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PLANTS AND MAXIMUM PERMISSIBLE CONCENTRATIONS OF HEAVY METALS IN SOIL

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ABSTRACT

The tentative permissible concentrations and the maximum permissible concentration of heavy metals do not always give a complete adequate assessment of the effect on plants. Plant growth inhibition can be at concentrations below the maximum permissible concentrations and tentative permissible concentrations.

We studied the effect of copper, zinc, cadmium, and lead concentrations on plants. The object of the research is the lawn grass, the Agrostis stolonifera used in urban greening. According to the data obtained, Agrostis stolonifera showed a low degree of resistance to copper, lower than the tentative permissible concentration and the maximum permissible concentration. Consequently, the tentative permissible concentration and the maximum permissible concentration do not fully reflect the real phytotoxicity of copper.

Plants of Agrostis stolonifera demonstrated a relatively high sensitivity to zinc in comparison with the maximum permissible concentration and the tentative permissible concentration. The content of cadmium and lead corresponding to the tentative permissible concentrations did not have a significant effect on the plants.

Keywords: *maximum permissible concentration, soil, copper, zinc, urban greening*

INTRODUCTION

The environmental rationing of the content of heavy metals in the soil is quite difficult due to the difficulty of taking into account all environmental factors. The standards also do not take into account the climatic and geochemical features of the regions [1].

According to literature data, even in some isolated cases, the values of the background content of some metals obtained by researchers can differ up to 10 times [2].

The regional average level can be used as a background level, and in its absence - the clarke or the world average content of this element in the soil [3,4]. To assess the level of chemical pollution of soils, the total indicator of pollution is also used [5]. The main criterion for the hygienic assessment of the hazard of soil contamination with harmful substances is the maximum permissible concentration (MPC) of chemicals in the soil [6].

The soil is a complex heterogeneous system, and therefore the development of unified the maximum permissible concentration becomes an extremely difficult task. The hygienic concept of the maximum permissible concentration is based on four main indicators of harm [7]. Soil hazard assessment is carried out according to the use of territories. The main indicator is the impact of soil pollution on humans [6].

Changes in soil acidity can significantly affect the phytotoxicity of metals.

The tentative permissible concentrations of the gross content of heavy metals [8-9] gives a more complete characterization of soil contamination by some heavy metals.

The dependence of the tentative permissible concentrations on factors (soil acidity, granulometric composition of the soil) is very significant. The tentative permissible concentrations of copper is 33 mg / kg for sandy and sandy loam soils, 132 mg / kg for slightly alkaline and neutral soils [8-10].

Soil quality assessment is based on sanitary and hygienic standards [8-10]. With the ecosystem (biogeochemical) approach, there should be no significant anthropogenic disturbances in all parts of the ecosystem [11].

The maximum permissible concentration of heavy metals in the soil has a number of disadvantages:

- lack of a unified approach to the development of the maximum permissible concentration of heavy metals in the soil
- the maximum permissible concentration does not take into account the properties of all constituent ecosystems (when determining the maximum permissible concentration, emphasis is placed on safety for humans)
- the maximum permissible concentration in soil does not fully take into account the effect of heavy metals on plants, first of all, the accumulative capacity of plants is taken into account;
- the complex interaction of heavy metals is not taken into account
- a significant difference in the standards of the maximum permissible concentration and the tentative permissible concentrations

An alternative is to introduce the tentative permissible concentration of the most dangerous heavy metals for sensitive groups of living organisms.

However, maximum permissible concentration and tentative permissible concentrations are currently used.

Therefore, it is advisable to compare the level of soil pollution and the phytotoxicity of metals with the tentative permissible concentration and the maximum permissible concentration. Therefore, the influence of the concentrations of copper, zinc, cadmium and lead (below the maximum permissible concentration and the tentative permissible concentrations (pH KCl > 5.5)) on plants was investigated.

METHODOLOGY OF WORK

The phytotoxicity of heavy metals was estimated in aqueous solutions in Petri dishes [12-14]. The seeds were germinated on Petri dishes on filter paper moistened with solutions of heavy metals . Water was taken as a control medium.

We used salts of heavy metals $CuSO_4 \cdot 5H_2O$, $ZnSO_4 \cdot 7H_2O$,$CdCl_2$, $Pb(NO_3)_2$ (data are presented in terms of pure metal). The seeds were incubated in Petri dishes at 26°C, exposed to a 16-h photoperiod in the light and humidity 70%.

Inhibitory (active) concentration was a concentration that slows down the growth of shoots by more than 25 - 30% compared to the control. The concentration of heavy metals in the soil was selected in accordance with the results obtained in aqueous solutions.

Plants for the assessment of phytotoxicity were grown in a greenhouse in vessels. Heavy metals were added to the soil (pH 6.5 -7.0, N – 150 mg / l, P – 250 mg/ l, K – 300 mg / l) as an aqueous solution.

The object of the research is the lawn grass, the common bent (*Agrostis stolonifera* L.) used in urban greening.

Agrostis stolonifera L. is a perennial grass in the Poaceae family. This grass has an advantage over many other lawn grasses because it is capable of vegetative reproduction and permits to create lawn for different purposes only from it.

Figure 1. Agrostis stolonifera

RESEARCH RESULTS

As an tentative permissible concentration for plants, we took a concentration that slows down the growth of shoots by less than 25-30%. Copper has shown the greatest effect on *Agrostis stolonifera*. In aqueous solutions, the tentative permissible concentration of copper is 30 mg /l [13]. Copper had less effect on the plants in the soil within the first two weeks (figure 2).

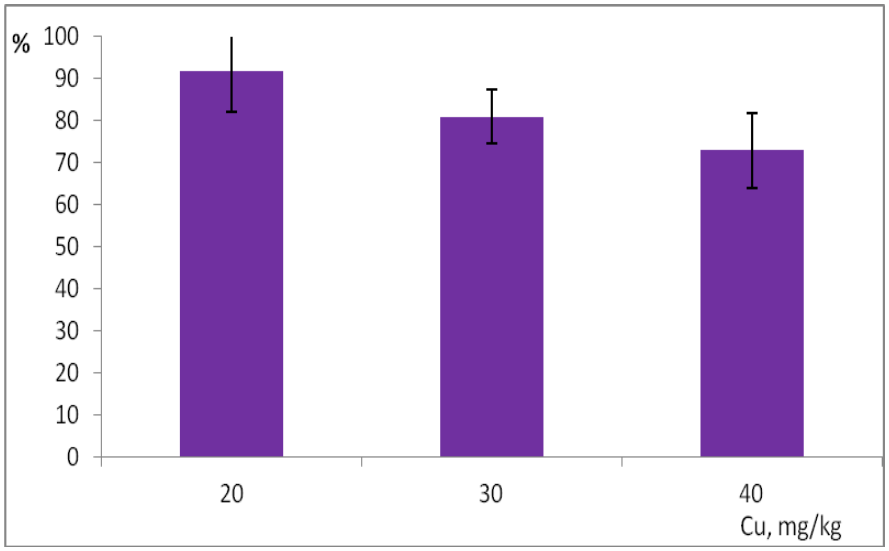

Fig. 2. Effect of copper on lawn grass within 14 days (% relative to control)

The greatest toxicity of copper to plants was observed on the 26-28 day. Shoot growth inhibition was 33% at 40 mg/ kg copper (figure 3).

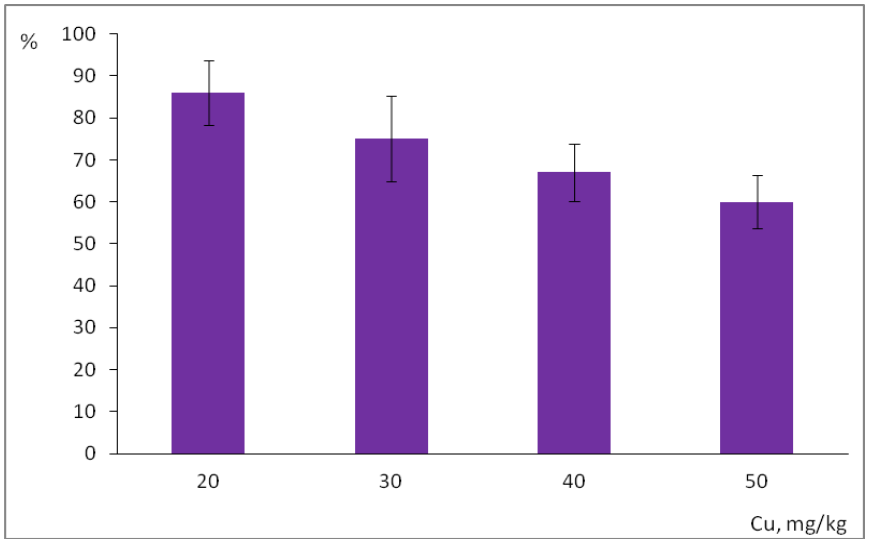

Fig. 3. Effect of copper on lawn grass (% relative to control)

However, elevated concentrations of zinc, cadmium and lead can have negative effects on urban plants.

Agrostis stolonifera demonstrated a low degree of resistance to copper, lower than the tentative permissible concentration and the maximum permissible concentration (table 1, table 2).

Table 1. Effect of heavy metals on plants in water solutions
(Inhibition of the growth of shoots of Agrostis stolonifera plants, no more than 25 - 30 %)

heavy metal	concentration (mg /l)
Cu	30
Zn	80
Cd	15
Pb	500-630

Table 2. Effect of heavy metals on plants in soil
(Inhibition of the growth of shoots of Agrostis stolonifera plants, no more than 25 - 30 %)

heavy metal	concentration, (mg/kg)	tentative permissible concentrations (pH KCl >5,5) (mg/kg)	maximum permissible concentration, (mg/kg)
Cu	30	132	55
Zn	80	220	100
Cd	15 -20	2	-
Pb	650	130	30

Therefore, the tentative permissible concentration and the maximum permissible concentration do not fully reflect the real phytotoxicity of copper.

Plants of *Agrostis stolonifera* demonstrated a relatively high sensitivity to zinc in comparison with the maximum permissible concentration and the tentative permissible concentration.

DISCUSSION

Thus, the tentative permissible concentrations and the maximum permissible concentration of the studied heavy metals does not always give a complete adequate assessment of the effect on plants. Zinc and especially copper have a significant inhibitory effect at concentrations well below the tentative permissible concentrations.

The content of cadmium and lead, corresponding to the tentative permissible concentrations, did not have a significant effect on plants. The development of tentative permissible concentrations of copper and zinc for plants is advisable.

Given the high level of copper phytotoxicity, it is necessary to obtain plants resistant to this metal and use technologies that reduce the level of soil pollution [15-16]. The use of urban biotechnology methods can increase the resistance of plants to environmental factors [15-18].

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