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RAINWATER RESERVOIRS IN THE URBAN LANDSCAPE – CASE STUDY

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ABSTRACT
Anthropopressure is considered as one of the most important causes of disorder of natural water relations in the environment and impoverishment of the landscape. This is particularly evident in urban areas, where the degree of built-up areas and participation of impervious surfaces are still increasing. The result of such processes are extreme phenomena – more frequent droughts and floods. One way to keep a good state of water resources in urban catchments is creating retention and infiltration of rainwater. The paper presents examples of sustainable rainwater management that determine change of the face of the city and increase its friendliness towards the environment.

Keywords: rainwater, retention reservoir, urban landscape.

INTRODUCTION

Protection and management of water resources should become one of the main goals of strategic planning in urban areas in the near future. This is due to deepening water deficit and growing water needs, parallel to increasing amounts of rainwater (impervious surfaces) which must be periodically collected and safely discharged into the receiver. In the country the need to develop and implement different methods of collecting and using rainwater for natural and economic purposes (in place of precipitation) is emphasised increasingly. Such activities should effectively reduce the risk of hydraulic overload of sewage systems and reduce the amount of water outflows to the rivers - thereby reduce the risk of flood. Additionally, the biologically active surfaces or objects of surface retention could serve aesthetic and recreational functions. This contributes to the improvement of local microclimate, enriches the urban landscape and improves the quality of retained rainwater (self-cleaning processes).

The paper analyses the problem of water resources modification and rainwater management in urban areas in the context of sustainable development, and also presents concrete solutions in this field, which are recently functioning in the urban landscape of the Lublin agglomeration.

URBAN LANDSCAPE AND THE CONCEPT OF SUSTAINABLE DEVELOPMENT

Urban landscape is formed from biotic and abiotic components of urban space - often significantly transformed and shaping by man. Among the same components numerous relationships and dynamic interactions are also observed (including related energy flow and circulation of matter). Man, as the dominant entity, contributes directly or indirectly to the changes in the landscape, which is important for living conditions and climate of built-up areas [Kozłowska 2008]. Influences of human stem from the need of environmental management (use of natural resources and values), which is the fundamental process of activity, enabling survival and development in the biological and social sense. Unfortunately, during the "industrial revolution" and "technocratic" decades after World War II, anthropopressure in ecosystems and landscapes was so strong that it caused hardly reversible adverse effects (environmental crisis). It manifests itself, among others, in degradation of water resources in urban areas, and consequently reduction of biodiversity (impoverishment of vegetation cover). With the advent of "ecological era" desire to increase the production and development at the expense of the nature was replaced by the idea of sustainable development.

The idea relates to such a way of running business, shaping and exploiting the potential of the environment and organization of social life that provide dynamic development of qualitatively new production processes, sustainability of natural resource use and improving and preserving the high quality of life [Poskrobko 2007]. Among the priorities of the concept of sustainable development can be distinguished by rational exploitation of water resources, including the promotion and implementation of water saving and creating national and regional water programs (problems of use, protection and development of resources). In urban areas one should pay special attention to the issue of water retention, which conditions the diversity of biological elements, preservation of natural values and shaping the ecological balance [Mioduszewski 2003].

ISSUE OF WATER RESOURCES IN URBAN AREAS

In urban areas abnormal water cycle and deepening water deficit are observed more and more frequently. This results mainly from human activity, including a way of land management. The effects of anthropogenic pressure relate to virtually all phases of the hydrological cycle, while damage concerns both the urban ecosystem and the man who is functioning in it (including reduced quality of life). One of the biggest problems of modern cities is excessive runoff of rainwater. Reasons should be sought in the significant participation of impervious surface and high degree of the built-up. In some areas, the possibility of infiltration are close to zero. As a result, a large part of precipitation does not take part in the reconstruction of underground water resources (lowering the groundwater level), is not also retained and can not be used by vegetation [Sawicka-Siarkiewicz, Błaszczyk 2007].

According to Geiger and Dreiseitl [1999], in the case of a large slope of impervious surface, nearly 100% of rainwater maybe outflow directly into the receiver (including hydraulic overload of sewage systems and local flooding). Rapid surface runoff into the valleys can lead further to increase risk of flood. The presented information points to the need of rational management of rainwater in urban areas. Good results can bring an increase of retention in the system basin and the existing sewage system. It is recommended, among others, to prefer the infiltration of as much as possible amount of rainwater straight into the ground, as a fundamental process which improves water conditions in urban areas (i.e. permeable paving of sidewalks and parking lots, ditches and soakaway basin). Rainwater reservoirs provide large capacity to collect and slow infiltration. However, they should not be too large due to the limitation of available space in the city. They are situated usually in remote areas, parks and residential areas. They may fulfill the functions of aesthetic and recreational facilities. Tanks planted with water-loving plants enrich the urban landscape and help to improve the quality of retained rainwater. The important procedure for improving water conditions in urban areas is increasing the share of biologically active surfaces (bioretention). In this solution, rainwater is used by plants in their life processes and then introduced into the atmosphere through transpiration. Biologically active surfaces can be parks, squares, basins with vegetation cover, or increasingly popular green roofs (these surfaces serve aesthetic and landscape functions, reviving dead built-up spaces) [Geiger, Dreiseitl 1999; Kozłowska 2008; Słyś 2008].

EXAMPLES OF RAINWATER MANAGEMENT SYSTEMS IN THE LUBLIN AGGLOMERATION

The objects presented in this paper are located in the vicinity of the city boundaries - in areas characterised by varying degrees and types of investment and varied loessic relief. There are visible numerous, dry erosion valleys and slopes with falls facilitating gravity transport of rainwaters to the receivers. Described issues are becoming increasingly important, because the Lublin agglomeration is extremely poor in water resources. The water cycle is characterised by the impact of a cone of depression, resulting from intensive groundwater exploitation. As a consequence, surface waters infiltrate into underground layers in the catchments of smaller rivers [Michalczyk et al., 1997], which may result in decreasing in the share of the open water – changes in ecosystems and the impoverishment of the landscape.

Infiltration tank for rainwaters runoff from the part of the national road

Modernisation of a part of the national road No. 19, which changes in Lublin into Spoldzielczosci Pracy Avenues, was associated with, among other things, the construction of the rain drainage channel and the soakaway tank, whose task is adoption and retention of rainwaters. The reservoir is located in the bottom of the ravine approximately 30 meters away from the two-lane road. In the immediate vicinity there are also local roads, fields and wastelands (Figure 1). The reservoir is the recessed earthen construction (partial excavation) of the lagoon area of 0.34 hectares and the capacity of 9860 m^3. From the north it is limited by high sodded dike made of local earth. The object was designed taking into account the maximum flow rate – 1.5 $m^3 \cdot s^{-1}$ and a disposable rainwater volume of 1800 m^3. If necessary, rainwater may be partly discharged from the tank through the concrete monk to the drainage channel, which is also a ring ditch of the object (Figure 1).

Sealed settler and infiltration tank for rainwater runoff from the area of the agri-horticultural market-place and petrol station

Agri-horticultural market-place (Lubelski Wholesale Market S.A.) and the adjacent petrol station are located on a plateau and cover an area of 23.45 hectares, of which the impervious surface constitutes nearly 20 hectares. The area is fitted out with a separable sewage system – rainwater is discharged through traditional network of open gutters and underground cannals. Rainwater tanks are located in the bottom of the valley, which limits the drained area from the south (Figure 2). These objects are typical for earthen structures, the first serves as a sealed settler (bentonite insulation) and the second as an infiltration reservoir. Tanks are designed for reliable rain about the probabilities of p = 50%, the maximum flow rate – 2.07 $m^3 \cdot s^{-1}$ and a disposable rainwater volume of 2839 m^3 (settler: F = 0.43 ha, V = 3900 m^3; infiltration tank: F = 0.60 ha, V = 5600 m^3). In the settler pre-treatment of rain runoff occurs (mainly sedimentation), and in the infiltration reservoir its introduction into the ground. The flow of liquid between tanks is done through a reinforced overflow in the dike crown. The embankments of reservoirs are made of local earth and sodded. In case of overflow, behind the infiltration tank additional soakaway surface (rigol) was separated for security (Figure 2). As a result, the total area of evaporation expanded to 1.27 hectares, and the volume of water retention in the area of infiltration has increased to 9200 m^3. The fact of creating a kind of closed water circulation within the described investment is particularly noteworthy. Installation of submerged pumps at the end parts of the tanks enables to recycle clarified water onto the market-place and re-use it to wash impervious surfaces. This solution allows for large savings of tap water in short supply in this respect the Lublin area.

Sealed tank for rainwater runoff from the housing estate area

The Szerokie housing estate (with Luzyczan Street) is situated on the slopes of southern exposure. The drained area has the total area of

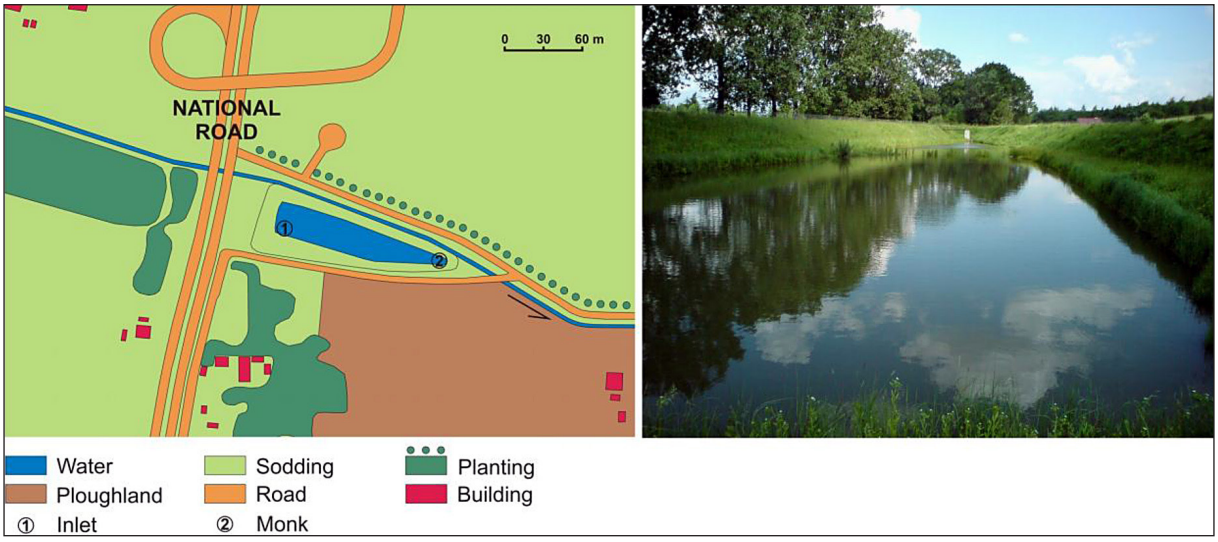

Figure 1. Location and general view of retention reservoir for rainwater from the road

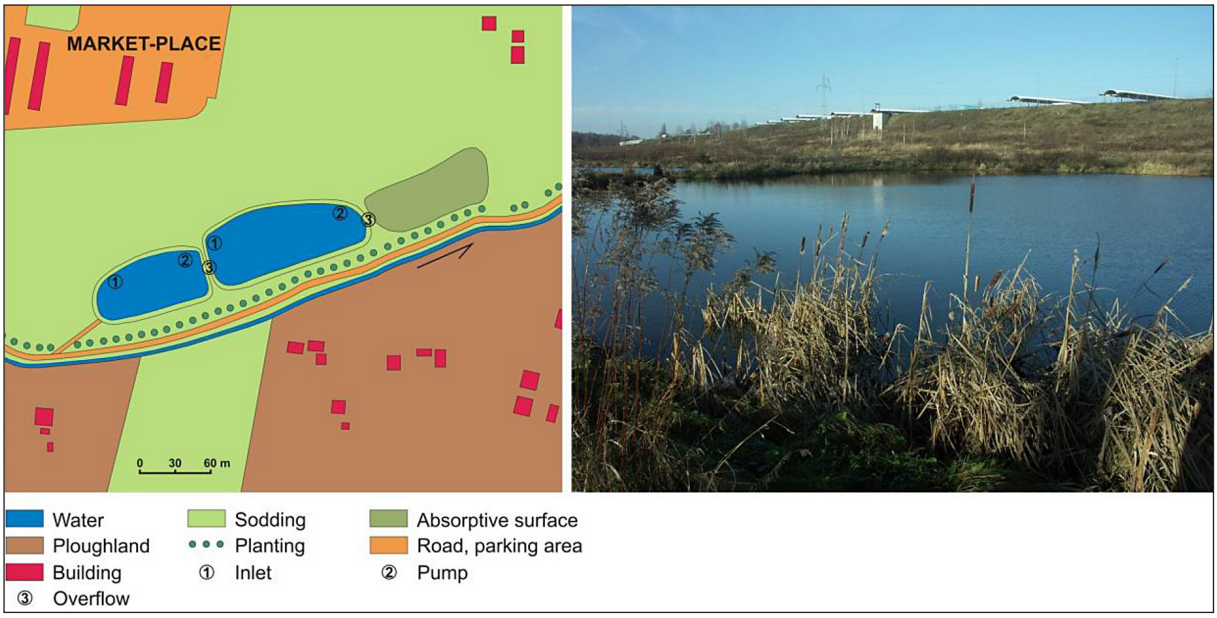

Figure 2. System of reservoirs for rainwater from the market-place and petrol station

14.57 hectares and because of construction of the reservoir it was also equipped with a rainwater drainage network. Rainwater reservoir is recessed (digged) earthen object located in the bottom of the valley (Figure 3). In its immediate vicinity (on a steep slope on the southern side) there are also allotment gardens. The tank is designed for reliable rain p = 20%, the maximum flow rate – 1.24 $m^3 \cdot s^{-1}$ and a disposable runoff volume of 1608 m^3. The lagoon area of the tank is 0.23 ha and active capacity of 2013 m^3 (incorporates large reserve for sediments). With concerns about the stability of silty ground, and the presence of residential buildings it was decided to seal the tank bowl with concrete, which completely eliminates the infiltration process (it is noteworthy that the objects described earlier, despite similar geotechnical conditions, there was no risk of negative impacts of water on the ground). The ability of safe storage of all runoffs from the housing estate excluded the need to introduce additional significant changes in the landscape, even the construction of embankments. After temporary water retention in the tank water is drained to periodical stream from Konopnica, which supplies the Czechowka river (Figure 3). The outflow is possible through the use of a steel monk and a frontal emergency spillway.

CONCLUSIONS

The presented examples of rainwater management show that the city can change its image and become more environmentally friendly as well. These solutions enable to achieve nature aims (improvement of living conditions for plants and animals, stabilisation of water relations, mitigation of microclimate), economic (no need of construction

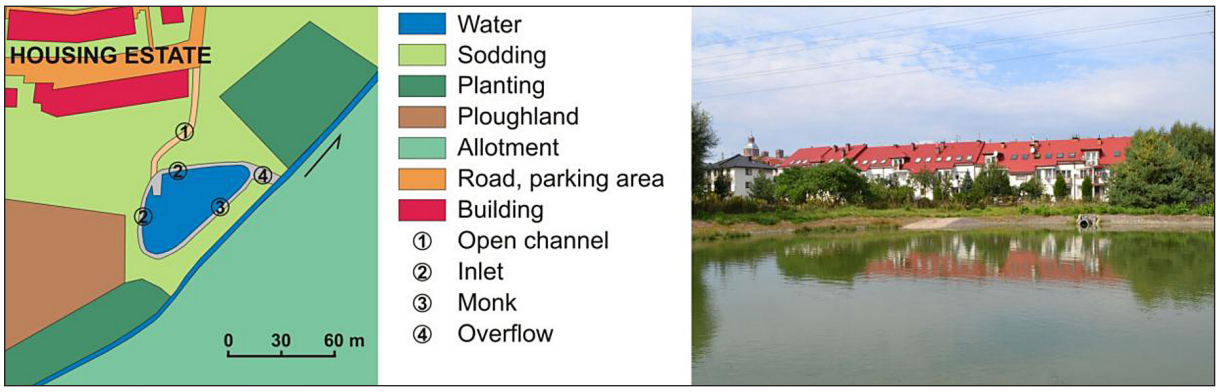

Figure 3. Location of sealed rainwater reservoir in the housing estate

of stormwater drainage, lower costs of nurturing greens and wash of impervious surfaces) and related to flood protection (reduction of stormwater discharges to rivers and leveling outflow).

The structure of the Lublin city is relatively diversified, and therefore, in different parts slightly different rainwater management systems were used. Projects took into account, among other things, the size of the drained area (volume of expected runoff), the degree of accumulation of impurities (intensity and use of the land), type of adjacent infrastructure, etc. Rainwater reservoirs in most cases are preceded by pre-treatment devices (settlers and separators). However, due to the presence of the water-loving vegetation, prolonged time of retention and infiltration, they can themselves contribute to improve the quality of water resources in the urban area (self-cleaning in the aquatic environment). Tanks fulfill not only the function of stormwater retention, but also landscape shaping – in their area biodiversity should usually rise. Creating the image of the city based on the concept of sustainable development in the long term will certainly be combined with the improvement of life quality for its residents.

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