developed at the Department of Ecology and Life Safety of the Uman National University of Science and Technology;
- to conduct a comparative analysis of the results of monitoring the radiation background of the territory of the city of Uman 10 years ago and today.

Research methodology

Monitoring surveys at the local level, in particular, the city (as in our case) should be carried out according to an extended program that includes measurements not only on the territory of the city, but also outside its borders, as well as at different heights above the city. This is necessary in order to assess the range and height of the spread of harmful impurities from cities, their influence on the change in concentrations in the entire vital layer in the territory of the city or in the entire industrial district.

According to the generally accepted method of monitoring at the local level [3], observation posts are located at the intersections of streets with busy traffic, at regular major highways, at different distances from powerful industrial enterprises or industrial sites according to the prevailing wind direction. Posts are also located in residential areas of various types of buildings, in public recreation areas, on the territories of schools and kindergartens, in landforms (hills and depressions), in the area of the weather station. The selected points should be located as evenly as possible throughout the

city on sites with a dust-free regime or in ventilated places. To detect the impact of the city on the surrounding area, it is also advisable to install one stationary post at a distance of 1-3 km from the city on the windward side in the prevailing wind direction and at a distance of 2-5 km. The authors of the studies conducted in 2013-2014 followed these exact requirements. In particular, more than 300 measurement points of the radiation background were designated on the territory of the city of Uman (Fig. 1). Measurements were made using two devices "BELLA" and "TERRA-P" (to reduce the measurement error).

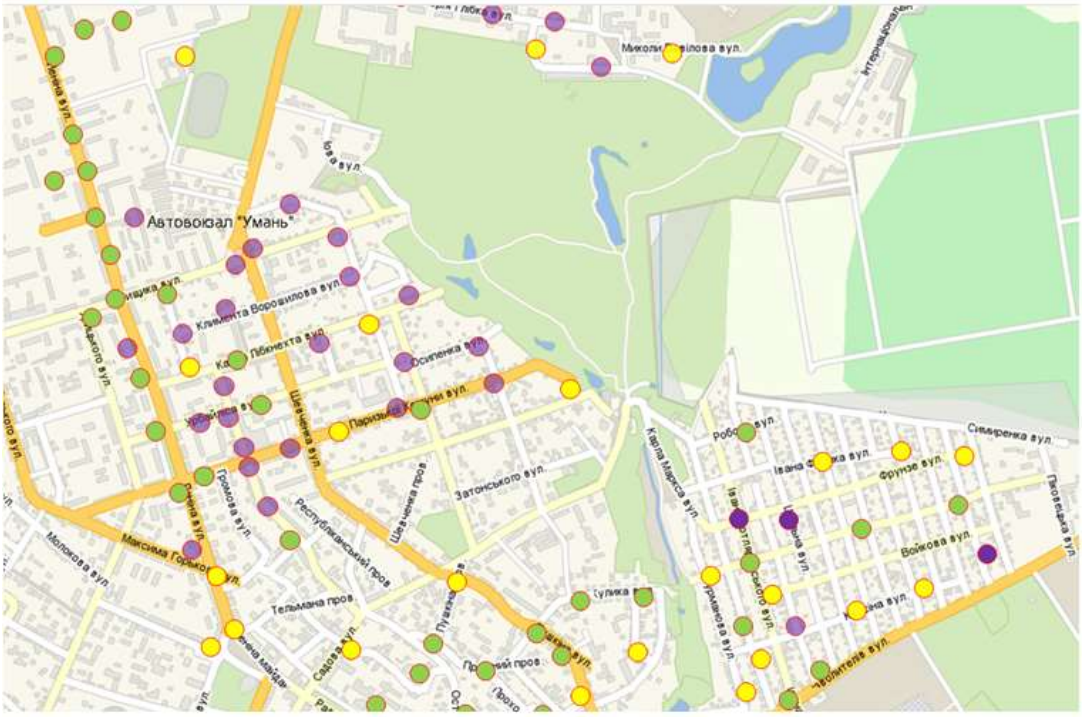

Fig. 1 – Measurement points of the radiation background in the territory of the city of Uman (fragment)

Therefore, our task was made easier, because there was no need to choose the measurement points again. They were already appointed. However, to facilitate the further comparison of data for 2013 and 2023, we have developed a corresponding database in the form of tables (Tabl. 1). The coordinates of the points and their height above sea level were determined using the tools of the popular and publicly available program "Google Earth". In particular, we deliberately included the value of height above sea level in the database due to the fact that in previous studies the slope of the terrain could affect geochemical processes in the urban landscape. For example, in work [4], the moderately dangerous areas were assigned to sites No. 6, 23, 29, 33 and 37, where the indicators are within the range of 0.16-0.22 (from the incidence level) and 0.19-0.22 μSv/ hour (from the radiation background level). The reasons for such a radiation background at sites No. 33 and No. 37 are that they are located near the bulk cargo unloading area of the Uman railway station, which has been in operation for more than 40 years (coal, granite chips, mineral fertilizers, etc.). During this time, various radioactive particles accumulated on the soil surface, which can cause an increased radioactive background. The increased radiation background at site No. 29 is explained by the

Table 1

Database for conducting a comparative analysis of radiation background values (fragment) when the water converges from sites No. 33 and No. 37 to site No. 29.

ID №	Address binding of radiation background measurement points	Latitude coordinates (N)	Longitude coordinates (E)	Altitude (м)	Value of radiation background (mSv) in 2013	Value of radiation background (mSv) in 2023	Belonging to a medical ward (number of the medical ward according to the map)
Medical ward No. 9							
1/9	St. Lisna	48°45'42"	30°13'20"	218	>0.23	**0,27**	9
2/9	St. Tishchika	48°45'37"	30°13'14"	225	>0.23	**0,28**	9
3/9	Corner of St. Tyshchika - str. Kirova	48°45'40"	30°13'27"	210	>0.23	**0,25**	9
4/9	St. Voroshilov	48°45'35"	30°13'29"	213	>0.23	**0,25**	9
5/9	St. Liebknecht	48°45'33"	30°13'37"	210	>0.23	**0,27**	9
6/9	prov. Palanin	48°45'29"	30°13'24"	222	>0.23	**0,28**	9
7/9	Corner of St. Liebknekhta - Kirova	48°45'31"	30°13'31"	217	0.18 - 0.23	**0,24**	9
8/9	Corner of St. Gogol - Osypenka	48°45'27"	30°13'37"	218	>0.23	**0,24**	9

fact that the sloping topography of this part of the city promotes the biogeochemical migration of radioactive and toxic substances, due to rain showers, when water runs from sites No. 33 and No. 37 to site No. 29.

The second important part of the research methodology was the use of elementary GIS (EGIS), implemented in the standard MS Office package, in particular, MS Word. The sequence of instrumental operations in EGIS is described in [5], so we will not dwell on it in detail. The main ones are:

- vectorization from a detailed raster map (Google Maps) of the territory of the city of Uman (the scale is not deliberately indicated, as the Google Maps toolkit allows you to use almost unlimited scaling possibilities in both directions);

- plotting the measurement points of the radiation background (according to the results of previous studies);

- creation of a database with the assignment of an ID for each point (Tabl. 1);

- creation of a search and reference system using the tool "MS Word" "hint" (Fig. 2);

- comparative analysis of current measurement values with previous ones (10 years ago).

Measurements of the radiation background were carried out by us with the help of the "TERRA-P" dosimeter by traveling by car along routes that included predetermined points (Fig. 1).

The author tries to fit the above methodological techniques into a rather unusual methodological scheme for monitoring studies [6]. In particular, we consider the connection paths along which the measurements were carried out as "infraecosystems", or ecosystems that have a linear spatial configuration and along which specific ecosystem relations are formed. This methodological approach is outlined in the studies of Professor Sonko S.P. and confirmed in other works [7] and we fully adhere to it.

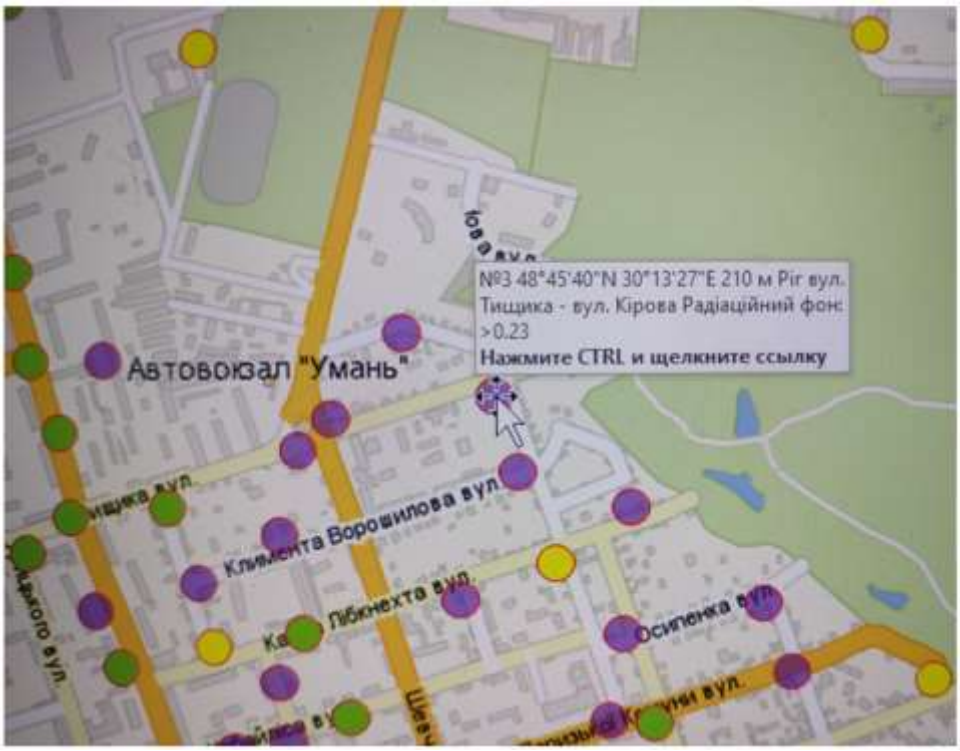

Fig. 2 – Creating a search and help system using the "hint" tool (fragment)

In the future, the author will not limit himself to measurements of the radiation background, but will try to investigate the dynamics of spatial changes in linear ecosystems in a larger area (Cherkasy region) depending on distance towards landscapes typical for a certain area (mainly anthropogenic).

Research results

The map of medical districts of the city of Uman, of which there are 38 (Fig. 3), became the cartographic basis for the research. According to the requirements [8], about 2,000 residents are attached to each of the medical districts, whose health is taken care of by district doctors. As a matter of fact, this connection to medical districts became the basis for easier formalization of information in the database (Tabl. 1).

Further reform of the health care system slightly changed the status of both district doctors and health care institutions. Today, the health of citizens is not taken care of by district doctors, but by family doctors, however, the distribution of the number of residents per doctor has hardly changed. Despite the fact that we did not conduct medical-geographical studies due to the lack of data on the incidence of the population, we consider it appropriate to link the updated data (for the year 2023) precisely to the borders of the medical districts, as this will help in the future to establish a connection between the incidence and radiation background to those researchers who are interested in this problem.

The first stage of our research was familiarization with possible sources of environmental pollution. In particular, with productions that (at a certain concentration of the finished product or waste) can be a source of a slight increase in the radiation background. In particular, in previous studies [9] it was established that the storage of bulk goods such as coal, mineral fertilizers, gravel, crushed stone can be a source of a slight

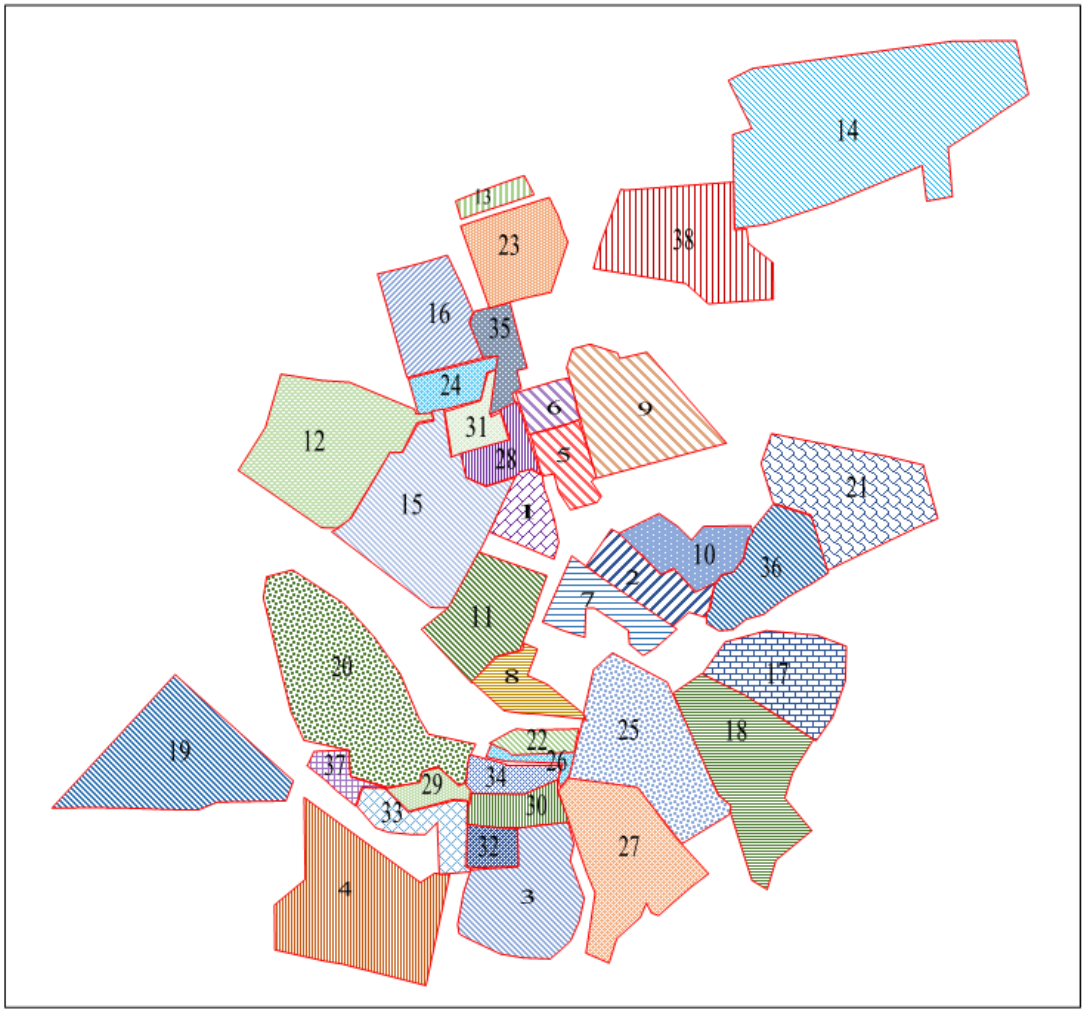

Fig. 3 – The boundaries of medical districts of the city of Uman (as of 2013-2014)

increase in the radiation background. In addition, temporary sources of a slight increase in radiation can be food waste (for example, potato husks or wood) obtained from products grown in radiation-contaminated regions [9].

According to the estimates of specialists of the Department of Ecology and Natural Resources of the Cherkasy Regional State Administration [10], the main polluters of the environment in the territory of the city of Uman and its surroundings are PJSC "Umansky Zavod "Megommetr", Uman (production of instruments and equipment for measurement, research and navigation);

- PJSC "Umanfermmash", Uman (production of machines and equipment for agriculture and forestry);

- "SerNik and Co" LLC, Uman (production of bricks, tiles and other construction products from fired clay);

- PE "Uman Factory of Reinforced Concrete Products", Uman (production of reinforced concrete products);

- ABZ of the branch "Umanskyi RAD" SE "Cherkasky Oblavtodor" OJSC "State Joint Stock Company "Automobilni dorogi Ukrainy", Uman city (construction of roads and freeways);

- PJSC "Umansky "Agroshlyahbud", p. Pikivets, Umansky district (construction of roads and highways);

- OJSC "Umanavtodor", Uman (construction of roads and highways);

- PrJSC "Technology", Uman (production of basic pharmaceutical products);

- PJSC "Vitaminy", Uman (production of basic pharmaceutical products);

There are 28 gas stations operating in the territory of the city of Uman and the Uman district, which trade in solid, liquid, gaseous fuel and similar products.

17 registered landfills also operate on the territory of the Uman district. They can have a harmful effect on the territory of the city of Uman due to the accumulation of both household and some construction waste, which can be a potential source of radiation.

Enterprises that discharge waste water into the rivers of the district operate on the territory of the Uman district. It:

- KP "Umanvodokanal" the volume of discharge of return water into the Umanka River in 2016 was 2,538.0 thousand m3/year, including the amount of pollutants discharged together with return water, 885,774 t/year;

- LLC "Umanskiy Grankarrier" discharged return water into the Umanka River in 2016, 31.0 thousand m3/year, including the amount of pollutants discharged together with return water 5.01 t/year;

- Starobabaniv correctional colony No. 92, the volume of return water discharge into the Revukha River in 2016 was 189.0 thousand m3/year, including the amount of pollutants discharged together with return water, 3.37 t/year.

There are 6 registered and 11 non-registered waste disposal sites of category B (hazardous) in the Uman district[4].

From the listed economic facilities, the following may cause a possible dangerous influx with a possible increase in the radiation background on the territory of the Umansky NUS:

- OJSC "Starobaban Granite Quarry", p. Stari Babany, Uman district (mining of decorative and building stone, limestone, gypsum, chalk and clay slate);

- LLC "Umansky Grankarrier", p. Pikivets, Umansky district (extraction of sand, gravel, clay and kaolin);

- PJSC "Kyiv Granit Plant", p. Tanske, Uman district (cutting, processing and decoration of decorative and building stone);

Their impact occurs mainly through products used in the improvement of the city of Uman and which have a slightly higher radiation background (0.23-0.28 MZv/h) [4].

From the point of view of the monitoring of communication routes, measurements of the radiation background conducted along these routes focus the observer's attention, as it were, on the sources associated with road transport. However, other ways of gradually increasing the radiation background cannot be excluded. Thus, according to the results of previous studies [11], significant values of the radiation background (more than 0.22 μSv/h) were noted within medical districts No. 5,9. According to these studies, the reason for this is also the powerful outcrops of Precambrian granites in the Sofiivka Arboretum. Precincts Nos. 6, 23, 29, 33 and 37 were classified as moderately dangerous, where the indicators of the radiation background level were equal to 0.19-0.22 μSv/hour. The reasons for such a radiation background at sites No. 33 and No. 37 are that they are located near the bulk cargo unloading area of the Uman railway station, which has been in operation for more than 40 years (coal, granite chips, mineral fertilizers, etc.). During this time, various radioactive particles accumulated on the soil surface, which can cause an increased radioactive background. The increased radiation background at site No. 29 is explained by the fact that the sloping topography of this part of the city promotes the biogeochemical migration of radioactive and toxic substances, due to rain showers, when water runs from sites No. 33 and No. 37 to site No. 29.

Supplementing the database with new information, as well as comparing them using EGIS tools, made it possible to identify certain regularities in the changes in the values of the radiation background over the past 10 years. At most medical centers, which are located either in the zone of private development or away from busy highways, the general picture of the values of the radiation background has not changed much. Below, we will dwell in more detail on those precincts where the radiation background was exceeded in 2013-2014

- 9 points remained at the level of 10 years ago (0.22-0.25 μSv/h) in medical district No. 9

(Str.: Lisna, Tyshchika, Gogolya, Par. Komuny, etc.) out of 14 sampling points. In four points, the values reached 0.25-0.27 μSv/h (ID: 1/9,2/9,5/9,6/9). And only at one point (ID12/9) was a slight decrease in the values of the radiation background (0.16 μSv/h).

- In the medical district No. 5 (Str.: Respublikanska, Urbailisa, Ave. Sadovy, etc.), 4 points remained from 10 sampling points at the level of 10 years ago (0.22-0.25 μSv/h) (ID: 1/5,5/5,75,9/5). In two points, the values reached 0.26-0.27 μSv/h (ID: 2/5,3/5). And in four points (ID: 4/5, 6/5, 8/5, 10/5) a slight decrease in radiation background values (0.15 - 0.19 μSv/h) was found.

- In the medical district No. 6 (Str.: Tyshchyka, Voroshilova, R.Luxemburg, etc.), of the 6 sampling points at the level of 10 years ago (0.21-0.23 μSv/h), 2 points remained (ID: 2/6, 3/6). In two points (ID: 4/6, 5/6) the values reached 0.21 μSv/h. And in two points (ID: 1/6, 6/6) a slight decrease in the values of the radiation background (0.12 - 0.13 μSv/h) was found.

Conclusions

From the point of view of the methodology of monitoring studies of transport routes, the following points attract attention:

1. The study of the radiation background, taken as the main indicator, can give an approximate idea of the role of transport routes in the spread of this type of pollution in cities. In particular, within the city of Uman, where car traffic is not characterized by significant intensity, it can be confidently asserted that the value of the radiation background does not depend on the movement of motor vehicles, since it cannot be a source of radionuclides distribution.

2. Repeated (after 10 years) measurements of the radiation background confirmed the conclusions of previous studies regarding purely natural (Precambrian granites) or purely anthropogenic (storage of bulk goods) sources of small doses of radionuclides entering the environment within the city of Uman.

3. When conducting monitoring studies of communication routes in the future, it will be most appropriate to divide the methods of conducting such studies on linear sections of roads (between populated areas) and directly in populated areas. At the same time, measurements of the radiation background are not enough to establish geographic patterns in the spread of pollution.

4. The elementary GIS methodology makes it possible to conduct comparative monitoring studies in the conditions of the city of Uman.

In the future, conducting monitoring studies of communication routes will require the study of other environmental parameters in roadside lanes [12]. In particular, it can be soil research for the presence of heavy metals, the presence of residues of organic substances, plastic, detection of violations of the groundwater regime due to the support of aquifers by a road embankment (on intercity sections of roads). As for cities, the most probable results, in our opinion, can be given by measurements using special devices of gas and dustiness of the environment [13]. Ecosystem studies on the distribution of various plants (including invasive ones) along the roadways, as well as the formation of food chains "tied" to the roadways, can be of considerable interest.

Conflict of interest

The author declares that there is no conflict of interest regarding the publication of this manuscript. In addition, the author fully complied with ethical standards, including plagiarism, falsification of data, and double publication.

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МОНІТОРИНГ РАДІАЦІЙНОГО ФОНУ МІСТА УМАНЬ: ЧЕРЕЗ 10 РОКІВ

Мета. Оцінити можливість використання показників радіаційного фону для екологічного моніторингу.
Методи. Емпіричний; моделювання; порівняльний.
Результати. Основним методологічним підходом є припущення про можливість застосування концепції ноосферних екосистем (зокрема інфраекосистем) для моніторингових досліджень. Небезпечний вплив з можливим підвищенням радіаційного фону на території Уманського НУС можуть спричиняти підприємства: по

видобутку та обробці декоративного та будівельного каменю, вапняку, гіпсу, крейди та глинистого сланцю, піску, гравію, глини та каоліну. Цей вплив може відбуватися переважно через продукцію, яка використовується при благоустрої міста Умань і має дещо вищий радіаційний фон (0,23-0,28 Мзв). Поповнення бази даних новою інформацією, а також їх порівняння за допомогою засобів EGIS дозволили виявити певні закономірності у зміні значень радіаційного фону за останні 10 років (2013 – 2023 роках): у більшості медичних центрів, які розташовані або в зоні приватної забудови, або далеко від жвавих магістралей, загальна картина значень радіаційного фону суттєво не змінилася.

Висновки. Повторні (через 10 років) вимірювання радіаційного фону підтвердили висновки попередніх досліджень щодо суто природних або суто антропогенних джерел надходження малих доз радіонуклідів у навколишнє середовище в межах міста Умань.

КЛЮЧОВІ СЛОВА: *моніторинг, радіаційний фон, шляхи сполучення, забруднення, захворюваність, екологія*

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