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ROLE AND THREATS OF WATER RESERVOIR IN THE URBAN PALACE AND PARK COMPLEX IN PUŁAWY

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Summary. The assessment of functioning of small astatic reservoir located in the palace and park complex in Puławy was made in the study. This object is an important element of the urban landscape where it performs both aesthetic and landscape functions. Unfortunately, because of the presence of numerous pollution sources in immediate vicinity, the existence of the reservoir is seriously threatened (including pollution inflow from arable lands and neglected built-up area). Progressive degradation of this water reservoir is observed.

Key words: urban landscape, water reservoir, water pollution

INTRODUCTION

Urbanised landscape is monotonous and very simplified. The elements that make its value higher – of both landscape and recreational character – are water reservoirs. Besides better aesthetic virtues, water reservoirs increase the species diversity within poor urban landscape through creating habitats with various trophies and moisture contents [Kasprzak 1985, Hłyńczak *et al*. 1995]. Lakes of floodplains (fragments of oxbow lakes) are a valuable component of urban aquatic ecosystems. Their trophy level depends on the degree of connection with a river, but mainly on management of adjacent areas [Obolewski 2006, Koc *et al*. 2009]. Moreover, considerable susceptibility of small water reservoirs to anthropogenic influence is a threat for their existence, which can transform them into arduous objects [Jankowski and Rzętała 2003, Frąk and Nestorowicz 2009].

The study deals with the evaluation of possibilities of small water reservoir functioning in the palace and park complex in Puławy taking into account the threats resulting from the current ways of adjacent areas management as well as the importance of the reservoir for local landscape.

MATERIAL AND METHODS

The astatic reservoir being a fragment of an oxbow lake was the studied object. It is situated within the lower flood terrace of the Vistula river at the bottom of a steep slope occupied by the Czartoryskis' Park (Fig. 1 and Photo 1, 2). The reservoir

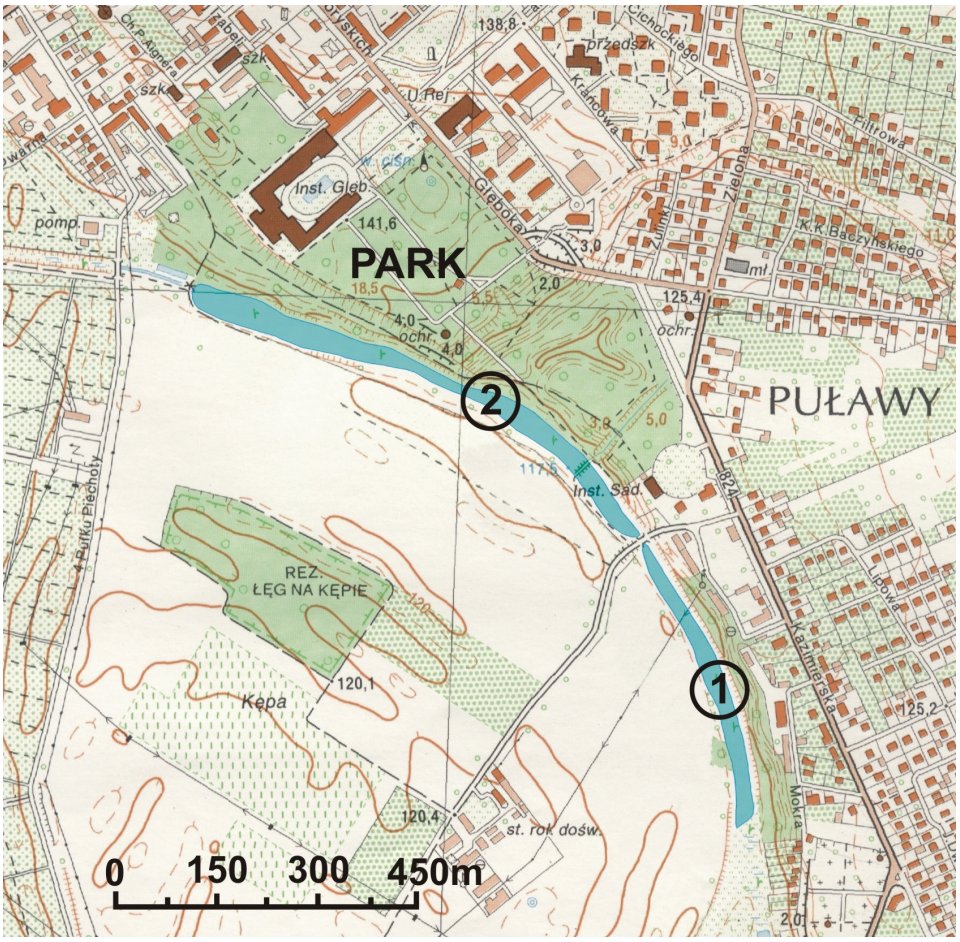

Fig. 1. Location of the palace and park complex and the examined water reservoir (1, 2 – control points)

is of 3.1 ha area and 1.2 km length. It is supplied mainly by ground waters. The surface supply occurs only during thawing and intensive rainfalls – namely by means of surface runoffs from the slope adjacent to the reservoir from the east. The palace and park complex of 30 ha area is floristically unique due to the number of species and varieties of trees introduced by Princess Izabela Czartoryska (over 200 years ago). At present, trees in the park consist mainly of small-leaved lime (*Tilia cordata*), pedunculate oak, sessile oak (*Quercus robur et pet raea*),

Photo 1, 2. View of the ox-bow lake (June, 2010)

beech (*Fagus*), black locust (*Robinia pseudoacacia*) and gingko (*Ginkgo biloba*). Besides, numerous bush and undergrowth species grow in the park. Landscape virtues of the park are completed by garden buildings and monuments located around the park [Zub 2002].

The structure of adjacent grounds management and water pollution sources survey were made as part of the field observations. Analysis of the quality of water from the reservoir was also carried out. Water samples were collected every season at two control points – above the park (2006–2010, 18 dates) and at the height of the park (2009–2010, 4 dates) (Fig. 1). Following items were determined in water: electrolytic conductivity (conductometry), pH (potentiometry), total suspension (drier-weighing method), dissolved oxygen, BOD_5 (dilution method), COD (dichromate method), ammonia (NH_4^+), nitrates (V) (NO_3^-), nitrates (III) (NO_2^-), phosphates (PO_4^-), potassium (K^+), and chlorides (Cl^-) (photometry). In order to classify the water quality, extreme and mean values of examined indices for every control point were calculated. Statistical comparison of achieved results was made on the basis of standard deviation and variability coefficient values.

RESULTS AND DISCUSSION

The importance of small water reservoirs within a landscape varies depending on their type, size, location, quality of accumulated water, etc. The most important goal of water reservoirs creation is enhancing the surface waters resources within a catchment, but they often play economic, ecological, and recreational functions [Mioduszewski 1997, 2006]. The water reservoir in question is an important landscape element in the palace and park complex, which refers also to water as an element that can be observed from the park hill slopes (namely from the viewpoint near the Temple of the Sibyl) and situations when the park is observed from the reservoir's shores with water in the foreground. Considering physiocenotic features, the reservoir is some kind of ecological island located at the border of agricultural and urban ecosystems. It contributes to wider biodiversity. Aquatic plant species grow within the littoral zone and many animal species develop and successfully survive: mute swan (*Cygnus olor*), grass snake (*Natrix natrix*), or European pond turtle (*Emys orbicularis*). Trees of black alder (*Alnus glutinosa*) and willows (*Salix* sp.) can be met on adjacent areas, while rush-plants grow at the reservoir's edges.

The reservoir existence is seriously threatened – presence of numerous contamination sources in the direct neighbourhood and progressing degradation of the reservoir can be observed. From the west, the oxbow lake borders with a large farm (winter wheat and rapeseed plantations), while the park, shelterbelts, and neglected built-up areas are situated on the east of the studied reservoir. Intensified agricultural production has led to considerable simplification of natural structure of cultivated fields, thus opening the matter cycles. Increasing mineralisation of humus resources and washing out of released minerals is a real threat to the water reservoir [Burt and Haycock 1993, Ekholm *et al*. 2000]. In the case of other areas, sites of illegal waste dumping and leachate drain from there are a significant source of contamination (Photo 3 and 4). A fast outflow of contaminated

Photo 3, 4. Threats to the water reservoir – intensively using of arable land (March, 2010) and places of illegal deposition of municipal wastes (March, 2008)

rainfall and thawing waters toward the reservoir is additionally favoured by large inclination of the slope running along the eastern shore, where it reaches up to 19%.

During the study, water retained in the reservoir was characterised by usually low quality determined by unsatisfactory oxygen balance. Very low levels

of dissolved oxygen along with high values of BOD_5 and COD_{Cr} were often determined (Tab. 1), namely at the first control point, where mean oxygen concentration amounted to 4.2 mg·dm^{-3} (and minimum of 0.7 mg·dm^{-3}), while BOD_5 and COD_{Cr} reached maximum levels of 22.3 and 61 mg·dm^{-3}, respectively. Satisfactory water saturation with oxygen was recorded only in winter – despite the high BOD_5 and COD_{Cr} values its average level was 8.3 mg·dm^{-3}. Low temperatures favoured the process of oxygen penetration from the atmosphere and its retention in water, making organic pollutants distribution rate slower [Dojlido 1995].

Table 1. Characteristic values of water quality indices in the reservoir in 2006–2010

Indicator	Control point	Minimal value	Maximum value	Average	Standard deviation	Variation coefficient
Conductivity, μS·cm^{-1}	1	119	1477	463	372.5	80.4
	2	213	620	434	172.4	39.7
pH	1	6.7	7.9	7.2	0.3	4.1
	2	7.1	7.7	7.4	0.3	3.9
Suspension, mg·dm^{-3}	1	4	27	9	5.2	55.5
	2	6	18	12	5.0	41.4
O_2, mg·dm^{-3}	1	0.7	11.3	4.2	3.1	73.9
	2	3.6	7.7	5.5	1.7	31.1
BOD_5, mg·dm^{-3}	1	3.3	22.3	8.3	4.1	50.1
	2	4.0	7.2	5.0	1.5	29.6
COD_{Cr}, mg·dm^{-3}	1	13	61	37	11.9	32.2
	2	6	34	23	12.6	54.1
NH_4^+, mg·dm^{-3}	1	0.05	1.06	0.32	0.3	84.2
	2	0.26	0.86	0.59	0.3	44.1
NO_3^-, mg·dm^{-3}	1	0.10	0.80	0.45	0.2	45.5
	2	0.10	0.95	0.43	0.4	90.6
NO_2^-, mg·dm^{-3}	1	0.01	0.17	0.05	0.04	83.2
	2	0.03	0.05	0.04	0.01	22.5
PO_4^-, mg·dm^{-3}	1	0.2	2.1	0.8	0.5	62.0
	2	0.6	1.1	0.7	0.2	32.2
K^+, mg·dm^{-3}	1	1.2	16.6	7.5	5.1	67.8
	2	14.5	27.0	20.2	5.9	29.1
Cl^-, mg·dm^{-3}	1	7.4	178.0	46.7	44.6	95.4
	2	19.7	48.1	31.0	13.4	43.2

Phosphates (main eutrophication factor) were the factor that also decreased the water quality. Their extreme concentrations were 0.2 and 2.1 mg·dm^{-3} at mean value of about 0.8 mg·dm^{-3}. At five measurement dates, contents of PO_4^- exceeded 1 mg·dm^{-3}, whereas an excessive accumulation also occurred both in warm and cold halves of the year. Among mineral forms of nitrogen, nitrates (III) represented the least favourable; their average concentrations amounted to 0.05 mg·dm^{-3} (0.01–0.17 mg·dm^{-3}). A slight decrease of nitrates (V) level was

observed during the vegetation season, which may be attributed to better assimilation of these components by developing plants. Mean values of electrolytic conductivity were determined at the low level of about 450 $\mu S \cdot cm^{-1}$; however, in winter, they sometimes exceeded 1200 $\mu S \cdot cm^{-1}$ at the first control point. Increase of chlorides concentration was recorded on the same dates, which may indicate the supply of thawing waters containing large amounts of salts.

The observed degradation of examined water reservoir results not only from the presence of anthropogenic contamination sources in adjacent areas, but also hydraulic conditions within. Reduced water exchange favours the contaminants to concentrate. No efficient buffering zone that would separate the oxbow lake from cultivated fields is quite a significant problem. Losses can be found among trees along the western shore and fields adjoin the reservoir edge in some places. The oxbow lake protection requires more efficient barriers for migrating contaminants – making the band of a sustainable green area near the coastal shelterbelt would be a solution which would also result in „separating" the arable land border from the reservoir [Koc and Szyperek 2001, Zubala *et al*. 2006]. Contamination of the water in the reservoir may be also associated with physical and chemical processes occurring periodically in bottom sediments as well as secondary release of some minerals. It would be necessary to perform some reclamation operations along with thorough removal of sediments, precipitation of phosphates, and water aeration during the oxygen deficits to maintain the reservoir in satisfactory condition [Ryborz-Masłowska 2004].

CONCLUSIONS

1. Studied water reservoir – as an element that increases the aesthetic virtues of the urban palace and park complex – also plays an important role in enhancing its biodiversity by means of formation of favouring habitats for aquatic flora and fauna.

2. Water retained in the reservoir is characterised by low quality. An excessive concentration of organic contaminants is found, confirmed by poor values of oxygen indicators and high phosphate levels, which intensifies the eutrophication processes (e.g. intensive plant development during vegetation).

3. Supply of contaminants from arable lands, neglected areas, and sites of illegal municipal wastes dumping are a serious threat to water quality in the reservoir.

4. To maintain the oxbow lake in satisfactory condition is possible through making the reclamation operations preceded by elimination of the contamination sources and inhibiting their migration and concentration. Reduction of the supply of contaminated waters and utilisation of the largest possible amounts of biogens at the site of their generation is crucial.

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ZNACZENIE I ZAGROŻENIA ZBIORNIKA WODNEGO W MIEJSKIM ZESPOLE PAŁACOWO-PARKOWYM W PUŁAWACH

Streszczenie. W pracy dokonano oceny funkcjonowania małego zbiornika astatycznego zlokalizowanego w zespole pałacowo-parkowym w Puławach. Obiekt ten jest ważnym elementem krajobrazu miejskiego, w którym pełni zarówno funkcje estetyczne, jak i krajobrazowe. Niestety, z powodu obecności licznych źródeł zanieczyszczeń w bezpośrednim sąsiedztwie, istnienie zbiornika jest poważnie zagrożone (m.in. dopływ zanieczyszczeń z pól uprawnych i zaniedbanych terenów zabudowanych). Obserwuje się postępującą degradację akwenu.

Słowa kluczowe: krajobraz miejski, zbiornik wodny, zanieczyszczenie wód