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Ecological and Landscape Valuation of Small Water Bodies in the Selected Municipalities of the Małopolska Province***

1. Introduction

It is the first time when a chance to take under legal protection some natural small water bodies has appeared. It is possible due to the Law on the Protection of Agricultural Land and Forests (Journal of Law of 1995, No. 16, item 78) [16] and the Law on Nature Conservation (Journal of Law of 2004, No. 121, item 1266) [17].

By natural small water bodies we mean small area naturally filled in water, not exceeding 1 hectare, situated among fields or forests, where soil classification is inapplicable. This definition is given by the Law on the Protection of Agricultural Land and Forests [16]. According to this Law, the agricultural lands are all the inventoried grounds used in an agricultural way, and also grounds under ponds and other water bodies, used only for agricultural purposes, bogs and small water bodies, village parks and grounds under trees and bushes growing among fields.

The Law on Nature Conservation [17] defines ecologically usable land as worth protection remains of ecosystems significant for the preservation of biodiversity: natural water bodies, situated among fields and forests, groups of trees and shrubs, marshes, bogs, dunes, areas of not cultivated vegetation, old riverbeds, rock outcrops, scarps, monadnocks, natural habitats and habitats of rare or protected species of plants, fungi and animals, their refuges and places of bing or seasonal migrations. The ecologically usable land makes one of newly introduced forms of nature conservation in Poland. Theoretically, this may be any object, which cannot be used in an agricultural way.

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2. The Goal and Scope of the Study

The goal of the paper was ecological characteristics and identification of the functions fulfilled by the objects located in the municipalities of Krakow and threats to them. Small water bodies are components of natural environment that are very susceptible to anthropogenic pressure. Their protection is particularly important in dynamically developing areas of city agglomerations and industrial areas, where the process of the expansion of all the infrastructures is observed. This paper is the first inventory of small water bodies occurring within administrative borders of Krakow.

3. The Review of Literature of the Subject

Small natural water bodies make common element of natural environment in the young ial areas of central Europe. Thus the majority of available literature refers to the areas of north and central Poland [1, 10, 14] or north Germany [5, 6, 8]. These are mainly papers of inventory and review character. However, there are no literature data referring to the studies of small natural water bodies in the region of Krakow agglomeration, because in the Małopolska landscape natural small water bodies are rare. Also numerous popular scientific publications are useful [7, 9, 12, 13, 15].

Literature referring to the methods of studying small water bodies is generally scarce. It mainly refers to post-ial water bodies. Pieńkowski [14] as well as Klafs *et al.* [8] give the classification criteria of natural small water bodies, taking as reference points their origin, size and ecological functions. Regarding the origin and developmental stages natural small water bodies are divided into primary (post-ial), secondary (arising due to the impact of ground waters and surface waters) and areas of subsidence temporarily filled with water.

The following functions decide on environmental values of water bodies: biocoenotic function (the presence of flora and fauna) and physiocoenotic, allowing migrations of species between objects [12, 14].

The main threat of small water bodies is related to their sensitivity to degradation and the processes of disappearance. These processes lead to the disappearance of small water bodies can be divided into natural and anthropogenic [15]. The natural threats are: ecological succession (leading to the colonization with terrestrial vegetation) and periodic deficiency of atmospheric precipitation, lowering the level of ground waters. Among anthropogenic threats one should mention: melioration work, vegetation burning, cutting down trees and shrubs surrounding

water bodies, release of wastewater and disposal of wastes. Small water bodies occurring near agricultural land are exposed to eutrophication, caused by field pollution. Water bodies are filled with ground and levelled to increase a production area. Another kind of anthropogenic pressure is the neighbourhood of roads and other elements of infrastructure, which enforce changes in the routs of animal migration [4]. The result of the described hazard is a permanent process of decreasing the number of objects, as well as their progressing degradation, observed in the northern part of Poland [14]. There are no equivalent assessments in south Poland.

4. Material and Methods

The study area included south-western part of the urban municipality of Krakow, i.e. to jest the fragments of the quarters of Krowodrza (VI Bronowice, VII Zwierzyniec) and Podgórze (VIII Dębniki). The choice of the area was not accidental, for this fragment of Krakow agglomeration is characterized by great values of nature, landscape and recreation. At the same time, the area is subdued to great anthropogenic pressure, including constant expansion of urbanised areas, industrial and transport infrastructure. In the study area, according to the mentioned above criteria, 29 objects were included into inventory (Tab. 1 on the interleaf, Fig. 1).

The inventory included the objects, the surface of which does not exceed 1 ha. In the study artificial objects were put into inventory, among others ponds and water gardens near manor houses and farmhouses. These objects do not fit the definition of natural small water bodies; however they fulfil similar environmental functions as natural objects do.

Also periodical water bodies were taken into account. The uniform scheme of the object description was proposed, including: detail address (street name, the no. of nearest building) physical features (surface of water mirror and relative size), environmental characteristics, functions, threats and conflicts. Taking as the base of classification by Klafs *et al.* [8] a simplified division was accepted: very small objects (<0.125 ha), medium (0.125–0.5 ha) and relatively large ones (0.5–1.0 ha). Environmental characteristics of small water bodies included such elements as: origin (natural objects: old river beds, land slide structures, karst forms and artificial objects), the state of preservation (permanent/temporary), type (among forests, among agricultural land (fields), among fields and forests, in the urbanized area), vegetation around shores (trees, shrubs, terrestrial vegetation, beds, lack of vegetation).

Fig. 1. The localisation of small water bodies

Among the most important functions of small water bodies the following were specified: biocoenotic, physiocoenotic, landscape and potential functions: research-didactic, recreational and economic. The two first are of typically environmental qualification. Biocoenotic function is fulfilled when a water body makes the place of living for the species flora and fauna. While assessing biocoenotic functions of water bodies one should take into account not only the bowl of the water body and surrounding vegetation (biological lining), but also the surround-

ings (up to 50m from the borders of the pond), which can include meadows, shrubs, trees, usually represented by semi-wetlands. Well formed vegetation forms a so-called vegetation buffer. In case of a very small surface of water and considerable anthropogenic pressure, very small water bodies do not fulfil biological function. Such a situation is seen in object 3, in the Ojcowska street (Tab. 1).

Physiocoenotic function is fulfilled when the migration of species between objects is possible. The condition is a small distance between water bodies and natural elements of environment or barriers of anthropogenic character, found on the shortest distance joining the objects. For example, the maximal distance between objects that would allow free migrations of most amphibian species is about 0.5 km [3].

Landscape function contains a subjective element, such as aesthetics of the area. Scientific and didactic functions and recreational function join both ecological and aesthetic elements. Scientific and didactic function should be fulfilled on the objects of particular environmental values, by (among others) making educational routs. By economic function a potential possibility to rear fish should be understood. Biocoenotic and landscape functions should be fulfilled in all the studied objects, while recreational scientific-didactic and economic functions have not been fulfilled so far.

The identified threats and conflicts were divided into natural (processes of succession and covering with terrestrial vegetation) and anthropogenic (covering with ground or other forms of liquidation, wastewater release, drainage in melioration processes, water flow from the surface, disposal of rubbish, vicinity of a road, vicinity of buildings and other objects, making barriers and isolation of the object by linear development and fences). Covering with ground, rubbish, wastewater release, drainage, water flow from the surface, etc. threaten the water body directly. Other examples of threat, such as the vicinity of roads, buildings or the isolation of objects by a system of fences – in an indirect way – contribute to the degradation of small water bodies.

5. Results and Discussion

The size of the water body is one of the factors deciding on its susceptibility to degradation. The most threatened by degradation are small water bodies. The studied water bodies are in most cases very small, of a surface not exceeding 0.125 ha (24 objects). Only four of them were classified as medium size (0.125–0.5 ha). There were no objects exceeding 0.5 ha. It means that the studied bodies are, in most cases, subdued to negative environmental changes.

Twenty objects are of natural character, nine are artificial water bodies, remains of old ponds near manors or farmhouses. Three water bodies: ponds in

Bronowice at the Stawowa street (object no. 4) and Ojcowska street (object no. 3) and a natural water body at the Pylna street (object no. 5) near the Rudawa River are periodically filled with water. Almost a half of the inventoried water bodies (13 objects) are located in urbanized areas, four objects are among forests, other four – in the fields, and the remaining eight are situated in agricultural and forest areas.

Environmental values of small water bodies, and thus their ecological significance are: size (very small, medium, relatively large), the state of preservation (temporary, permanent) and type (among fields, forests, in urbanized areas), while the origin (natural/artificial) is not important. Large and medium, forest and field permanent small water bodies present highest environmental values and the smallest susceptibility on all the types of threat. These criteria are fulfilled by five objects: Rząska (no. 2), three small water bodies at the. Polnych Kwiatów street (no. 8, 10, 11) and Wilga (no. 26) (Tab. 1). It has been stated that at present they fulfil the following functions: biocoenotic, physiocoenotic and landscape, while didactic and economic functions should be treated as potential. The exception is object Rząska (no. 26), under legal protection in the form of ecologically usable land, at present fulfilling recreational function. This does not mean that in some objects biocoenotic or physiocoenotic functions cannot be restored, although it requires expensive re-naturisation work.

Biocoenotic function is conditioned by permanent or temporary presence of water in the pond, because it enables the existence of flora and fauna. It is the case of all the objects apart from two ponds in Bronowice (no. 3, 4), where there is no water. Physiocoenotic function is limited to the ponds found close together to one another and not to the ones isolated by the roads and fences, etc. Such criteria are fulfilled by the complexes of objects, that are old riverbeds of: the Vistula River (four small water bodies at the Polnych Kwiatów street, in the Zwierzyniec quarter, no. 8, 9, 10, 11), Wilga River (three small water bodies located in the quarter of Dębniki no. 26, 27, 28) and a local water stream going through Skotniki (the municipality of Dębniki no. 15, 29).

The taken into account threats were treated subjectively, regarding the easiness of their identification and common occurrence. These are: covering with ground (liquidation), wastes disposal, wastewater release, changes in water balance (meliorations), flow from the surface, vicinity of roads and buildings, isolation of the object and colonization of terrestrial vegetation. All the threats, apart from the process of covering the ponds with terrestrial vegetation have anthropogenic character. Devastation means the liquidation of the object, and the remaining threats cause only its degradation. Growing terrestrial vegetation can also be caused by anthropogenic factors, increasing the eutrophication of water. In natural environment this process is carried out spontaneously.

The greatest threat is caused by covering small water bodies with ground, resulting in their devastation, or even total liquidation. It was found among seven inventoried objects, including a group of small water bodies in Skotniki (no. 15, 16). The most common threats are: the vicinity of buildings (18 objects), the vicinity of buildings (17 objects) and waste disposal (16 objects).

The analysis of the fulfilled functions and the occurring threats was the base of proposals and optimal use of the individual objects. A particular attention was paid on the threat to fauna, caused by the vicinity of roads. Also the possibility of the management of objects was shown, preferring recreational and scientific--didactic functions. This first of all refers to the objects situated close together, or localized in places attractive in environmental and landscape areas. Referring to the groups of objects localized in the Vistula valley (the Polnych Kwiatów Street no. 8, 9, 10, 11), Wilga valley (no. 26, 27, 28) and alongside the local stream in Skotniki (no. 15, 29) there was a proposal to make a walking recreational route, being a scientific-didactic route. The same referred to small water bodies situated in the area of Skały Twardowskiego (objects o no. 20, 21, 22), showing a mosaic structure of ecosystems (wychodnie of rock limestones and xerothermal meadows directly neighbouring with small water bodies and wetlands, covered with vegetation characteristic to marshlands and szuwarową), and at the same time exposed to immense anthropopressure (building residential areas, commercial objects and road infrastructure). As a result, in recent years there was a liquidation of small water bodies in the area of St. Jacek and Twardowski Streets. These objects are still seen in older maps of Krakow. Valuable is a complex of small water bodies within a water stream in the area of Lasek Wolski. They make the only major resource of drinking water for wildlife there.

Small water bodies in the Vistula valley (objects no. 8–16) are in the area of the international ecological corridor covered by a pan-European network ECONET [11]. Moreover, some objects are within local ecological corridors, such as valleys of the Vistula tributaries, including Rudawa (object no. 5) and Wilga (objects no. 26, 27, 28) or major woodland complexes in the region of Pasternik (object no. 1), Tyniec and Pychowice (objects no. 14, 15, 16, 17, 18) and in the Las Wolski (objects no. 6 and 7).

It is important that the majority of the presented above small water bodies is within the borders of the Complex of Jurassic Landscape Parks: Bielany – Tyniec and Tenczyn. Objects no. 6–11, 13–14, 19 and 24–25 are situated within the borders of the Bielany – Tyniec Landscape Park, and objects no. 1 and 2 – in the peripheral eastern part of the Tenczyn Landscape Park. This makes a possibility to take them under a legal protection. According to article 17.1 chapter 2 of the Law of Nature Conservation [17] in a landscape park it can be forbidden to liquidate, cover with

ground or convert in any other way water bodies, old river beds or wetlands, as well to liquidate or destroy trees alongside water bodies or streams. Several small water bodies have direct borders with the Bielany-Tyniec Landscape Park (Winnica no. 15 and Skotniki no. 16–18). The water body located in Rząska (object no. 2) with the neighbouring woodland is protected by law as an ecologically usable land.

To provide a proper protection of small water bodies it is necessary to carry out re-naturisation treatment. These are, among others [18]:

- hydrotechnic work: deepening ponds, removing mud and forming variable slope of the shores;
- sewing and growing plants in the littoral part of a water body;
- management of vegetation – completing in case of the death of trees or shrubs.

Apart from the most ecologically valuable objects situated alongside the valley of the Vistula (objects no. 8, 10, 11), Wilga (object no. 26) and in Rząska (Tab. 1), all the other objects, because of their small surface and depth, or anthropogenic threats are in the state of progressing degradation. In their case it is necessary to improve environmental conditions by adequate re-naturisation treatment.

For objects: no. 3 at the Ojcowska street, no. 5 at the Pylna street, no. 6 and 7 in the Las Wolski and no. 19 in the vicinity of the exit from the Krakow bypass towards Oświęcim, it is justifiable to deepen the water bodies, due to their small size and progressing succession process towards terrestrial ecosystems. In a small water bodies situated at the Polnych Kwiatów street (objects no. 1–4) shores are too steep and inclined with the same angle. This requires re-modelling of scarps. A field water body near the road Tyniec – Skawina (object no. 13) does not have vegetation in the littoral part, and objects: 16 in Skotniki, and no. 24 and 25 in Sidzina require supplementation of vegetation by growing proper species of trees or shrubs. On the roads in the vicinity of small water bodies: in Skotniki (objects no. 16–17 at the road Kobierzyn – Kostrze) and in Sidzina (objects no. 24–25 at the road Libertów – Skawina) it seems reasonable to put information-warning signs to protect amphibians.

6. Conclusions

- Among 29 inventoried small water bodies in the area of Bronowice, Zwierzyniec and Dębniki w the south-west part of the urban municipality of Kraków, most water bodies (20 objects) are of natural origin.

- Definitely the most numerous group (24 objects) make very small water bodies of the surface not exceeding 0.125 ha. They are most threatened by degradation and liquidation.
- Twelve small water bodies are localised within urbanized areas, and differentiated infrastructure (buildings, roads) additionally intensify the processes of their degradation.

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Table 1. The characteristics of small water bodies

Object No.	The Name of the Object	Localisation (City Quarter)	Characteristics				Functions						Threats								
			Size	Origin	State of Preservation	Type of the Object	Biocoenotic	Physiocoenotic	Landscape	Recreational	Scientific and didactic	Economic	Covering with ground	Rubbish	Wastewater	Meliorations	Flow from the surface	Close to the Road	Close to buildings	Isolation	Succession
1	Pasternik 1	Bronowice	S	N	P	F	X	X	X		X	X		X	X						
2	**Rząska**	**Bronowice**	**M**	**N**	**P**	**U**	**X**		**X**	**X**	**X**	**X**							**X**	**X**	
3	Ojcowska	Bronowice	S	A	T	U								X			X			X	
4	Stawowa	Bronowice	S	A	T	U						X		X				X	X		X
5	Pylna	Zwierzyniec	S	N	T	A	X	X	X				X	X		X	X		X		
6	Lasek Wolski 1	Zwierzyniec	S	N	P	A	X	X	X		X								X		
7	Lasek Wolski2	Zwierzyniec	S	N	P	F	X	X	X		X										
8	Polnych kwiatów 1	Zwierzyniec	M	N	P	F/A	X	X	X	X	X						X				
9	Polnych kwiatów 2	Zwierzyniec	S	N	P	F/A	X	X	X	X	X		X	X				X	X		
10	Polnych kwiatów 3	Zwierzyniec	M	N	P	F/A	X	X	X	X	X								X		
11	**Polnych kwiatów 4**	**Zwierzyniec**	**M**	**N**	**P**	**F/A**	**X**	**X**	**X**	**X**	**X**								**X**		
12	Skały Twardowskiego 1	Dębniki	S	A	P	A	X		X	X	X								X		
13	Bogucianka	Dębniki	S	N	P	A	X	X	X										X		
14	Tyniec	Dębniki	S	A	P	U	X	X				X	X	X			X	X			
15	Winnica 1	Dębniki	S	N	P	U	X	X	X		X							X	X	X	
16	Skotniki 1	Dębniki	S	A	P	U	X	X	X	X		X	X	X		X		X	X		X
17	Skotniki 2	Dębniki	S	A	P	U	X	X	X	X		X	X	X		X		X	X		X
18	Skotniki 3	Dębniki	S	A	P	U	X	X	X	X		X		X		X		X	X		
19	Krakow Bypass	Dębniki	S	N	P	F	X	X										X			
20	Skały Twardowskiego 2	Dębniki	S	N	P	F/A	X		X	X	X		X	X				X			X
21	Skały Twardowskiego 3	Dębniki	S	N	P	U	X		X	X	X			X					X	X	
22	Skały Twardowskiego 4	Dębniki	S	N	P	U	X		X	X	X			X			X	X		X	
23	Kobierzyńska	Dębniki	S	N	P	U			X				X					X	X		
24	Sidzina 2	Dębniki	S	A	P	U	X	X	X	X		X						X	X		
25	Sidzina 1	Dębniki	S	A	P	U	X	X	X	X		X						X	X		
26	**Wilga 1**	**Dębniki**	**M**	**N**	**P**	**F/A**	**X**	**X**	**X**	**X**	**X**			**X**			**X**	**X**			
27	Wilga 2	Dębniki	S	N	P	F/A	X	X	X	X	X			X			X	X			
28	Wilga 3	Dębniki	S	N	P	F/A	X	X	X	X	X			X			X	X		X	X
29	Winnica 2	Dębniki	S	N	P	F	X	X	X		X			X				X	X		

Size: S – very small, M – Medium.
Origin: N – natural, A – artificial (anthropogenic).
State of preservation: P – permanent, T – temporary.
Type of the object: U – urbanized area, F – forest, A – agricultural land (fields), F/A – forest-field.
Objects of the highest environmental values were put in bolds.