Fish Capacity of a Sand Pit by Zoobenthos of the Sura River Floodplain within Penza Region

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Abstract. Sand pits have great potential in terms of domestic aquaculture development, therefore assessment of their natural fish capacity is essential in terms of food resources. The assessment of fish capacity by zoobenthos in a sand pit deprived of representatives of ichthyofauna was carried out. It was found out that zoobenthos of a sand pit in the flood plain of the Sura river has not rich species composition that varies considerably by seasons with multiple fluctuations of population number and biomass. At the same time the highest values were observed in June, the productivity of zoobenthos increases with increasing water temperature and decreasing water level. By the number of taxa, the number of population and biomass of fodder zoobenthos the sand pit is inferior to the Municipal water storage basin on the Sura river. Fish capacity of forage zoobenthos of the pit by zoobenthos was 14.42 kg/ha, which was 2-3 times lower than in Sursky and City reservoirs, the natural bed of the Sura river. Due to reclamation works in drained pits it is possible to increase the productivity of zoobenthos. In permanently watered pits the cultivation of benthic fishes is rather limited.

1. Introduction
The total area of inland water bodies exceeds 25 million ha, including the area of multi-purpose water bodies and ponds formed on peat, sand or gravel pits - about 1 million ha [1]. Thus, pits have great potential in terms of domestic aquaculture development. One of the most important factors for effective fishery use of pits is the assessment of their natural fish capacity in order to manage fish breeding processes - norms of juvenile fish stocking, feeding, fertilization of ponds. Macrozoobenthos is one of the main components of the fish food base.

In a number of water bodies, it may have a dominant importance in the composition of the food base. Therefore, the assessment of fish capacity according to this indicator is an integral part of fishery research [2, 3]. The peculiarity of our research is not simply the study of zoobenthos in a sandy desiccated pit, but in a pit devoid of representatives of ichthyofauna, i.e. in the basic water body of this type. The value of the work is also the study of the elements of seasonal zoobenthos fluctuations, which material is very limited in the water bodies of the region. The aim of the study is to assess the fish productivity of zoobenthos in a sand pit, devoid of ichthyofauna representatives.

2. Materials and Methods
The sand pit, 0.5 ha in area, is located 25 m from the Sura River (City Water Reservoir), on its right bank. The topography of the pit bottom is heterogeneous, so that its depths exceed 2 m in several places. The water level in the pit depends on precipitation and the water level in the Sura River, with which it is connected by groundwater. There was no external hydrological connection to the reservoir during the
2013-2017 observation period. In the study years, the pit completely dried up by August and re-filled with water in autumn. There was no discharge of nutrients affecting the natural productivity of the pit.

Pit sampling was carried out at three mid-month points in the presence of watering during the ice-free period of 2015 - in May, June, November and in May of 2016. Macrozoobenthos samples were collected with a hydrobiological scraper with a cutting edge length of 16 cm and then were fixed with formalin, a total of 12 samples were collected in the pit. For the comparative analysis, 12 samples were collected in parallel in the adjacent coastal section of the City Water Reservoir on the Sura River. The samples were processed according to generally accepted methods [2, 3].

The changes in zoobenthos species composition by months and years were calculated as a percentage according to the modified version of Jaccard's coefficient: \[ X = \frac{B \times 100}{A_1 + A_2 + B}, \] where B is the number of species encountered in both months, A1 is the number of species of the initial month, A2 is the number of species of the following month.

Correlation coefficients were calculated using Microsoft® Excel® 2010 program between monthly average zoobenthos abundance and biomass with monthly average indicators of temperature, transparency and level of water in the pit; between monthly average indicators of zoobenthos in the pit and the Sura river (City Water Reservoir).

The fish production is based on the hydrobiological method with coefficients adapted to the Volga region [2, 3].

3. Discussion

Species composition of zoobenthos. During the whole period of research 15 zoobenthos species were found in the pit: Olygochaeta - 2 species, Mollusca - 4 (gastropods - 2, bivalves - 2), Odonata - 1, Chironomidae - 4, Heteroptera - 1, Coleoptera - 3. At the same time, the number of species varied by month from 2 in May to 8 in June before the pit dried up in 2015 (average of 5 species). Monthly species composition varied by 60-100% (78% on average) (Table 1). Olygochaeta were consistently found in the samples, while Chironomidae and various Mollusca were also common. The most frequently recorded species was Tubifex tubifex (Olygochaeta).

Abundance. The lowest abundance was recorded in November and the highest in June of 2015. (Table 1). High abundance in some months were shown by: the gastropod Choanomphalus rossmaessleri - in May 2016; the gastropod Choanomphalus rossmaessleri - in 2015; oligochaetes Tubifex tubifex - in May 2015; the chironomid mosquito larvae Chironomus sp. - in June; the polychaetes Lumbriculus variegatus and the bivalve Pisidium amnicum - in November. The most abundant over the whole observation period were the chironomid mosquito larvae Chironomus sp.

Biomass. The lowest zoobenthos biomass values were recorded in November and the highest in June (Table 1). High biomass in some months was shown: in May 2016 - by the gastropod Choanomphalus rossmaessleri; in 2015 - by the oligochaetes Tubifex tubifex (May), the gastropod mollusk Lymnaea stagnalis (June), and the bivalve Pisidium amnicum (November). Before the pit dries up, the Lymnaea stagnalis, which has reached its maximum developmental stage in mass, produces a huge biomass, with an average biomass of 2 g per specimen.

In 2015, the number of zoobenthos differed by months by 3.0-19.2 times; the total bio-mass - 5.8-247.3 times, excluding Lymnaea stagnalis - by 5.8-9.8 times. In May 2015 and May 2016 the number of zoobenthos differed by 2.2 times; the biomass - by 1.1 times.

The dependence of the pit zoobenthos development on natural factors. Assessing the monthly correlation between zoobenthos number and biomass indices with water temperature a high positive correlation coefficient of +0.887 and +0.676 respectively is noted (Table 2). Without Lymnaea stagnalis the correlation of benthos biomass with water temperature is even higher - +0.988. The abundance and biomass of zoobenthos also increases with decreasing water level in the pit, the correlation coefficient is -0.680 and -0.855 respectively. There is no correlation between zoobenthos abundance and water transparency (-0.275), while zoobenthos biomass increases with the decrease of water transparency (-0.744).
Table 1. Species composition and number of zoobenthos in the pit during the observation period, specimen/m²/g/m².

| Taxa                   | 2016                        | 2015                        |       |
|------------------------|-----------------------------|-----------------------------|-------|
|                        | May | May | June | November |       |
| Oligochaeta            |     |     |      |          |      |
| Lumbriculus variegatus (O.F. Müller, 1773) |     |     |      | 12.50/0.06 |      |
| Tubifex tubifex (O.F. Müller, 1774) | 6.25/0.11 | 181.25/1.44 | 12.50/0.13 |      |
| Chironomidae           |     |     |      |          |      |
| Chironomus sp. (Meigen, 1803) | 18.75/0.02 | 18.75/0.02 | 462.50/1.31 |      |
| Psectrocladius sp      | 18.75/0.02 |     |      |          |      |
| Cricotopus sp.         | 12.50/0.01 |     |      |          |      |
| Mollusca               |     |     |      |          |      |
| Gastropoda             |     |     |      |          |      |
| Choanomphalus rossmaessleri (A. Schmidt, 1851) | 375.00/1.38 |     |      |          |      |
| Lymnaea stagnalis (Linnaeus, 1758) |     |     | 31.25/59.38 |      |
| Bivalvia               |     |     |      |          |      |
| Pisidium amnicum (O.F. Muller, 1774), |     |     |      | 12.50/0.13 |      |
| Sphaerium nitidum (Clesson m Wester-lund, 1876) |     |     |      | 6.25/0.06 |      |
| Odonata                |     |     |      |          |      |
| Lestes barbara (Fabricius, 1798) |     |     | 6.25/0.38 |      |
| Heteroptera            |     |     |      |          |      |
| Micronecta griseola (Horváth, 1899) |     |     | 31.25/0.19 |      |
| Coleoptera             |     |     |      |          |      |
| Coleoptera sp.         |     |     |      |          |      |
| Rhantes sp.            |     |     |      | 6.25/0.01 |      |
| Gyrinus sp.            |     |     |      | 43.75/0.44 |      |
| Total                  | 431.25/1.53 | 200.00/1.46 | 600/61.85 | 31.25/0.25 |      |
| Number of species      | 5   | 2   | 8    | 3        |      |
| Changes in species composition, % |     |     |      |          | 60   |

Table 2. The dependence of zoobenthos indicators of the pit and the City Water Reservoir on natural conditions.

| Indicators           | Water body | 2016                      | 2015                      |       |
|----------------------|------------|---------------------------|---------------------------|-------|
|                      |            | May | May | June | November | Average |
| The number of taxa   | sand pit   | 5   | 2   | 8    | 3        | 4.50 ± 2.00 |
|                      | water reservoir | 12 | 15 | 8 | 6 | 10.25 ± 3.25 |
| Abundance, thous. specimen/m² | sand pit | 431.25 | 200.00 | 600.00 | 31.25 | 279.17 ± 213.89 |
|                      | water reservoir | 725.00 | 1593.70 | 562.50 | 268.75 | 787.49 ± 403.11 |
| Biomass, g/m²        | sand pit   | 1.53 | 1.46 | 61.83 | 0.25 | 16.27 ± 22.78 |
|                      | sand pit a | 1.53 | 1.46 | 2.45 | 0.25 | 1.42 ± 0.59 |
|                      | water reservoir | 27.14 | 13.13 | 6.13 | 3.33 | 12.43 ± 7.70 |
|                      | water reservoir b | 9.07 | 13.13 | 6.13 | 3.33 | 7.92 ± 3.19 |
| Water temperature, °C | sand pit | 17.0 | 18.0 | 26.0 | 0.5 | 15.38 ± 7.44 |
|                      | water reservoir | 14.0 | 14.0 | 23.0 | 2.5 | 13.38 ± 5.44 |
| Water level, m       | sand pit   | 0.3 | 0.5 | 0.05 | 0.3 | 0.29 ± 0.12 |
|                      | water reservoir | 1.0 | 0.5 | 1.0 | 0.7 | 0.80 ± 0.20 |
| Transparency, cm     | sand pit   | 70 | 80 | 10 | 30 | 47.50 ± 27.50 |
|                      | water reservoir | 73 | 53 | 100 | 105 | 82.75 ± 19.75 |

a Without large clams Lymnaea stagnalis. b Without large clams Anodonta stagnalis.

Ratio of zoobenthos indicators of the pit with the Sura river (City Water Reservoir). The distance between the quarry and the regulated section of the Sura River - City Water Reservoir is 25 m. The
distance between the sampling points is on average 50 m. The shallow pit with standing water is characterised by earlier warming-up periods and higher water temperatures during the spring-summer period. However, in autumn the water in the pit cools down faster (Table 2).

The number of detected zoobenthos taxa in the pit, except for June, is 2.0-7.5. The number of detected zoobenthos taxa in the pit, except for June, is 2.0-7.5 times lower by months and 2.3 times lower on average for the period of observations. A similar trend is observed with zoobenthos abundance. Except for June, benthos abundance in the pit by months are 1.7-8.6 and 2.8 times lower on average for the observation period than in the reservoir.

![Figure 1](image1.png)

**Figure 1.** Dynamics of taxonomic groups in terms of number of species (a), number of specimens/m² (b) and biomass - g/m² (c) of zoobenthos of the pit and the Sura river (City Water Reservoir).

Except for June, benthos biomass in the pit is 9.0-17.7 times lower than in the water reservoir. However, due to large gastropods Lymnaea stagnalis, the biomass in June is 25.2 times higher in the pit and 1.3 times higher in the whole period of observations. Without large clams the biomass of benthos
in the pit was 2.5 to 13.3 times lower by months and 5.6 times lower on the whole for the period of observations.

There is no correlation between the abundance of animals and biomass of zoobenthos in the pit and the reservoir. The correlation coefficient was -0.039 and -0.267, respectively.

The ratio of zoobenthos indicators of the pit and the Sura river (City Water Reservoir) by taxonomic groups is given in Figure 1. In most cases (5) there is species predominance of zoobenthos taxonomic groups in the reservoir in comparison with the pit. In terms of abundance and biomass, Olygochaeta and Mollusca are also significantly dominant in the reservoir.

**Fish capacity.** To determine fish capacity a separate calculation was made for "soft" benthos and mollusks. The average index of the pit "soft" benthos for 4 months was 1.04 g/m², for mollusks - 15.24 g/m². Hence the fish capacity of the pit by zoobenthos: $8.32 + 6.10 = 14.42$ kg/ha. Average soft benthos for 4 months in the water reservoir was - 3.09 g/m², for molluscs - 9.11 g/m². Hence the fish productivity of the reservoir by zoobenthos: $24.72 + 3.65 = 28.37$ kg/ha. Fish capacity by zoobenthos of the Sura (Penza) water reservoir was 36 kg/ha and of the Sura river - 21.8 kg/ha [2, 3]. Thus, despite the fact that the pit lacks ichthyofauna in the most influential forage organisms, fish capacity of the sand pit by zoobenthos is low.

In general, sand pits are characterized by low fish capacity. Thus, the biomass of benthos in the Oka river basin is 2.4-3.6 g/m², fish capacity of sandy and peat pits is 100-300 kg/ha [4, 5].

4. Conclusion

The zoobenthos of the pit in the floodplain of the Sura river (and in fact, a digged isolated water body of the region) is characterized by poor species composition, which varies to a considerable extent over the seasons with multiple fluctuations in abundance and biomass. The highest values were recorded in June, while in adjacent years the zoobenthos biomass was fairly equal in May. The zoobenthos indicators increased with increasing water temperature and decreasing water level (depth) in the pit. By the number of taxa, abundance and biomass of forage zoobenthos the pit is inferior to the City Water Reservoir. Fish capacity of forage zoobenthos of the pit is 2-3 times less than that of Sursky (Penza) and City water reservoirs, the natural channel of the Sura river.

To increase the productivity of zoobenthos in drained pits it is possible to carry out reclamation works - plowing the bed and seeding with legumes. In such a water body it is advisable to raise juvenile fish. In a permanently watered pit, the cultivation of benthophages such as carp and hybrid crucian carp is rather limited.

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References

[1] 2015 Sectoral program “Development of commercial aquaculture (commercial fish farming) in the Russian Federation for 2015-2020” (Moscow: Rosinformagrotech) p 133
[2] Asanov A 2016 Bulletin of the Astrakhan State Technical University Series Fisheries. 1 7–14
[3] Asanov A 2017 Niva Povolzhya. 4 (45) 10-6
[4] Kozlov A 2010 Ecological assessment of the biological productivity of small water bodies for the creation of farms (Kaluga: Eidos) p 148
[5] Kozlov V 1998 Farmer's Handbook (Moscow: VNIRO) p 447