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Bivalve mollusks (mollusca, bivalvia) indicators of different types of reservoir bodies and watermarks of the rivers basin of Uzbekistan

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Abstract. As a result of studying different types of reservoirs and watercourses of rivers in Uzbekistan, the species composition of indicator bivalve mollusks was established, belonging to 24 species, 3 subspecies, 11 genera and 5 families. 10 species and 3 subspecies of them are large, the rest 14 are small bivalves. All of them are good water biofilters. The majority of biofilters inhabit reservoirs and canals (11 species), but in the latter there are more α – mesasaprobic mollusks and they are more polluted, and the anthropogenic influence is clearly manifested here. In terms of water pollution, the rivers are classified as moderately polluted classes III – IV; differences in the composition of saprobic species in the middle and lower reaches of rivers have been identified. In general, the water bodies of Uzbekistan are clean and there are no polysaprobic mollusks here.

1 Introduction

Currently, the increasing pace of industrialization and urbanization, as well as the imperfection of technologies used in industry, leads to increasing pollution of the external environment, which leads to undesirable consequences for humans. In this regard, the problem of clean water becomes urgent, i.e. protection of water bodies from pollution.

As far back as at the end of the 19th Century (1868-1870), German researchers A. Muller and F. Koch drew attention to the enormous role of biological self-purification of reservoirs carried out by various hydrobionts. It became clear that studying the issues of pollution and purification of water bodies is impossible without taking into account the role of aquatic organisms and without knowledge of their ecology.

For the first time R. Kollwitz and M. Marson [1] divided reservoirs and their zones into poly- meso- and oligosaprobic depending on the degree of pollution with organic substances. Subsequently, in the works of Ya.V.Nikitinsky, G.I.Dolgov and S.N.Strogonov carried out at the end of the 19th and the beginning of the 20th Centuries, the role of individual organisms in the processes of self-purification of water bodies was clarified and the principle of assessing the degree of pollution of the latter was developed by the presence of aquatic organisms with different requirements for water purity.

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Moller Pillota's Research [2] is devoted to assessing the degree of pollution by animals, in which mollusks were indexed on a scale of frequency of occurrence in the aquatic environment.

Based on information about the species composition of aquatic organisms found in certain waters, one can form an idea of how clean and polluted the latter are.

In literary sources, hydrobionts characteristic of different saprobity are called indicators of the degree of pollution of water bodies. The indicator role of hydrobionts is characterized not only by the fact of their presence or absence in a reservoir, but also by the degree of quantitative development, and in this regard, the characteristics of waters should be carried out taking into account not only the species composition of organisms, but also their numbers and biomass [3, 4]. To improve health [5] suggest using a number of mollusks and other invertebrate natural and waste waters [4]. The system for assessing water pollution by the degree of saprobity is currently becoming clearly insufficient, since it does not take into account presence of toxic substances in water. Therefore, V.I. Zhadin [6] considered it expedient to accept and experimentally substantiate three scales for assessing the pollution of water bodies, the degrees of saprobity, taxability, and saprobity and, depending on the pollution of water bodies with toxic substances, he distinguished poly-meso and oligosaprobic zones inhabited by organisms, which, respectively, tolerate strong, medium and weak degrees of toxic pollution of water bodies. bioelectronic systems and functional state of bivalves.

It should be especially noted that until now, mollusks as indicators of pollution of water bodies and watercourses have been taken into account in conjunction with other planktonic and benthic invertebrates, such as cladocerans, chironomids, oligochaetes and other animals [7, 8, 9]. According to O.L. Kachalova [4], from the general complex of hydrobionts, the best indicators of the biological state of water bodies are zoomacrobenthos organisms; they are long-lived, inactive and, therefore, more sensitive to the quality of soils and upper layers of water. She further emphasizes that mollusks and oligochaetes are among the hardiest biotas and form the usual basis of benthos in reservoirs rich in organic matter. Her indication that bivalve mollusks, due to the thickness of their shells, and combbranchs, due to their operculum, are often isolated from the environment and cannot always serve as reliable indicators of saprobity in comparison with other animals, this is apparently not entirely fair, because precisely unfavorable conditions force mollusks to close their shells and therefore this reaction is one of the acts that makes it possible to indicate pollution of water bodies. This can also be confirmed by the fact that bivalves, permanent inhabitants of reservoirs and watercourses (in Central Asia, large bivalves live only in lowland reservoirs), are excellent orderlies in them. These mollusks are very demanding on water quality; their presence in aquatic biocenoses is an indicator of its purity. In a toxic environment, they do not feed, close their shells and do not respond to food [10].

Among animal filter feeders that actively participate in the processes of purifying waters polluted by allochthonous organic matter, the first place is rightfully occupied by mollusks. By passing all the water through themselves, they filter out suspended particles. The number of bivalve mollusks can also be used to judge the cleanliness of a reservoir. According to G.P. Kondratiev [11], toothless fish Colletopterum piscinale Nilson, 1822, from the Volgograd reservoir, reaching a length of 9-11 cm, can filter up to 60-70 liters of water per individual per day. According to our data [10, 12], one individual of the Central Asian toothless *c. cyreum sogdianum (Kobelt, 1896*) from the Zarafshan River, which reached 5–7 years of age and a size of 25–27 cm, passed through itself 180–200 liters of water per day . From this it is clear what a big role shellfish can play in cleaning polluted waters. To quantify the role of mollusks in purifying the water of reservoirs from suspended substances A.F. Alimov [13] proposes to use the dependence of the rate of water filtration by animals on their size. For example, he showed that the number of *Sphareum corneum (L., 1758*) was 565 specimens/m^2 the average weight of one animal in the population did not exceed 0.096 g. Mollusks of this size filter water at a rate of 69.6 ml/day. Consequently, all mollusks on an area of 1 m^2 filter 39.1 liters of water per day, and the entire animal population filters 4.2 m^2 or 8.2% of the volume of water in the pond. Mollusks filter their weight and volume of water in about 24 days [13].

From the above it is clear that in general, the study of bivalves as water biofilters is of not only theoretical, but also of great practical interest. It should be noted that earlier, when studying mollusks as indicators of reservoirs and watercourses of Central Asia, gastropods and bivalves groups of mollusks were considered together [14], and then in the works of the authors [12, 15] bivalves were considered separately. Recently, studies have appeared on the indicator role of marine macrobenthic organisms; one of them analyzed the composition of 15 species of marine mollusks belonging to 14 families and classes (gastropods and bivalvia) [16]. The work of Kanieva et al. [17] studied the effects heavy metals on the chemical composition of the body of bivalve mollusks.

The purpose of this work is to study bivalves as indicators in various types of reservoirs and watercourses in river basins of Uzbekistan.

2 Materials and research methods

The studies were conducted during 2004-2016. A toothed dredge and a bottom grab were used to catch mollusks. Petersen, and also used manual collection.

Maintaining the "purity" and information content of biosamples at the stages of transportation and storage was achieved by using glass and polyethylene containers and fixing animal samples with 50% ethyl alcohol. Then in the laboratory they were replaced with 70% alcohol. All dry shellfish collections were stored in various large boxes. In total, more than 5 thousand shellfish shells were collected and processed from the floodplains and backwaters of the Sirdarya, Zarafshan (Fig. 1.2.) and Amu Darya rivers, of which 50 were alcohol samples._The material is stored in the laboratory of mollusks of Samarkand State University named after. Sharof Rashidov.

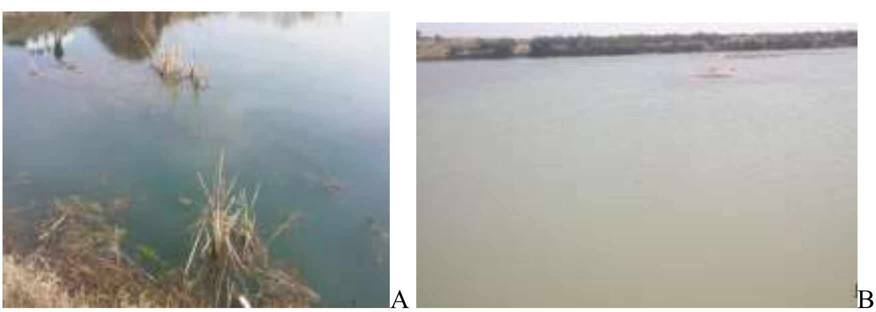

Fig.1. A - Floodplain of the river. Syrdarya near the city of Yangiyul, Tashkent region; B - Middle reaches of the river. Syrdarya beyond the city of Khujand (Tajikistan) (Photo by Z. Izzatullaev, 2017)

Fig.2. A - Floodplain of the right branch of the Zarafshan River near the village of Dagbit, Samarkand region. B - Zarafshan River near the city of Samarkand (Photo by Z. Izzatullaev , 2019)

The degree of pollution of water bodies was determined by the degree of their pollution with organic substances into catarobic, polymeso- and oligosaprobic [10, 14] . To determine the species composition of mollusks, we used the works of [10, 18-24]. Water quality discharge and bioindication saprobity is given according to A.N. Zhukinsky et al., [25], J.Slanki [26].

3 Research results and Discussion

For the first time, in different types of reservoirs and watercourses of river basins of Uzbekistan, the habitat of 24 species and 3 subspecies of bivalve mollusks, belonging to 11 genera and 5 families, was established as indicators of water saprobity. Of these, 10 species and 3 subspecies of them belong to large, the rest 14 are small bivalve mollusks. Among the total number of mollusks in reservoirs and canals, an equal number of saprobic species (11 each) live, however, both reservoirs are equal in the number of β - mesosaprobic mollusks (8 species each), on the contrary, two more species were found in the canals (Corbiculina ferghanensis Kurs. et. Star.,1971, and Euglesa obliquata Clessin, 1874) α – mesasaprobic mollusks (see Table 1).

Table 1. Indicator bivalves living in various types of reservoirs and watercourses of river basins of Uzbekistan

No	Families and species of mollusks	Keys	Springs and	Rivers	Lakes	Reservoirs	Channels	Water quality indicator
1	Family *Unionidae Collotopterum bactrianum Rolle, 1877*			β	β	β	β	β
2	*C.cyreum sogdianum (Kobelt, 1896).*			β	β	β	β	β
3	*C.kokandicum Starobogatov et Izzatullaev, 1984*			β	β			β
4	*C.ponderosum volgense (Shadin, 1938)*					β	β	β
5	*Sinanodonta woodina (Lea, 1854)*					β	β	β
6	*S. orbicularis (Heude, 1880)*					β	β	β
7	*S.pueropum (Heude, 1880)*					β	β	*β*
8	C family *Dreissenidae Dreissena polymopha aralensis (Andrusov, 1897)*			β	O			β-O
9	*C family Corbiculidae Corbicula cor (Lamarck, 1818)*			*O*	*O*	*O*		*O*
10	*C.fluminalis (OFMuller, 1774)*			O		O		O
11	*C. purpurea Prime, 1864*			O			O	O
12	*Corbiculina tibetensis (Prashad, 1925)*			O		β	β	O - *β*
13	*C. ferghanensis (Kursatova et Starobogatov, 1971)*			O	β	β	α	O-β-α
14	C family *Sphaeriidae*				α			α

	Spaerium corneum (L., 1758)							
15	*Family Pisidiidae Pisidium amnicum (O. F. Muller, 1774)*				β		β	β
16	*Kuiperipisidium terecense (Kazannikov in Izzat. et Star., 1986)*	K						K
17	*K.issikkulense (Izzat.et Starobogatov., 1986)*	K						K
18	*K.sogdianum (Izzat.et Star., 1986)*	K						K
19	*K.polytimeticum (Izzat. et Star., 1986)*	K						K
20	*Odnepisidium prashadi (Odhner, 1977)*	K						K
21	*O.behningi Izzat.et Star.1986*	K						K
22	*O.kungejense (Butenko et Star., 1967)*	K						K
23	*Family Euglesidae Eulessa turkestanica (Izzat., 1974)*			O		O		O
24	*E. obliquata (Clessin, 1874)*		β	β		α	α	β - α
25	*E. heldreichi (Clessin, 1874)*		O					
26	*Cuclocalix turanica (Clessin in Martens, 1874)*	K						K
27	*Cingulipisidium hissarica Izzat . et Starti ., 1985*	K						K
	Total types of mollusks:	9	3	10	8	11	11	

1. Previously known in literature as Sinanadonta gibba (Benson, 1855) [10] is currently considered a junior synonym of S. wodiana (Lea, 1854) [27].

K – catarobes, living in clean water;
O – oligosaprobic, moderately polluted;
β – mesasaprobic contaminated;
α – mesasaprobic, contaminated water.

This leads to the conclusion that canals are more polluted than reservoirs. Among the total number of 10 species of indicator mollusks of the rivers here, species of β- mesasaprobic (6 species) mollusks also predominate, while there are five oligotrophic species. Nine species of catarobe mollusks live in springs with clean water.

Previously living in desalinated areas of the Amudarya River delta and the shores of the Aral Sea *, D. polymorpha aralensis* (Fig. 3) from the genus *Dreissena van Beneden*, 1835 due to sea salinity became extinct. The mollusk now lives only in the river basin. Danube in Ukraine and river deltas of Volga [28].

Fig.3. Dreissena polymorpha aralensis (Andrusov) from deltas rivers Amu Darya (Karakalpakstan) (volumes E. Arystanova, 1984; photo Z. Izzatullaeva, 1987). Shell length 24 mm.

It should be especially noted that large bivalves of the large rivers of Uzbekistan: Syrdarya, Amudarya and Zarafshan were subjected to detailed research as indicators of various polluted waters, in particular, saprobity [15]. In general, polysaprobic groups of bivalves were not found in the rivers of Uzbekistan, which means that they are not able to live in polluted waters. However, species close to the polysaprobic α- mesasaprobic groups account for about 60% of all bivalve mollusks living in water bodies. This is clearly seen from Fig. 4.

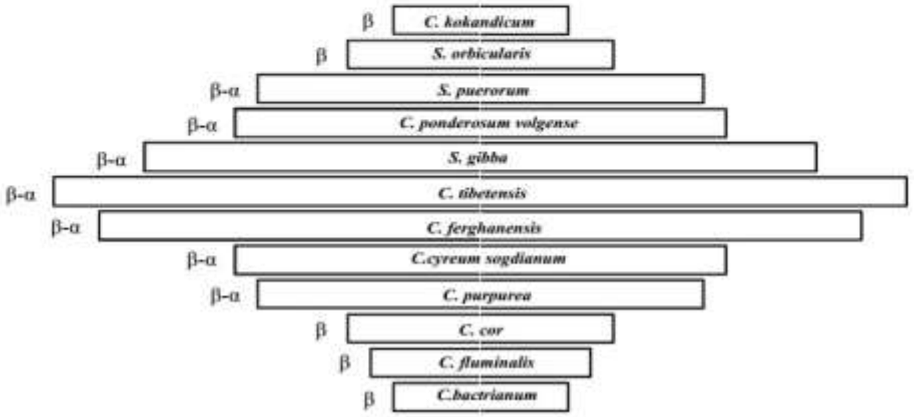

Fig.4. Spectrum of saprobity of species of the families *Unionidae* and *Corbiculidae* [15].

These species include species common in the Syrdarya basin of the Sirdarya region and in the lower reaches of the Zarafshan River: *Sinanodonta woodiana, S. puerorum, S. orbicularis* (Fig. 5. A.B.C.)

Fig.5. Shells of species of the genus *Sinanodonta Modell, 1944:*
A - S. *wodiana (Lea , 1854):* Shell length 156. Shell height at the crown 105. Shell height at the wing apex 111, convexity (both valves) 57 mm.
B - *S. puerorum (Heude)*: Shell length 159. Shell height at the umbos - 101. Shell height at the apex of the wing 106, convexity (both valves) 63 mm.
C - *S. orbicularis (Heude)*: Shell length 98. Shell height at umbos 66. Shell height at wing apex 67, convexity (both valves) 31 mm. All collections from the Kattakurgan reservoir Kh.T. (Boymuradov, 1999; photo by Z. Izzatullaev, 1999).

Here *S. woodiana,* previously referred to by us as S. gibba [10], however, as malacologists later found out that this species by DNA sequencing to belong to S. woodiana [27]. This mollusk was identified by malacologists in Western Europe [32, 33] Mlanmara [30] and Ukraine [28,31-33] and Russia [34] was noted as an East Asian adventitious species. More recently, it was discovered in the USA (Bigon, 2010, 2011. quoted from [33].

From the Syrdarya, Zeravshan and Amu Darya the following are known: *Colletopterum bactrianum , C. ponderosum volg e nse , C. cyreum sogdianum* (Fig. 6. A.B.C)

Fig.6. Species of the genus *Colletopterum Bourguigat, 1882:*
A - *C . bactrianum (Roll)* - from the vicinity of Bukhara. Kuyumazar channel. vicinity of the village of Sayyot , collected by Z.I. Izzatullaev , 1976. Shell length 131. Shell height at the crowns 75. Shell height at the apex of the wing 76, convexity (both valves) 43 mm.
B - *C. ponderosum volgense (Shadin)* - from the Kattakurgan reservoir, collected by Z.I. Izzatullaeva, 1979. Shell length 120.5. The height of the shell at the crown is 65. The height of the shell at the apex of the wing is 67, the convexity (both valves) is 57 mm.
C - *C. cyreum sogdianum (Kobelt)* - from the Kattakurgan reservoir, collected by Z.I. Izzatullaeva, 1979. Shell length 150. Shell height at the crowns 76. Shell height at the apex of the wing 80, convexity (both valves) 53.5 mm.

And kinds *Corbiculidae : Corbicula fluminalis , Corbiculina ferghanensis and C.tibetensis* (Fig.7 A. B. C).

Fig.7 . Kinds families *Corbiculidae:*
A - *Corbicula fluminalis (OF Müller)* - from rivers Zarafshan, fees Z. and Izzatullaeva, 1978. Height shells 20-21. Length shells 19-20. Thickness shells 17 mm.
B - *Corbicula ferghanensis (Kursalova et Starobogatov)* - from Kattakurgan reservoirs , volumes Z. Izzatullaev, 1978. Height shells 14-43.8. Length shells 18-38.8. Thickness shells 12-26 mm.
C - *Corbicula tibetensis (Prashad)* - from channel Khisrav near Samarkand , both collection Kh. Boymuradov, 2004; photo Z. Izzatullaev, 2004. Height shells 17-32. Length shells 21-36. Thickness shells 12.5-13.5 mm.

Among the above species, *Sinanodonta* has a wide range of saprobity *Woodiana, Corbiculina ferganensis* and *C. Tibetensis*, according to the saprobity index (equal to an average of 3.3), it approaches the polysaprobic level (3.5) (Fig. 4). It should be especially noted that the last two species, with a saprobity index of 3.3 - 3.5, live even in the conditions of the salt lake Ashikul in Karakalpak [9], where other bivalves are not found at all and this corresponds to their saprobity index. The remaining species (40%) belong only to the β-mesasaprobic group: (*Sinanodonta orbicularis, Colletopterum bactrianum, C. kokandicum, Corbicula cor, C. fluminalis),* a large proportion of which are rare and not common groups. According to the spectrum of β – mesasaprobicity S. orbicularis superior to the other 4 species.

Thus, the data obtained on bivalves are important in determining water quality, especially the correspondence of most β- mesasaprobic species to rare and rare species and the impossibility of living in polluted waters, and this factor indicates the importance of their distribution. Water pollution where such species are common can be classified as group III (moderately polluted). The possibility of survival in saprobic zones of other β-α mesasaprobic species is much higher and the occurrence of *Sinanodonta species in water bodies Woodiana, Corbiculina ferghanensis And C. tibetensis* means that these bodies of water belong to III and IV contaminated group. If we compare the data on the degree of distribution of bivalve mollusks in rivers in their middle and lower reaches (Fig. 8) with their saprobity spectrum (Fig. 4), then we can see the presence of a relationship between the saprobity spectra of bivalve mollusks and their distribution.

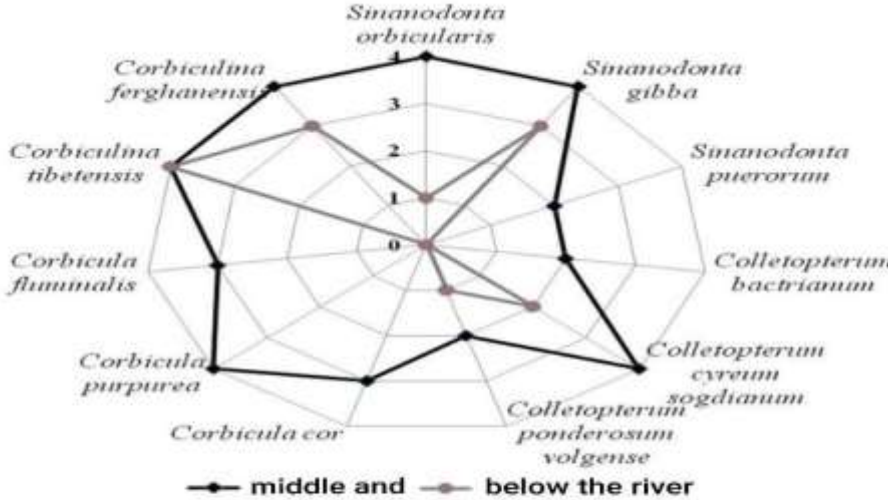

Fig.8. Distribution of species of the families *Unionidae* and *Corbiculidae* in the middle and lower reaches of rivers of Uzbekistan [15].

Based on this, we can conclude that for the distribution of bivalves in water bodies, the saprobic feature of water is important. Based on this, we can come to the conclusion that among the species listed in the "Red Book" of the Republic of Uzbekistan (2019), *Colletopterum cyreum sogdianum* belongs to β – α mesasaprobic species and, at the same time, positive indicators were noted in all reservoirs in its population. From this we can come to the conclusion that there is a relationship between the degree of distribution of bivalves and their saprobic characteristics.

Conclusion.

In different types of reservoirs and watercourses of different river basins of Uzbekistan, 24 species and 34 subspecies of bivalve mollusks, belonging to 11 genera and five families, were recorded as indicators of water saprobity, 10 species and 3 subspecies of them are large bivalve mollusks from the genera *Colletopterum, Sinanodonta and D reisena*, the rest of 14 are small bivalves.

These filter-feeding mollusks are important in determining the saprobic qualities of water in reservoirs. Belonging of rare and endemic species of mollusks to β – mesasaprobic group means that their distribution is associated with the level of water pollution. Only among the species listed in the "Red Book" of the Republic of Uzbekistan is *Colletopterum cyreum sogdianum* in the β – mesasaprobic group and the positivity of population indicators in all water bodies substantiates the relationship between saprobity and its level of distribution in different parts of rivers.

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