Duration of vegetation disturbance in urban hydrogenic ecosystems due to drainage

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Abstract: Duration of vegetation disturbance in urban hydrogenic ecosystems due to drainage.

Urbanization is a factor strongly affecting the landscape and natural ecosystems existing within the city. The purpose of this study was to assess habitat and vegetation changes in an alder wetland in the Natural Landscape Complex “Olszyna” in Warsaw. Semi-natural ecosystems existing within the city limits have a unique value. They create biodiversity hotspots, play an important social and educational role and intersperse monotonous urban landscape. That is why preserving the relics of natural habitats is essential for sustainable management of urban areas. The Natural Landscape Complex “Olszyna” exists in hydrogenic site of important ecological value. Habitat and vegetation were studied in the years 2006–2008 and the study included selected soil and surface water characteristics and vegetation changes. Obtained results were compared with previous investigations that had been carried out since the 1970’s. Hygrophilous vegetation in the area, after drainage that followed the construction of the Toruńska Artery, has gradually been changing into mesopholic one. Despite the existing system of ditches built to keep the water level high, the maintenance of properly functioning riparian ecosystem seems improbable. A lack of spring floods results in negative changes of vegetation. The layer of shrubs has strongly developed and the number of plant species has increased, unfortunately these are mainly ruderal species.

Key words: Natural Landscape Complex “Olszyna”, vegetation change, eutrophication.

INTRODUCTION

Natural hydrogenic ecosystems in towns are rare and, even in protected areas, are being disturbed because of the neighbourhood of industrial companies, housing estates and traffic routes. The effect of urban-industrial surrounding on the type and rate of such disturbances is poorly understood mainly because of only a few objects studied (Symonides, Solińska-Górnicka, 1990). Transformation of vegetation is best visible in hydrogenic soils whose physical properties are affected by the regulation of water relations. Surface runoff from paved surfaces of urban areas delivers less water of heavily altered quality (Paul, Meyer, 2001) which results in changes of soil moisture. Apart from mechanical transformation and creation of anthropogenic overlayers, urban soils undergo alkalinization and accumulate calcium carbonate, heavy metals and trace elements (Czerwiński, Pracz, 1990). Proceeding drainage caused by both natural factors and human impact leads to the transformation of plant communities (Kloss, 2001). Substitute communities are being formed as a result of intensive drainage. Groffman et al. (2003) are of the opinion that man affects hydrologic...
regime mostly by the regulation of rivers and channels. Reinforcement of banks with concrete, built-up of rivers, their canalization and the development of rain collectors directs the water from impermeable surfaces straight to channels. Water flows out much faster and more frequently than under natural infiltration of rainfalls. Surface waters permeating to the ground are important for the quality of ground waters (Trowsdale, Lerner, 2007) but the degradation of water resources proceeds in towns with long time delay.

Habitats of the Natural Landscape Complex “Olszyna” in Warsaw are a valuable testing ground to study the changes in hydrogenic sites. Ground water table has decreased in this area since building the Toruńska Artery in the neighbourhood, but natural riparian ecosystems have been preserved thanks to the system of channels and water reservoirs. Chemical parameters of the soil have not changed with the exception of a slight increase of potassium content (Sikorska, 2008).

This study was undertaken to assess the duration of disturbances in wood and grassland vegetation caused 34 years ago in the complex Olszyna by the construction of the Toruńska Artery and associated increase of the ground water outflow. The assessment was based on indices of synanthropisation and diversity and on directions of changes tested with the detrended canonical analysis (DCA).

STUDY AREA
The Natural Landscape Complex “Olszyna” is the only area with preserved habitats of the former valley of the Rudawka River. It is located in the north-western part of Warsaw, in Wola. It consists of 2.23 ha and is mostly covered by alder woodland Fraxino-Alnetum. This area is situated at the edge of the former famous Izabela Czartoryska’s garden and was a part of former hunting grounds (Kwiatkowski, 1969). Alder-ash riparian communities locally dried out into low

FIGURE 1. Map of the depths of ground water table in the Natural Landscape Complex “Olszyna”: 1 – > 2 m, 2 – 1.5–2 m, 3 – 1–1.5 m, 4 – 0.5–1 m, 5 – 0–0.5 m, 6 – underground pipelines, 7 – water table (Pajnowska et al., 1996, modified)
dry ground forests have been preserved there. Most valuable parts of the area are now protected as the Natural Landscape Complex “Olszyyna”. Development of road infrastructure resulted in the decline of ground water table and in limited infiltration of rainfall waters that had fed this wetland before. In the 1970’s some actions were undertaken to protect “Olszyyna” through the regulation of reservoirs and open ditches. “Olszyyna” suffered most severe losses during the construction of the Toruń Artery in its closest neighbourhood. Despite protective measures, marked changes in plant communities took place there. Nevertheless, the Natural Landscape Complex “Olszyyna” is still a unique natural biologically valuable habitat in Warsaw (Pajnowska et al., 1996, 1997; Sikorska, 2008).

Such shallow ground water depth is rare in Warsaw. In prevailing area the water table is free and situated under peat layer (Pajnowska et al., 1996).

METHODS

Changes in synanthropization and plant diversity were assessed using phytodication methods in 39 test plots. The share of anthropophytes and apophytes in a sample was used as a synanthropization index (Jackowiak, 1990). Simpson and Shannon indices of floristic diversity (Magurran, 2004) were calculated with the PAST programme (Hammer et al., 2005). Moreover, the indices describing the contribution of species from particular phytosociological classes were calculated acc. to Matuszkiewicz (2008). Listed species belonged to the classes: Phragmitetea, Stellarietea, Querco-Fagetea, Artemisietea and Molinio-Arrhenatheretea which were most numerous in 39 samples analysed in various periods and originated from both forest and non-forest habitats. Qualitative changes of indices from various study periods were compared with the analysis of variance and Tukey test at p < 0.05 using the STATISTICA software.

Phytosociological data from woods of the “Olszyyna” Complex in the years 1973, 1996 and 2007 were analysed with analysis of variances. Trends in vegetation changes between 1973 and 2007 were determined using data from 1973, 1996 and 2007 based on a diagramme of Detrended Canonical Analysis which is one of the best methods of arrangement of plant samples (Piernik, 2008). Non-transformed data were analysed with the CANOCO 4.5 software (ter Braak, Smilauer, 2002) using the parameter of decreased weighs for rare species.

RESULTS

Phytosociological data from woods of the “Olszyyna” Complex in the years 1973, 1996 and 2007 analysed with ANOVA revealed statistically significant differences in the mean number of species in a relevé which increased more than two times since 1973 (Fig. 2). Significant change of the index of synanthropization was noted for woods; the index of anthropization did not show significant differences at p < 0.05. Species diversity measured with the Simpson and Shannon indices significantly increased after 1973. Significant changes were noted in the share of species in particular phytosociological classes. The share of rush plants of the class Phragmitetea significantly
decreased. Forest species of the class *Querco-Fagetea*, ruderal species of the class *Artemisietea* and meadow plants of the class *Molinio-Arrhenatheretea* increased their share. Changes in the class *Stellarietea* appeared insignificant.

The number of species in grasslands increased (Fig. 5) as it did in woods. No differences were found in both diversity indices and in the share of species from particular phytosociological classes.

Changes in woods between 1973 and 1996 were more dynamic than those between 1996 and 2007 (Fig. 6). The difference reflected habitat changes after drainage caused by building the Toruńska Artery in the first period and stabilization of vegetation in the second. Hence, single drainage event had long lasting consequences operating still 12 years later. Changes in grasslands that followed earth works resulted in homogenization of species composition in the years 1973–1996. Later, in the years 1996–2007 the dynamics of changes was much slower (Fig. 6).

Typical for the alder-ash riparian forest in the Natural Landscape Complex “Olszyna” is permanently high moisture of upper soil layers associated with several weeks’ long floods every year (Matuszkiewicz, 2001). Drainage leads to degradation of such habitats and is one of the most frequent reasons for disappearance of riparian vegetation (Pawlaczyk, 2004).

The number of species in the communities *Fraxino-Alnetum* increased two times (8 more taxa) during the study period. It was mainly the result of increased number of synanthropic species from the class *Artemisietea*. Only few synanthropic apophytes and a total lack of anthropophytes from this class were noted in 1973. Constant increase of the number of anthropophytes is an evidence of long lasting effect of disturbance caused by draining. In natural, non-disturbed riparian communities the number of species during one generation of the tree stand is stable (Czerepko, 2008). The number of forest species of
FIGURE 3. Mean indices of: A – synanthropization \((p = 0.006)\), B – diversity by Shannon \((p = 0.000)\),
C – diversity by Simpson \((p = 0.001)\) for woods in the years 1973–2007.
FIGURE 4. Mean values of the share of species from particular phytosociological classes in woods. A – species of the class Phragmitetea (p = 0.000), B – species of the class Querco-Fagetea (p = 0.000), C – species of the class Artemisietea (p = 0.000), D – species of the class Mollinio-Arrhenetheretea (p = 0.000)

FIGURE 5. Mean number of species in grasslands in the years 1973, 1996 and 2007 (p = 0.030)
the class *Querco-Fagetea* was observed to increase in the “Olszyna” Complex which Czerwiński (1999) explained by gradual habitat drying, decreased water table and peat mineralization. The same process is being observed in natural conditions but it proceeds slower there and is not associated with plant disturbance but rather with slow exchange of plant species. The community *Alnus-Urtica* might be formed as a consequence of declining ground water table and mineralization of upper peat layers. Tree stand with the black alder and more or less species of the class *Alnetea glutinosae* and *Phragmitetea* are present in this community (Czerwiński, 1999). The latter species are, acc. to Czerwiński (1999), replaced by species of broadleaved forests and wet meadows. Enhanced water outflow in the “Olszyna” Complex was followed by a rapid decline in the number of rush species of the class *Phragmitetea* and meadow species of the class *Molinio-Arrhenatheretea*. The latter effect is undoubtedly associated with limited light penetration to the forest bottom. Shading by dense canopy of old trees is
enhanced by the well developed undergrowth layer composed of *Sambucus nigra*. Tree stand condition is still considered good but natural recruitment of the black alder is not observed. Changes in grassland vegetation are associated with habitat stabilization in the 1990’s. Observed effect of these changes is the increase in the number of species.

- Existing network of ditches with weirs sufficiently compensates for the draining effect of infrastructure associated with residential and traffic buildings. It does not, however, provide spring floods which are necessary for appropriate functioning of this type of ecosystems.
- Phytosociological analysis demonstrated the impoverishment of communities in rush species and simultaneous increase in the number of forest and meadow, mainly synanthropic, species.
- Due to high natural, recreational, landscape and educational values of the object, further actions should be carried out to preserve alder-ash riparian ecosystem. They should focus on maintaining ground water level at a mean depth of 0.5 to 1 m and on the necessity of spring floods.

CONCLUSIONS

1. Natural hydrogenic ecosystems in urban areas are suffering from constant long-term changes of strength and direction hard to predict, especially when the water regime was changed. Results of these changes can usually be assessed after tens of years.

2. Regulations of the water outflow and as a result temporal drainage contribute to changing of the hydroenic vegetation into more mesophilic one.

3. Rapid changes in habitat are also associated with ruderal species emerging. Slight dispersion of plant species typical for natural mesophilic habitats into isolated areas in cities creates as a result plant communities of low biodiversity.

4. Facilities within cities given to people, such as „Olszyna” Complex, are subjected to additional threats of damaging the vegetation that is being adapted to new conditions. Temporarily drier objects are becoming more accessible at not sufficient communication infrastructure.

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REFERENCES


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