Selection of Stormwater Priority Pollutants in the City of Malmö, Sweden

Sélection de polluants prioritaires dans les eaux pluviales pour la ville de Malmöe, Suède

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RESUME

Les précipitations exceptionnelles ont été dans le passé considérées, comme un problème hydraulique dans beaucoup de municipalités, y compris la ville de Malmö, en Suède. En raison de la connaissance accrue concernant la pollution provenant de ces précipitations exceptionnelles et de la mise en place de la directive européenne (2000/60/EC) définissant la qualité chimique et biologique des fleuves, lacs, eaux souterraines et plages côtières, une attention plus grande a été donnée à la pollution due aux décharges des précipitations. Un groupement des départements de la ville de Malmö développe une stratégie de gestion à long terme de ces précipitations exceptionnelles et le but de cette étude était de choisir les polluants prioritaires de précipitation (SSPP) et les inclure dans le plan stratégique. L'outil chimique d'identification et d'évaluation de risque (CHIAT) a été utilisé à cette fin et deux programmes de contrôle orientés par cible (un pour la phase aqueuse et un pour les sédiments) ont été déterminés.

ABSTRACT

Stormwater has previously been regarded as a hydraulic problem in many municipalities, including the City of Malmö, Sweden. Due to the increased knowledge regarding stormwater pollution and the implementation of the European Framework Directive (2000/60/EC) which addresses the chemical and biological quality in rivers and lakes, groundwater and coastal beaches, increased attention has been given to pollution due to stormwater discharges. A joint venture of the departments in the City of Malmö is developing a sustainable stormwater management strategy, while the aim of this study was to select stormwater priority pollutants (SSPP) for inclusion in the strategic plan. The Chemical Hazard Identification and Assessment Tool (CHIAT) was used for this purpose and two target-oriented monitoring programmes (one for the aqueous phase and one for sediments) were set forth.

KEYWORDS

Priority pollutants, Stakeholder involvement, Stormwater discharges, Strategic planning.

1 INTRODUCTION

Stormwater contains a vast range of different pollutants such as organic matter, nutrients, suspended solids, metals, inorganic trace elements and xenobiotic organic compounds (XOCs). For the evaluation of alternatives in stormwater handling, it is necessary to assess potential hazards and problems related to the water constituents. Hazards regarding exposure of e.g. humans, livestock, aquatic and terrestrial organisms have to be considered, as well as technical and aesthetical problems. The chemical hazards that are needed to be taken into account are both acute and long-term adverse effects to living organisms, e.g. toxicity, bioaccumulation, carcinogenicity, mutagenicity, reproduction hazards (CMR) and endocrine disrupting effects, as well as the persistence of the compounds in the environment.

The City of Malmö is currently developing a handling strategy for sustainable stormwater management in a project called BEATA. The project is a joint venture for the city's Waterworks, Environment and Health Administration, City Planning Committee, Road department and Real estate department. The presence of toxic and in any other way unwanted pollutants in stormwater and stormwater affected recipients is a new focus area for the City of Malmö as well as for many municipalities in Sweden and all over Europe. Stormwater has primarily been regarded as a hydraulic problem where flooding of, for example, basements and roads have received most attention.

In the municipality of Albertslund (Denmark) it has been shown that, the stormwater contributes with a higher quantity of heavy metals to the receiving waters compared to treated municipal wastewater on an annual basis (Rasmussen et al., 2006). This illustrates that the issue of stormwater pollution should be dealt with in earnest and that there is a need for long-term stormwater handling strategies. Furthermore, with the implementation of the European Water Framework Directive (WFD) (European Commission, 2000) which addresses the importance of diffuse pollution and its effect on the environment and the knowledge of the vast stormwater pollution (Eriksson, 2002; Makepeace et al., 1995), an increased interest in new ideas for stormwater management has been raised.

The pollution issue can be handled in an array of different ways; the municipality can enforce restrictions on certain enterprises or introduce requirements for stormwater treatment before allowing discharged to the stormwater sewers or the recipients. In Malmö's new strategy, organic pollutants, XOCs, will have a prominent role and thus is it important that the selection of pollutants for inclusion in a monitoring programme and in the remedial measures is carried out in a structured and scientifically based manor and not arbitrary inspired by e.g. old monitoring programmes. The present established monitoring programmes include nutrients (N and P), organic matter (e.g. COD/BOD) and heavy metals (e.g. Cd, Cu, Pb and Zn) and thus there is no need for further investigation and selection of pollutants within these categories.

1.1 Aim

The objective for this study was to identify selected stormwater priority pollutants (SSPP) for the City of Malmö, Sweden to be included in their strategic plan for stormwater handling in the city.

2 METHODOLOGY

The selection was performed by applying the CHIAT-procedure (Chemical Hazard Identification and Assessment Tool) which aim at selecting the most important pollutant in a given case (Eriksson et al., 2005 and Ledin et al., 2006) and consist of five steps:

1) Source characterisation
2) Recipient, exposure objects and criteria identification
3) Hazard and problem identification
4) Hazard assessment
5) Expert judgement/stakeholder involvement

The hazard and problem identification were performed by applying the RICH-procedure (Ranking and Identification of Chemical Hazards; Baun et al., 2006).

It was agreed that no “Hazard assessment” (step 4) should be carried out in this project. The City of Malmö is aiming at selecting the most relevant pollutants to focus on in the coming 10-15 years. It can be assumed that the data needed for carrying out a hazard assessment for these pollutants is not available. This means that the work will be hampered by lack of data, and it was believed that this will bias the outcome from the project as it would be prone to old pollutant that are closely studied.

The experts and stakeholders involved in the process were representatives from Malmö Waterworks, the City of Malmö's Environment and Health Administration and the Technical University of Denmark.

3 RESULTS AND DISCUSSION

3.1 Application of CHIAT

3.1.1 Source characterisation

The first step revealed that at least 780 XOCs could be present in stormwater (Ledin et al., 2004; Makepeace et al., 1995). The list included a wide range of organic compounds (aliphatic and aromatic amines, alkanes, alkenes, alcohols, chlorinated alcohols, amines, benzenes and phenols, detergents, dioxins and furans, ethers, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, phenols, phthalates, etc.) originating from a range of different sources, such as traffic, building materials, atmospheric deposition, weed control, de-icing, construction chemicals and accidental spills.

3.1.2 Recipient, exposure objects and criteria identification

In step two, the stream Risebergabäcken was identified as the major recipient for stormwater in Malmö, see figure 1. It discharges into Öresund, a brackish water constituting the border between Sweden and Denmark.

The major exposure objects are water living organisms (e.g., algae and fish for recreational angling) and the cattle grassing along the stream (sheep and cows).

There are no beaches or other bathing places along the stream and hence is human exposure not included. It was decided to include both water-soluble compounds and sediment/particle adsorbing compounds since these organisms are in contact with both the water and the sediments.

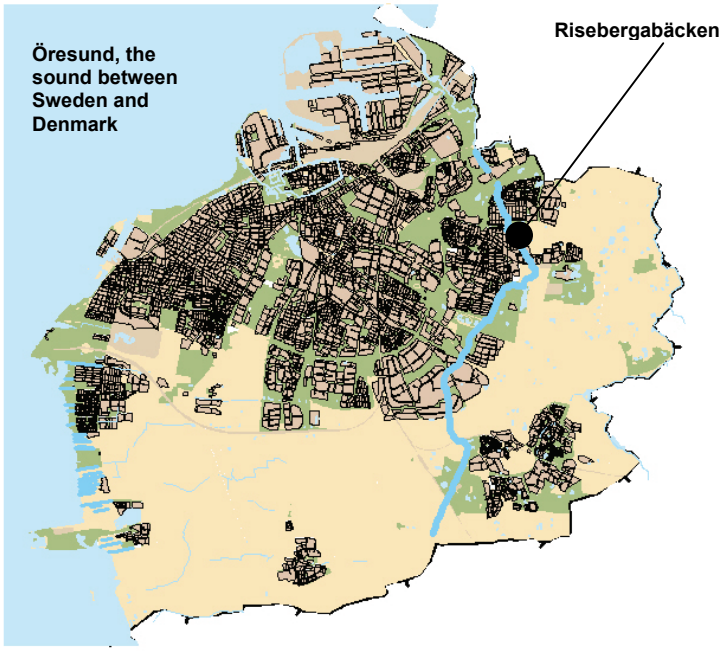

Figure 1. The City of Malmö and the primary recipient Risebergabäcken

There is not legislation regulating discharges of stormwater to surface water recipients in Sweden, However, there are regulations regarding the use of pesticides and it can be expected that the implementation of the WFD (European Commission, 2000 and 2001) will result in regulations in the future although the suggested environmental quality standards (European Commission, 2006) does not target stormwater. Furthermore, the Swedish Chemicals Inspectorate's PRIO and Restricted Substances Databases (2006), The Swedish Chemical Products and Biotechnical Organisms Regulations (1998), OSPAR Commission (for the protection of the marine environment in the North-East Atlantic, 2002-2004), HELCOM (the Baltic marine environment protection commission, 1998, 2005) and Danish guidelines for discharge in to the sea, lakes and rivers (Statutory order 921, 1996) were identified as relevant lists with priority pollutants for this project due to their national or intra-governmental coverage.

3.1.3 Expert judgement/stakeholder involvement

Different experts with different background discussed the outcome from step 3 and made the final selection SSPP. The expert group decided to prepare two types of lists with compounds; one that should be included in initial monitoring programmes (one list for water and one list for sediments) and the second should be used for surveillance during, for example, permission processes or construction work outdoors, e.g. tunnel building.

Over 300 XOCs were however way too many to include in a target-oriented monitoring programme due analytical costs and the limitations to the commercial analyses available or for inclusion in the remedial measures. Hence, one of the tasks for the expert judgement/stakeholder involvement was to reduce the number of XOCs and selecting indicator compounds.

It was decided that compound that had been classified as potentially hazardous due to long-term effects related to human effects such as CMR were of low priority as no immediate human contact with the stream were expected. Additionally, it was decided that the first version of the monitoring programmes should be implemented as a primary screening and the output, in conjunction with a new expert judgment, would be used to generate revised versions. The final decision of compounds to include for surveillance was also postponed pending the output from the screening.

The version of the monitoring programmes with SSPP for water included 17 compounds or groups of compounds, and correspondingly sediment list included 21 (Table 1). The monitoring programmes contain well-know pollutants existing in stormwater, i.e., the PAHs originating from exhaust (see for example Marsalek et al., 1997; Sansalone and Buchberger, 1997) as well as an oil index (short and long-chain aliphatic compounds) representing fuel and lubricant dispersal. Furthermore, were some substituted PAHs included, as they will be formed during incomplete combustion. The nonyl- and octylphenols are included in the WFD and are the breakdown products of the corresponding ethoxylates, which are used as surfactants. The PCBs were banned in sealants in 1972 and banned entirely in Sweden during 1978. However, they still remain in buildings etc that were constructed prior to these bans and since they are subjected to continuous release, and well as potential point sources during demolition of older buildings, it was decided to screen for this group. Furthermore, the group of plasticizers (phthalates) were included where different compounds were selected for the water and sediment phase respectively.

One pesticide, glyphosate, and its degradation product AMPA were included in the monitoring programme as it is one of the most frequently used pesticides in Sweden, and thus it is anticipated to be used in private gardens and business plots in Malmö. The Road department does not however use glyphosate but only acetic acid for weed control within the city boundaries.

Triphenyl phosphate was selected as an indicator for the organophosphate group (plasticizers and flame-retardants) and similarly was BHT (antioxidant) to represent a range of compounds with similar chemical structures and inherent properties

MTBE (petrol additive) and LAS (surfactant) will act as indicator for different processes and thus different sources as MTBE are connected to petrol spillage and use whereas LAS mainly will derive from laundry wash (municipal wastewater). Bisphenol-A-diglycidylether originate from epoxy resins and are used as a general indicator for structural density and 3,3-Dichloro-benzidine has been included in the US. National Pollutant Discharge Elimination System (US. EPA, 2006).

Water	Sediments
1-Chloro-4-nitro-benzene/1-chloro-2-nitrobenzene, di-chloro-nitro-benzene	2-Chloro-naphthalene, methyl-naphthalene
3,3-Dichloro-benzidine	3,3-Dichloro-benzidine
BHT (butylated hydroxytoluene)	BHT (butylated hydroxy toluene)
Bisphenol-A-diglycidylether	Bisphenol-A-diglycidylether
Di-n-butyl phthalate, di-ethyl phthalate, mono-ethyl-hexyl phthalate	Di-n-butyl phthalate, DEHP, di-n-octyl phthalate, di-ethyl phthalate, di-methyl phthalate, butyl-benzyl phthalate, mono-ethyl-hexyl phthalate
Glyphosate/AMPA	Glyphosate/AMPA
MTBE (Methyl tert-butyl ether)	LAS (linear alkylbenzene sulfonate)
Octylphenol, nonylphenol as well as their ethoxylates and carboxylates	Octylphenol, nonylphenol as well as their ethoxylates and carboxylates
PAH (16 according to U.S. EPA)	PAH (16 according to U.S. EPA)
PCB (standard analysis package)	PCB (standard analysis package)
	Oil index
Triphenyl phosphate	Triphenyl phosphate

Table 1. Selected Stormwater Priority Pollutants (SSPP) for inclosing in monitoring programmes in the City of Malmö.

3.2 Continued work

The next steps in the implementation of a handling strategy for sustainable stormwater management in City of Malmö include evaluation of the status in the primary recipient and the stormwater sewer system. During the coming year analyses of stormwater and stormwater, affected surface waters will be done in parallel with analyses of sediments in stormwater manholes, stormwater pond and affected recipients.

New questions has also been raised during this study which will be addressed in upcoming projects; how will chemicals used in the ongoing drilling of a new train tunnel affect the stormwater?; which pesticides (herbicides and rodenticides) are used in Malmö?; and how can the city handle pollution directed to Risebergabäcken that originate from businesses that the municipality do not control, for example golf courses and agriculture?

4 CONCLUSIONS

The present study showed that the CHIAT tool in combination with the RICH-procedure are two very useful tools for selection of priority pollutants. The selection of priority pollutants can largely be performed based on scientific knowledge. However, the final selection has to be based on more or less subjective opinions. The major limitations in this approach are the need for relatively large amount of data regarding inherent properties, the difficulties to find data and finally the lack of data for some compounds.

Relatively many compounds (about 40%) were classified as potential hazards to the environment and the aquatic ecosystem in particular, if they are present in elevated concentrations. About one fifth of the compounds were classified as potentially non-hazardous. Though the study was hampered by the lack of inherent data, which resulted in that only 60% of the compounds actually could be classified.

For the monitoring programme to be applied on stormwater and stormwater sediments were 17 and 21 compounds or compounds groups selected, respectively. The output from the monitoring programme will be used for a revision in order to further streamline it and as well as used devise the surveillance compound list.

It was also concluded that the number of stakeholders participating in this project not represented all departments in the municipality and further benefits could be obtained if the departments, for this purpose, communicated more regarding, for example, mapping of pesticide used and spreading patterns.

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