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Mykola Ananiyovych Fedoniuk,

PhD (Geography), Associate Professor, Department of Ecology and Agronomy,
Faculty of Environmental Studies, Tourism and Electrical Engineering,
Lutsk National Technical University, 75 Lvivska St., Lutsk, 43018, Ukraine,
e-mail: m.fedoniuk@lntu.edu.ua, https://orcid.org/0000-0002-4034-3695;

Vitalina Volodymyrivna Fedoniuk,

PhD (Geography), Associate Professor, Department of Ecology and Agronomy,
Faculty of Environmental Studies, Tourism and Electrical Engineering, Lutsk National Technical University,
e-mail: ecolutsk@gmail.com, https://orcid.org/0000-0002-1880-6710;

Vasyl Volodymyrovych Ivantsiv,

PhD (History), Head of Department of Ecology and Agronomy,
Faculty of Environmental Studies, Tourism and Electrical Engineering, Lutsk National Technical University,
e-mail: ivv@email.ua, https://orcid.org/0000-0003-4710-3245

POSSIBILITIES FOR IMPROVEMENT OF ENVIRONMENTAL MONITORING OF PRECIPITATION IN THE CITY (A CASE OF LUTSK)

М. А. Федонюк, В. В. Федонюк, В. В. Іванців. МОЖЛИВОСТІ ВДОСКОНАЛЕННЯ ЕКОЛОГІЧНОГО МОНІТОРИНГУ ОПАДІВ У МІСТІ (НА ПРИКЛАДІ ЛУЦЬКА). Розглянуто можливості удосконалення системи екологічного моніторингу атмосферних опадів у місті в процесі створення недержавної мережі пунктів спостереження за кількісними фізико-хімічними показниками, що характеризують динаміку їх випадання, суми, кислотність, мінералізацію. Проаналізовано сучасну організацію системи моніторингу атмосферних опадів та їх хімічного складу. Подано аналіз наукових публікацій, присвячених питанню спостережень за фізико-хімічними параметрами опадів в контексті їх впливу на екологічний стан навколишнього середовища.

Описано результати власних спостережень за такими показниками, як кислотність, мінералізація та суми опадів у місті Луцьку. Виявлено окремі просторові та сезонні відмінності розподілу цих показників. Вказані окремі недоліки існуючої системи державного моніторингу, що здійснюється гідрометеорологічними підрозділами, і виділено критерії створення удосконаленої схеми локального моніторингу дощових вод.

Обґрунтовуються принципи розміщення постів спостережень по відношенню до районів житлової і промислової забудови. Описано особливості програми моніторингу показника рН опадів: зокрема, вказано на необхідність врахування ряду супутніх факторів (температури дощової та талої снігової води, загальної мінералізації, тривалості випадання опадів). Розглянуто перспективи і можливості впровадження пропонованої системи моніторингу та її автоматизації. Представлені розроблені авторами карти розподілу кислотності опадів у місті Луцьку, картосхему локальної моніторингової мережі. Оцінено можливість автоматизації пунктів контролю атмосферних опадів, окреслено перспективи використання зібраної таким чином інформації для науковців, а також у практичній сфері (міські комунальні служби, транспортні служби, ремонтні підрозділи по обслуговуванню електромереж).

Запропонована схема розміщення постів екологічного моніторингу кислотності та інших супутніх показників, що характеризують хімічний склад атмосферних опадів, була розроблена із урахуванням переважаючого напрямку надходження повітряних мас, рози вітрів, а також специфіки міської забудови та розміщення промислових зон у обласному центрі. Встановлення в межах міста відповідно обладнаних пунктів мережі екологічного моніторингу дасть змогу оперативно відстежувати та аналізувати важливі показники якості оточуючого середовища. Це сприятиме, в тому числі, і покращенню якості життя людей, що проживають в місті.

Ключові слова*: опади, урбоекосистеми, просторовий розподіл, екологічний моніторинг, кислотність опадів, мінералізація опадів, пункт контролю, Луцьк.*

Н. А. Федонюк, В. В. Федонюк, В. В. Иванцив. ВОЗМОЖНОСТИ УСОВЕРШЕНСТВОВАНИЯ ЭКОЛОГИЧЕСКОГО МОНИТОРИНГА АТМОСФЕРНЫХ ОСАДКОВ В ГОРОДЕ (НА ПРИМЕРЕ ЛУЦКА). *Рассмотрены возможности усовершенствования экологического мониторинга атмосферных осадков в городе в процессе создания негосударственной сети пунктов наблюдения за количественными физико-химическими показателями, которые характеризуют динамику их выпадения, суммы, кислотность, минерализацию. Проанализирована современная организация системы мониторинга атмосферных осадков и их химического состава. Представлен детальный анализ научных публикаций, посвященных вопросу наблюдений за физико-химическими параметрами осадков в контексте их влияния на экологическое состояние окружающей среды.*

Описаны результаты собственных наблюдений за такими показателями, как кислотность, минерализация и суммы осадков в городе Луцке. Выявлены отдельные пространственные и сезонные различия распределения этих показателей. Указаны отдельные недостатки существующей системы государственного мониторинга, осуществляемого гидрометеорологическими подразделениями, и выделены критерии создания усовершенствованной схемы локального мониторинга дождевых вод.

Обосновываются принципы размещения постов наблюдений по отношению к районам жилой и промышленной застройки. Описаны особенности программы мониторинга показателя рН осадков; указана необходимость учета ряда сопутствующих факторов (температуры дождевой и талой снеговой воды, общей минерализации, продолжительности выпадения осадков). Рассмотрено перспективы и возможности внедрения предлагаемой системы мониторинга и ее автоматизации. Представлены разработанные авторами карты распределения кислотности осадков в городе Луцке, картосхема локальной мониторинговой сети. Осуществлена оценка возможности автоматизации пунктов контроля атмосферных осадков, описаны перспективы использования собранной таким образом информации для научных работников, а также в

практической деятельности (городские коммунальные службы, транспортные службы, ремонтные подразделения, обслуживающие электросети).

Предложена схема размещения постов экологического мониторинга кислотности и других сопутствующих показателей, которые характеризуют химический состав атмосферных осадков. Эта схема была разработана с учетом преобладающего направления циркуляции воздушных масс, розы ветров, а также специфики городской застройки и размещения промышленных зон в областном центре. Установка в пределах города соответственно оборудованных пунктов сети экологического мониторинга позволит оперативно отслеживать и анализировать важные показатели качества окружающей среды. Это будет способствовать, в том числе, и улучшению качества жизни людей, проживающих в городе.

Ключевые слова: *осадки, урбоэкосистемы, пространственное распределение, экологический мониторинг, кислотность осадков, минерализация осадков, пункт контроля, Луцк*

Formulation of the problem. Atmospheric precipitation, their, dynamics, physical and chemical composition, the seasonal distribution is a significant factor affecting a number of geochemical and ecological processes in the lithosphere and hydrosphere. Global climatic changes observed over the past decades have also affected the dynamics of rainfall, their spatial-geographical and temporal distribution. Investigating of the nature and main trends of such changes, their influence on transformations occurring in landscape complexes is an important task.

The dynamics of precipitation in urban ecosystems, as a rule, has its own specifics. The city is an "island of heat" and a dynamic obstacle to the air masses, so urban areas are characterized by the fallout of higher rainfall than adjacent territories. The variability of other meteorological phenomena in the city, which are interrelated with precipitation (terrestrial hydrometeors, thunderstorms, etc.), is also significantly increasing.

Rain water largely determines the ecological state of the urban landscapes, architectural complexes, reservoirs, green areas, parks and squares, household farms. Indirect rainfall can also affect the quality of life and health of the urban population.

The peculiarities of the chemical composition of atmospheric precipitation also depend to a large extent on the features of the arrangement of cleaning systems on the collectors of city sewage drainage.

Therefore, the monitoring of qualitative and quantitative characteristics of atmospheric precipitation and thawed waters is an important element in the system of environmental monitoring. At the same time, in cities such monitoring has its own peculiarities - due to the occurrence of specific meteorological conditions, the presence of powerful sources of atmospheric pollution, vulnerability of components of the urban environment, etc.

Analysis of previous research (dealing with this problem). One of the most important (though the simplest measured) indicators of the chemical composition of precipitation is the pH level, which characterizes their acid-base properties. The increased attention to the precipitation acidity was formed in the 1960-1970s, when the link between anthropogenic emissions of sulfur and nitrogen acid residues and acid rainfall was evident. Since then, specialized networks of atmospheric air monitoring were formed, which had to track the formation and spread of such phenomena.

Lennart Granat in 1972 [1] analyzed over 2,000 rain samples from the countries of Northern and Western Europe. As a result, the empirical dependence of pH on the chemical composition of rainwater (based on the content of acids and bases) is established. A model has been constructed that found a reliable link between the sums of bases (alkalinity) and the pH value in the range from 3.8 to 6.4 (from -90-100 at pH 3.8-4.0 to +50 + 70 at pH 6.3-6.4). At the same time, it was found that relatively small deviations from the natural values of the content of sulfate or nitrate acid residues cause an imbalance of the acid-base equilibrium. Important in this case also has the content of bicarbonate (hydrocarbon-calcium equilibrium).

J. Morgan (1982) described in detail the basic chemical reactions that contribute to the formation of precipitation acidity [2]. Among the main components that influence the pH of rainwater, sulfate and nitric acids with precursor oxides, as well as NH_3 and $CaCO_3$ are isolated, among the minor ones are weak organic acids and weak bases based on the oxides of the most common metals. The contribution of anthropogenic sulfur and nitrogen oxides to acidification of rainwater is estimated at 0.5-1.5 in relation to background values. In the paper [3] a decrease in pH was observed in co with the increase in the CO_2 content in the atmosphere. It has been argued that over the past 200 years, the pH of rainwater has averaged from 5.68 to 5.62, and in 2100, at 700 ppmv CO_2, it may be 5.49. This, at first glance, slight acidification will increase the solubility of carbonates by 25-30%.

However, the analysis of rainwater monitoring data in Europe over the past decade has shown a tendency to increase the pH. The maximum acid rain was observed in the 1970s and 1980s, and since the mid-1990s their incidence rates, as well as average acidity, are constantly decreasing. This trend is also fixed for Belarus [4, 5], and for Ukraine [6, 7], and for individual stations in Poland [8]. The obvious reason for such tendencies is the structural changes in the economy of the countries of both

Western and Central and Eastern Europe, which led to the closure or transfer of many large industrial enterprises, reducing the share of heavy industry and thermal energy, etc.

The spatial analysis of the chemical composition of atmospheric precipitation in the territory of Ukraine is given in the works of the scientists of the Kyiv National University. T. Shevchenko (V. Peleshenko, M. Romas, V. Khilchevsky, O. Kosovets-Skavrovska) and others. In particular, it was established that from 1963-2011's changes in mineralization were accompanied by a decrease in the composition of atmospheric prec ipitation of ions of anthropogenic origin and an increase in ions of mainly natural origin [9, 10].

But the pH of urban rainfall and the resulting storm water can often differ significantly from global and regional indicators. This is facilitated by, in particular, the presence of various coatings of buildings and road pavement [11, 12] significant pollution of urban air [2], a combination of large-scale and local meteorological factors [13]. Therefore, the monitoring of atmospheric precipitation in the city requires more detail in obtaining observational data and their scientifically substantiated analysis.

Existing monitoring system. Monitoring of the chemical composition of atmospheric precipitation is carried out at special stations of the Hydrometeorological Center of Ukraine and / or the Ministry of Ecology and Natural Resources of Ukraine.

To obtain adequate results, individual monitoring points should be merged into a single network which would ensure the comparability of the data received.

In Ukraine, according to the Central Geophysical Observatory, the measurement of precipitation acidity is carried out at 40 stations [7], in recent years their number varied within 37-46. In the Volyn region, there are weather stations Svityaz, Volodymyr-Volynsky, Lyubeshiv, Manevichi, and Lutsk, in the neighboring Rivne - weather station Sarny and Rivne. In the Republic of Belarus there are 22 monitoring points for the chemical composition of precipitation [5], in Poland, such a network brings together 23 monitoring points. In addition, observations on the acidity of precipitation are also carried out at specialized stations of integrated environmental monitoring and in some natural preservation sites.

The analysis of the location of the monitoring points for the chemical composition of rainwater in the border regions of Poland, Belarus and Ukraine (according to [14] [5] [7]) shows a greater density of the monitoring network in the Ukrainian territory. But in reality, regular monitoring of the pH of precipitation is carried out only on a part of these stations. The most complete monitoring program at the Svityaz meteorological station, which (with the Rava-Ruska station in the Lviv region) is a transboundary air mass transfer research station.

The state network of environmental monitoring is characterized by a number of problems associated with outdated methods of collecting and processing information, inactivity in communicating this information to the end user, inadequate funding, which complicates or prevents in to modernization. Therefore, the need to create non-state monitoring networks is brewing. In this study, an attempt was made to substantiate the feasibility of developing and implementing such a local network for monitoring the environmental parameters of atmospheric precipitation and thawed waters on an example of a separate city - Lutsk.

The technology of carrying out such activities on the example of specific settlements of Ukraine is presented in the works of V.Yu. Mokin, S.M. Dzyuba, N.V. Belyanin, M.N. Prokopenko, S.O. Serovikov, M.A. Fedonyuk [15, 16, 4, 17] and other researchers.

But there are almost no special studies on a specialized network of local environmental monitoring of atmospheric precipitation and thawed waters in the city. This is an urgent task that requires detailed scientific analysis.

The purpose of the research - based on the analysis of literary sources and own monitoring researches to identify the features of the organization and implementation of environmental monitoring of atmospheric precipitation in urban areas, with the justification of the main parameters of observation and spatial placement of points created network.

The results and the discussion. In the course of the analysis of data from the observation posts of the Hydrometeorological Center of Ukraine, it was found that official statistical information is not enough for a comprehensive assessment of atmospheric pollution in cities. In Lutsk, for example, there are 3 stationary monitoring points for chemical pollution and one meteorological station, the location of which does not provide a complete picture of meteorological conditions and ecological status. The Lutsk Meteorological Station is located outside the town, on its southeastern edge, and the ecological control posts are located on the northern and eastern outskirts of the city and in the green park area of the city center. The entire left bank part (along the Styr River), the Southern industrial zone, and a number of locations of intense pollution in the center, western and north-western outskirts of Lutsk are not covered by monitoring.

For more complete and detailed information, from 2014 we conduct our own monitoring surveys of the environmental condition of the city. One of the first such works was the implementation of li-

chen indicatory research in all major quarters of Lutsk. It is known that lichens are quite sensitive to atmospheric pollution, in particular to a number of acid oxides. Thus, the study of the species composition and the degree of coverage of the lichen trees enables to indirectly evaluate the content of certain pollutants and the precipitation acidity. The result of our work was, in particular, the environmental mapping of the atmospheric air in Lutsk based on lichen indicative studies [18].

To obtain more reliable quantitative indicators, we conducted a sampling of rain and thawed waters to determine their pH. Most measurements were made initially at 2 points in the left bank of the city (a distance of about 3.5 km), but on some days we managed to organize simultaneous sampling at 5-7 points in different neighborhoods. Part of the measurements was carried out directly at the monitoring points by portable pH meter 009 (I). Also, all samples were later analyzed by a professional pH meter AI-123 in the laboratory of the ecology department in the Lutsk NTU. It should be noted that, despite the declared function of ATC, measurements of the pH of cold rain water by a portable tester were sometimes found to be overestimated by 0.1-0.3 units.

The analysis of the obtained results suggests that precipitation in the studied period (end of 2015-beginning 2018) in Lutsk was predominantly (56% of samples) neutral or close to neutral (pH = 6-7), or slightly acid (28%). In some cases (9.3%) a weakly alkaline reaction (8.0-8.25) was observed, in individual cases the pH was less than 5.0.

By comparing precipitation acidity among the seasons of the year and in separate months, it can be noted that periods with high pH are winter months, and the warm period is characterized by a slightly higher acidity of precipitation. During almost three years of observations, the lowest levels of pH were recorded during the summer-autumn of 2017 (an average of 5.912, a minimum of 4.804).

The highest acidity (and hence the lowest pH) in rainwater was noted mainly when the rain dropped out after a long rainless period. Such rains wash out of the air accumulated there contaminants, including acid oxides of sulfur, carbon and nitrogen.

To assess the content of dissolved substances in rainwater, the mineralization of the selected samples was also measured (using calibrated tds-3 tester). During the time of observations, the average value of mineralization of rainwater was 14.5 ppm, the minimum - 4 ppm, maximum - 108 ppm. A regularity was also confirmed in relation to increase of mineralization of precipitation with increasing duration of the previous rainless period.

The expected reverse dependence between the amount of precipitation and its mineralization (Figure 1) was revealed. The correlation coefficient between these indicators ranged from -0.52 to -0.83 (for different periods).
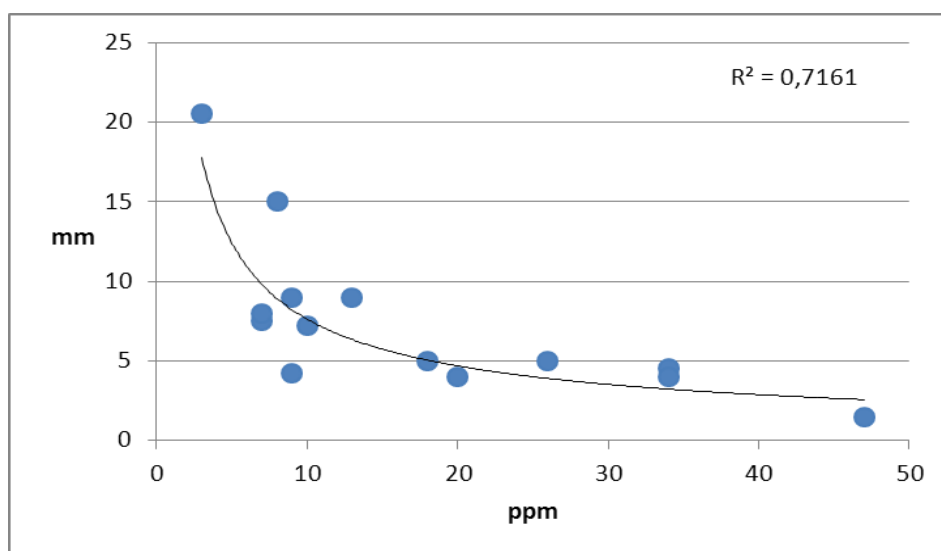

Fig. 1. Dependence of mineralization of rainwater on the amount of precipitation (average values or the period August-September 2018, Lutsk)

Our results of measurements (in terms of pH) were compared with the official data of the Hydrometeorological Center and were comparable to them. At the same time, the difference in the obtained values at separate points in the city was every time quite significant. For example, on 10.10.2015, the measured pH values ranged from 5.99 in the western part of the city to 6.81 in the south (amplitude 0.82), on November 23, 2015 - from 6.44 in the park area in the flood plain of Styr River to 7.35 on the southern outskirts near the sugar factory (amplitude 0.91). The character of the distribution of indi-

cators also significantly differed (Fig. 2). Note that for the fresh snow, the amplitude of the pH indicators at different points was significantly lower - within the range of 0.15-0.25. Obviously that the snow can not quickly dissolve and bring with it the same impurities as rainwater.
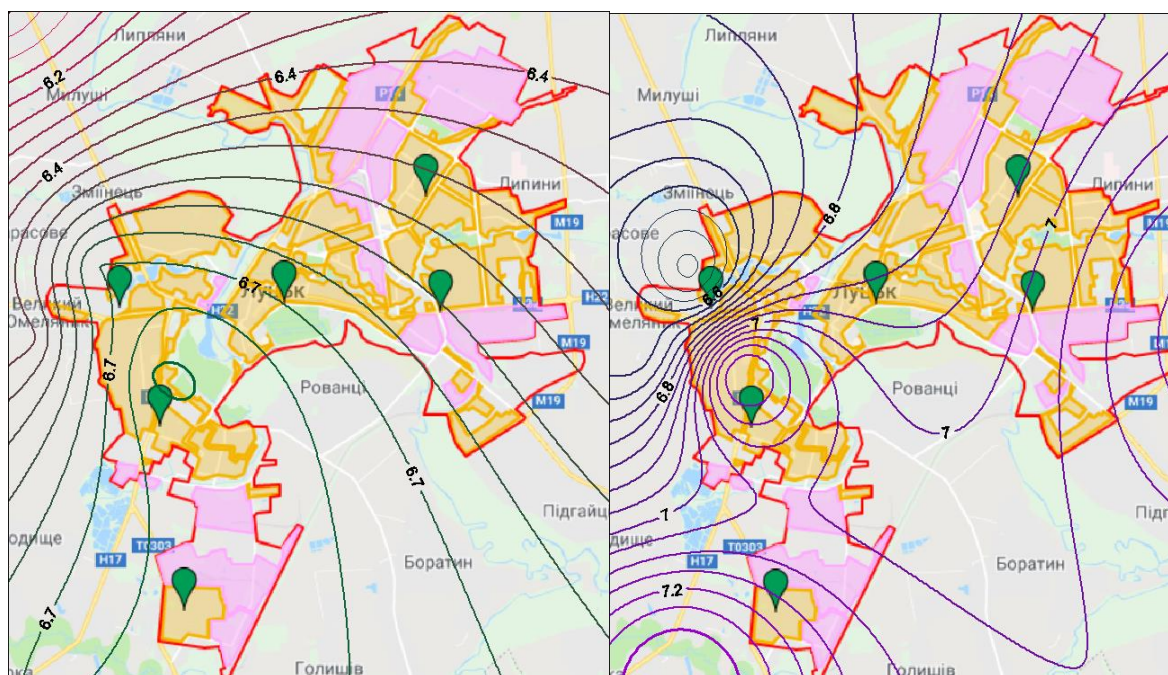

Fig. 2. Differences in the distribution of the pH of rainwater in Lutsk city under different conditions of precipitation (isolines built in GS Surfer according to data from 6 sampling points, October-November, 2015)

In these cases, a gradual increase in the pH of precipitation from the northwest to the southeast was observed more frequently (which coincides with the direction of movement of prevailing rain air masses). However, many times the distribution within the city was uneven, with separate local maxima and minima.

The conducted studies allowed to reveal a number of spatial patterns and to more clearly and reasonably design a network for monitoring the precipitation acidity in the city.

Factors that are taken into account when planning a monitoring network. The practical experience gained in determining the individual parameters of precipitation in the city, combined with the analysis of the relevant literary sources, allows us to distinguish a number of features necessary to be taken into account when organizing such monitoring.

Time of sampling and averaging. Previously, at state offices, the pH indicator was measured, averaged from all samples taken for a week or a month. Such practice is not suitable for detailed monitoring in the city; measurement of the parameters of each individual rain or snow is required. At the same time for heavy precipitation it is expedient to select two samples - initial and total. In most cases, the initial test has considerably other, more aggressive indicators [19], since it forms the so-called "firstflush" from a contaminated, yet not sufficiently washed

atmosphere. In some cases, it is advisable to carry out both direct measurements of pH at the place of selection and later measurements in laboratory conditions. Sometimes, for example, at high temperatures, after a long storage of the sample, partial evaporation and pH change within 2-10% may be possible.

Related monitoring parameters. Significantly facilitates further analysis and identification of causal, fixing of additional parameters - rainwater temperature (°C), its mineralization (TDS, mg / dm^3 or ppm), rainfall (in mm). Of course, a complete chemical analysis allows for more detailed information, but it is too costly for daily monitoring. And the above parameters are easily measured by available portable devices.

Note that the determination of the temperature of rainwater is important for the correct setting of the pH. Since pH reflects the chemical potential of Hydrogen ions (in relation to the ions of the hydroxyl group OH), it can change significantly when the temperature of the solution changes. Typically, with decreasing temperature, the pH increases. As rainwater temperature is almost always low, its pH at the point of selection is higher than the index, which is fixed at standard conditions (+18-20°C). But it is important to evaluate both indicators. For example, storm sewage receives rain water "as is,"

and to filter or, if necessary, neutralize it in real conditions, the ratio of temperature and acidity.

Meteorological conditions are one of the main risk factors for the environmental safety of atmospheric precipitation [20].

For a reasonable estimation and forecast of the ecological characteristics of precipitation, it is important to simultaneously record a number of such meteorological characteristics: the duration of the previous rainless period, the air temperature, the presence of temperature inversion, the direction and velocity of air masses, and others like that.

One of the most important is the definition of the type / class of weather and the direction of

movement of rain air masses. For example, in the study P.Tanner (1999) found that the acidity of precipitation for 7 different types of weather may differ even by an order of magnitude (by the content of H +) [13].

For the studied territory, we have constructed diagrams of repeatability of precipitation depending on the direction of arrival of rain fronts and cloud systems (Fig. 3). For this purpose, a number of meteorological online services (SAT-24, windy.com, blitzortung.org) have been used, which allowed to be quite confident in tracking the direction and velocity of large air flows.
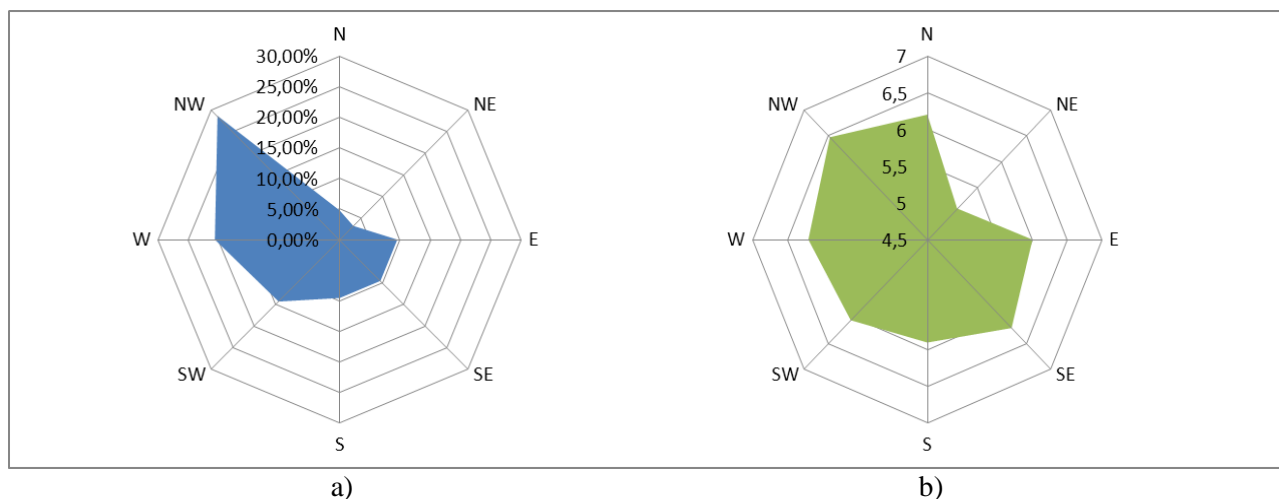

Fig. 3 Chart of repeatability of rainfall (a) and their pH (b), depending on the direction passage of atmospheric fronts and cloudy rain systems (for 2017)

The second figure shows the average pH for rainfall in different directions of clouds.

Analysis of these data contributes to the possibility of a partial forecast of the properties of the main rain and its changes during the period of rainfalls crossing the city. Considering these diagrams is also important when choosing a place to post control over acidity and chemical composition of precipitation.

Selection of locations for monitoring points. The proposed scheme for posting of ecological monitoring of acidity and other related indicators characterizing the chemical composition of atmospheric precipitation in Lutsk is developed taking into account the prevailing direction of air masses into our territory, "wind roses," as well as the specifics of urban development and the location of industrial zones in the regional center (Fig. 4).

Among the nine posts on which the regular sampling of rainwater for analysis is scheduled to take place, posts 1, 2, 3 can be attributed to the background: they are located, respectively, in the western, northwest and southwestern suburb of Lutsk, in these directions there are over 60% of the

trajectories of air masses and cloud systems with precipitation.

Observation post № 6 will play the role of control, since it will be located on the opposite outskirts of Lutsk.

Positions No. 5 and 9 are located practically in the center of the city, one of them - in the residential area of development, the other - in the park area near the main Styr River. Which, in particular, will allow control measurements of acidity and chemical composition of rainfall that flow from the roofs of buildings, for comparative analysis of their composition and properties with those rain and melt water entering the soil and surface water without prior contact with artificial surfaces and coatings.

Positions 3, 4, 7, 8 are located near the largest industrial zones, major enterprises, transport interchanges, in areas that are regularly suffering from traffic congestion due to excessive traffic load and an outdated system of road communications.

At four points (No. 1, 3, 8, as well as in one point outside the city, 4 km on the coast), we are already monitoring the pH, mineralization and rainfall. In case of successful development of the net-
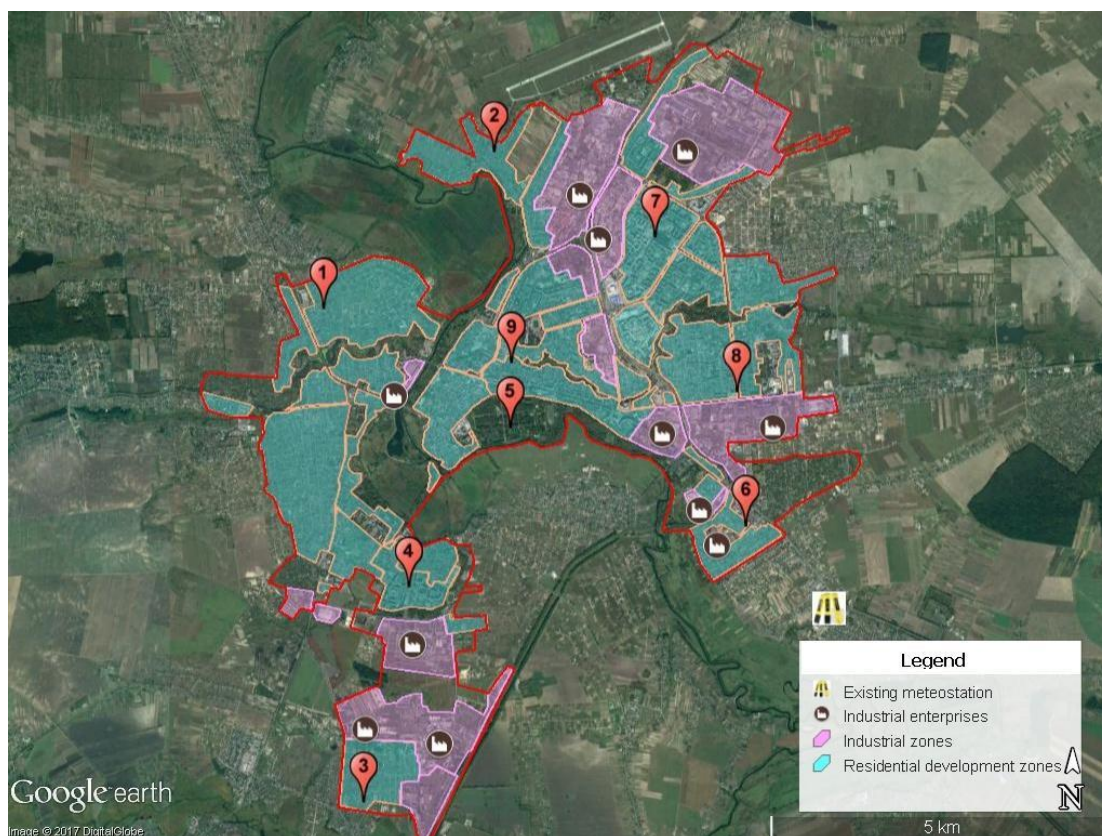
Fig. 4. Project placing of monitoring points in Lutsk.

work, organization of such monitoring is expected on the other mentioned posts.

Analysis of samples of rain and melt snow waters, selected at such points, will determine the presence or absence of anthropogenic impact on the chemical composition of precipitation, parameters of such impact, as well as develop a system of measures to optimize the environmental situation.

Conclusions.

1. The existing state air monitoring system often does not reflect the spatial differentiation of environmental parameters of atmospheric precipitation and needs to be improved. In addition, the creation of additional non- state specialized networks of monitoring of precipitation for the prompt informing of the population and interested organizations is also relevant.

2. Conducting own observations and measurements of individual parameters of atmospheric precipitation in the city allowed to reveal the dependence of the indexes of acidity and mineralization on the amount of precipitation, air pollution, directions of inflow of air masses, temperature, etc. The spatial differentiation of these indicators in the city is significant (the difference can reach up to 0.9 units of pH and 15-17 ppm of mineralization) and is related, first of all, to the distribution of anthropogenic emissions and microclimatic differences.

3. When forming the system of environmental monitoring of precipitation in the city it is necessary to focus on the definition of such basic parameters: pH, total mineralization, amount of precipitation, and also concomitant - water and air temperature, direction of movement of air masses, carbon dioxide concentration, duration of the previous rainless period, etc. In the future, it is advisable to automate the measurement of these indicators by compiling a system for reading and rendering data from the corresponding sensors in real time.

4. When choosing sites for sampling or positioning of automatic control posts, it is necessary to consider such parameters as the direction of prevailing winds, the proximity of large stationary sources of emissions, landscape and geomorphological features, the nature of development, and the presence of green zones. In this case, it is expedient to consider the placement of such points on the near and far vicinity of the city (in relation to the arrival of prevailing air masses), on the leeward sides of large industrial zones or transport interchanges, in the largest green zone, near the main water reservoir, as well as in 2-3 neighborhoods of residential development.

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UDC 556.12:551.5

Mykola Fedoniuk,
PhD (Geography), Associate Professor, Department of Ecology and Agronomy,
Faculty of Environmental Studies, Tourism and Electrical Engineering,
Lutsk National Technical University, 75 Lvivska St., Lutsk, 43018, Ukraine,
e-mail: m.fedoniuk@lntu.edu.ua, https://orcid.org/0000-0002-4034-3695;
Vitalina Fedoniuk,
PhD (Geography), Associate Professor, Department of Ecology and Agronomy,
Faculty of Environmental Studies, Tourism and Electrical Engineering, Lutsk National Technical University,
e-mail: ecolutsk@gmail.com, https://orcid.org/0000-0002-1880-6710;
Vasyl Ivantsiv,
PhD (History), Head of Department of Ecology and Agronomy,
Faculty of Environmental Studies, Tourism and Electrical Engineering, Lutsk National Technical University,
e-mail: ivv@email.ua, https://orcid.org/0000-0003-4710-3245

POSSIBILITIES FOR IMPROVEMENT OF ENVIRONMENTAL MONITORING OF PRECIPITATION IN THE CITY (A CASE OF LUTSK)

Formulation of the problem. The environmental parameters of precipitation in the city often differ from the background values and require the special observations program. The existing state monitoring system does not reflect the spatial differentiation of such parameters in urban areas, so it needs to be improved.

The purpose of the article: to find out the features of organization and implementation of rainfall environmental monitoring in urban areas, with the justification of the main parameters of observation and spatial placement of network points.

Methods. The main results are based on the authors' experience in own observations on the amount, acidity and mineralization of precipitation in several quarters of Lutsk during 2015-2018.

Results. Own observations and mapping of individual parameters of atmospheric precipitation in the city allowed to reveal the dependence of the indexes of acidity and mineralization on the amount of precipitation, air pollution, directions of air inflow, temperature, etc. The spatial differentiation of these indicators in the city is significant (the amplitude can reach up to 0.9 units of pH and 15-17 ppm of tds) and is related to the distribution of anthropogenic emissions and some microclimatic differences.

Therefore, by organization the system of ecological monitoring of precipitation in the city it is necessary to focus on the definition of such basic parameters: pH, total mineralization, amount of precipitation, and also concomitant: water and air temperature, direction of airflows, carbon dioxide concentration, duration of the previous rainless period, etc.

To select the representative locations for the control of precipitation in the city, it is necessary to analyze the following indicators: direction of prevailing winds, landscape and geomorphological features, the proximity of the most sources of anthropogenic contamination, building types etc. In this case, the minimum monitoring scheme should include such control points: the near and far outskirts (in relation to the arrival of prevailing air masses), the leeward sides of large industrial zones or transport interchanges, the largest green zone, area near the city water body, and several points (1-3) in residential areas.

Scientific novelty and practical significance. The main parameters and principles of the spatial organization of environmental monitoring of rainwater in the city are identified. The algorithm for creation such network has been tested in Lutsk and can be used for realization in other cities. Automation of similar measurements based on microcontrollers will to create quality non-state monitoring networks with the display of data in real time.

Keywords: precipitation, urban ecosystems, spatial distribution, environmental monitoring, precipitation acidity, precipitation mineralization, monitoring station, Lutsk.

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