Chapter 6
The New Map of Soil Salinity and Regularities in Distribution of Salt-Affected Soils in Russia

Ye. I. Pankova, A.F. Novikova, and A. Kontoboytseva

Abstract Among the numerous adverse processes related to the soil and the environment is the soil salinization, which affects more extended areas posing a real global problem. This chapter presents a new soil salinity map, which was compiled with the aim of specifying the information on geographical distribution and peculiar features of soil salinization in the vast areas of the Russian Federation. The new map of soil salinity as well as the map of chemical composition in salinization at a scale of 1:2,500,000 allowed identifying the main regularities in geographical distribution and genesis of salt-affected soils in Russia. This information helps to give the comparative characteristics of soil salinization in different regions of the country.

Keywords Geographical distribution • New map • Regularities • Russia • Soil salinity

6.1 Introduction

Salt-affected soils and their mapping have acquired primary importance in soil research of Russia. The salt-affected soils of different genesis are widely distributed in the south of Russia within semidesert, dry steppe, steppe zones and in the forest-steppe zone to a lesser extent (Fig. 6.1). They occur also less frequent in northern coastal areas of the White Sea, Kara Sea, Laptev Sea, etc.

Y.I. Pankova (✉) • A.F. Novikova • A. Kontoboytseva
V.V. Dokuchaev Soil Science Institute, Russian Academy of Agricultural Sciences, Pyzhevskii 7, 109117 Moscow, Russia
e-mail: pankova@agro.geonet.ru; kontoboysteva@gmail.com

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Fig. 6.1 Schematic map of the distribution of salt-affected soils in Russia (1)

In 1946, the first schematic map has been published to show the current salt accumulation in the soils of Russia (Kovda 1946); the map of soda salinization appeared in 1963 (Kondorskaya 1965). The small-scale map (1:2,500,000) of soil salinity types at the territory of the former Soviet Union was published on Kovda's initiative within the framework of FAO/UNESCO project in 1976. This project was implemented under the guidance of Prof. Szabolcs as a chairman of International Subcommission on Soil Salinization of the International Society of Soil Science (ISSS) with the aim of compiling the maps of salt-affected soils in different regions of the world. The obtained results were published in a monograph (Szabolcs 1989) that provided information on the global distribution of salt-affected soils and peculiar features of soil salinity throughout the world.

The above map allowed studying the main regularities in the distribution of salt-affected soils in Russia. It was established that the soil salinization is often associated with the solonetz (sodicity) process. The vast areas of deeply (100–200 cm) saline soils were shown on this map for the first time, because this fact has not been taken into account in cadastre surveys. The regions were identified as dominated by a definite type of salt chemical composition; at the same time, it was shown that the soils of different salinization occur in the same region (Fig. 6.1).

However, this map demonstrated the chemical composition of soil salinization in a general way, thus reflecting peculiar features of salinization in the main soil types of different country's regions only on qualitative level. It was impossible to estimate the percentage of areas covered by salt-affected soils using this map. Some data were given in a very schematic form. For example, solonetz soils have not been differentiated according to their percentage in the soil cover; the soil salinization degree was not indicated.

Lately, new results have been obtained on salt-affected soils; new mapping materials and data of remote monitoring have made it imperative to compile a new map of salt-affected soils in Russia.

6.2 Materials and Methods

The creation of new soil salinity map was aimed to obtain more accurate data about geographical distribution and specific features of soil salinity not only in the total area of the country but also in all the natural zones and economic and administrative regions. This problem has received attention because the process of secondary salinization became accelerating due to human-induced soil degradation especially in southern arid regions of Russia. Moreover, this map can be considered as a set of soil-ecological maps, reflecting properties and processes that have restricted the soil productivity and fertility of croplands. In compiling the new map, various cartographic materials obtained in the 1980s–1990s, original and literature data were used. The soil map of the Russian Federation at a scale of 1:2,500,000 (1988) was applicable as a contour base for the map under consideration. Herewith, the contours of salt-affected soils were specified using the map of soil reclamation at a scale of 1:500,000 compiled in 1987. In some cases, the pattern configurations were changed and being added by new information on saline soils. In regions where the soils are not affected by salinization, the soil contours were partially generalized. Under use were also the soil, lithologic-geomorphological maps, the maps of soil geographical and natural regionalization, characterized the complex of natural conditions and factors responsible for the development of salt-affected soils.

To the salt-affected soils identified on the map, we relate all the soils of different genetic types, which contain the water-soluble salts in the amount exceeding the toxicity threshold for crops characterized by moderate salt tolerance at least in one horizon of 2-m-thick profile. According to analytical data about the soil/water extracts (1:5), this threshold is >0.3 meq/100 g soil for Cl^- ion, >1.7 meq/100 g soil for SO_4^{2-} ion (bonded to Na^+ and Mg^{2+}), and >1 meq/100 g soil for HCO_3^- ion (bonded to Na^+ and Mg^{2+}).

The salt-affected soils are grouped into proper saline and saline-solonetz ones. The salt-affected soils delineated on the map are distinguished according to (1) the depth of the upper boundary of the salt-bearing horizon, (2) the percentage of soils with salts in the upper 1-m layer in the soil contour, (3) the chemical composition of salts and the percentage of moderately and strongly saline soils in the soil cover, and (4) the percentage of solonetzes and solonetzic soils in the soil contour.

The above information cannot be shown clearly on a single map, so it was decided to compile a set of maps comprising (1) a map of saline, deeply saline, and potential saline soils indicating their percentage in the soil contour; (2) a map of the salt chemical composition taking into account the percentage of moderately and strongly saline soils in the soil cover structure; and (3) a map of solonetzes and solonetzic soils. The soil map was taken as a basis for all the maps of salt-affected soils. Every contour delineated on the map shows the soil cover structure represented by the percentage of different soils. The soil nomenclature is well agreed with classification and diagnostics of soils adopted in Russia in 1977 and shown in the soil map (1:2,500,000) of the Russian Federation (1988). In the final version of the map, the synonyms of soil names are given according to the new Classification of Russian Soils (2004).

The new map of soil salinization in Russia reflects the percentage of soils containing salts in the upper 1-m layer and the areas of deeply and potential saline soils. As a rule, the soil contours, containing saline soils, reveal their heterogeneity being composed of two or three different soils; their percentage in the area is shown by dots under the soil index: 3 dots indicate 50–25% of salt-affected soils, two dots for 25–10%, and one dot for 10–1%. When saline soils occupy very small areas, they are not included in the soil index being shown by the out-of-scale symbols.

The sandy-loamy and sandy soils as well as sands and stony soils are identified in the soil map; loamy and clay texture does not show on it. Soils of mountain areas are given by traditional diagonal hatching.

6.3 Results and Discussion

The main information presented in the soil salinity map is the percentage of soils affected by salt accumulation in the upper 1-m layer as well as the areas occupied by deeply and potential saline soils.

Depending on the depth of the upper boundary of the salt-bearing horizon, saline soils are divided into the following way: (1) saline soils containing the salts in the upper 1-m layer; (2) deeply saline soils, in which the upper boundary of salinization is within the 100–200-cm soil layer; and (3) potential saline soils (the upper boundary of salt-bearing horizon is in the 200- to 500-cm-deep layer). The latter may be not assigned to the group of saline soils properly at the moment due to their observation; however, the salt-bearing bedrocks serve as evidence of possible occurrence of the secondary salinization. Saline soils and namely those containing the salts in the upper 1-m layer are divided into solonchak (surface saline) and solonchak-like soils (saline in the middle of the soil profile). Saline soils may comprise more than 75, 75–50, 50–25, 25–10%, or less than 10% of the soil contour. Local occurrence of soil salinization is shown by conventional symbols. Deeply and potential saline soils are not specified with respect to their percentage in mapping areas.

This map reflects only the soils affected by salts within the upper 1-m layer, that is, solonchak and solonchak-like soils. The percentage of moderately and strongly saline soils in every soil contour is also given (more than 50, 50–25, 25–10, and <10%). The soil contours revealing no moderately and strongly saline soils are identified; the percentage of slightly saline soils (more than 10%) is given on the map.

The map provides the information on chemical composition of salts in soils. The soil salinization degree with respect to chemical composition of salts is estimated according to indices presented in Table 6.1.

The maps compiled in such a way allowed identifying regularities in distribution of the salt-affected soils within the natural zones of different regions in Russia.

6.3.1 Zonal Regularities in the Distribution of Salt-Affected Soils

In Russia, the salt-affected soils are widespread in the south of the European part of the country, in the Ural, in Western and Eastern Siberia. Every region is characterized

Table 6.1 Classification of soils according to the degree and type of salinization (in numerator, toxic salts[a] in denomerator); data in parentheses correspond to salinization degree in gypsum-bearing soils ($CaSO_4 2H_2O > 1\%$); water extract (1:5)

Soil salinization degree	Chemical composition of salts (ion ratios, meq/100 g soil)					
	Neutral salinization, pH < 8.5		Alkaline salinization, pH > 8.5		Bicarbonate-alkaline salinization	
	Chloride, sulfate-chloride	Chloride-sulfate	Sulfate	Soda and soda-chloride	Sulfate-soda and soda-sulfate	Sulfate-chloride-bicarbonate
	$Cl:SO_4 > 1$	$Cl:SO_4$ 1–0.2	$Cl:SO_4 < 0.2$	$Cl:SO_4 > 1$; $HCO_3 > Ca + Mg$; $HCO_3 > Cl$	$Cl:SO_4 < 1$; $HCO_3 > Ca + Mg$; $HCO_3 > Cl$	$HCO_3 > Cl$; $HCO_3 > SO_4$; $HCO_3 < Ca + Mg$
Toxicity threshold (non-saline soils)	$\frac{<0.1}{<0.05}$	$\frac{<0.2}{<0.1}$	$\frac{<0.3(1.0)}{<0.15}$	$\frac{<0.1}{<0.05}$	$\frac{<0.15}{<0.15}$	$\frac{<0.2}{<0.15}$
Slight	$\frac{<0.1-0.2}{0.05-0.12}$	$\frac{0.2-0.4(0.6)}{0.1-0.25}$	$\frac{0.3(1.0)-0.6(1.2)}{0.15-0.3}$	$\frac{0.1-0.2}{0.05-0.15}$	$\frac{0.15-0.25}{0.15-0.25}$	$\frac{0.2-0.4}{0.15-0.3}$
Moderate	$\frac{0.2-0.4}{0.12-0.35}$	$\frac{0.4(0.6)-0.6(0.9)}{0.25-0.5}$	$\frac{0.6(1.2)-0.8(1.5)}{0.3-0.6}$	$\frac{0.2-0.3}{0.15-0.3}$	$\frac{0.25-0.4}{0.25-0.4}$	$\frac{0.4-0.5}{0.3-0.5}$
Strong	$\frac{0.4-0.8}{0.35-0.7}$	$\frac{0.6(0.9)-1.0(1.4)}{0.5-1.0}$	$\frac{0.8(1.5)-1.5(2.0)}{0.6-1.5}$	$\frac{0.3-0.5}{0.3-0.5}$	$\frac{0.4-0.6}{0.4-0.6}$	Not found
Very strong	$\frac{>0.8}{>0.7}$	$\frac{>1.0(1.4)}{>1.0}$	$\frac{>1.5(2.0)}{>1.5}$	$\frac{>0.5}{>0.5}$	$\frac{>0.6}{>0.6}$	-``-

[a]Sum of toxic salts is equal to the sum of toxic ions given in percent: Σ tox. salts (%) = (Cl + Na + Mg + SO_4 tox + HCO_3 tox), %. Ions of Cl, Na, Mg are toxic; HCO_3 tox = HCO_3 total – Ca; SO_4 tox = SO_4 total – (Cl – HCO_3). Calculation of the sum of toxic ions is performed in mmol; data are transformed into percentage and summed up. In the map the soils are shown as affected predominantly by chloride and sulfate salts and soda. There is also a group of soils, containing chlorides and sulfates with soda. This group includes (1) soils with soda traces only in the solonetz horizon (according to data of water extract 1:5) and neutral salinization in the other parts of the soil profile and (2) soils with a small content of soda throughout the soil profile against the background of chloride and sulfate salinization

by different natural conditions providing a clear evidence of provincial features, which are rather peculiar for the development of salt-affected soils (Pankova et al. 2006).

In European Russia, the percentage of salt-affected soils is increasing south- and eastwards. Within the forest-steppe zone, the local salinization occurs predominantly under semi-hydromorphic and hydromorphic conditions, being caused by close depth of salt-bearing clays in flat areas and close level of slightly saline groundwaters under conditions of weakly expressed drainage. Sodium sulfates frequently with soda are dominant in the composition of water-soluble salts. The salt-affected and moderately saline soils are represented by meadow chernozems and solonetzes accounting for 1–10 to 25% in soil contours.

In the steppe zone of European Russia, the salinization is developed under automorphic conditions. The salt-affected soils are estimated as 1–25% and represented by solonetzic chernozems and meadow-chernozem moderately saline soils. Dominant is the sulfate type of salinization. The strongly saline soils are observed under hydromorphic conditions in the Kuban and Don deltas. The chemical composition of salinization varies from sulfate-chloride to chloride-sulfate. In the Don Valley, the salinization is sodium-sulfate and sulfate-sodium. The huge areas are occupied by deep and potential saline soils. The basic source of salinization is the close depth of saline parent materials or groundwaters. The human-induced factor is also responsible for soil salinization – the secondary hydromorphism and irrigation. In the Kuban delta, the hydromorphic salt-affected soils have been developed as resulted from periodical flooding by seawaters.

Widespread are such soils within the dry steppe and semidesert zones, where all the soils are practically affected by salinization at different depths. They are estimated as 25–75% in the soil contour being represented by soils of solonetz complexes. In these zones, soils are developed not only moderately saline but also surface saline containing the salts in the upper 0–30-cm layer. Peculiar features of natural conditions in these zones are the climate aridity and rather wide distribution of saline soil-forming rocks frequently covered by saline loess-like loams. The majority of soils are affected by salinization in the above zones, where the strongly saline soils are confined to Ergeni and Manych depressions and the Pre-Caspian lowland. Among the salt-affected soils, dominant are automorphic soils of chloride-sulfate and sulfate-chloride salinization often with soda in the middle part of the soil profile. The semi-hydromorphic and hydromorphic strongly saline soils are widely spread in Manych depression, at the territory of Tersko-Kumskaya lowland, in plains of Terek and Sulaka, Volga deltas, and in the coastal zone of the Caspian Sea.

In the Pre-Caspian lowland within the semidesert zone, the strongly saline soils with chloride chemical composition prevail; in Terek and Sulaka floodplains, the chemical composition of salinization varies from sodium to sulfate and chloride. The surface saline soils occupy about 50% of the total area in steppe and dry steppe zones and 70–90% in the Pre-Caspian lowland. Within the steppe zone in the south of European Russia, the deeply and potential saline soils are predominant.

Widespread are the salt-affected soils in the Trans-Ural region. They are also met in the Pre-Ural region, the latter being considered as a transitional zone between the Russian plain and the Ural Mountains. The soil cover pattern and peculiar distribution of salt-affected soils and their chemical composition are determined by geographical location and the development history of this territory. Like as in European part, the soil salinization is increasing here from the north to the south and eastwards.

In the steppe zone of the Pre-Ural region, the percentage of salt-affected soils and solonetzes makes up 1–10 and 10–25%, respectively, and only in the south within the dry steppe zone, they occupy over 75% of the total area being represented by automorphic and semi-hydromorphic solonetzes. The soil salinization is associated with distribution of saline neogenic-paleogenic clays and the salt redistribution at the soil surface under conditions of weakly expressed drainage.

In the steppe zone of ordinary and southern chernozems as well as in the zone of dry steppes represented by dark-chestnut and chestnut soils, the sulfate salinization is prevailing, and only in the south, it is by chloride type.

At the territory of the Trans-Ural region and West-Siberian lowland, the salt-affected soils are widely spread in the forest steppe and especially in steppe and dry steppe zones. The salinization is resulted from saline neogenic soil-forming rocks covered frequently by fluvial-alluvial deposits as well as from the close groundwater level in non-drained and slightly drained areas. Within the forest-steppe zone in flat almost non-drained interfluve areas, the hydromorphic and semi-hydromorphic saline soils are predominated and characterized by sodium together with soda and sulfate salinization. They occupy 1–10 and 10–25% of the total area, respectively.

The soil salinization is increasing in the steppe zone and especially in dry steppe zone occupying an insignificant part of the southwestern Trans-Ural region. In the steppe zone, the salt-affected soils are developed under hydromorphic and semi-hydromorphic conditions and estimated as 1–10 and 10–25% in the northern part to 50–70% in southern and eastern part of this region. The salinization is predominantly chloride and sulfate; in the eastern part of the Trans-Ural region, it is sodium with participation of soda. In the dry steppe zone of the extreme southwestern Trans-Ural region, the salt-affected soils occupy more than 75% of the total area. Their salinization is mainly sulfate.

Among the salt-affected soils in the Pre- and Trans-Ural regions, widespread are moderately saline soils; deeply and potential saline soils take place as well.

Western Siberia is a natural region characterized by manifestation of recent salt processes. The hydromorphic saline soils with sodium chemical composition occur. The soil salinization is frequently associated with the solonetz process and conditioned by salt accumulation for a long period of time in depressions. At present, the salt redistribution takes place in landscape. Under hydromorphic conditions, soda appears as a result of recent soil-forming processes – sulfate reduction. According to investigation data obtained in the latest years, the aeolian process is recognized as a main salt source in Western Siberia.

The salt-affected soils of Western Siberia are confined to insufficiently wet parts of the forest-steppe and steppe zones. They account for 50–75% of the total area being represented by hydromorphic moderately and surface saline soils in depressions. Under automorphic conditions, the salt-affected soils make up not more than 20%, and their salinization degree is significantly lower. Widespread are the potential saline soils represented by a great variety of chernozems. At the territory under moistened conditions – in the southern taiga zone, in Pre-Altai steppes, and in the piedmont area – the salt-affected soils occupy the river floodplains and closed territories accounting for 20% in soil contours.

Within the dry steppe zone of Western Siberia, the salt-affected soils are estimated as more than 75% being prevailed by surface and moderately saline soils. In elevated relief elements, dark-chestnut potential saline soils are concentrated. The degree, depth, and the chemical composition of soil salinization are determined both by recent geomorphological conditions and the history of the landscape development.

The salt-affected soils in the southern taiga that has been considered as a slightly elevated area of salt accumulation in the past contain an insignificant amount of water-soluble salts in the topsoil now. Their salinization is hydrocarbonate-sodium. In depressions, the soils are developed as characterized by chloride and sulfate salinization frequently with soda.

In central forest-steppe and steppe zones of West-Siberian lowland, the salt accumulation is conditioned by peculiar features of relief and the moisture regime. Being in autonomous position, they are characterized by slightly sodium or sodium-sulfate chemical composition. The deeply saline soils are met in such landscapes. In trans-accumulative (gently sloping) landscapes, the relief is responsible for soil chemical composition. In upper parts of slopes, the salinization is sodium and sulfate-sodium, whereas in middle and lower parts, it varies from sodium to chloride. The salt-affected soils confined to depressions within accumulative landscapes in the southern part of the steppe zone are characterized by chloride and sulfate salinization. In the dry steppe zone, the soils have neutral salinization with soda; in rare cases, their salinization is chloride or sulfate.

At the current stage of the development taking place at the territory of Western Siberia, there is a tendency toward dissolution of automorphic and salinization of accumulative landscapes.

Special attention should be paid to the salt-affected soils of Eastern Siberia and the Far East (Pre-Baikal, Trans-Baikal regions, and Yakutia). These soils are developed in depressions of steppe and dry steppe landscapes under conditions of semi-arid and arid climate. Their distribution is limited being associated with hydromorphic and semi-hydromorphic conditions. Such soils occupied the zones of tectonic faults; groundwater outcrops are mainly represented by moderately saline soils of different genesis. Their area exceeds 75% of soil contours. The deeply and potential saline soils such as southern solonetzic chernozems and chestnut soils are widely spread especially in the southern part of this region. The sulfate salinization is dominant in the Pre-Baikal region. The soils with different chemical composition including sodium salinization are met at the territory of Trans-Baikal region. However, the soil salinization has been so far examined insufficiently in the given region.

The salt-affected soils of Yakutia attract special attention. This is the most northern region where the salt-affected soils found their distribution. Their genesis and geography are mainly associated with climatic, hydrogeological, and lithologic-geomorphological conditions as well as the permafrost and the impact rendered by southern seas on coastal areas. The salt-affected soils are predominantly concentrated within Central-Yakutia plain and confined to closed depressions on the Lena river terraces and its tributaries. They are represented by frost solonchaks, solonetzes, meadow-chernozem, meadow, and alluvial soils of chloride-sulfate and rare chloride-sodium and sodium-sulfate salinization.

The marsh soils of Northern Yakutia are observed in coastal areas of the Arctic Ocean and characterized by chloride salinization.

There exists a local distribution of salt-affected soils in the Far East. They are predominantly developed in the southern part of this region (in Pre-Khanka lowland, in river valleys and lake terraces, in coastal areas and terraces of the Japan and Okhotsk Seas). The genesis of soil salinization is quite different there. The continental soils have the hydrocarbonate-sodium salinization due to outcrops of salt-bearing rocks. The salinization of coastal marsh soils is chloride being affected by seawaters and salt impulverization.

Apart from Yakutia, the salt-affected soils are also developed in the coastal zone of Northern Seas particularly on seashores of the White and Karsk Seas within the Northern Dvina delta. They are rarely met in coastal plains of the Barents, Chukotsk, and Laptev Seas.

Thus, the coastal plain zones of Northern Seas reveal the presence of salt-affected soils; however, like the soils of the Far East, they have been so far studied insufficiently.

The genesis and chemical composition of soil salinization (chloride) in coastal plains are determined by shore relief, composition of seawaters, and climatic parameters of the given territory. Not only marsh soils but also the soils of coastal meadows and terraces are affected by salinization resulting from groundwaters and salt impoverization.

The maps under discussion are exemplified by fragments for Kalmyk Republic and Astrakhan region, situated in the southeast of European Russia (Figs. 6.2 and 6.3).

As is evident from Fig. 6.2, the major part of the area suffers from salinization. The salt-affected soils in the north of Pre-Caspian lowland are referred to a group of solonchak soils; huge areas of Ergeni upland are occupied by solonchak-like soils; in the south (Chernosemelskaya and Astrakhan plains), the sands with traces of salt-affected soils are observed. The legend used in Fig. 6.2 is described as saline soils (the upper boundary of salt-bearing horizon is in the 0–1-m-deep layer): (1) The share of saline soils is >75%; the upper boundary of salt-bearing horizon is at a depth of less than 30 cm. (2) The share of saline soils is >75%; the upper boundary of salt-bearing horizon is in the 30–100-cm-deep layer. (3) The share of saline soils is 75–50%; the upper boundary of the salt-bearing horizon is at a depth of less than 30 cm. (4) The share of saline soils is 50–25%; the upper boundary of salt-bearing horizon is at a depth of less than 30 cm. (5) The share of saline soils is 50–25%; the upper boundary of the salt-bearing horizon is in the 30- to 100-cm-deep layer. (6) The share of saline soils is 25–10%; the upper boundary of the salt-bearing horizon is at a depth of less than 30 cm. (7) The share of saline soils is 25–10%; the upper

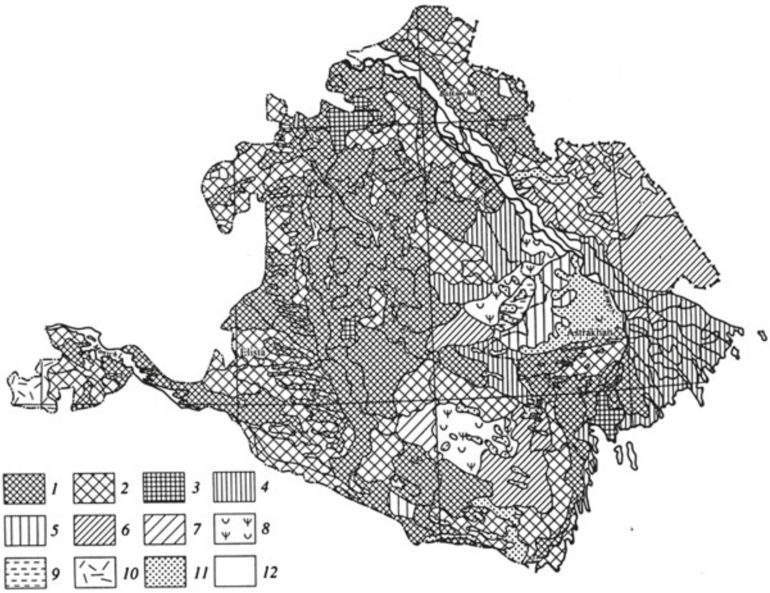

Fig. 6.2 Map of deep and potentially saline soils in the Kalmyk Republic and Astrakhan oblast

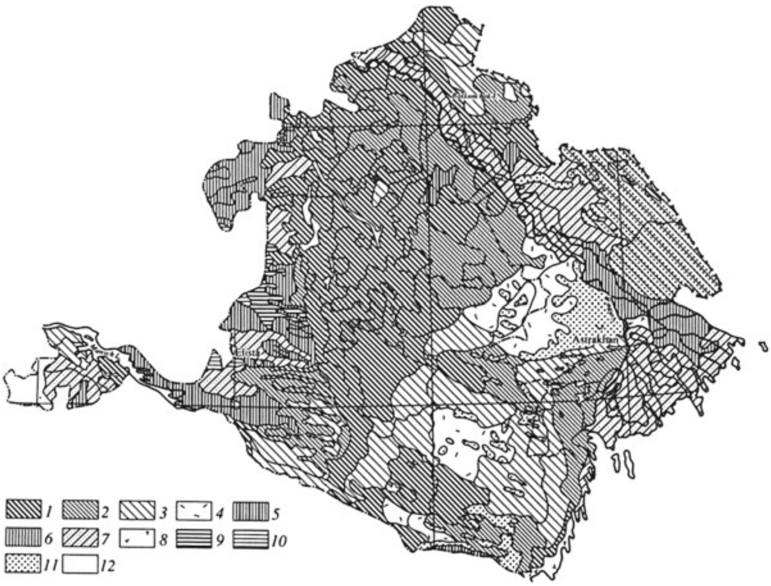

Fig. 6.3 Map of salt composition and the ratio of moderately and strongly saline soils in the soil cover of the Kalmyk Republic and Astrakhan oblast

boundary of salt-bearing horizon is in the 30- to 100-cm-deep layer. (8) The share of saline soils is <10%; the upper boundary of salt-bearing horizon is in the 0–30- or 30–100-cm-deep layer. (9) In deeply saline soils, the upper boundary of the salt-bearing horizon is in the 100–200-cm-deep layer without taking into consideration their percentage in the area. (10) In potentially saline soils, the upper boundary of the salt-bearing horizon is in the 200–500-cm-deep layer without taking into consideration their percentage in the area; Mainly non-saline soils: (11) sands and (12) non-saline soils of various textures.

In Fig. 6.3, the soil grouping is given according to chemical composition of salts and percentage of moderately and strongly saline soils at the territory of Kalmykia and Astrakhan region. The soils are highly affected by chloride salinization. In Ergeni upland, the sulfate saline soils sometimes with soda are dominant.

The legend used in Fig. 6.3 is described as: Soils of predominating chloride salinization ($Cl > SO_4$; $HCO_3 < Ca + Mg$); shares of moderately and strongly saline soils, (1) >50, (2) 25–50, (3) 25–10, (4) <10% (or slightly saline soils >10%). Soils of predominating chloride-sulfate and sulfate salinization ($SO_4 < Cl$; $HCO_3 < Ca + Mg$); shares of moderately and strongly saline soils, (5) >50, (6) 50–25, (7) 25–10, (8) <10% (or slightly saline soils > 10%). Soils with predomination of chlorides or sulfates but with soda ($HCO_3 > Ca + Mg$; $Cl > HCO_3$ or $SO_4 > HCO_3$); shares of moderately and strongly saline soils, (9) >50, (10) 50–25%. Mainly non-saline soils: (11) sands and (12) non-saline soils of various textures.

Figure 6.4 illustrates the distribution of solonetz and solonetzic soils. The solonetz soils are not divided according to zonal features in soil classification and diagnostics adopted in Russia; however, they occur in composition of zonal soils being regarded as chernozem solonetzes in the steppe zone, chestnut solonetzes in the dry steppe zone, and brown desert-steppe solonetzes in the semidesert zone. Moreover, in the map, the solonetz soils are divided according to the hydromorphism degree including automorphic, semi-hydromorphic, and hydromorphic ones. But the map provides the main information – the percentage of solonetz soils: >50, 50–25, 25–10%, and less than 10%. Thus, solonetz soils are widely spread at the territory under consideration, and their percentage varies from more than 50% to less than 10% being automorphic and semi-hydromorphic by nature. It is interesting to stress that these soils display peculiar salinization. They are different according to the depth of salinization and the salt composition. Among them are met the chloride or sulfate saline soils; frequently, the solonetz and subsolonetz horizons reveal the presence of soda.

The legend used in Fig. 6.4 is described as: Chernozemic zone: (1) chernozems with participation of meadow-chernozemic solonetzic soils (<10%). Zone of chestnut soils: (2) automorphic solonetzes (>50%), (3) automorphic solonetzes (50–25%), (4) automorphic solonetzes (25–10%), (5) automorphic solonetzes (<10%), (6) semi-hydromorphic solonetzes (>50%), (7) semi-hydromorphic solonetzes (50–25%), (8) semi-hydromorphic solonetzes (25–10%), and (9) hydromorphic solonetzes (meadow solonetzes) (>50%). Zone of brown desert-steppe soils: (10) automorphic solonetzes (>50%), (11) automorphic solonetzes (50–25%), (12) automorphic solonetzes (25–10%), (13) automorphic solonetzes (<10%),

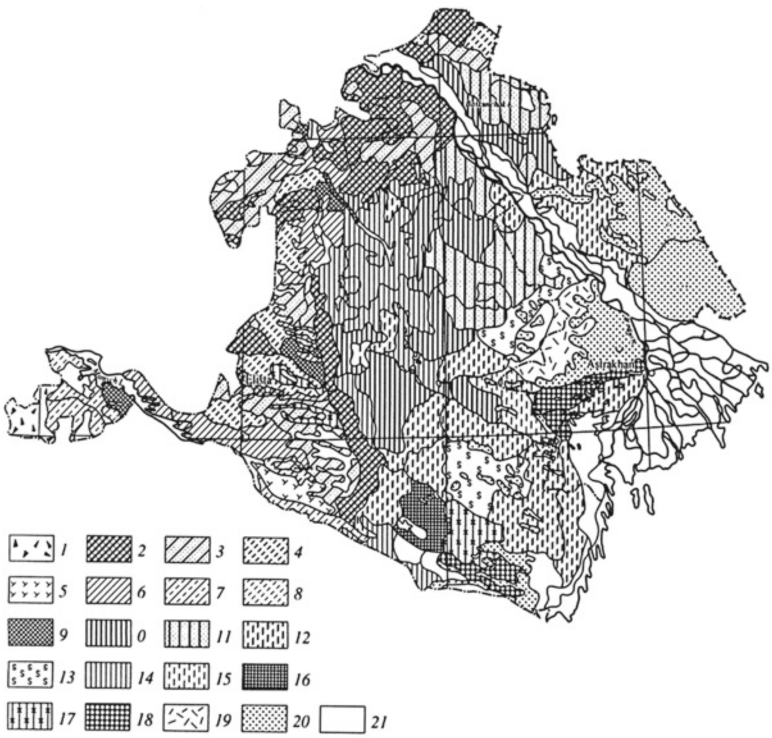

Fig. 6.4 Map of solonetzes and solonetzic soils in the soil cover of the Kalmyk Republic and Astrakhan oblast

(14) semi-hydromorphic solonetzes (>50%), (15) semi-hydromorphic solonetzes (50–25%), (16) hydromorphic solonetzes (>50%), (17) hydromorphic solonetzes (25–10%), and (18) hydromorphic solonetzes (<10%). Non-solonetzic and slightly solonetzic soils with local solonetzes: (19) slightly solonetzic and non-solonetzic soils with local solonetzes, (20) sands, and (21) areas without solonetzes and solonetzic soils.

6.4 Conclusion

The new soil salinity map as well as the map of chemical composition in salinization at a scale of 1:2,500,000 allowed identifying the main regularities in geographical distribution and genesis of salt-affected soils in Russia.

The electronic version of the map for the entire territory of European Russia made it possible to estimate the areas covered by salt-affected soils including those occupied by solonetzes (chernozem, chestnut, semidesert, automorphic, semi-hydromorphic, and hydromorphic ones) and solonetzic soils of different genesis. The saline soils as affected by salts within the upper 1-m layer are estimated as 23.3×10^6 ha in European Russia. This information helps to give the comparative characteristics of soil salinization in different regions of the country. It may be very useful for typification of lands affected by salinization, for monitoring of salt-affected soils with the aim at specifying genetic problems and those related to soil improvement, prediction, and prevention of soil salinization.

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