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METHODOLOGY OF SURVEYING SMALL BODIES OF WATER IN URBAN AREAS

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Abstract

The aim of the article was to present the development of methodology of surveying small water bodies in urban areas. The term "small body of water" is not precisely defined. Most often, it is assumed that the surface of a small water body is up to 1 hectare. In addition to natural hazards, small water bodies in urban areas are subjected to an anthropogenic pressure. In many cases, this pressure leads to a rapid degradation or even a complete liquidation. Urban areas are characterized by a low rate of biodiversity. Therefore, the efforts to preserve the surface of waters are essential for the maintenance of biodiversity and improvement of aesthetic values of the landscape. Surveying of small urban water bodies is extremely important, as it is the first step to take protective measures. The proposed methodology takes into account a number of natural and hydrological parameters as well as potential threats. The methodology was presented in the form of a surveying sheet, including both photographic and cartographic documentation, as well as the descriptive data pertaining to a specific water body and a fragment of its catchment in the immediate vicinity.

METODYKA INWENTARYZACJI MAŁYCH ZBIORNIKÓW WODNYCH NA TERENACH ZURBANIZOWANYCH

Słowa kluczowe: miejskie zbiorniki wodne, oczka wodne, ochrona przyrody, waloryzacja przyrodnicza, różnorodność biologiczna, zagrożenia środowiska

Abstrakt

Artykuł prezentuje koncepcję metodyki inwentaryzacji małych zbiorników wodnych na terenach zurbanizowanych. W przepisach brak jednoznacznej definicji powyższych zbiorników. Najczęściej przyjmuje się, iż są to obiekty o powierzchni nieprzekraczającej 1 ha. Oprócz naturalnych zagrożeń, akweny na terenach miejskich, poddane są szczególnej presji antropogenicznej, która prowadzi do szybkiej degradacji lub nawet całkowitej likwidacji. Ponieważ obszary miejskie charakteryzują się niskim wskaźnikiem różnorodności biologicznej, stąd też dążenie do zachowania powierzchni wodnych ma zasadnicze znaczenie dla jej utrzymania oraz podniesienia walorów estetyczno-krajobrazowych. Dlatego obiekty te powinny zostać objęte ochroną, której pierwszym etapem jest przeprowadzenie inwentaryzacji. W propozycji inwentaryzacji uwzględniono szereg parametrów przyrodniczych i hydrologicznych a także potencjalne zagrożenia. Zaproponowana metodyka ujęta została w formie karty inwentaryzacyjnej obejmującej zarówno dokumentację fotograficzną i kartograficzną oraz dane opisowe charakteryzujące zbiornik i fragment jego zlewnii w bezpośrednim sąsiedztwie akwenu.

1. INTRODUCTION

Inland surface waters: lotic (running) and lentic (standing) are an essential element of the natural environment, determining its biodiversity. Standing waters include the water found in lakes, ponds and other natural bodies of water, which are not related directly to surface running waters (Water Law Act, 2001). Bodies of water, together with swamps, marshes and peat bogs are the wetlands (Convention on Wetlands of International Importance, Especially as Waterfowl Habitat, 2002). The term “small body of water” has not been precisely defined. The Act on the Protection of Agricultural and Forest Land (1995) sets out a definition of the waterhole as an object of small size, not exceeding 1 hectare, located in the agricultural or forest land. The definition includes both natural and artificial standing waters of a small surface area. The EU Water Directive (Directive 2000/60/EC) or other EU documents do not provide an unambiguous definition of small bodies of water.

Although this Directive aims to protect all surface bodies of water, small basins do not enjoy great interest and mostly remain beyond the monitoring control of the Member States of the European Union. Schwartz and Jenkins (2000) see the cause of the current marginal interest in small, especially periodic, water bodies in the absence of their economic significance and limited possibilities of use for recreational purposes. It should be noted that, until recently, their natural values were almost completely underestimated. The significance and the necessity to protect small bodies of water are the issues which appear in the literature more and more frequently (Oertli et al. 2002, Oertli et al. 2004, Akasaka et al. 2010, Oertli et al. 2009, Boix et al. 2012).

The world literature on the subject also includes a definition of *urban water bodies* relating to those located in urban areas. It emphasizes the different nature and importance of surface waters in urban areas (Sun, Chen and Lu 2012, Sun and Chen 2012, Hassall 2014, Steele et al. 2014, Hassall 2015). One of the characteristic features of standing waters in urban areas is a marginal percentage of swamps, peat bogs and small bodies of water. In the cities, intensive transformation of water bodies in urbanization processes may lead to the domination of the waters with little varying morphometric parameters. The dominant water bodies in all classes of urbanized land cover include medium-sized lakes and ponds. In urban areas, compared with the adjacent agricultural or forests land, unchanged or partially changed, these water bodies are characterized by a poorly diversified shoreline, and they usually have no hydrological connection to waterways (Steele *et* al. 2014, Steele and Heffernan 2014). No hydrological connection and shortage of water bodies with a small surface may lead to the destabilization of the processes occurring in urban catchments.

Standing waters are a labile component of the natural environment. Especially small water bodies are extremely vulnerable to all kinds of anthropogenic pressures, leading to their degradation or devastation. The features such as size, shape, land cover and land use structure around the water body, as well as hydraulic connection, determine the proper functioning of the ecosystems of small bodies of water. Those located in cities are becoming of interest due to their diverse and specific functions, including the widely understood ecological function. These basins are important because of their biocenotic, physiocenotic, hydrologic and biogeochemical values, and they also have a beneficial influence on the microclimate of urban areas (Mitsch and Gosselink 1986, Ryszkowski, Bartoszewicz and Marcinek 1990, Ryszkowski and Kędziora 1996, Briggs 2001, Oertli et al. 2005, Szyperek 2005, Céréghino et al. 2008, Sun, Chen and Lu 2012, Sun and Chen 2012, Céréghino et al. 2014, Ferenc, Sedláček and Fuchs 2014). Their functions are not to be disregarded either. These include: research and academic function, landscape function, contribution to the aesthetisation of the environment and, to a limited extent, recreational or economic function. Considering the above-mentioned facts, what should be emphasized is the importance of the performed research studies related to the existence and functioning of small bodies of water in urban areas, where they are subject to numerous additional pressures. It illustrates how complex the functioning mechanisms of water bodies in the urban environment are, and it induces to take actions to protect them.

Continuous depletion of the biotic surface in urban areas is due to the global urbanization process, associated with population growth and migration from rural areas (Grimm et al. 2008). The emerging abiotic surfaces in urban areas cause the substantial homogenization of nature, as well as the fragmentation of the environment and the low rate of biodiversity, also called biotic diversity (Marzluff and Ewing 2001, McKinney 2006, Marzluff *et* al. 2008, McKinney 2008, Lososová et al. 2012, Groffman et al. 2014). Thus, so much attention is devoted to the studies on the basic factors of the habitat, which are important for the preservation of biodiversity in cities. Protective measures in urban areas should be focused on maintaining biodiversity of the ecosystems and diversity of the preserved patches of natural vegetation in the areas subjected to human pressure. In addition, it is essential to create and maintain functional connections between these areas through wildlife corridors

(McKinney 2002, Chace and Walsh 2006, McKinney 2008, Evans, Newson and Gaston 2009, Fontana et al. 2011). Urbanized areas are characterized by the shortage of waters in relation to the adjacent areas (Steele et al. 2014). Therefore, one of the important tasks in the field of nature conservation in cities, is striving for the preservation of water areas, which is crucial for the preservation of biodiversity, not to mention the increased aesthetic values of the landscape.

This project aims to develop a methodology of surveying small bodies of water in urban areas, taking into account, for example, their natural and hydrological characteristics and the potential threats which may contribute to their degradation, or even disappearance. The proposed methodology was presented in the form of a surveying sheet, including both photographic and cartographic documentation, as well as the descriptive data describing a specific water body and a fragment of its catchment in the immediate vicinity. Such surveying procedure is necessary to protect the small, urban bodies of water, due to the fact that maps, including hydrographic maps, present surface waters only in the instantaneous state. In the case of small water basins, field studies exhibit a large discrepancy between the cartographic documentation and the actual situation (GUGiK, 2005). Even tens of percent of small bodies of water shown on the maps, are periodic or disappeared completely. Moreover, numerous existing, small water bodies are omitted in the cartographic documentation.

Surveying methodology

The developed methodology assumes the scheme of the object description taking into account the graphic and descriptive documentation. The first part of the surveying procedure includes the cartographic presentation (fragments of the topographic map and of the orthophotomap), and the photographic presentation, demonstrating the location of the water body and its immediate surroundings. The descriptive part contains detailed information on the location of the object, its origins, morphometry (selected surface parameters), insolation, unbound water, degree of its preservation, supply, characteristics of the shore and catchment, vegetation of the water body and of the surrounding area, as well as the distance from another, the nearest body of water, the legal form of nature conservation, ecological barriers and threats (Tab. 1).

Water body location

The description of the water body location should take into account: city or town, district (in the case of water bodies located in large urban areas), detailed location (street name and number of the nearest real property; if it is not possible, other characteristic field data should be provided), plot number according to the cadastral data, geographical coordinates, altitude.

Water body description

Taking into consideration the origin of the water body basin, the surveying sheet proposes a division into natural (glacial, karst, landslide, aeolian, oxbow lakes, marshes, etc.), semi-natural (the basin shaped by the deepening of the existing concave form or heaped embankment) and artificial – men made objects (village and court ponds, garden waterholes, water storage tanks for fire protection, reservoirs created in excavation voids) (Starmach, Wróbel, Pasternak 1976, Kajak 2001, Mizerski 2005, Choiński 2007, Dodds and Whiles 2010, Cole and Weihe 2016). The origin of the water body basin is reflected in the characteristics of the parameters which are relevant from the environmental and landscape point of view. Sometimes, it is difficult to determine unambiguously, whether a specific body of water is natural or artificial. Its anthropogenic origin may be suggested by steep banks and underwater slopes, regular shape and straight sections of the shoreline.

Among the artificial water bodies in urban areas, urban ponds and private small-size garden waterholes occupy a special place. Regarding the first ones, seasonal filling with water and concrete, steep banks restrict, or even make it impossible, for them to perform the biocenotic function. Mass- created waterholes in home gardens do not exceed a few dozen square meters, in most cases, and therefore, they can only have a limited influence on the biological diversity of the city. Nevertheless, it should be noted, that they fulfill the microclimate and landscape aesthetisation function, to some extent.

The water table is one of the basic morphometric parameters of each body of water. Pursuant to the Act on the Protection of Agricultural and Forest Land (1995), the surface of small bodies of water does not exceed 1 ha. According to the water body surface (P), this methodology proposes to distinguish three groups of objects: small water bodies of less than 0.125 hectare

Table. 1. A proposed surveying sheet for a small body of water
Tabela. 1. Propozycja karty inwentaryzacyjnej małego zbiornika wodnego

<table>
<tr><td>Topographic map</td><td>Orthophotomap</td></tr>
<tr><td>Photo of water body</td><td rowspan="3">Description of water body
Degree of the water body preservation: permanent/ periodic and ephemeral/ dry Supply: exorheic / endorheic
Slope: steep / gentle
Height of banks: m
Insolation: ≤ 50 %/>50 %
Zone of unbound water: ≤ 50 %/>50 %
Shape: irregular / oval / rectangular
Land cover: CORINE Land Cover code
Terrain relief: flat / hilly area

Floral characteristic
Amphiphytes and helophytes:
Hydrophytes:
Shoreline vegetation:
Tree species:
Synanthropic species:

Distance to another, nearest water body:
Legal forms of conservation: national park / nature reserve / nature park / protected landscape area / Natura 2000 area / ecological land / natural monument
Ecological barriers: linear / surface
Threats to water bodies: shallowing / expansion of land vegetation / backfilling pollution with sewage / drainage / depositing waste</td></tr>
<tr><td>Description of location
Town:
District:
Detailed location:
Plot number:
GPS Coordinates: N:00°00’00”, E:00°00’00”
Altitude asl:</td></tr>
<tr><td>Description of water body
Origin: natural/semi-natural/anthropogenic

Water body surface (P): small: <1,250 m², medium: 1,250 – 5,000 m²,large: 5,000 - 10,000 m²
Length (D):
Maximum width (S):
Average width (Sśr.): Sśr = P/D
Length of the shoreline (L):
Shoreline development factor (K): $K = \frac{L}{2\sqrt{\pi P}}$

Depth: <0,5m / >0,5m</td></tr>
</table>

(1250 m²), medium – from 0.125 to 0.5 hectare (1,250 – 5,000 m²) and large of the surface of more than 0.5 to 1.0 hectare (5,000–10,000 m²). The limit minimum surface area of the surveyed water bodies is adopted at 100 m². Due to the lack of a clear definition of small bodies of water, the literature provides other suggestions as to their classification. The size of small bodies of water may fall within the range from 25 m² to 2 hectares (Collinson et al. 1995), from 1 m² to 2–5 hectares (Céréghino et al. 2008), or from 1 m² to 5 hectares (Oertli et al. 2009). However, water bodies of less than 100 m² are generally characterized by high instability and accumulate water only periodically. Moreover, these are frequently shallow basins, which are not emphasized strongly in the terrain morphology.

The length of the water body (D) is the distance connecting the outermost points, measured along its axis. The maximum width (S) is measured perpendicular to the length at the widest point of the water body. The average width (Sśr) is calculated as the ratio of the water body surface (P) to its length (D). The length of the shoreline (L), or the line of the contact of water with land at the line of the mean water level, in the case of small water bodies where there are large fluctuations in water levels, is not possible to be determined. In this case, it is proposed to measure the length of the basin shoreline. The shoreline development factor (K) is calculated as the ratio of the shoreline length (L) to the shoreline length of an object of the same area but in the shape of a circle, whose area is equal to the surface of the test water body, according to the formula: $L/(2\sqrt{\pi \cdot P})$. The higher the ratio, the more developed shoreline of the water body (Kajak 2001, Löffler 2004, Choiński 2007, Timms 2010). Steele and Heffernan (2014) demonstrate that this ratio is a fundamental parameter of the water body shape, and it is important for the ecological functions of the object, affecting the biotic diversity. From the biocenotic point of view, an irregular shape with numerous pools, bays or peninsulas, is very desirable. On the other hand, artificial bodies of water of regular shapes: round, oval, and especially rectangular, not only have lower natural values, but do not harmonize with the natural landscape, either. These parameters, determined using planimetric methods based on orthophotomaps, do not always reflect the actual state of objects. These discrepancies may especially refer to the bodies of water characterized by high fluctuations in the water level. In order to verify the factual state of the surveyed objects, at least two field inspections are recommended: during the early-spring period and at the end of the vegetative period. The subaquatic parameter which is proposed to be included in the study, characterizing the underwater relief of the basin, is its approximate depth (H). However, it is suggested to include only two groups of basins in the classification: up to 0.5 m in depth (very shallow) and more than 0.5 m (shallow).

In addition to the morphometric parameters, the description also covers other, essential in environmental terms, characteristics of small objects in urban areas. When describing the degree of the water body preservation, three categories can be distinguished: permanent, periodic and ephemeral, and dry. In terms of their supply, basins can be classified as: exorheic (supplied by flows, i.e. located on watercourses) and endorheic (located in depressions, supplied with groundwater absorption and rainwater).

Description of shorelines should include their height and slope, as these parameters, to a large extent, decide on the natural value of the water body. The slope is proposed to be classified in two categories, as steep or gentle. This parameter is important because steeply sloped and high banks create a barrier for many organisms, and so the natural value of the water body is reduced.

Insolation of the water body surface, expressed as a percentage of the sunlit surface of the water table, has been classified in two ranges: ≤ 50% and > 50% of the sunlit water table. It is proposed to classify the zone of unbound water, which is an area of open water table, not covered with vegetation, in the corresponding ranges (≤ 50% and > 50%).

It is proposed to restrict the area surrounding the body of water to the zone within a radius of about 100 meters from the shore. In order to define the land cover of the area around the basin, it is proposed to use the classification of the European Environment Agency (EEA), proposed as part of the environmental information system CORINE Land Cover. Out of the three levels of the hierarchical classification of land cover, the second level seems to be sufficient for the surveying purposes. It includes the following classes of land use: 1.1 – Urban development, 1.2 – Industrial, commercial and communication areas, 1.3 – Mines, excavations and construction sites, 1.4 – Urban green areas and recreation areas, 2.1 – Arable land, 2.2 – Permanent crops, 2.3 – Meadows and pastures, 2.4 – Mixed crops areas, 3.1 – Forests, 3.2 – Trees and shrubs, 3.3 – Open areas devoid of vegetation or with scarce plant coating, 4.1 – Inland wetlands, 4.2 – Coastal wetlands (European Environmental Agency, 2006). In the case of anthropogenic areas, it is advisable to detail the classification to the third level.

Classification of the terrain relief surrounding the body of water should identify: a flat area (a plain) and hilly area (including convex landforms such as hills, and concave landforms such as valleys, basins and troughs).

Short-term observations, repeated twice during each year, do not allow for an exhaustive inspection of the fauna, which can be limited only to identifying the presence of species of mammals, representatives of avifauna, herpetofauna and fish fauna. In the case of the biotic environment, it is suggested to limit its description only to the floral characteristic of the water body and its surroundings, basing on the identification of the occurrence of selected plant species (macrophytes) and shoreline vegetation. The identified vegetation is proposed to be divided into: hydrophytes, or typically aquatic plants, including pleustophytes and rysophytes, and amphibious plants growing in a shallow water zone, namely amphiphytes and helophytes (Westlake, Kvet and Szczepanski 2009, Tiner 1999, Janauer, Schmidt-Mumm and Reckendorfer 2013, Baláži and Hrivnák 2015). In small water bodies, due to the instability of the water table, it is difficult to draw a line between the vegetation occupying the transition area between land and water, most commonly the wetland or marshes, and the vegetation growing permanently in shallow water. Therefore, the group of amphiphytes and helophytes are proposed to be inspected together, as emergent vegetation. In addition, it is essential to identify the shoreline vegetation, based on the occurrence of the most important tree species and synanthropic species in the immediate vicinity of the water body. From the ecological point of view, the identification of species associated with man is particularly significant, especially ruderal plants, the presence of which indicates the degree of anthropogenic alteration of a habitat.

A crucial physiocenotic parameter of water bodies is their mutual relationship enabling the movement of species between the waterholes. The shorter the distance between the specific bodies of water, the greater number of species is able to migrate. The water bodies located close, representing a water region, become green corridors, which is essential for the maintenance of biological diversity by exchanging the genetic pool and the expansion of species. Therefore, the characteristic of a water body should take into account the distance to another, nearest water body. These distances are proposed to be classified in three groups: up to 100 m, between 100–500 m and above 500 m.

Threats to small bodies of water can be conventionally divided into natural (e.g. shallowing, ecological succession, expansion of land vegetation) and anthropogenic (backfilling leading to the disappearance or shallowing of a water body, pollution with sewage, drainage, surface runoff, depositing waste – mostly municipal and construction, proximity to traffic routes, buildings and other infrastructure, separation by fences). Backfilling or drainage are the direct threats, they are irreversible processes, resulting in the disappearance of bodies of water. Other examples of threats contribute indirectly to their degradation. The elimination of these risks could result in the improvement of the condition of water bodies. Ecological barriers: linear (communication routes, fences, etc.) as well as surface (buildings, industrial sites, parking lots and other anthropogenic abiotic surfaces) should become a particular subject of surveying.

During the performance of the surveying procedure, it is essential to pay attention to the object location within the legal forms of conservation areas: national park, nature reserve, nature park, protected landscape area, Natura 2000 area or individual forms of nature conservation such as ecological land use or natural monument (Nature Protection Act 2004).

CONCLUSION

The increased interest in the issue of water bodies in cities, which has been observed in recent years, also applies to small basins. In urban areas, they represent a specific group of bodies of water, extremely important, though not fully appreciated. Their occurrence in urban areas is largely associated with the patches of natural vegetation or little changed ecosystems, as well as urban cultivated greenery. In addition to the typical natural functions which they perform: biocenotic and physiocenotic, bodies of water in urban areas are also of microclimatic, landscaping and recreational importance.

Small water bodies in urban areas are subjected to an anthropogenic pressure, which is stronger than in the case of mid-field or mid-forest objects, and consequently, many of them have been degraded (changes in morphometry, chemistry), or even disappeared, mainly due to the development, backfilling or drainage. Depending on the size of the town or city, the role and participation of the above-described threatening factors are changing. The processes of land use changes make the bodies of water located in urban areas very little diversified in environmental and morphometric terms. This particularly applies to the water bodies of anthropogenic origin.

Due to the instability of small bodies of water in the anthropogenic landscape, as well as the strongly growing urbanization pressure, their surveying is extremely important, as it is the first step to take protective measures.

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