Geobotanical indication of flooding and salinization of lands the Volga region and Western Kazakhstan

I A Trofimov¹, V M Kosolapov¹, L S Trofimova¹, E P Yakovleva¹, D M Teberdiev¹, A A Kutuzova¹, K N Privalova¹, A V Yemelyanov², E V Skripnikova² and B Koshen³

¹ Federal Williams Research Center of Forage Production & Agroecology
1 st. Nauchny gorodoc, Lobnya, Russia, 141055
² Tambov Derzhavin State University. Institute of Natural Sciences
5 Komsomolskaya square, Tambov, 392008, Russia
³ Kokshetau State University Sh. Ualikhanov
76 Abaya street, Kokshetau, 020000, Republic of Kazakhstan

Corresponding author’s e-mail: viktrofi@mail.ru

Abstract. In order to study the spatial distribution of biological and ecological patterns on the territory of the Volga region and Western Kazakhstan, geobotanical indication of flooding and salinization of the lands these regions was carried out. Geobotanical indication is used in the study, assessment, mapping and monitoring of territorial complexes and their components and is based on the analysis of the relationships of the geographical envelope as a whole. The article is the result of many years of interdisciplinary research. It is based both on the data obtained by the authors as a result of agro-landscape and ecological zoning and in the course of field expedition research, and on the analysis of long-term series of statistical information and literature sources. Intensive economic activity that requires the use of large amounts water resources, against the background of modern climate changes, leads to waterlogging in large areas. The weakening or termination of economic activity, the decrease in the volume of water resources used under certain conditions leads to the spread of land salinization. Flooding and salinization of arid lands near reservoirs, channels, reclamation facilities, functioning and abandoned irrigation fields, etc. occupy significant areas and are of great importance as environmental problems in the Volga region and Western Kazakhstan. The most dynamic and fast-responding biotic component of ecosystems to the occurrence of flooding and salinization is vegetation.

In order to study the spatial distribution of biological and ecological patterns on the territory of the Volga region and Western Kazakhstan, geobotanical indication of flooding and salinization of the lands these regions was carried out. Geobotanical indication is used in the study, assessment, mapping and monitoring of territorial complexes and their components and is based on the analysis of the relationships of the geographical envelope as a whole.

The article is the result of many years of interdisciplinary research. It is based both on the data obtained by the authors as a result of agro-landscape and ecological zoning and in the course of field expedition research, and on the analysis of long-term series of statistical information and literature sources.
Water is one of the most important components of the biosphere, a necessary resource for the existence of humans and all living organisms. Water is necessary in the implementation of economic activities in agriculture, industry, energy, providing household needs.

On the other hand, water use can lead to "water environmental problems", negative consequences for human life and sustainable management.

Intensive economic activity that requires the use of large amounts of water resources, against the background of modern climate changes, leads to waterlogging in large areas. The weakening or termination of economic activity, the decrease in the volume of water resources used under certain conditions leads to the spread of land salinization.

Thus, as a result of irrational land and water use in the Aral sea basin, large-scale negative environmental consequences have occurred. The best agricultural lands were degraded, salted and put out of circulation, unique lands of the Delta plains were subjected to desertification, and the Aral sea disappeared irrevocably.

Biotic components of ecosystems, by their responses to changes in the quantity and quality of water resources, make it possible to detect the spatial distribution of water environmental problems.

Flooding and salinization of arid lands near reservoirs, channels, reclamation facilities, functioning and abandoned irrigation fields, etc. occupy significant areas and are of great importance as environmental problems in the Volga region and Western Kazakhstan.

The most dynamic and fast-responding biotic component of ecosystems to the occurrence of flooding and salinization is vegetation.

Over a long period of research, a vast amount of information has been accumulated on the impact of reservoirs, natural reservoirs, channels, reclamation facilities, and irrigation fields on the environment. It has received fairly complete coverage in scientific publications [1–7].

The following factors determine the impact of the environment on vegetation: location in the topography, soil and hydrological conditions. They, in turn, are derived from the climatic conditions, topography, parent species, flora and fauna of the surrounding territories, and the direct impact on vegetation of animals and humans [8–13].

The study of components of natural complexes in areas experiencing different impacts (flooding and assessment of the depth and extent of changes in the direction of hydro-morphization) is carried out on the basis of a system of indicators and criteria and specially developed scales. As well as in areas with saline ground water and (or) saline soils in arid conditions, where salinization of territories is observed [14–19].

In the Arsenal of geobotanical indication, an important role is played by the assessment of environmental conditions for vegetation, which we conducted using L G Ramensky's ecological scales. In L G Ramensky's ecological scales, the response of vegetation and individual plants to changes in soil, hydrological and other conditions of their habitat is taken as a basis. This reaction is expressed in the change of plant communities and changes in the abundance of each plant, depending on the change (increase or decrease) in the severity of the environmental factor [20].

The revealed regularities of vegetation relationships with other components of the biogeocenosis (natural-territorial complex) make it possible to determine the other components of the plant Association as one of the components. As a result, geobotanical indication provides the possibility of knowing the whole complex of phenomena, their physical and geographical content. This makes it possible to accurately assess the practical value of land, its appropriate use and improvement.

As a result of studying the spatial distribution of biological and ecological patterns on the territory of the Volga region and Western Kazakhstan, the authors established geobotanical indicators of flooding and salinization of the lands these regions.

Geobotanical indicators of land flooding, flooding and salinization include the following main indicators (table 1):
- Main phytocenoses,
- Main plants,
- Soil moisture and salinity according to L G Ramensky scales.
Table 1. Geobotanical of flooding and salinization of lands the Volga region and Western Kazakhstan.

| Indication objects | Geobotanical indicators | Soil moisture and salinity according to L G Ramensky scales |
|--------------------|-------------------------|--------------------------------------------------------|
| 1. Lands with episodic inundation by atmospheric and flowing water, constant and slightly variable moisture, with loamy saline soils | The main phytocenoses: White wormwood, white wormwood-cereals, white wormwood-pyrethrum | White and Austrian wormwood, desert wheatgrass, fescue, feather grass, hairy sedge, narrow-leaved sedge, pyrethrum tysyachelistnika, yarrow, whitebug, burachok desert |
|                    | The main plants:         | Humidification is semi-desert, desert-steppe (18–30), weak and medium saline soils (17–21) |
| 2. Land with episodic heating by atmospheric and flowing water, constant and slightly variable moisture, with loamy soils with strong salinity and salt | Black wormwood, white wormwood, wormwood-cereal, wormwood-twig, camphor, wormwood-camphor, wormwood-biyurgun | Black and white wormwood, camphorosma, pruntyak, fescue, oarticile, leafless and saline analbizis, annual hodgepodge, petrosimonia, prickly-leaved bedbug |
|                    |                         | Humidification is semi-desert (17–29), soils are weak, medium, and strongly saline (17–23) |
| 3. Lands with episodic and short-term flooding by atmospheric waters, weakly variable moisture, saline soils and solonetz | Solyanka, saline wormwood, saline wormwood-cereal-saltwort | Saline wormwood, oarticile, rattle, annual hodgepodge, petrosimonia, sveda |
|                    |                         | Humidification is desert-steppe, dry-steppe (22–37), medium, strongly-, and sharply saline (20–24) |
| 4. Land with short-term flooding by atmospheric and flowing water, soil and water are not saline | Wheatgrass, fescue, wheatgrass, cereal, cereal-al-forb, cereal-wormwood | Crested wheatgrass, fescue, creeping wheatgrass, thin-legged slender, feather grass of hairwort and Lessinga, narrow-leaved sedge, Austrian wormwood, tenacious woodruff |
|                    |                         | Humidification dry-steppe, meadow-steppe (30–52), unsalted or slightly saline soils (14–19) |
| 5. Land with short-term flooding by atmospheric and flowing water, not flooded or slightly flooded with fresh or brackish ground water at a depth of 2-5 m, slightly saline soils | Licorice, licorice-cereal-forb | Licorice naked, creeping wheatgrass, crested wheatgrass, cinquefoil forked |
|                    |                         | Humidification is steppe, meadow-steppe (40–50), unsalted or slightly saline soils (14–19) |
| 6. Land with short-term Dzhantak, djantak- | Dzhantak (camel) | Humidification is dry- |
| Land Type | Flooding Conditions | Vegetation | Humidification |
|-----------|---------------------|------------|----------------|
| 1.        | by atmospheric and flowing water, not flooded or slightly flooded with fresh and brackish (rarely salty) ground water at a depth of 2-7 (10) m, slightly saline, sometimes saline soils | cereal-forb, djangak-thorn, creeping wheatgrass, pin-worm, narrow-leaved sedge, cinquefoil, wormwood | steppe, medium-steppe (25–39), slightly saline soils (16–18) |
| 2.        | with moderate flooding by atmospheric and flowing water, weak or medium-thawed fresh or brackish ground water with persistent, sometimes weakly medium-level moisture, with saline, sometimes gleevatym soils | Wheatgrass, reed grass, wheatgrass-sedge, reed-sedge | Humidification is wet meadow (64–70), unsalted and slightly saline soils (12–19) |
| 3.        | with a long and permanent inundation, and (or) heavily flooded, with slightly varying degrees of hydration. Ground water is fresh or brackish. The soil is bare, not saline or slightly saline | Reed, bekman, reed-sedge forb, bekman-sedge | Moistening is damp meadow (77–88), unsalted and slightly saline soils (14–18) |
| 4.        | short-term or moderate flooding, slightly- or medium-flooded. Humidification is medium to highly variable. The soil is saline. | Wheatgrass, wheatgrass-cereal-forb | Humidification is wet meadow (77–88), medium-saline soils (19–21) |
| 5.        | short-term and moderate flooding or slightly and medium-flooded. Humidification is medium to highly variable. The soil is saline. | Azhrekovye, unclenaceous, cereal-forb | Humidification is wet and wet-meadow (70–83), medium and strong saline soils (20–22) |
| 6.        | with a short temporary and moderate flooding and (or) low- and medium-flooded. Moisture is highly variable. The soil is very, very salty and saline. | Saline wormwood, obion, obion-wormwood, obion-cereals, tartar swine | Humidification is dry and fresh-meadow (53–63), soils are strongly saline and saline (21–25) |
| Land Type | Soils Description | Plant Species | Moisture Range |
|-----------|-------------------|---------------|----------------|
| 12.        | Slightly flooded. Slightly- and medium-flooded. | Wheatgrass, fescue, cereal-wormwood, licorice, licorice-forb | Moisture from semi-desert to fresh-meadow (16–60), strongly and sharply saline and saline soils (23–28) |
| 13.        | Slightly flooded. | Wheatgrass, fescue, cereal-wormwood | Moisture from semi-desert to fresh-meadow (16–60), strongly and sharply saline and saline soils (23–28) |
| 14.        | Slightly- and medium-flooded. | Wheatgrass, wheatgrass-forbs, licorice, licorice-forb | Moisture is meadow-steppe (47–52), the soil is not saline (10–16) |
| 15.        | Slightly flooded. | Azhrekovo-mortukovy with hodgepodge | Humidification is dry and medium steppe (35–46), weak and medium saline soils (17–22) |
| 16.        | Not submerged or slightly submerged. | Dzhantak wormwood | Humidification is dry and medium steppe (38–47), medium-saline soils (19–22) |
| 17.        | Slightly flooded. | Wheat grass, unclean, pork grass, cereal and forb | Humidification is meadow-steppe and dry-meadow (47–63), slightly saline soils (16–20) |
| 18.        | Not saline | Wheat grass, reed grass, rump, cereal-forb | Humidification is wet-meadow (64–67), slightly saline soils (14–16) |
| Land Type                                                                 | Plant Communities                                      | Humidification | Soil Characteristics |
|-------------------------------------------------------------------------|--------------------------------------------------------|----------------|----------------------|
| 19. Land with prolonged flooding. Heavily flooded. Moisture is constantly stable or slightly variable. The soil is not saline | Beckmanniaceae, canary grass, large-grass, sedge, sedge-cereal, sedge-forb, sitnyag | Humidification is wet meadow (77–83), the soil is not saline (10–14) |                      |
| 20. Land with a moderate and prolonged flooding, medium-, and highly flooded. Moisture is weakly and moderately variable. The soil is saline | Uncilaceous, uncillic-herbaceous, reed-lurker | Humidification is wet and wet meadow (64–80), medium and strong saline soils (20–24) |                      |
| 21. Land with a moderate and prolonged flooding, medium-, and highly flooded. Moisture is weakly and moderately variable. The soil is very saline | Saline, saline-cereal-forb | Humidification is wet and wet meadow (68–80), strongly-, sharply-saline and saline soils (22–26) |                      |
| 22. Land of long-term flooding, heavily flooded. Moisture is weakly and moderately variable. Low - and medium-saline soils | Two-strand-sitnyag, sitnyag-wheatgrass, terb-chamois-sitnyag | Moistening is damp meadow (77–88), soils are weak and medium – saline (17–21) |                      |
| 23. Land of constant flooding, strongly flooded. Moisture is constantly stable or slightly variable. The soil is not saline or slightly saline | Reed, cattail, reed, sedge, headless, cereal-forb | Humidification of marsh-meadow and bogs (89–103), the soil is not saline and slightly saline (8–19) |                      |

Geobotanical indication of flooding and salinization processes in the Volga region and Western Kazakhstan is necessary for the management of ecosystems affected by them.

The advantages of geobotanical indication of the processes of flooding, flooding and salinization of territories are simplicity and reliability in use, economy and efficiency of monitoring the state and dynamics of development of these processes.

The withdrawal of land from agricultural circulation caused by flooding and salinization of soils is a major environmental and economic problem in crop production and irrigated agriculture. Natural conditions of territories that are agricultural are dangerous for the development of negative processes during irrigation: flat terrain, poor drainage, loess-like, clay saline marine deposits, excess of evaporation over moisture. Anthropogenic dangerous causes of land degradation are excessive irrigation rates that lead to rising ground water levels, flooding of adjacent land and salinization of soils.
Conclusions. Intensive human activities led to the emergence of waterlogging in large areas. The development of salinization, which accompanies moisture, caused the loss of soil fertility and the withdrawal of land from agricultural circulation. These processes are the main cause of modern water environmental problems in the Volga region and Western Kazakhstan.

Waterlogging and often accompanying salinization of the soil cause degradation and withdrawal of land from agricultural turnover, which reduces the efficiency of human economic activity in the agricultural landscape.

Geobotanical indication allows you to receive timely information about flooding and salinization of land for operational management of ecosystems.

References
[1] Climate, Ecology, Agriculture of Eurasia. Materials of the VII Int. Scientific-Practical Conf. Section "Protection and Rational Use of Animal and Plant Resources" Irkutsk, May 23–27, 2018 (Irkutsk: Publishing house: Irkutsk state agrarian University named after A A Ezhevsky)
[2] Bedareva O M 2009 Ecosystems of the Middle Deserts of Kazakhstan and their Inventory by Remote Sensing Methods Abstract of the Dissertation for the Degree of Doctor of Biological Sciences (Kaliningrad: Russian State University named after Immanuel Kant)
[3] Novikova N M, Konyushkova M V and Ulanova S S 2017 Arid Ecosystems vol 23 4 pp 11–21
[4] Novikova N M and Volkova N A 2016 Arid Ecosystems vol 22 4 (69) pp 52–63
[5] Nikolaeva O N 2018 Cartographic support of rational nature management of the region (Novosibirsk: Siberian state University of geosystems and technologies)
[6] Trofimov I A, Shamsudinov Z Sh, Orlovsky N S, Trofimova L S, Yakovleva E P and Shamsudinova E Z 2010 Adaptive Fodder Production I pp 26–35
[7] Otaev M K, Tuktarov R B, Tarbaev V A and Gafurov R R 2018 Advances in modern natural science 7 pp 183–188
[8] Novikova N M 2019 Ecosystems: ecology and dynamics vol 3 1 pp 5–66
[9] Trofimov I A and Kravtsova V I 1998 Space Methods of Geocology. Atlas Factors and types of desertification. Kalmykia (Moscow: Geographical Faculty of Moscow State University) sheet 53
[10] Trofimov I A, Kravtsova V I and Karpovich L A 1998 Space Methods of Geocology. Atlas Economic use of lands and desertification processes. Kalmykia. Map (Moscow: Geographical Faculty of Moscow State University) sheet 52
[11] Novikova N M 2017 Water Resources: New Challenges and Solutions. Collection of Scientific Papers: Dedicated to the Year of Ecology in Russia and the 50th Anniversary of the Institute of Water Problems of the Russian Academy of Sciences Sochi, October 02–07, 2017 (Novocherkassk: "Lik") pp 95–101
[12] Khitrov N B, Novikova N M, Vyshivkin A A and Volkova N A 2018 Ecosystems: ecology and dynamics vol 2 1 pp 34–72
[13] Novikova N M, Konyushkova M V and Ulanova S S 2018 Agroecology, Melioration and Protective Afforestation. Materials of the Int. Scientific and Practical Conf. Volgograd, October 18–20, (Volgograd: Federal Scientific Center of Agroecology, Integrated Land Reclamation and Protective Afforestation of the Russian Academy of Sciences) pp 410–413
[14] Semenov Yu M 2019 Geographical Studies of Asian Russia and Adjacent Territories: New Methods and Approaches. Proc. of the Int. Conf. Dedicated to the 70th Anniversary of the Faculty of Geography of Irkutsk State University Irkutsk, 01–03 October 2019 (Irkutsk: Irkutsk State University) pp 189–193
[15] Novikova N M, Konyushkova M V and Ulanova S S 2018 Arid Ecosystems vol 8 3 pp 213–224
[16] Trofimov I A, Trofimova L S and Yakovleva E P 2018 New methods and results of landscape research in Europe, Central Asia and Siberia. In 5 volumes vol 1 Landscapes in the XXI century: analysis of the state, basic processes and research concepts ed V G Sychev and L
Müller (Mосcow: publishing house "All-Russian Scientific Research Institute of Agrochemistry") pp 36–41

[17] Trofimov I A, Kosolapov V M, Trofimova L S and Yakovleva E P 2015 Proceedings of the Kuban State Agrarian University 54 pp 305–309

[18] Novikova N M, Volkova N A, Konyushkova M V and Ulanova S S 2018 Steppes of Northern Eurasia. Materials of the VIII Int. Symp. Orenburg, September 10–13, 2018 (Orenburg: Steppe Institute of the Ural Branch of the Russian Academy of Sciences) pp 695–699

[19] Novikova N M, Novikova A F and Konyushkova M V 2013 Biology Bulletin vol 40 10 pp 832–842

[20] Ramenskiy L G, Tsatsenkin I A, Chizhikov O N and Antipin N A 1956 Ecological Assessment of Forage Lands by Vegetation (Mосcow: Selkhozgiz)