Possibilities of saline soil use for the development of Ural and Siberia environment

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Possibilities of saline soil use for the development of Ural and Siberia environment

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Abstract. The problem of rational use of saline soils, as applied to the specific region, becomes one of the most important in Russia as well as abroad. The article reflects potential possibility to include these soils in the development of urban environment. This will allow us to extend the degree of use of the demographic capacity, as applied to the Siberian and Ural cities. The areas of these lands in respect to this territory makes up more than 10 mln ha.

To include these soils in the development of the urban environment of small and large cities on the level of zonal soils, it’s required necessary chemical melioration.

1. Introduction

Its carrying out with the use of gypsum, phosphogypsum and other meliorants-coagulants allows fundamental increasing of solonetzes fertility with their following involvement in the gardeners' non-commercial partnerships, individual construction and as agricultural fields for the suburban base. This will allow reduction of plough lands involvement in the urban environment. It’s important to note that the action of meliorants-coagulants lasts more than 40–50 years and their dosage is up to 20 tons per ha. The indicated regions possess mineral, production and scientific resources for the solution of such important problem in conditions of Siberia and Ural.

The problem of saline soils use is now one of the main problems in the land-use system. Saline soils include such soils which contain highly soluble salts in their content in volumes that are toxic for the plants. The source of salts for these soils is rock, volcanic eruption product, eolian transfer of salts, atmosphere precipitations, ground waters, irrigative ground-waters, vegetation (saltwort). The most widespread among the saline soils are solonetzes containing the increased amount exchangeable sodium in the illuvial horizon (more than 15 % of thecation exchange capacity) [1].

It's important to note that such soils can adjoin with their large missivesto the towns of Siberia and Ural and other regions or be inside them. Their biological productivity is very low 3–5 cwt/ha of dry mass while it’s multiple times higher on the zonal soils. Such phenomenon decreases biogenic circulation of the substances in the vicinity as well asinside the urban environment. At the same time presence of such soils almost excludes their use for gardeners' non-commercial partnerships, individual construction, recreational zones and for other purposes [2].

Nowadays the solonetz soils can serve as an important reserve for the creation of demographic capacity of small as well as big cities by the availability of territory for the individual construction, satisfaction of citizens' needs on gardening plots and possibility of their use as agricultural fields for suburban base. The approximate index of the need of one thousand citizens on gardening plots is from 500 to 2000 ha [3].
Solonetz soils have a series of negative hydro physical and chemical properties: high dispersion, swelling ability, weak water permeability, lack of structure, slow physical ripening of the soil, adhesiveness under humidification, low water mobility, decreased air exchange, strong compression of soil material in case of drying, solidity and larger resistance, alkaline reaction of the environment, toxicity of the salts, calcium deficit and sodium excess [1].

It suffices here to remark that the area of indicated soils in complex with zonal soils in Ural and Western Siberia is more than 10 mln ha (table 1) [4, 5].

Table 1. Structure of solonetz complexes in Ural and Western Siberia, thousands of ha

| Region         | Total | 10–30 | 30–50 | >50  |
|---------------|-------|-------|-------|------|
| Orenburg      | 1431  | 720   | 99    | 606  |
| Chelyabinsk   | 1365  | 721   | 92    | 551  |
| Kurgan        | 2203  | 636   | 190   | 1377 |
| Sverdlovsk    | 631   | 225   | 50    | 302  |
| Tyumen        | 389   | 176   | 30    | 182  |
| Omsk          | 3364  | 485   | 678   | 1812 |
| Novosibirsk   | 4317  | 2311  | 233   | 2258 |
| Kemerovo      | 146   | 1826  | 44    | 21   |
| Altai Territory| 1798  | 1183  | 143   | 472  |
|               | 15254 | 6108  | 1562  | 7581 |

The territory including Orenburg, Chelyabinsk, Kurgansk, Tyumen, Omsk, Novosibirsk regions and Altai territory are characterized by large heterogeneity of natural conditions. There are landscapes of the dry steppe with south and ordinary chernozems (Omsk, Chelyabinsk, Orenburg, Novosibirsk regions and Altai territory), landscapes of forest-steppe with kolkis with ordinary solonetz-like chernozems (Chelyabinsk, Kurgansk, Omsk region) and landscapes of Northern forest-steppe with meadow-chernozem soils, lixiviated and gray forest soils (Tuymen, Kurgansk, Chelyabinsk, Omsk, Novosibirsk regions and Altai territory) [6].

With the ameliorative diagnostics of solonetz soils, a number of important characteristics are taken into account, in particular, soil complexes where among zonalones, the solonetzes occupy 10–30 %, 30–50 and more than 50 %. Fertile lands with less than 10 % of solonetzes are not included in the land reclamation fund. On complex soils with the availability of 10 to 30 to 50 % of solonetz, selective chemical melioration (if solonetzes are located in the shallow spots) is expedient, and over 50 % is continuous. Hydrodynamic regime determines the numerous ameliorative properties of the solonetzes. The type of this mode is established by the level of ground water occurrence, taking into account the content of soil-forming and basement rocks.

The expediency of melioration depends on the type of hydrological regime. The character of solonetz use is determined according to the regime. Meadow solonetzes can be developed only when the mineralization of groundwater doesn't exceed the critical values. Melioration of meadow-steppe and steppe solonetzes doesn't depend on the state of ground waters (table 2) [5].

Table 2. Critical mineralization of ground waters depending on the depth of their occurrence and the rock composition

| Depth of the groundwater occurrence, m | Heavy clays, light loams | Medium clay, heavy loam | Medium clay | Mineralization, g/l |
|---------------------------------------|--------------------------|-------------------------|-------------|---------------------|
| <1.0                                  | <1.2                     | <1.5                    | <1.5        |                     |
| 1.0–1.2                               | 1.2–1.5                  | 1.5–2.0                 | 1.5–3.0     |                     |
| 1.2–1.5                               | 1.5–2.0                  | 2.0–2.5                 | 3.0–5.0     |                     |
| 1.5–2.0                               | 2.0–2.5                  | 2.5–3.0                 | 5.0–10.0    |                     |
| 2.0–2.5                               | 2.5–3.0                  | 3.0–3.5                 | >10.0       |                     |
| >2.5                                  | >3.0                     | >3.5                    | -           |                     |
The character of the solonetzes salinization determines the features of their utilization methods. The most important salinity indicators are the depth of the salt horizon, the chemistry and the degree of salinity. The most laborious in the ameliorative plan is the development of solonetzes with a high level of location of the maximum salts and with a high content of soda.

The degree of solonetzzicity of soils depends on the exchangeable sodium and plays a decisive role in the calculation of the dose of chemical ameliorant. According to the content of exchangeable sodium, solonetzes are divided into residual (less than 10% of the capacity of absorption), low-sodium (10–20%), medium sodium (20–40%) and high sodium (more than 40%). Methods of melioration of solonetzes must be strictly differentiated in connection with their qualitative and quantitative diversity [4].

With the melioration of solonetz soils (improvement if physical properties, creation of powerfertile soil level, replacement of sodium with calcium, removal of water soluble salts from the root habitable layer) to increase the efficiency of grown cultures it’s recommended to apply two main methods: chemical and self-melioration. Chemical method of solonet amelioration provides for the introduction of chemical ameliorants from the outside. This method is the only mean to increase the solonetz fertility with deep occurrence of carbons and gypsum (deeper than 40–50 cm). On the steppe solonetzes, the gypsuming is reasonable to combine with the watering. Under the high occurrence of carbons and gypsum it’s used the method of self-amelioration at the expense of use of deep trench and step tillages [5].

2. Materials and Methods
The experiments carried out in Western Siberia and Ural showed high efficiency of chemical amelioration. The term of consequences lasts more than 40–50 years [1–3, 6–11].

Local deposits of gypsum are in the Altai Territory where there were revealed about 20 deposits. The most promising for use is the Jirin deposit (Lake Jira, Kuluddinsky district), the reserves of which are sufficient for complete reclamation of all solonetzes of the Altai Territory and neighboring regions of other regions. Its effectiveness has been tested and proven in the West Siberian region of Ural and the Republic of Kazakhstan [4].

Large reserves of natural gypsum are located in the Perm Krai (Kungur), near the city of Salikamsk there is a carnallite deposit, which has proven itself as a good coagulant.

However, it should be noted that the waste product of chemical industry – phosphogypsum, is very promising as the ameliorant. Besides gypsum, it contains 0.5–1.5% of labile phosphorus (P_2O_5). Its huge reserves are in Sverdlovsk region of the town Revda.

A similar effect on the soil is provided by green vitriol – a waste of paint and varnish industry. It is used in the Chelyabinsk region and is a fine-grained powder, which has good flowability and weak caking ability, its dose compared with gypsum should be increased by 1.6 times.

It is important to note that theoretical and practical issues related to the development of solonetzes have been substantiated in the works of scientists in Siberia and other regions. However, taking into account the genetic characteristics of solonetzes in different zones and even within a certain region, it is necessary to continuously improve the applied methods of chemical and agrobiological melioration, as well as their integrated use in relation to specific agro-ameliorative conditions.

The goal of the studies is to reveal long-term influence of ameliorants containing the calcium on the water-physical and physically-chemical properties of solonetzes and their efficiency as applied to Western- Seberian region.

Study objectives: to provide theoretical and practical reasoning of the dose of introduced ameliorant taking into account the outflow intensity of exchange reactions products; to follow the change of quantitative and qualitative composition of the salts in the soil under the influence of different dose gypsuming, to find the possibilities of displacement of exchangeable sodium from the soil adsorption complex during the long ameliorative period, to determine the response of cultures-phytoameliorants to the long-term consequence of chemical melioration. To determine the possibility
of gypsum solonetz using for the extension of demographic capacity of small and large town of Ural and Siberia.

Research methods: experiments were conducted on hydromorphic chernozem-meadow saline sulphate-sodic medium-saline deep-carbonate deep-gaseous cortical high-sodium columnar solonetzes in the Tyumen region. Experiments on chemical reclamation began in 1972, plots area 400 m², tier is 4-fold. Exchangeable sodium was determined by the method of Gedroits. The analysis of aqueous extract was carried out according to the following procedures: alkalinity from the soluble carbonates – potentiometrically, chloride ions – complexometric, potassium and sodium in difference.

The studies have shown that during the observation period the level of subsaline groundwater varied from 1.2 to 2.4 m, it was maximal after the total snow melting. Long fallow solonetz was used as control. Saline regime of the long fallow solonetz showed that the general content of salts in the meter-deep layer varied within the limits of 48–58 t/ha, their maximum amount took place in the dry years. Soda in amount of 28.2 t/ha prevailed in the composition of salts, chlorides made up to 7 t/ha and sulphates made up 5.3 t/ha. Predominance of soda in the solonetzes added them sulphate-sodium carbonate salinization that led to the strengthening of their alkalinity and toxicity. Introduction of phosphogypsum, in 1972 changed significantly the qualitative and quantitative content of water extract in the whole soil crossover (fig. 1).

![Figure 1](image)

**Figure 1.** After action of phosphogypsum doses on the leaching out of salts from the crusted solonetz during 34 years

So, the amount of salts in the meter-deep layer decreased in comparison with control variant by 15–20 t/ha. At the same time significant decrease was noted at the expense of soda content decrease. Its amount in this layer dropped by 3.6–5.4 times. With the full dose of phosphogypsum leaching of soda from the soil crossover took place more intensively. At the same time, content of exchange reactions products in a form of sulphates increased by 2 times. This phenomenon didn’t lead to the intensification of salt regime stress, since the toxicity of sulphates is few times lower than the soda toxicity.

The data in the figure 2 shows that the introduction of ameliorants in the full and half doses led to the significant weakening of solonetizcity. Thus, initially the content of exchangeable sodium in crusted solonetz (0–40 cm layer) was on the level from medium-sodium to the high-sodium (28.8–53.4 % of the exchange capacity), then after the gypsuming in the declared doses the level of solonetizcity decreased to the residual and low-sodium, 2.2–19 %, respectively. The thesis about the short duration or total absence of ameliorative process in conditions of close location of the groundwaters hasn't been confirmed. It's important to note that the phosphogypsum dose for 0–15 cm layer (21 t/ha) didn't yield to the complete predicted dose of the layer for 0–30 cm (43 t/ha).
The amount of exchangeable sodium maintained in 0–20 cm layer was on the same level as with half as well as full doses of ameliorant.

![Figure 2. After action of phosphogypsum doses (34 years) on the replacement of exchangeable sodium from SAC](image)

The productivity of the dry mass of the grass stand of perennial grasses over the years of research at half the dose was 21.2 c/ha, with the total dose being 24.7 c/ha. In the fallow area (control), it did not exceed 3.2 c/ha.

3. Conclusions
The use of phosphogypsum waste in the crusted solonetzes allows the production of perennial grasses for more than 30 years, with a significant improvement in the basic chemical properties of these soils. For the reclamation of ameliorated solonetzes, it is sufficient to apply a half dose of phosphogypsum for the 0–30 cm layer calculated according to Gedroits.

Increase of the fertility of solonetz soils up to the level of zonal soils will allow them to be used for the increasing of the demographic capacity of small and large cities in Ural and Siberia. It will also allow exclusion of the reduction of forests near the urban environment for construction and gardeners’ partnership. For the introduction of ameliorant and its embedding, special road service vehicles can be used. Projects for chemical reclamation are capable of forming regional centers of agrochemical service.

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