

Review of the Implementation Process of Sustainable Stormwater Management in the Czech Republic

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Abstract The paper describes a process of implementing sustainable stormwater management in the Czech Republic, including motivations behind the process, the situation in stormwater management before the implementation, actions undertaken during the preparation of a national stormwater concept, obstacles and the current status of implementation. The first large scale pilot study is given as an example of the process and lessons learned are summarized in order to give the experience to other countries.

1 Introduction

Sustainable urban drainage systems (SUDS) are systems promoting good practice leading to sustainability in the sector of urban drainage. Application of SUDS demands both philosophical and technical changes that must be incorporated in all forms of urban re/development and represents a shift from the traditional approach to an adaptive, participatory and integrated approach (Brown and Farrelly 2009). It means that SUDS implementation is not a task for water branch only, but an all-society task.

The process of SUDS implementation in the Czech Republic was delayed compared to the most developed countries. The reasons were: (i) the international isolation of the Czech Republic during the second half of the 20th century and (ii) the transition to capitalism after the revolution in 1989, which was in the first phases much more oriented on economical issues rather than on environmental and social ones. Till 2007, virtually no SUDS techniques were applied with exception

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of individual projects of environmental enthusiasts and EU financed projects (e.g. INTERREG IIIB CADSES project RainDROP, code: 5C052).

At the beginning of the year 2007, the situation in the Czech Republic was as follows:

- *No decentralized stormwater management systems.* In the past, most sewer systems in the Czech Republic were built as combined systems. Later, separate systems were constructed at the outskirts of municipalities. Decentralized systems for the retention and infiltration of stormwater were used only rarely.
- *A lack of political will to implement sustainability principles in stormwater drainage.* Other environmental issues, such as recycling of home wastes, highway construction in sensitive areas and industrial development projects, were considered more critical.
- *An underestimation of urban drainage problems, a lack of awareness in society.* The discharge of sewer systems and pollution in receiving water are often not visible, and thus these problems are underestimated by the public and politicians. A series of 10 floods in the rivers between 1997 and 2010 accompanied by casualties initiated a discussion on water in the society; however, most people do not relate the impacts in receiving waters to urban drainage. Major projects were directed towards flood protection.
- *No legislation encouraging sustainability principles, no technical standards.* The majority of engineers design traditional urban drainage concepts (see later); thus there is no need for technical standards regarding best stormwater management practices. The legal status of stormwater runoff and combined sewer overflows (CSOs) is not specified (CSOs overflows are not considered to be wastewater).
- *Conservatism of engineers.* Before the political changes in 1989, the urban drainage, as with other specializations, had lost contact with international research and development. During that period, many senior engineers were educated and started their work.
- *Stormwater fees exist for only a minority of stormwater producers.* Stormwater fees are regulated by Czech legislation and only apply to some impervious surfaces connected to combined sewers (mainly associated with companies) with many exemptions such as roads, rails, households and recreational buildings. The stormwater fee from impervious surfaces drained by storm sewers is not prescribed by law, i.e. the municipalities can regulate it themselves. However, no municipality yet collects this fee.
- *Information and experience from abroad.* Some of the community of engineers is aware of the problem and looks for information abroad (mainly from Germany). They have started to hold regular seminars on SUDS topics. Also, foreign manufacturers of artificial infiltration devices have started to advertise their products on the Czech market.

Increasing rate of urbanization and expected climate change have become the main driving forces for implementing sustainable stormwater management in the Czech Republic. These forces are manifested through an increased frequency of

local floods (due to overloaded sewer systems or receiving waters), water quality deterioration, biodiversity degradation and decreased quality of living, with increased mitigation costs as a consequence.

The rapid urbanization occurred in the Czech Republic after the political changes in 1989. According to The Report on Environment (Ministry of Environment of the Czech Republic 2009), the annual urbanization of agricultural land increased from 0.02 % in 1994 to 0.18 % in 2009 (Fig. 1), i.e. nearly 14 ha are converted daily. Today, the urbanized area in the Czech Republic approaches 5000 km², i.e. 6.5 % of the country. Considering the mean rainfall height of 640 mm per year, and assuming an increase in surface runoff volume from original 10 % for a natural catchment to 35 % for an urbanized catchment (Paul and Meyer 2001), the natural annual flow volume from the Czech Republic to neighboring states has increased by 0.8 km³ (about 6 %). Continuing the current trend of urbanization, this number could increase by a factor of 2 by the year 2050.

According to the National Program to Abate Climate Change Impacts (Ministry of Environment of the Czech Republic 2004), a small change of annual rainfall depth is predicted for the Czech Republic. However, a significant change is expected in the distribution of rainfall activity throughout the year, together with increases in temperatures and evapotranspiration. In consequence, more frequent heavy storm events (as well as flash floods) and prolonged periods of drought may appear.

In reaction to the situation in 2007, a specialists group on Urban Drainage (SGUD) was established under the Czech Water Association (CzWA), the national member of the International Water Association. The goal of this group is to promote the transition from current urban stormwater drainage systems to sustainable ones based on experience from abroad (esp. Germany, Switzerland, UK, Canada, USA and Australia). The actions of the SGUD are not primarily oriented toward research and technology, but rather how to implement sustainable stormwater management in Czech conditions.

The goal of this paper is to describe the paradigm change regarding stormwater in the Czech Republic, the motivation behind it, the process of implementing necessary changes aimed at sustainable stormwater management, and the restrictions and obstacles to implementation. We also present a pilot study from the city of

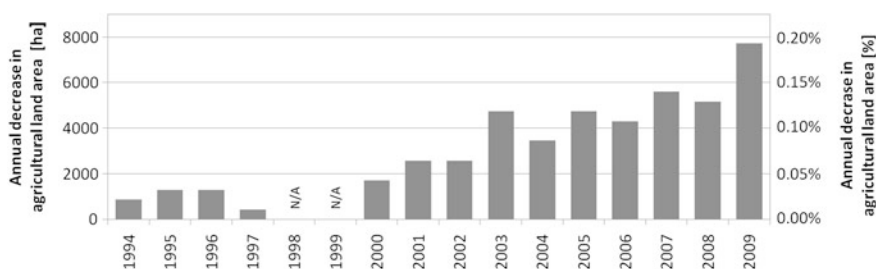


Fig. 1 The annual decrease of total agricultural land area in the Czech Republic (Ministry of Environment of the Czech Republic 2009)

Hradec Kralove. The experience that the Czech Republic has had with implementation can serve as a useful example of the transition towards sustainability for other countries facing similar problems.

2 Methods: Strategy of Implementation

2.1 Background

The Plan of Main River Basins (Ministry of Agriculture of the Czech Republic 2007) as a national planning document introduced a framework for implementing sustainable stormwater management. Due to harmonization with the EU water policy (Directive 2000/60/EC), increased stress was put on stormwater infiltration, runoff attenuation and reuse, instead of connections to combined sewer systems. The Plan also requested that a National Concept of Stormwater Management in Urbanized Areas be created. Using this Plan as a starting point, the SGUD (on contract with the Ministry of Agriculture) created a *Background document* for the Concept (Czech Water Association—SGUD (2007), which proposed:

- *In newly developed areas*—to shift the obligation for managing stormwater on the originator, i.e. the owner of the property where runoff originates,
- *In existing urban areas*—to create an economic motivation, i.e. a property owner who wants to improve the current state (to disconnect surface runoff from the combined sewer) should profit economically (e.g. by a decreased or eliminated stormwater fee).

2.2 Implementation

The background document was followed by an *Implementation strategy document* (Czech Water Association—SGUD 2009) which specified a set of necessary changes in the legislation, proposed new technical standards and methodical approaches, and stressed the need for education, research and dissemination of information related to sustainable stormwater management.

2.3 Legal Framework, Methodologies and Technical Standards

First, a legal framework creating a basis for implementing the Concept must be formed. In the Czech Republic, these changes concern mainly the Water Act, the Building Act and delegated legislation (implementing regulations). The most

important is: (i) specification of the legal status of stormwater runoff and priorities regarding stormwater management; (ii) definition of the legal status of CSOs; (iii) elaboration of an impacts-based guideline on CSOs and (iv) declaration of general liability of the property owner for stormwater.

In specific areas, the following actions were proposed:

- *Setting priorities of stormwater management in newly developed areas.* Stormwater management on ground plots must take into account applicability, feasibility and economical adequacy. Priorities concerning the choice of recipient (groundwater, surface water, sewer system) must be given. Polluted and unpolluted stormwater runoff must be defined and permissible infiltration method must be specified, taking into consideration soil and groundwater protection. A maximum specific discharge from newly urbanized sites must be set as a basis for the design of devices.
- *Introduction of economical motivation.* Exemptions from stormwater fees must be minimized. In addition, a methodology for runoff quantification should be specified.
- *Incorporation of sustainable stormwater management into city planning.* Changes at the level of municipal legislation concern the City Development Plan, where conditions for the retention, infiltration and utilization of stormwater must be created through setting limits of stormwater discharge from areas with site-specific local conditions (type of development, hydrogeological conditions, recipient availability/capacity, etc.). Rules on how to set these limits and how to introduce SUDS must be specified in a methodical guidance publication produced by the Ministry for Regional Development.
- *Creating technical standards for the design, operation and maintenance of SUDS.* Technical standards must be created to ensure technical quality and safety of SUDS devices including their design, operation and maintenance on the state-of-the-art level.

2.4 Education and Research

The implementation strategy document suggests the following:

- To create courses for officials (esp. for Building authority and city administration)
- To launch a broader education program “Stormwater in the city and landscape”, informing children and teenagers (through school and after-school activities) about the role of stormwater, its function in the hydrological cycle and its function in cities
- To support related topics through grant agencies and systems (e.g. analysis of the socio-economic effects of stormwater fees, the effect of stormwater infiltration on

different subsoil types, treatment efficiency for different soil profiles, the effect of decreased discharge in combined sewers caused by disconnecting stormwaters on sedimentation)

3 Methods: Strategy of Implementation

3.1 *Newly Developed Areas*

3.1.1 Implementation

The implementation itself started in 2009 by a parallel novelisation of the Water Act and the Building Act. The Water Act (Act 254/2010 Coll.) newly defines stormwater as a special category of water, obliging its sustainable management by developers. A developer must ensure infiltration or retention with regulated discharge, i.e. a direct connection to the combined sewer is no longer allowed. A revised regulation (Regulation 501/2006 Coll., novelized 2009) to the Building Act (Act 183/2006 Coll.) further specifies the rules of stormwater management (Table 1). The basics for SUDS were created.

In 2012 and 2013 two new Czech technical standards were published. The first one (CSN 759010 2012) deals with soakaways, the second one (TNV 759011 2013) covers the whole field of sustainable stormwater management obeying the priorities given by Table 1 (Fig. 2).

3.1.2 Obstacles

Despite these updates to the Water Act and the Building Act, many obstacles still limit the full implementation of these new principles:

- Time needed by the engineers and officials to get acquainted with the two new Czech technical standards and to use them properly.
- The low level of stormwater-related education for many officials, resulting in situations where they often do not know what to demand and how perform controls.

Table 1 Priorities of stormwater management in the regulation to the Building Act (Act 183/2006 Coll.)

Priority	Stormwater management
1	Infiltration, pre-treatment in the case of polluted runoff. If not possible, then:
2	Retention and regulated discharge to the surface waters (directly or by a separate storm sewer system), pre-treatment if needed. If not possible, then:
3	Retention and regulated discharge to the combined sewer system

- The efforts of (some) developers to evade the rules, e.g. they consider a whole development area (often tens of hectares) as one building site. Then, a central rather than decentralized retention system is built, despite the fact that the site will be later parceled (Fig. 2).
- Poor understanding by other professions (architects, city planners, road engineers and even civil engineers). The new approach to stormwater is considered to be a complication.

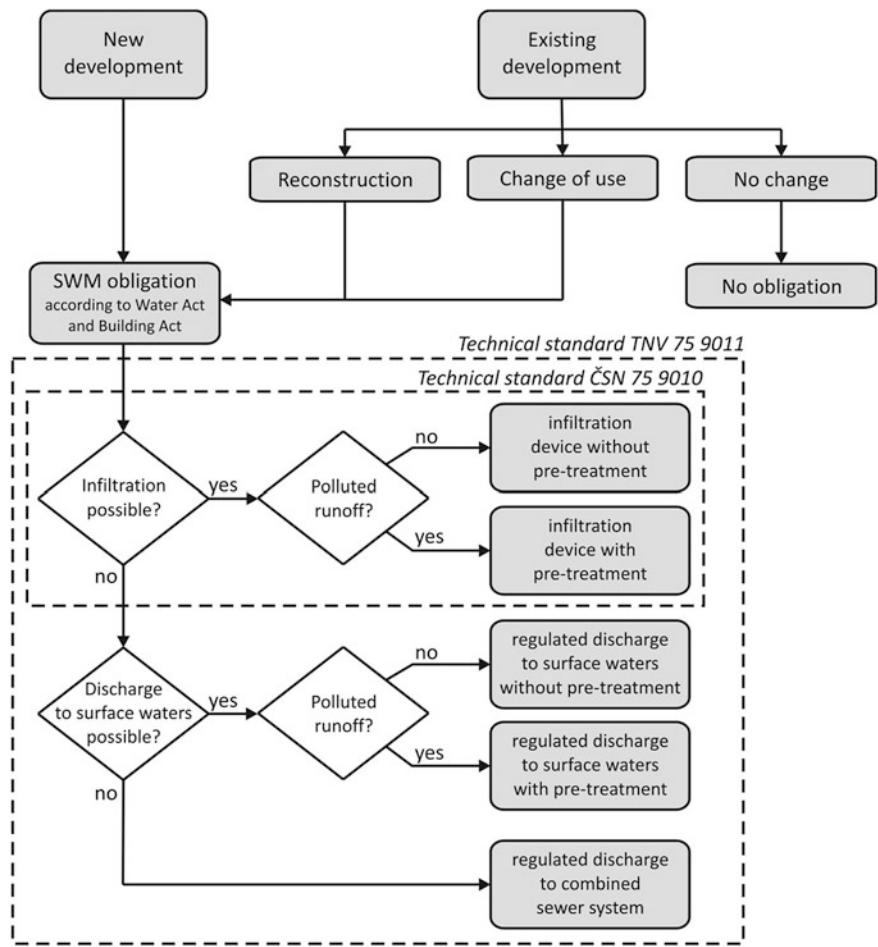


Fig. 2 Stormwater management rules in the Czech legislation and the scope of the technical standards

3.1.3 Pilot Study

The city of Hradec Kralove (96,000 inhabitants in 2010) was planned as a green city before the Second World War by architect Josef Gocar. Today, it is still an excellent example of clever urban planning. Stormwater drainage was solved as a first priority before starting planning the urbanization itself. Gocar designed a system combining natural water bodies and open vegetated channels. Moreover, infiltration systems were created in some areas. However, in the past few decades, Hradec Kralove has suffered from massive urbanization resulting in overloading of water bodies, open channels and of the sewer system. In response, the city ordered a Stormwater Drainage Area Plan (SDAP) in 2008 (DHI and JVPROJEKTVH 2011), focusing on sustainable stormwater management and its relation to urban planning. The project went beyond the requirements of current legislation.

The SDAP incorporates hydrodynamic modeling of the sewer system (mainly combined), water bodies, artificial open channels, underground waters (JACOBS 2010) and SUDS elements. Limits on the areas to be urbanized were implemented by:

- Defining areas of natural water retention (due to a high underground water level; less than 1 m below surface) and areas of flood risk, where urbanization is forbidden,
- Setting a maximum specific regulated discharge of $3 \text{ l s}^{-1} \text{ ha}^{-1}$ for a 5-years storm event for individual developments (scattered),
- Demanding recalculation of the water regime in terms of the hydraulic capacity of the sewer system, water bodies and artificial channels, and of groundwater level changes in the case of extensive individual developments or large development projects.

The above mentioned rules will be incorporated into the new City Development Plan and into the administration of new development by the Building Authority. Boundary Conditions Sheets (Table 2) for individual planned development areas were elaborated where possibilities of stormwater management are evaluated respecting priorities set in Table 1.

3.2 Existing Urban Areas

3.2.1 Implementation

The implementation of necessary changes has not made as much progress as in the case of new development. The cancellation of stormwater fee exemptions was discussed in 2012 during the revision of the Water Distribution and Drainage Act (Act 274/2001 Coll.) and most recently rejected by officials. One positive point is

Table 2 Example of a boundary conditions sheet for planned development (DHI and JVPROJEKTVH 2011)

Development area	No. 3	Za Metelkou, Drtinova Street	
General information			
Identification of areas		Acreage of areas	Functional type
6-9/6, 7-9/14, 7-9/30, 6-9/4		18,013 m ²	Suburban low-storey development
6-9/7		5487 m ²	Multi-storey dwellings
Studies and regulation plans		No	
Areas of special water regime			
Natural water retention area		No	
Flood risk area		No	
Inundation area		No	
Adjacent recipients			
Groundwater	Groundwater level	2–5 m below surface	No limitations for infiltration
	Hydraulic conductivity	≥1 × 10 ^{−6} m/s	
	Ecological burden	No	
Available receiving surface waters/storm sewers		Melounka Brook (Identification No. 10101505, Hydrological catchment No. 1-03-01-005)	
Available combined sewers/foul sewers		Combined sewer B (DN 500)—Petra Jilemnického Street	
		Combined sewer B 18 (DN 300)—U Drevony Street	
		Combined sewer B 19 (DN 300)—Predmericka Street	
Drainage concept for stormwaters			
Groundwater		Decentralized infiltration devices recommended (detailed hydrogeological survey necessary)	
Receiving surface water / storm sewer		Melounka Brook recommended for overflows from infiltration devices	
Combined sewer		–	
Drainage concept for foul waters			
Combined sewer system, sewers B, B18 or B19			

that the updated Water Act is valid not only for new development, but also for reconstruction and changes to building uses (e.g. changes from housing to administrative purposes) (Fig. 2).

3.2.2 Obstacles

The government did not accept ending the stormwater fee exemptions, considering this to be politically hazardous. Thus, the SGUD is promoting not to introduce a new fee for stormwater producers with exemptions, but rather to divide the current

sewage fee (collected according to drinking water consumption) into two fees—a decreased sewage fee and a stormwater fee. The explanation is backed by the following arguments:

- The sewer operator maintains the sewer system draining both sewage and stormwater.
- The operator collects an amount of money sufficient to maintain the system, therefore:
 - A certain stormwater fee is hidden in the sewage fee; i.e. sewage producers pay for stormwater drainage according to their drinking water consumption instead of according to the runoff volume originating from associated impervious areas. This system is inequitable, as exemplified by the following: a household with a high consumption of drinking water and a small roof per inhabitant (as in a typical block of flats) pays a considerably higher hidden stormwater fee than a single-family house with a lower drinking water consumption and a larger roof area per person.
 - Due to the exemptions from the stormwater fee, subjects obliged to pay the fee also pay the costs of stormwater drainage for other producers (also an inequitable system).

3.2.3 Pilot Study

The economical motivation cannot be introduced by the SDAP (DHI and JVPROJEKTVH 2011), as it does not comply with the national law. However, the city wants to serve as an example and disconnect selected areas from the combined sewer system. These areas were selected by a detailed field survey according to the following criteria (Table 3):

- the area must have potential to infiltrate or to delay stormwater runoff (e.g. sufficient green areas, suitable hydrogeology),
- this potential must be available (i.e. under city ownership).

By disconnecting these areas, the city can reduce the area of impervious surfaces connected to the combined sewer system by 15 % within the next 30 years.

4 Discussion on Further Actions

The SGUD oversees the implementation and attempts to overcome the obstacles described above through discussions with authorities, creating new methods and technical standards, and organizing conferences, seminars and education for

Table 3 Example of a boundary conditions sheet for planned development (DHI and JVPROJEKTVH 2011)

Streets	Pod Zameckem, Milady Horakove, Prostejovska, Fricova, Urxova	Local part	Trebes
		Acreage	35 ha
		Hydrological catchment No.	1-03-01-002
		Trunk sewer	C
<i>Criteria</i>		<i>Classification</i>	
Information on the development	Prevailing development	City centre	5 %
		Multi-storey dwellings	95 %
		Low-storey dwellings	
		Industrial area	
		Traffic infrastructure	
	Ecological burdens	Yes	
		No	•
	Stormwater infiltration	No limitations	10 %
		Conditionally suitable	
		Difficult	90 %
		Impossible	
	Technical potential of infiltration	Presence of areas suitable for stormwater infiltration	Yes
No			
Prevailing slope of surface		<3 %	•
		≥3 %	
Available potential of infiltration	Owner of buildings	City	•
		Other	
	Owner of adjacent areas suitable for stormwater infiltration	City	•
		Other	

officials, engineers and the public (including children). In the next stage, dissemination will be focused on local administrators, land-use planners, architects and the public.

It is crucial to create a methodical guideline for the Building authority that should enforce the priorities required by law. This guideline must include criteria under what conditions the infiltration (or regulated discharge to receiving waters) is possible, how to document it and how to control it. The guideline should be supplemented by educational training for Building authority employees.

Future actions will also focus on implementing the economic motivation. First, it must be demonstrated how the stormwater fee affects different owners of properties (private, city, region, state). A project studying social and economic effects is currently being prepared.

5 Conclusion

Launching SUDS principles in areas to be developed is much easier than in existing urban areas as clear rules can be given. However, the experience from the pilot study in Hradec Kralove confirms foreign experience that it is possible (Moore et al. 2011) and has a promising potential of upgrading living and health standards of urban citizens.

During the transformation of the stormwater management in the Czech Republic, many obstacles were faced and still are not overcome. Some obstacles we identified are similar to those in countries, which have already implemented SUDS principles (e.g. Brown 2008).

Experience gained in the Czech Republic can be transferred to countries with similar political, social and economical background, i.e. mainly to Central and East European countries. However, some findings can be useful generally, as stated in the following points:

- Paradigm changes regarding stormwater management require a substantial change of thinking at all levels (engineers, land-use planners, architects, officials and local, regional and national authorities).
- It is relatively easy to change the thinking of water engineers (the only problem is learning new methods), it is moderately easy to convince local and regional authorities (since they need to solve problems at a local level) and it is very demanding to convince national authorities (e.g. regarding the stormwater fee), land-use engineers and architects (as they are used to their practices, i.e. water is solved at the end of the process).
- Demonstrating examples from abroad is not as efficient as actual examples in the country of interest.
- The sustainable water management lobby is not very powerful compared to much stronger lobbies driven by financial interests (e.g. big developers companies).
- It is not possible to introduce new rules without explaining them thoroughly as people have to understand the reasons behind them. This should be mainly the role of the state.
- Transition to sustainable stormwater management must be coordinated from the national level in order to prevent problems between the actors of the process having often contradictory interests.

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