ECOLOGY

UDC 504.062(477.75)

ECOLOGICAL PROBLEMS OF LANDSCAPES IN NEARBY SIVASH REGION

Fyodor Fyodorovich Adamen[1], Yury Plugatar[2], Alyona Fyodorovna Stashkina[1]

Department RAS in cooperation with scientific organizations of the Crimean federal district
295000, RF, Republic of the Crimea, the city of Simferopol, 5, Oktyabrskaya str.
vitainviva@ukr.net

Nikita Botanical Gardens – National Scientific Centre, the city of Yalta
298648, Republic of the Crimea, Yalta, urban vil.Nikita
plugatar@ukr.net

Introduction

Basic of stable and efficient agricultural production is rational soil and water use having constant control of evolutional environmental changes.

Control of soil fertility dynamics is necessary to accomplish guided not only by culture productivity but dynamics of humus concentration and soil saline regime. Therefore principal task with further positive effect on soil fertility is science-based reclamation work, keeping and storage of organic substances what is caused by culture introduction into agrocenosis that contributes to soil fertility. These requirements are satisfied due to plant root systems what has been so far impossible to replace by other measurements.

Salinization and desalinization prevention of grounds with higher standing mineralized waters remains extremely urgent problem especially these soils and ground water contain natural storage of readily soluble salts, that due to ground water rising could be a source of their deposit in root layer. The problem becomes more complicated as different regions of melioration have differences at climatic conditions, soil cover, hydrological conditions and vegetation.

Besides soil fertility reduction as a result of resaliniation, increasing the alkalinity, sodium formation, alkalinization are hard-reversible phenomena, demand huge expenses and applying the chemical irrigation as well.

That`s why strict control after qualitative and quantitative composition of getting out and keeping in soil salts and nutrients, reliable methods of their prognostication based on analysis of peculiarities of engineering irrigation systems and total diversity of natural conditions where irrigation occurs.

Near-by Sivash region is the most subjected to anthropogenic load area within Republic of the Crimea.

Reduced complex alkaline steppe or actually near-by Sivash region takes a beginning off-shore Sivash and Karkinitsky bay and runs out on the territory with points 30-40 m above the sea level. On the area of this soil and climatic zone there are farms of Krasnoperekopsky (besides its southern part), near-by Sivash part of Dzhankoisky, Nizhnegorsky, Sovetsky and Kirovsky regions.

Transition of low alkaline steppe into high steppe is gradual and almost un-noticeable. Soil cover of this zone is presented by dark-chestnut poorly- and medium alkaline soils. In the lower relief there are meadow and chestnut soils. Type of salinization is chloride-sulfate and sulfate-sodium. Soils of this zone are characterized by high level of water permeability and water-retaining capacity. In 1 meter layer they are able to deposit 324-365 mm of

moisture, though about half of this deposit is unavailable for plants. Dark-chestnut poorly alkaline soils possess the most favorable agrophysical properties [3].

Relief of a low complex alkaline steppe was more plain and even, than high area, in places gullies with steep waved slopes here and there can be found. Waved nature is grounded by system of ancient nowadays matted wide but not deep gullies, their slopes gradually transform into watersheds. River valleys (river Salgir, Bulganak, Indol and etc.) are not so marked on relief map, near-by the river mouth they form floodplain terraces. Coast line is a complicated combination of many bays, regularly flooded, previously mouth parts of peninsular gullies, deeply jutted out into Sivash, and alluvial islands and spits. Surface of the plain is slightly inclined to north and north-east. On the background of a common even macrorelief, in the low steppe a microrelief is quite well-marked, especially in the coastal zone.

Hydrographic system in Steppe Crimea is presented by a few of small rivers with graded plains, that getting full of current water in spring and dry up in summer. The most major by length is the Salgir river and river-gully Chatyrlyk vanishing nowadays. In western near-by Sivash region there is a large group of saline lakes (Staroye, Krasnoye, Aigulskoye and etc.), lengthened along the meridional direction and isolated from the sea. Lakes have abrupt banks from 3 to 10 m. Lake depth ranges during a year from 0,2 till 0,5 m. Salt replenishment happens due to surface flow and underground waters, that have outlets all over the whole lakes square within coastal cliffs [2].

In Steppe Crimea underground waters are united into one water-bearing horizon that increases its level as far as close to Sivash, everywhere spread, generally inclined from south to north and north-east. At the joint with coastal zone of near-by Sivash region there is back up of underground waters by Sivash water, where there level rises reaching 1,5-0,5 m deep near Sivash and Karkinitsky bay coasts, - occurrence of neutral hydro-isohypse not far from the coast is a certain proof (table 1).

Table 1

Balance of underground waters on different elements of relief (Krasnoperekopsky region RC)

Datum	Average depth of underground waters	Balance elements m^3/day.		±
		inflow	outflow	
More than 7 m	1,50	0,0089	0,0148	-0,0059
4,3	1,20	0,0148	0,0151	-0,0003
2,3	1,0	0,00013	0	+0,00013

The main points of underground water flow rate are evaporation, human use and partly – outflow. Water regime of near-by Sivash region is closely connected with a number of environmental parameters that can intensify or reduce its rate. These factors are atmospheric precipitation, irrigation, underground water, river waters, canals filtering; they replenish moisture reserve in soil. Its consumption is accounted for other factors: evaporation, transpiration, underground outflow, drainage. The problem is complicated by considerable differences in relief, soil cover, hydrologic conditions, vegetation within different irrigation regions

As far as underground waters reach ground surface level of their mineralization increases from 3-5 g/l till 20-60 g/l or more. At the same time chloride concentration of underground waters goes up.

As a result of natural rising of underground waters level the importance of ground flow in soil formation is various. Within territory with high hypsographical levels (high steppe, raised areas of a low steppe), where underground waters are deposited deeper than 10 m from ground surface, they are not so considerable in process of soil formation, but they

transfer salts, leached out of soil and rocks, and get away from that region to Sivash coast. Therefore underground waters contribute to salts outflow from uplands soils favoring their desalinization. And vice versa in places with low hypsographical level, where underground waters possess high concentration of mineral substances and reach the ground surface, they cause soil salinization. [1] As far as underground waters get critical level (critical depth of deposit 0,5-1,5m) it makes possible to use them intensively for evaporation and transpiration. As soon as water balance gets point when water consumption is more than income (precipitation, irrigation water and underground inflow), the process of resalinization begins. Water regime of soils is closely connected with a number of environmental parameters, capable to intensify or reduce its fluctuations. They are natural climatic conditions.

Climate of lower complex alkaline steppe is extremely dry. Hydrothermal coefficient, rate of precipitation to evaporation, is 0,47-0,50. Average temperature of the coldest month January is 2,20° below zero, frost -19-21°C are registered in 50% of winters, absolute minimum 29-31°C below zero is possible in 5% of winter periods. Depth of frost penetration gets 30-70 sm. Cold season (period with daily average air temperature below zero) lasts 75-80 days. Vegetative thaws ("winter windows") occur in 15-20% of winter periods. Annual temperature sum above +10°C makes 3360°C.

Autumn frosts happen in the third decade of April. Free frost period includes 186 days. Annual average temperature is about + temperature 10°C. The warmest month is July (annual average temperature +23). In some years day temperature gets +40-42°C.

Annual precipitation sum in western zone makes 340, in eastern – 445mm. During period with air temperature above +10°C (time of intensive crop vegetation) it falls 195 and 205mm. June is a month with maximum amount of precipitation – 45mm, in March this number gets minimum point – 22mm.

Continentality and aridity of climate in this region gain strength due to wind regime. Dry winds of north-east direction - 47% and wet winds of west direction – 39% prevail in this zone. Winds with velocity of 15m/sec occur often here, what dry soil extremely. In summer there are 13-17 days with hot dry winds. Drought frequency in western part of the zone is 50-60%, in eastern – 40-50%. During vegetative period water balance with area of dry steppes is negative. In July-August deficit gets the highest point.

Soil and climatic conditions of Lower complex alkaline steppe are considered rather severe. The principal reason of ecological problems is climatic and anthropogenic impact on environment by the way of geological space alienation, changing the properties of geological environment, changing the surface shape and drastic changing the hydrodynamical and hydrogeochemical situation caused by water cut by North Crimean canal.

Among soil forming rocks of near-by Sivash region yellow-red loess-like loam soils and light clays prevail. Distinctive feature of loess-like loams is their porosity (40-45%), comparatively small weight – 1,2-1,45 sm^2, occurance of carbonates (10-22% CaCO – salinity). Granulometric composition of forests is variable. In near-by Sivash region light clayey, silty-pulverescent variations that contain 60-70% of clay fractions, that`s why soils of this region are subjected to wind erosion, cracking, silting. Discharges of chemical plants, located in the region, increase concentration of heavy metals and polluting substances in the upper soil layer. Process of soil fertility loss is worsened by anthropogenic impact. The first anthropogenic load on landscapes of near-by Sivash region occurred in period of construction and exploitation start of North Crimean canal accompanied by system of water intake and drainage in 70-90s last century, the second one happened in 2014 when Ukraine cut water supply by canal.

Area of North Crimean irrigation system of the near-by Sivash region is located on Pliocene terrace, irrigation and underground waters of its north part deposit rather close to ground surface, what is favored by general drainlessness of the area. Besides active practice

of paddy sowing caused underflooding and raising the water level in the Sivash lake. Horizontal drainage constructed on a big area improves reclamative situation, but irrigation and underground waters deposit here quite close about 3-5 m deep. Before irrigation system was set up underground waters in the Crimean near-by Sivash region were saline by neutral salts, sodium wasn`t fixed. As far as irrigation process develops sodium occurred in irrigation and underground waters, though it wasn`t found out everywhere, but sporadically. Therefore conclusion comes to mind: though sodium in irrigation and underground waters didn`t occur within every irrigated area, but sporadically, in general it`s typical for the whole Black sea coast, what wasn`t registered before irrigation system started up. That`s why based on study processes going on in soils of Ingulets irrigation system after irrigation had stopped on some crop rotations and within Spanish areas requiring irrigation, especially on Castillo plateau, in Andalucía and Aragón, where saline ground is developed as well as mineralized underground waters in range, a supposition takes place that in soils of near-by Sivash region process of sodium occurrence in underground waters, transfer into soils and their resalinization are quite possible.

It`s necessary to determine correlation between dynamics of salts and moisture as salt migration and accumulations mainly occur in aquatic environment therefore if not to consider characteristics of this environment regime it`s impossible to explain process of salt accumulation and work out measurements to prevent it. In soils of near-by Sivash region circulation of soil solutions in the main part of soil profile doesn`t stop in winter. There is a frequent change of soil frost penetration and defrosting, falling precipitation in winter-spring period (about 150-160 mm) are absorbed by soil and moisten it till 100 sm deep or more what rises underground waters level.

According to our observations maximum rising of underground waters level happens in spring time. As far as air temperature goes up intensity of evaporation from the soil surface increases. Evaporation process depends upon temperature and humidity of air and soil, wind strength, vegetation density, area relief, degree of soil structural properties and level of underground waters deposit.

Therefore moistening is principally seasonal process. In autumn-winter-spring time landscapes are subjected to washing out that is salts gravitational transfer. In spring-summer period having active evaporation process rising capillary currents of moisture and salt accumulation in the upper profile layer prevail.

Within landscapes with close surface underground water deposit evaporation value gets critical parameters in late spring and early summer, what increases salt concentration in soil strata. When North Crimean canal functioned, poorly mineralized waters on irrigated areas reduced salt concentration in soil under washing out regime. But now for lack of irrigation in this region productive desalinization of soils isn`t possible due to summer precipitations only. As the aqueous and salt balances present difference between total income and consumption of water and salts, equal to variations of their deposits within a certain soil difference during particular period of time it can be expected that annual concentration of salts in the upper horizon of soil will increase and soon resalinization will make impossible to cultivate majority of field crops in this soils.

North Crimean canal stretches along the whole near-by Sivash region, along its border on hypsometrical points of 30-40 m above the sea level with the total length on this territory about 300 km.

Such natural and practical organization predetermines way of certain processes, particularly development of regional current of filtering water loss from the main canal (up to 450 mil m^3 per year) that causes natural load (Sivash lake). Besides according to project irrigation water discharge into these receivings waters was provided (emergency discharge,

water discharges from puddlings and etc.) what was flagrant violation of nowadays ecological demands.

But along with shallow discharges there is regional underground flow, its velocity and consumption are determined by inclination and granulometric rock composition. particularly power of quaternary rocks makes 25-40 v, they are poorly pervious and saline (till 2% of salts). Than closer to Sivash than velocity of side stream becomes lower, while underground waters level goes up since 8-10 m till 0,5 m from the soil surface (flow rate is 0,1 l/sec/km^2).

At points 4-5 above the sea level velocity of side stream and rising flows becomes equal and water discharges into atmosphere. Allowing for mineralization of underground waters ranges from 7 to 21 g/l, irrigation extinction and disability of soil washing out regime will cause immediate salinization of arable layer if watering (approximate area is 108 thousand hectars) and as a result reduction of crop capacity in the near future (2-3 years). In 5-6 years this area will occupy 30-40 % as much [3].

Possibility for areas previously being irrigated to get saline is extremely urgent problem, especially these soils, grounds and underground waters contain natural deposit of freely soluble salts, which in case of underground waters level rising up could become a source of their accumulation in root-inhabited layer. Moreover decreasing of soil fertility caused by resalinization, alkalinity, sodium formation are hard reversible phenomena, demand a lot of time and funds and applying the chemical amelioration as well.

Based on methodic of V.A. Kovda (1954), that suggests to carry out assessment of seasonal salinization allowing for coefficient of salt seasonal accumulation, which presents correlation of autumn concentration to spring one. If this coefficient is "one", seasonal salinization doesn`t occur. In case it is more than "one" seasonal salinization takes place, but if it`s less than "one" we are talking about desalinization. Analyzing results of stationary observations for aqueous-salt regime in near-by Sivash region it`s possible to conclude that for 2014 this coefficient is more than "one" and seasonal salt accumulation was registerd. Unfortunately, in 2015 researchers of the Crimean agrotechological University, department of agriculture, didn`t have any admission to most stationary objects.

At the same time importance of these investigations is undoubted and carrying out of stationary researches needs to solve the following problems:

- to conduct qualitative and quantitative assessment of soil salt composition and point out borders of geographical distribution of possible resalinization;
- to find out character of soil aqueous-salt regimes, caused by irrigation extinction;
- based on direction of salinization processes to determine volume and measurements in chemical and agrotechnical soil melioration;
- to define drainage system efficiency, its impact on outflow of strongly mineralized underground waters.

CHARACTERISTICS OF SOIL ECOLOGICAL EVOLUTION IN CASE OF RICE CULTIVATION IN NEAR-BY SIVASH REGION

Rice irrigation systems with total area of 30 thousand hectares are located in the most unfavorable conditions at points of 12,0-1 m above the sea level and only about 10% are in high-water bed of the Salgir river with relatively free-salined soils.

As rice is cultivated by means of submersion, the field should be thoroughly flatted (±5 sm). While constructing the field was divided into maps, each map was divided by cross shafts into puddlings of 2,5 ha. According to hydrotechnical system, water supply is provided to puddlings and drainage system directs it from the field by canals. Majority of rice canals was built in earthen channel and just a few of them in concrete slabs or in trays. Drainage system is totally organized in earthen channel.

Through the whole area of irrigated rice systems the main soil top horizon was shifted, fertile soil layer is used for road construction as well, puddling, walls of canals. Therefore building of rice map-basins caused anthropogenic load and brought to the total vanishing of natural landscape characteristics.

Before paddy culture areas, allotted for rice growing, belonged to continental type of annual variation of precipitations with arid climate (humidity factor – 0,38-0,42), drought, hot-dry winds, duststorms and automorphic regime of soil formation. Along coasts of sea bays alone salted and extremely salted chloride-sodium underground waters were involved into process of soil formation, loess-like loams on the rest territory were waterless [4].

While rise irrigation systems were in use level of underground waters mineralization was decreasing. In early years of irrigation salt concentration rose in underground waters of meadow saline soils only, but there were no any changes in ground waters under the rest types of soils. It should be noted that in 2010 concentration of sodium cations increased in underground waters for all soil types, rate of underground water desalinization reduced as well. According to Titkov`s opinion (2011), it`s caused by mineralization reduction 3-4 times less in comparison with initial level.

Qualitative parameters were closely connected with genetic soil type, what was keeping up during the whole period of rice growing, though ion composition has some variations. On the background of general reduction of underground water mineralization under all soil types their composition is various according to content of Na_2S0_4 and $MgS0_4$. All soil types are characterized by stabilization of the general alkalinity, calcium sulphate and sodium chloride almost vanished out of solution, but content of Na_2S0_4 increased especially on meadow saline soils. Before irrigation process was launched this salt wasn`t presented at all in saline soils, but 20 years after it became a basic component (90% of total). Besides concentration of salts, washed out of principal soils of near-by Sivash region under rice culture, has considerable variations (table 2).

Rice cultivation was desalinating soils during 50 years just in upper soil layers (dark-chestnut soils), the rest territory didn`t have any considerable changes in soil salt concentration, but qualitative composition became different (at present 90% is toxic salt Na_2S0_4), content of calcium sulphate and sodium chloride dropped out at all.

Nowadays within area of paddy fields it`s possible to grow any cultures, but as far as water regime changes, from descending to ascending, process of resalinization will begin almost all over the whole territory of rice irrigated systems, but with different rate. It means that on soils of saline type (there about 200 thousand of hectars in near-by Sivash region) soil degradation can be launched up to removal out of agricultural industry, that is transition from cultivated soils to their previous natural condition.

Table 2

Total concentration of salts (mg-equivalent per 100 g of soil), washing out of principal soils within near-by Sivash region under rice culture

Terms of sampling	Depth of sampling				
	0-20	20-50	50-100	100-150	0-150
Dark-chestnut soils					
1964	0,09	1,65	4,41	10,46	17,51
2010	0,20	0,18	0,190	0,26	0,83
± to initial	-0,79	-1,47	-4,22	-10,2	-16,68
% to initial	79,8	89,1	95,6	97,5	96,3
Meadow-chestnut soils					
1964	2,32	3,27	5,12	9,59	20,3
2010	2,95	3,65	3,53	11,79	21,92
± to initial	+0,63	+0,33	-1,59	+2,50	+1,62

% to initial	127,1	111,6	67,7	122,9	107,9
Meadow saline soils					
1964	2,72	3,81	5,18	7,19	18,9
2010	3,73	4,70	4,99	8,68	22,1
± to initial	+1,01	+0,89	-0,19	+1,49	+3,2
% to initial	137,1	123,3	96,3	120,7	116,9

Therefore it can be concluded that irrigation by landflood, to grow rice culture, changed soil salt composition in dark-chestnut and very saline soils dramatically for quite long period since rice irrigated systems on these soils started to work. In spite of long washing out period on paddy fields the problem of soil and ground resalinization is still urgent even after 40 years because of close to surface deposit of high-toxic underground waters. Extinction of water supply to paddies, having close to surface deposit of mineralized waters, anyway causes soil resaliniation.

It should be considered that Lower complex saline steppe, according to data of E.A. Ryshes (1967), V.A. Kovda (1967), Ye.V. Lvov (1982), A.A. Titkov (2011), is an object of salts accumulation and simultaneously zone of mineralized solutions discharge, which deposit in the ground strata and underground waters. These properties made construction of irrigated-drainage systems in nearby Sivash region necessary.

Though in recent years there are some disorders in natural process of water and salt exchange, especially on soils with lack of underground natural flow-out that cause changes in mineralization of underground waters, rehead, strengthening of salt accumulation, development of area resalinization and intensification of salt inflow into Sivash due to high level of mineralized underground waters.

At the same time worsening of reclamation condition within area of near-by Sivash region occurs as a result of administration breach at drainage systems operation and disability to maintain working state of this complicated complex, that`s why efficiency of irrigated-drainage systems reduced itself, especially it concerns inhouse systems. Unreasonable technique and economical decisions at melioration speeded up ecological disbalance in this region.

No matter that renewal of irrigation of areas in near-by Sivash region from North Crimean canal is the only way to keep ecological balance here, it`s necessary to launch a number of large-scale melioration events on saline areas as soon as possible:

1. To create system of experimental-industrial areas all over the irrigated territory of near-by Sivash region, where it could be possible to conduct fieled observations of ecological-reclamative processes and manage them.
2. To carry out reclamation works of irrigated-drainage systems, that control water-saline regime of soils.
3. Annually gypsuming of soils to keep and improve their fertility.
4. To grow plants with fibrous root system and relative resistance to saline soil (wheat, flax oil, safflower and etc.) and permanent grasses (alfalfa, esparcet, tall-fescue, payza and etc.) on areas with high level of underground waters deposit.
5. At government level to manage the point of water supply resumption in North Crimean canal.

References

1. *Bazhanov V.F., Gusev P.G.* Izmeneniye strukturno-agregatnogo sostoyaniya lugovyh solontsov Krymskogo Prisivashya pri monokulture risa // Pochvovedeniye. – 1981. - № 8. – S.84-89.

2. *Danilchenko P.T., Ponizovsky A.M.* Hydrokhimiya Sivasha. – M.: Izd-vo AN SSSR, 1954. – 230 s.

3. *Gusev G.P., Titkov A.A.* Solevoy rezhym poimennyh pochv nizovoy reki Salgira pod kulturoy zatoplyaemogo risa // Melioratsiya i vodnoye khoz-vo. – 1973. – Vip.24. – S. 75-85

4. *Titkov A.A., Koltsov A.V.* Vliyaniye orosheniya zatopleniyem na meliorativniye usloviya i pochvenny pokrov Prisivashya. – Simferopol, 1995. – 160 s.

5. *Kovda V.A.* Proiskhozhdeniye i rezhym zasolennyh pochv. T.1. – M.-L.: Izd-vo AN SSSR, 1946. – 568 s.

The article was received at editors 29.06.2015

Adamen F.F., Plugatar Yu.V., Stashkina A.F. Ecological problems of landscapes in nearby Sivash region // Bull. of the State Nikit. Botan. Gard. – 2015. – № 116. – P. 15-22.

This article deals with ecological problems of landscapes in nearby Sivash region, reduction of soil fertility as a result of resalinization, increasing of alkalinity level, alkalinization. Peculiarities of soil ecological evolution while rice growing in nearby Sivash region is also studied here. A number of large-scale measurements was suggested for melioration of saline soils.

Key words: *landscapes; ecological problems; nearby Sivash region; melioration; ground water.*