SMALL WATER RESERVOIRS IN THE CITY
A CASE STUDY OF CHORZÓW

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Abstract: There are numerous water reservoirs of different sizes in the cities of the Upper Silesian Agglomeration. The genesis of water bodies in urban areas of Upper Silesia is not the same. There are four main types of reservoirs: dam reservoirs, subsidence reservoirs, excavation reservoirs and industrial reservoirs. The most characteristic are ponds created by subsidence caused by underground exploitation. Small water reservoirs are the most important elements of urban areas because of their unique natural and aesthetic values, especially because of many species of protected plants and animals. Most valuable natural reservoirs are situated outside built-up areas. In this paper we present the classification of water reservoirs located in Chorzów (33.5 km²). We classified these reservoirs in the context of natural values i.e., using the indicator of biodiversity: the number of amphibian species found in the area of the reservoirs.

1. Introduction

Chorzów is a city of the Upper Silesian Agglomeration, which is situated in the southern part of Poland. According to the Central Statistical Office (Central Statistical Office, 2006), the agglomeration consists of 19 cities, covering the area of 1471 km² with 2.2 million inhabitants. Chorzów takes up 33.5 km² of this area.

The Upper Silesian Agglomeration has been a region of intensive operation of the industry for over 200 years now. This is why the industrial land use had such an impact on the transformation of the environment. A decrease of green areas and agricultural areas is observed. The overall water relations have been transformed. The consequence of progressive land development, investment and operation of industry were: the river network regulation, elimination of surface reservoirs and water quality degradation. On the other hand, the deformation of the ground caused by mining activities was conducive to the formation of flood plains. Other reservoirs were formed also in abandoned pits on the surface. Some reservoirs were created or adapted for recreation. A succession process has occurred with the formation of reservoirs. It

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often happens that they are taking over the natural features of already liquidated reservoirs. Simultaneously, many reservoirs were built for industrial purposes.

Water reservoirs have various functions. Many of them are important for biodiversity – ecosystems with the highest species richness are associated with aquatic habitats (Ożgo, 2010; Scheffer and van Ness, 2007).

2. Spatial structure of Chorzów

The area of Chorzów is 33.5 km$^2$; it is inhabited by more than 106 000 people (www.chorzow.eu). There is a closely built-up city center and peripheral areas with less development in the spatial structure. Undeveloped areas are situated near the borders. In the north, near the border with Bytom, a landscape area called the Frog Pits is located. In the central-eastern part of the city, the Silesian Park is located, with an area of 6 km$^2$. In the southern part of the city there is a forest complex (Fig. 1). Table 1 shows types of land use and data on how the use of land changed over the past 150 years. It is worth noting, how the built-up areas were expanded, and how farmland and forest areas were reduced.

Tab. 1. Land use in Chorzów in the mid-nineteenth century and today (Central Statistical Office, 2006; Czaja and Rzętała, 1999).

<table>
<thead>
<tr>
<th>Type of land use</th>
<th>Chorzów</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>~1860</td>
</tr>
<tr>
<td>Built-up areas (industrial areas included)</td>
<td>0.8 km$^2$</td>
</tr>
<tr>
<td>Agricultural land</td>
<td>25.4 km$^2$</td>
</tr>
<tr>
<td>Forests</td>
<td>5.7 km$^2$</td>
</tr>
<tr>
<td>Urban green areas</td>
<td>0</td>
</tr>
<tr>
<td>Wasteland</td>
<td>0</td>
</tr>
<tr>
<td>Allotment gardens</td>
<td>0</td>
</tr>
<tr>
<td>Heaps</td>
<td>0</td>
</tr>
<tr>
<td>Recultivated land</td>
<td>0</td>
</tr>
<tr>
<td>Land under water</td>
<td>0.3 km$^2$</td>
</tr>
<tr>
<td>Other areas (with transport areas)</td>
<td>0.9 km$^2$</td>
</tr>
</tbody>
</table>

Chorzów lies on the watershed between the Vistula and the Oder, so the river network is rare. The main river in Chorzów is Rawa, which flows in a sewer pipe since 2010. The forest area in the southern part of Chorzów is drained by the stream from Kochłowice.

Chorzów is a typical industrial city in the Upper Silesian Agglomeration, but the importance of industry has been diminishing in recent years. What is important, is
that the whole area of the city is located above the underground coal mines; and because of subsidence basins and bayous form. Currently, coal mining takes place in the southern part of Chorzów, under the forest areas.

Natural valorization of Chorzów was made in 1994. Twelve valuable natural areas were indicated (Cabala et al., 1994). Ten of these areas have reservoirs within their own boundaries.

3. Methods

Our first stage of work included a review of available cartographic materials. Topographic maps at a scale of 1:10000 and orthophotos were used (www.geoportal.gov.pl). Another element of the work was to review the actual water reservoirs in the area; the collected data allowed us to classify the reservoirs. The classification takes into account the following elements: the purpose of the reservoir, the position of the reservoir in relation to any possible buildings, the condition of the reservoir, the way the

Fig. 1. Current land use in Chorzów. (a) boundary of the city; (b) rivers; (c) reservoirs; (d) allotment gardens; (e) agricultural lands; (f) urban green areas and parks; (g) forest areas; (h) recultivated heaps; (i) built-up areas; (j) fallow land; (k) transport areas.
reservoir is managed, they way the land around the reservoir is used, and the potential importance of the reservoir as a part of the local ecosystem. We excluded all swimming pools or waste reservoirs in sewage-treatment plants for the purposes of this study.

In total, we identified 19 types of reservoirs. We took into account the varying degree of the above criteria. Another element of the study was analyzing the biodiversity around the reservoirs – amphibians were used as an indicator. Amphibians are a phylum of animals that is extremely sensitive to any changes in the environment. Because of anthropopressure amphibians are in decline and the whole species is disappearing (Berger, 1989; Houltahan et al., 2000; Rybacki and Berger, 2003). Moreover, it is the amphibians that – as a phylum of vertebrates – are the most threatened with extinction. The most important reasons for their disappearance, observed in urban areas, are as follows: transformations and destruction of habitat, changes of water relations (including elimination of water reservoirs), road traffic, environmental pollution and mechanization of horticultural works.

Amphibians live in an aquatic and terrestrial environment. Water reservoirs are needed for them to reproduce: amphibians lay their eggs (squawk) there, which then develop into larvae. Amphibians are attached to their breeding sites. Water reservoirs are also a wintering place for three domestic species of amphibians (marsh frog Rana ridibunda, edible frog R. esculenta, and grass frog R. temporaria). Amphibians move over short distances from their breeding sites – typically their migration range does not exceed 1500 m (Juszczyk, 1987; Gunther, 1996; Berger, 2000; Glowaciński and Rafiński, 2003; Glandt, 2008). Their terrestrial habitats are equally important for amphibians. They must guarantee the possibility of predation, shelter and hibernation. Amphibian habitats must have adequate humidity as well. For these reasons, transformations of both the aquatic and terrestrial habitats have a huge impact on this species. In order to illustrate the degree of human impact on the natural environment, we looked at cartographic materials, and compared the number of water bodies in the nineteenth and twentieth century with the current situation (Tab. 2). The rapid increase in the number of subsidence reservoirs in the twentieth century resulted from mining activity. It is a typical phenomenon in the region of the Upper Silesia.

The study was based on the results of our own herpetological research, which was carried out in Chorzów in 2003 and 2004 (Sołtysiak, 2004). It was the time, when water reservoirs used by amphibians, were inventoried. Using the information on the state of batrachofauna was used to identify the most valuable natural reservoirs. It was taken into account that amphibians are an umbrella species for other ones. For this reason it can be assumed that the reservoirs which are valuable breeding sites of amphibians are also important for other valuable species.

11 amphibian species have been found in the area of Chorzów (Tab. 3). We have identified green frogs Rana esculenta complex, ordinary newt Lissotriton vulgaris, common toad Bufo bufo, grass frog R. temporaria and green toad B. viridis as the most frequent species in the tested reservoirs. The least frequently encountered species is the common spadefoot Pelobates fuscus (Tab. 3).
Tab. 2. Genetic types of water bodies in Chorzów (Czaja and Rzętała, 1999), with new additions by the authors of this study.

<table>
<thead>
<tr>
<th>Year</th>
<th>Dam reservoirs</th>
<th>Subsidence reservoirs</th>
<th>Excavation reservoirs</th>
<th>Industrial reservoirs</th>
<th>Other</th>
<th>Area [ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1801</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>No data</td>
<td>30.2</td>
</tr>
<tr>
<td>1860</td>
<td>17</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>No data</td>
<td>34.3</td>
</tr>
<tr>
<td>1900</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>No data</td>
<td>70.1</td>
</tr>
<tr>
<td>1950</td>
<td>3</td>
<td>52</td>
<td>3</td>
<td>23</td>
<td>No data</td>
<td>75.9</td>
</tr>
<tr>
<td>1994</td>
<td>0</td>
<td>48</td>
<td>4</td>
<td>20</td>
<td>No data</td>
<td>79.8</td>
</tr>
<tr>
<td>2013</td>
<td>0</td>
<td>66</td>
<td>26</td>
<td>15</td>
<td>68</td>
<td></td>
</tr>
</tbody>
</table>

Tab. 3. The number of amphibian breeding places in Chorzów (Sołtysiak, 2004).

<table>
<thead>
<tr>
<th>Species</th>
<th>Chorzów</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total number of breeding places</td>
<td>in the Frog Pits*</td>
<td>in the Silesian Park**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ordinary newt Lissotriton vulgaris</td>
<td>44</td>
<td>8</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Great crested newt Triturus cristatus</td>
<td>16</td>
<td>2</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire-bellied toad Bombina bombina</td>
<td>21</td>
<td>8</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spadefoot Pelobates fuscus</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common toad Bufo bufo</td>
<td>43</td>
<td>10</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green toad B. viridis</td>
<td>39</td>
<td>10</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree frog Hyla arborea</td>
<td>12</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass frog Rana temporaria</td>
<td>39</td>
<td>8</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moor frog R. arvalis</td>
<td>32</td>
<td>9</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green frogs: water and/or pool R. esculenta complex</td>
<td>57</td>
<td>9</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The Frog Pits area is situated in the north part of Chorzów
**The Silesian Park is situated in the central-eastern part of Chorzów
4. Classification of reservoirs

Taking into account the specificity of the study area, as many as 19 types of reservoirs (or 16 types without liquidated or unavailable reservoirs) were distinguished. The following features were analyzed: the use of the reservoir, the shape and characteristics of its shores, the presence of vegetation, the development of its surroundings. The following types of reservoirs have been distinguished (Fig. 2), where types A, B, C, D, and U are a group of industrial reservoirs:

- **Type A** – storage reservoirs for water spillways; they are characterized by dynamic changes in the water level; they usually have vertical walls; they cannot fulfill their natural function at all - usually they are traps for animals (6 reservoirs).

- **Type B** – technological and/or fire protection reservoirs, with slanting walls that allow free scope for animals; without vegetation; surrounded by buildings. Because of the surrounding buildings they cannot fulfill their environmental role (7 reservoirs).

- **Type C** – as above, but with access to open space. In favorable conditions they can be a breeding site of amphibians (3 reservoirs).

- **Type D** – artificial and industrial reservoirs but with coastal vegetation, they can be important for local ecosystems (2 reservoirs).

- **Type U** – unavailable, industrial reservoirs in closed areas.

- **Type E** – degraded reservoirs due to filling them with waste and/or due to their contamination. They played a natural function in the past; it is possible to restore their natural functions (3 reservoirs).

- **Type F** – developed reservoirs, with a structured surrounding and a natural shore. They are important for recreation and landscape. Simultaneously they can fulfill their environmental role (16 reservoirs).

- **Type G** – reservoirs in public areas, structured, with concrete edges and bottoms; seasonally dry (5 reservoirs).

- **Type H** – reservoirs used intensively by anglers (7 reservoirs).

- **Type I** – reservoirs in the zoo functioning in a different way from other reservoirs. They act as a display, but due to the proximity of green spaces, occasionally they may function as natural ones (8 reservoirs).

- **Type J** – undeveloped reservoirs, with a buffer zone, with access to the open space in at least 50% of the length of their coastline (23 reservoirs).

- **Type K** – reservoirs that are intermediate between types F, J and H (5 reservoirs).

- **Type M** – reservoirs with natural features, undeveloped, with a buffer zone, but isolated by built-up areas (4 reservoirs).
• Type N – temporary reservoirs (1 reservoir).
• Type O – ponds in allotments (7 reservoirs).
• Type P – reservoirs, which were rebuilt or newly formed, devoid of vegetation (1 reservoir).
• Type R – reservoirs near buildings, usually in home gardens, in closed areas (1 reservoir).
• Type S – non-industrial reservoirs; liquidated.
• Type T – industrial reservoirs; liquidated.

All of the identified 19 types covered the abovementioned criteria, although to a varying degree.

In Chorzów there are 107 water reservoirs of different sizes, origins and used in different ways (Fig. 2). Their area covers about 68 ha. A significant group is industrial reservoirs. They can perform functions of natural reservoirs (type C and D). Many industrial reservoirs have vertical walls (type A), which changes them into traps for animals. Map analysis shows a decline in the number of industrial reservoirs – 11 of them were liquidated during the last few years as a result of industrial plants liquidation or changes in technology. On the other hand, some new industrial reservoirs were built, mainly as reservoirs for water from transport areas and roofs.

From the natural point of view, type J reservoirs are of particular importance. These reservoirs are valuable amphibian breeding sites. They are located outside the built-up areas and they are the largest group of reservoirs.

Another group of reservoirs are the recreation reservoirs (types F and H). Usually they are characterized by high aesthetic value and they are located in recreational areas, penetrated by humans. This type includes reservoirs in parks and lawns, if only their edges are formed from a material other than concrete. They are often used by anglers. In Chorzów we identified 23 type F and H reservoirs. Ponds of these types can serve a limited natural function because of gardening and fishing activities. For this reasons, the habitat conditions of these reservoirs are significantly worse than for type J reservoirs. This is confirmed by the results of herpetological research (Sołtysiak, 2004). Reservoirs in allotments are of similar importance to amphibians (type O).

There are some reservoirs surrounded by buffer zones, which are isolated by built-up areas (type M). Their buffer zones are gradually absorbed by growing building development. The importance of this type of habitats decreases with the progress of area development.

Type G and I reservoirs are of minor importance due to their specific purpose (elements of architecture, decorative or exhibition function). Occasionally they can be used as a breeding site.

Water reservoirs are not lasting components of the environment. Many reservoirs are illegally degraded (type E). Many reservoirs are backfilled to change the land use, so the number of water reservoirs in Chorzów is decreasing. 21 reservoirs were destroyed during the last twenty years. It equals the loss of 11 documented breeding sites plus 4 potential ones.
An attempt was made to assess the value of natural reservoirs. The criterion was the number of amphibian species which use the reservoir as a breeding site. We have identified four classes of reservoirs inhabited by one, two or three species (the first class), inhabited by four or five species (the second class), inhabited by six or seven species (the third class), and inhabited by 8 or more species of amphibians (the fourth class).

In Chorzów, there are: 41 reservoirs of the first class, 25 reservoirs of the second class, 11 reservoirs of the third class, and 2 reservoirs of the fourth class. The most valuable reservoirs (of the fourth class) are located in the northern part of Chorzów, in the Frog Pits area, in the vicinity of wastelands and agricultural lands (Fig. 3, Tab. 3). One of the most valuable amphibian breeding sites in the area was completely destroyed and currently there are only two of them. Other important areas for biodiversity are: the Silesian Park (Tab. 3), western borderlands and forest areas in the southern part of the city (Fig. 3). The lower anthropopressure on a reservoir and on its surroundings in these areas results in a higher number of amphibian species there.

![Fig. 2. Types of reservoirs in Chorzów (description in the text). Types: (a) A; (b) B; (c) C; (d) D; (e) E; (f) F; (g) G; (h) H; (i) I; (j) J; (k) K; (l) M; (m) N; (n) O; (o) P; (p) R; (q) S; (r) T; (s) U; (t) boundary of Chorzów; (u) rivers.](image-url)
5. Summary and conclusions

A large number of reservoirs is a characteristic feature of Chorzów. Generally, the subsidence and excavation reservoirs are the most numerous. Water reservoirs have various functions. They are important for recreational purposes (including angling) and for biodiversity. Their environmental importance increases with the distance from development areas and roads. This fact was confirmed by herpetological research, which can be used to assess natural values of habitats associated with water reservoirs. Technological reservoirs, situated at closed and built-up areas, generally do not matter for biodiversity. They may be important if they are located outside the built-up areas, their edges are not vertical, and if they are overgrown with vegetation.

A significant decrease in the number of reservoirs has been lately observed. Reservoirs are eliminated as a result of progressive land development or as a result of

Fig. 3. Evaluation of the reservoirs in Chorzów. (a) not classified reservoirs; amphibian breeding place: (b) of 1 or 2 or 3 species of amphibians; (c) of 4 or 5 species; (d) of 6 or 7 species; (e) of 8 or more species; (f) non-existent reservoirs from the 1930s; (g) boundary of the city; (h) main roads; (i) rivers; (j) built-up area.
changes in industry and its modernization. Destruction of reservoirs which are amphibian breeding sites, results in a decrease in biodiversity. Over the past 20 years, 21 reservoirs were destroyed in Chorzów. 11 of them were documented as breeding places of amphibians, 4 others were very attractive for amphibians. Habitat destruction of legally protected fauna is often done unconsciously. For this reason, there is need for legal protection of reservoirs and their surroundings, which are important for biodiversity.

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