THE POTENTIAL ROLE OF URBAN GREEN INFRASTRUCTURE IN SUSTAINABLE MUNICIPAL WATER SUPPLY MANAGEMENT IN A HUNGARIAN TOWN

Gabriella Hancz, János Bíró

GISPARK Partnership, 13 Baross Street, Debrecen, Hungary

Abstract

Measures of deep ground water conservation involve the protection of their quality and quantity. However, development of water resources is also feasible by means of green infrastructure. So far quality protection zones in Debrecen are marked out and designated for limiting certain polluting activities. The quantity aspect of conservation is confined to water exploitation activities which impair the operation of the wells owned by the water works. The aim of this paper is to expose the high potential of using GI elements in water resource development in areas already designated to quality protection. Our study also touches on the usefulness of GIS as a method in finding the primary places for GI with intention of water resources development.

Keywords: *urban rainwater management; green infrastructure; sustainable water resources development*

1. INTRODUCTION

The greatest part of deep groundwater in Hungary – as it is the case in Debrecen as well - is suitable for drinking water supply. The drinking water supply in Debrecen, Hungary is mainly based on deep ground water resources. These resources are plentiful and are of good quality but their conservation is inevitable. Shallow aquifers and also deep ones with good recharge and of high permeability are sensitive against pollutions from the surface: in the areas of natural infiltration and recharge of the aquifers the contamination can move downwards with rainwater.

Hungarian legislation in harmony with the EU directives is appropriate for the protection of groundwater. On the other hand engineering measures appropriate not only for the protection but for the development of groundwater resources are nearly totally unexploited.

1.1. European and Hungarian legal aspect

A groundwater body is in good quantitative status, if the long-term - min. 10 years - annual abstraction rate does not exceed the available groundwater resource; and the abstraction does not cause sustained decrease in groundwater level or groundwater pressure level in any part of the water body.

The objective of the Water Framework Directive is to establish a framework for the protection of waters, among them for the protection of groundwater, which among others promotes sustainable water use based on a long-term protection of available water resources. This means that water resources are to be protected not only in terms of quality but in terms of quantity as well. The main issue is to maintain the balance of withdrawal and recharge. In terms of quantity groundwater is in good status if water level changes of anthropogenic origin do not cause alterations in surface waters influencing terrestrial ecosystems and when they do not cause changes in the flow direction thus leading to the deterioration of water quality.

Special rules concerning drinking water resources and those serving the utilisation of mineral and medicinal waters are defined by the Government Decree No. 123/1997. (VII. 18.).

In the first phase of diagnosis water resources had been designated sensitive or non-sensitive based on proper investigations. The sensitive ones had been designated vulnerable or non-vulnerable depending on the existence of polluting activities on their recharge areas.

In the second phase of protection, in order to achieve and/or preserve the good quantitative and qualitative status protection blocks and areas are designated in the various zones of which the activities endangering the quality of groundwater are to be limited to various extent.

1.2. Main tasks regarding groundwater quantity

The quantity objective for groundwater comprises the following tasks of outstanding importance:

– hampering the decrease of groundwater level (pressure head), ensuring and promoting its regeneration, the recovery of the water household in the endangered regions, – developing the equilibrium of abstraction and recharge so that the level of near-surface water does not fall below the long term quasi-natural average due to anthropogenic activity, except in the immediate vicinity of the abstractions.

2. MATERIAL AND METHOD

2.1. Material: used data and software

- official up to date map of Debrecen, inner city
- the topographic map of Debrecen, inner city
- digitalized form of the designated water resource protection areas
- open access Open Jump software

2.2. Engineering measures, based on the literature

Beside demand control and other non-engineering management tools well-known engineering measures must be considered in order to enhance the performance of the above mentioned tasks. These are the following, without hierarchy:

- Best practices in urban storm water management or green infrastructure also known as Low Impact Development and Sustainable Drainage Systems in urban areas where sealing the surface along with the drainage of precipitation is a widespread development practice which - from our point of view - prevents rainwater from infiltration into the ground and groundwater [MacAdam, J. et al. 2010.; EEA Report on Urban adaptation to climate change in Europe; Guo, J.C.Y. et al. 2006.]. Even the topic of urban gardening is touched upon when dealing with GI.
- Artificial recharge into shallow groundwater for purpose of drinking water supply [*Recharge systems for protecting and enhancing groundwater resources*, 2005.]
- Re-injection of thermal water used for energetic purposes or oil production does not pose a risk on groundwater quality under the present conditions taking into consideration the strict legal regulations.

2.3. Facts about the Debrecen water recharge and protection areas, based on official data

The regional Directorate of Water Management has provided us with the protection zones of the sensitive deep ground water sources of Debrecen.

The depth of the 36 wells ranges between 86 and 133 meters below surface. The number of people served with drinking water from this resource is 214 287.

Shallow groundwater levels in Debrecen ranges between 3 and 5 meters below surface level. Consequently it means no disadvantage when considering the technical aspects like potential risk on houses having basements due to infiltrating rainwater [database of the Water Directorate].

2.4. Using GIS in determining the area of potential water resource development

The digital form of two designated protection areas belonging to the 36 wells has been provided for us for research purposes. One of them is the area from where rainwater infiltrate from the surface to the wells within 100 years, the other one is that of fifty years.

Using the Open Jump open source software we have defined the area of the two overlapping protection zones. The area of the overlapping protection zone is 34,6 km^2 (Figure 1.). Great proportion, about two third of the urban area of Debrecen forms the designated protection zone.

Using Open Jump we have digitalized all the streets in the overlapping protection zones in order to determine the total length of streets which is 301 km-s (Figure 2.).

In the planning phase more data - which have direct impact on the storm water runoff volume generation - will be needed to be digitalized according to the literature. These are the following, without hierarchy:

- elevation data (Figure 3.)
- proportion of impervious surface
- proportion of disturbed, compacted soils causing reduced pore space – can be taken as impervious
- existing green spaces in private properties as well
- private lot sizes to consider the feasibility of on-site measures
- infiltration capacity to consider need for soil amendments
- runoff coefficient
- design rainfall depths
- shallow groundwater levels below surface-the usefulness of the recommended measures is very limited in case of high levels
- permeably paved areas, etc.

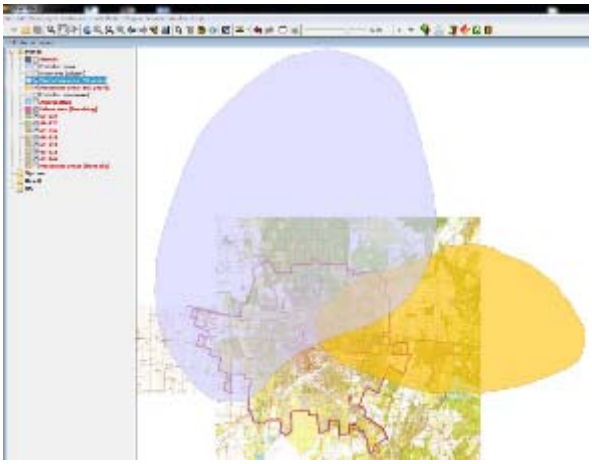


Figure 1. Protection areas from where rainwater may reach the operating wells of Debrecen within 100 (with violet) and 50 years (with orange). The figure shows the great proportion of the urban area of Debrecen forming the designated protection zone

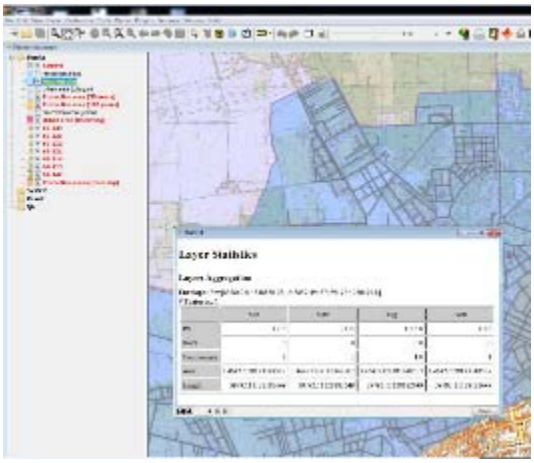


Figure 2. All the streets located in the protection zones were digitalized in order to determine the total length of streets.

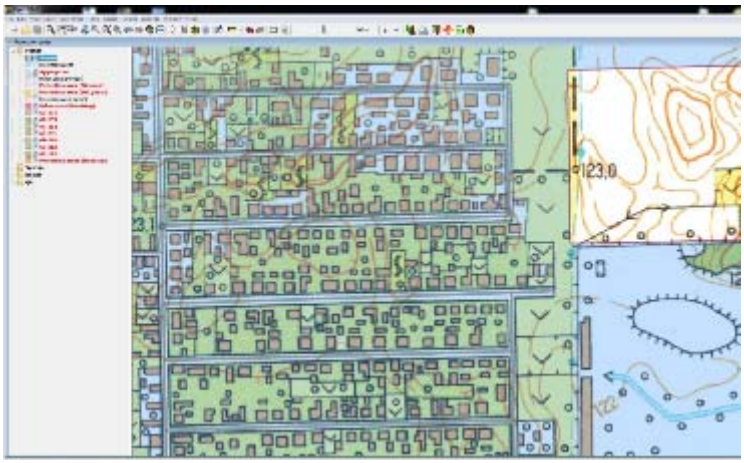


Figure 3. In a later phase of planning GI measures the elevation data derived from the topographic map will be used in lack of further measurements.

2.5. Investigation of applied green infrastructure in Debrecen

We were interested in finding Green infrastructure measures [MacAdam, J. 2010.] applied in those urban areas where rainwater is supposed to recharge the drinking water resource of the population of Debrecen. GI refers to constructed features that use living, natural systems to provide environmental services, such as capturing, cleaning and infiltrating stormwater. In most cases - and even in cases of newly realized developments like walking streets - runoff is found to be drained into combined sewers instead of being disconnected and diverted into rain gardens or bioswales or planter boxes. Along with this practice treated drinking water is being provided through irrigation pipes for the plants in the parks. That is, mainly the shortage of these measures could be detected (Figures 4.-10.). However - besides this tendency - we have found many good examples as well even in older developments of concrete blockhouses as can be seen in Figures 11.-12..

The GI measures we were looking for are the following [MacAdam, J. 2010.], which is not at all the entire list of the existing measures. These are the ones which can be surveyed easily in the street:

- Downspout Disconnection
- Rainwater Harvesting
- Rain Gardens

- Planter Boxes
- Bioswales
- Permeable Pavements
- Green Streets and Alleys
- Green Parking
- Urban Tree Canopy



Figure 4. On the left – a Debrecen street (our own photo): rainwater from the roof is diverted into the sewer system while plants in the green zone get little runoff; right: [Mac Adam, J. 2010.]



Figure 5. On the left – a Debrecen street (our own photo): this parking lot could be covered with permeable elements or runoff could be diverted onto the surface covered with grass. On the right: A bioretention basin captures and filters stormwater from a restaurant parking lot and the street [Mac Adam, J. 2010.]



Figure 6. On the left – a Debrecen street (our own photo): a planter box without letting any runoff water to the plants. Furthermore, a waterproof plastic layer is placed below the mulch which would be a good technic to enhance infiltration. On the right: a curb cut captures storm- water from the street to feed vegetation [Mac Adam, J. 2010.]



Figure 7. On the left – a Debrecen street (our own photo): rainwater from the rooftop is disconnected – not discharged along with sewage, but then it is diverted onto the impervious road reaching the combined sewer anyway. On the right: stormwater-fed vegetation and slopes lined with rock to reduce erosion [Mac Adam, J. 2010.]



Figure 8. A Debrecen street (our own photo): rainwater from the rooftop is connected onto the combined sewer; instead, bioswales and permeable paving could be applied (own photo).



Figure 9. A Debrecen street (our own photo): trees need water and soil; runoff from the sidewalk and roofs is diverted onto the road and into the sewer. Trees obtain very little water while the sewers are overloaded.



Figure 10. A walking street in Debrecen (our own photo): runoff from the pavement is diverted away from the plants-they are irrigated with drinking water from pipes instead. These plants should be

placed in a rain garden instead of these separated boxes. New developments like this should include bioinfiltration, subsurface detention/infiltration, or other source controls.



Figure 11. An own picture taken in a Debrecen residential with concrete block-of flats: runoff water is captured and diverted onto a parked area where it can infiltrate later on. Aside from the garbage which can as well cause pollution, the conception approaches GI measures.



Figure 12. On the left - An own picture taken in a Debrecen street. Although not a proper solution, it is still a good one compared to the above shown cases as it stops the water from reaching the sewer system also applying grass and trees in this green infiltration area. However, a designed raingarden - on the right - is developed in a way that runoff by design flow into a small depression, giving the storm water more time to infiltrate and causing no puddles as can be seen in the picture http://thinkgwi.com/wp-content/uploads/2012/08/DSCN4268.jpg



Figure 13. An own picture taken in a Debrecen private property. The car drive is covered with permeable solid blocks letting rainwater infiltrate and providing passive irrigation for the plants in the garden.

SUMMARY AND CONCLUSIONS

This initial analysis shows that there are significant opportunities to incorporate green infrastructure in great areas. In spite of the many benefits of green infrastructure the practice is not yet widespread in the Hungarian rain water management as it can be detected on the example of Debrecen. It is highly recommended that the GI measures should be applied in urban areas, mainly in the protection zones of the groundwater sources which are at the same time the recharge areas of these resources. In this way this would not only serve to reduce hydraulic loads of the combined sewer system but as a most effective way of increasing water resources.

However, we learned from the literature that much more data is needed to be considered in the phase of planning. Onsite measurements and several ways of GIS applications will have to take place to result sustainable water management solutions. This study can be a first step.

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