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Strategies for stormwater quality assessment

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Legislation - Stormwater Management

- There is no EU Directive regulating stormwater nor, in general, set national discharge limits set.
- Country-specific and case specific procedures are applied.
  - Can be and should be integrated into River Basin Management Plans under the Water Framework Directive
  - Poland: TSS and oil index
  - Finland: (se next slide)

Legislation – Finland as an example

- The assessment of the needed stormwater treatment is often voluntary and based on local consideration
- There are no exclusive environmental regulations for stormwater in Finland
- Environmental permits may still have obligations concerning stormwater, especially in groundwater

Promenade tunnel at Pori train station 2007. Picture: Jari Hietala.
Source: https://www.talouselama.fi/uutiset/pori-voisi-kokea-houstonin-tulvaa-muistuttavan-suurtulvan-vahinkojen-arvo-voisi-olla-3-miljardia-euroa/f2a559ad-dc22-3d2a-9005-3e5e546bdb3a

Strategies for stormwater quality assessment

- Select sites expected to have a high negative environmental impact on the recipient
- **Take appropriate samples**
- **Select relevant parameters to analyse**
- **Determine stormwater quality**

and

- Depending upon impact and legislation choose suitable treatment strategies

Take appropriate samples!

Photo: Municipality of Söderhamn

Factors influencing stormwater characteristics

- Bedrock and natural catchment characteristics
- Land use
  - % Impervious surface
  - Anthropogenic activity
- Precipitation
  - Amount and pattern
  - Season

Helsinki, Finland, 5 year study, major ions (Taka et al. 2016) Median and min-max values presented

- Intensity of land use is influencing the levels of pollutants.
- Overall largest load of ions from diffuse sources were detected during summer and autumn
- Na and Cl which is used in road salt (point source) and they were most abundant during winter

Parameter	W1 Intense	W2 Medium	W3 Low
% Imp area	65.7	52.0	36.3
Na	51.3 (1.9-1017.5)	17.3 (3.6-237.8)	9.9 (3.3-84.0)
Cl	76.3 (0.0-1714.9	22.0 (3.7-352.8)	9.6 (1.5-132.4)
NO_3	10,7 (0.1-164.6)	7.1 (1.9-30.0)	5.8 (1.4-18.0)
SO_4	33.2 (4.4-116.7)	14.5 (3.9-44.9)	24.4 (2.1-83.4)
TDS	303.6 (53.7-4829.0)	139.0 (4.0-505.0)	117 (21.2-789.0)

Devote time and resources to sampling and analyses! Concentrations will vary spatially and temporally!

How should stormwater be sampled?

- In an ideal world Event Mean Concentrations (EMC) and Site Mean Concentrations (SMC) should be calculated.

  For this purpose flow-weighted sampling using an autosampler is recommended during several rain events and different seasons. Still data from more than 10 rain events (depends on parameter measured) might be needed for determining Site Mean Concentration

  To reduce the number of samples analysed during one event a flow-weighted composite sample may be analysed.

For flow-weighted composite samples (i.e. flow weighted discrete samples collected in one container) the pollutant concentration is assumed to represent the entire composite sample and by taking a representative sample from the flow-weighted composite the pollutant load can be calculated according to;

$$M = V_T C_C$$

Where:

M=total mass of pollutant

V_T= total discharge volume (V_T=nV)

C_c = composite sample pollutant concentration in sample i

Assessment schemes tested in the NOAH project can be applied to EMC and SMC

- Water quality parameters – the most stringent condition for effluents from WWTP to the Baltic Sea.
  - Legislation: EU 91/271/EEC (2014) and national guidelines.
- Water quality parameters – the most stringent condition in surface water in the Baltic Sea
  - Legislation: According to WFD and EQS Directive, classification according to ¨other water¨ if no special regulation for transitional waters and coastal areas
- **¨Gothenburg values¨ with additional parameters as suggested in the NOAH project**
  - Guideline values for industry wanting to make discharges to inland recipients or separate sewers.
- General characteristics of stormwater (No specific regulation).
  - Water quality assessment has been conducted using Stormtac Web database 2019 for similar land use.

The Gothenburgs values (2020)

Riktlinjer och riktvärden för utsläpp av förorenat vatten till dagvattennät och recipient R2020:13

- Guideline values for discharge to stormwater networks or recipients
  - Values set for inland water independent of recipient sensitivity
  - Valid for continuous or temporary discharge
  - Values are set based upon the maximal concentration (MAC-EQS from the EQS Directive) when applicable.

    - Values are strict but they are guidelines and not set discharge limits. Not used very often so far (used for stormwater from big constructions sites and landfill leachate).
    - No dilution in recipient is expected.
    - Dissolved concentrations of metals (from EQS) have been multiplied by two to get total concentrations of metals.
    - To the list we have added indicator organisms of faecal origin from the Bathing Water Directive and unionized ammonia. The presences of road salts or other deicing solutions should also be monitored.

Accounting for exposure duration in EQS for pelagic species (water column)

- Long term standard
  - AA-EQS, Annual average normally based upon **chronic toxicity** data
- A short term standard to protect for storm events or shorter use of chemicals for example for pesticides).
  - MAC-EQS, Maximum Allowable Concentration which is based upon **acute toxicity** data. These have been used when applicable to derive the Gothenburg values.

Transitional waters-
EQS for freshwater vs saltwater species

- At salinity levels between 3 and 5 ‰ there is a shift from a community dominated by freshwater species to a community dominated by saltwater species. As a default a cutoff value of 5 ‰ is recommended. The Bothnian Sea in the Baltic Sea is a brackish water body that has a salinity around 5 ‰ and it has so far been treated as a saltwater system. (TGD 2018).
- Observe! Metal bioavailability is different in saltwater compared to freshwater and consequently for metals, EQS are usually set differently for marine vs freshwater species. However, for organic pollutants the starting point is always to derive an EQS that is valid for both freshwater and saltwater species.

Metals and metalloids

- For some elements the total concentration is used in the EQS. For other elements such as Cd, Pb, Hg and Ni it is referring to the dissolved phase after filtration through a 0.45 um filter or any equivalent pre-treatment. This dissolved phase is considered as the bioavailable fraction.

- For some elements natural background concentration is used by using the added risk approach (ARA).
  - The natural background concentration should then be subtracted from the measured environmental concentration and the resulting value should be compared with the
    - Sweden, Denmark for national priority pollutants

The approach depends on the knowledge about natural background conditions and how different environmental factors affect metal bioavailability.

Gothenburg values and additional parameters

Parameter	Guideline value[1]
Routine parameters	
pH	6,5-9[2]
Total Suspended Solids (mg/l)	25[2]
Organic sum parameters	
Total Organic Carbon (TOC) (mg/l)	12[3]
Eutrophying substances (µg/l)	
Total phosphorus (TP)	0.050[3,4]
Total nitrogen (TN)	1250[3,4]
Half-metals, metals and metalloids (µg/l)[4]	
As (Arsenic)	16[2,5]
Cd (Cadmium and its compounds)	0,9[2,5]
Cr (Chromium)	7[2]
Cu (Copper)	10
Hg (Mercury)	0.07[2,5]
Ni (Nickel and its compounds)	68[2,5]
Pb (Lead)	28[2,5]
Zn (Zinc)	30[2]

Organic micropollutants (µg/l)	
Benzo (a) pyrene indicator of PAH	0.27[3]
Benzene	50[3]
Methyl-t-butyl ether (MTBE)	2600 µg/l[3] 500 µg/l within water protection area in Göta älv, 15 µg/l close to raw drinking water intake (approx. 1-2 km upstream)
Polychlorinated biphenyls (PCB)	0.014[3]
Perfluoroalkyl substances (PFAS)	0,09[3]
Tributhyltin (TBT)	0.0015[3]
Trichlorethylene	10[3]
Oil (µg/l)	
Oil index	1000 µg/l 500 µg/l within water protection area in Göta älv, 100 µg/l close to raw drinking water intake (approx. 1-2 km upstream)
+ extra recommended parameters as discussed in the NOAH project	
NH_3-N (HVMFS 2019:25)	MAC: 6.8 µg/l AA: 1.0 µg/l
Microorganisms (cfu/100 ml) – Bathing Water Directive	
Interstinal enterococci	200/400/330
E.coli	500/1000/900

Footnotes

[1] *becomes a limit value after legal decision on discharge*

[2] *mandatory to monitor*

[3] *depends on discharge and discharge point*

[4] *mandatory for continuous discharges*

[5] *total concentration assuming that 50 % occurs in dissolved form*

Conclusions and suggestions for the future

- **Taking representative samples for stormwater assessment needs planning, patience and financial resources** however, these data are extremely important for increasing the knowledge on stormwater pollutants and their concentrations in areas with different land-use.
- Choose parameters to analyse according to project aims, recipient sensitivity, environmental quality standards and discharge limits.
- A way to reduce cost for analyses is to analyse a flow-weighted composite sample.
- When installing green infrastructure or other stormwater management solutions do make sure that their function can be. evaluated **Invest in monitoring and maintenance programs!**