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| **Document title** | Proposal to update HELCOM Recommendation 23-5 |
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## Background

Storm water is considered as one of the important sources of micro particles, including various types of micro plastics to the aquatic environment. PRESSURE 9-2019 agreed on a number of regional joint actions to mitigate littering of the marine environment proposed by the Third Workshop on implementation of the Regional Action Plan on Marine Litter (WS RAP ML 3-2018). One of the actions was to produce a draft of revised HELCOM Recommendation on waste and storm water management with support by the FanpLESStic-Sea project. HELCOM national experts were invited to provide national available information (Annex 5 to the Outcome PRESSURE 9-2019). PRESSURE 9-2019 welcomed the offer by CCB to compile national available information and produce an initial draft.

HELCOM Recommendation 23/5 discusses the "Reduction of discharges from urban areas by the proper management of storm water systems". The document was written in 2002 and contains general recommendations mainly on reduction of stormwater volumes and mitigation of oil contamination in stormwater. As new techniques and knowledge have emerged since the document was composed, there is a need to update and revise it.

The attached document contains a report summarizing current knowledge on stormwater problems and major contaminants, as well as current best management practices, techniques and solutions to treat stormwater, reduce flow and remove contaminants. The report also includes a chapter describing several good examples of well-functioning stormwater systems and sites in the Baltic region. Based on the information reviewed, this document gives a recommendation for an updated version of HELCOM Recommendation 23/5, found in Appendix 1.

## Action requested

The Meeting is invited to consider the proposals to update HELCOM Recommendation 23/5 and agree on their integration to the text of the Recommendation.

The Meeting is also invited to discuss other measures of relevance to the Recommendation which might also be integrated into the document e.g. related to climate change etc. and agree on further steps to update the Recommendation.

Water Revival Systems

# Recommendations on improving Helcom Recommendation 23/5

*Including a brief identification of major stormwater issues, pollutants and treatment methods*

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Coalition Clean Baltic

[PRELIMINARY VERSION 2019-03-22]

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| TITLE | Recommendations on improving Helcom Recommendation 23/5<br>- *Including a brief identification of major stormwater issues, stormwater pollutants and stormwater treatment methods* |
| REPORT NUMBER | 2019-1393-A |
| CLIENT | Coalition Clean Baltic |
| AUTHOR | Hannes Öckerman, WRS |
| REVIEWED BY | Dimitry van der Nat, WRS |
| EDITION | First draft |
| DATE | 2019-03-22 |
| COVER PHOTO | Stormwater pond in Stockholm suburbs.<br>Photo by: Hannes Öckerman, WRS. |

# Table of Contents

# 1 Introduction and aim

The Helcom Recommendation 23/5 discusses the "Reduction of discharges from urban areas by the proper management of storm water systems". The document was written in 2002 and contains general recommendations mainly on reduction of stormwater volumes and mitigation of oil contamination in stormwater. As new techniques and knowledge have emerged since the document was composed, there is a need to update and revise the document.

This report summarizes current knowledge on stormwater problems and major contaminants, as well as current best management practice, techniques and solutions to treat stormwater, reduce flow and remove contaminants. The report also includes a chapter describing several good examples of well-functioning stormwater systems and sites in the Baltic region. Based on the information reviewed, this document gives a recommendation for an updated version of the Helcom Recommendation 23/5, found in Appendix 1.

# 2 Stormwater pollutants and its sources

Stormwater is defined as runoff, generated from rain or snow, which flows over land or impervious surfaces to recipient water bodies, either as surface flow or via culverts, gutters, swales or ditches. The ongoing urbanization and the sprawling of impervious surfaces cause two major stormwater-related problems; flooding and contamination. The focus on this report is on stormwater contaminants (this chapter) and available techniques for contaminant removal (following chapter).

Stormwater is a diffuse source of a wide array of pollutants to recipient waters. Concentrations and loads of contaminants can vary largely both spatially despite similar land use, as well as in time depending on seasonal variations. Quantifying the contribution of different sources of stormwater pollutants thus poses a challenge. Even removal efficiencies of treatment facilities presented vary largely. It is thus important to realize that all data presented in this report has a relatively high degree of uncertainty.

## 2.1 Nutrients

The leakage of nutrients via urban stormwater per area unit is today in many countries comparable to contributions from agricultural land use. Sources of nitrogen and phosphorous include fertilizers and yard waste. However, the largest contribution to nitrogen load in stormwater usually originates from atmospheric deposition that mostly can be traced back to emissions from traffic and industrial processes. Generally, most of the nitrogen stormwater load is found in a dissolved state.

Phosphorous in stormwater on the other hand, is predominantly in particulate fraction and its sources can be more difficult to trace. Local land use and activities have a large impact on the phosphorous concentrations in stormwater, which is why its main sources can vary geographically. US numbers estimate road surfaces and adjacent grass areas such as road shoulders and embankments to be the major source of phosphorous. Feces from domestic animals can also be an important source of phosphorous from urban areas. Decomposition of leaf litter and other plant parts can contribute with both nutrients and smaller organic particles in the stormwater.

## 2.2 Metals

One of the most significant contributions to metal loads in storm water is traffic (Viklander 2017). Motor vehicles contribute to metal loads in storm water by their exhaust fumes, fuel, oil and other lubricants corrosion and wear and tear of brake pads, tires and road surfaces.

Construction works are generally regarded as the second largest source of metal contaminants in stormwater, but can even be the largest depending on geographical variations, choice of building material and safety precautions taken during the construction process. Zinc and copper can leak from metal sheets, as well as other metals from sheets that are galvanized or welded. Studies have shown that stormwater generally contains higher concentrations of metals and particles suspended in the water during the construction period (of traffic or buildings constructions) in an area compared to when the work is finished (Burton Jr. 2001).

There are several metals which can be found in significant concentrations in stormwater, however, copper, zinc, chromium, nickel and lead are most commonly associated with stormwater pollution and are good indicators of water quality.

## 2.3 Micro litter and plastics

Micro litter is defined as man-made particles with a size smaller than 5 millimeters. Many of the particles are composed of plastic derivatives but can also be of other synthetic materials. Microplastics occur in stormwater both as intentionally produced primary products, and as secondary ones which are formed during the use and wear of other products.

Studies in Sweden, Norway, Denmark and The Netherlands have all identified traffic as the largest source of micro plastics in stormwater. Main contributions originate from, abrasion of car tires but also of road marking paint and other traffic related materials (Sundt et al. 2014; Verschoor et al. 2014; Lassen et al. 2015; Magnusson et al. 2016).

The Swedish study concludes that out of the quantifiable sources, artificial turfs and surfaces (for instance artificial football fields and playground areas where rubber granulates are used) constitute the second largest source of micro plastics in storm water (Magnusson et al. 2016). Danish and Norwegian studies conclude that fragmentation of plastic litter is a major source of marine microplastic contamination (Sundt et al. 2014; Lassen et al. 2015) even though the studies do not estimate the micro plastic load from littering.

A more recent study ordered by the municipality of Stockholm states that some of the most feasible and cost-effective measures to lower the levels of micro plastics in storm water is to minimize littering from public spaces and construction sites. The authors point out clarification of responsibilities, cooperation within the municipality, more refuse bins that are emptied more frequently and less consumption of disposable plastic articles as possible measures (Ejhed et al. 2018).

Other probable sources of microplastics in stormwater are industrial production and handling of primary plastic, surface treatment and painting of buildings and plastic recycling facilities (Swedish Environmental Protection Agency 2017).

## 2.4 Organic compounds

There are many different organic compounds to be found in stormwater. Some of the major categories are listed below with a short description of possible sources. Many of these organic compounds enter the stormwater via traffic and building materials. Some can also be derived to industrial processes, where the type of industry plays a large role on the quantity and type of contaminants in the effluent.

- Polycyclic Aromatic Hydrocarbons (PAHs) – sources include exhaust fumes, car tires, road coating, bitumen (asphalt, also used sometimes as roof cover).
- Alkyl phenols - a group of industrial chemicals which can be found in many products such as detergents, car tires and paints. Even exhaust fumes from vehicles contribute to emissions of alkyl phenols.
- Phthalates - mainly a plasticizer, occurring in amongst others car paint and building materials.
- Perfluorinated alkylated substances (PFASs) - enters stormwater mainly through the use of firefighting foam.
- Polychlorinated biphenyls (PCBs) - Main sources are lubricants, hydraulic oils, exhaust fumes, and roof and facade paint. Concentrations of PCBs are declining since their phase-out started in the 1970s.
- Pesticides – usually originate from building material, lawns and parks.

### 2.4.1 Oil

Oil is also an organic compound consisting of hydrocarbon chains. The commonly used analysis method "oil index" gives an indication of oil content in stormwater but the method only detects some hydrocarbon chains, and not those included in petrol for instance.

Sources of oil can be unintentional spills, vehicle (engine oil, brake oil) and cistern leakage, traffic accidents, erosion of tires and roadway, vehicle and street washing, gas stations and incomplete combustion (Larm and Pirard 2010).

# 3 Stormwater treatment techniques

In an earlier report written by WRS for Coalition Clean Baltic (2017), different stormwater treatment techniques were described in detail. This earlier rapport described aspects such as climate change issues and where in the stormwater chain the measures should be incorporated. The descriptions below aim to briefly describe the principle function of the techniques and roughly what level of stormwater pollutant removal can be expected. As for nutrients, metals, oil and some of the most common organic compounds, there are several studies on removal efficiencies of different stormwater treatment techniques, while there are very few studies on microplastics and more recently detected anthropogenic pollutants, such as PFAS.

## 3.1 Oil separators

Oil separators are mainly designed to remove higher concentrations of oil contaminants and their removal efficiencies for lower concentrations of oil and other volatile pollutants are limited. They are suitable as a complement to other stormwater facilities where there is a need of protection against temporary, larger spills of oil; for instance, at bigger parking areas or fuel stations.

An oil separator consists of a tank through which the water flows. It works according to gravimetric principles where substances lighter that water (such as oil and petrol) settle in a layer on the water surface and are prevented from flowing out of the tank by a screen or a similar device. Under low flow conditions, some larger particle-bound metal contaminants are also removed through sedimentation.

## 3.2 Technical filters

Filters can be installed in existing stormwater drains and can therefore be an option in already densely urbanized areas. They are most applicable in areas with moderate to high contaminant loads and places that lack the spatial requirements for the implementation of other techniques, such as for instance parking lots, industrial areas, gas stations and other densely urbanized areas.

The choice of filter substrate determines the removal efficiency of different contaminants. Examples of filter material include bark, wood fiber, zeolite, polypropylene, peat, activated carbon and iron hydroxide. Most filters can remove some of the particle-bound phosphorous and metals, as well as some organic compounds such as PAH. They have, however, not proven efficient in removing oil or any of the dissolved fractions of metals, nor nitrogen.

## 3.3 Green roofs

Vegetated roofs receive relatively clean rain water, which is why pollutant removal often is seen as secondary to runoff reduction (through evaporation, uptake by plants and storage in the soil). As some studies have shown a low net rate of nutrient leakage from green roofs it is considered important to avoid the need for regular fertilization (an initial fertilization at the establishment of the plantation can be justified). It is important to choose plants that thrive in nutrient-poor conditions.

## 3.4 Bioretention and infiltrations paths

Bioretention areas (also called "rain gardens") and infiltration paths are two techniques that work in similar ways. Rain gardens are used as on-site management close to the source whilst infiltration paths are regarded as slow drainage pathways between the source and the recipient water body. They are green low-lying areas that can be temporarily inundated and are covered by grass and/or other vegetation adapted to both dry and temporary wet conditions. Because these stormwater facilities have elevations lower than adjacent areas, they provide a storage volume for stormwater retention above ground. Retained water can then infiltrate through a topsoil layer where nutrients, particles and contaminants are removed both by the vegetation and the soil medium. Below the top soil there is usually a drainage layer for further transportation, either to the groundwater or to the stormwater system.

Adequately dimensioned bioretention or infiltration facilities have been shown to effectively remove between 60 to 80 percent of phosphorous, most metal pollutants (such as copper and zinc), particles, PAH and oil. By retention in the filtrating soil layer and to some extent even uptake of the vegetation, these facilities can also remove part of the dissolved contaminants (such as nitrogen) that occur in stormwater.

## 3.5 Permeable surfaces

As an alternative to traditional asphalt and concrete surfaces, different kinds of permeable surfaces can be used which still have enough bearing capacity for vehicles but at the same time allow water to infiltrate instead of running off. Gravel, permeable pavers, permeable asphalt and paving with permeable joints are some examples.

Pollutant removal of permeable surfaces is generally high since the removal occurs in several steps; sedimentation, filtration and immobilization in the soil. Thus, generally between 50 and 90 percent of pollutants are removed in both particulate and dissolved form. Permeable surfaces are especially suitable for parking areas, streets and roads since they can also contribute to the removal and decomposition of oil and most other organic compounds. It is crucial, however, for the long-term operation of the facility that is regularly serviced (vacuuming/washing) in order to maintain its infiltrating capacity.

## 3.6 Infiltration on green surfaces

A simple, robust and cost-effective measure to detain and clean stormwater is to spread it out on a green surface. Here, both the vegetation and the soil contribute to flow reduction and pollutant removal of stormwater diverted from close-by roads, streets, parking lots, roofs and residential courtyards. It is desirable that the top soil layer has a high infiltration capacity. Sand can be used as a main component, or gravel mixed with compost. Green surfaces as stormwater treatment are most suitable in places with access to more space as the technique has a relatively large surface requirement.

The pollutant removal of green surfaces has been shown to be high. Particle-bound pollutants are removed in the interval 60 to 95 percent (phosphorous and the majority of metal pollutants) but also dissolved substances are retained in the infiltration process. Nitrogen, for instance, is usually removed by 80 to 90 percent.

## 3.7 Swales and dry ponds/flooding areas

Swales are wide green ditches with gentle side slopes constructed on a level below the road, street or surface from which the stormwater is being diverted. They are usually bowl-shaped with a grass-covered top soil layer. with. The main purpose of a swale is to provide a stormwater pathway with slow flow velocity in order to increase the residence time for stormwater.

A similar treatment technique is the use of dry ponds, also called flooding basins. Similar to swales, they are typically constructed below street level elevation grass-covered and retain water to protect flood prone areas downstream and reducing stormwater flow velocity. While swales are used as pathways, dry ponds are usually used as an "end-of-pipe" solution to provide retention before the recipient or low-lying areas that need protection from flooding. Outlets are generally placed below ground level meaning that ponds completely drain during dry periods. Under wet conditions when the ponds begin to inundate it is important that water is spread evenly over the surface to avoid channel building processes that would lead to increased flow velocities. After flooding, the water can slowly drain either by infiltration (if the topsoil layer allows for it) and/or via a throttled outlet or ditch.

Both treatment techniques foremost remove stormwater pollutants through sedimentation due to reduced flow velocity. Coarse particles are removed to a high extent and even finer particles are typically removed to a certain degree, meaning that the removal efficiency for metals and phosphorous is moderate to quite high. Additional pollutant reduction can be achieved with increased residence time and porous soil conditions. Both these factors facilitate infiltration rates and thereby removal of fine particulates and dissolved substances such as nitrogen and fractions of some metals. Even vegetation in swales and dry ponds can contribute to pollutant and nutrient removal. Both swales and dry ponds have been shown to be able to remove 60 to 80 percent of oil and PAH. These pollutants are partly caught onto the vegetation where they are decomposed when the surface dries up and is exposed to sunlight. Oil can also be decomposed in in the soil layer.

## 3.8 Infiltration trenches

Infiltration trenches fill a similar purpose to swales; retaining and diverting stormwater in order to reduce the flow and achieve some pollutant removal through sedimentation and infiltration. Infiltration trenches require less surface area than swales since the detention volume is created by filling a trench with about a meter depth of crushed rock (stone and gravel fractions of different sizes excluding the smallest fractions). A drainage culvert at or near bottom level is often installed to ensure slow drainage after periods of heavy rain.

The primary pollutant removal mechanism is sedimentation and removal efficiencies for particle-bound pollutants (such as phosphorous and the majority of metals) are estimated to be50 to 90 percent. The removal efficiency is also relatively high for organic compounds such as oil and PAH while dissolved pollutants are removed at lower rates. However, estimated removal efficiencies are uncertain as only very few studies have been made on infiltration trenches. Higher removal rates can be established by using smaller fractions of gravel/aggregate and putting the drainage pipe at a certain level above the bottom of the trench.

## 3.9 Stormwater ponds and artificial wetlands

Stormwater ponds and artificial wetlands are usually a so called ”end-of-pipe" solution to retain and remove pollutants at the end of the stormwater system. Ponds and wetlands can show large similarities and can be often be difficult to distinguish. Typically, ponds are deeper and have less emergent vegetation than wetlands, but often ponds nevertheless have more shallow parts that resemble wetlands. Wetland on the other hand often have deeper sections that are reminiscent of ponds.

In ponds, pollutant removal is mainly achieved by the sedimentation of particle-bound compounds. Further removal can be achieved by increasing the biomass in and around the pond, as the vegetation and biological processes can reduce the concentrations of dissolved pollutants. Therefore, wetlands usually have a higher potential of pollutant removal.

Wetlands and stormwater ponds with a vegetative zone generally remove phosphorous and metals well at 50 to 60 percent. If the facility contains larger shallow areas with plenty of vegetation, biological processes can also contribute to further pollutant removal such as immobilization of nitrogen and other dissolved substances. A well dimensioned pond or wetland where smaller particles have enough time to settle also has the potential to remove oil, organic compounds and pathogens.

A Swedish study by Jönsson (2016) indicated that  stormwater ponds and artificial wetlands have potential capacity of effectively reducing concentrations of microplastics.. The main principle behind microplastics removal is expected to be sedimentation but additional studies of microplastics removal are required to further investigate.

## 3.10 Overland flow systems

An overland flow system can be described as a moderately inclining grass surface that are inundated with evenly distributed sheet flows of stormwater. As the water slowly flows over the surface, particle-bound contaminants settle or adhere to vegetation. Organic substances and dissolved matter are immobilized and decomposed. Biological process that degrade organic substances are enhanced by intermittent periods of inundation and dry periods. At the downstream end of the grass surface there is usually a ditch for collecting and rerouting treated stormwater. Overland flow systems can be installed to handle stormwater from roads and parking areas, but even as a final "end-of-pipe" solution for a larger catchment.

As for many other stormwater facilities, pollutant removal efficiency of overland flow systems depends on design, dimensioning, pollutant concentrations in the incoming stormwater and the properties of the underlying soil. Properly designed and dimensioned, they are able to remove up to 80 percent of most metals and phosphorous. Average facilities, however, remove approximately 50 percent. The vegetation and microorganisms also contribute to some pollutant removal, both of particle-bound and dissolved substances through decomposition and immobilization. In order to remove substantial loads of dissolved pollutants, such as nitrogen, it is important that the infiltration capacity of the topsoil layer is good.

Several stormwater facilities, including overland flow systems, are designed to remove metal pollutants through immobilization/sorption in the soil layer, which leads to accumulating metal concentrations over time. A study performed by Forsberg (2015) indicate, however, that the time required for the soil to reach "sensitive land use" is relatively high for most metals, ranging from 50-60 years to several hundred years.

## 3.11 Possible treatment techniques for microplastics

Few studies have been conducted on removal techniques and mechanisms, of microplastics in stormwater. This paragraph discusses potential for microplastic removal as the authors see it but we want to point out that empirical data on microplastic removal is scarce and our recommendations therefore have a large degree of uncertainty.

Several suppliers of stormwater filters claim significant reductions of microplastics in their products. It is possible that filters, mainly working as physical barriers, could be a suitable on-site treatment in stormwater wells close to the source, i.e. around artificial turfs and traffic-related areas. The filters need to be designed with suitable pore sizes to separate the microplastic particles from the stormwater and retaining them in the filter. This would also allow for recycling of for instance granulate from artificial football turfs. Filters can be made of different materials, but those made out of plastic compounds run the risk of being punctured by cigarette butts. Stainless steel could therefore be a more suitable option.

As there are good indications that artificial wetlands and stormwater ponds can be efficient mechanisms to remove microplastic content (Jönsson 2016), other treatment techniques that rely on flow reduction and subsequent sedimentation (dry ponds/flooding areas, swales gravel ditches and permeable surfaces) could also have the potential to remove microplastic from stormwater. These include

Furthermore, techniques that operate with pollutant removal through infiltration in the soil layers could possibly remove microplastic from the stormwater. If the particle sizes of the microplastic correspond with the sizes of the pores in the ground, the soil layer could work as a physical barrier. Also, small microplastic particles could possibly obtain an electrostatic charge and therefore bind to soil/clay particles with the opposite charge. It is doubtful, however, that microplastic could be retained in the soil layer in any significant amounts through biological or chemical processes, as its properties are diverse and differ from those of metal and phosphorous compounds or ions.

# 4 Examples of well-functioning stormwater systems

As an inspiration we list a number of examples of successfully incorporated stormwater management in the urban landscape from the Baltic region below. All examples have been developed through the concept of Low Impact Development (LID), where local and small-scale design techniques are used to mimic the original (natural) hydrology pattern of a site. The techniques all use natural processes to infiltrate, filter, store, evaporate and retain stormwater runoff close to its source. LID techniques are also known as stormwater

Best Management Practice (BMP), and usually show a more cost-effective and environmentally more beneficial way of handling rainwater compared to conventional systems.

## 4.1 Augustenborg, Malmö (SE)

Augustenborg is a 20-hectare settlement in the city of Malmö which is an excellent example of a sustainable open stormwater management in an existing neighborhood. Augustenborg had recurring cellar flooding before the decision was made in the 1990s to reconstruct the neighborhood into an "eco-village", including the stormwater system. The basic idea was to take care of as much of the stormwater as possible near the source and to handle any excess water in an open drainage system.

Some of the techniques applied in Augustenborg include:

- Local infiltration on vegetated roofs, lawns, permeable paving, parking lots etc.
- Flow detention in ponds and on green areas dedicated for temporary flooding
- Slow transport in swales, ditches, canals etc.

The new integrate system has worked well. During the cloudburst rainfall in the summer of 2014[1], Augustenborg suffered significantly fewer damages than other parts of Malmö.

Further reading
Stahre, P. (2008) *Blue-green fingerprints in the city of Malmö, Sweden* (pp. 42-60). Available: https://greenroof.se/gr-16/wp-content/uploads/2017/04/BlueGreenFingerprintsPeterStahrewebb.pdf

## 4.2 Norra Djurgårdsstaden, Stockholm (SE)

While the integrated stormwater management in Augustenborg was developed in an existing neighborhood, Norra Djurgårdsstaden of Stockholm is an example where sustainable stormwater systems have been implemented already during the construction phase. Situated adjacent to Lake Mälaren, Stockholm's drinking water reservoir, the municipal requirements for stormwater treatment and retention for Norra Djurgårdsstaden were put high. The strategy for the new neighborhood was to:

1. Infiltrate the stormwater locally as close to the source as possible in order to reduce stormwater volumes.
2. Retain stormwater locally to reduce peak flows.
3. Reserve areas for secondary stormwater management within the system.
4. Treat the "dirty" stormwater in several steps in order to meet requirements stating that the pollution load on Lake Mälaren should not increase after construction compared to a before scenario.

This has been done by implementing rain gardens, green roofs and planting trees in structural soils for local stormwater management in parks, streets and courtyards. Green areas in parks have been constructed as low points in the landscape where excess

[1] On August 31st, 2014, around 120 mm of precipitation fell during 6 hours in some parts of Malmö, corresponding to a rainfall of 360 years return time.

stormwater is allowed to infiltrate and buildings are constructed on elevations above predicted stormwater flooding.

## 4.3 Tåsinge plads, Copenhagen (DK)

Tåsinge plads in Copenhagen is a reconstructed town square. More than 1 000 $m^2$ of asphalt has been transformed into a stormwater garden and a "climate block". The plaza collects rainwater from the surrounding roofs and roads. The road water flows into roadside swales which contain infiltration trenches. Here the stormwater infiltrates through a thin layer of filter earth to remove contaminants such as oil.

The roof water is diverted through drain pipes underneath the square into a large reservoir. On its way to the reservoir, it undergoes multiple purification steps so that it actually becomes clean enough for children to play with. The square also contains submerged plantations where stormwater is diverted during heavy rainfall in order to infiltrate gradually.

Further reading
City of Copenhagen et. Al. (2015). *Tåsinge plads.* http://klimakvarter.dk/wp-content/uploads/2015/06/T%C3%A5singeplads_pixi_2015_UK_WEB.pdf

## 4.4 Norra Böle, Helsinki (FI)

This is the first natural stormwater solution close to central Helsinki. It is located in a park where nearby stormwater from residential areas and roads is diverted initially to a pre-sedimentation pool that removes the coarser material. The stormwater is subsequently lead to a biofilter pond (dry pond) which removes pollutants through filter layers consisting of sand, and gravel followed by meadow and wetland vegetation. The treatment plan aims foremost at removing nutrients and metals.

## 4.5 Along river Svete, Jelgava (LT)

In Jelgava there are recurring problems with flooding from the adjacent river. The stormwater challenge here has been to upgrade an old conventional stormwater system consisting of channels, pipes and a main draining ditch.

Green solutions have been chosen in order to reduce the risk of flooding as well as reducing the pollutant load on the river. Wetlands or marshland (cane fields) have been constructed as well as several lowered areas with increased moisture level. The stormwater system has also been supplemented with sedimentary basins to allow for pollutant removal before runoff into the river. Both the wetlands and the sedimentary basins are at groundwater level during normal water levels but are allowed to flood during high water levels. Other measures that have been taken are new drainage ditches and elevating some carriage ways that are prone to flooding.

## 4.6 Hoppegarten, Berlin (DE)

Hoppegarten, situated in the periphery of Berlin, had severe stormwater problems during the 1990s as receiving waters had low additional volume capacity and infiltration capacity in the area was poor. To solve the issue, an engineering company developed the "The Mulden-Rigolen system" which is designed to mimic the pre-development pattern of an urban area.

The system is based on infiltration in swales built on green spaces along private roads or on private property. Rainwater is diverted to the swales and infiltrated through an active topsoil layer of 10-30 cm where retention and degradation of pollutants occur. It then continues down below into a gravel trench where the stormwater is temporarily stored and gradually emptied through infiltration into the surrounding soil. Here, a drainage pipe is also usually installed in order to divert larger stormwater flows.

The system has shown to significantly reduce stormwater flows into the conventional systems as well as reducing the pollutant loads of nutrients and metals. It has been implemented in several other cities of Germany, including Berlin, Dortmund and Hamburg.

Further reading

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# 5 Suggested updates of Helcom Recommendation 23/5

Based upon the current knowledge on stormwater pollutants, treatment techniques and the experiences of well-functioning LID and BMP stormwater systems, a suggested draft of a new Helcom Recommendation has been elaborated in Appendix 1. The suggested draft contains the following eight categories:

A. Embrace a holistic view to develop a sustainable stormwater management
B. Upstream measures
C. A transition from combined sewer systems to separate sewer systems combined with Low Impact Development (LID) systems and recycling
D. Flow retention
E. Limiting pollutant load to surface water recipients
F. Inventory and identification of "hot spots"
G. Smart planning
H. Planning for the future

Some of the changes we are suggesting include:

- The recommendations need to cover a wider range of the issues, problems but also possibilities with stormwater management in urban spaces than the current recommendations that focus solely on oil.
- We suggest that the recommendations should encourage local authorities and actors to work with stormwater systematically and in all stages of municipal planning.
- One of the most cost-effective measures to reduce stormwater pollution load is to plan for a sustainable stormwater system early with new development.

- Another cost-effective measure is to identify and remedy emissions from potential “hot spots” such as different industries, harbors, petrol stations and similar areas.
- We see the Water Framework Directive (WFD) as a suitable legal base to work from when planning for stormwater measures.
- Regarding stormwater pollutants, much focus is put on limitation of oil in the existing recommendation. A more thorough approach should include all common stormwater pollutants and water quality parameters from the WFD such as nutrients, metals, organic compounds (including oil), microplastic and other compounds of anthropogenic origin. As acceptable pollution loads differ locally, focus should lay on identifying the local stormwater quality issue(s) and design treatment methods to address that/those issue(s).
- Generally, a local stormwater management with on-site treatment should be sought after, but also needs to be complemented with treatment to reduce flow and pollutants along the whole stormwater system.
- Combined sewer overflows (CSO) implicate the discharge of untreated overflow from sewage treatment plants and is a significant source of nutrient transport. Disconnecting stormwater from the sewage water grid (i.e. through local management) should be given high priority. As a second (or parallel) measure, a switch to duplicate separate drainage systems for sewage and stormwater is desirable.

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# Appendix 1

This text is proposed to replace points A 1-5 and B 6-7 of the Helcom Recommendation 23/5.

**A. Embrace a holistic view to develop a sustainable stormwater management**

1. Preserve the water balance and the natural hydrology. The natural water balance and the existing groundwater should not be affected negatively by urban development.
2. Plan according to the status of the receiving water body (recipient). The stormwater management must enable recipients to achieve or maintain good ecological and chemical status.
3. Create a robust stormwater management. The stormwater systems should be designed in a way to avoid or minimize damage to public and individual property and interests.
4. Stormwater systems should be designed if possible, to enrich the urban landscape. Stormwater can be used as a resource and has the potential to contribute to an attractive urban landscape.
5. Acknowledge other interests. In urban development, aim at intertwining interests of other actors into the development of stormwater management, rather than separating them.

**B. Upstream measurements**

1. The main focus should always be to minimize the pollutant load at the source. Minimizing pollutant emissions at the source reduces the need of measures further downstream.
    a. Streets and paved surfaces should be cleaned regularly and preferably before large rainfalls in order to prevent pollutants originating from vehicles to be transported with the stormwater.
    b. In urban areas with cold winter conditions, deicing on roads, with for instance salt and sand, should be done with moderation, balancing the interest of person safety and environmental impact.
    c. In urban areas with cold winter conditions, a strategy should be developed for snow plowing and handling that actively avoids heavily polluted snow masses from reaching the stormwater system untreated.
    d. Petrochemical waste, oil polluted waters and other industrial pollutants should be collected and if possible, treated at the source.
    e. New development and buildings should be designed and constructed with outer materials and paint on roofs and facades that do not jeopardize the environment. Unsuitable materials found in construction work include i.e. zinc from galvanized surfaces, cadmium from dyes and paints and copper used on roofs.
    f. Vegetated surfaces in urban areas should be planned in order to avoid or minimize the use of pesticides and fertilizers.

g. Routines and materials for artificial surfaces should be adapted to minimize the spread of, for example, microplastic.

2. Communication and information aimed at the public, industries and businesses should be carried out systematically in order to prevent and minimize emissions of stormwater pollutants.

**C. A transition from combined sewer systems to separate sewer system to Low Impact Development (LID) systems and recycling**

1. In general, a local stormwater management and on-site treatment is desirable.
2. In areas with existing combined systems:
    a. A switch to duplicate systems and/or LID systems should be prioritized in order to avoid overflows in the sewage system
3. In areas with existing duplicate systems:
    a. LID systems should be implemented where needed in order to reduce stormwater flows and pollutant load to recipient. Regards need to be taken to cost, feasibility and the potential improvement of water quality.
4. In new development areas:
    a. Stormwater should be managed as close to the source as possible in order to avoid increasing flows and pollutant emissions.
    b. Stormwater from paved surfaces should be retained and, if necessary, treated in LID systems before subsequent discharge to culverts, ditches or surface water recipients.
    c. Only as a last option should the stormwater be directly diverted to the existing stormwater system.
    d. For high intensity rain events, secondary runoff paths should be prepared to divert stormwater exceeding the stormwater systems capacity, preferably to suitable low-lying areas that can be used as temporarily flooded retention basins. Buildings and infrastructure should be planned on adequate elevations to avoid damage during flood events.
    e. “Clean” stormwater from roofs and similar surfaces should preferably be collected and reused for irrigation of trees and plantations, flushing toilets and other suitable activities.

**D. Flow detention**

1. Locations should be identified where it is strategic to minimize and reduce the stormwater flow. This could include infiltrations systems (under favorable soil conditions) or creating temporary storages volumes for high flows.
2. Stormwater from larger paved areas, such as bigger parking lots and roofs, should always be retained and treated before discharge to the stormwater network.
3. In the urban planning process, impermeable surfaces should be kept at a minimum in favor of permeable and vegetated surfaces in order to reduce stormwater runoff.
4. Infiltration of stormwater should be prioritized as the preferred technique in all situations, in order to reduce runoff and maintain groundwater recharge.

Stormwater that carries high pollutant loads (i.e. from larger highways or thoroughfares) may need pretreatment before infiltration in order to avoid pollutants from reaching the groundwater.

**E. Limiting pollutant load to recipient**

1. The Water Framework Directive of the European Union and its accompanying Environmental Quality Standards (EQS) should guide the work of limiting stormwater pollutant loads to recipient water bodies.
    a. Both nutrients and heavy metals are water quality parameters that have implications for a water body's ecological. The classification of individual water body's status can be used to determine acceptable stormwater loads of these pollutants.
    b. Regarding a recipient's chemical status, there are EQS not to be exceeded of certain priority substances, of which many are found in stormwater.
2. Substances directly hazardous to the aquatic environment should not be used when washing boats, cars or other vehicles
    a. Boats should be placed on grassy or gravel surfaces where water can infiltrate as far as possible from stormwater wells and the recipient water body.
    b. Cars and vehicles should be washed in certified washing stations equipped with necessary treatment systems. Cars and vehicles should never be washed directly on streets, pavements or other impervious surfaces.
3. Stormwater considered to be heavily polluted, i.e. from larger parking lots, distribution terminals, heavily trafficked roads, industrial areas with environmentally hazardous activities, and central urban areas should always be treated in stormwater treatment facilities. Stormwater from larger parking lots should pass through an oil separating function, either technical or biological.
4. Stormwater facilities should be adequately dimensioned for treating stormwater based on removal efficiencies found in scientific literature.
5. Stormwater facilities aimed at pollutant removal should be designed and optimized to remove those pollutants identified as the most important ones in the local setting, in relation to the emission load and the acceptable load on the local recipient.
6. New and future knowledge regarding pollutants should be followed and incorporated in future stormwater strategies, such as sources and transport of microplastic, PFOS and other lesser studied substances.

**F. Inventory and identification of "hot spots"**

1. An inventory of the local stormwater impact should be carried out for catchments. In this inventory, necessary measures to be taken should be identified and prioritized.
2. Critical spots where accidents can lead to potential major pollutant emission to stormwater (i.e. oil tank leakage) should be identified. Preventive measures

should be implemented to avoid negative impacts downstream in case of spills and accidents (i.e. installing a sufficiently large oil separator).

3. “Hot spots” of potential high pollutant risk should be identified and prioritized. These could include distribution terminals, certain industries, harbors, fuel stations and other potentially environmentally hazardous activities with potential emissions near the stormwater grid or the surface water recipient.
4. Businesses and activities that classify as “hot spots” must meet requirements to treat stormwater from their facility before discharging it to the stormwater system or recipient water body.

**G. Smart planning**

1. All stormwater planning should be catchment based and take the natural runoff paths of stormwater into consideration. Water often does not follow municipal or other legislative borders!
2. Municipalities or corresponding authorities should develop stormwater policies and/or plans in order to systematically work with stormwater issues.
3. Stormwater should be considered early in the urban planning process and at every stage of the process in reconstruction and new developments. This is usually a very cost-efficient way of mitigating stormwater issues.

**H. Planning for the future**

1. Stormwater systems and facilities should be planned, designed and dimensioned according to future predicted scenarios of climate change, including predictions of changing precipitation volumes, changing patterns of precipitation intensity and rising water levels in seas, lakes and rivers.
2. A clear and fair distribution of responsibilities (costs, maintenance etc.) between different actors needs to be embedded within the local administration.
3. Stormwater systems and facilities (both mechanical, technical and biological) should be maintained and monitored regularly, in accordance with the need of each individual facility. It needs to be clearly stated which actor(s) are responsible of carrying out maintenance and monitoring.
4. The stormwater management should be systematically reviewed and changed when new measures are implemented in the urban space, such as roads, streets and town squares.