Primary tool base for the initial stage of environmental monitoring in a megalopolis

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Abstract. The methodical issues of monitoring urban facilities on noise pollution and the state of radiation conditions as an integral part of general environmental monitoring conducted as a part of the training course “Environmental Monitoring Devices” are considered. The results of the study of the water quality of the Great Garden Pond in the Northern Administrative Okrug (district) of Moscow on the state of zooplankton and zoobenthos in autumn of 2019 are presented. The state of the water body was conducted on species composition and number of the major taxa of zooplankton and zoobenthos. Noise pollution was assessed in connection with the reconstruction of Bolshaya Akademicheskaya Street.

1. Introduction

Modern cities are special ecosystems that differ significantly from natural cenosis. They occupy about 1.5% of the total earth’s surface, a significant part of the population is concentrated in them, as well as a huge number of various transport and industrial production [1, 2, 3].

Intensive industrial, economic, and household activities of a person are often accompanied by undesirable consequences — environmental degradation: pollution of urban water bodies and negative effects on human health, as well as acoustic, light, and radiation effects [4].

Currently, there is a huge need for research and assessment of changes in the environment, depending on the natural processes occurring in it and the anthropogenic impact [2, 5, 6].

Fundamental and applied research, technological and design solutions in the field of ecology should be carried out by specialists who are well aware of environmental protection issues, the environment assessment systems

The bachelors’ program within discipline "Environmental Monitoring Devices" in K.A. Timiryazev Moscow State Agricultural Academy is aimed at obtaining knowledge by senior students of the full-time department in accordance with the qualification requirements for graduates of higher educational institutions on speciality 05.03.06 "Ecology and nature resources management".

The purpose of teaching the discipline is to provide students with theoretical and practical knowledge about ecological monitoring of the environment, as a part of environmental protection activities and environmental management; the knowledge of modern methods, technologies and technical means of measuring, analysis and environmental quality control.

The objects of study of this course are such components of the urban environment as soil cover, urban water bodies, atmosphere, tree plantations, etc.
2. Description of the object of the research
The Big Garden Pond is one of the oldest and largest ponds in the city of Moscow. According to historical information, this pond was built in the middle of the XVIII century on the territory of the Petrovsko-Razumovskoye estate.

The pond belongs to the dam type of reservoirs, it has an area of approximately 19 hectares, the average depth is 2 meters. The reservoir is fed from the Khimki reservoir along the Likhoborsk irrigation system. The reservoir also includes the waters of the Zhabenka River and Koptevsky Stream. The banks of the pond are strengthened with reinforced concrete slabs.

In the process of creating the Northwest Chord, Bolshaya Akademicheskaya Street was reconstructed, it was expanded from two to three lanes in each direction. At the intersection of Bolshaya Akademicheskaya and Mikhalkovskaya streets, builders erected a tunnel. It passes along Bolshaya Akademicheskaya Street and under the existing tram tracks of Mikhalkovskaya Street. This is a six-lane tunnel, it consists of 20 sections for transit traffic.

3. Devices and research methods
During the inspection, the following instruments and equipment were used: TDS3 water quality analyzer, SOEKS Ecotester 3, multifunctional device No. DT-8820, net for catching hydrobionts (zoobenthos), Apstein net for catching zooplankton organisms.

The TDS3 device is designed to measure the level of total mineralization (salinity) and water temperature. Mineralization is the total quantitative indicator of the content of substances dissolved in water (TDS - total dissolved solids). This parameter is also called the total salt content, since the substances dissolved in water are found in the form of salts. Among the most common are inorganic salts (mainly bicarbonates, chlorides and sulfates of calcium, magnesium, potassium and sodium) and a small amount of organic substances soluble in water. Operation principle of TDS3 is based on the direct dependence of the conductivity of the solution on the amount of compounds dissolved in water.

SOEKS Ecotester 3 is designed to assess the level of radioactive background and the detection of objects, food, construction materials contaminated with radioactive elements. The radiation background is estimated by the amount of the ionizing radiation power (gamma radiation and beta particle flux) taking into account x-ray radiation. The built-in Geiger-Müller counter SBM 20-1 (Rosatom) makes it possible to evaluate the radiation safety of surrounding objects with high accuracy and speed.

In order to conduct research to determine the level of water pollution in a given water body, it is necessary to take water samples with the presence of both zooplankton organisms and zoobenthos in it. The following equipment was used to successfully take samples: a net for catching hydrobionts (zoobenthos), an Apstein net for catching zooplankton organisms [7, 8, 9].

Pantle-Buck sapробity index is a universal index that is used in various water bodies. Both planktonic and benthic organisms are used to determine sapробity. Pantle-Buck sapробity index in the modification
of Sladechek is one of the most popular hydrobiological indicators of water quality. It is adopted by the Hydrometeorological Service of the Russian Federation [10, 11].

The first step in assessing saprobity is to collect and determine the macrobenthos of the studied reservoir and compile a list of taxa. The definition is carried out to the level of the species or, in extreme cases, of the genus. The index is calculated by the formula:

\[ S = \frac{\sum_{i=1}^{n} (Sh)}{\sum_{i=1}^{n} h} \]  

where: h is the relative frequency of occurrence (abundance) of aquatic organisms; S - indicator significance (saprobic valency).

The saprobity of taxon S shows in which degree of pollution it is usually found in waters. The relative frequency of occurrence (h) is estimated by standard methods.

The conclusion about the degree of water pollution is usually given by a score system from one to six with an accuracy of one hundredth [10, 12, 13].

Noise affects the entire human body: depresses the central nervous system (CNS), causes a change in respiration rate and heart rate, disrupts metabolism, stomach ulcers, hypertension, occupational diseases [14, 15]. With regular noise exposure, vegetovascular dystonia, heart failure develops, severe headaches appear. Noise with a sound pressure level of 30 ... 35 dB is familiar to a person and does not bother him. Increasing the sound pressure level to 40 ... 70 dB in a household or natural environment creates a significant load on the nervous system, causes a deterioration in well-being and with prolonged exposure can cause neurosis. Noise Exposure levels above 75 dB can lead to hearing loss [16, 17].

Assessment of noise pollution at the control points of the studied intersection was carried out by measuring the noise level with a digital environmental meter DT-8820, which combines the functions of sound level, light, humidity and temperature meters [16].

4. Research results

**Figure 3.** Sampling points for salinity, radiation, and transparency (squares) and for hydrobiological analysis (circles).

Salinity, radiation background, and transparency were determined at 4 points.

**Figure 4.** Noise measurement points at the intersection of Bolshaya Akademicheskaya and Mikhalkovskaya streets.
Table 1. Salinity, radiation, and transparency point values.

| Point | Salinity, ppm | Radiation, μSv/h | Transparency (cm) |
|-------|--------------|------------------|-------------------|
| Point 1 | 125 | 0.11 | 15 |
| Point 2 | 95 | 0.09 | 15 |
| Point 3 | 93 | 0.09 | 20 |
| Point 4 | 110 | 0.07 | 20 |

Sampling for hydrobiological analysis was carried out at three points in 2019. The sampling technique and determination of the value of the saprobity of the reservoir by the Pantle-Buck saprobity index is as follows:

- At each point of the object, samples were by a net for catching hydrobionts.
- 100 liters of water were passed through the Apstein net.
- The samples were delivered to the laboratory for a full and detailed study.
- Using the determinants of aquatic organisms, the species of hydrobionts found were determined, as well as their saprobity and frequency of occurrence.
- According to the calculation results, a conclusion is drawn on the level of pollution of the water body at each of the points considered, and then the average value is found and a general conclusion is made for the entire reservoir.

During the study, a qualitative sampling method was used [10, 11]. In the samples taken at points 1, 2, and 3, the following species of representatives of zooplankton organisms and zoobenthos were found, which are presented in table 2.

Table 2. Organisms found in samples at points 1, 2, 3.

| Type | Class | Name | Point 1 | Point 2 | Point 3 |
|------|-------|------|---------|---------|---------|
|      |       |      | Qty in pcs |         |         |
| Mollusca | Gastropoda | Planorbis corneus | 6 | 4 | 6 |
|        |       | Bithynia tentaculata | 5 | 8 | 6 |
|        |       | Anisus vortex | 7 | 7 | 6 |
|        |       | Viviparus viviparus | 3 | 2 | 6 |
|       | Bivalvia | Dreissena polymorpha | 4 | 5 | 5 |
|        |       | Sphaerium corneum | 4 | 4 | 5 |
|        |       | Euodiaptomus vulgaris | 6 | 5 | 5 |
|        |       | Cyclops strenuus | 8 | 9 | 10 |
|        |       | Sida crystallina | 16 | 18 | 15 |
| Arthropoda | Crustacea | Daphnia pulex | 14 | 13 | 12 |
|        |       | Simocephalus serrulatus | 18 | 11 | 9 |
|        |       | Ceriodaphnia reticulara | 6 | 6 | 6 |
|        |       | Caenis horaria | 4 | 4 | 1 |
|        | Insect | Baetis rhodani | 6 | 5 | 3 |

Then, using the determinants of aquatic organisms, organisms that have saprobity were identified, their frequency of occurrence was found, the saprobity index was calculated. The assessment was made at three points of the survey, the article in table 3 presents an example at point 1.
### Table 3. Determination of saprobity index at point 1.

| Species name          | Saprobity score (s) | Number of copies of the same species in pcs. | %   | Relative frequency of occurrence (h) | s*h  |
|-----------------------|---------------------|----------------------------------------------|-----|-------------------------------------|------|
| Bithynia tentaculata  | 2.15                | 5                                            | 5.62| 3                                   | 6.45 |
| Anisus vortex         | 1.4                 | 7                                            | 7.87| 3                                   | 4.2  |
| Viviparus viviparus   | 1.8                 | 3                                            | 3.37| 2                                   | 3.6  |
| Dreissena polymorpha  | 1.4                 | 4                                            | 4.49| 3                                   | 4.2  |
| Sphaerium corneum     | 2.2                 | 4                                            | 4.49| 3                                   | 6.6  |
| Cyclops strenuus      | 2.2                 | 8                                            | 8.99| 3                                   | 6.6  |
| Sida crystallina      | 1.3                 | 16                                           | 17.98| 5                                | 6.5  |
| Daphnia pulex         | 2.8                 | 14                                           | 15.73| 5                                | 14   |
| Simocephalus serrulatus | 2.2               | 18                                           | 20.22| 5                                | 11   |
| Caenis horaria        | 2.2                 | 6                                            | 6.74| 3                                   | 3.6  |
| Baetis rhodani        | 1.2                 | 4                                            | 4.49| 3                                   | 6.6  |
| Total                 | 89                  | 100                                          | 100 | 38                                  | 73.35|

Saprobic index $S$ = 1.93

### Figure 5. Traffic jams at the intersection of Bolshaya Akademicheskaya St. and Mikhalkovskaya St. by day of the week.

The results of the noise level at the control points of the intersection are presented in Table 4.

### Table 4. The noise level at the intersection of Bolshaya Akademicheskaya St. and Mikhalkovskaya St.

| Point 1 | Point 2 | Point 3 | Point 4 | Point 5 | Point 6 |
|---------|---------|---------|---------|---------|---------|
| 72.8    | 62.1    | 64      | 62.2    | 51.8    | 53.8    |
| 71.1    | 67      | 64.3    | 68.4    | 52.2    | 50.2    |
| 74.3    | 60.4    | 72.1    | 69.7    | 48.4    | 42.5    |
5. Conclusions
The highest salinity is observed at the beginning of the river, when it expands and merges with the Great Garden Pond. No radiation exceedance has been found. At the moment, the color of the water in the pond is brown, the smell is earthy. The Pantle-Buck saprobity index is 1.93 at all three points. We conclude that the reservoir belongs to the beta-mesosaprobic zone (III class of purity) - the water is "slightly contaminated". In general, no noise disturbance have been recorded at the studied intersections. Directly on the roadway, the noise level is 60-70 dB, which is the norm. In residential areas at these intersections, the noise level drops sharply and amounts to 44.4-53.8 dB, sometimes drops to 40 even at large and busy intersections.

References
[1] Avilova K V 2016 The Life Cycle and Number Dynamics of the Urban Mallard Population (Anas platyrhynchos, Anseriformes, Aves) in Moscow Biology Bulletin 43 1212-24
[2] Novikov A V and Sumaruakova O V 2018 Analysis of landscape and ecological transformations in the city environment within the framework of summer educational practice Modern landscape-ecological state and problems of optimization of the natural environment of the regions pp 394-5
[3] Shi Y A 2018 Moscow Place Names in "Master and Margarita" by M. A. Bulgakov: Patriarshiye Ponds: History and Literature Nauchnyi Dialog pp 210-7
[4] Novikov A V and Sumaruakova O V 2017 Assessment of the current state of urban protected areas within the framework of educational practice Landscaping: theory, methods, landscape and environmental support for nature management and sustainable development pp 497-9
[5] Frishter L 2017 The survey of hydraulic facilities of the cascade of ponds of "Exhibition of Achievements of National Economy" landscape park
[6] Skoulikidis N T et al. 2017 Non-perennial Mediterranean rivers in Europe: Status, pressures, and challenges for research and management Science of the Total Environment 577 1-18
[7] Mukherjee B, Nivedita M and Mukherjee D 2010 Plankton diversity and dynamics in a polluted eutrophic lake Journal of Environmental Biology 31 827-39
[8] Oprea L, Gergely I et al. 2011 Some aspects regarding the ecological monitoring of aquatic systems in the crisul alb river basin Journal of Environmental Protection and Ecology 12 841-50
[9] Wu S S et al. 2018 Study on the influence on water ecosystem by a lake inflow filtration system 8th International Water Resources Management Conference of ICWRS pp 363-9
[10] Borisov R R, Chertoprud E S and Kovacheva N P 2016 Water Quality Assessment in Reservoirs: Comparative Analysis of Bioindication Systems Based on Macrobenthos Characteristics Water Resources 43 818-27
[11] Chertoprud M V and Chertoprud E S 2004 Spatial pattern of lithorheophile macrobenthos (by the example of a stream in Moscow region) Zhurnal Obshchei Biologii 65 480-9
[12] Lagutina N V et al. 2019 Hydrobiological Studies of the Kosinskie Lakes International Symposium "Engineering and Earth Sciences: Applied and Fundamental Research" dedicated to the 85th anniversary of HI Ibragimov (ISEES 2019) (Atlantis Press)
[13] Zueva N V and Bobrov A A 2018 Use of Macrophytes in Assessing the Ecological Status of Small River (by the Example of the Okhta River, St. Petersburg) Inland Water Biology 11 34-41
[14] Alves J A, Silva L T and Remoaldo P C 2018 Impacts of Low Frequency Noise Exposure on Well-Being: A Case-Study From Portugal Noise & Health 20 131-45
[15] Lagutina N V, Novikov A V and Sumaruakova O V 2019 Evaluation of noise of the Moscow metro Akustika 32 216-21
[16] Lagutina N V, Novikov A V and Sumarukova O V 2019 Assessment of changes in the noise level from land transport in Moscow *Protection from increased noise and vibration: materials of the national scientific-practical conf. with the international participation* (March 19-21, 2019) pp 533-41

[17] Laxmi V, Dey J, Kalawapudi K, Vijay R and Kumar R 2019 An innovative approach of urban noise monitoring using cycle in Nagpur, India *Environmental Science and Pollution Research* 26 36812-9