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MIGRATION AND ACCUMULATION OF Cu, Pb, Zn and Cd WITHIN THE LIMITS OF ZHYTOMYR AGROPOPULATED LANDSCAPES

The paper discusses the monitoring studies of urbanozems (urban soils) in the city of Zhytomyr. It has been found that the main pollutants of the soils studied in the north-east, west and south-west parts of the city are strongly fixed forms of copper, zinc and lead.
Key words: *urbanozems, heavy metals, strongly fixed forms of heavy metals, concentration factor, total pollutional index*

Introduction. The natural soil cover in agropopulated landscapes is destroyed or undergoes major changes [2 – 11], being transformed into urbanozems – complex natural-and-anthropogenic formations that differ from the natural ones by the intensive accumulation of anthropogenic deposits of specific composition and structure, the proportion of which may amount to 25-50 per cent [7, 8, 15]. Under the influence of anthropogenesis and depending on the intensity of its effect, physical and chemical properties of soils also undergo changes: their acidification or leaching takes place, humus content and absorbing capacity decrease, etc. [9 – 14]. In urban soils some anthropogeniously polluted areas of complex structure and spatial localization are formed. They include different native-functional zones of urboecosystems and form contrasting anomalies of elements [9 – 11].

Soil cover as one of the most conservative landscape components is a reliable indicator of the general environmental state of the territory; therefore, the determination of the state and characteristics of soil cover is now quite a pressing problem [2 – 6]. The study of the forms of chemical elements existence and migration within the limits of populated territories gives an opportunity to assess both the degree of their pollution and possibility of human body intake of pollutants.

Analysis of the latest research results. Intensive research of heavy metals influence on soil cover began since the middle of the last century. A number of publications are also dedicated to the peculiarities of heavy metals distribution in the soil cover of urbanized territories that are subjected to intensified anthropogenous pressure, however, the overwhelming majority of investigations touch upon the estimate of urbanozem pollution level in such megalopolises as Kyiv, Lviv, Dnipropetrovsk, Kharkiv and cities of the regions with a high degree of industrial production concentration [8, 12 – 14].

The issues of urboedaphotope pollution on the territory of the populated zones located beyond the range of industrially developed regions of Ukraine with heavy concentration of industrial, chemical, power engineering and other enterprises escaped the attention of researchers. Insufficient research concerning the estimate of the ecological state of urbanozems in Ukraine's agrarian regions, particularly in the Zhytomyr oblast, have been conducted.

Purpose and tasks of the research. The research aims at estimating the level of urbanozem pollution with heavy metals within the limits of Zhytomyr agropopulated landscapes.

To achieve this aim, it is necessary to carry out the following tasks:

- to lay out control plots in the city's residential areas and take soil samples;
- to investigate agrochemical soil indicators;
- to determine the content of strongly fixed forms of heavy metals in the soil cover;
- to calculate the concentration factor, index of soil saturation with elements and total pollutional index.

Materials and methods. The investigation of the agropopulated landscapes in the city of Zhytomyr was carried out between 2008 and 2013. We studied the soil cover within the limits of individual house building in the west (the Malyovanka residential area), south-west (the Korbutivka residential area) and north-east (the Skhidnyi Promvuzol residential area) parts of the city. The research within the limits of the agropopulated landscapes has been conducted in accordance with S. Balyuk's methodology (2004) [1]. The soil sampling was carried out according to the requirements of DSTU (State Standard of Ukraine) ISO 10381-5 (ISO 10381-5:2005, IDT). In all, we laid 28 control plots and took 122 soil as well as 416 plant samples. The investigated area amounted to 1,38 km^2.

The content of alkali-hydrolized nitrogen in the soil was determined after Cornfield (GOST [State All-Union Standard] 26211-84); mobile forms of phosphorus and exchangeable kalium – by Kirsanov's method in the modification of the National Scientific Centre 'Institute of Soil Science and Agrochemistry' (DSTU 4405:2005); humus content – according to DSTU 4286:2004; pH_{kcl} – according to GOST 26483-85. Strongly fixed forms of heavy metals were extracted with 1n HNO_3. The concentration of chemical elements was determined by the method of atomic absorption spectrometry with the instrument of C 115-1M model.

To estimate the degree of pollutant element hazard, we used the concentration factor – the ratio between the pollutant concentration and its background content (GOST 17.4.3.06-86). The index of soil saturation with an element/elements (I_{el}) was determined by the methods described in Yu. Dmytruk's work (2003) [8], and the total pollutional index – by S. Balyuk's technique (2004) [1].

Results and discussion. While estimating the soil pollution level, it is important not only to determine the content of pollutants in the soil but also to study its chemical characteristics that may undergo quite considerable changes under the influence of heavy metals what, in turn, will directly affect the quality of crop products. As a whole, all the urbanozems studied in the north-east, west and south-west parts of Zhytomyr have similar agrochemical properties (Table 1).

Table 1

Agrochemical and physicochemical indices of the urbanozems of the Zhytomyr agropopulated landscapes, areas of individual house building, 2003-2013, the layer of 0-20 cm

Place of sampling and the number of samples	Agrochemical indices				
	humus, %	pH_{slt}	N	P_2O_5	K_2O
			mg/kg of soil		
Skhidnyi Promvuzol residential area					
Baranov St., n=20	2,19-4,35	7,1-7,2	92-112	800-990	508-1189
Promyslova St., n=12	1,91-3,26	6,8-7,0	69-91	960-1130	527-900
Malyovanka residential area					
Geroyiv Pozhezhnykh St., n=12	2,93-4,76	6,7-6,9	88-178	287-671	181-372
Zakhidna St., n=16	1,20-2,46	7,0-7,1	40-57	534-979	155-300
Pionerska St., n=20	2,08-2,90	7,0-7,1	72-81	740-1000	160-411
Chkalov St., n=8	2,84-4,46	6,4-6,7	79-110	850-1010	89-384
Korbutivka residential area					
Guivynskyi Lane, n=6	2,70-3,56	6,9-7,0	407-739	55-91	737-1000
Ozdorovchyi La., n=8	1,82-2,90	6,5-6,6	232-481	60-102	756-980
Tsyurupa La., n=6	1,91-2,73	6,9-7,0	159-377	52-84	721-941
Pionerskykh Taboriv La., n=8	1,80-2,90	6,9-7,0	148-409	57-80	701-936

The urbosoils of the agropopulated landscapes in the Skhidnyi Promvuzol residential area are characterized by quite a high humus content – 1,9-4,4 per cent, the maximum figures being registered within the limits of Baranov Street. Its residents are traditionally engaged in growing vegetables and gardening on their personal household plots, and thus apply heavy rates of chemical

fertilizers. This contributes to the increase in the soil cultivation level. The soils of household plots in this part of the city also contain a considerable amount of carbonates in the upper (0-20cm) layer, the source of their introduction being individual house building. Just on this account, soil solution pH within the limits of this territory has neutral and close to neutral indices.

The urbanozems within the limits of the Malyovanka residential area are also characterized by quite favorable agrochemical properties (see Table 1). Their humus content varies between 1,2 and 4,8 per cent, and soil solution pH is neutral or close to neutral (pH=6,4-7,1). The soils in this part of the city have a high and very high content of mobile phosphorus and exchangeable kalium, their indices varying within 287-1010 and 89-384 mg/kg respectively.

The similar agrochemical properties also characterize the urbanozems of the Korbutivka residential area that borders on the suburban recreation zone (see Table 1). The soils here have neutral or close to neutral pH of soil solution, their humus content varies from 1,5 to 3,6 per cent reaching peak values in the urbanozems of Guivynskyi Lane.

It should be mentioned that variation in agrochemical and physicochemical indices in the urbanozems under study is generally slight and makes 21-32 per cent for humus content, 13-34 per cent for the content of nitrogen which is easily hydrolyzed, 12-32 per cent for mobile phosphorus content, 22-48 per cent for exchangeable kalium content, and the coefficient of soil solution pH variation does not exceed 4 per cent, which testifies to the relative uniformity of the soil cover within the limits of the territory studied. Considering the above stated, it can be affirmed that all the studied urbanozems of the agropopulated landscapes in the city of Zhytomyr are well-cultivated in the process of individual gardening and vegetable growing and have favorable agrochemical properties for growing potatoes and other vegetables.

It has been found that the main pollutants of the urbanozems studied are copper, zinc and lead, whereas the excess of standards of cadmium content in the soil was insignificant (Tables 2-4).

A high level of copper pollution is characteristic of the urbanozems within the limits of the Skhidnyi Promvuzol residential area, where the excess of this element background content averages 10,2-16,7 times (Table 2), and of the soils within the limits of the Malyovanka residential area in which the excess of the content of strongly fixed copper forms was 4,3-19,1 times. As to individual streets, the most polluted with this element proved to be the urbanozems within the limits of Baranov and Pionerska Streets; fifty per cent of the studied areas contained from 17,0 to 23,0 mg/kg and from 19,0 to 25,0 mg/kg of strongly fixed forms respectively.

Table 2

Content of strongly fixed forms of heavy metals in the agropopulated landscape urbanozems of the Skhidnyi Promvuzol area, Zhytomyr, 2008-2013, n=3

Investigated area, ha	Interval of pollutant element content, mg/kg				
62	Cu				
	7,0-10,0	10,0-13,0	13,0-16,0	16,0-19,0	19,0-22,0
	*25 15,5	25 15,5	15,63 9,69	18,75 11,63	15,63 9,69
	Zn				
	35,0-50,0	50,0-65,0	65,0-80,0	80,0-95,0	95,0-110,0
	28,13 17,44	34,38 21,31	12,50 7,75	12,50 7,75	12,50 7,75
	Pb				
	15,0-25,0	25,0-35,0	35,0-45,0	45,0-55,0	55,0-65,0
	21,88 13,56	31,25 19,38	18,75 11,63	18,75 11,63	9,38 5,81
	Cd				
	0,10-0,15	0,15-0,20	0,20-0,25	0,25-0,30	0,30-0,35
	9,38 5,81	28,13 17,44	34,38 21,31	18,75 11,63	9,38 5,81

*Note: * numerator – the percentage of samples located in the indicated interval; denominator – the area on which the calculated samples are found.*

The agropopulated landscapes within the limits of the Korbutivka residential area are the least polluted with strongly fixed copper, since its background content in the soil on average does not exceed 5,5 times (Table 4). The pollution of the soil cover with copper is, in our opinion, caused by both anthropogenous factors and additional introduction of this element with fertilizers and pesticides as a result of their uncontrolled application by the population in individual vegetable growing and gardening within the limits of agropopulated landscapes [2 – 10].

The excess (100,5-248,3 times) of the amount of strongly fixed forms of zinc in comparison with its background content is registered in the soils within the limits of the north-east part of the city: over 37 per cent of the area investigated contain from 65 to 110 mg/kg of soil (Table 2). In our opinion, the above is caused by the fact that the given territory is located in the close vicinity of the railway station which brings in the strengthening of anthropogenous influence on the adjacent territory and intensity of pollutant migration.

Table 3

Content of strongly fixed forms of heavy metals in the agropulated landscape urbanozems of the Malyovanka residential area, Zhytomyr, 2008-2013, n=56

Investigated area, ha	Interval of pollutant element content, mg/kg				
63	Cu				
	1,0-5,0	5,0-10,0	10,0-15,0	15,0-20,0	20,0-25,0
	*25,0 15,75	16,07 10,13	26,79 16,86	16,07 10,13	16,07 10,13
	Zn				
	15,0-25,0	25,0-35,0	35,0-45,0	45,0-55,0	55,0-65,0
	17,86 11,25	25,0 15,75	17,86 11,25	16,07 10,13	23,21 14,63
	Pb				
	4,0-7,5	7,5-11,0	11,0-14,5	14,5-18,0	18,0-21,5
	50,0 17,64	26,79 9,45	8,93 3,15	3,57 1,26	10,71 3,78
	Cd				
	0,06-0,15	0,15-0,24	0,24-0,35	0,35-0,44	0,44-0,53
	14,29 9,0	21,43 13,50	16,07 10,13	21,43 13,50	26,79 16,88

*Note: * numerator – the percentage of samples located in the indicated interval; denominator –the area on which the calculated samples are found.*

The soil cover of the agropopulated landscapes within the limits of the Malyovanka residential area is characterized by an insufficient level of pollution with strongly fixed zinc, the content of which varies between 16,7 and 62,9 mg/kg of soil (see Table 3). Nearly 43 per cent of the investigated area of the urbanozems in the south-west part of the city is characterized by a high content of strongly fixed forms of zinc, namely from 75 to 115 mg/kg of soil (Table 4).

The priority pollutant of all the urbanozems studied was lead. The concentration of its strongly fixed forms within the limits of the Skhidnyi Promvuzol residential area amounted to 15,7-59,8 mg/kg of soil. The major source of its introduction into the environment is road transport. It is just on this account that the maximum excess of the standards established for the above element is registered in the region of Baranov Street with its heavy large-capacity transit traffic and within the adjacent Promyslova Street.

Table 4

Content of strongly fixed forms of heavy metals in the agropopulated landscape urbanozems of the Korbutivka residential area, Zhytomyr, 2008-2013, n=28

Investigated area, ha	Interval of pollutant element content, mg/kg				
12,7	Cu				
	2,5-4,0	4,0-5,5	5,5-7,0	7,0-8,5	8,5-10,0
	*50,0 6,35	3,57 0,45	21,40 2,72	10,70 1,36	14,30 1,81
	Zn				
	15,0-35,0	35,0-55,0	55,0-75,0	75,0-95,0	95,0-115,0
	46,43 5,90	3,57 0,45	7,14 0,91	39,29 4,99	3,57 0,45
	Pb				
	1,5-5,5	5,5-10,5	10,5-15,5	15,5-20,5	20,5-25,5
	21,43 2,72	28,57 3,63	7,14 0,91	17,86 2,27	25,0 3,18
	Cd				
	0,18-0,27	0,27-0,36	0,36-0,43	0,43-0,50	0,50-0,57
	57,14 2,26	21,43 2,72	3,57 0,45	14,29 1,81	3,57 0,45

*Note: * numerator – the percentage of samples located in the indicated interval; denominator – the area on which the calculated samples are found.*

Within the limits of the Korbutivka residential area the content of Pb in the soil was between 2,6 and 25 mg/kg, and the most polluted with this element were the urbanozems along Guivynskyi Lane, where 33 per cent of the investigated soil area contained over 16 mg/kg, and those along Pionerskykh Taboriv Lane with 50 per cent of its investigated urbanozem area containing 23-25 mg/kg of this element. In the soils within the Malyovanka residential area, only 10.7 per cent of the investigated urbanozem area contained 18-21,5 mg/kg of strongly fixed forms of lead.

In all the cases the content of strongly fixed forms of cadmium proved to be the lowest and was at the level of 0,07-0,50 mg/kg of soil.

It is possible to estimate the diversity and contrast of the structure of atmoanthropogenous areals of technogenesis products dispersion on the investigated territory using the value of variation coefficient which is a qualitative criterion of estimating the degree of urbanozem pollution. The higher is the coefficient of variation, the more uneven is the distribution of geochemical parameters in space, and the more fragmentary and contrasting is the structure of atmoanthropogeneous dispersion areals, as the pollutant element has a higher degree of variability in space than the pedogenic one [11].

The content of the forms, close to the immobile ones, of all the heavy metals studied particularly varies in the agropopulated landscape urbanozems of the Korbutivka residential area and is 32 per cent for copper, 33 per cent for zinc, 29 per cent for lead and 11 per cent for cadmium. Among strongly fixed forms of heavy metals the greatest variation of copper and cadmium was in the urbanozems within the limits of the Malyovanka residential area – 54 and 30 per cent respectively and that of zinc and lead was in the urbanozems on the territory of the Korbutivka residential area – 47 and 58 per cent respectively.

We have calculated the concentration factors for heavy metals (Cu, Zn, Pb, Cd) that made it possible to estimate the pollution level of the urbanozems studied in agropopulated landscapes (Table 5).

The concentration factor for copper in the urbanozems on the territory of the Skhidnyi Promvuzol residential area was between 7,9 and 22,1, on the territory of the Malyovanka residential area – from 3,1 to 24,4 and on the territory of the Korbutivka residential area it was 2,7- 10,1. Its

highest values were registered in the region of Baranov, Geroyiv Pozhezhnykh and Pionerska Streets. The concentration factor for strongly fixed forms of zinc varied from 41,0 (Zakhidna Street) to 231-248,2 (Promyslova Street, Guivynskyi and Pionerskykh Taboriv Lanes). The concentration factor for lead in the investigated urbanozems of the north-east, west and south-west parts of Zhytomyr varied within 6,3-145,9, reaching its peak values in the soils adjacent to Baranov Street. High concentration factors for Pb are also characteristic of the urbanozems within the limits of Promyslova Street and Pionerskykh Taboriv Lane (70,5 and 56,1) respectively. The concentration factor for cadmium in the urbanozems under study varied from 1,0 (Baranov Street, Ozdorovchyi Lane) to 2,2 (Chkalov Street), which testifies to the fact that this element is not the main urbanozem pollutant on the territory of Zhytomyr.

Table 5

Concentration factors for heavy metals in the urbanozems of the agropopulated landscapes of Zhytomyr, 2008-2013

Observation place and the number of samples drawn	Concentration factor, Kr			
	Cu	Zn	Pb	Cd
Skhidnyi Promvuzol				
Baranov St., *n=20*	* 16,73 / 8,33 – 22,08	135,88 / 100,50 – 233,75	98,20 / 42,20 – 145,85	1,0 / 0,65 – 1,30
Promyslova St., *n=12*	10,23 / 7,92 – 12,50	204,06 / 104,0 – 248,25	70,47 / 38,29 – 103,42	1,21 / 0,55 – 1,60
Malyovanka				
Geroyiv Pozhezhnykh St., *n=12*	11,15 / 6,46 – 16,04	150,46 / 122,25 – 157,25	17,02 / 12,68 – 23,66	1,86 / 0,80 – 2,30
Zakhidna St., *n=16*	4,34 / 3,13 – 7,29	71,49 / 41,0 – 110,25	17,05 / 9,76 – 30,0	1,87 / 1,10 – 2,45
Pionerska St., *n=20*	19,13 / 12,81 – 24,38	85,75 / 51,25 – 150,75	26,91 / 12,20 – 47,07	0,86 / 0,35 – 1,45
Chkalov St., *n=8*	12,16 / 4,79 – 20,52	120,91 / 100,50 – 147,50	28,70 / 15,12 – 47,32	2,16 / 1,80 – 2,45
Korbutivka				
Guivynskyi La., *n=6*	9,11 / 6,79 – 10,10	215,08 / 201,25 – 230,75	37,70 / 34,15 – 40,66	1,32 / 1,15 – 1,60
Ozdorovchyi La., *n=8*	3,38 / 3,15 – 3,61	71,84 / 57,25 – 86,25	20,53 / 19,46 – 22,15	1,04 / 0,95 – 1,20
Tsyurupa La., *n=6*	2,79 / 2,67 – 2,92	78,92 / 71,0 – 87,0	7,08 / 6,34 – 8,41	2,27 / 2,0 – 2,50
Pionerskikh Taboriv La., *n=8*	6,84 / 5,45 – 8,16	209,44 / 179,75 – 247,75	56,12 / 49,51 – 60,98	1,21 / 0,95 – 1,45

*Note: * numerator – mean value of the index, denominator – fluctuation limits.*

The general ecological state of agropopulated landscapes may be estimated by the index of soil saturation with heavy metals within the layer of 0-20 cm and by the total pollutional index (Table 6).

The values of the indexes of soil saturation with elements within the layer of 0-20 cm at the level of 3,09-4,11 testify to the predominance of the processes of the pollutant accumulation in urbanozems.

Table 6

Total pollutional index and indexes of soil saturation with heavy metals in the agropopulated landscape urbanozems of Zhytomyr

Observation place	Soil saturation index, $Ip_{Cu\ Pb\ Cd\ Zn}$	Total pollution index, Zc
Skhidnyi Promvuzol		
Baranov St., *n=20*	* 3,98 / 3,51 – 4,48	248,80 / 148,68 – 399,99
Promyslova St., *n=12*	4,11 / 3,50 – 4,37	282,97 / 147,76 – 362,77
Malyovanka		
Geroyiv Pozhezhnykh St., *n=12*	3,67 / 3,45 – 4,27	177,49 / 139,19 – 330,21
Zakhidna St., *n=16*	3,12 / 2,72 – 3,50	91,75 / 51,98 – 146,99
Pionerska St., *n=20*	3,39 / 2,96 – 3,87	129,66 / 73,61 – 220,65
Chkalov St., *n=8*	3,58 / 3,32 – 3,84	160,93 / 119,21 – 214,79
Korbutivka		
Guivynskyi La., *n=6*	4,03 / 3,95 – 4,10	260,20 / 240,34 – 280,11
Ozdorovchyi La., *n=8*	3,14 / 3,0 – 3,26	93,79 / 77,81 – 110,21
Tsyurupa La., *n=6*	3,09 / 3,01 – 3,17	88,06 / 79,01 – 97,83
Pionerskykh Taboriv La., *n=8*	4,07 / 3,92 – 4,22	270,60 / 232,66 – 315,33

*Note: *numerator—mean value of the index, denominator – fluctuation limits.*

According to the approximate estimation scale of soil pollution danger, by the total pollutional index Zc the urbanozems of agropopulated landscapes are referred to the category of extremely dangerous pollution and are unsuitable for individual vegetable growing. The exception constituted only Zakhidna Street (Malyovanka), Ozdorovchyi and Tsyurupa Lanes (Korbutivka) with their soils falling under the category of dangerous pollution. The most critical situation as to soil pollution was observed within the limits of Baranov (Zc=248,8) and Promyslova (Zc=283) Streets in the Skhidnyi Promvuzol residential area as well as Guivynskyi (Zc=260,2) and Pionerskykh Taboriv (Zc=270,6) Lanes in Korbutivka.

By the intensity of agropopulated landscape soil cover pollution heavy metals form the following descending series: Zn>Pb>Cu>Cd.

Conclusions:

1. The analyzed urbanozems of Zhytomyr are well cultivated and have favorable agrochemical properties for growing potatoes and other vegetables: humus content – 1,2-4,76 per cent, soil solution pH – 6,2-7,2, alkali-hydrolyzed nitrogen - 40-178 mg/kg of soil, mobile phosphorus - 287-1130 mg/kg, exchangeable kalium - 89-1189 mg/kg of soil.

2. The main pollutants of the urbanozems studied in the north-east (Skhidnyi Promvuzol) west (Malyovanka) and south-west (Korbutivka) parts of Zhytomyr are strongly fixed forms of copper (Kr=2,7-22,1), zinc (Kr=41,0-248,2) and lead (Kp=6,3-145,9).

3. By the total pollutional index Zc the urbanozems of agropopulated landscapes fall under the category of dangerous (Zakhidna Street, Osdorovchyi and Tsurupa Lanes) and extremely dangerous pollution, and so they are unsuitable for individual vegetable growing. The most critical situation as to soil pollution is within the limits of Baranov Street (Zc=248,8) and Promyslova Street (Zc=283) in the Skhidnyi Promvuzol residential area as well as in the region of Guivynskyi (Zc=260,2) and Pionerskykh Taboriv (Zc=270,6) Lanes in the Korbutivka residential area.

References

1. Балюк С.А. Проведення грунтово-геохімічного обстеження урбанізованих територій / С.А. Балюк, А.І. Фатєєв, М.М. Мірошниченко Харків: ННЦ «ІГА ім. О.Н.Соколовського» УААН, 2004. - 62 с.

2. Валерко Р. А. Забруднення важкими металами ґрунтового покриву і фітоценозів на території м. Житомира та прилеглих до нього агроекосистем / Р. А. Валерко // Вісник ДАЕУ. – 2008. – № 1. – С. 356–366.

3. Валерко Р. А. Оцінка екологічного стану ґрунтового покриву приміської зони м. Житомира / Р. А. Валерко // Вісник ХНАУ ім. В. В. Докучаєва. Сер. «Ґрунтознавство, агрохімія, землеробство, лісове господарство». – 2011. – № 2. – С. 207–211.

4. Валерко Р. А. Особливості акумуляції свинцю у едафотопах і фітоценозах м. Житомира / Р. А. Валерко, Т. М. Мислива, Л. О. Герасимчук // Вісник ЖНАЕУ. – 2011. – № 1. – С. 179–189.

5. Герасимчук Л. О. Важкі метали в агроселітебних ландшафтах південно-західної частини м. Житомир / Л. О. Герасимчук // Сучасні проблеми збалансованого природокористування. – Кам′янець-Подільський: Подільський держ. аграр.-техн. ун-т, 2011. – Спец. вип. до VI наук.-практ. конф. «Сучасні проблеми збалансованого природокористування», (листопад, 2011 р.). – С. 78–82.

6. Герасимчук Л. О. Моніторинг екологічного стану урбанізованих ландшафтів на прикладі м. Житомира / Л. О. Герасимчук, Т. М. Мислива // Охорона навколишнього середовища та раціональне використання природних ресурсів : зб. доп. XXI Всеукр. наук. конф. аспірантів і студ, 12-14 квіт. 2011 р. – Донецьк, 2011. – Том 1. – С. 215–216.

7. Гладков Е. А. Влияние комплексного взаимодействия тяжелых металлов на растения мегаполисов / Е. А. Гладков // Екологія. – 2007. – №1. – С. 71–74.

8. Дмитрук Ю. М. Оцінка вмісту нікелю в грунтах Покутсько-Буковинських Карпат на основі геохімічних коефіцієнтів / Ю. М. Дмитрук // Грунтознавство. – 2003. – Т. 4. – № 1 – 2. – С. 78–83.

9. Мислива Т. М. Важкі метали в урбаноземах агроселітебних ландшафтів південно-західної частини м. Житомира / Т. М. Мислива, Л. О. Герасимчук // Науковий вісник Національного університету біоресурсів і природокористування України. – Сер. Агрономія. – 2011. – Вип. 162, ч. 1. – С. 155–165.

10. Мислива Т. М. Важкі метали в урбоедафотопах і фітоценозах на території м. Житомира / Т. М. Мислива, Л. О. Онопрієнко // Вісник Харківського національного аграрного університету імені В.В.Докучаєва. Сер. Ґрунтознавство, агрохімія, землеробство, лісове господарство. – 2009. – №1. – С. 89–95.

11. Мыслыва Т. Н. Тяжелые металлы в урбаноземах парково-рекреационных ландшафтов г. Житомир/ Т. Н. Мыслыва // Агрохимия. – 2011. – № 1. – С. 67–74.

12. Пасічний Г. В. Динаміка важких металів в ґрунтовому покриві у зв’язку з техногенним забрудненням оточуючого середовища (на прикладі м. Дніпропетровська) / Г. В. Пасічний, С. М. Сердюк // Екологія і природокористування : наук. пр. Ін-ту проблем природокористування та екології НАН України. – Дніпропетровськ, 2002. – Вип. 4. – С. 111–117.

13. Ричак Н. Л. Поведінка важких металів у ґрунтових покривах міських ландшафтів / Н. Л. Ричак // Вісник СумДу. – 2006. – №5 (89). – С. 145–151.

14. Розподіл важких металів у ґрунтах південнополіських ландшафтів Києва та приміської зони / І. В. Кураєва, А. І. Самчук, Л. Ю. Сорокіна [та ін.] // Мінералогічний журнал. – 2010. – 32, № 1. – С. 77–90.

15. Соколов О. А. Экологическая безопасность и устойчивое развитие. Кн. 1. Атлас распределения тяжелых металлов в объектах окружающей среды / О. А. Соколов, В. А. Черников. – Пущино : ОНТИ ПНЦ РАН, 1999. – 164 с.

Анотація

Герасимчук Л.О., Валерко Р.А.

Особливості міграції і акумуляції Cu, Pb, Zn і Cd у межах агроселітебних ландшафтів м. Житомира

Проведено моніторингові дослідження урбаноземів м. Житомира. Встановлено, що основними забруднювачами досліджуваних ґрунтів північно-східної, західної та південно-західної частин міста є міцнофіксовані форми міді, цинку та свинцю.

Ключові слова: *урбаноземи, важкі метали, міцнофіксовані форми важких металів, коефіцієнт концентрації, сумарний показник забруднення*

Аннотация

Герасимчук Л.А., Валерко Р.А.

Особенности миграции и акумуляции Cu, Pb, Zn и Cd в пределах агроселитебных ландшафтов г. Житомира

Проведены мониторинговые исследования урбаноземов г. Житомира. Установлено, что основными загрязнителями исследуемых почв северно-восточной, западной и юго-западной части города являются сильнофиксированные формы меди, цинка и свинца.

Ключевые слова: *урбаноземы, тяжелые металлы, сильнофиксированные формы тяжелых металлов, коэффициент концентрации, суммарный показатель загрязнения*