Inventory of water objects for purposes of development objectives and design of natural frame of Kazan (Russia)

N M Mingazova

Kazan (Volga) Federal University,
Institute of Management, Economics and Finance,
Department of Environmental Engineering and Water Management,
Kazan, 420008, Russia
E-mail: nmingas@mail.ru

Abstract
The article is devoted to the results of the inventory and certification of water objects in the city of Kazan in 2007-2017. Inventory of water objects contributes to the formation of the natural framework of the city, improvement of the quality of the environment, preservation of the local gene pool of flora and fauna in urban conditions. During the research, 236 small lakes, rivers and their tributaries, as well as wetlands, were identified. The environmental passports were developed for each of them. Registries of water bodies were developed for administrative regions. The inventory and certification of water objects are an effective measure in the conservation of lakes and rivers in urban conditions.

1. Introduction
Small lakes of the world are subject to human impact, including industrial, agricultural, communal and recreational [1]. This is especially the case within cities and settlements. Silting, pollution and development of the banks influence reduction in catchment area and water area, deterioration of water quality, loss of biological diversity [2,3].

According to the cadastral records of the Institute of Ecology of Natural Systems, records of the Republic of Tatarstan (Russia) display about 10 thousand small lake [4], however only a little more than 8100 lakes have been preserved as per records in the 2000s. About 20% of the republic's lake fund has disappeared due to formation of new water reservoirs and as a result of agricultural impact (siltation due to removal of suspended solids from arable land and due to erosion of shores and pollution from watering and grazing).

A bright example is the anthropogenic transformation of the lakes of Kazan (Russia), an industrial city with a population of more than 1 million people, where in the 19-20 century about 50 small lakes with an area less than 1 ha have disappeared.

Meanwhile, small lakes and rivers serve as sites for preserving the fauna and flora, providing biological diversity and sustainable development of the territories. Lakes, being accumulating systems, in fact, serve as indicators of the state of the territories. Small lakes and rivers are important links in the "green corridors" of the natural (ecological) frame of territories; they often play an important recreational role.

Therefore, it is extremely important to provide regional and federal measures for the conservation of small water bodies (lakes and rivers), to adopt special programs for the revival and restoration of small lakes and rivers in Russia, and to provide accounting and inventory work.

2. Inventory of water bodies in Kazan
A distinctive feature of the territory of Kazan is diverse water bodies (about 250), that are widely used for recreational purposes, water supply and sanitation. Large water bodies, such as the Kuibyshev Reservoir, the Kazanka River, Kaban and Lebyazhye lakes are present on maps of various sizes and are monitored by environmental authorities. Small objects mostly were not studied, there was no information about them, and
they were mostly ignored by city structures and environmental services. Lack of information on the number of small water bodies, their characteristics and ecological state is noticed in the 2000s. Thus, cases of destruction of water bodies due to the trade of water fund as the land for housing and communal construction increased sharply.

All this caused serious concern among the population, public environmental organizations, environmental authorities, deputies of the republic. "Improvement of the Environment of Kazan in 2004-2008" program and certification of water objects was suggested as an alternative to the uncontrolled use of water resources the inventory.

3. Methodology
Large-scale works on inventory and certification of water objects were carried out, considering the experience of the Nizhny Novgorod University [5,6], in Kazan in 2002-2008. During the inventory all available lakes, rivers, ponds and wetlands were identified and investigated in each administrative district. Cartographic and topographic materials were preliminarily analyzed, space images were analyzed. Clarification of the boundaries of the reservoir directly at the site of the water body was conducted later.

Methodological approaches to the inventory and certification of water bodies were developed in 2007-2008, the work continues to the present [7].

Environmental passports were developed within the course of environmental certification, filled with data for each water body. In addition, 7 registers of water bodies were compiled for each district of the city.

The following information on water bodies was available: the type of water body; administrative location; land user; GPS coordinates; explication of a water body in the region; origin; morphometric characteristics (area, length, width, depth); bathymetric chart; character of water exchange; type of water (ionic composition); assessment of water quality by physicochemical indicators; the results of microbiological and hydrobiological studies; composition of higher aquatic vegetation; composition of aquatic and near-water vertebrates; anthropogenic impact on the water body; environmental assessment; the value of the water body [6]. This information was covered fully in environmental passports and briefly in registers.

4. Results and discussion

Data on the number of water bodies per administrative district
Aviastroitelny administrative district of Kazan at the time of the research (2007-2008) had 32 water objects were identified from 42 known for 2002. These included 26 lakes, 4 marshs and 2 rivers. The most valuable natural sites are the Solonka River, Sukhaya River, Lesnoye Lake, Borisoglebskoe Lake, wetlands in the Sukhaya river valley and in the Borisoglebsk village.

6 water bodies were identified in the Vakhitovsky administrative district: the Nizhniy Kaban lake (area 47.5 ha); Kazanka river, the Bulak channel and 2 water basins with a total area of 1.44 ha. The reservoirs of the Vakhitovsky district have a large historical and recreational significance for the residents of Kazan.

54 water bodies were identified on the territory of the Kirov region: 34 lakes (with a total area of 142.5 ha), including valuable recreational lakes such as Bolshoe Glubokoe, Maloe Glubokoe, Izumrudnoe, Lebyazhye and others; 7 small (0.5 ha) artificial reservoirs; 7 wetlands with the area of 38.2 ha; 1 channel (0.6 ha). The southern part of the area adjoins the Kuibyshev reservoir, there are 4 gulfs (39.3 ha).

7 water bodies were identified and inspected in detail within the Moscow administrative district. In addition, inventory revealed that 3 previously existing reservoirs were filled up (Tolstovsky pond, underground channel of the Komarovka River, the second lake along Serova Street). Inventory discovered 1 river (part of the mouth of the Kazanka River), 5 lakes with a total area of 2.55 ha, and 1 channel (0.036 ha).

34 water bodies were identified in 2007-2008 out of 66 known in 2002 within the Novo-Savinovsky administrative district. This included river Kazanka; 1 duct; 27 lakes with a total area of 34.83 ha; 3 wetlands (total area 51.53 ha) and 2 drainage ditches. During the inventory it was revealed that 32 water bodies ceased to exist due to backfilling for the construction of residential buildings, parking lots and gas stations, some reservoirs are covered with garbage. Objects of high species richness are the wetlands in the floodplain of the Kazanka River and the Kazanka river channel, the wetlands in the Victory Park, the Small Chaykovy Lake and the Big Chaykovy Lake (there is a massive nesting of colonial bird species - gull and tern seagulls, high diversity duck birds).

66 water bodies were identified for the Privolzhsky administrative region, including 1 reservoir - Kuibyshev reservoir (area of 4375 ha in the city), 2 gulfs, 6 streams, 38 lakes (total area 264.4 ha), 1 river -
Noksa River, 1 pond (area 0.508 ha), 2 swimming pools (1.2 ha) and 5 drainage ditches. During the inventory, it was also revealed that 10 water bodies no longer exist due to backfilling for the construction of residential buildings, parking lots, gas stations, lowering the water level and drying out. The most valuable water objects in the Privolzhsky district include: Lake Middle Kaban - the largest lake in Tatarstan (119 ha), Lake Upper Kaban and the Poduválje Lake-Bay. Those are favorite recreational areas for residents of Kazan. Other important water bodies include Boriskovo village wetland complex and Lake Shanghai as they are the habitat of rare species of birds; Pobedilovsky Bay and the Volga River and Kuibyshev reservoir itself.

51 water bodies were identified in the Soviet administrative district and on the border with the Vysokogorsky district. Through the territory of the district there are 3 rivers (the Kazanka river and its tributaries - rivers Noksa and Kinderka); 1 stream (Vertelevka); 3 ponds (with a total area of 0.24 ha); 4 basins (3 of them are sedimentation tanks of 0.2 ha); 1 wetland (next to the Torfyanoy village) with a total area of 55.1 ha; 1 bay and 38 lakes (a total area of 49.18 ha). The lacustrine marsh Torfyanoy includes oxbow lake of origin, a number of lakes and a channel, wetlands. During the inventory it was also revealed that 3 water bodies do not exist due to backfilling with debris, lowering of the water level and drying out (Pioneer basin Lake, Malye Klyki village reservoir and the Karyer settlement reservoir). The most valuable water objects of the Soviet district are the waterways (rivers Kazanka, Kinderka and Noksa, the Torfyanoy village lacustrine marsh, the old Kazanka River, Karasinoye lake, lakes along Kazanka river, Derbyshtky village cemetery lakes.

Due to the high natural value of many water bodies, it is possible to recommend assigning them the status of protected natural areas as conservation sites of rare plant and animal species.

Comparative analysis and identified trends
During the 2007-2008 inventory it was revealed that Volga region (66), the Soviet (51) and Kirov (54) administrative districts have bigger number of water objects, although Novo-Savinovsky District was the richest one in terms of water bodies in 2002 (66 objects in 2002, 34 in 2007, with a tendency to further reduce the number and area of water bodies). Aviastroitelniy and Novo-Savinovsky districts are now referred as "medium-rich" of water bodies with 32 and 34 objects respectively. The smallest number of water bodies was found in Vakhitovsky and Moscow districts, 6 and 7 water objects respectively.

Given that a number of watercourses in the city pass through several regions (the Kazanka River, Noksa River), as well as the reservoir, as well as the connection of the bays with the reservoir, 236 water bodies were identified in Kazan, according to the inventory for 2007-2008 [7].

58 water bodies were not found in Kazan. In comparison with the previously known information (10 in Privolzhsky district, 3 in Soviet district, 10 in Aviastroitelniy district, 32 in Novo-Savinovsky and 3 in Moscow administrative district).

Consequently, by 2008, due to the construction of the urban area, about 20% of water bodies (1/5 part) ceased to exist. 236 water bodies were noted by 2007-2008, but by 2017 fife water bodies had completely ceased to exist or were flooded to a considerable extent in the Novo-Savinovsky area, 1- in the Moskovsky District, 1- in the Soviet district. For the rest of the areas monitoring is needed to clarify the information.

Biodiversity of water objects of Kazan
The problem of destruction and degradation of small water bodies is a very acute environmental problem for the city, especially given the fact that water bodies within the city serve as conservation sites for biological diversity, ensuring sustainable development of the territories.

This is confirmed by data on biological diversity obtained during the inventory. It is revealed that the water objects of Kazan are distinguished by a significant variety of aquatic and coastal plants and animals. The specious composition varied significantly, with 190 species of phytoplankton composition, 185 species of aquatic and coastal vegetation, 204 species of zooplankton, 163 species of zoobenthos. In addition, 30 fish species, 11 amphibian species, 4 reptiles, 104 bird species and 14 mammal species were revealed. Up to 95% of the species found live in small lakes, and floodplain lakes are the most valuable for the species diversity of plants and animals.

5 species of vascular plants, 2 species of zoobenthos and 16 species of vertebrates, listed in the Red Book (recording endangered species) of the Republic of Tatarstan [8] were also revealed. The most valuable in respect of the species diversity of aquatic and coastal plants and animals are the water bodies located on the first above-flood terrace of the rivers Kazanka and Volga (Novo-Savinovsky and Privolzhsky districts).
The collected materials can serve as a basis for creating sections on rare aquatic plants and invertebrates in the regional "Red Book". Water bodies are an essential link in the conservation of biological diversity of aquatic plants and animals and need protection and improvement policies.

Practical implementation of inventory results
The results of the inventory of water bodies in Kazan have become a serious database for studying and further monitoring of the state of urban lakes, rivers and wetlands. The results of the analysis of the state of water bodies on physicochemical and hydrobiological indicators were included in the databases of the Laboratory for Optimization of Aquatic Ecosystems of the Kazan (Volga Region) Federal University.

On the basis of these results, a number of hydroecological questions were studied, including biological diversity, limnological classifications, monitoring of the state of hydrological and hydrochemical parameters [9]. This is important for controlling anthropogenic eutrophication of lakes [10].

As a result, 173 small and very small lakes with the area from 0.01 to 129 hectares were revealed in Kazan.

The conducted inventory of water objects in Kazan ended with the development of ecological passports, registers and lists of water bodies. Due to the lack of a mechanism for the approval of environmental passports in Russia in general, environmental passports have not been approved as normative documents in Kazan so far. They exist, in fact, in the status of reporting materials with inventory results. This circumstance does not prevent, however, the protection of water bodies.

So, the results of the inventory and the presence of environmental passports helped protect 5 small lakes from development, as law enforcement agencies took into account the presence of an environmental passport as a document confirming the presence of a water body.

5. Conclusion
To conclude, the experience of the inventory of water bodies, which began from Nizhny Novgorod and Kazan, gradually spreads to other regions.

Inventory and certification of water bodies undoubtedly serve as an effective way to save small lakes and rivers. The works serve the purposes of territorial development. Particularly, they allow developing elements of the ecological framework of the territory (the river as a "core" or "green corridors" of the frame, the lake as "nuclei" and "nodes" of the natural frame) on their basis. Materials are used in the design and operation of environmental authorities.

For greater efficiency of work on inventory and environmental passportization, it is necessary to develop the procedure for approving environmental passports as normative documents at the level of the Ministry for Ecology of the Russian Federation.

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