To the characteristics of water-coastal flora steppe rivers of the central Caucasus

Z N Amalova¹, Z I Iriskhanova¹, L G Molochaeva¹, B A Khasueva² and L K Khashieva³

¹Chechen State University, Grozny, Russia
²Chechen State Pedagogical University, Grozny, Russia
³Ingush State University, Magas, Russia

E-mail: pk@chesu.ru

Abstract. When studying the vegetation of water bodies, it is necessary to pay attention not only to the vegetation of the water body itself, but also to the vegetation of the low part of its shores. Thus, we study plants with a different attitude to water: hydrophytes that are real aquatic plants, fully or mostly immersed in water. Hygrophytes, hygrophilous plants that live on excessively moist soil under neutral acidity conditions, are usually found in swamps, along the banks of water bodies, on the swampy soils of meadows and forests. The transition group between hydrophytes and hygrophytes is hygrophytes – amphibians or wetland plants (helophytes). They occupy both aquatic and humid habitats on the shores. Aquatic vegetation is divided into real aquatic and amphibian vegetation.

1. Introduction
Plants occupy the most important place in the diversity of human relations with nature. Their vital activity ensures the very existence of the biosphere in its current state.

The study of small rivers is especially relevant because their ecosystems respond extremely quickly to physical and geographical conditions and climate change, as well as to anthropogenic stress.

Studying the qualitative and numerical data of algocenoses allows us to establish the laws of the formation and functioning of biohydrocenoses, to monitor the ecological state of water bodies and determine possible ways to use them.

The most important problem of modern science is the study of biological diversity. In an era when the anthropogenic impact on the natural complexes of the globe is increasing; the relevance is especially huge.

2. Methods of the research
The data is based on an analysis of field studies and observations of the authors. Route-geobotanical, route-floristic methods were used taking into account the characteristics of aquatic plants [2–4, 10]. About 2500 herbarium plant samples were collected. Species are determined using the identifiers of I.S. Kosenko, A.I. Galushko [5, 12]. A comprehensive floristic analysis was carried out: systematic, biomorphological, ecological. Systematic analysis makes it possible to conclude which families occupy a leading position in the flora. Biomorphological analysis is the distribution of plant species based on their biormorph or plant life forms.

The macrophyte and hygrophyte groups in the biota of the rivers of the Central Ciscaucasia comprise 193 species combined into 42 families and 97 genera (Table 1).
Flowering plants living in water are called **hydrophytes**. Water for them is not only an environmental factor, but also a habitat [18].

**Table 1.** The structure of the water-coastal flora of the steppe rivers of the Central Ciscaucasia

| Families                        | Hydrophytes Genera (species) | Hydrophytes % | Helophytes Genera (species) | Helophytes % | Hygrophytes Genera (species) | Hygrophytes % | Whole flora Genera (species) | Whole flora % |
|---------------------------------|-----------------------------|---------------|-----------------------------|--------------|------------------------------|--------------|-------------------------------|---------------|
| Equisetaceae (the horsetail family) | (–)                        | –             | (–)                        | –            | (1)                          | 2.1          | (1)                            | 1.6           |
| Typhaeae (the cattail family)    | (–)                        | –             | 1(4)                       | 11.4         | (–)                          | –            | (1)                            | 2.1           |
| Sparganiaceae (a family of flowering plants) | (–)                        | –             | 1(2)                       | 5.7          | (–)                          | –            | (1)                            | 1.0           |
| Potamogetonaceae (the pondweed family) | 1 (6)                     | 35.3          | (–)                        | –            | (–)                          | –            | 1 (6)                          | 3.1           |
| Ruppiaceae (the widgeonweeds)    | 1 (1)                      | 5.9           | (–)                        | –            | (–)                          | –            | (1)                            | 0.5           |
| Najadaceae (the water-nymphs)    | 1 (1)                      | 5.9           | (–)                        | –            | (–)                          | –            | (1)                            | 0.5           |
| Alismataceae (The water-plantains) | (–)                        | –             | 1(3)                       | 8.6          | (–)                          | –            | (1)                            | 1.6           |
| Butomaceae                       | (–)                        | –             | 1(1)                       | 2.9          | (–)                          | –            | (1)                            | 0.5           |
| Hydrocharitaceae (tape-grasses)  | 1 (1)                      | 5.9           | (–)                        | –            | (–)                          | –            | (1)                            | 0.5           |
| Potamogetonaceae (the pondweed family) | 1 (3)                     | 17.6          | 1(1)                       | 2.9          | 2 (4)                        | 2.8          | 3 (8)                          | 4.2           |
| Ranunculaceae (the crowsfoot family) | 1 (3)                     | 9.1           | 2 (3)                      | 8.6          | 1(1)                         | 0.7          | 2 (4)                          | 2.1           |
| Brassicaceae (the cabbage family) | (–)                        | –             | 1 (2)                      | 1.4          | (–)                          | –            | (1)                            | 1.0           |
| Calthaceae (the bean family)     | (–)                        | –             | 5 (7)                      | 5.0          | 5 (7)                        | 3.6          | (–)                            | –            |
| Calthirhizaceae (water-starrow)  | 1 (1)                      | 5.9           | (–)                        | –            | (–)                          | –            | (1)                            | 0.5           |
| Malvaceae (the malows)           | (–)                        | –             | 1(2)                       | 1.4          | (–)                          | –            | (1)                            | 1.0           |
| Hypericaceae (the St. John’s wort family) | (–)                        | –             | 1 (1)                      | 0.7          | (–)                          | –            | (1)                            | 0.5           |
| Tamaricaceae (the tamarisk family) | (–)                        | –             | 2 (2)                      | 1.4          | (–)                          | –            | (1)                            | 1.0           |
| Eleagnaceae (the oleaster family) | (–)                        | –             | 1 (1)                      | 0.7          | (–)                          | –            | (1)                            | 0.5           |
| Lythraceae (the loosestrifes)     | (–)                        | –             | 1 (3)                      | 2.1          | (–)                          | –            | (1)                            | 1.6           |
| Onagraceae (the willowherb family) | (–)                        | –             | 1 (5)                      | 3.6          | (–)                          | –            | (1)                            | 2.6           |
| Haloragaceae (the watermilfoil family) | 1 (2)                     | 11.8          | (–)                        | –            | (–)                          | –            | (1)                            | 1.0           |
| Apiaceae (the celery family)     | (–)                        | –             | 2 (2)                      | 5.7          | 1 (1)                        | 0.7          | 3 (3)                          | 1.6           |
| Primulaceae (the primrose family) | (–)                        | –             | 2 (2)                      | 1.4          | (–)                          | –            | (1)                            | 2.0           |
| Apocynaceae (the dogbane family)  | (–)                        | –             | 1 (1)                      | 0.7          | (–)                          | –            | (1)                            | 1.0           |
| Convolvulaceae (the bindweed family) | (–)                        | –             | 1 (1)                      | 0.7          | (–)                          | –            | (1)                            | 1.0           |
| Boraginaceae (the forget-me-not family) | (–)                        | –             | 2 (3)                      | 2.1          | (–)                          | –            | (1)                            | 1.6           |
| Lamiaceae (the mint family)      | (–)                        | –             | 6 (10)                     | 7.1          | 6 (10)                       | 5.2          | (–)                            | –            |
| Scrophulariaceae (the figwort family) | (–)                        | –             | 1 (2)                      | 5.7          | 2 (5)                        | 3.6          | 2 (7)                          | 3.6           |
| Rubiaceae (the coffee family)    | (–)                        | –             | 2 (4)                      | 2.8          | (–)                          | –            | (1)                            | 0.5           |
| Dipsacaceae (the teasel family)  | (–)                        | –             | 1 (1)                      | 0.7          | (–)                          | –            | (1)                            | 0.5           |
| Asteraceae (the aster family)    | (–)                        | –             | 10 (14)                    | 9.9          | 10 (14)                      | 7.3          | (–)                            | –            |

Total: 8 (17) 100 16 (35) 100 78 (141) 100 97 (193) 100
Hydrophytes of the steppe rivers of the study area comprise 17 species. The maximum number of species is the Potamogetonaceae family and 6 species (Potamogeton pectinatus L., P. berchtoldii Fieb., P. crispus L., P. lucens L., P. perfoliatus L., P. natans L.) (35.3 %); the Ranunculaceae family is presented by 3 species (R. sceleratus L., R. repens L., Ranunculus caucasicus Bieb.) (17.6 %); the Ceratophyllaceae family (Ceratophyllum demersum L., C. submersum L.) and the Haloragaceae family (Myriophyllum verticillatum L., M. spicatum L.) are presented by 2 species (11.8 %); the Ruppiaceae, Najadaceae, Hydrocharitaceae, Callitrichaceae families have a minimum number of species (1 specie) (5.9 %).

A geographical analysis of the studied flora showed that the maximum number of species belongs to pluri-regional and pan-Arctic elements that makes up 7 species (41.2 %). Holarctic elements comprise 4 species (23.5 %). Endemics and relics are absent [1].

Helophytes of the study area are represented by 35 species. Helophytes include 3 types of glacial relics – Cladium mariscus, Carex pseudocyperus и Carex lasiocarpa, which makes up 14.3 % of the flora of wetlands and waterlogged habitats of the Central Ciscaucasia.

Water-coastal species, hygrophytes of the studied flora, are represented by 141 species. The Poaceae family is represented by the largest number – 22 species: (Phalaroides arundinacea (L., Crypsis schoenoides(L.)Herm, Carex alpina (L.)Schrad. (H. alopecuroides(Pill.et Mitt.Schrad.),(Host ex Roem.), Alopecurus myosuroides Huds., A. aequalis Sobol. – J., A. arundinaceus Poir., Agrostis stolonifera L., A. gigantea Roth – II., Calamagrostis pseudophragnites (Hall.fil.) Koel., Beckmannia eruciformis(L.)Host, Phragmites australis(Cav.)(Trin.ex Steud.), Poa palustris L.-M., Poa trivialis L., Catabrosa aquatica(L.)Beauv., Glyceria fluitans(L.)R.Br., G. notata Chevall. (G. plicata(Fries)Fries) – M., G. arundinacea Kunth – M., G. maxima (C.Hartm.)Holub (G. aquatica(L.)Wachhbnb. – M., Puccinellia distans(Jacq.)Parl. (Atrotis distans(Jacq.)Griseb.), P. dolicholepis V.Krecz. – B., Bromus scoparius L., Elymus caninus(L.)L. (15.6 %), the Asteraceae family has 14 species: E upatorium cannabinum L., Triolium vulgare Nees, Filaginella rossica(Kirp.)Tzvel., Filaginella rossica(Kirp.)Tzvel., Inula helemnica L., I. britannica L., Plicaria vulgaris Gaertn. (P. prostrata(Gilib.)Aschers. nom. illegit.), P. dyssenterica(L.)Bernh. (P. uliginosa Stev.ex DC.), Bidens cernua L., B. tripartita L., Petasites hybridus(L.)Gaertn.,Mey.et Schreb., P. albus (L.)Gaertn., Senecio erucifolius L., Sonchus palustris L., Mycelis muralis(L.)Dumort. (9.9 %), the Cyperaceae family has 11 species: Cyperus fuscus L., C. glomeratus L., Pycreus flavescens(L.)Beauv.ex Reichenb., Scirpoides holoschoenus(L.)Sojak (Holoschoenus vulgaris Link, H. romanus(L.)Fritsch), Scirpus lacustris L. Palla (Schoenoplectus lacustris (L.)Palla), S. tabernemontanii (C.C.Gmel.)Palla (Sch. tabernemontanii C.C.Gmel.), Bolboschoenus maritimus(L.)Palla (B. compactus(Hoffm.)Drob.), Eleocharis austriaca Hayek (E. leptostylopodiata Zinserl.), E. interstica Zinserl., E. palustris(L.)Roem.et Schult. (E.crassa Fisch.et C.A.Mey. ex Zinserl.), E. uniglumis(Link)Schult. (E. uniglumis(Link)Zinserl.) (7.8 %), the Lamiaceae family has 10 species: Teucrium scordoides Schreb., Scutellaria galericulata L., S. hastifolia L., Prunella laciniata(L.)L., Stachys palustris L., Stachys palustris L., exaltatus L.fil., Mentha arvensis L., M. caucasia Gand. (M. longifolia(L.)Huds.), M. spicata L., the Polygonaceae family has 9 species: Rumex patientia L., R. sanguineus L., R. stenophyllus Ledeb., R. maritimus L., Polygonum patulum Biem., Persicaria amphybìa(L.)S.F.Gray (Polygonum amphybium L.), P. maculata(Rafin.).et D.Love (Polygonum maculatum Rafin.; P. persicaria L.), P. hydropiper(L.)Spach (Polygonum hydropiper L.), P. lapathifolia(L.)S.F.Gray (Polygonum lapatattolium L.), P. minor (Huds.)Opiz (Polygonum minus Huds.) (6.4 %), the Juncaceae and Salicaceae families have 8 species: Juncus inflexus L.Salix cinerea L., J. effusus L., J. buxifolius L., J. compressus Jacq., J. gerardii Loisel. S., J. articulatus L., J. soranthus Schrenk, Salix cinerea L., S. viminalis L., S. purpurea L., S. triandra L., S. alba L., S. excelsa S.G.Gmel. (S. australoir Anderss.), S. fragilis L., Populus alba L. (5.7 %). Hydrophytes comprise 31 families and 78 genera, which accounts for 73.1 % of the macrophyte and hygrophyte flora of the territory and 48.3 % of the flora, wetland and waterlogged habitats of the Central Ciscaucasia.
The priority place in the biomorphological range in the group of hygrophytes is occupied by hemicryptophytes (70.2%) and therophytes (18.4%), nanofanerophytes (4.3%) are less numerous, other biomorphs (cryptophytes, mesofanerophytes and microfanerophytes) contain from 2.1 to 2.8%.

Among hygrophytes, there is a tertiary relic (Equisetum hyemale) and 7 glacial relics – Carex panicea, Oberna procumbens, Ranunculus auricomus, Lythrum thesioides, Galium uliginosum, Galium mollugo and Filaginella rossica.

The flora of macrophytes and hygrophytes of the study area makes up 66.1% of the flora of these ecological groups of plants of the Central Ciscaucasia, and macrophytes – 14.5% of the flora of the represented ecological group of plants of Russia.

The largest number of species is represented by the families Cyperaceae (7.3%) and Poaceae (11.4%). In third place are representatives of the Asteraceae family (7.3%), in fourth place are the species Polygonaceae (5.2%) and Lamiaceae (5.2%). These 5 families comprise 83 species (43% of the flora) [1].

Figure 1. The structure of large families of the studied flora steppe rivers of the Central Ciscaucasia

According to K. Raunkier, the classification of biomorphs is widely used. It is based on a feature illustrating the adaptation of a species to conditions of an unfavorable period. In accordance with this classification, all plants are divided into five types:

- **phanerophytes (Ph)** are plants whose wintering renewal buds are located high above the ground, divided into megafanerophytes (Phmg). Renewal buds are located on an elevation of more than 30 m, mesofanerophytes (Phms) (from 8 to 30 m), microfanerophytes (Phm) (from 2 to 8 m), nanofanerophytes (Phn) (from 0.15 to 2 m);
- **chamephites (Ch)** are plants with non-dying shoots for the winter, whose renewal buds are located near the surface of the earth (at a height of up to 30 cm);
- **hemicryptophytes (HK)** are herbaceous plants with dying aerial shoots, whose regeneration buds are at the level of the soil surface under the protection of dead (or alive) leaves and snow;
- **cryptophytes (K)** are perennial herbaceous plants, the ground organs of which die off in the unfavorable season for vegetation, and the buds of renewal are laid on rhizomes, tubers and bulbs underground or under water (hydrophytes);
- **terophytes (T)** are annual herbaceous plants that completely die off by winter [19].

In the studied flora, biomorphological analysis showed the predominance of hemicryptophytes (52.3%), cryptophytes (27.5%) and therophytes (14.0%). Megafanerophytes and chamefites are absent. The entire flora of the studied region is characterized by a predominance of hemicryptophytes (Ivanov, 1996). The ratio of the main biomorphs of macrophyte and hygrophyte flora is depicted in Figure 2.
Geoelement system developed by N. N. Portenier [16, 17] underlies geographic analysis. In studies of the flora of this territory, this system of geoelements was modified and supplemented by A.L. Ivanov [8]. The compilation of the spectrum of geographical elements of the studied flora is the basis of geographical analysis. 19 geographical elements were identified in the flora of the steppe rivers of the Central Ciscaucasia. This analysis showed that the largest number of species belong to the general Arctic elements of 111 species (57.5 %), the predominant geoelement is 81 Palearctic species (42.0 %). The Holarctic element has 30 species (15.5 %).

**Table 2. The biomorph structure of the water-coastal flora of the steppe rivers of the Central Ciscaucasia**

| Life form | Phms (Mesophanerophyton) | Phm (Microphanerophyton) | Phn (Nanophanerophyton) | HK (Hemicryptophyte) | K (Cryptophyte) | T (Therophyte) | Total |
|-----------|--------------------------|--------------------------|-------------------------|----------------------|----------------|--------------|-------|
| Hydrophytes species | 1 | 15 | 1 | 15 | 1 | 17 |
| % | 5.9 | 88.2 | 5.9 | 100 |
| Helophytes species | 6 | 99 | 4 | 26 | 100 |
| % | 2.9 | 97.1 | 100 |
| Hygrophytes species | 3 | 3 | 6 | 99 | 4 | 26 | 141 |
| % | 2.1 | 2.1 | 4.3 | 70.2 | 2.8 | 18.4 | 100 |
| Whole flord species | 3 | 3 | 6 | 101 | 53 | 27 | 193 |
| % | 1.6 | 1.6 | 3.1 | 52.3 | 27.5 | 14 | 100 |

**Figure 2.** The structure of life forms of the water-coastal flora of the steppe rivers of the Central Ciscaucasia: 1 – HK (Hemicryptophyte); 2 – K (Cryptophyte); 3 – T (Therophyte); 4 – Ph (Phanerophyte)

The pluriregional geoelement totals 13 species (6.7 %), the European 11 species (5.7 %). The correlation of the main groups of geoelements of the studied flora is presented in Figure 2.

According to the prevailing groups of geoelements, macrophytes and hygrophytes of the steppe rivers of the Central Ciscaucasia can be characterized as pan-Arctic-pluriregional-European [1].

In the studied flora there are 11 relics, which is 5.7 % of the flora. Glacial relics include 10 species of macrophytes and hygrophytes, which is 23.3 % of glacial relics of the entire flora of the Central Ciscaucasia.
Figure 3. The spectrum of geoelements of water-coastal flora steppe rivers of the Central Ciscaucasia: 1 – General Arctic, 2 – Boreal, 3– Connecting, 4 – General Ancient Mediterranean, 5 – Pluriregional

Table 3. Analysis of geoelements of the water-coastal flora of the steppe rivers of the Central Ciscaucasia

| Geoelement                  | Whole Flora (Hydrophytes, Helophytes, Hygrophytes, number of species ( %)) |
|----------------------------|--------------------------------------------------------------------------------|
|                            | Pluriregional elements | General Arctic elements                                                                 |
| Pluriregional              | 13                                                                  | 6.8                                                                                        |
| Holarctic                  | 30 (15.5)                                                          | 111 (57.7)                                                                                  |
| Palearctic                 | 81 (42.0)                                                          |                                                                                             |
| Boreal elements            |                                                                    |                                                                                             |
| Panboreal                  | 3 (1.6)                                                             |                                                                                             |
| Euro-Siberian              | 6 (3.1)                                                             |                                                                                             |
| Euro-Caucasian             | 5 (2.6)                                                             |                                                                                             |
| European                   | 11 (5.7)                                                            |                                                                                             |
| Caucasian                  | 2 (1.0)                                                             | 31 (16.2)                                                                                   |
| Ciscaucasian               | 1 (0.5)                                                             |                                                                                             |
| Pont-South-Siberian        | 2 (1.0)                                                             |                                                                                             |
| Pontific                   | 1 (0.5)                                                             |                                                                                             |
| Ancient Mediterranean Elements |                                                                     |                                                                                             |
| General Ancient Mediterranean | 8 (4.2)                                                        |                                                                                             |
| Western Ancient Mediterranean | 5 (2.6)                                                      |                                                                                             |
| Eastern Ancient Mediterranean | 3 (1.6)                                                        | 18 (9.5)                                                                                    |
| Turan                      | 2 (1.0)                                                             |                                                                                             |
| Connecting Elements        |                                                                    |                                                                                             |
| Sub-Mediterranean          | 8                                                                   |                                                                                             |
| Subcaucasus                | 1 (0.5)                                                             | 4.2 (0.5)                                                                                   |
| Subpontific                | 1 (0.5)                                                             |                                                                                             |
| Subturan                   | 9 (4.7)                                                             |                                                                                             |
| Total:                     | 193                                                                 |                                                                                             |

3. Conclusions
Hydrophyte flora is represented by 8 families and 8 genera. Hydrophytes of this territory make up 5.8 % of the flora of wetlands and waterlogged habitats.

According to the dominant groups of geoelements, hydrophytes of the steppe rivers of the Central Ciscaucasia can be characterized as pluriregional-general-polar ones. According to Raunkier’s
classification, biomorphs are represented by cryptophytes (88.2 %), hemicryptophytes (5.9 %) and therophytes (5.9 %).

The largest number of helophytes is represented by the Cyperaceae family of 16 species (45.7 %). The Typhaceae family has 4 species (11.4 %). The Alismataceae, Brassicaceae families are represented by 3 species (8.6 %). The Sparganiaceae, Apiaceae and Scrophulariaceae families have two species (5.7 %). The families Butomaceae, Polygonaceae and Ranunculaceae are represented by 1 specie (2.9 %). Helophytes flora is common holarctic with predominance of palearctic (16 species, 45.7 %) and holarctic (5 species, 14.3 %) geoelements. The Palearctic elements are represented by 16 species (45.7 %) and Holarctic 5 species (14.3 %) of geoelements. According to the Raunkier system, the biomorph spectrum of the helophyte group is represented by cryptophytes (97.1 %) and hemicryptophytes (2.9 %).

In the largest composition, the number of hygrophytes is represented in the Poaceae family of 22 species (15.6 %), in the Asteraceae family of 14 species (9.9 %), and the Cyperaceae family of 11 species (7.8 %). According to the prevailing groups of geoelements, the flora of hygrophytes can be characterized as general-Arctic-boreal ones.

The leading position in the biomorphological spectrum in the group of hygrophytes is occupied by hemicryptophytes (70.2 %) and therophytes (18.4 %) [1].

References
[1] Amalova Z N and Erzhapova R S 2012 Phyto-diversity of aquatic ecosystems of the steppe rivers of the Central Ciscaucasia and problems of its conservation (Grozny: Chechen State Univer.)
[2] Bogdanovskaja-Gienet I D 1950 Materials for the knowledge of the lakes of the Volga floodplain of the Saratov region Works of Leningrad Society of Naturalists (Leningrad)
[3] Belavskaja A P 1979 To the methodology of studying aquatic vegetation Botanical magazine 1
[4] Galushko A I 1978–1980 Flora of the North Caucasus: vol 1 1978 317 p; vol 2 1980 350 p; vol 3 1980 (Rostov: Rostov State Univer.)
[5] Ivanov A L 1997a On the Genesis of the Stavropol Flora Bull. of Stavropol State Univer. 12
[6] Ivanov A L 1997b Summaries of the flora of Stavropol (Stavropol: Stavropol State Univer.)
[7] Ivanov A L 1998 Flora of the Ciscaucasia and its genesis (Stavropol: Publ.of Stavropol State Univer.) 204 p
[8] Katanskaia V M 1956 Methodology for the study of higher aquatic vegetation Freshwater Life vol 4 (Moscow; Leningrad)
[9] Katanskaia V M 1981 Higher aquatic vegetation of the continental reservoirs of the USSR (Leningrad: Nauka)
[10] Kokin K A 1982 Ecology of higher aquatic plants (Moscow: Moscow State Univer.)
[11] Kosenko I S 1970 Key to higher plants of the northwestern Caucasus and Ciscaucasia (Moscow: Kolos)
[12] Geiny S and Sytnika K M 1993 Macrophytes – indicators of environmental changes (Kiev: Naukova dumka)
[13] Portenier N N 1993a Geographical analysis of the flora of the Cherek Bezengi basin (Central Caucasus). I. Natural conditions of the region and general characteristics of its flora and vegetation Botanical magazine 78(10) 16–22
[14] Portenier N N 1993b Geographical analysis of the flora of the Cherek Bezengi basin (Central Caucasus). II. Geographic elements Botanical magazine 78(11) 1–17
[15] Prima V M 1987 Aquatic plants in the vicinity of Grozny (Grozny) p 21
[16] Rusakova E G 2007 Methods of studying flora and vegetation (Astrakhan: Publ. House Astrakhan Univer.)
[17] Sviridenko B F 1987 Aquatic macrophytes of the North Kazakhstan and Kustanai regions (species composition, ecology, productivity) (Cand. Dissertation thesis) (Tomsk)
[18] Sviridenko B F 1991 Life forms of flowering macrophytes of Northern Kazakhstan *Botanical magazine* 76(5)
[19] Sytnik K M and Vasser S P 1992 Modern views on biological diversity *Algology* 2(3)
[20] Tkachev B P 2002 *Small rivers: current status and environmental issues: Analytical Review* (Novosibirsk: GPNTB SO RAN)
[21] Sheliag-Sosonko Iu R, Didukh Ia P, Ena V G and Tarasenko V S 1998 Biodiversity Threat Assessment, Crimea *Nature*