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THE USE OF HYDROMACROPHYTES FOR COMPLEX EVALUATION OF THE ECOLOGICAL STATE OF WATER BODIES OF ISHIM AND ITS SURROUNDINGS

SUMMARY. The paper summarizes quantitative data on the tolerance of type-indicators to the leading factors of water environment based on the published scientific evidence. Assessment of ecological condition of water ecotopes of the main economically significant water bodies of Ishim and its surrounding area (the river Ishim, the river Karasul, the river Mergenka, the dead arm of the river Ishimchik, Lake Anikino, Lake Chertovo) is undertaken. The assessment takes into account the following: the data on hydromacrophytes of each of the studied water bodies; the information on individual valence of each species in relation to trophic groups and saprobity; the values of the indicator weight (obtained by studying the distribution of individual valences on trophic groups and saprobity); the analysis of the upper limits of mineralization and endurance limits of hydromacrophytes relative to pH. The data have enabled to characterise the water bodies as eutrophic, mesotrophic, oligo-beta mesosaprobic (the Ishimchik – alpha-beta mesosaprobic). Water in most of the water bodies is fresh (in the Karasul – soft), low mineralized, moderately rigid (in Lake Chertovo – rigid, salty, with an average mineralization), the active reaction of water is slightly alkaline.

KEY WORDS. Ecological condition, water ecotopes, hydromacrophytes.

Introduction

Due to significant anthropogenic impact experienced by ecosystems in recent years there is a strong need to develop and approve methods which would allow evaluating environmental conditions of natural and natural anthropogenic landscapes. Since all components of the environment are closely interconnected, damaging one component inevitably produces changes in the others. Thus, assessing the state of one component, one can assume certain changes of the other components. Living organisms, including those of flora species, respond most sharply to environmental changes.

The last few decades have seen progressive deterioration in environmental conditions of inland water bodies of the Tyumen region which led to simplification

of aquatic flora and vegetation, loss of some rare species and plant communities. This situation is characteristic of water bodies of the city of Ishim.

Hydromacrophytes are stabilizing components of water ecosystems as they make up perennial plant communities. They form and sustain environmental conditions of water bodies and make the existence of other groups of hydrobionts possible. Hydromacrophytes have a number of adaptation abilities which allow them to survive wide fluctuations of different environmental factors, not only seasonal within a year, but also those taking place over a number of years. Hydromacrophyte communities are adapted to regimen established over prolonged periods in the past. This regimen is characterized by a certain range of environmental fluctuations inherent in each type of water bodies. Therefore the data on taxonomic composition of hydromacrophytes, composition and structure of plant communities can be used for complex evaluation of environmental conditions of water bodies.

At present there are some data on aquatic and riparian vegetation of miscellaneous water bodies found in the city of Ishim (dead river channel Ishimchik, Lake Chertovoe, the Ishim, the Mergenka, and the Karasul rivers), there are also data on environmental conditions and phytometer significance of some species [1–9]. Furthermore, [1] considers the potential of using aquatic plants and plant communities along with other organisms for evaluation of aquatic environment.

The multi-author work "Current state of terrestrial and water ecosystems of the city of Ishim" integrates data on complex evaluation of ecological states of water ecotopes carried out with the help of bioindication and biotesting of the dead river channel Ishimchik, Lake Chertovoe and the river Ishim [10].

The above-named water bodies are of great significance for the life of the town. The Ishim river is the major waterway and the southern boundary of the town which is situated along its left bedrock bank. The river supplies the town's water needs. The river Mergenka flows from the south-western boundary of the town to its north-west part and falls into the river Karasul to the right within the city limits. The river Karasul is the northern boundary of the town. Lake Anikino, adjoining the town, is situated on the north-west, east of the cemetery. Agricultural fields are found to the north of the lake, the south-western banks are occupied by private housing. The dead river channel Ishimchik and Lake Chertovoe are situated within the town limits and they are included in the town beautification plan.

The aim of the work was to evaluate the ecological state of water ecotopes of the river Ishim within the town limits (the Karasul and the Mergenka rivers, Lakes Anikino, Chertovoe and the dead river channel Ishimchik) using phytoindication data.

Material and method

The hydrobotanic operations were carried out on the waterbodies in the summer seasons of 2008-2010.

The river Ishim. The length of the river within the town limits is 15 km. The average current velocity is 0.1–0.2 m/s. The riverbed is 80-100 m wide, with sandy mud bottom, steep, bluff banks. Maximum depth is 10 m.

The river Karasul is the left tributary of the Ishim, it rises in the boggy lake Karasul. The length of the river is 128 km (14 km within the town limits), the banks are steep. Meandering riverbed is 5-20 m. wide. Maximum depth is 3 m. Muddy bottom at the reaches of the river, sandy or clay at the shallows.

The river Mergenka is the right tributary of the river Karasul which takes off from lake Mergen. The length is 10 km, 7 km within the city limits. The depth of the river in low water is rarely more than 0.5 m. The river bed is 1.0-3.0 m, it has sandy mud bottom.

Lake Anikino is a pit lake situated within the first terrace above the floodplain of the river Ishim. The total area is 325.3 thousand square meters. Pit lakes are characterized by round shape, small depth of no more than 6 m., sloping and, as a rule, swampy banks. The bottom of the lake bed is saucer-shaped, with gradual descent towards the middle. The origin is usually due to subsidence.

The dead river channel Ishimchik is situated in the south-western part of the city on the floodplain of the river Ishim. The water-surface area is 2.8 km^2. The length of the dead river channel is 3 km, width – 20-80 m. The bottom is muddy. Maximum depth is 5.0 m.

Lake Chertovoe occupies the bottom of a large subsidence pothole (1 km^2) on the first terrace above the floodplain in the eastern part of the town. The total area of the lake is 0.07 km^2. The bottom is muddy. The maximum depth is 1.5 m.

For the complex evaluation of water bodies' ecological state we have used the methodological approaches presented in [11–12], data on species composition, data on individual valence of each species according to their trophic and saprobic groups, the implications of indicator values obtained from studying the distribution of individual valences (points) into trophic and saprobic groups, the tolerance limit of hydromacrophyte species to water salinity and acidity levels.

An assessment of trophic and saprobic indices of biotopes was undertaken based on a complete flora inventory of each waterbody; weighted average valencies of hydromacrophytes were calculated using the following formula:

$$V_t = \sum (v_t J_t) : \sum J_t;\ V_s = \sum (v_s J_s) : \sum J_s,$$

where V_t (V_s) = weighted average valency for trophic (saprobity) level, v_t (v_s) = individual valency for trophic (saprobic) level, J_t (J_s)= indicative weight of hydromacrophytes determined from the distribution of individual valencies according to their trophic and saprobic index.

The assessment of water salinity was made with the minimal highest tolerance limit of indicator species to water salinity for each waterbody. To assess the water hardness of lakes and rivers (Ishim and Mergenka) we used a regression formula

$y = 4.6 \times x + 2.8$,

where y= water hardness mg-eq/l, x= salinity level g/L; the salinity levels were defined by phytoindication method and ranged from 0.3 to 1.0 g/L. To assess the hardness of water in the Karasul river we used a regression formula $y = 4.2 \times x + 0.8$ as the salinity level measured by phytoindication method was 0.2 g/L [12]. To assess the acidity

level (pH) of the water we looked at the maximum concordance of the acidity tolerance range of indicator species.

Results and discussion

The aquatic flora of the water bodies under discussion includes 54 species from 36 genera, 26 families and 4 divisions (Table 1).

Table 1

Taxonomic structure of aquatic macrophyte flora of the water bodies of the city of Ishim and its surroundings

Division, class	Family		Genera		Species	
	quantity	%	quantity	%	quantity	%
Chlorophyta	2	8	2	6	2	4
2. *Charophyta*	1	3	1	2	1	2
3. *Bryophyta*	2	8	2	6	2	4
4. *Magnoliophyta*	21	81	31	86	49	90
Total	26	100	36	100	54	100

The aquatic macrophyte flora of the rivers is diverse. The total number of species is 46; 23 of those were found in the Ishim river, 37 in the Karasul river, 21 in the Mergenka river. The aquatic macrophyte flora of lakes includes 24 species; 23 species of those were found in the dead river channel Ishimchik, 22 in Lake Anikino and 11 in Lake Chertovoe.

Based on the values of individual trophic valence and indicative weight of hydromacrophytes we calculated the weighted average valency values for the studied water bodies of the city of Ishim and its surroundings (Table 2).

Table 2

Weighted average valency values based on individual trophic valency and indicative weight of hydromacrophyte species in the studied water bodies of the city of Ishim and its surroundings

Water bodies	Weighted Average Valency Value (Vt)		
	Trophic Index		
	Oligotrophic	Mesotrophic	Eutrophic
The Ishim River	0,5	7,9	1,5
The Karasul River	1,0	6,6	1,8
The Mergenka River	0,7	7,5	1,7
The Dead river channel Ishimchik	0,9	7,2	1,7
Lake Anikino	0,9	6,8	2,2
Lake Chertovoe	0,6	7,0	2,4

According to the weighted average valency index found in Table 2, water bodies can be characterized as eutrophic-mesotrophic, as the values in these groups are significantly higher than for ologotrophic.

The distribution of weighted average saprobity valencies into saprobity groups in the studied water bodies is represented in Table 3.

Table 3

Weighted average valency values, based on individual saprobity valency and indicative weight of hydromacrophyte species in the studied water bodies of the city of Ishim and its surroundings

Water bodies	Weighted average valency value (Vs) Saprobic Index				
	χ	*o*	*β*	*α*	*ρ*
The Ishim River	–	1,2	2,4	0,5	0,0
The Karasul River	0,0	1,4	7,5	0,9	0,0
The Mergenka River	0,0	1,4	7,9	0,6	0,0
The Dead river channel Ishimchik	0,0	1,4	7,0	1,8	0,0
Lake Anikino	0,0	1,1	7,3	0,7	0,0
Lake Chertovoe	0,0	1,5	2,6	1,1	0,1

Note: Saprobic value groups: χ – xenosaprobic, o – oligosaprobic, β – beta-mesosaprobic, α – alpha-mesosaprobic, ρ – polysaprobic.

As seen from the data in Table 3, most water bodies (except the dead river channel Ishimchik) can be considered oligo-beta-mesosaprobic. However, comparing the saprobity index of rivers and lakes, it should be noted that the lowest values are found in the Ishim river and Lake Chertovoe which are beta-mesosaprobic. The dead river channel Ishimchik has a higher weighted average valency in the alpha-mesosaprobic group as compared with oligosaprobic group, in contrast to the other water bodies. Therefore, the dead river channel is alpha-mesosaprobic.

Salinity, general hardness and acidity values observed in the studied water bodies of the city of Ishim and its surroundings, according to the results of phytoindication, are presented in Table 4.

Table 4

Assessment of environmental state of aquatic biotopes in the city of Ishim and its surroundings based on the salinity, general hardness and acidity levels as shown by phytoindication

Water bodies	Salinity		General Hardness		Active Water Reaction	
	The lowest salinity value in upper extreme g/L	*category*	*mg-eq/l*	*category*	The zone of maximum concordance of the acidity tolerance range	*category*
The Ishim River	0,6	fresh	5,6	moderately hard	7,6–8,0	alkalescent
The Karasul River	0,2	fresh	1,6	soft	7,6	alkalescent
The Mergenka River	0,6	fresh	5,6	moderately hard	7,6–7,8	alkalescent
The Dead river channel Ishimchik	0,3	fresh	4,2	moderately hard	7,6	alkalescent
Lake Anikino	0,6	fresh	5,6	moderately hard	7,6	alkalescent
Lake Chertovoe	1,0	bracken	7,4	hard	7,6–8,2	alkalescent

As seen from Table 4, the lowest salinity level is observed in the Karasul River which rises from a swampy lake, while the highest salinity level is a characteristic of Lake Chertovoe. Thus, the water in most water bodies is fresh, with low mineralization level (no more than 1.0 mg/L); in Lake Chertovoe the water is fresh, with moderate mineralization.

The species *Scirpus ehrenbergii* and *Sparganium emersum* have high indicative value for the studied area of the Ishim River, as they are marked by the lowest (0.6 g/L) salinity tolerance. The main indicator species for the Karasul river is *Plagiomnium ellipticum* (the lowest salinity tolerance 0.2 g/L). The species *Potamogeton compressus, Sparganium emersum* and *Agrostis stoloniferaare* have indicative value for the river Mergenka (the lowest salinity tolerance 0.7 g/L).

The salinity of water in the dead river channel Ishimchick is indicated by the species *Drepanocladus aduncus* and *Myriophyllum sibiricum* (the lowest salinity tolerance 0.3 g/L). The main indicator species for Anikino Lake are *Agrostis stolonifera* and *Carex pseudocyperus* (the lowest salinity tolerance 0.6 g/L). The fresh water of Chertanovo Lake is indicated by the species *Spirodela polyrhiza, Butomus umbellatus* and *Alisma plantago-aquatica* which have the lowest upper extreme salinity tolerance (1.0 g/L).

Values of water hardness obtained using regression formula show that in most water bodies the water is moderately hard (5.5 mg-eq/l), in the Karasul river it is soft (1.6 mg-eq/l) and in Late Chertovoe it is hard (7.4 mg-eq/l).

The active water reaction (pH) in water bodies under study is alkalescent with pH values ranging from 7.6 to 8.2. Indicative of the alkalescent water reaction are the species for which this acidity level (7.6-8.0) is at the top of the tolerance range. These are *Potamogeton crispus, Nuphar lutea, Scirpus ehrenbergii, Lemna minor* and *Sparganium emersum.* For the Karasul river indicator values have the species *Plagiomnium ellipticum, Myriophyllum verticillatum, Callitriche hermaphroditica, C. palustris, Potamogeton natans* (their acidity tolerance ranges coincide at pH 7.6). The active water reaction of the Mergenka river of 7.6-7.8 is indicated by species *Lemna minor* and *Potamogeton compressus.*

Indicators of active water reaction of the dead river channel Ishimchik are the species *Lemna minor, Myriophyllum sibiricum, Batrachium circinatum* and *Drepanocladus aduncus.* Lake Anikino has species *Lemna minor* and *Carex pseudocyperus* as indicator ones ((their acidity tolerance ranges coincide at pH 7.6). The species Butomus umbellatus and Typha latifolia are the indicator species of the acidity level in Lake Chertovoe (7.6-8.2).

Conclusion

Thus, summarizing the quantitative data on the tolerance of indicator species towards the main factors of aquatic environment, we evaluated the ecological state of Ishim water ecotopes which have a great economic value. We performed an assessment of the following aquatic environment characteristics: trophic and saprobic indices, salinity, general hardness and active water reaction.

According to the obtained data, the water bodies of Ishim and its surroundings are eutrophic-mesotrophic. The saprobity index values show that most water bodies

under study are oligo-beta-mesosaprobic (except the dead river channel Ishimchik), their saprobity index is considerably lower than that of the dead river channel Ishimchik which is alpha-beta-mesosaprobic. The water in most water bodies is fresh, with low mineralization level, in Lake Chertovoe the water is fresh, with moderate mineralization. The values of water hardness obtained using regression formula show that the water of most water bodies is moderately hard, with soft water in the Karasul river and hard in Lake Chertovoe. Based on the probable range of active water reaction we conclude that the water of most water bodies under discussion is alkalescent.

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