AZERBAIJAN NATIONAL ACADEMY OF SCIENCES
INSTITUTE OF SOIL AND AGRO-CHEMISTRY

M. R. ABDUYEV

SALINIZATION OF THE LANDS OF THE SHIRVAN PLAIN AND MEASURES OF STRUGGLE AGAINST THEM

PUBLISHING HOUSE OF THE AZERBAIJAN NATIONAL
ACADEMY OF SCIENCES

Baku - 1957
Baku - 2003
Baku - 2006

FOREWORD

Even in the program, accepted in May 1919 by the 8th Congress of All-Union Communist (Bolsheviks') Party, was especially indicated the employment of large melioration system.

The industrializing of the country and the victory of the structure of collective farm brought our agriculture from the remaining behind little sparse farms changed to the largest, advanced and having mechanized farm in the world.

Sowing fields of cotton and gathering of raw materials increased with having no like speed during the Soviet period. According to average productivity of cotton, the Soviet Union left behind all capitalist countries.

Increasing of agricultural plants rapidly and connected with it the ways of the use of virgin and respite lands had been defined in a number of decisions of the Communist Party.

It must be mentioned that the great part of the virgin and respite areas consists of saline and swamped lands. In order to use such lands rationally, it is demanded to improve them by melioration ways. The main principle of melioration consists of changing of the nature, especially water and salt regimes of the being meliorated area thoroughly. Soils needing to be improved this way cover smooth field of our republic, especially wide area in the Shirvan plain. Here is widely spread getting salty, saline lands and appearing of scabs on the surface of lands during the irrigation. However, these having mentioned events hadn't increased equally in every part of the plain.

From economical point of view, the main place in agriculture of the Shirvan plain belongs to cotton, grain and fruit growing. The people here are busy with cattle breeding as well. The majority of collective and state farms are spread in the parts of the riverbanks. However, the great part of the Shirvan plain area is not used as arable fields. Unused lands occupy more areas especially in the Eastern part of the plain. The main reason of remaining useless of such wide areas is connected with not having great irrigation system here and because of it, the lack of irrigation waters and also the increase of salinity and not carrying out of rational struggle against it.

The building of the Mingachevir hydro-unit opened wide perspectives for the use of having mentioned lands. After the building of this unit, there were built several irrigation canals in Azerbaijan, including the main Shirvan canal, which was begun since 1954 according to the decision of the Soviet of Ministers and Communist Party of the Soviet Union. The building of this canal gave opportunity of irrigating of 45 thousand *ha* of lands in the Shirvan plain and supplying of almost 50 thousand *ha* of lands by water. Connected with this, it is expedient to show the reasons of salinity of lands of the Shirvan plain, the measures of barring of them and improving of having saline lands.

A BRIEF DESCRIPTION OF THE LANDS OF THE SHIRVAN PLAIN

Before beginning to speak about getting salty of the soils of the Shirvan plain, we would like to give short information about the lands of this place.

Mountain chains, surrounding the Shirvan plain from the north and northwest, influence the climate of the area causing to form climate zones in that plain. It influenced the spreading of the plant cover according to the zones. Having got a zonal character of the climate and plant cover, which form superiority in the formation of soils, at the same time this caused the spreading of land cover according to the zones.

The great part of the Shirvan plain was covered by grey lands. Chestnut lands cover the foothill part of this area.

There are a number of half-types, kinds and half-kinds of such lands inside the having mentioned land zones.

Crusty lawn, lawn-grey, light lawn-grey, brown and other soil types are defined in the grey land zone of the Shirvan plain (H.A.Aliyev, V.R.Volobuyev, 1953). These land types differ from each other sharply. Though briefly, let us characterize each of them.

The formation of c r u s t y l a w n is going on by the participation of surface waters and in some places, by subsoil waters. Such kind of soils is widely used at present for cotton and grain plants. Crusty lawn soils were formed on prolluvial-alluvial drifts. Usually, the upper layer of crusty lawn soils is rich with organic substances. The amount of humidity in this layer sometimes goes beyond 4%. The amount of carbonate in soil profile contains 4-5%. Calcium and magnesium cations in the absorbed complex compose priority.

As it is known from the name, p r e s e r v e soils multiply in preserve areas, rich with organic remainders. Separate genetic layers are openly seen in these lands. The structure of the land is heap-like or heap-nut-like. The main layer of these lands also consists of prolluvial-alluvial heaps. The amount of humus in the land is high. The amount of damping in a half-meter upper layer is not less than 2%. At the same time, carbonates had been washed to lower layers of the soil. Calcium cation in the absorbed complex of the land composes priority.

L a w n – g r e y soils spread onto cones, having brought anciently by rivers and the accumulation of rivers here nearly stopped here. These areas had been drained well by the deep rivers' beds and valleys. That is why subsoil waters locate very deeply in these areas. The amount of humus in the upper layers of the lands is about 3% and in the direction of lower layers, it gradually diminishes. However, in the contrary to humus, great part of carbonate accumulated in the low layers of the land. The amount of calcium cation in the absorbed complex of the land composes 80% of having absorbed substances.

L i g h t l a w n – g r e y lands highly spread in the ancient dry part of the plain, coming forth from the sea beds. The soil consists of alluvial heaps of main rocks. The amount of humus in the upper layer of the land is about 2% and going downwards, diminishes very gradually. On all profile of the land, carbonate is high, reaching 5-6%.

G r e y – b r o w n lands were also multiplied on ancient dry part, coming forth from the seabeds. Such soils widely spread in the east part of the plain on the ancient terrace of the Caspian Sea. The main rock, forming a soil, is dealluvial and lagoon sediments. The process of solution is observed in these lands.

According to morphological structure, separate layers of soils openly differ from each other. Light-colored salty A_1, brown, prism-like B_1, B_2 with carbonate and being less subjected to soil forming process S layers are defined in the land profile.

The amount of humus in the A layer is about 2-6%. The amount of humus diminishes very much below the B_2 layer. Being less in A and B layers (1-3%), carbonate increases towards the lower layers (up to 23%) as these soils are formed on the sediments with carbonate. SiO_2 combination prevails in the upper

layer of soil (about 5%), which shows the salinity of the land. The amount of easily soluble salts in the upper one-meter layer is little (0,1-0,2%), increasing towards below (more than 1%). Though calcium cation prevails in absorbed complex of the soil having absorbed sodium is much (up to 8-14%) as well.
In addition to the types of grey lands having mentioned above, lawn-boggy soils also spread surrounding Garassu of the plain. Such kinds of soils are also met in cone-like depressions of the rivers and in the areas of water lost, having appeared because of the breaking of irrigation orders. The amount of humus in the upper layers of those soils is 2-3%, diminishing towards down. Lawn-boggy soils were also formed in the area, where subsoil waters locate shallow, in the area where the waters of Qarassu cover periodically. Cane widely spread in that area. Soil-forming main rock consists of polluvial-alluvial heaps. The amount of humus in the upper layer of the soil is 3,0% diminishing sharply towards down and being 0,4% below of the 95 *cm* layer. The amount of carbonate onto all soil profile composes 5-8%. The soil is averagely saline. The amount of absorbed carbonate: 10-20% of Na, 30-50% of Mg, 40-60 % of Ca. The density of the soil is high.
Chestnut soil zone embraces the foothill area in the north part of the having described grey lands. Three half-types of chestnut soils were defined in this land zone. They are dark chestnut, chestnut and light chestnut soils. Being dark-colored a little, these soils differ by their grainy and sometimes nut-like structure. The thickness of humus layer is 70-80 *cm*, in some cases reaching one meter. According to chemical composition, the upper layers of these soils had been mainly washed of carbonates. In some cases, they are with carbonates (light chestnut soils). The amount of humus is 3-4%, easily soluble salts doesn't go beyond 0,1%. Calcium cation contains majority of absorbed essences and there is some magnesium as well. The amount of sodium cation in the composition of absorbed complex is very little. Mechanical composition of chestnut soils is clayey and loamy.

SALINE SOILS AND THEIR INFLUENCE TO AGRICULTURAL PLANTS

Saline soils are called the ones in the composition of which the amount of easily soluble salts is enough to be able to influence the normal growth of plants. The amount of salts in such soils in the upper one-meter layer mainly is more than 0,3%. The salinity of soils is defined by the amount of easily soluble salts in their composition. Prof. V.R.Volobuyev (1941) divides the degree of salinity of soils into the following types:

1. Un-saline soils, dry remainder	less than 0,10%	
2. Very weakly saline soils	"from 0,10%	up to 0,25%"
3. Weakly saline soils	"0,25%	0,50%"
4. Averagely saline soils	"0,0%	1,0%"
5. Cutting saline soils	"1,0%	2,0%"
6. Very cutting saline soils	"2,0%	3,0%"
7. Salt-ridden lands	"3%	and more"

Having got different natures of saline degrees of soils and their natural conditions influence the growth of different agricultural plants in that area. It can be openly seen from table 1.
Though having mentioned plants grow up in definite saline lands, these diminish their amount and quality very much.

Table 1

Firmness of plants to salts

(It was composed according to L.P.Rozov's,
V.V.Yeqorov's and our materials)

Qroup	Amount of salts in one-meter layer of soil	The name of plants
The plants, stable to weak salinity	0,1–0,4 %	Oats, pea, bean, some sorts of sunflower and maize, potato, cucumber, garden radish, garlic, carrot. Herbs: lucerne, esparto Trees: apricot, peach, almond, plum, some sorts of apple tree
The plants, stable to averagely salinity	0,4–0,6 %	Spring wheat, barley, spring rye, millet, sesame, onion, turnip, tomato, long stable cotton. Trees: fig-tree, pear, alycha, olive, mulberry, pistachio, white acacia, some sorts of oak etc.
The plants, stable to cutting salinity	0,7–1 %	Some sorts of barley and cotton, aubergine, pumpkin, water-melon; Grasses:old alfalfa,wild saline barley ets. Trees:poplar,elm,pomegranate ets.

REASONS OF SALINITY OF THE SOILS OF THE SHIRVAN PLAIN

The history of the formation of the Shirvan plain helps much in defining of the reasons of salinity of these lands**.**

A little before the fourth age (during oligosen), great part of Azerbaijan (especially the area of the Kur-Araz lowlands), including the Shirvan plain, was the western bay of the present Caspian Sea. According to geological information, the sea repeatedly went off these areas and then reappeared again. Great lagoons were formed in that area when the sea completely left the place. In the period of the moving back of the sea, there existed a tropical climate in the area. This caused the evaporation of salty seawaters during short lack of time and salts in the composition of the evaporated waters settled down making sediments of this area saline. It must be mentioned that a great influence of salinity of the soils of the Shirvan plain made by sea sediments as well. As it is known, the chemical composition of and plain area and subsoil waters is closely connected with the chemical composition of high mountain part surrounding of that place. The Shirvan plain can be more open example for it.

According to geological information, great part of the sediments of surrounding of the Shirvan plain mountains got salinity by different salts. As N.B.Vossovich and V.Y. Khain (1953) indicated, in the mountainous part of the Girdman and Aghsu rivers' basins, among the sediments can be met pir-oxen, iron or yaroizit combinations. The sediments in this part of the third period especially paleogene, and neogene, were enriched by the combinations with sulphate, yarizite, iron and manganese. The spreading of the sea sediments of the Absheron period in the having mentioned part affirms the above mentioned. As D.M.Gavrilov indicated, the sediments of the Absheron period got saline much in this part. Namely

because of this, the salinity degree of the subsoil waters onto the sediments of the Absheron period is very high. In addition, V.A.Priklonsky (1932) defined that the sediments of subsoil waters in the plates of the Garamaryam plateau and O.I.Lukashevich (1932) – in the Western Boyagdagh part of Mingachevir got saline by sodium-sulphate salts.

During the weathering of the mentioned saline sediments, the carrying of salts from one field to another is being settled by surface and subsoil flows. The rivers, running through the Shirvan plain, form a surface flow. The greatest among them is the Kur River, annual flow of which is equal to 18 km^2. The Kur River brings almost 4,4 million tones of salts to this area annually. The second place in carrying of salts is occupied by the small rivers running to the Shirvan plain from the Great Caucasus. It can be seen from the table 2 below.

As it is seen in the table, all Shirvan rivers bring to the plain 4,806 million tones of salts, including 1,650 million tones of harmful salts.

If we accept the past hydro-chemical composition of those rivers as rich as present times, then during million years of period when the plain freed from the seabed, the Shirvan rivers had brought and settled in the area 500^{10} tones of salts (these figures must be accepted in comparative degree).

Table 2

Salts and liquid flow having carried by the rivers of the Shirvan plain [1]

Rivers	Yearly liquid flow rate in km^3	The yearly amount of carried salts		
		In g/l	In million tons	Harmful salt in million tons
Kur	18,0	0,249	4,39	1,44
Alicanchay	0,12	0,40	0,048	0,021
Turyanchay	0,49	0,376	0,19	0,07
Goychay	0,37	0,273	0,10	0,08
Girdimanchay	0,10	0,640	0,06	0,03
Agsu	0,03	0,614	0,018	0,009
Total:	19,11	2,552	4,806	1,650

There are a number of mineral springs in addition of having mentioned rivers in the Shirvan plain and surrounding of it mountainous part, forming the origin of big and small rivers. At the same time, the majority of waters of these springs are salty. Namely because of this, waters of the rivers running through the place are very saline. For example, the Yassamal ravine takes its origin from the mineral spring with 5,64 *g/l* salt in the composition. That is why the salinity degree of waters running through the ravine reaches up to 1,7 *g/l*.

Waters, running through the Kukash ravine, having located in the north of Yassamal ravine, are more saline. Its salt degree reaches 6,35 *g/l*. The information, about the chemical composition of the waters of the mentioned ravines can be seen from the table 3 below.

Both Yassamal and Kukash ravines' waters flow onto the plain.

Table 3

Chemical composition of waters of the Yassamal and Kukash ravines

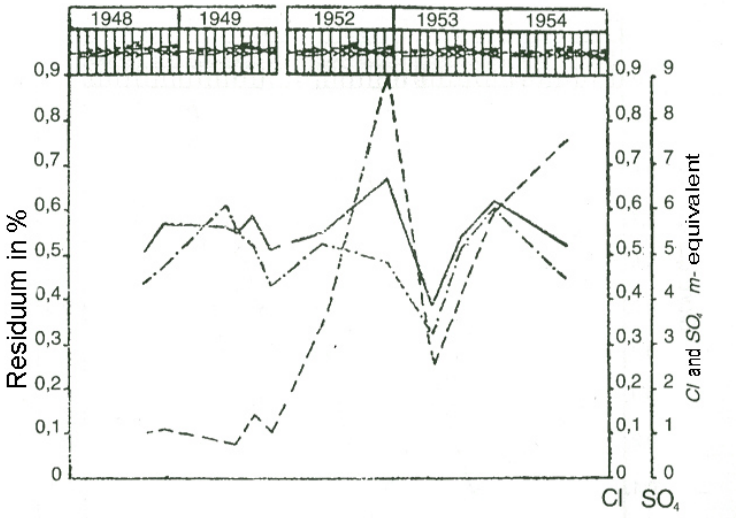
The name of ravines	The time that water examples had been taken	Residuum	The amount of salt in a litr of water $\frac{q}{m\text{-}gkv}$					
			HCO'_3	Cl'	SO''_4	Ca	Mg	Na+K Due to difference
Yassamal ravine	14/V 53	1,715	0,131	0,395	0,658	0,103	0,064	0,381
			2,14	11,12	13,71	5,15	5,27	16,55
Kukash ravine	22/V 53	6,354	0,134	0,245	0,604	0,454	0,172	1,090
			2,2	6,9	75,0	22,7	14,1	47,4

Apart of these ones, there are a number of other ravines in that area, waters of which flow onto the plain and spread to surrounding areas. Namely because of this, the soils of that area got very saline.

According to our observations, having carried out in the Girdman and Aghsu rivers, the amount of salts diminishes in summer period

[1] Were used: O.A.Alekin – "Гидрохимия рек СССР", part 2, 1948; part 3, 1949.

in these rivers. Gradually increasing in autumn months, the amount of salts reaches its maximum in winter months. Beginning since May, the amount of salts diminishes, falling to the minimum in August-September. Looking through the drafts 1 and 2 below, one can get an open imagination. It must be mentioned that the dynamics of salts in river waters corresponds with the regime of flow of them. In fact, in the period of rivers' having much water, the amount of salts in each liter of water also rises. In the period of less water, the amount of salts diminishes very much.



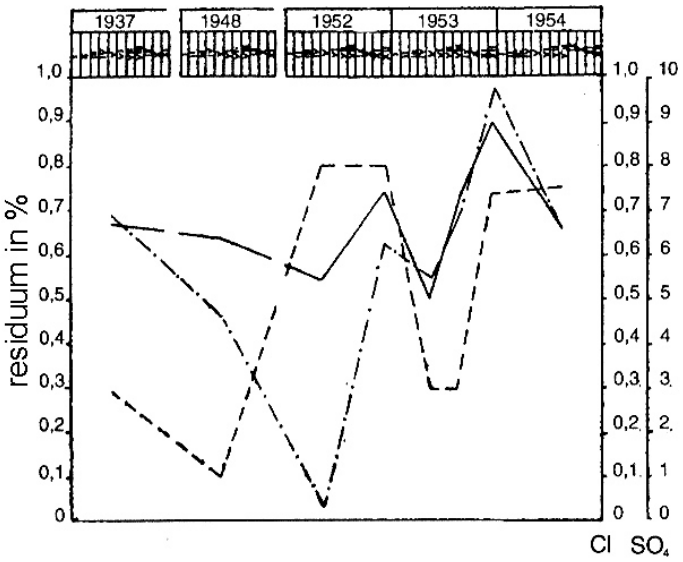
Picture 1. The Girdmanchay River. Dynamics of salt composition of river waters (- dry remainder, - Cl, - SO_4).

As it is seen from table 4, $HCO`_3$ and $SO``_4$ anions prevail in the composition of rivers' waters. There is less Ca cation, lesser Cl`, Na and Mg ions there.

Prevailing of $SO``_4$ ion in river waters is connected of sulphate and sulphide sediments (pirit, yarozit, gypsum etc.), having taken by them in their origins. At the same time, there are a number of mineral springs with sulphur in this area.

Thus, it must be mentioned that those rivers play a great role in salinity of the soils of the Shirvan plain.

We've mentioned above that the subsoil flows play an important role in carrying salts from this place into another one. According to hydro-geological information, there exists a subsoil flow from the Great Caucasus towards the Shirvan plain.



Picture 2. The Aghsu iver. – dry remainder – Ci, - SO_4

Table 4

Chemical composition of rivers' waters of the Shirvan plain

Rivers	The dates that water examples had been brought	residuum In q/l	The amount of salt in a litr of water $\frac{q}{m\text{-}ekv}$						
			HCO'_3	Cl'	SO''_4	Ca	Mg	Na+K Due to difference	SiO_2
1	2	3	4	5	6	7	8	9	10
Kur (near Sabirabad)		0,364	0,222	0,033	0,063	0,052	0,011	0,043	Not Analyzed
			3,63	0,95	1,32	2,56	0,86	1,99	
Alicanchay		0,342	0,201	0,017	0,108	0,059		0,015	Not Analyzed
			3,28	0,49	2,25	2,96	2,37	0,69	
Turyanchay	1/5V/52	0,286	0,251	0,011	0,044	0,060	0,016	0,024	0,010
			4,12	0,30	0,92	3,00	1,30	1,04	
Goycay	15/V/52	0,232	0,237	0,012	0,005	0,050	0,013	0,017	0,012
			3,88	0,35	0,10	2,50	1,10	0,73	
Girdimanchay	28/XII/52	0,668	0,192	0,032	0,230	0,064	0,026	0,014	0,032
			2,12	0,90	4,79	3,20	1,12	0,065	
Agsu	29/XII/52	0,752	0,170	0,028	0,302	0,084	0,066	0,006	0,037
			2,80	0,80	6,28	4,20	5,40	0.27	

Though the count of this flow is not known, nevertheless, the role of this flow in salinity of the soils of the plain is much. It can be proved with that that the sediments of lower layers are very saline.
In addition to all these, in salinity of the soils of the Shirvan plain some influence has the mud volcanoes in the foothill zone and dealluvial sediments flowing off them.
During the strong rains, the salts in the foothill zone sediments are being washed and carried to the plain part by those waters. Especially during the erupting of muddy volcanoes, surrounding areas are covered by salty sediments, and then, having washed by rain waters, they are carried to the plain part.
Though we didn't carry out chemical analysis of plant remainders, nevertheless, we can mention that they also play a definite role in salinity of the soils of the Shirvan plain. Especially there is defined the accumulation of salts in the result of mineralization of plant remainders in the lawn-boggy and lawn-saline soils of the plain. Cane and other salinity plants growing here like salts and because of it, they have much salt in their composition. That's why when these plants finish their vegetation period and die off, they accumulate salts together with them in the soils.
At present, the most important factor influencing salinity of the soils of the Shirvan plain is considered the salty subsoil waters. Subsoil waters located in different depths of the plain. In some areas, the depth of them is 10 or more meters, in other ones – 5-10 meters and in remaining ones – less than that depth. There are such places in the plain that the subsoil waters appear onto the surface. In such areas, i.e. in the places, where the subsoil waters are close to the surface, the salinity process of the lands goes on more rapidly. In fact, in the areas, where the subsoil waters locate in the depth of 1,5-3 *m*, they rise to the surface of the soil by capillary pipes and subject firm evaporation. In this case, having evaporated subsoil waters leave the salts in their composition onto the surface of lands. If this process lasts for a long time, the upper layer of the land becomes saline and unfit.
Sometimes there appear views that the salinity of soils is only connected with the closeness of subsoil waters to the upper layer of lands. But one must not forget that the rising of the level of subsoil waters up is the result f other factors as well. That is why, in order to bar the salinity of soils, one must fight against the influence of those factors. The factors, rising subsoil waters up are as follows:

1. Not defining correctly the norms of irrigation norm, breaking of regulations of the use of waters, carrying out of irrigation in the way of torrents;
2. The application of old irrigation technique and damping of soils very much because of badly preparing of being irrigated area;
3. Growing of paddy in the field of cotton and grain plants and its irrigation with great water norm;
4. Floating of unfit waters, having appeared because of the breaking of irrigation regulations, to neighbor fields or trenches;
5. As the result of looking after irrigation net badly, the floating of additional waters from that net and absorbing of additional waters into the lower layers of the land;
6. Floating of much water through the main canal during the stop of irrigation;
7. Flooding of surrounding areas in watery periods of the rivers during the overflow etc.

All of these reasons rise the level of subsoil waters up during short of time and cause the salinity of lands.
It is known that the geographical view of the Shirvan plain has different geo-morphological and hydrological structures. Because of it the process of salinity of these places goes on by different ways and there appear soils with different degrees of salinity. in different areas of the territory, in order to define the way of salinity and natural washing, in the result of observations during two years we came to the conclusion that in our having described regions, together with the process of salinity, there is going on the process of washing of the soils naturally. We must mention that the process of salinity and washing naturally of the soils is not the same in different places of the plain. If in one area the process of naturally washing prevails, then in other part getting of soils saline covers large areas. Though natural washing of soils from salts in the zone of the foothill area is observed easily, nevertheless, getting saline cases are seen in the areas with incorrect application of irrigation regulations.

However, in small fields, this was spread not regularly. Naturally washing of salts is going on more rapidly in virgin lands with light mechanical composition of the plain zone. The reason of it is connected with much precipitation during the years of our observation than the previous one. Saline lands of these areas with light mechanical composition are easily washed under the influence of heavy precipitations. It can be simply seen from the following example. According to our observations, we made clear that, if the amount of easily soluble salts in the upper half-meter layer of the saline lands contained 4,813%, i.e. 376 tons in each *ha* in August 1952, this count diminished to 2,755% (239,8 tons per-*ha*) in August 1954. Thus, during two years of observation, the amount of salts in each *ha* diminished for 136,3 tons.

No doubt, that this comparison can't be accepted equally for each year. As this changing is connected with the climate condition of the area, during the years of droughty, there is observed not natural washing of soils from salts, but the process of salinity.

The case of getting saline of soils in the southern regions of the plain is observed in a number of areas. At the same time, the process of salinity here is going on more rapidly. The described case occurs especially in the surroundings of the Garassu, which is connected with periodical floating of the Garassu and covering that area. The soils of this area, having less ability of water permitting, evaporate much water under the influence of high temperature before its absorbing into the lower layers of the land during the floating of the Garassu. In this case, salts in the composition of waters, having accumulated on the surface of the land, make it saline. As it is seen from table 5, there are a lot of salts in the composition of the Garassu waters. Being saline in such a high degree causes the surrounding areas to get highly saline. In general, the process of getting saline of the soils of the Shirvan plain goes beyond the process of natural washing.

GEOGRAPHICAL SPREADING OF SALINE LANDS IN THE SHRVAN PLAIN

In order to know the store of easily soluble salts in the composition of lands of the drought regions, it is important to value that area from the agricultural point of view. Firstly, according to the amount of salts in the composition of the soils, there is defined what agricultural plant can be grown there. At the same time, according to the amount of salts there is defined what irrigation works must be carried out there.

With this aim, it is necessary even briefly to note the geography of spreading of saline lands in the Shirvan plain.

It must be said that the salinity degree of the soils of the Shirvan plain is very different. The amount of salts in one-meter soil layer can be from 0,1% up to 3% or even more. In the areas locating in the foothill zone of the plain, soils are less saline. In each one-meter layer here, the amount of salts is not more than 0,1%. Slightly more salinity signs in this part are observed in deeper layers of the soil profile (lower than about two-meter's layer).

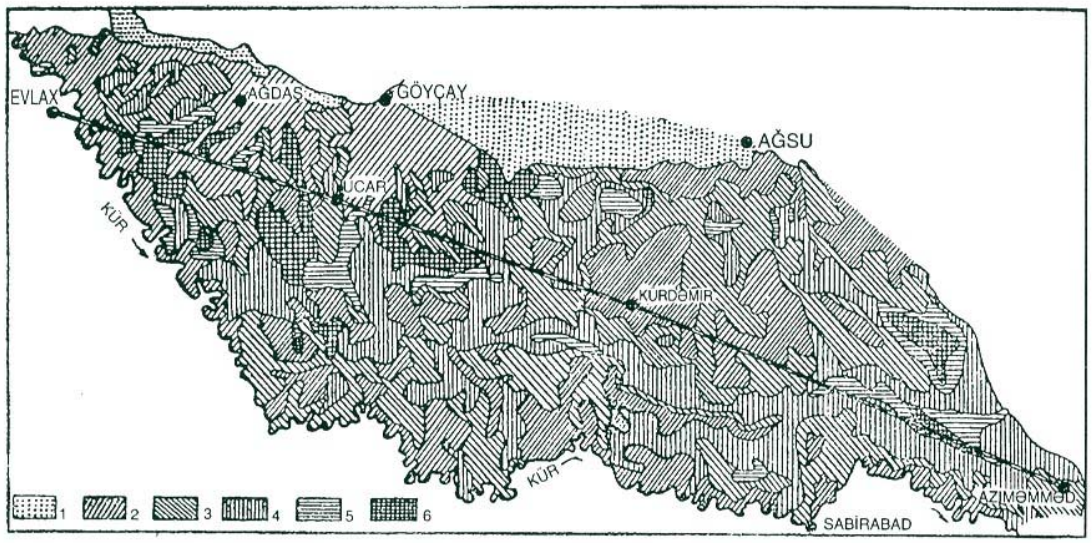
The process of getting saline is observed more openly in the middle part of the rivers' bringing cones.

Table 5

Chemical composition of Garassu and surface waters

surrounding it

The place that the water examples were taken	The date that the examples were taken	Dry Residuum in q/l	The amount of salt in a litr of water $\frac{q}{m\text{-}ekv}$						
			$NCO`_3$	$Cl`$	$SO``_4$	Ca	Mg	Na+K Due to difference	SiO_2
Qarasu	7/V 53	1,092	0,170	0,032	0,636	0,052	0,084	0,098	0,037
			1,80	0,90	13,24	3,62	7,06	4,35	
Surface water on the plain around Qarasu	11/V 52	1,650	0,438	0,248	0,466	0,088	0,081	0,300	Not Determined
			7,18	7,00	9,71	4,40	6,70	13,03	

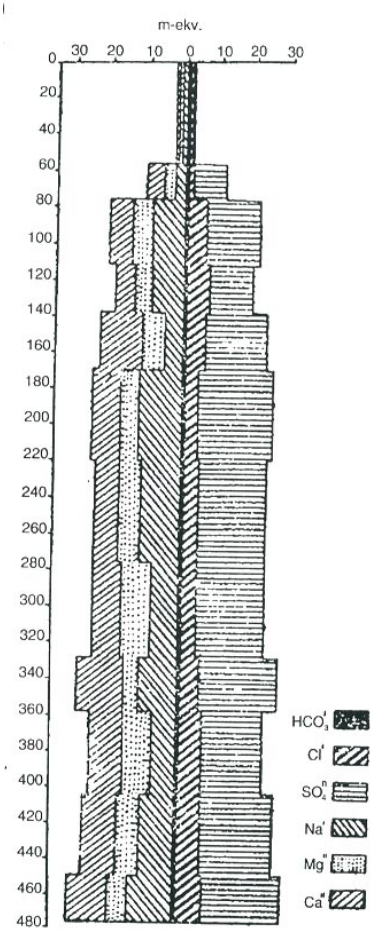


Picture 3. Schematic map indicating salinity of the soils of the Shirvan plain. Dry remainder, with % %.
1 - <0,25; 2 – 0; 3 – 0,50-1,0; 4 – 1-2; 5 – 2-3; 6 - >3.

The amount of salts can reach up to 2-3% in a soil layer in some areas here. In lower parts of the rivers' bringing cones, the degree of salinity of lands diminishes. In this part, especially in the upper layer, the amount of salts is less not going beyond 0,2%. Slightly more salinity (0,5-1,5%) appears in the second meter layer of soils.

The amount of salinity again increases in the part surrounding of Garassu of the plain.

It must be mentioned that, according to the degree of salinity of soils, there is great difference between the western and eastern parts of the plain. In fact, the process of salinity spread wider in the soils of Aghdash and Ujar regions of the western part. The process of salinity had spread here so widely here (in western part), that it caused the diminishing of arable fields very much and lessening of productivity of agricultural plants. In order to widen arable lands, the collective farmers began using their garden-water melon fields at present. Such cases can be met in Aghdash, Goychay and Aghsu regions, partly in Ujar and Kurdamir regions of the plain.



THE TYPES OF SALINE SOILS OF THE SHIRVAN PLAIN

1. According to salinity degree and type

According to salinity degree, the saline soils of the Shirvan plain can be divided into three groups:

Saline-like; Saline; Salty lands.

Located in slightly higher parts of the plain according to the surface structure, saline-like soils embrace big areas.

The great amount of salts in such soils is located below the 50-70 *cm* layer. The amount of salts in 0-50 (70) *cm* layer of these lands is not more than 0,10-0,2%. This amount can reach 1-2% in lower layers. It can openly be seen in table 6 and picture 4.

Saline soils are formed in the layers close to upper ones of subsoil waters. In such soils, the high amount of salts is accumulated below of 20-40 *cm* layer. In fact, locating slightly shallow, subsoil waters rise to upper layers of the soil through capillary pipes, wet the upper part up to 20-40 *cm* layer.

Gradual evaporating of salty waters from here causes the accumulation of great amount of salts. As in saline-like soils, the amount of salts in saline soils is less.

But such kind of saline-like soils prevails a little. That count averagely changes among 0,3-0,6%. Being under the influence of the atmospheric precipitations, it causes the washing of salts from there and accumulating in lower layer from the having mentioned one. At the same time, the influence of subsoil waters to the upper layer of the land is very little. Much salt is accumulated in the layers being under the influence of subsoil waters and as it is seen from table 7, its amount can reach 1-2%.

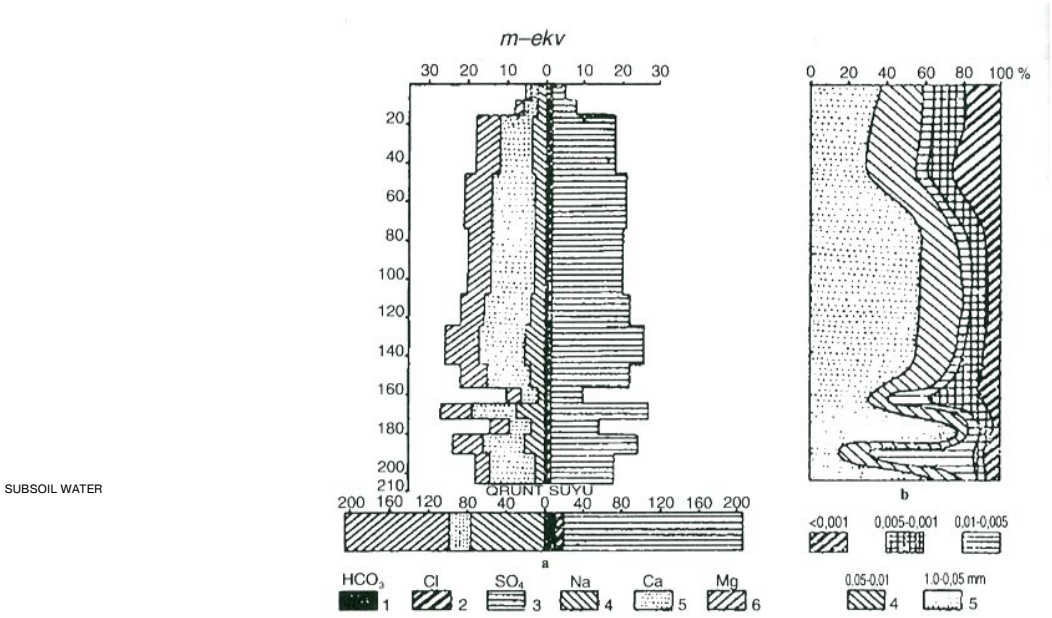
Table 6

The results of analyses of water extracts in saline-like soils (in absolutely dry soils by % % m-eqv)

Picture 4. Salinity profile of saline-like soils.

№ of section	Depth In sm	Dry residuum	Total Salt	CO'_3	Cl'	SO''_4	Ca	Mg	Na + K Due To difference
1	2	3	4	5	6	7	8	9	10
2(9)	0-6	0,205	0,148	0,046	0,022	0,043	0,010	0,014	0,013
				0,75	0,63	0,89	0,50	1,20	0,57
	6-17	0,110	0,094	0,046	0,013	0,012	0,012	0,007	0,004
				0,75	0,38	0,24	0,60	0,60	0,17
	17-35	0,110	0,094	0,043	0,009	0,019	0,010	0,007	0,006
				0,70	0,25	0,40	0,50	0,60	0,25
	35-56	0,120	0,084	0,036	0,009	0,018	0,010	0,006	0,005
				0,60	0,25	0,37	0,50	0,50	0,22
	56-76	0,838	0,719	0,027	0,044	0,444	0,100	0,036	0,068
				0,45	1,25	9,25	5,00	3,00	2,95
	76-113	1,465	1,411	0,024	0,200	0,764	0,140	0,066	0,212
				0,40	5,63	15,90	7,00	5,50	9,43

1	2	3	4	5	6	7	8	9	10
	113-138	1,257	1,199	0,018	0,222	0,592	0,115	0,054	0,198
				0,30	6,25	12,34	5,75	4,50	8,64
	138-170	1,480	1,396	0,018	0,155	0,822	0,195	0,078	0,128
				0,30	4,38	17,12	9,75	6,50	5,55
	170-220	1,688	1,619	0,021	0,33	0,986	0,150	0,060	0,269
				0,35	3,75	20,54	7,50	5,00	12,14
	220-276	1,531	1,582	0,015	0,169	0,921	0,165	0,060	0,252
				0,25	4,75	19,19	8,25	5,00	10,94
	276-330	1,610	1,532	0,018	0,169	0,904	0,180	0,080	0,181
				0,30	4,75	18,83	9,00	7,00	7,88
	330-360	1,860	1,792	0,024	0,191	1,052	0,195	0,090	0,240
				0,40	5,38	21,91	9,75	7,50	10,44
	360-406	1,600	1,455	0,018	0,195	0,822	0,165	0,090	0,165
				0,30	5,50	17,12	8,25	7,50	7,17
	406-452	1,645	1,574	0,018	0,232	0,830	0,185	0,078	0,231
				0,30	6,13	17,37	9,25	6,00	10,05
	452-488	2,040	1,950	0,018	0,266	1,069	0,230	0,066	0,301
				0,30	7,50	22,27	11,50	5,50	13,07



Picture 5. Salinity and mechanical composition profile of saline soils: a) salinity profile; b) mechanical composition profile.

Saline lands in the Shirvan plain don't form an entire area, spreading as here and there in different fields of the plain. Such kind of soils is formed in the parts, where subsoil waters are close to the upper layer of the land. Such kind of fields mainly spread in the middle part of the rivers' bringing cones, in the plain running along Garassu and onto the banks of the Kur River. The observations indicated that the maximum amount of salts is accumulated in the upper part of saline lands.

The amount of salts in this part goes beyond 3%. In some cases, this amount reaches 10-15%. As it is seen from our investigations, carried out in the Shirvan plain, the amount of salts in lower layers of saline soils is not less. It can be seen from table 8 and picture 6.

Table 7

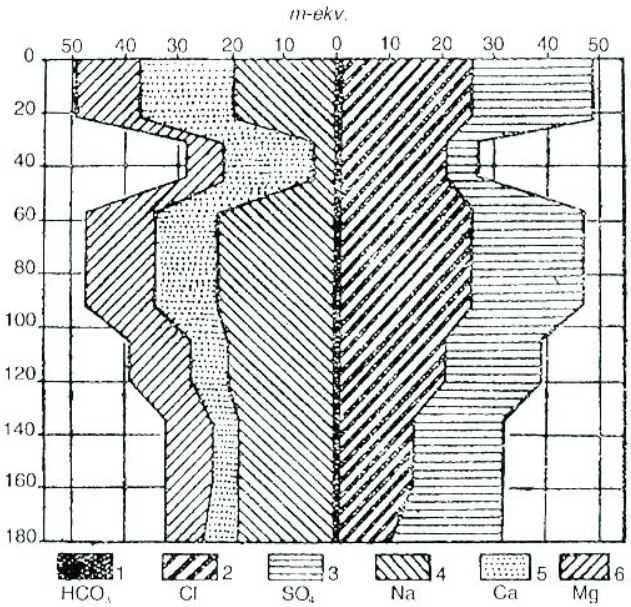
Results of analyses of water extracts in saline lands

№ of section	Depth in sm	Hygroscopic Water	Dry Residuum	Total Salt	HCO'_3	Cl'	SO''_4	Ca	Mg	Na + K Due to difference
1	2	3	4	5	6	7	8	9	10	11
208	0-9	3,02	0,330	0,314	0,051	0,035	0,155	0,040	0,012	0,052
					0,84	0,98	3,13	1,70	0,99	2,27
	9-16	3,00	0,559	0,517	0,037	0,016	0,330	0,086	0,020	0,046
					0,60	0,44	6,88	4,30	1,63	1,99
	16-47	3,23	1,330	1,169	0,026	0,023	0,809	0,169	0,071	0,084
					0,042	0,66	16,86	8,45	5,83	3,66
	47-74	2,97	1,566	1,365	0,022	0,021	0,957	0,217	0,082	0,077
					0,36	0,60	19,94	10,80	6,74	3,36
	74-109	3,35	1,456	1,272	0,022	0,017	0,889	0,221	0,066	0,068
					0,36	0,49	18,52	11,00	5,43	2,94
	109-124	4,50	1,626	1,422	0,021	0,021	0,992	0,235	0,072	0,092
					0,34	0,60	20,67	11,70	5,92	3,99

(in absolutely dry soil with

1	2	3	4	5	6	7	8	9	10	11
	124-145	5,05	1,846	1,633	0,024	0,027	1,137	0,240	0,090	0,127
					0,40	0,77	23,70	11,95	7,40	5,52
	145-156	5,33	1,662	1,448	0,020	0,025	1,010	0,222	0,081	0,100
					0,32	0,71	21,05	11,05	6,66	4,37
	156-162	2,02	0,660	0,588	0,021	0,10	0,464	0,084	0,035	0,045
					0,34	0,27	8,42	4,20	2,88	1,95
	162-172	5,12	1,804	1,783	0,026	0,041	1,218	2,221	0,101	0,176
					0,42	1,15	25,38	11,00	8,31	7,64
	172-180	2,31	0,942	0,845	0,021	0,017	0,578	0,111	0,046	0,082
					0,35	0,49	12,04	5,55	3,78	3,55
	180-190	6,15	1,758	1,537	0,024	0,029	1,067	0,223	0,087	0,119
					0,40	0,82	22,23	11,10	7,16	5,19
	190-206	2,98	1,316	1,178	0,021	0,013	0,821	0,240	0,046	0,04
					0,34	0,38	17,11	11,95	3,78	2,10

%%/*m.equiv*.)



Picture 6. Salinity profile of saline lands.

Sometimes there occur such cases that there is a little amount of salts in the crust onto the soil. It mainly is observed in rainy weathers. Thus, rain water wash to lower layers easily soluble salts, having accumulated on the surface.

At the same time, it must be mentioned that together with saline lands in the Shirvan plain, there also spread un-saline lands as well. Such kind of lands especially cover the foothill zone of the plain, Garamaryam plateau, Padar bloc, the upper part of the rivers' bringing cones and other areas. Slightly saline lands spread in the plain as well. However, such soils don't refer to our subject and we don't speak about them here.

Table 8

Results of analyses of water extracts in saline lands (in absolutely dry lands by %%/*m.equiv.*)

№ of section	Depth in sm	Dry residuum	HCO'_3	Cl'	SO''_4	Ca	Mg	Na + K Due to Difference
1	2	3	4	5	6	7	8	9
32	0-12	3,652	0,022	0,923	1,068	0,368	0,132	0,442
			0,36	26,00	22,25	18,40	11,00	19,21
	22-30	1,912	0,024	0,745	0,330	0,348	0,081	0,094
			0,40	21,00	6,87	17,40	6,80	4,07
	45-57	3,362	0,022	0,891	1,032	0,248	0,149	0,499
			0,036	25,10	21,05	12,40	12,40	21,71
	92-102	2,736	0,024	0,728	0,865	0,136	0,144	0,463
			0,40	20,50	18,02	6,80	12,00	20,12
	120-134	2,080	0,024	0,507	0,833	0,110	0,102	0,415
			0,40	14,30	17,35	5,50	8,50	18,05
	178-200	2,188	0,022	0,419	1,008	0,126	0,099	0,427
			0,36	11,80	21,00	6,30	8,30	18,56

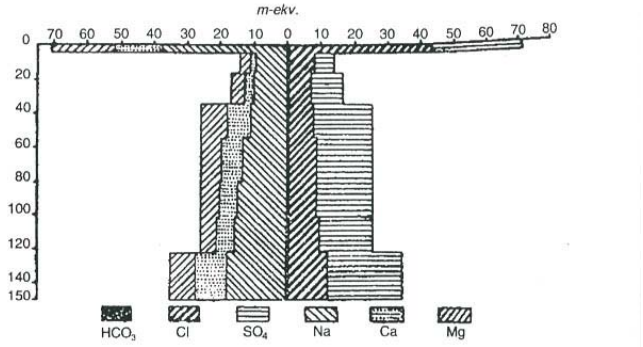
2. According to chemical composition of salts

According to chemical composition of easily soluble in water salts, saline lands of the Shirvan plain can be divided into following types.

1. S a l i n e s o i l s w i t h c a r b o n a t e. Such kind of lands spread in the northern part of the plain and mainly in the territory of the Kurdamir region. The amount of easily soluble in water salts in 1-1,5 *m* layer reaches 0,1-0,2%, in some cases – 0,3-0,4%. The amount of salts increases in lower of this layer, reaching 1-2%.

The comparison of m-equiv. % and general amount of salts show that both in the upper layers and in the lower layers the amount of calcium carbonate salt prevails, reaching up to 30-40%.

2. S o i l s s a l i n e w i t h s u l p h a d e. Such soils cover the upper and middle parts of the rivers' bringing cones and Garamaryam mould. Here are met soils with different salinity. The main part of it consists of saline-like and saline soils. Salty lands are also met in some areas. Sodium-sulphade prevails in the chemical composition of salts. The amount of sulphade in the composition of these lands goes beyond 40 m-equiv.%. Sodium changes among 30-40 m-equiv.%.

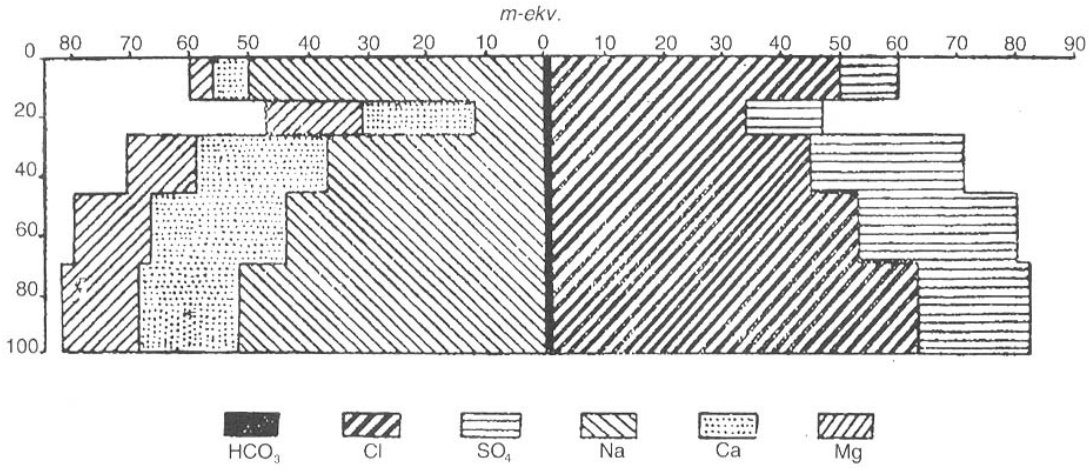


Picture 7. Salinity profile of saline soils with sulphade.

Table 9

Results of water extracts in saline lands with chloride (in absolutely dry land by %%/ m-equiv.)

№ of section	Depth in cm	Dry residuum	HCO'_3	Cl'	SO''_4	Ca	Mg	Na + K due to difference
1	2	3	4	5	6	7	8	9
44	0-14	3,630	0,037	1,757	0,493	0,132	0,049	1,142
			0,60	49,50	10,27	6,60	4,10	49,67
	14-25	2,276	0,027	1,171	0,637	0,385	0,165	0,315
			0,44	33,00	13,27	19,25	13,75	13,71
	25-45	4,660	0,027	1,597	1,253	0,450	0,147	0,846
			0,44	45,00	26,10	22,50	12,23	36,79
	45-70	4,840	0,024	1,846	1,274	0,465	0,138	1,016
			0,40	52,00	26,54	23,25	11,50	44,19
	70-100	4,400	0,022	2,236	0,904	0,345	0,159	1,189
			0,36	63,00	18,83	17,25	13,25	51,69



Picture 8. Salinity profile of saline soils with chloride.

In the areas with spreading of saline lands with sulphade, subsoil waters mainly are met in shallow and are very salty. In some areas, the amount of salts in each liter of water even reaches up to 100 *g*. sodium-sulphate prevails in such subsoil waters. Namely because of it, soils, spreading in that area are rich with sodium-sulphate.

3. S a l t y s o i l s w i t h c h l o r i d e. Such kind of salty soils embraces great area in the Shirvan plain and it mainly spread in the eastern remotes of the plain. In some areas here, soils became saline by sodium-chloride salts. The amount of chlorides in such lands contains more than 40% of dry remainder. The soils of this part are mainly salty or saline-like. In one-meter layer of the soil, the amount of salts reach 2-3%, sometimes – 4-5%. The profile of salinity and table 9, having presented by us, create open imaginations about it.

In the above-mentioned part of the plain, the salinity of soils by sodium salts can be explained by the salty dealluvial flows, coming down by mud volcanoes. There are several groups of mud volcanoes in the Langabiz Mountains in the northeast part of the plain. Sometimes they erupt plenty of volcanic productions.

As it is seen from table 10, the salinity degree of the having erupted productions is very high.

It becomes clear from the table that sodium-chloride salts prevail in the production. As these salts are solved easily than the other ones, they are easily washed by rainwater from the sloppy plates of the mountainous part ad brought to the plain area. Because of this, the soils get salty by those salts in the mentioned part of the plain. Subsoil waters, having met here, became salty by sodium-chloride salts. The level of these subsoil waters is slightly shallow. In such cases, because of continuous evaporations, it causes getting saline of surrounding areas very much and enriching by sodium-chloride salts.

Table 10

Chemical composition of the production having taken from the crater during the eruption of mud volcano in Akhtarma-Pashali

The date examples were taken	Dry residuum	The amount of salt in a liter of water $\frac{q}{m\text{-}ekv}$						
		CO''_3	NCO'_3	Cl'	SO''_4	Ca	Mg	Na+K Due to difference
31/V–54	12,980	0,066	0,537	7,100	0,033	0,199	0,072	4,512
		2,20	8,80	200,00	0,67	9,50	6,00	196,17

Salty lands with chloride-sulphate and sulphate-chloride spread as separate spots in this part of the Shirvan plain.

4. Soils, got saline by mixed salts. Such kind of salty soils covers surrounding of Garassu area of the plain.

The soils of this area differ by salts with very different chemical composition. There are soils, having saline both with sulphate-chloride and sulphade-carbonate-chloride salts. According to the salt cations, those soils compose difference.

All these soil types had spread in very disconnected order. That's why it is not possible to join these lands in separate groups. The mentioned area's lands, having got different kinds of salinity depend on Garassu regime and bringing different salts from saline lands. As we have mentioned above, Garassu floods its surrounding areas during separate times of a year and evaporating, those waters absorb the salts in their composition into the place. Namely because of it, generally, the soils of this part are saline.

3. According to forming condition and morphological composition

According to forming condition and morphological structure, the saline lands of the Shirvan plain are divided into three groups:

1. Soft (salient) salty soils.
2. Lawn-salty soils.
3. Crusty salty soils.

Soft salty soils are mainly spread in the western part of the Shirvan plain. These lands especially cover the areas in Aghdash and Ujar regions, near-along the railway and along the banks of the Kur River. These soils are also met as separate spots in the eastern part of the plain, near Garassu and Mughali village.

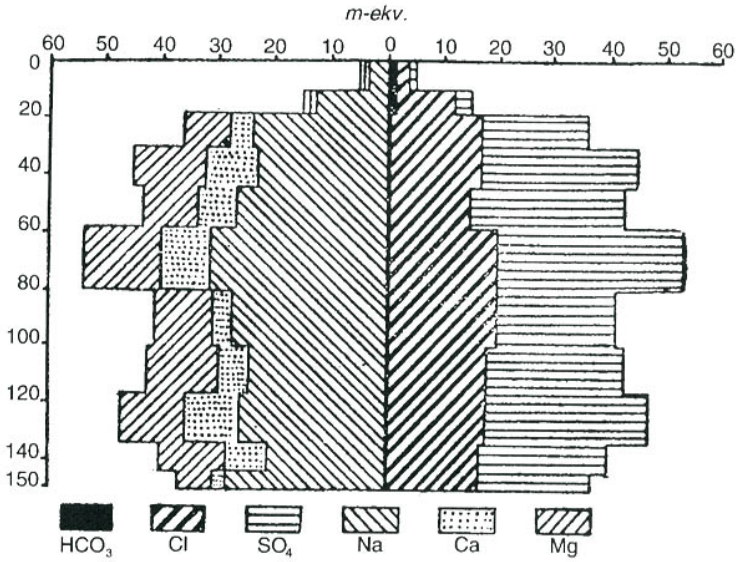
According to morphological composition, it is typical for soft soils having of 5-10-*cm* soft soil layer.

The structure of this layer resembles dust. "Lying grainy" structure is noticed in lower layer. It is connected with the accumulation of much salt in that layer.

Nearly 20-*cm* below, the denseness of the soil contains firm character and has a mixed structure.

Walking onto the soft soils, it is pollinated very easily and sometimes hampers moving.

The color of soft layer is usually grey, sometimes, depending on surplus of salts – whitish. Soil layer below it differs by its brown color. Soft salty lands are mainly formed in the areas, where subsoil waters are close to the surface. Sodium-sulphate salt especially plays an important role in the formation of these soils. The surplus of these salts causes the softness of the upper layer of the land.



Picture 9. Salinity profile of soft saline soils.

Chloride salts occupy main place in the described salty lands after sulphate combinations.
The amount of salts reaches 2,5-3,5% in the soft saline lands of the Shirvan plain. There occur such cases that the amount of salts in the upper soft layer appears very little. Such state is also typical for soft saline lands of the Garabagh plain (M.E.Salayev, A.G.Zeynalov, E.F.Sharifov, 1955). This state is observed especially in rainy months. So, when raining, the salts in the soft layer dissolve easily and being washed accumulate in lower layers. During of hot drought times, as capillary pipes break off, subsoil waters can't rise to the upper layers, evaporating under the soft layer and accumulating salts there. Namely because of it, the maximum amount of salts begins either from the second or from the third layers. The amount of salts in the upper layer composes 0,4-0,8%. It can be seen from table 11 and picture 9.
L a w n s a l i n e soils in the territory of the Shirvan plain spread in the areas, where subsoil waters are close to the surface, in the middle part of the rivers' bringing cones and near the banks of the Kur River. The described lawn soils are mainly observed in the zone of the lawn grey lands. Lawn saline lands here spread in the form of separate small spots.

Table 11

Results of analyses of water extracts in soft saline soils
in absolutely dry soil by %%/m-equiv.)

№ of section	Depth in cm	Dry residuum	HCO'_3	Cl'	SO''_4	Ca	Mg	Na + K Due to delfference
1	2	3	4	5	6	7	8	9
163	0-9	0,364	0,081	0,084	0,034	0,009	0,008	0,075
			0,32	2,36	0,70	0,45	0,45	3,28
	9-18	0,804	0,072	0,364	0,143	0,013	0,018	0,282
			1,18	10,26	2,97	0,84	1,48	12,29
	18-30	2,494	0,051	0,621	0,858	0,077	0,107	0,541
			0,83	17,51	17,85	3,84	8,79	23,56
	30-43	3,164	0,042	0,578	1,350	0,184	0,162	0,519
			0,68	16,29	28,10	9,18	13,32	22,57
1	2	3	4	5	6	7	8	9
	43-58	2,812	0,035	0,542	1,264	0,029	0,110	0,628
			0,57	15,28	26,30	6,43	9,04	26,68
	58-80	3-411	0,037	0,660	1,655	0,175	0,168	0,175
			0,60	18,61	34,44	8,73	13,81	31,11
	80-100	2,545	0,037	0,661	1,069	0,084	0,120	0,630
			0,60	18,64	22,24	4,19	7,86	27,43
	100-117	2,737	0,038	0,624	1,134	0,108	0,153	0,548
			0,62	17,59	23,57	5,38	12,58	23,82
	117-134	3,489	0,031	0,622	1,384	0,189	0,131	1,072
			0,50	17,54	28,80	9,43	10,77	26,64
	134-144	2,679	0,035	0,559	1,116	0,136	0,146	0,477
			0,57	15,76	23,22	6,78	12,22	20,77

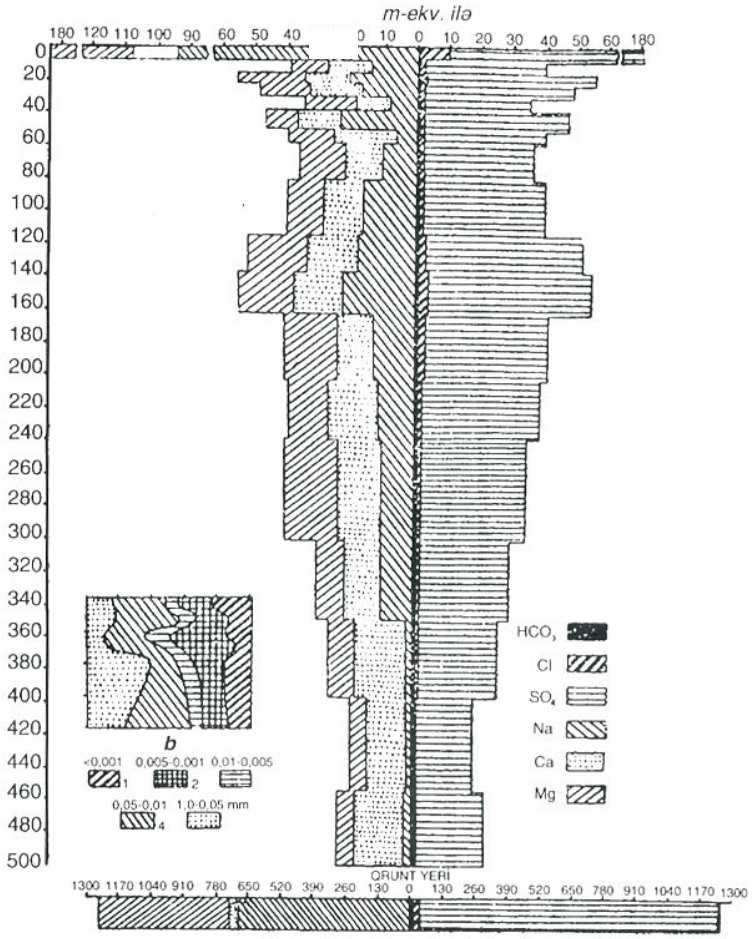
Having of humus in high amount is typical for lawn saline soils. The amount of humus in these lands averagely is 2,0-3,5%. General thickness of the layer with humus reaches 80 *cm*. According to all having said, it can be said that lawn saline soils had been formed of the salinity of the past lawn grey soils.
Describing of lawn soils of the Garabagh plain, A.O.Zeynalov noticed this stand.
As lawn saline soils had been formed in shallow location of subsoil waters in the Shirvan plain, these soils constantly are in the state of sated of humidity. Subsoil waters of this part got much saline and depending on different seasons of a year, the amount of salts having dissolved in these waters, changing sharply appears up to 25-115 *g* per-liter. The same state at the same time causes the dynamics of salts' amount in the layer of this soil. This is especially openly observed in the first upper layer of the soil. Depending on the climate and hydro-geological conditions, the amount of salts changes among 2,0-

14,0% in different times of a year. It can be said that the amount of easily soluble in water salts is never below 2% in all profile of lawn saline soils. sodium-sulphate salt prevails in these soils. Sulphate combinations contain more than 45% m-equiv. of general amount, sodium – 25% m-equiv. and other salts – relatively less. The distribution of salts on soil profile and their chemical composition are openly shown in table 12.

According to mechanical composition, lawn soils are suitable. In fact, the amount of physical clay in separate layers of these lands does not go beyond 60%. In general, according to its mechanical composition, the soil is averagely clayey. Soils, being slightly light according to mechanical composition, cause the salts in their composition to be very dynamic.

Namely because of this, during very rainy spring-autumn seasons, the salts in the upper parts of salty soils are washed easily towards lower layers and very thick grass plants appear here. Because of high evaporation during hot summer months, the upper layer of the soil gets firmly saline and the area gains a whitish "bare" look.

C r u s t y s a l i n e soils spread as separate spots in the territories of Goychay, Ujar, Aghsu, Kurdamir and Zardab regions of the Shirvan plain. The thickness of crust layer in such soils reaches 3-8 *cm*, going into different geometrical pieces. In some cases, between crusty and lower layers, there occurs not very thick (1-2 *cm*) "lying" grain half-layer, i.e. an interim layer, having broken into fine pieces. Below this layer, the denseness of the soil becomes a little stronger and then sticky because of humidity.



Picture 10. Salinity of lawn saline soils and the profile of mechanical composition.

a) salinity profile; b) mechanical composition profile.

Table 12

Results of analyses of water extracts in lawn saline soils (in absolutely dry lands, with %%/ m-equiv.)

№ of section	Depth in cm	Hygroscoptik	Dry residuum	Total salt	CO'_3	HCO'_3	Cl'	SO''_4	Ca	Mg	Na + K Due to difference
1	2	3	4	5	6		7	8	9	10	11
203	0-7	7,64	13,472	11,654	0,052	0,052	0,312	8,066	0,287	0,979	1,906
					0,26	0,86	8,80	167,87	14,34	80,49	82,87
	7-13	4,14	2,658	2,601	0,004	0,019	0,050	1,800	0,267	0,152	0,309
					0,12	0,32	1,40	37,46	13,33	12,53	13,44
	13-21	5,69	3,782	3,640	0,002	0,019	0,077	2,536	0,277	0,246	0,483
					0,08	0,32	1,90	52,78	13,83	20,24	21,01
	21-30	1,64	3,460	3,407	0,002	0,016	0,058	2,240	0,328	0,187	0,576
					0,08	0,26	1,60	46,62	16,35	15,42	16,79
	30-38	2,13	2,212	2,190	0,002	0,018	0,035	1,537	0,212	0,158	0,226
					0,12	0,30	1,00	31,98	10,56	13,01	9,27
	38-50	4,73	3,296	3,81	0,004	0,017	0,048	2,186	0,252	0,135	0,641
					0,08	0,28	1,35	45,49	12,58	11,09	23,54
	50-58	2,56	2,620	2,611	0,001	0,015	0,044	1,841	0,398	0,170	0,139
					0,12	0,24	1,12	38,31	19,86	13,98	6,03
	58-80	2,89	2,738	2,354	0,001	0,015	0,046	1,664	0,442	0,164	0,222
					0,04	0,24	1,30	34,63	12,07	13,49	9,65

№ of section	Depth in cm	Hygroscoptik	Dry residuum	Total salt	CO'_3	HCO'_3	Cl'	SO''_4	Ca	Mg	Na + K Due to difference
1	2	3	4	5	6		7	8	9	10	11
	80-114	3,64	2,726	2,579	0,001	0,013	0,048	1,775	0,237	0,223	0,382
					0,04	0,22	1,35	36,94	11,82	10,12	16,61
	114-136	1,89	3,420	3,318	0,004	0,013	0,066	2,310	0,328	0,199	0,401
					0,16	0,22	1,85	48,08	16,35	16,39	17,44
	136-162	3,24	3,599	3,593	0,005	0,027	0,096	2,450	0,297	0,211	0,508
					0,16	0,44	2,70	50,98	14,84	17,35	22,09
	162-202	2,48	2,924	2,629	0,002	0,015	0,066	1,829	0,227	0,199	0,288
					0,08	0,24	1,85	38,06	11,32	16,39	12,55
	202-238	2,06	2,856	2,549	0,001	0,017	0,058	1,763	0,302	0,152	0,255
					0,04	0,28	1,65	36,69	15,05	12,53	11,08
	238-300	6,05	2,336	2,230	yox	0,012	0,044	1,549	0,277	0,123	0,224
					"	0,20	1,20	32,24	13,83	10,12	9,73
	300-350	1,98	1,962	1,948	"	0,017	0,038	1,340	0,232	0,088	0,237
					"	0,28	0,95	27,89	11,57	7,23	10,32
	350-397	2,55	1,662	1,650	"	0,004	0,030	1,173	0,328	0,083	0,032
					"	0,06	0,85	24,41	16,35	6,75	1,41
	397-455	1,53	1,558	1,234	"	0,035	0,019	0,843	0,237	0,064	0,036
					"	0,58	0,55	17,54	11,82	5,30	1,55
	455-500	2,07	1,490	1,460	"	0,021	0,025	1,003	1,313	1,053	0,045
					"	0,34	0,70	20,87	15,59	4,34	1,98

The color of crusty layer is light-grey, having heap-like structure. It is dry and very dense according to denseness. The color of soil profile becomes lighter towards below. One can meet crystal sulphate combinations in the form of small brains beginning from the upper 35-*cm* layer. Crusty saline soils are formed onto clayey with heavy and light composition in the Shirvan plain. The mechanical composition of them consists mainly of heavy clayey and clay. In such cases, the crust layer is thick and firm.

As the amount of clay fraction increases in the soil, then, cracks of crust deepen as well.

The formation of crust in saline soils especially occurs after heavy rains. In fact, there occurs air in porosities of soil masses, especially in its dry period. When water easily enters those porosities, it forces air to get out of them. In such cases, by the influence of strong energy, the soil mass becomes broken into small fractions. At the same time, heavy rains tear soil fractions mechanically and thus, small soil fractions become more pounded. Salts, special sodium combinations in the composition of crusty saline soils influence it as well.

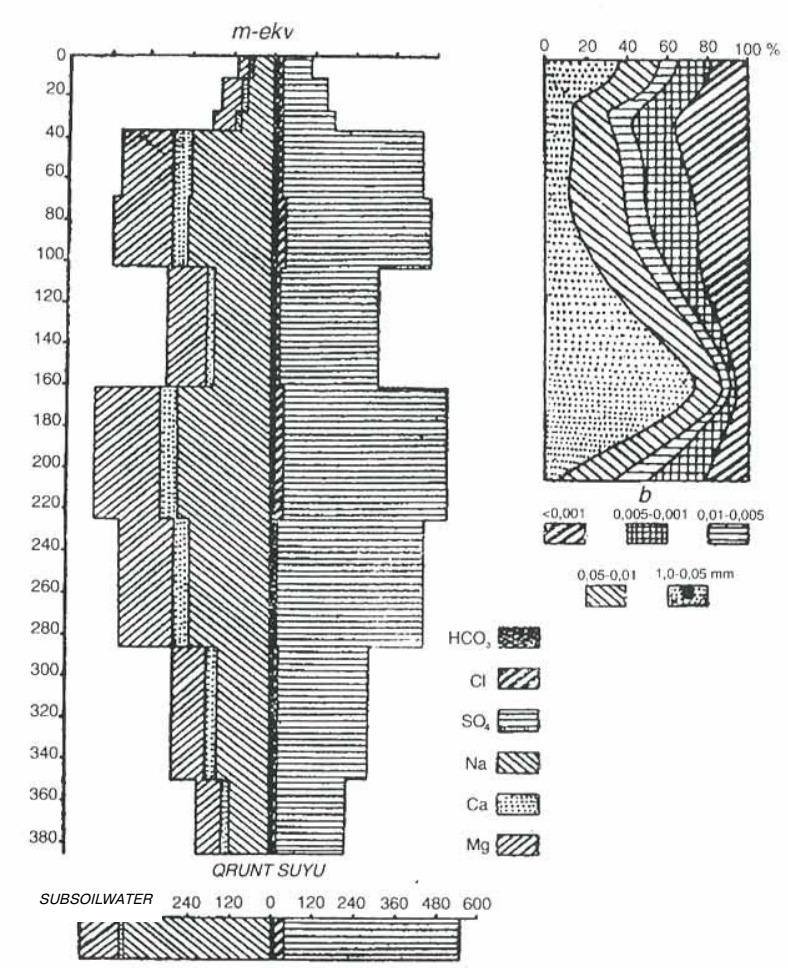
Thus, having mixed with water, pounded soil fractions change into wash-like mud. Then, gradually getting dry, firstly, it forms sticky and then firm mass. At the end, it tears to separate pieces, getting above-mentioned geometrical forms. N.I.Gorbunov and N.Y.Bekarevich (1951) also explain the forming of crusts nearly by this way. Looking through the cuts of crusty saline soils, there can be observed the accumulation of salts in mold-like form on the walls of the cut below nearly 10-15 *cm* layer. Having got a mid-stratum causes the accumulation of main parts of salts below that layer, as rising to the upper layer of the ground through capillary pipes, salty waters evaporate before reaching of the crusty layer through clefts of it, accumulating salts below of the crusty layer.

In the cases, when subsoil waters are in shallow, connected with damping of crusty layer, force to saline the upper part of the soil in the highest level.

Sodium-sulphate salt prevails in crusty saline soils. 1,68% of 2,50% of salt, easily soluble in water, accumulated in 35-65-*cm* layer is SO_4 anion, 0,46% - Na cation. This comparison is observed in other layers of the soil as well.

The thickness of highly saline (more than 1-2%) layers having observed in the Shirvan plain is more than 1,5-2 *m*, mainly forming the bed part of the soil.the upper 10-20-*cm* layer mainly is naturally washed off salts. It must be mentioned that this state is observed in much soils of the Shirvan plain. There was defined that the degree of salinity in crusty saline soils of the Shirvan plain is relatively less that in soft and lawn saline soils. However, the amount of common salts in one-meter from the surface layer is not less than 2%.

Apart of openly expressed crusty saline soils, there are crusty saline-like and salty soils as well. The amount of easily soluble in water salts in the upper 30-50-*cm* layer is among 0,6-1%. Below that layer, up to 285 *cm* depth, the degree of salinity of the soils increasing reaches 2-3%. Below that layer, the degree of salinity, changing sharply, falls to 1,5-1,3%. According to the composition, as in crusty soils, sodium-sulphate salt prevails in these lands as well. Magnesium and calcium cations compose relatively less content. As it is seen from table 13 and the draft, the amount of chlorine in the upper layer of soil is less, increasing towards the lower layers.



Picture 11. Salinity profile and mechanical composition of crusty saline-like lawn-grey soils:
a) salinity profile;
b) mechanical composition profile.

Table 13

Results of the analyses of water extracts in crusty saline-like lawn-grey soils (in absolutely dry lands with %%/m-equiv.)

№ of section	Depth in cm	Hygroscoptik water	Dry residuum	HCO'_3	Cl'	SO''_4	Ca	Mg	Na + K Due to difference
1	2	3	4	5	6	7	8	9	10
210	0-9	3,67	0,602	0,028	0,029	0,337	0,012	0,033	0,114
				0,46	0,82	7,02	0,62	2,71	4,97
	9-26	4,87	0,820	0,029	0,016	0,517	0,032	0,048	0,141
				0,48	0,44	10,77	1,62	3,95	6,12
	26-35	3,59	0,980	0,024	0,023	0,626	0,030	0,058	0,180
				0,40	0,66	13,04	1,51	4,75	7,84
	35-67	4,87	2,500	0,020	0,037	0,677	0,191	0,143	0,460
				0,34	1,04	34,94	4,55	11,76	20,01
	67-101	3,48	2,640	0,018	0,068	1,744	0,073	0,169	0,483
				0,30	1,91	34,36	3,64	13,90	21,00
	101-159	3,91	1,750	0,019	0,047	1,131	0,030	0,113	0,380
				0,32	1,31	13,56	1,52	9,29	14,36
	159-224	4,26	3,001	0,020	0,064	1,938	0,088	0,184	0,526
				0,34	1,80	40,27	4,40	15,13	22,88
	224-285	5,85	2,700	0,019	0,035	1,718	0,080	0,162	0,455
				0,32	0,98	35,79	3,99	13,33	19,77
	195-350	3,79	1,590	0,016	0,023	1,066	0,058	0,095	0,293
				0,26	0,66	22,21	2,90	7,48	12,75
	350-386	3,33	1,318	0,017	0,021	0,795	0,040	0,066	0,230
				0,28	0,60	16,55	1,99	5,43	10,02

Apart of the above-mentioned types of saline soils in the Shirvan plain, there are met salty-saline and having got saline soils as well. Having got saline soils are met in some parts of the area beginning from the foothill zone up to Garassu side. Saline-saline like soils spread in the plain surrounding Garassu as separate spots. The amount of sodium cation contains 10-20% of the absorbed cations in absorbed complex of such soils. The mentioned amount especially prevails in 10-35-*cm* middle layer. According to morphological structure, it is noticed that high clayey process is going on in that layer. Water permeability ability of these soils is very weak.

Maximum amount of salts is observed below 0-35-*cm* layer. The amount of easily soluble in water salts in that depth is about 1,5-1,8%. However, the upper layer of the soil has been washed off salts very much. The amount of dry remainder here doesn't go beyond 0,2-0,7%. Chemical composition of salts in these lands mainly contains sodium-sulphate. The amount of sulphat anion in one-meter layer composes 40% of dry remainder by m-equiv.%. The thickness of highly saline layers of the described soils is more than 4,5 *m*.

According to mechanical composition, these soils are very heavy. The amount pf physical clay in these lands is near 80-90%, in some layers reaching up to 90%.

It must be mentioned that in this part of the plain (near Garassu), the process of swamping also developed. The flood of Garassu in different times, the influence of subsoil waters, growing heavy of mechanical composition of the soil and deteriorating of water permeability caused those lands' swamping. Swamping soils are also observed in inter-cone depressions of the rivers and in the areas along the banks of the Kur River.

As swamp soils are very salty, they got the name of boggy soils. The amount of dry remainder below 0-40 *cm* of these lands contains 1-2%. The thickness of firmly salty layer is 4,5 *m*. According to chemical composition, salty swamp soils are with sulphate. $SO``_4$ anion forms nearly half of dry remainder in them. The amount of chloride anion is mush in low layers of the soil. It shows its subjecting of natural washing.

According to mechanical structure, salty swamp soils are included to clayey and heavy clay soil group. The amount of physical clay here composes surplus in all layers of the soil, going beyond 90% in separate layers.

High accumulation of salts in salty-swamp soils is connected with its being under the influence of salty subsoil waters. At the same time, surface waters, especially the overflow of Garassu also influence greatly to this.

MELIORATION OF SALINE SOILS (improving)

1. Putting resistance to salinity

Salty soils look-like to sick organism. In order to cure them, firstly, it is necessary to define their diagnoses and to carry out demanded measure against them.

We've mentioned above that the main reason of salinity is rising of salty subsoil waters to the upper layer of the ground. It comes forth in the result of breaking of irrigation regulations in irrigation regions and because of the lost of water. In order to bar of the getting saline, firstly, there must be carried out a struggle against water lost. It can be carried out by economizing of irrigation waters.

Some people consider that if lands are given much water, there will be much harvest. It is not correct. If arable filed is given more than norm water, air in sowing layer diminishes, the activity of microorganisms weakens, the level of subsoil waters rises and thus, there is going re-salinity process in the soil.

In order not to give surplus water to a field, firstly, there must be defined the norm of water, number of irrigations and the ways of irrigation.

In order to organize irrigation well, there must be defined the norm of demanded water and water capacity of this or that soil. Our observations, carried out in the Shirvan plain, indicate that for normal growth of cotton the amount of moisture in the soil must be 17-18%. This amount is equal to averagely 2300-2500 m^3 of water in one-meter soil layer of each *ha* of a field. 1500-1800 m^3 of that amount of water exist naturally in Shirvan soils. That's why, it is advised to give water for 5-6 times to each *ha* in 700-800 m^3 count.

In order to bar the lost of water and thus, to struggle against salinity of soils, there must be defined the correct irrigation way. Work experience of the advanced collective farms indicates that irrigation corresponds to the agro-technical demands only then, when field is irrigated by furrow, not destroyed the structure of a soil, got wet of in demanded depth and equally everywhere.

The structure of soils doesn't change, there doesn't appear a crust when irrigating fields by furrows. Irrigation of fields by furrow creates suitable condition for the work of agricultural machines. Irrigating their fields by deep furrows, in the way of less water floating, the collective farmers of the Aghdash region used to get rich cotton. Water norm in the fields of those collective farmers diminished from 1200-1500 m^3 to 600-800 m^3 per-ha. in the result of this measure, they barred the rising of subsoil waters up and didn't allow re-saline process.

In order to spread water to the field equally, having of the definite depth of irrigation furrows is important. According to the practice of advanced collective farms and scientific-research institutions, there had been defined that the depth of irrigation furrows had to be 14-16 *cm* for the first vegetation irrigation and 18-20 *cm* – for the following irrigations.

The importance of winter irrigation in the struggle of salinity of soils is great. As it is carried out in the period of weak evaporation, it causes the creation of more water stock in the soil. The soil is cultivated well when hot days begin. At the same time, plants cast a shadow to the field, weakening the evaporation of waters from the surface and thus, protect soils from salinity.

In the result of leaking of water from canals, there come forth water losses. In order to bar the additional water losses, it is necessary to diminish water permeability of the beds and sides of canals. There are a number of ways of diminishing of water permeability of canals at present. The easiest and cheapest of these ways is fixing of canals by heavy machines.

In some cases, forming artificial clay layer in the beds and sides of canals, one can bar the leaking of waters (V.V.Yegorov, 1954).

Recently, Academician A.I.Sokolovsky artificially created the process of salinity in the beds of canals by sodium chloride (NaCl) and advised this way for barring of water losses.

Planting trees and bushes along of canals also helps to bar water losses. Wood plants, having got long root system, assimilate leaking from canals waters before their reaching of subsoil waters and evaporate them through their leafs. In fact, wood plants increase the damping of the air and weaken the evaporation of waters from the surface. At the same time, wood plants evaporate subsoil waters as well and diminish their level very much. That is why it is offered to pant wood plants in both sides of all irrigation canals in the Shirvan plain. It is also advised to plant trees and bushes along the roadsides, in the borders of sowing fields and n the rivers with shallow subsoil waters. It is expedient to create parks and fruit gardens in the areas with shallow subsoil waters (not very saline).

As we have mentioned above, having appeared in the result of weathering of rocks in the mountains surrounding the Shirvan plain from the north, productions are washed by surface waters and carried to the plain. In order to bar this washing, it will be correct to form forest stripes consisting of fruit trees here.

It is advised to plant the following tree types for melioration aims in the Shirvan plain: poplar, elm, amorphous tree, white acacia and oak; from fruit plants: pomegranate, fig, mulberry, pear, olive, pistachio and cherry-plum. These trees develop well in the plain part of the republic. At the same degree, they don't feel themselves badly in the soils with high and average salinity. Planting of fruit trees is significant from the point of economy as well.

2. Agro-technical measures against salinity

Main measure in the struggle against salinity is to bar the evaporation of subsoil waters from the soil. As Academician V.R.Williams indicated, in comparison with structural soils, soils without structure evaporate subsoil waters more and rapidly.

Apart from diminishing of evaporation, structural soils increase water capacity, creating god conditions for accumulation of foodstuffs and air.

It is possible to improve the structure of soils in different ways. Sowing of leguminous plants, especially, alfalfa improves the structure of soils very much. Roots of alfalfa can go to 2 *m* of depth of soils. At the same time, roots of alfalfa can horizontally spread in fields as well. Such kind of case creates conditions for forming of heap-like structure in the soils with alfalfa plants. Alfalfa plant helps very much to the accumulation of foodstuff productions, especially nitrogen in soils.

As the root system of alfalfa goes very deeply, it uses subsoil waters and evaporates them very much, diminishing their level. Alfalfa plant can diminish the level of subsoil waters for 50-100 *cm* during one vegetation period. The surface of lands in the fields with thick alfalfa plants is shadowed and evaporation weakens, which protects soils from getting saline.

One of the important agro-technical measures in the struggle against salinity is the carrying out of deep autumn plough of soils. In the result of autumn plough though temporary, there appears heap-like structure, break capillary pipes and thus, the amount of evaporation going onto surface diminishes.

In order to bar salinity, soils must be correctly cultivated and sowing must be carried out according to agro-technical regulations. Sowing norm must be raised a little in saline lands.

The practice shows that after the irrigation of arable fields, cultivating of fields in time and with high quality is very important in order to bar salinity. It would be very nice that in arable fields, especially in having saline areas, cultivation is carried on as soon as the upper layer of lands get dry, i.e. in 2-3 days after irrigation. There had been defined that, delaying for three days of cultivation after irrigation causes of 50% of water loss through evaporation.
In many cases, under-plough layer of soils of the Shirvan plain appears very hardened. Such state prevents the pass of water into lower layers of soils and creates useful condition for the rise of subsoil waters to the upper layers. That is why it is advised to soften that layer by chisel in every 3-4 years.
Together with the struggle against salinity of lands, at the same time, it is necessary to adopt plants to develop in that state giving high harvest. Our physiologists had carried out great works in solving of this problem. Especially the experiment, having carried out by the physiologist P.A.Gengel (1954) is interesting.
He soaked cottonseeds in formalin and kept having swelled seeds in 3% solution of NaCl (table salt) for an hour and then washed them by water during an hour and a half. V.A.Kovda advices to soak cottonseeds in salty subsoil water instead of NaCl solution. Seeds are sowed after this operation. Seeds, having prepared by this way, are very firm to salts and give harvest for 1,5-2 times more than ordinary seeds. It can be observed from table 14.
From cottonseeds, having worked out from the mixture of salts of potassium, phosphorus and nitrogen acid can be got nicer results.

Table 14

Number of cotton plant bolls and harvest (P.A.Gengel)

Cotton seed centner	Number of bolls on a cotton bush	Cotton crop	
		sentner hectare	in %
Not mixed in solution	13	11,6	100
Mixed in solution	19	20,6	177

There are also met areas with not regularly saline fields in many parts of the Shirvan plain. All of these must be barred in time, as not regular saline places are considered main sources of general salinity. In order to fight against not regular saline soils, one must make smooth high and sunken places of the field and irrigate the same place. In this case, waters, having delivered equally in all places of the field, wash saline parts and free them from salts.
Fields with less salinity can be improved by preventive irrigation, giving 1200-1500 m^2 of water to per-ha in autumn and winter months.
If the field is very wide and with heavy salinity, then other ways are demanded for their melioration (improving).

3. Fighting measures against saline soils

Subsoil waters can be in different conditions in the nature. Subsoil waters have natural flows in some sloping places. In such cases, subsoil waters get less saline. However, there are cases that, subsoil waters don't have natural flow, being in static. In this case, as subsoil waters dissolve the salts in mother rocks

for a long period, they become saline very much. If having got saline subsoil waters are located in shallow, they increase evaporation very much. Such state causes the salinity of the soils during very short period. There is not natural flow of subsoil waters in the described territory of the Shirvan plain. That is why, as we've mentioned above, great part of soils here got saline. In this case, one can ask: "In order to fight against the salinity of soils, can't we create artificial flow of subsoil waters for diminishing the level of subsoil waters?". Of course, we can! At present in all soil fields of Azerbaijan (in the Mughan, southeast Shirvan and Salyan plains) this measure is carried out.

Creating of artificial flow and thus, diminishing the level of subsoil waters can be achieved by the way of drainage as well.

Some people indicate that as if the struggle against salinity of soils had appeared in America at first. This is not right. When there had been carried out a struggle against salinity by drainage in the Middle Asia (in Fargana valley) by the ways of "zaur" or "zakesh", America was not discovered by Europeans yet. In fact, this method had had a number of shortages then. By later on, scholars had been improved that method very much.

Draining of fields can be carried out by some ways. The most spreading way in our country is the putting into practice a horizontal deep open drainage at present. This is a deep canal – a collector with the depth of 3-4 *m*, sometimes reaching 5 *m*, having dug in definite distance from each other. As a rule, collectors are dug very far-between. However, in order to speed up of diminishing of the level of subsoil waters, there are dug some small drains as well. In the soils with heavy mechanical composition, in addition to small drains, there are created subsoil drains among collectors by special ploughs. It speeds up the flow of subsoil waters to collectors. We think that such kind of drainages can be built in the Garassu valley of the Shirvan plain, changing it into the main collector and using for the area surrounding Garassu.

The other kind of drainage is horizontal closed one. It is dug as horizontal open drainages, then, porous glazed earthenware pipes are put and covered by gravel or brick pieces and then, by earth. In comparison with open drainage, closed one demand much more means. That is why such drainages are used very little.

In addition to these, there exists a vertical drainage as well. Vertical drainages are wells, having dug about 1 *km* from each other, in the places with shallow subsoil waters. Salty subsoil waters, having leaked into these wells, are carried away to other places by pumps. Vertical drainages must be made not in all places, but in the areas with light mechanical composition. It doesn't give positive results in the soils with heavy mechanical composition. We think that, vertical drainage can be used in the middle part of cones, having brought by rivers of lawn saline soils with shallow subsoil waters. Mechanical composition of soils here is light and subsoil waters have un-flow character.

It must be mentioned that having got saline soils can't be improved by digging of drainage canals only. At the same time, one must wash saline areas. Before the washing of saline lands, weeds and stone pieces must be cleaned and there must be carried out deep plough. Then, cuts and spaces must be filled and the surface of the field must be evened perfectly. It will be nice if the ploughed field is squeezed by heavy machine, as, when plough is soft, it can cause an additional use of water and less washing of salts. Thus, after preparing of the field, it is divided into different spaces and defined amount of water is given them by norms. It is advised to give the defined water norm in 2-3 portions. In this case, salts are washed more rapidly and can be taken away easily.

In order to wash saline soils from salts in the Shirvan plain, because of the types of soils, their chemical composition and amount of salts in their composition, there is needed 6000-12000 m^3 water norm. In some fields, especially saline-salinity lands 12000 m^3 of water is less for washing of salts completely. 6000-8000 m^3 of water norm is enough for washing of alluvial light soils in rivers-side fields of the Shirvan plain. *In* this case, salts in the composition of soils are averagely washed for more than 2 times.

We have mentioned above that the soils of the Shirvan plain mainly get saline by sulphate salts. In these cases, Mirabelle salt – $Na_2SO_4 \cdot 10\ N_2O$ prevails both in soils and in subsoil waters. As Mirabelle salt dissolves in water in high temperature, it is advised to wash these kind of soils, being spread in the

Shirvan plain, in spring-summer months. M.A.Aghamirov's experiments (1954), having carried out in the western Shirvan gave positive results.

When washing saline soils, together with harmful salts, food substances also are washed away. At the same time, the structure of soil is destroyed and air-water regime becomes worse. Because of it, planted cotton in the washed field does not grow up well, giving less harvest. In order to improve these characters of soils and to get high cotton harvest, after washing of saline lands, it must be fertilized and there must be planted one-year vegetations, especially solid to salinity plants. Plants, having planted with this aim in the Shirvan plain as sweet Indian millet, Indian broom millet and sunflower, give good results. After one-year of grass plants, there is planted chamomile and alfalfa, being solid to salinity, in order to form heap-like structure and food store. Cotton plant can be planted after these measures. According to the information of A.K.Akhundov, M.A.Aghamirov and T.A.Mammadov (1954), among the above-mentioned plants the best result is taken from Odessa sudanca. This plant shadows the ground well, barring evaporation and protects it from getting saline again. Together with shadowing of the surface of soils, the vegetation of Odessa sudanca lasts up to the end of autumn. This plant is useful for forage, giving a lot of grass.

Recently, in order to use clayey saline soils with less water permeability, there is carried out the ways of furrow and strip.

Zolotaryev and M.I.Dashevsky in the Middle Asia, M.A.Aghamirov, A.K.Akhundov and T.A.Mammadov in Azerbaijan had achieved good information about it.

Washing of soils with less water permeability (0,6-1) in the Shirvan plain by the ways of furrow and strip gives nice results. In the soils, having washed by this way, solid to salts shabdar plant develops well and gives rich harvest.

LITERATURE

1. Абдуев М.Р. О водном режиме почв восточной части Ширванской степи. Труды Ин-та почвоведения и агрохимии АН Азерб. ССР, т. 7, Баку, 1955.

2. Абдуев М.Р. Динамика засоления почв Восточной Ширвани. Труды 4-й конф. аспирантов АН Азерб. ССР, Баку, 1955.

3. Абдуев М.Р. и Таиров Ш.Г. Водно-солевой режим почв Ширваниской степи. Тезисы докладов научной сессии, посвященной вопросам гидротехнического строительства, орошения и мелиорации Азерб. ССР. Баку, 1955.
4. Агамиров М.А. Опыт промывки засоленных почв в Геогчайском районе Азерб. ССР. Труды почв. ин-та им. В.В.Докучаева АН СССР, т. 44, 1954.
5. Агамиров М.А. Подбор наилучших культур-освоителей на промывных почвах Ширвани. Труды почв. ин-та им. В.В.Докучаева АН СССР,т. 44, 1954.
6. Агамиров М.А. и Кулиев М.Б. Об агротехнике освоения глинистых засоленных земель в условиях Ширванской степи Азер. ССР. Труды 6-й сессии АН Туркм. ССР. Ашхабад, 1954.
7. Ахундов А.К., Агамиров М.А., Мамедов Т.А. О работе одиночной горизонтальной дрены и об эффективности различных способов промывки без дренажа в Западной Ширвани Азерб. ССР. Труды 6-й сессии АН Туркм. ССР. Ашхабад, 1954.
8. Волобуев В.Р. Засоление почв в Азербайджане в естественно-историческом и мелиоративном освещении. Баку, 1948.
9. Волобуев В.Р. Промывка засоленных почв. Баку, 1948.
10. Волобуев В.Р. Предупреждение и борьба с засолением почв. Изд. АзФАН. Баку, 1941.
11. Генкель П.А. Солеустойчивость растений и пути ее направленного повышения. М., 1954.
12. Горбунов Н.И. и Бекоревич Н.Е. природа образования почвенной корки и меры борьбы с ней. «Почвоведение», № 4, 1951.
13. Зейналов А.К. Засоленные почвы Евлахского района. Труды Ин-та почвоведения и агрохимии АН Азерб. ССР, т. 5, 1951.
14. Егоров В.В. Засоление почв и их освоение. М., 1954.
15. Иванова Е.И. и Розанов А.Н. Классификация засоленных почв. «Почвоведение», № 7, 1937.
16. Ковда В.А. Происхождение и режим засоленных почв, ч. 1. М., 1946; ч. 2, 1947.
17. Ковда В.А., Егоров В.В., Морозов А.Т., Лебедев Ю.П. Закономерность процессов соленакопления в пустынях Арало-Каспийской низменности. Труды почв. ин-та им. В.В.Докучаева АН СССР, т. 44, 1954.
18. Лукашевич О.И. Геологический очерк района Мингечаурской котловины на реке Куре. Тифлис, 1932.
19. Почвы Азербайджанской ССР под ред. Г.А.Алиева и В.Р.Волобуева. Изд. АН Азерб. ССР. Баку, 1955.
20. Приклонский В.А. Гидрогеологический очерк низменности Восточного Закавказья. «Материалы к общей схеме использования водных ресурсов Кура-Араксинского бассейна», т. 6. Тифлис, 1932.
21. Розов Л.П. Мелиоративное почвоведение. М., 1936.
22. Салаев М.Е., Зейналов А.Г., Шярифов Е.Ф. Земли Карабахской низменности (на азерб. яз.). Баку, 1955.
23. Тюремнов С.И. Общий очерк солончаков Восточного Закавказья. Труды Кубанского с.-х. ин-та, т. 6. Краснодар, 1929.
24. Хаин В.Е. Краткий геологический очерк эпицентральной зоны Шемахинских землетрясений. «Изв. АН Азерб. ССР», № 3, 7, 1953.

CONTENTS

Passed to type-setting: 20.04.2006
Passed to printing: 15.11.2006
Size of paper: 84x108 1/32. 2 quires.
Order: 166. Edition-500.

Printed in
CBS POLYGRAPHIC PRODUCTION
Tel/Fax: 447 75 04, Tel.: 447 75 05