The stormwater management information system - A GIS portal for the close-to-nature management of stormwater in the Emscher region

Le système d'information et de gestion des eaux pluviales – un outil SIG pour une gestion des eaux pluviales au plus près de la nature dans la région de l'Emscher

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RESUME

L'Emschergenossenschaft (Coopérative de l'Emscher), les communes de la région de l'Emscher et le ministère de l'environnement du land de la Rhénanie du Nord-Westphalie ont signé en octobre 2005 un contrat sur la gestion des eaux pluviales nommé „Zukunftsvereinbarung Regenwasser – contrat pour la gestion future des eaux pluviales". Le but du contrat réside dans la déconnexion de 15% du réseau d'eau pluviale en 15 ans dans le bassin versant de l'Emscher. Dans le cadre de ce contrat de gestion future des eaux pluviales, l'Emschergenossenschaft a développé un système d'information géographique et de gestion des eaux pluviales. Il s'agit d'un outil SIG qui aide les membres de la coopérative de l'Emscher à atteindre leur objectif. Il permet d'identifier des mesures de débranchement possibles et d'effectuer une première évaluation des variantes. Le présent article présente un exemple d'une telle estimation primaire et le compare avec les constructions réalisées sur place.

ABSTRACT

In October, 2005 the Emschergenossenschaft, the local authorities in the Emscher region and the Environmental Ministry of the Federal Land of North Rhine-Westphalia signed the "Agreement for the Future Management of Stormwater". The target of this agreement is that within the next 15 years 15 % of the stormwater arising will be decoupled from the sewer system. Within the framework of this agreement for the future the Emschergenossenschaft has developed the Stormwater Management Information System. This is a GIS portal which supports the members of the Emschergenossenschaft in building up their close-to-nature stormwater management systems. It serves to enable decoupling measures that are feasible to be identified and subjected to an initial evaluation. In this paper the mode of producing such an initial evaluation is sketched out using a concrete example and the initial evaluation is then compared with the result of the measures as subsequently realized.

KEYWORDS

GIS, spatial data infrastructure , stormwater management, urban drainage.

1 INTRODUCTION

The Emschergenossenschaft is the oldest of the 11 water resource management associations in North Rhine-Westphalia. It was founded in 1899 to find answers to the severe problems that had arisen through industrialization processes in the Emscher catchment area (Fig. 1). Thus the mining of hard coal brought about subsidence and this in turn removed the free flow of water to numerous bodies of water. At the same time the rapid increase in the quantities of wastewater led to hygienic problems as severe as epidemics. The mining subsidence prevented underground wastewater sewers being built since these would have been fractured over and over again. The sole economic solution for coping with the wastewater at that time was to develop the water courses into an open wastewater sewer system.

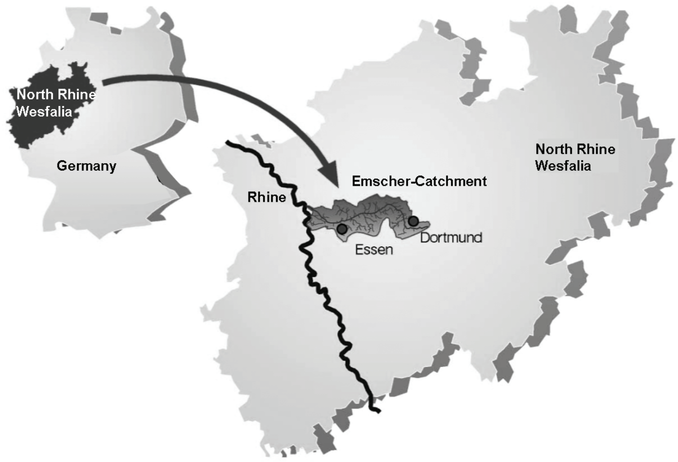

Fig. 1: Location of the Emscher catchment area

With the dying away of the mining subsidence it became possible to change this situation. At the beginning of the nineteen nineties it was resolved that this open wastewater sewer should be converted back into a close-to-nature river system. The conversion of the Emscher system, for which a total sum of 4.4 billion euros to be expended over a period of 30 years has been budgeted, offers a variety of opportunities which - under the slogan "masterplan emscher:future" - are being developed in co-operation with all the participating parties (Semrau et al. 2005). One opportunity lies in the fact that it will be possible to deal with the theme of stormwater in a different way. Thus, instead of passing stormwater into a combined sewer system and of then having to treat it at considerable expense, managing the stormwater in a close-to-nature manner suggests itself, e.g. by allowing it to seep into the ground or by collecting it and leading it into a water course. The advantages of doing this are manifold and range from balancing out flows of water via cost savings in the construction of sewers to opportunities in the area of urban planning (Becker, Raasch 2003).

In order to permit these advantages to be realized in a systematic manner, the Emschergenossenschaft, its local authority members and the Environmental Ministry of the Federal Land of North Rhine-Westphalia signed the "Agreement for the Future Management of Stormwater" in October, 2005. The target of this agreement is that within the next 15 years 15 % of the stormwater arising in the Emscher catchment area will be decoupled from the sewer system and managed in a close-to-nature way. Also resolved within this agreement was the development of the "Stormwater Management Information System" (hereafter also SMIS), with the aid of which the decoupling measures that are feasible can be identified and the related measures which are realized documented to permit the level of success to be monitored.

2 THE STORMWATER MANAGEMENT INFORMATION SYSTEM

2.1 Overview

The Emschergenossenschaft offers the local authorities support in many different forms to assist them in their work in reaching the joint decoupling objective. One of these is the stormwater management information system. The target group here are above all those persons in the Emscher Region local authorities who deal with the management of stormwater or who administer large areas (public real estate) which have an effect on run-off.

With the information system questions such as the following can be answered:

- What ways are there of uncoupling stormwater from the combined-water sewer system, i.e. what modes of dealing with the stormwater come into question in a particular area?
- What percentage of the paved areas in a particular area can be uncoupled?
- From what areas does the stormwater, which should be uncoupled from the sewer system, come?
- What percentage of the paved areas have already been uncoupled?

To answer these questions special fundamental data systems were developed and made available to the users via the SMIS (Becker et al. 2006). These include the mode-of-management map, which gives recommendations on the possible ways of managing the stormwater - in each case in accordance with the geogenic factors such as the permeability of the ground, the soil thickness, the depth of the groundwater table or the gradient of the slope. The decoupling potential map shows the potential for decoupling as a percentage in relation to the paved part of the particular area. It gives the percentage of the paved area that can probably be decoupled on the basis of the structural factors of the built-up areas as existing. The decoupling potential is derived from the situation in each particular built-up area, e.g. from the availability of free areas (areas on which there are no buildings), on the structure of the development/buildings as existing and on the proximity to a body of water. Here differentiation is made between short-term and long-term decoupling potential. Short-term means that the potential can be realized with a measure involving only a small amount of constructional work while under long-term potential is to be understood decoupling that can only be achieved with a relatively large amount of constructional work, e.g. within the framework of remediating a building. Here the paved areas (as determined from the interpretation of aerial photos) form the basis for the calculation of area balance sheets whereby account is taken of the short-term and long-term potential factors. For the preparation of area balance sheets, districts can be digitalized with the SMIS. For these districts the forecast scope of decoupling measures is calculated. Abandoned sites suspected of being contaminated provide indications on the possibility of the ground being polluted, potential flow paths, which are calculated on the basis of a terrain model, provide information on the possibility of leading stormwater away at ground level. The decoupling land register for the whole of the area under administration of the association serves finally for documenting the progress of decoupling and thereby represents a check on the success achieved as aimed for with the "Agreement for the Future Management of Stormwater".

2.2 Concept of the system

By reason of the data used only a Geographical Information System (GIS) came into question as the foundation of the stormwater management information system. Geographical information systems have been in use in the area of water resource management for many years, e.g. as tools for hydrology and hydraulics as well as for determining the quality of water (Sample et al. 2001, Treis and Wessels 2005). These are mainly specialist systems realized as desktop solutions. Here however a desktop solution could not be considered since the workplaces of the users, who should all be able to access the same data, are "scattered" over the whole area covered by the Emschergenossenschaft. Accordingly the SMIS was realized as a web-based GIS portal. GIS portals had already been developed in the water resource management area as a consequence of the passing of the European Water Framework Directive as well as for the management of river basins. Although such portals do not offer a wide range of opportunities in respect of analysis, they do generally provide a wide range of information. Recently there has been a trend in the area of GIS portals towards specialized systems with a scope of functions customized on particular questions, these systems also containing calculation and analytical functions (see for example Choi, Engel and Farnsworth, 2005). Such portals can be designated specialist portals (Wessels and Fitzke, 2006). The stormwater management information system represents such a specialist portal.

The SMIS is based on the standards of the Open Geospatial Consortium (OGC) and follows the concept of a spatial data infrastructure (SDI). Spatial data infrastructures serve to facilitate the accessing and availability of geoinformation resources of the most different kinds. They are built up on the different levels of economic or administration related fields of action - from the level internally within an institution, via local, regional and national levels up to across-border and global spatial data infrastructures (Rajabifard, Feeney and Williamson, 2002). In the field of water resource management, spatial data infrastructures are already being successfully used in the context of the water framework directive and for river basin management (Spies and Förster, 2005). The stormwater management information system represents a regional spatial data infrastructure, the technical content of which was developed especially for the close-to-nature management of stormwater. The specific requirements of the participating parties in respect of data protection are taken into account in that it is possible to limit access rights to the information in accordance with technical criteria (e.g. no access to particular functions) or spatial criteria (e.g. to an area of a city). The SMIS makes it possible for further data from the local authorities or from third parties, that is relevant for stormwater management, to be integrated without any problem in so far as this data is made available in conformity with the OGC standards.

An essential precondition for the creation of a spatial data infrastructure between the Emschergenossenschaft and its local authority members is that standards be defined in respect of content. Accordingly a further objective of the stormwater management information system is that through this portal standards will be established at the same time for the fundamental data for the close-to-nature management of stormwater and that these standards be then employed in the participating local authorities.

3 SYSTEM IN OPERATION

In the following section the mode of working with the system and the result achieved are presented using a concrete decoupling measure as actually realized. The SMIS presents itself to the user in the first place as a GIS portal with the "usual" functions such as navigation and zoom functions as well as enquiry and search functions.

In Fig. 2 the fact that access to the data is limited spatially to a particular municipal area can be seen. In this way only the data that concern him are presented to each user in a local authority. In addition to the data held in the SMIS, further data such as the sewer network data of the local authorities, protected areas etc. can be of interest for planning the close-to-nature management of stormwater. Such data is already available in part as a web service in conformity with OGC standards and can also be loaded into the SMIS without it having to be held in the system itself.

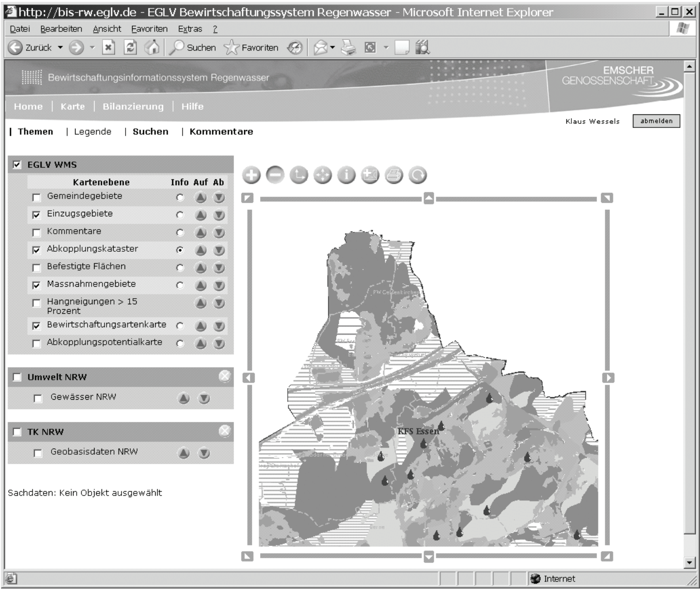

Fig. 2: Stormwater management information system

What opportunities does the system offer for identifying areas that could be decoupled from the sewer system? The identification of such areas is commenced with the search for developed areas which show preferably large areas suitable for decoupling. Such areas are to be found at public institutions such as schools, on industrial and trade sites but also on densely populated residential areas. Since the actual decoupling has to be carried out by the owners of each particular property, the decoupling of large areas in residential areas can best be achieved when many of the properties belong to one owner, e.g. a housing association.

However the existence of large paved areas is on its own not a criterion from which the success of decoupling measures can be concluded. Accordingly with the stormwater management mode map the system provides the user with a map which gives recommendations on possible modes of stormwater management. The chances that the decoupling of a paved area will also make economic sense are greater the smaller the expenditure for managing the stormwater will be. Here attention has to be paid to the fact that the statements in the stormwater management mode map represent recommendations determined on the basis of geogenic factors. This means that it is quite possible for decoupling to make economic sense even when the geogenic situation is unfavourable if, for example, the stormwater can be led off in a throttled manner to a body of water in the vicinity. A favourable mode of seepage as provided in a gravel-filled trench system will on its own not be sufficient to permit an area to be decoupled if, for example, the space for this type of stormwater management facility is not present. For this reason the potential for decoupling is additionally evaluated in the decoupling potential map in cases where parameters related to the structure of the particular built-up area play a role. The evaluation here is carried out with the aid of the statement of a percentage of the paved area which can probably be decoupled.

If when looking through the different fundamental maps a developed area is found, the decoupling of which appears to promise success, then an area balance sheet can be prepared for this with the SMIS. To do this the area in which measures will be carried out must first be digitalized. For this area the size of the paved area is calculated in total and also with account being taken of the short-term and long-term potential for decoupling it. In addition the amount of the areas that have already been decoupled - in so far as they exist - are issued.

Fig. 3: Area for measures in SMIS

Fig. 3 shows such an area for measures (within the dashed line; the paved areas are shown in grey). It is a matter with this area of a school which was in need of being remediated. The paved areas were to be decoupled concurrently with the remediation measures. Accordingly in this case the long-term decoupling potential was activated. On the basis of the paved areas and decoupling potential map the SMIS calculated a decoupling potential of 3685 m², whereas 4024 m² were found to be incapable of being decoupled (Tab. 1).

	Roof area (m²)	Area for public traffic (m²)	"Clean" private area (m²)	"Dirty" private area (m²)	Total (m²)
Decoupling potential	1895.40	27.80	1761.90	0	3685.09
No decoupling potential	2038.44	64.87	1920.64	0	4023.95
Total area	3933.84	92.67	3682.53	0	7709.04

Tab. 1: Area balance sheet of the area for measures, calculated with SMIS

According to the mode-of-management map there was no seepage system in situ and a seepage system would only be feasible with a large storage volume whereby this facility would require an appropriate amount of space. The reasons for this evaluation were the low permeability coefficients of approx. 20 mm/h. Since no large areas were available for such a storage facility, seepage had to be ruled out. Instead decoupling was realized by means of the throttled discharging of the stormwater into the nearby Emscher and rendering the surface of the school yard permeable by using water-permeable sett paving. Fig. 4 shows the areal decoupling actually achieved within the framework of the remediation measures. 4840 m² of the total paved area were decoupled, 1720 m² thereof being roof areas and 3120 m² thereof being the school yard and parking areas. Accordingly the potential actually realized lay approx. 1/3 higher than as estimated in the decoupling potential map.

Fig. 4: Areas actually decoupled (hatched in)

The reason for this variance is of a conceptional nature: The estimating of the decoupling potentials is based on systematic considerations so that variances are not only possible but are indeed to be expected in each individual case. However, as the studying of numerous other projects has shown, calculation of the decoupling potential with the aid of the SMIS permits an initial estimate to be made as to whether a more detailed check is likely to bring success. As a rule, if the recommended measure is actually carried out, the potential achieved will be higher than forecast since the owners will be keen to realize the highest possible potential.

4 CONCLUSION AND A LOOK AHEAD

The stormwater management information system has been developed as an instrument to support the members of the Emschergenossenschaft in working out feasible measures for managing stormwater in a close-to-nature nature. The example presented here as well as numerous other cases that have been studied shows that it is indeed a suitable instrument for identifying decoupling projects that appear promising and for subjecting these to an initial process of evaluation. In addition, however, it fulfils further important functions. Thus it aids in the creation of common standards in respect of the fundamental data and serves not least to bring about a higher level of awareness on the problems in connection with stormwater.

The further development of the portal will be carried out in an iterative-incremental manner not only in respect of the technical content but also in terms of the mode of integration of the participating users. With the presentation of the first version of the SMIS, the opportunities given by such a system became perceptible for the first time to many of the participants and it became easier for them to articulate their wishes and requirements in respect of its further development. In respect of the technical content, integration of the theme of groundwater management is already planned. Thereby the system will also support, for example, monitoring groundwater table depths.

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