Hygiene prevails

HYGIENIC ASSESSMENT OF MICROELEMENTS AND HEAVY METALS CONTENT IN THE SOIL OF N. REGION

Content of the work

Actuality

Maintaining the main function of the soil – creation of the conditions for the normal life of agricultural crops – in growing pollution of the environment becomes a priority task. In order to form a high and qualitative harvest, it is important to provide plants with macro- and trace elements, the level of which depends on their content, above all, in the soil. Lacking or excessive micronutrients in the soil negatively affects the human body and animals that consume plant products from the relevant sites.

Also, soil is an indicator of the total technogenic contamination of the biosphere. Soil contamination by heavy metals has different sources: metal industry wastes, industrial emissions, fuel combustion products, exhaust emissions of car exhaust gases, agricultural chemicals. The World Health Organization considers the lead, mercury and cadmium as most dangerous contaminants among heavy metals. But high concentrations of other elements are not less harmful. Heavy metals, moving from soil to plants and passing through the food chains, have a toxic effect on plants, animals and man [1].

The importance of microelements for flora and fauna is multifaceted. They are intended to improve metabolism, eliminate functional disorders, promote the normal course of physiological and biochemical processes, and influence the processes of photosynthesis and respiration. Plant resistance to bacterial and fungal diseases and adverse environmental factors increases under the action of trace elements.

It is established that trace elements are a part of a large number of enzymes that play an important role in the life of plants, animals and humans. All biochemical reactions of synthesis, decay, exchange of organic substances proceed only with the participation of enzymes [2].

It should be taken into account that not the total amount of trace elements in the soil is important, but its content in a mobile form, available to plants. However, the degree of trace elements mobility in the soil depends on many conditions: the parent rocks, biological activity and soil properties, like environmental reactivity, carbonate content, granulometric and mineral composition, half-oxide and humus content, application of agronomic complex of measures, especially water and chemical soil development, application of organic and mineral fertilizers. All these factors have a significant impact on the content of trace elements in the soil [3].

Aim of the work:

Hygienic assessment of copper (Cu), zinc (Zn), cobalt (Co), manganese (Mn), lead (Pb), cadmium (Cd) mobile forms content in the soil of N. region

Tasks of the work:

1) To perform sampling and preparation of soil samples to carry out laboratory research.

2) To determine the content of Cu, Zn, Co, Mn, Cd, Pb trace elements mobile forms in the soil N. region.

3) To evaluate the state of the soil and give recommendations based on the results of the study.

Materials and methods:

Samples of soil were taken from the field (49°22'04 "N, 32°00'46" E), intended to grow wheat, the size of the site was 3 hectares. The studied territories were characterized by the same type of soil – typical black earth. Time of soil samples taking – July 10 and August 30, 2017. Sampling was carried out by the envelope method at a depth of 0-20 cm in accordance with current requirements and recommendations [4]. Soil samples were packed in polyethylene bags with accompanying labels, the average sample was 1 kg. The study of mobile forms of trace elements was carried out in the laboratory of monitoring research.

Soil samples were dried to the air-dry state in a soil drying dryer with air heating not higher than 40° C. The soil was poured onto an even surface, mixed well and distributed with a layer of not more than 1 cm before analysis. Samples for analysis were taken with a spatula not less than from five different places, evenly distributed throughout the surface.

A soil water extract was used to determine the content of potentially mobile metal forms. To prepare the soil extraction weighed soil (5.0±0.1 g) preliminary placed in the technological containers and 50 cm of extraction solution poured into these containers. The suspensions were filtered through paper filters. The first portions of the filtrate were discarded; the subsequent portions were collected in clean and chemically pure technological containers. To extract potentially mobile forms, the following extractant was used: acetate-ammonium buffer solution with a pH=4.8 by Krupskij and Aleksandrova in the modification of CINAO. Calibration solutions for analysis of each element were matching in accordance with current standards.

A quantitative evaluation of the Cu, Zn, Mn, Co, Cd, and Pb content in soil extracts was carried out using the atomic absorption method (atomic absorption spectrometer C-115-M1). Preparation of the device for operation, its turn-on and output to the working mode are carried out by technical instructions added to the spectrophotometer [5].

Zinc content was determined by absorption of the resonance line with a wavelength of 213.9 nm, copper – at a wavelength of 324.7 nm, manganese – 279.5 nm, cobalt by absorption of the resonance line of 240.7 nm, cadmium – 228.8 nm, lead – 217 nm, using acetylene-air flame for atomization [6, 7, 8, 9, 10].

Based on the results obtained for the comparison solutions, calibration graphs were constructed, drawing the mass concentrations of the studied element in the solutions of the comparison on the abscissa axis in terms of mass particles in the soil in millions of particles, and the corresponding indications of the device on the ordinate axis. According to the graph, the mass concentrations of the element in soil extracts and the control solution in terms of the mass fraction in the soil were found. The processing of the results was carried out by the calculation and statistical method of mathematical analysis of experimental data using the IBM SPSS StatisticalBase v.22 and MS Excel statistical software package.

Results:

All plants can be divided into three groups according to its ability to assimilate and meet the requirements for microelements according to the National Standards of Ukraine. The first group includes cereal crops, corn, legumes, potatoes characterized by a low carry-over of microelements and a relatively high uptaking capacity. The second group includes root crops (sugar, fodder, table beet and carrots), vegetables, perennial grasses (legumes and cereals), sunflower – plants with increased carry-over of microelements with low and medium uptaking capacity. The third group - agricultural crops grown under irrigation conditions with a background of high doses of mineral fertilizers – plants with high carry-over of microelements (table 1):

Table 1

Optimum content of trace elements in soils depending on cultures groups in a soil layer from 0 cm to 25 cm

Soil supply with trace elements	Microelements content, mg/kg			
	Manganese	Copper	Zinc	Cobalt
The first group (a low carry-over of microelements)				
Low	<5	<0/1	<1	<0.07
Medium	5-10	0.1-0.2	1-2	0.07-0.15
High	>10	>0.2	>2	>0.15
The second group (plants with increased microelements carry-over with low and medium uptaking capacity)				
Low	<10	<02	<2	<0.15
Medium	10-20	0.2-0.5	2-5	0.15-0.3
High	>20	>0.5	>5	>0.3
The third group (agricultural crops – plants with high carry-over of microelements)				

Low	<0.2	>0.5	<5	<0.3
Medium	20-40	0.5-1.0	5-10	0.3-0.7
High	>40	>1.0	>10	>0.7

Results of Cu, Zn, Co, Mn microelements content in the soils of N. oblast are given in the table 2.

Table 2

Content of Cu, Zn, Co, Mn in the samples, mg/kg

Sample	**Cu**		**Zn**		**Co**		**Mn**	
Date	**10.07**	**30.08**	**10.07**	**30.08**	**10.07**	**30.08**	**10.07**	**30.08**
1	0,211	0.273	0,801	0.784	0,360	0.567	10,550	9.566
2	0,191	0.251	0,798	0.801	0,345	0.476	9.047	10.653
3	0,200	0.282	0,790	0.776	0,387	0.505	10,889	10.320
4	0,206	0.293	0,800	0.731	0,306	0.435	10,258	9.876
5	0,195	0.260	0,802	0.788	0,336	0.487	9,356	10.543
6	0,199	0.278	0,793	0.802	0,344	0.543	9,832	10.050
7	0,192	0.27	0,795	0.695	0,356	0.456	10,080	10.32
8	0,194	0.259	0,792	0.754	0,339	0.562	9,655	9.876
9	0,199	0.256	0,801	0.784	0,352	0.416	10,532	9.565
10	0,208	0.265	0,799	0.687	0,348	0.485	10,445	9.766
Average	0.201	0.269	0.797	0.76	0.351	0.493	10.064	10.05
Taking into account the error	0.201± 0.005	0.269± 0.005	0.797± 0.16	0.76± 0.16	0.351± 0.18	0.493± 0.18	10.064± 0.03	10.05± 0.03
MAC*	3		23		5		50	

Footnotes: * MAC – maximum allowable concentration in the soil, mg/k;

** - Student t-criterion (p≤0,05) – 2,101.

Results of cadmium and lead heavy metals content in the soils of N. oblast are given in the table 3.

Table 3

Content of cadmium and lead in the samples, mg/kg

Sample	**Cd**		**Pb**	
Date	**10.07**	**30.08**	**10.07**	**30.08**
1	0,345	0.453	12,655	12.600
2	0,320	0.424	12,578	12.543
3	0,334	0.395	12,605	12.684
4	0,342	0.387	12,586	12.535
5	0,327	0.420	12,655	12.677
6	0,342	0.375	12,610	12.623
7	0,339	0.402	12,598	12.564
8	0,344	0.396	12,610	12.587
Average	0,337	0.406	12,612	12.601
Average square deviation (S_x)	0.009	0.025	0,029	0.057
Student t-criterion ($p \leq 0,05$)	2,145		2,145	
Average error (Δx)	0.009		0,022	

Discussion of the results:

The inadequacy (the lack) of mineral substances intake in the human body, the macro- and microelementosis, leads to a reduction in the working capacity and a predisposition to various diseases. But in the case of its excess, toxic effects of these elements on plants, animals and human health can also occur. Each trace element plays an important function in the human body and animals, and also affects a number of processes in plants.

The role of zinc is as follows: it has a great influence on the metabolism and energy in plants, as it is part of the enzymes. It participates in the synthesis of growths activators – auxins. Extremely important role of zinc in the human body too: it have an effect on all processes of hematopoiesis, organism development, growth, reproduction. In addition, it is important for the metabolism of proteins, fats and carbohydrates, as well as it strengthens the immune system [11].

The result of 0.797±0.16 mg/kg (sampling – 10.07) and 0.76 ± 0.16 mg/kg (sampling – 30.08) indicated a low soil level of zinc saturation by mobile zinc forms for all groups of plants according to the classification of optimum content of trace elements in soils. Studied soil in N. region has low zinc content for all three groups of plants.

Cobalt: This trace element is necessary for the biological fixation of molecular nitrogen and is a component of vitamin B_{12}. In humans, it promotes the production of thyroid hormones, lowers cholesterol levels in the blood, prevents the formation of atherosclerotic elements, participates in enzymatic processes. Cobalt is involved in the production of RNA and DNA and promotes the growth of bone tissue [11]. At the same time the smelting of non-ferrous metals is significant source of pollution by cobalt. The burning of coal and other fuels has less contributing value.

The studied soil samples have the following magnitudes of cobalt content: 0.351±0.18 mg/kg (sampling – 10.07) and a slightly higher values of 0.493±0.18 mg/kg, measured on 30.08. These values proving the high level of N. region soil provision by mobile cobalt forms for the first two groups of plants and low provision for the third group of plants.

Copper: It enters into the enzymes chemical composition, affects the physical-chemical properties and the metabolism of plants. Copper in plants involved in photosynthesis and the formation of chlorophyll, increases its protective properties and resistance to various adverse temperature conditions. Reducing copper reduces the synthesis of proteins most strongly, resulting in arrested grain formation due to copper fasting, which may even lead to the absence of its formation [12]. This element is involved in the construction of proteins, it also controls the growth of cells and tissues, participates in hematopoiesis in the human body. Daily requirements in copper for humans vary depending on the age from 0.3 to 2.5 mg per day (for adults – 2 mg).

The following results were obtained for studied soils: 0.201±0.005 mg/kg (sampling – 10.07) and a slightly higher content of 0.269±0.005 mg/kg, measured on 30.08. That indicates the average level of soil provision with mobile copper forms for the first two groups of plants and low provision for the third group of plants.

Manganese: It is part of the enzymes involved in the processes of respiration, photosynthesis, carbohydrate and nitrogen metabolism in plants, plays an important role in the assimilation of nitrate and ammonium nitrogen by plants. Beets and other root crops, potatoes, cereals, as well as apple, cherry and raspberries are the most sensitive to the lack of manganese [12]. It is important for reproductive functions and normal functioning of the central nervous system in humans.

The following values were obtained in the studied soils: 10.064±0.03 mg/kg (sampling – 10.07) and 10.05±0.03 mg/kg (sampling – 30.08), which indicates the average level of soil provision with the mobile forms of this element for the first two groups of plants, and low provision for the third group of plants.

The pollution of soil with cadmium is a dangerous risk factor to the human body. People are poisoned with cadmium, consuming water and grain, vegetables growing on lands located near oil refineries and metallurgical enterprises. The fact that cadmium is transferring extremely easy from the soil to plants: the latter absorb up to 70% of cadmium from the soil and only 30% from the air. Particularly big dangers are in this respect mushrooms, which can often accumulate cadmium in extremely high concentrations. Uncomfortable muscle pain, involuntary bone fractures (cadmium is able to wash calcium from the body), deformation of the skeleton, impaired functions of the lungs, kidneys and other organs can occur. Excess cadmium can also cause malignant tumors [13].

The following results were obtained in our study: 0.337±0.009 mg/kg (sampling – 10.07) and a slightly higher index of 0.406±0.009 mg/kg (sampling – 30.08), but these data are within the MAC = 0.7 mg/kg.

Poisoning with large doses of lead causing different health disorders and anemia, diseases of the cardiovascular system, nerve paralysis, kidney, liver, brain damage, rheumatic symptoms are observed. Lead has the property of accumulation in bones, partially replacing calcium in phosphate $Ca_3(PO_4)_2$. There is also a very large influence of lead on the nervous system, especially in the childhood, as their central nervous system is still in the process of formation. Elevated levels of lead in the blood pose a particular danger to pregnant women, since lead freely penetrates the placenta, giving a poisonous effect on the fetus [14].

The level of lead in the soili of N. region does not exceed MAC = 20 mg/kg and is 0.029±0.022 mg/kg (sampling – 10.07), but it increased twice as high as in samples taken on 30.08 – 0.057±0.022 mg/kg.

This suggests that the concentration of heavy metals in the soil solution is subject to sharp fluctuations, depending on the soil properties and external factors. Therefore, it is necessary to carry out continuous monitoring of heavy metals concentration in the dynamics to ensure the normal life of plants and organisms.

Conclusions:

The performed studies showed that according to the gradation of the soil's provision with mobile forms of trace elements, the obtained results indicate that the studied soils are poorly saturated by mobile zinc forms for all three groups of plants, medium level of saturation for mobile copper and manganese forms, and high level of cobalt for the first two groups of plants, and low level of provision of all trace elements for the third group of plants.

The obtained results on hygienic estimation of lead and cadmium mobile forms content in soils of N. region do not exceed the maximum allowable levels, which prove the favorable soil condition and the absence of its contamination.

In our case, the recommendations will be as follows: it is necessary to conduct regular monitoring of soil condition, to provide soil with appropriate nutrients and to control the amount of pollutants to ensure the stability of the agroecosystem in order to obtain plants useful in their properties and safe for consumers of agricultural products.

One of the effective methods for improving the saturation of soils by microelements is the application of selective organic fertilizers and microfertilizers. Effective and safe use of them is possible only taking into account the content of trace elements in soils, since copper, zinc and other trace elements are in the group of heavy metals and its content increase should be moderate and do not exceed the corresponding threshold values of MAC.

Increase in agrochemical and sanitary control of the use of fertilizers as waste from various industries, which often contain not only biogenic, but also toxic elements and compounds is strongly recommended. It is also possible to increase the efficiency of microfertilizers by converting them into complex compounds (chelates) that are effective in any soil-agrochemical conditions and are well-compatible with plant growth regulators.

In the particular case of the soils of the N. region, it was proposed to use micronutrients with high zinc content, the average content of copper and manganese, and low content or absence of cobalt for the cultivation of plants of the first and second groups.

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SUMMARY

Scientific work under the cipher "Hygiene prevails" highlights the actual issues of soil quality hygienic assessment taking into consideration its contamination by heavy metals and the content of trace elements (on the example of soils sampled on sites in the N. region).

Hygienic assessment of copper (Cu), zinc (Zn), cobalt (Co), manganese (Mn), lead (Pb), cadmium (Cd) mobile forms content in the soil of N. region was the aim of the work.

The objectives of the work were to carry out sampling of soil; performing laboratory analysis of soil to determine of copper, zinc, cadmium, lead, cobalt, manganese content; and to assess the results from the standpoints of hygiene.

The method of atomic spectrometry and statistical methods of information processing were used to perform the work. The objects of the study were samples of black soil typical of the N region field. The time of sampling is July 10 and August 30. The determination was carried out on an atomic absorption spectrophotometer C-115-M-1 with a complex of technical means for electrothermal atomization by direct injection of the solution into the acetylene-air flame of the atomic absorption spectrophotometer, taking into account "Guidance document. Methodical instructions. A method for measuring the mass fraction of mobile metal forms in soil samples by atomic absorption analysis. RD 52.18.289-90 "and" DSTU 4287: 2004. Soil quality".

General characteristics of scientific work:

structure: title page, content of work, relevance, main part, conclusions, list of used reference, abstract (summary), scientific supervisor's review; volume - 16 pages; number of schemes – 0; number of tables – 3; number of scientific references used - 14.

Key words: hygienic assessment, soil quality, hygienic norms, heavy metals, trace elements (microelements).

REVIEW

OF SCIENTIFIC ADVISER ABOUT THE DEGREE OF SELF PERFORMANCE OF THE WORK

The author together with the scientific adviser formulated the name of the work, the purpose, the task and its conclusions. During the work the author independently worked out the literature on the study subject.

The student personally sampled the soil samples and performed the determination of studied elements under supervision of trained laboratory staff, than statistically processed the results and suggested ways to improve the soil state for its usage as a growing base for important plats groups.

The author in the course of his work showed perseverance, a critical approach, demonstrated the understanding of the problem, the ability to analyze contemporary literature on selected topics.

Scientific advisor