E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2017; 5(6): 251-255

www.fisheriesjournal.com
Received: 05-09-2017
Accepted: 07-10-2017

Nasibulina Botagoz Murasovna
Faculty of Geology & Geography/ Innovative Natural Institute, Astrakhan State University, Astrakhan, Russia, Shaumyana Sq., 1

Kurochkina Tatyana F
Faculty of Geology & Geography/ Innovative Natural Institute, Astrakhan State University, Astrakhan, Russia, Shaumyana Sq., 1

Rusakova EG
Faculty of Geology & Geography/ Innovative Natural Institute, Astrakhan State University, Astrakhan, Russia, Shaumyana Sq., Russia

Popov NN
Atyrau Affiliate of LLP Kazakh Fisheries Research Institute, Atyrau, The Republic of Kazakhstan, Bergalieva Str., Kazakhstan

Omarova ZS
Faculty of Biology and Biotechnology/ Kazakhstan National University named after Al-Farabi, Almaty, The Republic of Kazakhstan, al-Farabi Str., Kazakhstan

Shalgymbaeva SM
Faculty of Biology and Biotechnology/ Kazakhstan National University named after Al-Farabi, Almaty, The Republic of Kazakhstan, al-Farabi Str., Kazakhstan

Correspondence
Nasibulina Botagoz Murasovna
Faculty of Geology & Geography/ Innovative Natural Institute, Astrakhan State University, Astrakhan, Russia, Shaumyana Sq., Russia

Features of development and distribution of higher aquatic vegetation in the outlets of the volga delta

Nasibulina Botagoz Murasovna, Kurochkina Tatyana F, Rusakova EG, Popov NN, Omarova ZS and Shalgymbaeva SM

Abstract
The features of the formation of aquatic plant communities and their spatial distribution at the outlet sections of the waterways of the Volga delta are shown. It can be noted that the coastal-aquatic vegetation of kultuk zone and island zone of the avandelta of the studied areas is similar in species composition, but differs in the structure of communities, projective cover and the abundance of individual species. In the riverbed area where the flow is strong enough with silty-sandy deposits the mass development of the reophilic communities of *Potamogeton lucens* is traced. With the weakening of the flow on the silty sediments forbs association with *(Butomus umbellatus, Sparganium ramosum, Nymphoides peltata, Trapa natans, Ceratophyllum demersum* and other plants observed. In the kultuk zone, mosaic poly dominant communities (*Phragmites, Sparganium, Potamogeton spp., Vallisneria* and other hydrophytes) are noted. The submerged vegetation is represented by the communities of *Potamogeton perfoliatus, Potamogeton pectinatus, Vallisneria spiralis, Ceratophyllum demersum* with a projective coverage up to 100%. Surface plants disappear from the composition of plant communities and submerged hydrophytes only remain. *Potamogeton pectinatus, Vallisneria spiralis* and *Ceratophyllum demersum* dominate and subdominate.

Keywords: Volga delta, higher water vegetation, hydrophytes, helophytes, submerged vegetation, surface vegetation

1. Introduction
The role and function of higher plants in the ecosystem is very significant. Higher water plants create a primary production more than provide a biotic cycling of matter and energy, underlying self-cleaning mechanism and productivity of water basin [1, 2, 3]. Thickets of higher aquatic plants serve as a barrier for suspended mineral and organic matter when various pollution entering the pond [4, 5]. Aquatic vegetation provides detoxification of particularly dangerous pollutants (phenol, oil, pesticides); it is not only absorbing them, but also included in the process of metabolism and turns them at the same time on the less toxic components [6, 7, 8]. Freshwater plants are able to absorb and accumulate of water and sediment a significant amount of biogens, dissolved organic matter, heavy metals and radionuclides [9, 10, 11, 12]. Higher aquatic vegetation is of great importance for the fish fauna and avifauna of the delta. Areas, overgrown vegetation, are fish spawning grounds and feeding their young, forage for waterfowl. Plant communities play a role in the balance of organic matter and nutrients in the water area of the Volga delta and its riverbed.
Thickets of submerged and emergent vegetation in the deltabed may reduce the water flow rate and accumulation transported alluvium. In areas of deltabed with dense vegetation part of sediment flow is deposited on the bottom, and a considerable part of suspended sediment remains on the leaves and stems [13].
The ecosystem of the Volga delta is experiencing intense anthropogenic pressure and it is a complex monitoring object due to an exceptional multi-component and a wide concentration range of pollutants of human origin, migrating from one subsystem to another, accumulating and causing pollution [14].
Under the conditions of the impact of anthropogenic factors, first of all, the implementation of management activities, the structural and functional characteristics of higher aquatic vegetation are subject to change, which often lead to negative consequences.

Therefore, the study of these communities with higher aquatic vegetation is relevant.

2. Material and Methods

2.1 Study area

The Volga delta is one of the largest of the deltas of the world and occupies about 20,000 km^2 in the Caspian lowland. The Volga delta is a unique geographical object with enormous natural resources.

The modern scheme of geomorphological zoning of the Volga delta [15] is shown in the figure1.

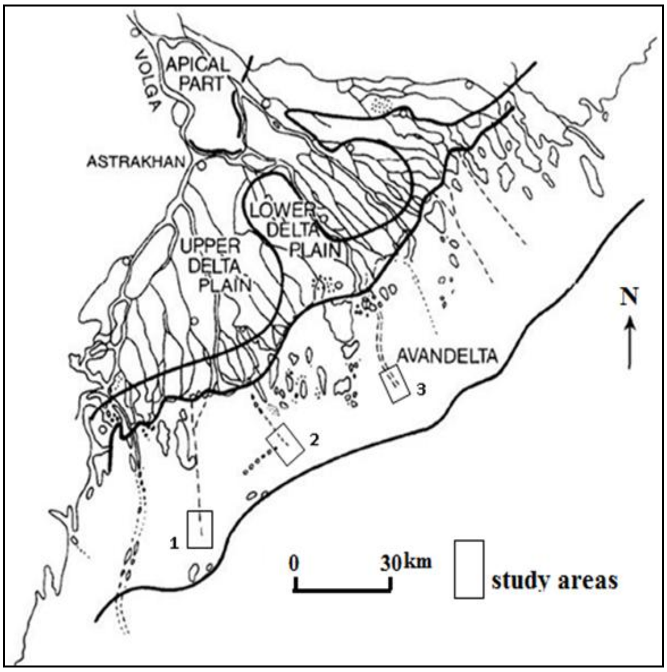

Fig 1: Scheme of geomorphological zoning of the Volga delta (Rusakov, 1990) and study areas: 1. Gandurinsky channel; 2. Kirovsky channel; 3. Belinsky channel.

The *apical part* of the delta is a transitional area from the flood plain of the Volga and its left tributary Akhtuba to the delta. Plain is complicated by a large number of oxbow lakes and dying channels.

In the upper delta plain the delta distributaries strongly fan out. This part consists of numerous islands, usually 3-4 m above low water level.

Lower delta plain wedged deep within the deltaic plain, repeating the contours of the existing bays here. These bays are called (kultuky) locally.

During rapid progradation of the coast, some (kultuky) become entirely isolated from the coast and the resulting lakes are called (ilmeny). Features of this district are channels or "banks" (artificially enhanced channel streams for the passage of ships and fish passes).

The prodelta (avandelta) is where active delta progradation takes place. At the very coast line over 800 outlets are found, up to 6 per km, with an average depth of 1-3 m. There are a few larger outlets, but there is no single main channel.

The prodelta is the youngest and most dynamic part of the delta; the presence of extensive shallow space, overgrown with surface and underwater vegetation, distinguishes this part from other delta parts. The avandelta and the shelf are dissected by submarine gullies (borozdiny) formed by subaerial erosion during former regressions, which pass into submarine canyons downslope from the shelf edge [16].

2.2 Sampling

The object of the study is higher aquatic and amphibious vegetation. The vegetation was studied from May to October. Three water-quality sampling sites were established. Sampling sites were shown in Figure 1.

Collection and processing of the material was carried out according to the methods adopted in the system of Federal Service for Hydrometeorology and Environmental Monitoring [17]. For quantitative account of vegetation sliding frame of 0.25 m^2 was used. Samples were taken at four replications. Plants were cut using a scythe, at depths greater than 1 m; mowing was carried out from a boat. Mowing processed in the following sequence: clearing of contamination and dirt, disassembly by species, groups and weighing.

All samples were identified based on the latest knowledge and ongoing taxonomic considerations using the considered guides. Those are followed in the case of the study of European regions, in addition to many published scientific reports [18, 19, 20].

3. Results and Discussion

The composition and the degree of development of aquatic vegetation in the water are due to the heterogeneity of environmental conditions and are subject to certain laws. The most important factors that determine the structure and the existence of vegetation are: morphological characteristics of the reservoir, bottom sediments, and the optical properties of the water masses, dynamical and chemical factors.

The outlet areas of the Volga delta, where the higher aquatic vegetation is represented widely and variously been studied. Phytocenosises are mainly represented by water (hydrophytes) and wetland (helophytes) plants.

Development of phytocenosises of Belinsky channel water area occurs on either side of its shores, parallel to the river bed through kultuk zone. In the riverbed area where the flow is strong enough and deposits are represented by fine sand covered a thin cover of silt; associations of shining pondweed *(Potamogeton lucens)* developed. Phytomass of family *Potamogetonaceae* communities reaches 4 kg/m^2 at a density of 76 ind./m^2. With increasing distance from the river bed and the weakening of the current dominant positions are transferred to the broad-leaved pondweed *(Potamogeton natans)* and perfoliate pondweed *(Potamogeton perfoliatus)* with a phytomass of 4.0 kg/m^2.

Further, with the weakening of the flow on the silty sediments with depths of 1.0-1.5 m, forbs association with flowering rush *(Butomus umbellatus)*, branched bur-reed *(Sparganium ramosum)* with the projective abundance of 6-10%, yellow floating heart *(Nymphoides peltata)* – up to 30%, water chestnut *(Trapa natans)* - 4-5%, hornwort *(Ceratophyllum demersum)* - 3%, and other plants observed. Phytomass of associated species can reach 3.9 kg / m2. In the middle of the kultuk zone in borozdina area with strong currents tall herb polydominant association of reed, branched bur-reed, pondweed, spiral wild celery and other hydrophytes is significant in length. The distribution of these associations represented mosaic. Reed meets separately strewn islands with an estimated coverage of 15-25%. The value of the diameter of the islands ranges from 20-30 m to 150-300 m. *Sparganium* also occurs in the form of separate islands, towering over the water, the size from a few meters to several hundred meters; sometimes branched bur-reed distribution by water area kultuk area becomes diffuse. Cane, flowering rush, yellow floating heart and others occur as related species.

The space between the island groups of the reed and branched bur-reed typical hydrophytes occupy such as perfoliate pondweed (*Potamogeton perfoliatus*), fennel pondweed (*Potamogeton pectinatus*), water chestnut (*Trapa natans*), spiral wild celery (*Vallisneria spiralis*), hornwort (*Ceratophyllum demersum*) with an estimated coverage of up to 100 %.

The height of a surface part of reed islands ranges from 2.5-3.0 m (sometimes up to 4.0 m). The height of the underwater part of the reed equal to the depth of this zone is 0.9-1.2 m. The density of reed beds ranges from 16 to 48 ind./m^2 and phytomass of a surface part there is 5-7 kg/m^2. Phytomass of *Sparganium* (surface and underwater parts) ranges from 3 to 13 kg/m^2 with a number from 1-2 to 12 ind./m^2. *Sparganium* height reaches 1.5-2.0 m.

Further, in the waterways of kultuk zone the shining pondweed association (*Potamogeton lucens*) is noted, and communities are located along the flow, and their width reaches several tens of meters and significantly, is 5-10 times greater than the width of a similar riverbed belts, formed the same view.

So, in small bights, where the influence of the flow affected to a lesser extent, formed the community of yellow floating heart (*Nymphoides peltata)*, water chestnut (*Trapa natans*), pondweeds (*Potamogeton natans*, *Potamogeton pectinatus*) and other hydrophytes. Depths in the bights range from 0.9 to 1.2 m, the soils are generally silty and silty-sandy. Water transparency in the bights is high and allows a high degree of accuracy to study the structure of the submerged vegetation. The central part of the bights is usually floating pondweed *(Potamogeton natans)* occupies an estimated coverage of 15-80%. The density communities in the center of the bight can reach 177 ind./m^2 and phytomass is up to 8 kg/m^2. Associated species in the community are fennel pondweed *(Potamogeton pectinatus)*, tending to ecotopes, which the impact of flow of borozdiny affects yellow floating heart *(Nymphoides peltata)*, which on the contrary prefers a more quiet, even stagnant water areas. However, in areas characterized by a high degree of stagnation in low water, yellow floating heart *(Nymphoides peltata)* are widespread and form communities over large areas, often in the tens of hectares. Phytomass of yellow floating heart *(Nymphoides)* in communities is up to 8 kg/m^2.

In the bights on the habitats with yellow floating heart (Nymphoides) there is a strong sedimentation of biogenous discharge of the Volga. The thickness of the silt layer in such places reaches 50-70 cm. Accordingly, the character of plant community changes: coverage yellow floating heart (Nymphoides) reduced to 40-10%; in the same time the projective cover of bur-reed (*Sparganium ramosum*) increased to 60%; flowering rush (*Butomus umbellatus*) appears with projective cover of 10-20%. Typically, these communities develop in areas with depths of 0.8-1.0 m. With a further decrease in the depth of 0.5 m in some parts of flowering rush coverage increased to 100%, arrowhead (*Sagittaria sagittifolia*) appears as a companion species. Arrowhead (*Sagittaria sagittifolia*) forms small clumps with a density of 40 ind./m^2 and phytomass of 4.4 kg/m^2. The arrowhead height is 0.9-1.0 m.

Butomus and *Sagittaria* also found on a completely drained area of kultuk zone directly adjacent to the sandy bar of the channel bed. Another distinctive feature of the vegetation of bights, abutting to the sandy bar of the bed, is what behind the flowering rush (*Butomus umbellatus*) communities, or instead of them, at a depth of 0.45-0.10 m the reed mace communities (*Typha angustifolia*) appear. Reed communities (*Phragmites australis*) are replaced by reed beds, facing the bar and form a continuous reed lining both sides of the sand bars and limiting the bank's direction on both sides of the plant wall. The height of emergent parts of reed reaches 5-6 meters at a density of 80-110 ind./m^2. Phytomass of reed communities in the bars reaches 5-12 kg/m^2.

Towards the open sea the nature of water phytocenoses of kultuk zone of avandelta changes, manifested rather in the structural changes under the previous species richness. It should be emphasized that those small fragments of associations presented in the form of a limited vegetable islands formed by reed *(Phragmites australis)* and bur-reed *(Sparganium ramosum)*, scattered across the middle part of the kultuk zone cause substantial sedimentation of suspended matter transported by the Volga to the Caspian Sea.

At the bottom part of the kultuk zone on the border with the open avandelta zone projective cover of vegetation produced by reeds and bur-reed gradually changes from 30-60 to 15-10%. Curtins formed reeds become looser, reduced in size and are much lower in height. In communities there is star duckweed (*Lemna trisulca*); its projective coverage is 10%. In the lower part of the kultuk zone visually it seems that the pure water area has increased almost twice. In the underwater part of the water area, on the contrary, the picture changes due to the appearance of submerged vegetation communities with a projective cover of 90-100%. The fennel pondweed *(Potamogeton pectinatus)*, spiral wild celery *(Vallisneria spiralis)* and hornwort *(Ceratophyllum demersum)* act as dominants and subdomains, projective cover of each species varies from 30 to 60%, and these species alternate in prevalence in the communities.

In the lower part of the kultuk zone, bulrush (*Scirpus lacustris*), yellow floating heart (*Nymphoides peltata*) are found as accompanying in these phytocenoses. In the open avandelta zone, the depths increase to 1.5-1.8 m. Plants that form surface forms disappear from the communities, apparently, do not withstand wind-induced surges and sea waves [21], only typical hydrophytes remain. Projective covering of submerged vegetation represented by communities spiral wild celery (*Vallisneria spiralis*), fennel pondweed (*Potamogeton pectinatus*), hornwort (*Ceratophyllum demersum*) reaches 90-100%, the height of underwater vegetation reaches 70-90 cm. These communities develop on silty and silty-sandy bottoms. Latter shows the importance of the substrate and the accumulation of sediment for the distribution of stream vegetation, like many other studies [22, 23, 24].

On sandy grounds in the lower part of the kultuk zone on a section to the east of the Belinskiy channel with depths of 1.2-1.5 m, the mosaic oligo dominant communities consisting of hornwort *(Ceratophyllum demersum)*, wild celery *(Vallisneria spiralis)*, whorled milfoil *(Myriophyllum spicatum)*, fennel pondweed *(Potamogeton pectinatus)* and holly-leaved naiad *(Najas marina)* alternate. The total projective coverage of vegetation is 70-100%, and the projective covering of species varies from a specific combination of natural environmental conditions. In the island part of the avandelta in the Belinskiy channel area, hydrobotanic studies conducted to depths of 3.0-3.5 m revealed that with increasing depth, submerged communities gradually become thin and in some species *(Vallisneria spiralis*, *Myriophyllum spicatum*, *Najas marina)*, natural sizes decrease. Reduction of the projective cover, as well as a sharp decrease in the phytomass of communities (with the exception of *Potamogeton perfoliatus*) is associated with this.

The water area of the Gandurinsky channel for geomorphological and ecological features has its own distinctive features, which have also affected the nature of the aquatic vegetation.

In shallow water areas (0.4 m) in the coastal part of the Gandurinsky channel, a common reed (*Phragmites australis*) with a projective covering of 5-20% is noted. In the same zone there are monodominant associations of cattail (*Typha angustifolia*), a length of 15-20 m. The curtains of the branched bur-reed (*Sparganium ramosum*) are adjacent to them, reaching 20-25 m across.

In the areas free from the bur-reed, communities of broad-leaved pondweed (*Potamogeton natans*) and fennel pondweed (*Potamogeton pectinatus*) appear, their total projective cover varies between 30-80%, and at this depth and in somewhat quiet conditions, broad-leaved pondweed is approximately two times larger than the fennel pondweed. The flow increases with distance from the shore. At a depth of 0.6 m, *Potamogeton natans* falls out of the composition of the communities, while the cover of *Potamogeton pectinatus* increases 2-3 times and reaches 80%.

To the center of the channel, *Potamogeton pectinatus* disappears from the composition of the communities, and the rheophilous communities of the shinning pondweed (*Potamogeton lucens*) occupy a dominant position. It forms monodominant communities located in a zone of strong flow, on either side of the riverbed. The width of its communities is insignificant and does not exceed 5-10 m.

Elodea canadensis, *Lemna minor*, *Butomus umbellatus*, *Nymphoides peltata*, *Potamogeton perfoliatus* are found as accompanying species. Similar patterns can be traced on the other side (to the west) from the channel. The phytomass of communities in the described area varies from 1.2 kg/m^2 in mixed communities of pondweeds, to 10.32 kg/m^2 in the bur-reed communities. The density of the communities ranged from 4 ind./m^2 in *Sparganium* communities to 56 ind./m^2 in *Potamogeton natans* and *Potamogeton pectinatus* communities.

With access to the open avandelta zone at a distance of 50 meters from the bed and over the flow power significantly weakened. On ecotopes with a smooth, slow flow and depths of 0.4-0.6 m on silty-sandy grounds, polydominant water phytocenoses with a total projective coverage of 70-100% develop. Surface tier consists of Sparganium and *Butomus*, towering above the water at 1.0-1.5 m. The underwater tier is represented by fennel pondweed, spiral wild celery and hornwort. The surface tier looks like islands, stripes, curtains, sometimes quite significant in length (0.5 km and more), scattered across the water surface.

The communities of hydrophytes are mono-and polydominant, and the *Vallisneria* communities gravitate toward the borozdina, where the strength of the underwater flows is more apparent, the hornwort communities prefer areas with little or no noticeable flow. A feature of the perfoliate pondweed communities is the attraction to silted ecotopes. *Sparganium* communities prefer areas with tangible manifestation of flows and are located along the borozdina or near them.

Often the projective coverage of the head of the head of the communities reaches 15-20 ind./m^2. In the underwater tier, *Ceratophyllum demersum* dominates, its projective coverage reaches 15-20%, whereas the projective covering of *Vallisneria spiralis* reaches only 10-15% of the total, *Potamogeton pectinatu*s coverage reaches 30-40%.

Butomus umbellatus occupies up to 5-10% of the total projective cover among the bur-reed thickets. *Nuphar luteum*, *Trapa natans*, *Potamogeton perfoliatus*, *Nymphoides peltata* are found as accompanying species in these associations.

Hydrobotanical studies in the area of the Kirovsky channel were carried out on areas with depths of 0.9-1.1 m.

In the most coastal part of the reed communities *(Phragmites australis)* developed, dense thickets of which go to land. On the silty ground, the associations *Potamogeton natans* are noted.

With the removal of the stagnant part of the avandelta in the direction where the high flow is noted, the character of the plant communities also changes sharply. The leading role belongs to the poly-species communities of submerged vegetation with the participation of *Ceratophyllum*, *Vallisneria spiralis* with a projective covering of 20%, *Najas marin*a and *Najas minor* with a projective covering of 15%. Single *Potamogeton* species were noted.

The lotus communities (*Nelumbo nucifera*), is located in the quiet areas, are a bright feature of the kultuk zone. In communities with lotus dominance, there are *Vallisneria spiralis* with a projective covering of 10-15%, *Najas marina* up to 30%, a white water lily (*Nymphaea alba*), a water nut *(Trapa natans)*, various *Potamogeton* species. The phytomass of hydrophytes in the lotus association is 11 kg/m^2. As a total our findings agree with observations that fine textured substrata are favourable for the aquatic plant development and growth [22, 25, 26].

4. Conclusion

Thus, it can be noted that the coastal-aquatic vegetation of kultuk zone and island zone of the avandelta of the studied areas is similar in species composition, but differs in the structure of communities, projective cover and the abundance of individual species. Based on the research, sections with a depth of up to 1.2-1.7 m (including a kultuk zone, an island zone and an open zone of the avandelta) were allocated, which are distinguished by the dominance of complex and mosaic associations of Sparganium, Phragmites, *Ceratophyllum*, Vallisneria and *Najas* with a total coverage of 90% -100%. The areas of the open avandelta zone with depths of 2.5-3.0 m are characterized by submerged vegetation consisting of *Vallisneria*, *Potamogeton*, *Myriophyllum* and *Elodea*. It should be noted that even small fragments of associations represented in the form of plant islands formed by individual plant species cause significant sedimentation of the suspended matter transported by the Volga to the Caspian Sea.

5. References

1. Ekzertsev VA. The hydrophilic vegetation (In Volga and its life, Science, Leningrad, 1978, 203-221. (in Russian).
2. Katanskaya VM. The higher aquatic vegetation of continental waters of USSR: methods of study. Moscow – Leningrad, Nauka, 1981. (in Russian).
3. Eynor LO. Macrophytes in the pond ecology. Institute of Water Problems RAS, Moscow, 1992 (in Russian).
4. Taubaev TT. Aquatic plants like water purifiers in hydro ecosystems (Paper presented at the III Conference Aquatic vegetation inland waters and the quality of their waters, Petrozavodsk, 1993. (in Russian).
5. Zhgareva NN. The trophic structure of the population of

macrophytes in terms of anthropogenic impact. Paper presented at the International conference Ecological problems of large river basins, Togliatti, 1993. (in Russian).

6. Yakubovskiy KB, Merezhko AI, Shiyan PN. Absorption of nutrients and pesticides by reeds and reed mace. Formation and control of the quality of surface waters. Naukova Dumka, Kiev. 1975; 1:109-114. (in Russian).
7. Morozov NV, Telichenko MM. Acceleration of purification of surface waters from oil and oil products by macrophytes installation. Water Resources. 1977; 6:120-131. (in Russian).
8. Jianping Gao A. Wayne Garrison, Christopher Hoehamer, C S Mazur and N Lee Wolfe. Uptake and Phytotransformation of Organophosphorus Pesticides by Axenically Cultivated Aquatic Plants. Journal of Agricultural and Food Chemistry. 2000; 48(12):6114-6120. DOI: 10.1021/jf9904968
9. Minkkinen P, Yliruokanen I, Sarkka I. Environmental effect on the minor and trace element patterns of some aquatic plants Health and Safety: (Paper presented at The Russian-Finnish seminar "Environmental Monitoring – 93", St. Petersburg, 1994.
10. Gapeeva MV, Dovbnya IV, Zakonnov VV, Shirokova MA. The empirical relationship between metal content in plants and sediments eutrophic lake Nero. Ecology, 1995; 3:217-221 (in Russian).
11. Jackson LJ. Paradigms of metal accumulation in rooted aquatic vascular plants. The Science of the Total World. 1998; 219(2-3):223-231.
12. Schneider Ivo Andre and Rubio J. Sorption of heavy metals by the nonliving biomass of freshwater Macrophytes. Environmental Science and Technology. 1999; 33(13):2213-2217. DOI: 10.1021/es981090z
13. Rusakova EG. The impact of water flow increasing of the Volga River and the Caspian Sea level increasing on the state of vegetation of Lower Volga delta. Dissertation, Astrakhan State Pedagogical University, 1998. (in Russian
14. Nasibulina Botagoz Murasovna. Ecology of benthic communities of the Volga delta in conditions of anthropogenic stress. A thesis for the Degree of Doctor of Biological Sciences. Moscow, 2006.
15. Rusakov GV. Geomorphological subdivision of the Volga Delta. Geomorphology. 1990; 3:99-106. (in Russian).
16. Kroonenberg SB, Rusakov GV, Svitoch AA. The wandering of the Volga delta: a response to rapid Caspian sea-level change. Sedimentary Geology. 1997; 107:189-209.
17. Abakumov VA, Bubnov NP, Kholikov NI, Goridchenko TP, Liepa RA, Svir NL, *et al*., (Eds.) Guide on methods of hydrobiological analysis of surface water and sediment. Gidrometeoizdat, Leningrad, 1983 (in Russian).
18. Kubitzki Klaus (ed.). The families and genera of vascular plants, Monocotyledons: Alismatanae and Commelinanae (except Gramineae). Springer-Verlag, Berlin, 1998; (4).
19. Haynes RR, Les D, Holm-Nielsen LB. Potamogetonaceae. In: Kubitzki K. (ed). Flowering Plants, Monocotyledons. The Families and Genera of Vascular Plants. Springer, Berlin, Heidelberg, 1998; (4). DOI https://doi.org/10.1007/978-3-662-03531-3_39
20. Haynes Robert R, C Barre Hellquist (eds.). Flora of North America. Potamogetonaceae Dumortier: Pondweed Family. Flora of North America North of Mexico. Magnoliophyta: Alismatidae, Arecidae, Commelinidae (in part), and Zingiberidae. 2000; 22:47-74.
21. Rusakov GV, Zhivoglyad AF, Moskalenko AV. The impact of the change in hydrological regime on the vegetation of the Volga delta lowlands. Water Resources. 1980; 4:178-182 (in Russian).
22. Ferreira MT, Moreira IS. River plants from an Iberian basin and environmental factors influencing their distribution. Hydrobiologia. 1999; 415:101-107.
23. Riis T, Sand-Jensen K, Vestergaard O. Plant communities in lowland Danish streams: Species composition and environmental factors. Aquatic Botany. 2000; 66:255-272.
24. Mackay SJ, Arthington AH, Kennard MJ, Pusey BJ. Spatial variation in the distribution and abundance of submersed macrophytes in an Australian subtropical river. Aquatic Botany. 2003; 77:169-186.
25. Chovanec A, Schiemer F, Cabela A, Gressler S, Gro tzer C, Pascher K, *et al*. Constructed inshore zones as river corridors through urban areas – the Danube in Vienna: Preliminary results. Regulated Rivers, Research and Management. 2000; 16:175-187.
26. Abou-Hamdan H, Haury J, Hebrard JP, Dandelot S, Cazaubon A. Macrophyte communities inhabiting the Huveaune (South-East France), a river subject to natural and anthropogenic disturbances. Hydrobiologia. 2005; 551:161-170.