Nat. Volatiles & Essent. Oils, 2021; 8(5): 11030-11038

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Natural Volatiles & Essential Oils

DYNAMICS OF MECHANICAL COMPOSITION, MOISTURE CAPACITY AND DENSITY OF TECHNOLOGICALLY CONTAMINATED SOIL

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Abstract :
The studies have established that the ratio of coarse and medium sand to the mechanical composition of the soil depends on the heavy metals content. A decrease in the ratio of coarse and medium sand shows a decrease in the toxic effect of technologically contaminated soil. As a result of the activities of CJSC "Yuzhpolimetall", technologically contaminated biochemical regions have been formed, the heavy metals compositionin which exceeds the MPC several times.Surveys conducted on the territory of the production cooperative (PC) "Karnak"and the settlements of "Balaburgem" and"Kushata"showed that the priority soil contaminants in this region are such HMs as zinc and lead. It is known that their accumulation in the soil increases the toxic potential and sharply reduces soil fertility. The urgency of this problem is due to the soil heterogeneity in our region.

Keywords: studies; established;mechanical composition; soil; heavy metals; toxic effect; technologically; contaminated; biochemical; region; zinc; lead;accumulation; fertility.

Introduction :

Due to the increasing environmental degradation on a global scale, the use of data such as quality indicators is necessary to assess each situation, predict trends and implement actions that lead to the prevention, correction, mitigation or restoration of the environment Velasquez, E., Lavelle, P, (2019).

Vegetation experiments are most often static complexes consisting of several independent samples-options. The independence of comparable options is achieved by regular movement of containers on the trolley. Consequently, there are usually no territorially organized repetitions in vegetation experiments. In such cases, a dispersive analysis of the data should be carried out as for non-conjugate samples. When the variants are combined territorially into repetitions in a vegetation experiment, then the statistical analysis is carried out in the same way as field experiments set by the method of organized repetition (Abdimutalip, N. et al., 2014, Imashev, A. et al., 2018, Abdimutalip, N. et al., 2017).

In our work, we investigated the mechanical composition dynamics of the soil contamination degree with heavy metals. In this regard, we conducted field research on arable lands within a radius of 25 km, starting from the Kargalinka tailing dump to the settlement of "Kyzylzhol" (Kurbanyazov, S., 2018, Akbasova, A, 2012).

For the analysis, testing of soil samples at each point at a distance of 5 km was taken. Fractional analyzes were conducted by sifting through a sieve with a diameter of 0.01–3 mm. As a result of the research work of the Giprozem Institute, the heavy metalscompositionin soils ranges from 1580 mg/kg to 70 mg/kg of soil. It is known that the mechanical composition affects the soil-forming processes and their use for agricultural purposes. Depending on the mechanical composition, the physical, physiomechanical, water-physical, air and thermal properties of the soil change. The value of the mechanical composition increases, especially in technologically contaminated soil (Lin, Y., et al., 2020). Therefore, the ratios of coarseto medium sand indicators are the indicators of technologically contaminated soil (Rau, G., et al., 1997, Mileev, V., 1990, Poponova, R. , 1991).

Results :

Ecosystem services develop at the core of the living organisms that inhabit the soil, from plants through macro -, meso-and microfauna to microbial communities. Effective soil management and use could change the chemical and physical parameters of the soil, thereby determining the structure of microbial communities that inhabit it (Esperón, F**., 2020**). A new problem is that crop rotation management and agricultural methods to manage the soil microbiome to increase soil fertility and improve yield (Wall, L.G., Gabbarini, L.A., Ferrari, A.E., Frene, J.P., Covelli, J.R., Robledo, N.B., 2019).

As a result of research, we observed a change in the ratio of coarseto medium sand depending on the heavy metals composition. With a heavy metalcompositionof 1580 mg/kg of soil at a distance of 0-5 km, the ratio coefficient of coarseto mediumsand is 0.66, with a heavy metal compositionof 70 mg/kg of soil at a distance of 21-25 km, the ratio of coarse to medium sand is 0.61.

Consequently, by reducing the ratio of coarse to medium sand, contamination is also reduced; by increasing the fraction of medium sand, the toxic effect of technologically contaminated soil can be reduced (Tables 1-5).

Soil depth, cm	Fraction, mm	Fraction name	Fraction weight, kg
0-20	3-1	gravel	1.92
	1-0.5	coarse sand	2.05
	0.5-0.25	medium sand	3.10
	<0.25	fine sand	2.93
21-40	3-1	gravel	0.67
	1-0.5	coarse sand	1.56
	0.5-0.25	medium sand	4.11
	<0.25	fine sand	3.56

Table 1. The fraction dynamics of the soil mechanical composition at a distance of 0-5 km (the heavy metals composition of 1580 mg/kg of soil)

Soil depth, cm	Fraction, mm	Fraction name	Fraction weight, kg
0-20	3-1	gravel	1.51
	1-0.5	coarse sand	2.22
	0.5-0.25	medium sand	3.46
	<0.25	fine sand	2.81
21-40	3-1	gravel	0.72
	1-0.5	coarse sand	1.13
	0.5-0.25	medium sand	4.70
	<0.25	fine sand	3.45

Table 2. The fraction dynamics of the soil mechanical composition at a distance of 6-10 km (the heavy metals composition of 1072 mg/kg of soil)

Soil depth, cm	Fraction, mm	Fraction name	Fraction weight, kg
0-20	3-1	gravel	1.71
	1-0.5	coarse sand	2.10
	0.5-0.25	medium sand	3.37
	<0.25	fine sand	2.82
21-40	3-1	gravel	0.87
	1-0.5	coarse sand	1.46
	0.5-0.25	medium sand	4.21
	<0.25	fine sand	3.46

Table 3. The fraction dynamics of the soil mechanical composition at a distance of 11-15 km (the heavy metal composition of 840 mg / kg ofsoil)

Soil depth, cm	Fraction, mm	Fraction name	Fraction weight, kg
0-20	3-1	gravel	1.32
	1-0.5	coarse sand	2.29
	0.5-0.25	medium sand	3.76
	<0.25	fine sand	2.63
21-40	3-1	gravel	0.52
	1-0.5	coarse sand	1.57
	0.5-0.25	medium sand	4.09
	<0.25	fine sand	3.82

Table 4. The fraction dynamics of the soil mechanical composition at a distance of 16-20 km (the heavy metal composition of 247 mg / kg ofsoil)

Soil depth, cm	Fraction, mm	Fraction name	Fraction weight, kg
0-20	3-1	gravel	1.14
	1-0.5	coarse sand	2.32
	0.5-0.25	medium sand	3.80
	<0.25	fine sand	2.74
21-40	3-1	gravel	0.48
	1-0.5	coarse sand	1.02
	0.5-0.25	medium sand	4.14
	<0.25	fine sand	3.76

Table 5. The fraction dynamics of the soil mechanical composition at a distance of 21-25 km (the heavy metal composition of 70 mg /kg of soil)

In addition, we studied the changes dynamics in soil moisture capacity and soil density depending on the heavy metals compositionandthe seasons of a year (Table 6).

Heavy metals distance and composition	Moisture capacity, %			density, y/cm^3		
	spring	summer	autumn	spring	summer	autumn
0-5 km, 1580 mg/kg of soil	37,5	23,9	28,8	2,17	2,20	2,19
6-10 km, 1072 mg/kg of soil	38,2	26,1	32,1	2,02	2,02	2,03
11-15 км, 840 mg/kg of soil	49,6	38,8	45,3	1,97	1,97	1,96
16-20 km, 247 mg/kg of soil	58,1	49,7	57,5	1,49	1,49	1,47
21-25 km, 70 mg/kg of soil	66,7	61,3	66,1	1,20	1,20	1,15

Table 6. Changes dynamics of soil moisture capacity and soil density

Discussion :

The generation of soil cover quality indicators requires a large amount of basic information, which is obtained by evaluating a variety of variables (related to the characteristics of each region) with a high degree of correlation and the analysis of which is translated into a synthetic form.

The food network of soil communities is allometrically restricted due to differences in body size. In such food networks, there is a close relationship between complexity and predictability. Certain species characteristics related to body size affect the response of the entire food web to disturbance. Therefore, hypotheses about the relationship between changes in the food web and emerging properties, such as stability or diversity, must take into account the characteristics of a particular species and physiological responses (Christelle G., Charles D., Terry S., Doyle Mc K., 2019).

It is known that soil moisture capacity and soil density are indicators of a decrease in soil fertility. As a result of the study, we found that with an increase in the heavy metalscontent, the moisture capacity indicator decreases, and the soil density increases. This is explained by the fact that in technologically contaminated soils the process of decomposition and mineralization of organic residues is delayed and the soil is compacted (Yagodin, B. et al., 1990, Torshin, O. et al., 1993, Avakian, N. et al., 1984, Paganini, N., 1984, Chernykh, M. et al., 1995, Potatuev, J. et al., 1994).

The soil moisture capacityvaries significantly during the seasons, i.e. in the spring; the capacity is higher than in the summer and autumn periods (Vinogradov, A. P., 1957).

The heavy metals concentration effect on the wheat varieties stability :

The results confirm our prediction that strong environmental heterogeneity is the main factor that determines the quality of soil on a local scale (Bostanova, A. et al., 2017).

An increase of heavy metals (HM) in the soil compared to the background leads to an increase in their concentration in the plant organism. This can become dangerous for the life of plants, as well as for the health of humans and animals that consume them for food (Yuan, C. G., Wang, J. & Jin, Y., 2012, Aragay, G., Pons, J. & Merkoci, A., 2011, Kalis, E. J., Weng, L., Dousma, F., Temminghoff, E. J. & Van Riemsdijk, W. H., 2006, Nolan, E. M. & Lippard, S. J., 2007, Long, F., Zhu, A., Shi, H. *et al.*, 2013, Tang, W., Shan, B., Zhang, H. *et al.,* 2015).

Currently, due to the suspension of the burial work on soil remediation of the Mirgalimsaysky ore deposit, there is a significant contamination of the territory, which is widely used for growing grain and vegetable melons.

The lead pollution of the soil, which was assigned by the UN interagency monitoring group in 1973 to be among the most dangerous pollutants requiring priority monitoring, is of particular concern.

The present work continues the study of the HM behavior in the soil-plant system in the ore deposits of CJSC Yuzhpolymetal. According to V.B. Ilyin (1985), the elemental chemical composition (EChC) of plants is affected by two factors working in opposite directions: 1) genetic control forming the EChC of plants and preventing its change, and 2) ecological causing a change in the EChC.

In our work, we consider the behavior of plants that steadily respond to an increase in the content of HM salts and give a planned yield in this region.

In this regard, we laid the experiment to determine the resistance of cultivated plants to HM.

For the experiment, winter wheat of the Vitreous 24 variety grown in peasant farms and production cooperatives of the Turkestan region of the South Kazakhstan region and the Sari sanak variety brought from the Republic of Turkey for comparison were taken (Bostanova, A. et al., 2018).

The wheat was grown in a growing house. The soil is ordinary sierozem серозем, medium loamy, the initial content of lead in it is 1072 mg / kg in the soil. The experiment was laid out in plastic containers in triplicate according to the scheme:

1) background (control) - 1072 mg / kg of initial lead content in the soil
2) background + 360 mg / kg of bird droppings per 1 kg of soil.
3) background + 100 mg / kg of lead per 1 kg of soil
4) background + 250 mg / kg of lead per 1 kg of soil
5) background + 100 mg / kg of lead + 360 mg / kg of bird droppings
6) background + 250 mg / kg of soil + 360 mg / kg of bird droppings

The toxicant was introduced into the soil when filling containers in the form of a water-soluble salt of lead acetate, and as an organic fertilizer in the form of bird droppings. The selected toxicant doses corresponded to the concentrations studied in the industrial areas.

Prior to the experiment layout, we added nitrogen, phosphorus and potassium in all variants to the required level of absorption of these elements by wheat. During the growing season, the wheat was watered with tap water on the 15th day after the experiment layout on all options.

During the experiment, we performed phenological observation as well as biometrics.

As a result of the experiment with wheat, the evidence was obtained that the reproductive organ of this plant, even at very high doses of a toxicant in the soil (1000 mg / kg of lead), contains as much metal in the soil as in the control.

In our experience, we did not study the metal content in wheat organs, but we studied the toxicant effect separately and in conjunction with organic fertilizer on the dynamics of dry matter accumulation and photosynthetic activity (fig.1-2).

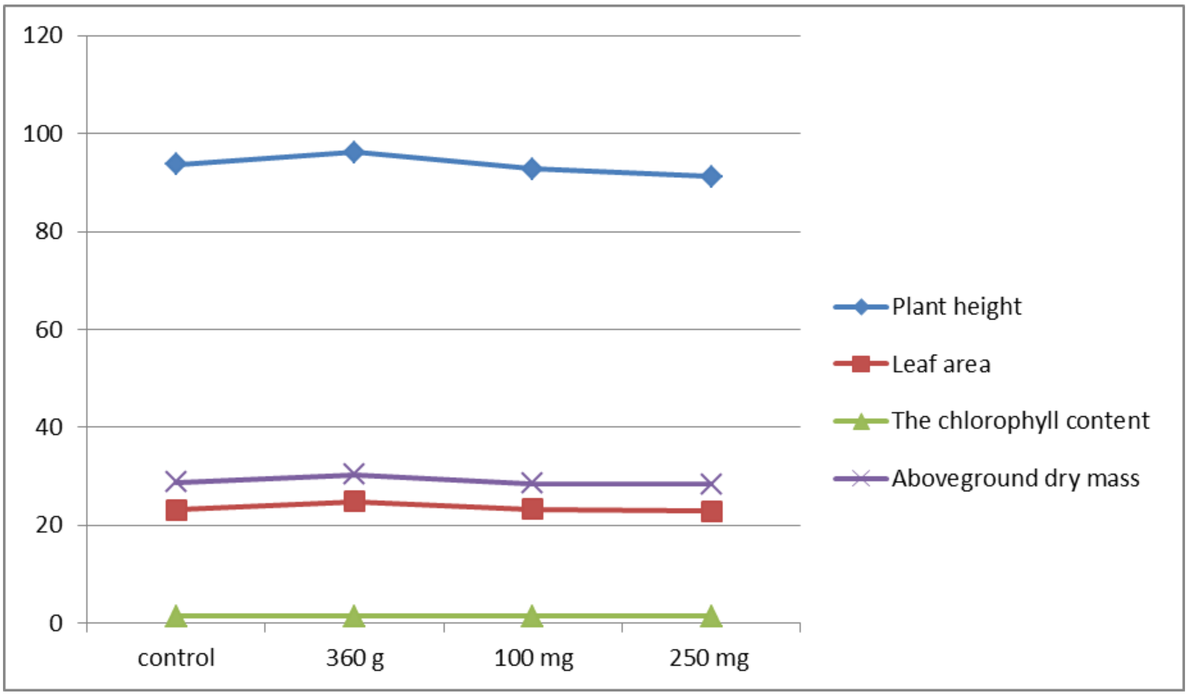

Figure 1 - Photosynthetic activity of winter wheat depending on the lead salts content (budding-flowering phase)

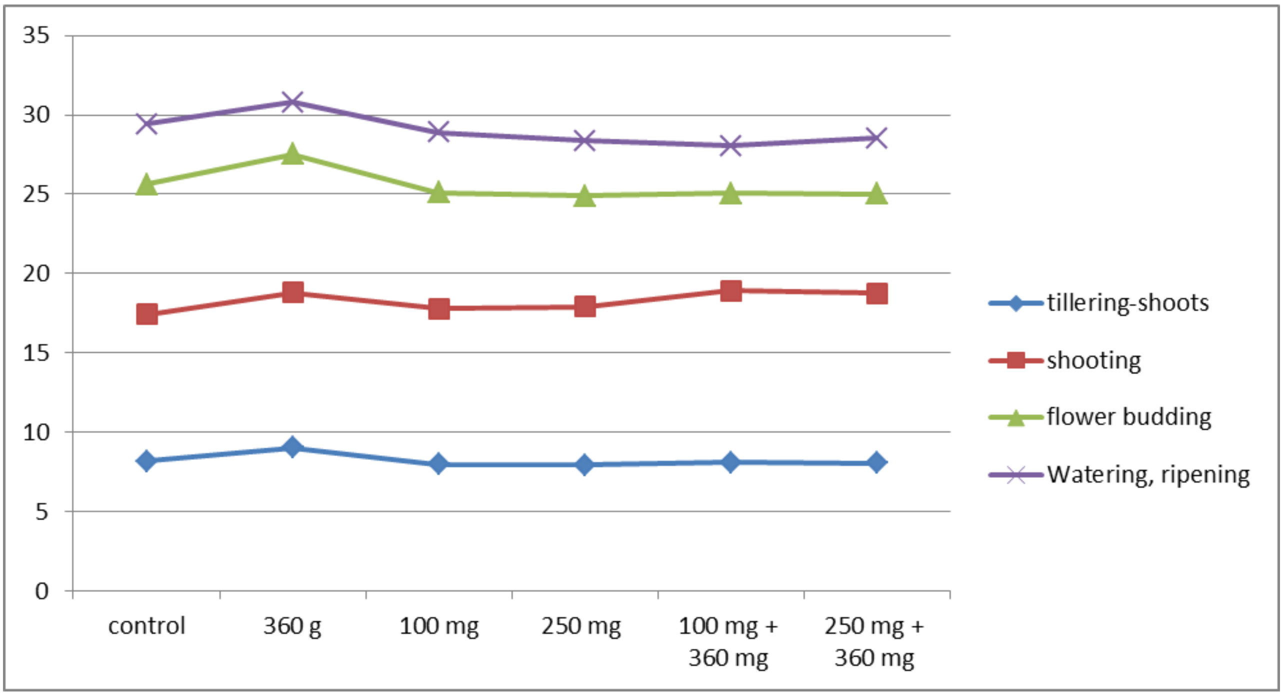

Figure 2 - Lead content effect on the dry matter dynamics of winter wheat, g /container

An analysis of the data obtained showed that in the variant where only bird droppings were introduced, all indicators of photosynthetic activity of winter wheat varieties were higher than in comparison with other options. These indicators were comparatively higher in the variants of co-introduction of bird droppings than in the cases where only lead salts were introduced. This is due to the fact that when organic fertilizer is applied, soil fertility increases.

When studying the lead content effect on the dry matter accumulation dynamics, we observed the same results.

Thus, in the conditions of sierozem, an increase in the lead content from 100 to 250 mg / kg of soil did not significantly affect the photosynthetic activity and the dry matter accumulation dynamics of winter wheat varieties, and the addition of only bird droppings increased the resistance of winter wheat varieties to a high background lead content in the soil (1072 mg / kg).

A dispersive analysis of the aboveground dry wheat mass :

Before the dispersive analysis of the data of the vegetation experiment, a task was set to test the null hypothesis H_o, which is formed as follows: there are no significant differences between the average options, i.e. $x_1=x_2=x_l$, or $x_1-x_2=d=0$. Briefly, the null hypothesis is written $H_0:d=0$.

For this, a statistical analysis of the data (aboveground dry mass) was conducted in three stages, we:

1. compiled a calculation table, placing in it the initial data for the rows and columns to determine the amounts and the average for the options, the total amount and the average value of the effective attribute by experience (annex 1).
2. calculated the sum of the squared deviations according to the formulas and determined the actual value of the criterion $Ꞙ_f$.
3. determined the error of experience and the significance of particular differences.

The theoretical value of $Ꞙ_{05}$ was found on the basis of 2 degrees of freedom for the dispersion variants (numerator) and 15 degrees for the remainder (denominator). At $Ꞙ_f > Ꞙ_{05}$ in the experiment there are significant differences in the options at the 5% significance level, that is, the null hypothesis is rejected $H_0:d=0$.

The outcomes of the experimental results and statistical data processing were recorded in the tables.

Thus, in conditions of technologically contaminated soils, and even at high concentrations of heavy metals, the use of organic fertilizers reduces the toxicity of soil contamination. Although, when organic fertilizer is applied separately and together with lead salts, it reduces the toxicity of contaminated soils, the resistance of wheat varieties is not the same.

The resistance of the local winter wheat variety Vitreous 24 to the effects of heavy metals when applying only organic fertilizer is significant and it is lower at a 5% significance level (1.31 and 0.62 g/vessel) in joint application, i.e. insignificant, whereas the resistance of the winter wheat variety Sari Sanak brought from the Republic of Turkey to technogenic soil contamination turned out to be insignificant, even when only bird droppings were introduced (annex 1).

Conclusion :

The studies have established that the ratio of coarse and medium sand to the mechanical composition of the soil depends on the heavy metals content. A decrease in the ratio of coarse and medium sand shows a decrease in the toxic effect of technologically contaminated soil.

The moisture capacity indicators decrease with an increase in the concentration of lead salts in the soil while the soil density increases.

The seasonal dependence of the soil moisture capacity indicator is significant, and the change in seasonal soil density is insignificant.

The indicators of photosynthetic activity of the winter wheat varieties were higher in the variant where organic fertilizers were applied, and in the variants where lead salts and organic fertilizers were introduced together, these indicators were comparatively higher.

Mathematical processing by the dispersive analysis method showed that in the variants where lead salts and organic fertilizers of above-ground dry mass of the winter wheat varieties were introduced together the dry mass addition is not significant, whereas in the variants where only organic fertilizers of the wheat variety Vitreous 24 were introduced it is significant, but it is insignificant for the wheat variety Sari Sanak. Thus, the most stable was the local variety of the winter wheat Vitreous 24.

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