Ecological and Biological Features of Artificial Lakes in Public Green Areas

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Abstract
Zagreb, a capital city with about one million inhabitants, is situated between the river Sava and the Zagrebačka Gora mountain. In areas that represent the remains of an old river watercourse together with its small backwater channels and deserted gravel pits, artificial lakes now stand, representing the remaining natural green oases in the town itself. The richness of the flora and fauna that is typical of the rivers in these areas has been conserved, its attraction and specific value adding to the possibility of taking recreation in a natural setting. The preservation of woods, wood sides, hedgerows, meadows, pastures, rocky and marshy biotopes and the incorporation of indigenous vegetation in the landscaping of public green areas is of crucial importance. Existing parts of biotopes near water, such as open water areas, coastal vegetation, little islands, shrubberies, and nearby woodlands, demand careful attention and manipulation so that the requirements for nature conservation and for peoples’ needs for recreation are respected. In this paper, the current state of different biotopes in two artificial lakes near the river Sava will be presented as well as an inventory of several valuable plant associations and some maintenance measures that are being carried out.

INTRODUCTION
Gravel excavations often result in the formation of lakes which, after the excavations are discontinued, are then given some secondary purpose, usually for sport and recreational activities. This is also the case with the large European rivers – the Rhine and the Danube.

In the river Sava region of Zagreb there is a long tradition of extracting gravel for the needs of structural engineering and the construction of buildings. This region also has specific ecological characteristics and attractions, which would be good to preserve and use as parks, park forests and natural water reserves. Such areas offer great potential to enable the urban population to spend time with nature and engage in various recreational activities (Burger 2000, Buchecker 2003).

The approach to the management of such areas is very delicate, especially with regard to the intended types of recreational activities, their intensity and timing (Shin and Jaakson 1997, Rubino 2003). The problem is how to develop the area and for which purposes, in order to minimize the damage to the natural environment and yet allow the city’s inhabitants to use it.

MATERIALS AND METHODS
In the area along the river Sava, by Lakes Bundek and Jarun, an inventory of the plant species was prepared and the main biotope types were identified. Landscape values were recorded and a value analysis of the subject area was conducted to assess the recreational potential by the lakes.

NATURAL CHARACTERISTICS OF THE AREA
Zagreb, the capital and the largest city of Croatia, is situated in Northern Croatia, on the river Sava, 122 m above sea level, 45° 49’ N, 15° 59’ E. The area is characterized by a continental climate, with a mean summer temperature of 20 °C and a mean winter
temperature of 1 °C. The city spreads over 650 km² and had 779,145 inhabitants at the time of the 2001 census.

Mt. Medvednica rises above the city, extending over an area of 270 km² in the southeast to northwest direction. Its highest peak, Sljeme, is 1035 m high and its southern slopes stretch down to the city center. Besides its great ecological importance, the natural attributes of Mt. Medvednica make it a large forest and recreational area.

The river Sava was once the southern boundary of Zagreb but it is now integrated into the city. By excavating gravel from the former backwaters, two lakes were created: Lake Jarun (in 1964; in its present form in 1987) and Lake Bundek (1960) (Figure 1).

Lake Jarun and its grounds cover an area of 240 ha, of which about 30% are under water. They have become a significant multi-purpose recreation-sports center for Zagreb (a regatta-course for water sports, primarily rowing and canoeing, and city bathing places with accompanying attractions). Lake Jarun is bounded by the river Sava in the south and by urban housing estates on the other sides. The lake is shallow, with a mean depth of 5 m. The water level varies depending on the water inflow, i.e. on the relative levels of the river Sava and the groundwater. The lake is fed by clean groundwater and emptied by water leaking into the ground and draining into the river Sava.

Despite various strong and long-term impacts, the water and land habitats of Lake Jarun abound in diverse animal and plant life. The land areas have been developed so that they are suitable for spending time with nature, for sports and recreation, while the landscape architecture involves a gradual transition from the indigenous Sava vegetation on the south bank to the park characteristics on the northern side. Lake Jarun, particularly the part next to Wilderness Isle, is an oasis of the natural swamp association which, along with the associations of willow and poplar stands, offers an authentically natural atmosphere and is a protected area. Ornithological studies of the Jarun ecosystem have so far recorded 129 bird species, of which 30 are water fowl.

At low water levels of the river Sava, Lake Bundek consists of two parts which at high water levels, merge to become a single lake about 500 m long by 200 m wide at its widest point. In 1987, the Lake Bundek was proclaimed the protected water-source area of Zagreb. The construction of camping sites and sports facilities was prohibited within the water-source and water margin. The indigenous vegetation of the river Sava prevails in this area (Table 1).

AN INVENTORY AND AN EVALUATION OF THE AREA

The outer limits of the coverage include the areas along the river Sava which are covered by the General Urban Plan for green areas intended for parks, park forests, landscape and protective greenery, and sport and recreation grounds. These are followed by zones intended for mixed and public purposes. The concept of broader location includes the area along the river Sava. The concept of narrower location includes areas around artificial lakes Jarun and Bundek (Figure 2). Valuable biotopes are found by the lakes, whose ecological specificities contribute to the quality and value of the area and enable a range of interesting and pleasant types of recreational activities to be conducted (Figure 3).

The inventory and value analysis of the subject area with respect to its potential for recreational activities revealed a wide spectrum of possibilities for land and water sports. The conceptual models covered different habitats and their suitability for recreational purposes. The ground by the lakes is preserved in a natural state, thus providing the conditions for birds to live and reproduce. These conditions also allow people to spend time in a natural environment and to enjoy bird watching (Table 2).

CONCLUSION

Within the area of the artificial lakes near the river Sava in Zagreb, several different habitats are apparent, such as forests, forest margins, meadows, marshes and water habitats. Lake Bundek was created in 60 by gravel excavation and it used to be a favorite bathing spot of the citizens of Zagreb. Within the last 40 years, the lake was
abandoned and the lack of maintenance resulted in the development of a distinctly rich ecological and biological ecosystem within the urban area of Zagreb.

Lake Jarun is a well maintained recreational and sport complex with a total area of 240 ha, including 74 ha of water. There are 2500 m of gravel beaches, well connected with footpaths and bicycle paths. Parts of the complex were left untouched so that the indigenous vegetation and associations of birds, amphibians and mammals could develop. There are considerable benefits, both landscaping, aesthetic and ecological from having these lakes just 5-6 km from the town center. Consequently, this area should be preserved for future generations by the timely implementation of appropriate maintenance and protection measures.

**Literature Cited**


Figures

Fig. 1. Map of Zagreb with Medvednička Gora on the north and river Sava on the south of town and with lakes situated near the river.

Legend:
1. Broader location
2. Narrower location
3. River
4. Roads and railways
5. Park lakes and natural water reservations
6. Parks and park-forests
7. Landscape vegetation
8. Sport and recreation areas
9. Protected water area
10. Objects of miscellaneous use
11. Objects of specific use
12. Industrial area

Fig. 2. Graphical imagery of area assignation near the river Sava.
Legend:
1 - Landscaped area
2 - Forest border
3 - Solitary trees
4 - Meadows and fields
5 - Water margin
6 - Remains of indigenous vegetation

Fig. 3. Example of marshy habitat on lake Bundek.
Table 1. List of species around Bundek lake.

<table>
<thead>
<tr>
<th>Group</th>
<th>Species</th>
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<tbody>
<tr>
<td>Trees</td>
<td>Acer campestre, Acer pseudoplatanus, Acer platanoides, Alnus glutinosa, Betula pendula, Carpinus betulus, Catalpa bignonioides, Fraxinus excelsior, Juglans regia, Pinus nigra, Platanus x acerifolia, Populus alba, Populus nigra, Populus nigra var. pyramidalis, Quercus robur, Robinia pseudoacacia, Salix alba, Salix vitelina var. pendula</td>
</tr>
<tr>
<td>Shrubs</td>
<td>Cerasus avium, Cornus mas, Crategus oxyacantha, Euonymus europaeus, Forsythia intermedia, Ligustrum vulgare, Prunus padus, Prunus spinosa, Rosa canina, Sambucus nigra, Viburnum opulus</td>
</tr>
<tr>
<td>Climbers</td>
<td>Clematis vitalba, Hedera helix, Humulus lupulus, Vicia sp., Vitis sp.</td>
</tr>
<tr>
<td>Annuals and Perennials</td>
<td>Achillea millefolium, Ajuga reptans, Anthriscus sylvestris, Asarum europaeum, Bellis perennis, Campanula patula, Capsella bursa pastoris, Chrysanthemum leucanthemum, Equisetum arvense, Knautia arvensis, Lathyrus pratensis, Lychnis flos cuculi, Plantago media, Ranunculus arvense, Salvia pratensis, Taraxacum officinale, Trifolium pratense, Trifolium repens, Typha angustifolia, Urtica dioica, Veronica chamaedris, Vinca minor</td>
</tr>
<tr>
<td>Grasses</td>
<td>Agropyron repens, Avena fatua, Briza media, Dactylis glomerata, Hordeum murinum, Lolium temulentum, Poa annua</td>
</tr>
</tbody>
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Table 2. Assessment of area for bathing and swimming (■) and bird – watching (●)

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<tbody>
<tr>
<td>Lakes</td>
<td>Forest</td>
<td>Shrubs and scrubs</td>
<td>Grass area</td>
<td>Without vegetation</td>
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<tr>
<td>Major</td>
<td>●</td>
<td>●</td>
<td>■</td>
<td>■</td>
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<td>Medium</td>
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<td>Minor</td>
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