поживних речовин з ґрунту у варіанті із внесенням гною.

Отже, такі складові технології вирощування кукурудзи на зерно на дерново-підзолистому ґрунті, як зелене добриво та передпосівна бактеризація, є екологічно доцільними, оскільки зменшують ризик забруднення довкілля, та економічно вигідними, зважаючи на показники врожайності культури і якість отриманої продукції.

ЛІТЕРАТУРА

1. Цикл азоту в ризосферному ґрунті рослин кукурудзи / Т.Б. Мілютенко, О.В. Шерстобоєва, В.В. Волкогон, О.М. Бердніков // Агроекологічний журнал. — 2013. — № 3. — С. 88–94.
2. Методологія і практика використання мікробних препаратів у технологіях вирощування сільськогосподарських культур / За ред. В.В. Волкогона. — К.: Аграрна наука, 2011. — 156 с.
3. *Голубев Б.А.* Лизиметрические исследования в почвоведении и агрохимии / Б.А. Голубев. — М., 1967. — 46 с.
4. *Аринушкина Е.Н.* Руководство по химическому анализу почв / Е.Н. Аринушкина. — [2-е изд.]. — М.: МГУ, 1970. — 487 с.
5. Практикум по агрохимии / Под ред. В.Г. Минеева. — М.: МГУ, 1989. — 304 с.
6. *Доспехов Б.А.* Методика полевого опыта / Б.А. Доспехов. — М.: Агропромиздат, 1985. — 351 с.
7. *Шкарда М.* Производство и применение органических удобрений / М. Шкарда; перевод с чеш. и ред. З.К. Благовещенской. — М.: Агропромиздат, 1985. — 364 с.

UDC 504.5

EXCHANGE PROPERTIES AND ACID MODE OF SOIL UNDER AEROTECHNOGENIC CONTAMINATION OF TERRITORIES IN THE CONDITIONS OF CEMENT PRODUCTION

O. Iziumova

Житомирський державний технологічний університет

Викладено результати досліджень впливу емісій цементного виробництва на формування агрохімічних показників чорнозему опідзоленого на відстані до 20 км від джерела техногенної емісії. Встановлено, що за дії кальцієвмісного цементного пилу формуються спрямовані зміни у складі ґрунтового вбирного комплексу, обумовлені віддаленістю досліджуваних територій від джерела його викиду. Найістотніші зміни спостерігались у 2-кілометровій зоні впливу. На цій території вміст Са, сума увібраних основ та ємність вбирання до семи разів перевищували вихідні параметри ґрунтової екосистеми, а частка Са у ємності вбирання зростала від 85 до 98%. Збагачення грунту обмінними основами спричиняло його підлуговування, внаслідок чого гідролітична кислотність знижувалась до 10 разів. За межами цієї зони згадані показники стабілізуються на помірніших рівнях, проте істотно перевищують кларкові величини, а на відстані до 20 км від джерела емісії наближаються до регіонального фону.

Ключові слова: *забруднення, чорнозем опідзолений, ґрунтовий вбирний комплекс, агрохімічні показники, обмінні властивості ґрунту, кислотність ґрунтового розчину.*

Man-caused pollution is the result of complicated processes of redistribution of chemical elements in the soil under the influence of human activity. It was found that dust emissions of industrial plants can affect the soil covering at a distance of 20–30 km [1, 2]. At a distance of 7 km this impact is assessed as significant [3], and the epicenter of pollution is traced within a radius of 1 km [4].

As multiphase complex system with a wide range of genetic properties, soil is an ideal reaction medium for various chemical, physicochemical, and other processes of transformation of chemical components of technogenic origin. Accumulation of excessive amounts of calcium, magnesium, potassium, iron contained in cement dust causes the changes in the composition of the soil absorbing complex. In turn, it determines the nature of physical and chemical processes in the soil, which can manifest itself in the change of its reaction, dynamics of biological activity, mobility of biogenous elements, intensity and direction of metabolism of organic matter [5, 6]. Such changes determine the nature of the formation and passing ground regimes and the efficiency of agricultural use of lands under aerotechnogenic emissions of cement production.

The qualitative composition of the soil absorbing complex determines its physicochemical, agro-chemical, biological and other properties which are important from the agronomic point of view. According to K.K. Hedroyts, all kinds of soil, depending on the composition of absorbed cations, are divided into base-saturated and base-unsaturated ones. Base-saturated soil, unlike unsaturated, does not contain significant amounts of hydrogen and aluminum in absorbed cations. Composition and correlation of exchange cations significantly affect the physical and chemical properties of soil, acid mode, mobility of organic matter. The dominant role is played by the absorbed bases (Ca^{++}, Mg^{++}, K^{+}, NH_4^{+}).

MATERIALS AND RESEARCH METHODS

The results of the study of exchange properties and acid mode of soils are given according to the results of our research conducted on ash-laden loamy black soil, located within the territorial limits of Zdolbuniv and Ostrog districts of Rivne region, which is influenced by aerotechnogenic emissions of the cement plant. Sampling of 0–20 cm soil layer was carried out taking into account the direction of the prevailing winds in the contaminated south-east direction at distances 0.2; 0.4; 0.6; 2.0; 4.0; 6.0; 10.0; 15.0; 20.0 and 25.0 km (control). Hydrolytic acidity was determined according to Cappen, pH — by electrometric method, exchange forms of Ca and Mg — by AAS.

RESULTS AND DISCUSSION

Our studies have shown the deep changes in the structure of the soil absorbing complex and the reaction of soil solution under the influence of cement dust (Table). Under the influence of the latter, absorbing complex of soil was significantly enriched with absorbing bases, the amount of which within 0.2–0.6 km from the emission source outnumbered the clarke numbers by 9 times and was at 149 mg-eq/100g level. Their abnormally high content (134.9 mg-eq/100g) was recorded at a distance of 2 km. However, at a distance of 4 km the content of absorbed bases decreased by half in 0–20 cm layer and was characterized by optimal parameters for this type of soil (at 70 mg-eq/100g). At a distance of 6, 10 and 15 km their content was stable at 30 mg-eq/100 g without significant fluctuations.

Calcium ranks first among absorbed bases. Ideally, according to the degree of saturation of the bases of soil (95%) its content should be 80–85% of absorption capacity. This soil is able, due to its favorable properties, to provide consistently high harvest under crop rotation [7].

Component analysis of soil absorbing complex showed that the profound changes that had taken place in it, were primarily due to the enrichment of the latter with the exchange forms of calcium. The table shows the rates of exchange calcium content considering its soluble form, the fraction of which was not deleted in the process of agrochemical analysis. Because of the carbonate bedrock and significant entry of calcium as a part of cement dust into the soil, its considerable amount was not absorbed by the soil complex and was a part of the soil solution, which resulted, to some extent, in abnormally high levels of its contents in the equivalent form.

Abnormally high content of exchange calcium was detected in 2-km zone of influence, where its concentration in soil exceeded the standard level by 6.6–7.2 times and was in an abnormally high range of 133–146 mg-eq/100g of soil. In more remote from the source of cement dust emission area (4 km) the content of this component in the absorbing complex of soil decreased almost by 2 times. However, the content still remains at a high level (71 mg-eq/100g) and it is higher than the control level by 3.5 times. Starting with the distance of 15 km the concentration of this cation in the soil is kept almost at the regional background (20.2 mg-eq/100g).

A similar spatial distribution patterns are established for the exchange magnesium (see Table). At a distance of 0.2 to 0.6 km from the release of dust its concentration in the soil was also the highest (2.65–2.79 mg-eq/100g). As the distance from the source of emission increased the contents of this component had a clear downward trend: from 2.31 (2 km) to 1.43 (20 km).

Enriching the absorbing complex of soil with metabolic bases, primarily due to saturation of it with calcium, leads to a significant reduction in the acidity of the soil solution. The most noticeable alkalinization of 0–20 cm soil layer occurred in a 6-kilometer zone of influence. Within this limit the hydrolytic acidity index was the lowest and varied from 0.16 to 0.22 mg-eq/100g of soil, which is almost by 10 times lower than the control value. The reaction of soil solution at pH index changed from alkaline at a distance of 0.2 km (pH 8.15) to alkali on the border of the specified zone (pH 7.58). At a distance of 6 to 15 km the most favorable conditions for plant growth in terms of soil acidity were formed. At this distance hydrolytic acidity increased markedly (to 1.35 mg-eq/100g) while the rate of actual acidity decreased to pH 7.14. On the border of the study area (15 km) acidity stabilized at pH 7.0 and hydrolytic acidity at 1.6 mg-eq/100g.

An important indicator of the soil is the absorption capacity that determines the exchange absorptive capacity of the absorbing complex of soil. Its value depends on many characteristics of the soil, and above all, on the presence of fine-dispersed factions and humus content. The higher is the content of fine-dispersed particles, the higher is the rate of absorption capacity. In this connection a crucial role is played by calcium cations that due to high coagulation ability contribute to the processes of microstructurization of soil. The results of our study [8] showed that under the influence of calcium compounds found in cement dust, the activation of the processes of microstructurization in the system of colloidal solution with the formation of primary microaggregates occurs. In addition, under the influence of calcium the humic substances in a state of colloidal solution coagulate and become insoluble, harden and turn into the state of micro-particles.

So within 2-km zone of influence the absorption capacity reached maximum values (150 mg-eq/100g) and was nearly by six times higher than the control values. At a distance of 2 to 6 km from the emission source the most prominent decrease of this index (from 150 to 38 mg-eq/100g) occurred. Beyond a 6-km zone of influence the absorption capacity rate stabilized at 25–32 mg-eq/100g, but it was significantly higher than the control values.

The saturation of the soil complex with absorbed bases and the share of calcium in absorption capacity increases significantly under the influence of aerotechnogenic calcium dust emissions (see Table).

Within 6 km from the source of influence the index of base saturation was maximal and varied from 99.8 to 99.4% of the absorption capacity. This increase is primarily due to a high degree of saturation of the absorbing complex with the cations of calcium, the share of which in absorption capacity near the emission sources was 98%. As the distance from the emission source increased, the hydrolytic acidity rate increased as well, and the percentage of calcium in the absorbing complex of soil decreased, and, consequently, the rate of saturation degree of soil with absorbed bases on the border of the 20-km zone of influence decreased to 92.6%.

CONCLUSIONS

As a result of the annual ingress of a large amount of calcium-containing cement dust in the 0–20 cm of soil layer permanent directed changes in nutrient regimes are formed, which turned out to be closely related to the remoteness of the study area from the source of man-caused emissions. Within 2-km zone of its influence, the conditions for the formation of the absorbing complex of soil with abnormal exchange characteristics appear. The rates of absorbed bases content and absorption capacity of this complex increase by 6.5 times. Due to

Indicators of absorbing complex of soil and acid mode in 0—20 cm soil layer in the zone of impact of cement dust

Distance, km	pH (water)	Hr	Ca	Mg	S	E	V, %	Share of Ca in E, %
		mg-eq/100g of soil						
0.2	8.15	0.17	146.3	2.79	149.09	149.25	99.85	97.95
0.4	8.15	0.16	146.7	2.65	149.35	149.51	99.80	98.05
0.6	7.92	0.18	149.9	2.68	152.58	152.75	99.80	98.10
2.0	7.99	0.17	132.6	2.31	134.92	135.09	99.80	98.10
4.0	7.71	0.19	70.5	2.31	72.81	73.36	99.70	96.50
6.0	7.58	0.25	35.9	1.91	37.76	37.98	99.40	94.35
10.0	7.19	0.91	30.0	1.84	31.49	32.40	97.15	91.45
15.0	7.14	1.35	28.6	1.48	30.03	31.38	95.65	90.90
20.0	7.07	1.81	21.7	1.43	23.08	24.89	92.65	86.95
Control	6.48	1.97	20.2	1.52	21.72	23.70	91.60	85.20

Notes: 1. Hr — hydrolytic acidity; 2. E — absorbing capacity; 3. S — amount of absorbed bases; 4. V — the degree of saturation of soil with bases.

the increase of the content of exchange forms of calcium (by 6.6–7.2 times) and magnesium (by 1.5–1.8 times) the degree of saturation of soil with absorbed bases increases from 91.6% to 99.8%, and the share of exchange calcium in absorption capacity increases to 98%. As a result of these transformations, alkalization of soil solution occurs, resulting in the reduction (by 11 times) of hydrolytic rate (from 1.97 to 0.18 mg-eq/100g) and the growth of actual acidity measured at pH (from 6.84 to 8.20).

The optimal exchange characteristics of the absorbing complex of soil are generated under moderate anthropogenic impact within 4–10 km from the source of emission of cement dust. In the composition of the absorbing complex the content of exchange forms of calcium and magnesium significantly increases (respectively by 3.5 and 1.5 times), the rate of absorption capacity increases by up to 3 times and it stabilizes at 32.4–73.3 mg-eq/100g. The amount of absorbed bases in soil increases from 21.7 to 30–70 mg-eq/100g, making the degree of saturation of the soil complex increase by 6 times and be at the level of 98%. As a result of these changes favorable conditions for plant growth in terms of hydrolytic soil acidity (at 0.91–1.35 mg-eq/100 g) and the actual acidity of pH 7.1–7.2 are created.

REFERENCES

1. *Минина А.В.* Распределение тяжелых металлов в почвах, прилегающих к промышленному предприятию / А.В. Минина // Бюл. Почв. Ин-та. — 1989. — № 49. — С. 23–26.
2. Technogenik pollution of environment in case of cement production / W.V. Snitynskyi, D.M. Puzenko, W.F. Jakobenchuk, T.G. Jakobenchuk // Zeszyty Naukowe Akademii Rolniczej im. H.Kollataya w Krakowie: Przyrodniczo-ekonomiczne aspekty zrownowazonego rozwoju rolnictwa w rajonie Karpat.– Krakow, 2001. — P. 3–7.
3. Исследование действия горных работ на прилегающие земли / Е.П. Писанец, В.И. Титовский, А.И. Бурыкин [и др.] // Горный журнал. — 1989. — № 2. — С. 59–61.
4. *Тютюнник Ю.Г.* О зависимости содержания тяжелых металлов в городских почвах от уровня загрязнения атмосферы / Ю.Г. Тютюнник // Агрохимия. — 1992. — № 7. — С. 115–117.
5. *Ворон В.П.* Кислотно-основні властивості ґрунтів в умовах забруднення довкілля викидами цементного виробництва / В.П. Ворон, С.П. Распопіна // Вісник ХДАУ. — Х.: ХДАУ, 1999. — № 2. — С. 302–308. — (Серія «Ґрунтознавство, агрохімія, землеробство, лісове господарство»).
6. Влияние атмосферного загрязнения на свойства почв / [под ред. Л.А. Гришиной]. — М.: Изд-во МГУ, 1990. — 205 с.
7. *Сытник К.М.* В.И. Вернадский. Жизнь и деятельность на Украине / К.М. Сытник, Е.М. Апанович, С.М. Стойко. — К.: Наук. думка, 1988. — 382 с.
8. *Ізюмова О.Г.* Структуроутворення в ґрунтах з аномальним вмістом кальцію у зоні впливу ПАТ «Волинь-цемент» / О.Г. Ізюмова, Г.А. Мазур // Агроекологічний журнал. — 2011. — № 2. — С. 63–67.