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Evolution, Transformation and Biological Activity of Degraded Soils

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Abstract

The features of morphogenetic characteristics, degree of gypsation and salinization, humusstate, total chemical composition, time history (over the years) of gray-brown, desert-meadow, meadow-alluvial, marsh-meadowsoilsoftheterritory are considered in the paper; the formation of a new genetic group of soils as a result of ecological-genetic aspects, transformation and evolutionary changes in the soil processes occurring under anthropogenic factors are determined;the formation of prairiefication processes as a result of soil transition from the automorphic to the semi-hydromorphic and hydromorphic regimes under the influence of the Tuyamuyun reservoir is determined; soil fertility of the territory is estimated according to their current state and properties; soil and soil-assessment maps, as well as the maps of crops distribution are developed.Determination of the influence of gypsum content and degree of salinization on enzymatic activity (catalase, peroxidase, polyphenol oxidase) and “soil respiration”, as well as on their alterations over the seasons of year; indicators of biological activity (BA), total relative biological activity (TBA) of soils, indicators on soil degradation have been developed. The aim of research is to determine the current state of the Tashsaka Plateausoils, the irevolution and climatic conditions, fertility assessment and the development of measuresaimedat distribution of agricultural crops, is a comprehensive study of the seasonal dynamics of the basic properties and biological activity of gypsum soils, development of criteria for the indicator of their degradation. The objects of study are the virgin and irrigated gray-brown, gray-brown-meadow, desert-meadow, meadow and marsh-meadow soils spread in the Tashsaka Plateau and adjacent territories of the Khazarasp region of Khorezm district, are gypsiferousand saline gray soils, meadow- gray soils, gray soils -meadow, meadow, meadow-marsh soils, as well as salt marshes soils, common in Zarbdar district of Jizzakh region.

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1. Introduction

Today, the world's growing population and the demand for food require rational and efficient use of land resources. “The majority of currently cultivated lands with adapted farming systems are of high (23% of the area) and good quality (53%). In recent years, interest in the development of gray-brown soils has increased. Gray-brown soils occupy 2% of the total area of Earth"(www.fao.org.). These soils are widespread in North America, Syria, Iraq, Saudi Arabia, China and Central Asia, and are of poor quality.

Scientific research is carried out all over the world on the restoration, preservation and enhancement of soil fertility, the prevention of negative processes occurring in them, the analysis of chemical, physicochemical properties of soil. Particular attention is paid to the implementation of scientific research in the definition, simulation and forecast of soil evolutionary processes, mapping, preservation and enhancement of fertility, improving the soil meliorative condition, and creating a database.

At the present time, investigations are conducted in the world: on determination of genesis (origin) and elicitation the properties of gypsiferoussoils, on research of alterations in soil cover during irrigation, on elimination of negative impacts on the soil, identification of the factors causing soil gipsation, on development of technologies to reduce the effects on growth and development agricultural crops taking into account soil gipsation. However, scientific investigations on the enzymatic activity, “soil respiration” properties, humus amount, and salinity level of gypsiferoussoils, the dynamics of changes over the seasons of year, soil indicators of degradation, biological activity indicators (BA), and the determination of the correlation between the properties of gypsum soils territories were not adequately performed.

Soil samples, taken according to genetic horizons, observations, and agrochemical and chemical analyzes of soils were carried out on the basis of methodological guidelines, such as the “Methods of agrochemical, agrophysical and microbiological research in irrigated cotton areas”, the methods by E.V. Arinushkina “Manual on chemical analysis of soils" [1], the soil analysis methods approved by Research Institute of Soil Science and Agrochemistry; and on the basis of the last edition of the "Instructions for the conduct of soil studies and plotting soil maps for the State Land Cadastre". Soil enzymes activity was determined by the methods of soil enzymology described by F.Kh. Khaziyev [1972]: catalase by the gasometric method according to Kruglov and Paromenskaya, peroxidase and polyphenol oxidase - according to Karagina and Mikhailovskaya. Mathematical-statistical analysis of the data obtained was performed according to B. A. Dospekhov’s methodology.

Laboratory and analytical studies included the following definitions: - humus; described in the manual "Methods of agrochemical, agrophysical and microbiological research in irrigated cotton areas". Tashkent, 1963

2. Materials of research

Large-scale research was conducted to study low fertile gray-brown soils. Such studies were conducted by foreign scientists: [25], [10], [26], [27] and others, by Uzbek scientists: [5], [4], [7,8], [23,24], [13,14], [20,21,22], [19]. [2,3], [6], [11,12], [10], [15],[16,17,18] and others. However, the conducted research and practical mechanisms for the utilization of virgin and irrigated lands in most cases are of a general nature; studies on the peculiar properties of assessing the ecological and genetic aspects of soil evolution and fertility have not been adequately carried out.

The construction of the Tuyamuyun reservoir, adjacent to the Tashsaka Plateau, increased the transition of automorphic soils to semi-hydromorphic and hydromorphic ones. Givenallthesefactors, wecandistinguish 3 stagesofsoilformation.

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1. Automorphic stage. The occurrence of groundwater levels is deeper than 5 m. The period of development of virgin soils covers the time until 1960.
2. Semi-hydromorphic stage. The period of gradual rise in the groundwater level covers the years 1960-1990.
3. Hydromorphic stage. The rise in the groundwater level to the day surface - wetting, in some places, waterlogging and salinization, the period is from 1990 to 2018.

Over this entire period, one can trace the transformation of virgin gray-brown soils into irrigated gray-brown-meadow, meadow and meadow-marsh soils.

Each type of soil in this chain has its own morphogenetic features depending on the conditions of formation.

Irrigated gray-brown and gray-meadow soils retain the signs of original virgin soils, such as the brownness, carbonate content; while in meadow and marsh-meadow soils, these signs disappear and the signs of prairiefication and swampiness appear.To some extent, the content of movable forms of phosphorus and potassium increases. There have been evolutionary changes in humus composition and, to some extent, in total chemical composition of the silicate part of soil, in the movable forms of sesquioxides discussed above. Under low drainage of the territory, conditions are created for secondary salinization processes. The chlorine ion content in irrigated meadow soil increased to 0.066%, which refers these soils to the ones of medium salinity.

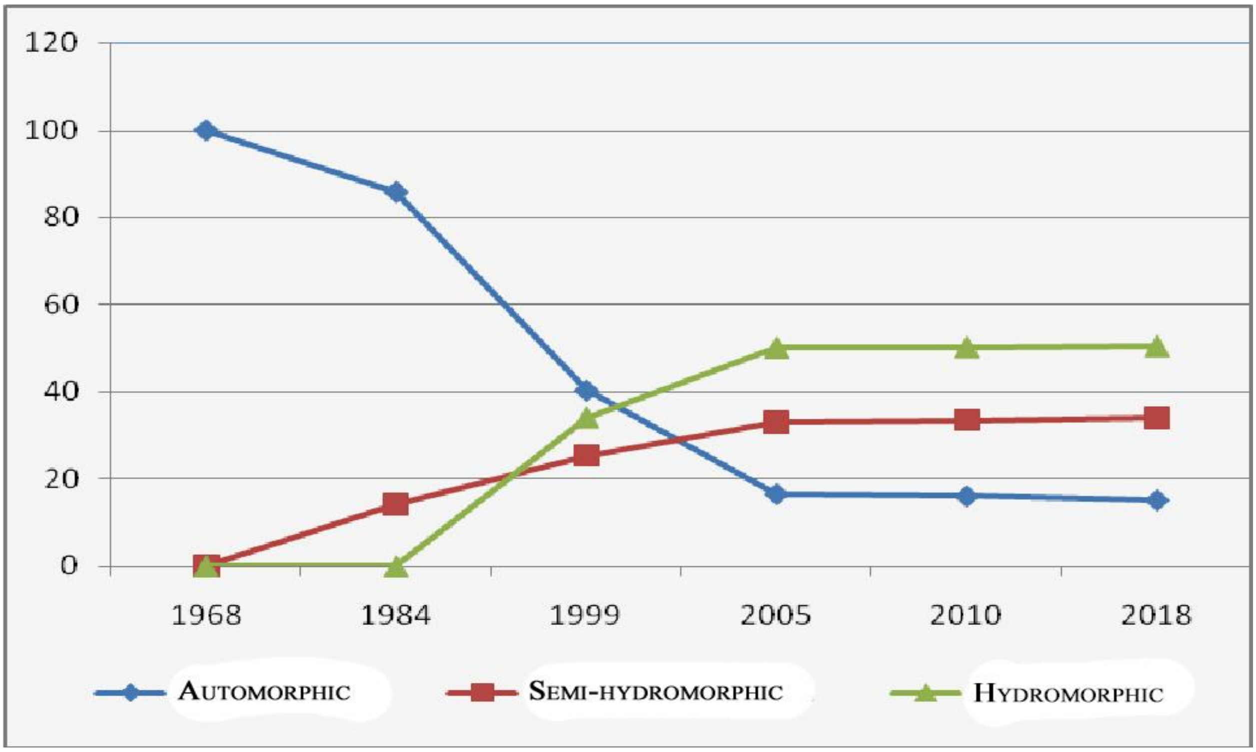

Figure.1 Time-history of the wetting regime of gray-brown soils for the period of 1968 - 2018

Variational-statistical processing of the research results shows that in new irrigated gray-brown-meadow soils, as compared to new irrigated gray-brown soils, there is an increase in humus content in the arable horizon. Among hydromorphic soils in old-irrigated meadow soils, there was an increase in humus by more than 2 times - from 0.351% to 0.743% (Table 1.). These data are directly related to the soil cultivation, morphogenetic and chemical properties of soil. As

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discussed above, a change in the qualitative composition of humus from fulvate to fulvate-humate one and an increase in hydromorphism and the time of irrigation directly affected its content. As evidenced by the data obtained by M.M. Tashkuziev, the impact of the anthropogenic factor acting for a long time together with the conditions of formation lead to evolutionary transformations of soils.

These are, first of all, the improvement of meliorative condition of lands, correct selection of crops and corresponding agricultural technology. Particular attention should be paid to crops distribution. Rice should be sown in the marshy and water-prone soils. On semi-hydromorphic soils cotton culture is alternated with grain-growing.

Alternation of crops should be carried out in accordance with the developed crop rotation schemes. In 2005, the area of irrigated gray-brown soil was 107 hectares only, or 1.41%, and irrigated medow soil - 3,301 hectares or 42.6% of the total area, the part of marsh-meadow soils was 586 hectares or 7.3%.

Table 1

Variational and statistical indices of humus content in the irrigated soils of the TashsakaPlateau and the Old river channel Daudan depending on the conditions of formation and the time of irrigation

Humus,% X	Averag e err-or, m	Standard deviation, σ	Credibi-lity index, P %	Cons-tant of varia tion, V, %	Average degree of reliabi-lity, t	Number of observa-tions, n
Newirrigatedgray-brownsoilsofTashsaka Plateau						
0,28	0,033	0,126	11,8	45	8,48	15
Newirrigatedgray-brown-medowsoilsofTashsaka Plateau						
0,361	0,038	0,142	10,5	39,3	9,5	15
Newirrigatedmarsh-medowsoilsofTashsakaplateau						
0,351	0,037	0,137	10,5	39	9,5	15
Old-irrigated meadow soils of old river channel Daudan						
0,743	0,046	0,173	6,12	23,3	16,1	15

In 1968, the staff members of affiliated company “Yer cadastre” of the Institute “Uzdaverloyiha” revealed 7747 hectares of virgin gray-brown soils on the Tashsaki Plateau, and in 1984 the soil map showed 5,291 hectares of virgin gray-brown soils, 1360 hectares of irrigatedgray-brown soils and 1096 hectares of irrigated gray-brown-meadow soils (Figure 1, Table 2).As can be seen, an intensive irrigation has led to a redistribution of the ratio of soil genetic groups, increasing the areas of semi-hydromorphic and hydromorphic soils, changing their morphological properties.

According to morphological indicators, soils of the investigated areas are distinguished by the presence of the following main morphological properties: relatively weak humus layer, the presence of a sod layer in the soil section of virgin soils on gypsum content and salinity, CO_2 on the presence of carbonates throughout the soil profile, distinct development of microaggregates and soil compaction down by profile.

At determination of salinization type and degree, content of easily soluble salts in their composition was taken into account. Depending on the quantity and distribution of salts along the profile, the following soils were identified: non-saline, weak, medium, strongly saline and salt marshes. The chlorine content in the soils is a

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small amount and is 0,003-0,056%, in highly saline horizons its amount reaches 0,203-0,262%. In most cases, the type of salinization is sulphate, in places it is chloride-sulphate. According to recalculation on the basis of $CaSO_4$* $2H_2O$ in the soil composition, the amount of SO_4 gypsum varies from 10-17% to 37-41%.

According to calculations of main sections based on soil samples, in the upper soil horizon the amount of salts on Cl^-, SO_4^- have a wide range of fluctuations, and an increase from 15,2 t / ha on slopes to 271,0-337,6 t / ha in bottom loops, and here, respectively, the proportion of chlorine was 0,44-22,8, and the proportion of sulfates was 6,6-177,6 t/ha.

In the mechanical composition of irrigated soils, amount of particles of different diameters have a wide range of fluctuations: including the number of particles of coarse sand varies (> 0.25 mm) from 1,6 to 3,0%; particles of fine sand (0,1-0,05) from 4,1 to 19,4%; coarse dust (0,05-0,01) from 12,3 to 33,7%; average dust (0,01-0,005) from 9,8 to 46,5%; fine dust (0,005-0,001) from 20,8 to 52,5%. Such variegation is also characteristic of clay particles (<0.001) and its value ranges from 1,3 to 18,5%. The amount of physical clay (<0,01 mm) in the composition of the studied soils varies within 53,6-81,6%. Irrigated meadow-sierozem soils (sections 17,18), by their mechanical composition, are mainly medium loamy, partly there are heavy and light loams, the lithological section has a sharply layered character. In the mechanical composition of irrigated meadow-sierozem soil, the number of particles varies widely: in particular, particles of coarse sand

Table -2
Time hystory of irrigated soils area for the period 1968 – 2018

Soil group	1968		1984		1999		2005		2010		2018	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Virgingray-brown	7747	100	5291	68.3	2022	26.1	1186	15.3	1103	14,6	1013	13,0
Irrigated gray-brown	-	-	1360	17.6	1108	14.3	107	1.4	150	1,9	175	2,3
Irrigated gray-brown-medow	-	-	1096	14.1	1969	25.4	2567	33.1	2597	33,5	2642	34,1
Irrigated medow	-	-	-	-	2648	34.2	3301	42.6	3311	42,7	3320	42,9
Irrigatedmarsh-medow	-	-	-	-	-	-	586	7.6	586	7,6	597	7,7
Total	7747	100	7747	100	7747	100	7747	100	7747	100	7747	100

(> 0.25 mm) vary in the range of 0,4-8,4%; medium sand (0,25-0,1) from 0,1 to 2,1%; fine sand (0,1-0,05) from 9,2 to 25,7%; coarse dust (0,05-0,01) from 43 to 62,0%; average dust (0,01-0,005) from 7,3 to 10,5%; fine dust (0,005-0,001) in the range of 5,6-13,2%. Such variegation is also characteristic of clay particles (<0,001) and its value ranges from 9,2 to 19,5%. The amount of physical clay (<0,01 mm) in the composition of the studied soils varies within 24,4-37,4%.

According to the investigations results of general physical properties of soils, low amount of the volumetric mass, relatively high specific gravity, and the correspondingly high amount of porosity express a homogeneous characteristic of sierozem soils in the upper zoning in terms of

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mechanical composition. Relatively high volume mass of soils formed on layered proluvial horizons was noted in soil horizons with maximum gypsum content**.**

Gypsum content in the composition of the investigated soils, based on the classification of I. E. Pankova (1987), is divided into the following 4 categories:

• soils with low gypsum content (gypsum content is 2-10%), including virgin soils (5, 6 sections), gypsum content in these lands in the arable horizon was 2,37-9,1%;

• soils with an average gypsum content (10-20 %), including virgin soils (1, 2, 12 sections), irrigated soils (13, 14 sections), gypsum content in the arable horizon of these soils was 11,47-19,05 %;

• soils with a high content of gypsum (20-40%), including virgin soils (3, 4, 7, 8, 9 sections), gypsum content in the arable layer of these soils was 26,04-37,62%;

• soils with the highest gypsum content (> 40%), including sierozem-meadow soils of the investigated territories, and maximum gypsum content in these soils was 41,31-43,74%;

It should be noted that in the upper horizons of some studied irrigated soils (15, 16, 17, 18 sections) gypsum content does not exceed 2%.

Activity of studied enzymes in all soil types decreases down the profile. According to the results of research of the seasonal dynamics of enzymatic activity of Jizzakh steppe soils, it follows that the hydrothermal conditions in gypsum soils are of great importance in the biochemical processes occurring in the soils. Relatively high activity of enzymes was noted in the upper humus and non-gypsum soil horizons. In spring, a higher enzymatic activity of the soil was observed compared to autumn. In arid climatic conditions, that is, in conditions of low precipitation, there is a change in the seasonal dynamics of enzymatic activity under the influence of air and soil temperature during the summer. These processes are interconnected, and the highest level is noted in spring, in summer there is a slight decrease, and by autumn a noticeable increase (Fig. 2).

In the investigated soils, a decrease of respiration intensity is observed down the profile. Based on the obtained results, it can be stated that the intensity of respiration in the soil depends on soil formation processes and soil properties (Fig.3).

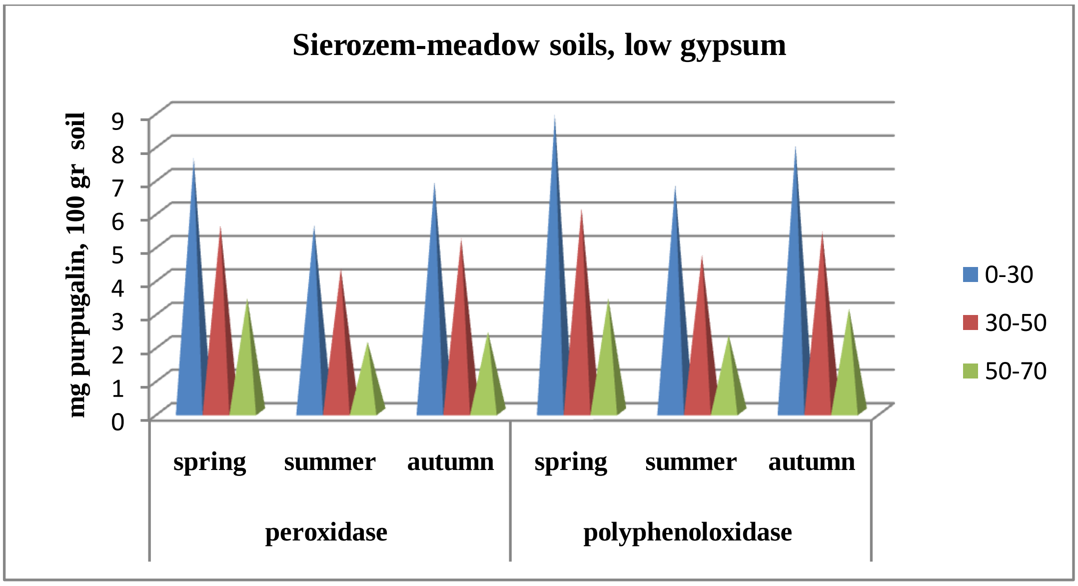

Fig. 2. Dynamics of peroxidase and polyphenol oxidase activity in the investigated soils by seasons of year

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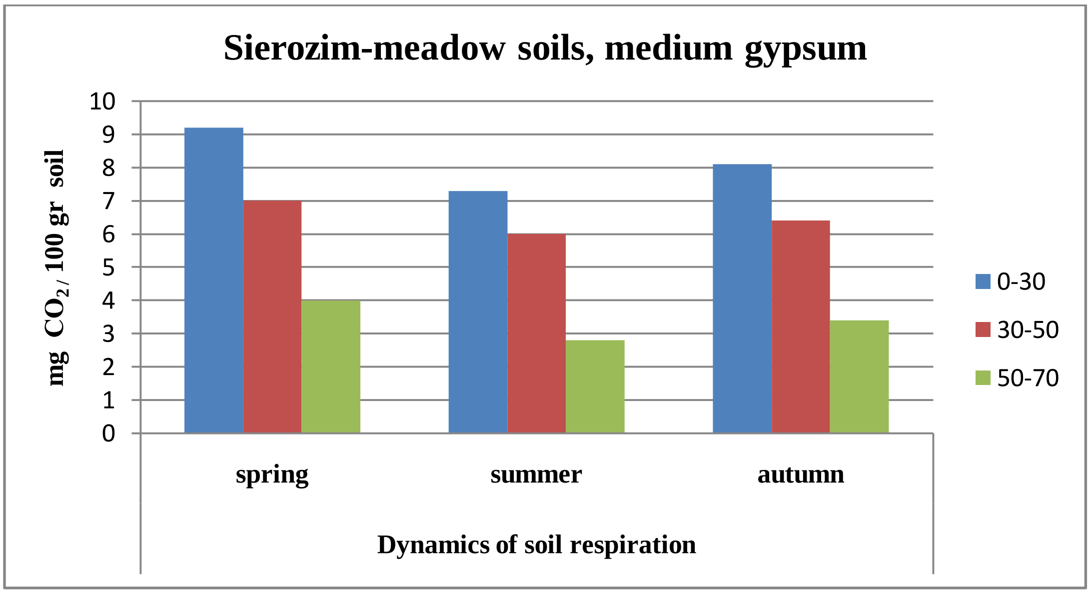

Fig.3. Dynamics of soil respiration by seasons of year

It was assessed biological activity (BA) of gypsum soils, effect of complex-comparative analyzes and the basic properties of the soil on relative biological activity of soils (RBA) on the gypsum content were studied. Relative biological activity of soils (RBA) in the amount of gypsum varies within 80%, a decrease in the relative biological activity (RBA) is observed (100-66-44-31-12). With an increase in gypsum content in soils with a weak - medium - high - and highest content of gypsum, a decrease in biological activity is observed (Table 3)

Table 3

Readings of biological activity (BA) of gypsum soils of Jizzakh steppe

Catalase, in 1 g of soil for 5 min.	Polyphenol oxidase, relative to 10 g of soil mg / puprurgaline	Peroxidase, relative to 10 g of soil mg / puprurgalin	Ammonifiers, KFUx10^3	Nitrificators, KFUx10^3	Cellulose decomposing,KFUx10^3	Actinomycetes, KFUx10^3	Fungus, KFUx10^3
Soils with a gypsum content of less than 2%							
13,2	8,6	7,3	5000	110	110	200	98
Low Gypsum Soils							
10,0	7,5	6,8	1800	30	40	180	82
Medium Gypsum Soils							
6,3	4,8	5,2	910	16	30	110	62
Soils are high in gypsum							
4,0	3,4	2,6	760	16	20	80	60
Soils with a very high content of gypsum							
2,4	1,8	1,2	250	1,5	0,5	43	15

Table4

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Indicators of degradation of gypsiferous soils of Jizzakh steppe

Readings	Soils not subject to degradation	Weakly degraded soils	Medium degraded soils	Highly degraded soils	Very highly degraded soils
Humus, %	>1,8	2,3	1,6	1,5	1,3
Dry residue, %	<0,6	0,6-0,9	1,0-1,8	2,0-3,0	>3
Amount of gypsum, % $CaSO_4*2H_2O$	>2	2-9	10-19	20-29	30-41
Toxic salts, by soil profile, %	>1,33	1,182	1,936	1,592	3,661
Groundwater salinity, g/l	2,4	8,4	12,6	16,4	25,1
On degree of salinization	Non salted	Lightly salted	Medium saline	Heavily saline	alkali soils
Relative BA	100	82	62	60	15
On to the content of gypsum	Non gypsum soil	Weakly gipsy soils	Medium gypsum soils	Heavily gypsum soils	Very highly gypsum soils

Comprehensive study of BA value of gypsum soils with different physicochemical, microbiological, and biochemical properties, as well as with an unequal soil structure, can clarify their ecological and genetic features, and can also clarify the extent of the impact of natural and environmental factors on soil fertility. Based on the results obtained, indicators of degradation for gypsum soils are recommended (table 4).

As a result of complex investigations, connection of total biological activity of soils was noted not only with the specific properties of the soil, but also the relationship with the surrounding system and processes.

At investigation of correlation between the properties of the soil in gypsum soils, a direct correlation was observed between microbiological and enzymatic activity with the content of gypsum (r = 0,70-0,90), this reflects dependence of gypsum soils on biological properties, as well as fertility and degradation processes in soils. Thus, all investigated soils are characterized by individual interconnection systems. As a result, it is possible to determine some general regularity of region's soils.

III. CONCLUSIONS

Evolutionary formation and gradual transition (transformation) of soils, as well as the changes in soil cover, are characterized by their relation to morphogenetic properties. Genetic groups of soils are distinguished by evolution and transformation: automorphic virgin gray-brown, irrigated gray-brown, gray-brown-meadow, meadow, meadow-marsh, desert-meadow, desert-sand, salt-marshes, sandy complexes.

Recently, the transition of soils from automorphic regime to semi-hydromorphic and hydromorphic regimes has been observed as a result of the irrigated land expansion under the influence of irrigation. As a result, irrigated gray-brown soils were formed from virgin gray-brown soils, desert-meadow soils - from desert-sandy soils, meadow-marsh soils - from meadow soils.

It has been determined that as a result of evolutionary transition of primary soils to the modern state, easily soluble salts in the

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composition of irrigated gray-brown and gray-brown-meadow soils were washed away as a result of irrigation, and non-saline, and in some cases, medium saline (as a result of groundwater level rise) gray-brown-meadow and meadow-marsh soils were formed.

In the studied soils, various effects of soil gypsum content, degree of salinization on the number of physiological groups of microorganisms, enzyme activity and carbon dioxide (CO_2) emission were determined. There was a decrease of biological activity (BA) of soils according to the degree of gypsation: non-gypsy soils - weakly gypsy soils - medium-gypsum soils - strongly gypsum soils - very strongly gypsy soils.

It is observed variation in relative biological activity (RBA) in the amount of gypsum within 80%. A decrease in the relative biological activity (RBA) (100-66-44-31-12) with an increase in the gypsum content was determined in the following decreasing order of soil with a content of less than 2% gypsum: low - medium - high - very high. The correlation between the number of microorganisms, enzyme activity, the content of humus and nutrients (r = 0,70-0,90) in soils can be used as a test to determine the amount of gypsum and manage it.

Criteria of indicators for gypsum, degraded soils serve as a scientific basis for the placement of crops, taking into account soil properties, development of measures for the rational use of soils.

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