Stormwater treatment and monitoring – Activities within Klima 2050

Bærekraft i vannbransjen kursdagene 9-10 jan. 2019

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CONSORTIUM

Private sector

SKANSKA
MESTERHUS
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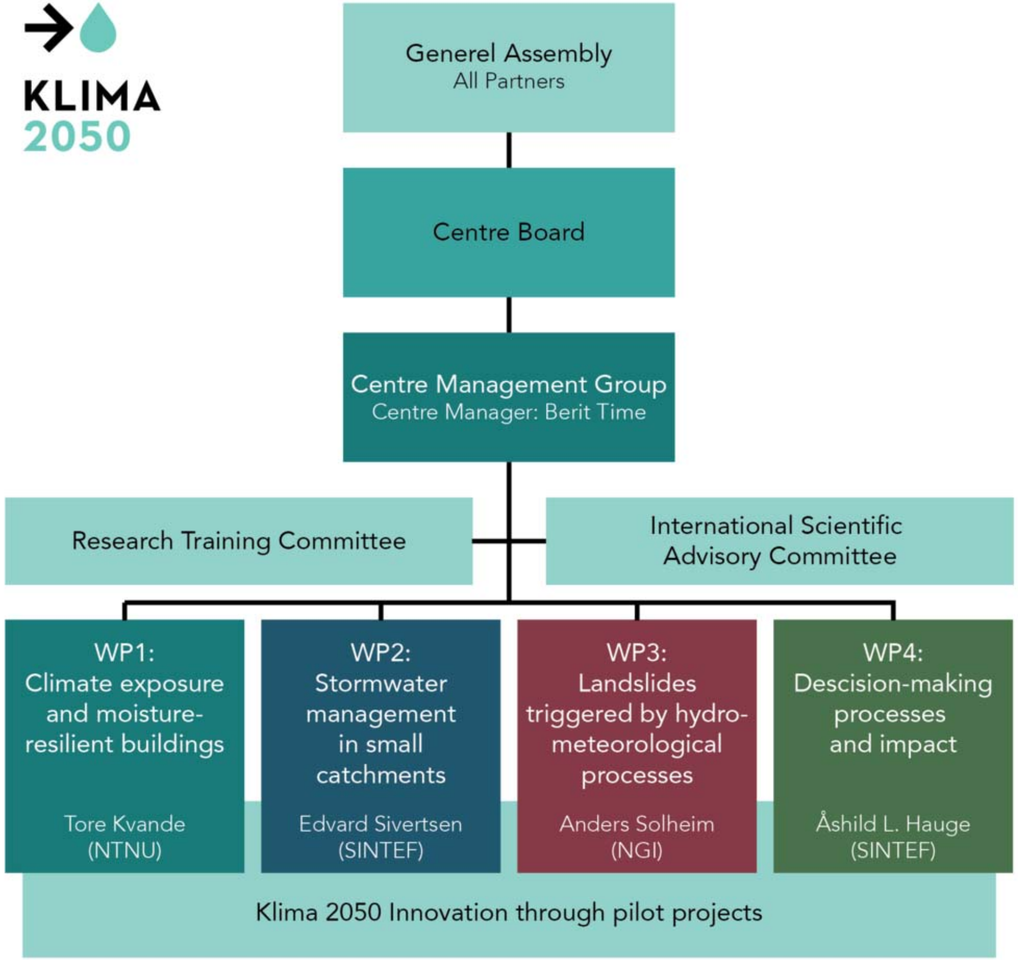
Statens vegvesen
Norges vassdrags- og energidirektorat NVE
AVINOR
Jernbane-direktoratet
STATSBYGG
TRONDHEIM KOMMUNE

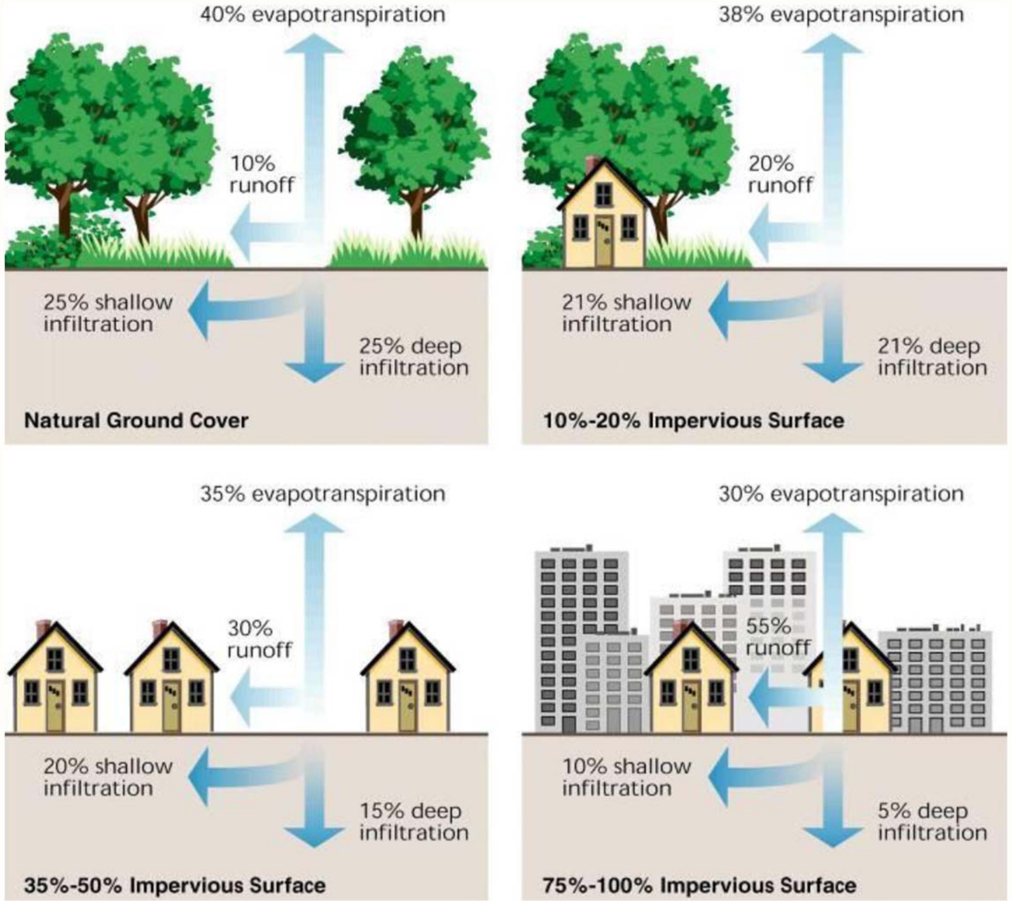
Research & education

SINTEF
BI
NTNU
Meteorologisk institutt
NGI



sfi = Senter for forskningsdrevet innovasjon
Norges forskningsråd

Modification of the watershed due to the urbanisation



Source: FISRWG (2001)

Climate change → Increased precipitation and urban flooding

High and diverse pollution

Variety of contaminants released to the environment:

- Particles
- Nutrients
- Salts
- Heavy metals
- Persistent organic micro pollutants
- Microplastics

→ **Increased awareness that contamination from road water should be eliminated or at least reduced below thresholds that cause significant harm!**

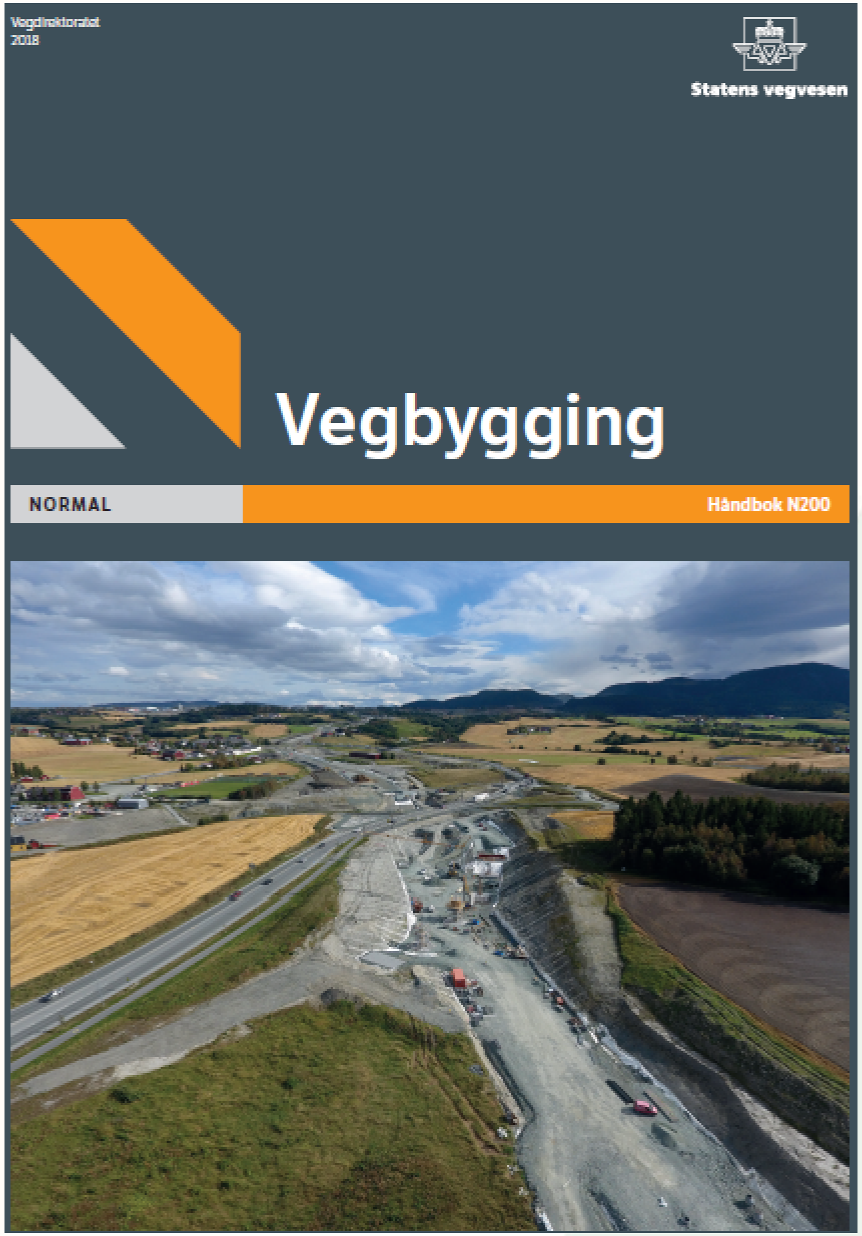
Scandinavian practices

- Several of examples of Low-cost nature-based solutions also known as Sustainable Urban Drainage Systems (SUDS) or Blue-Green solutions
- Most used are Sedimentation / detention ponds.
- Remove particle associated pollutants, but less effective on dissolved pollutants (cf. Governmental white paper National Transport Plan 2018-2029 (Meld. St. 33 (2016-2017)

Source: Sondre Meland (Statensvegvesen, NORWAT Teknologidagene 2015)

New N200

- New standard for road building
- Including new guidelines for when and how to treat runoff from roads
- Two or more treatment steps are required on major roads with high traffic density or on roads adjacent water recipients assessed to be vulnerable



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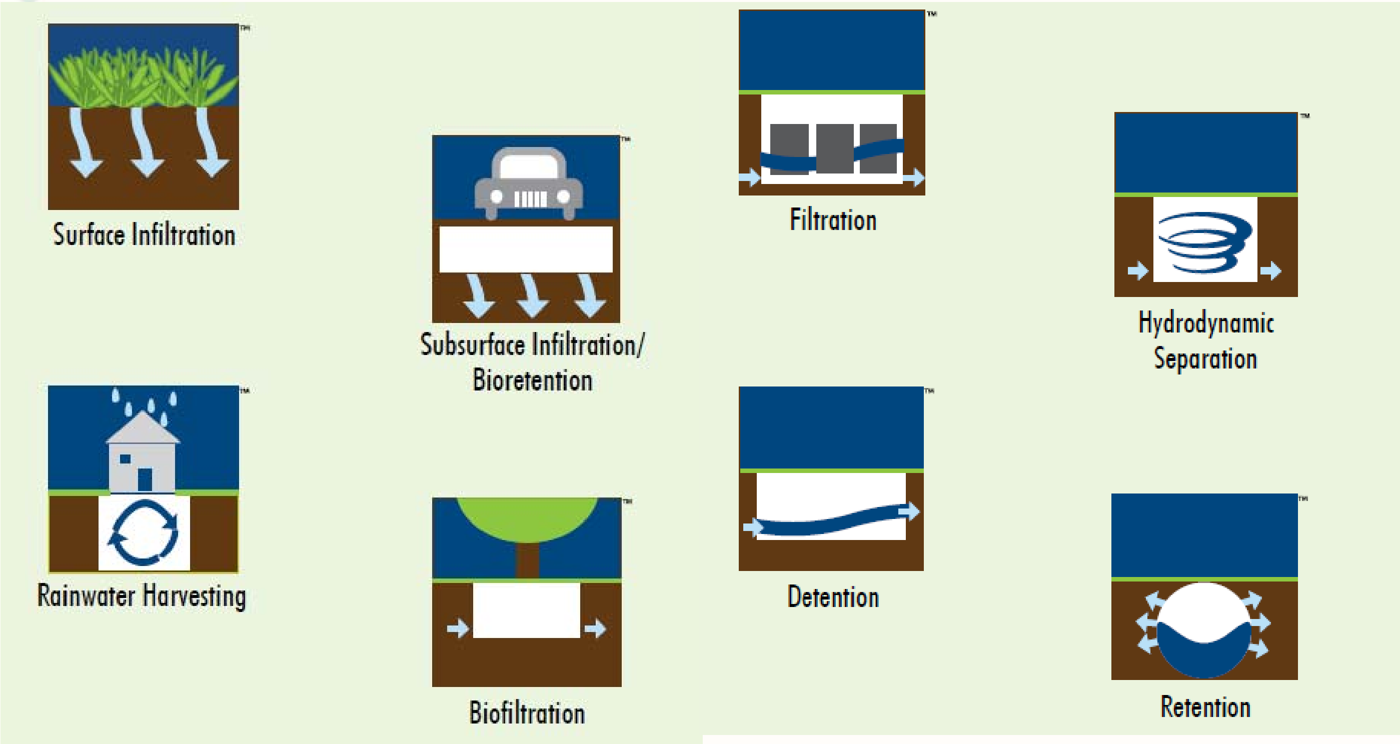
How to treat stormwater (Quantity, Quality or both)

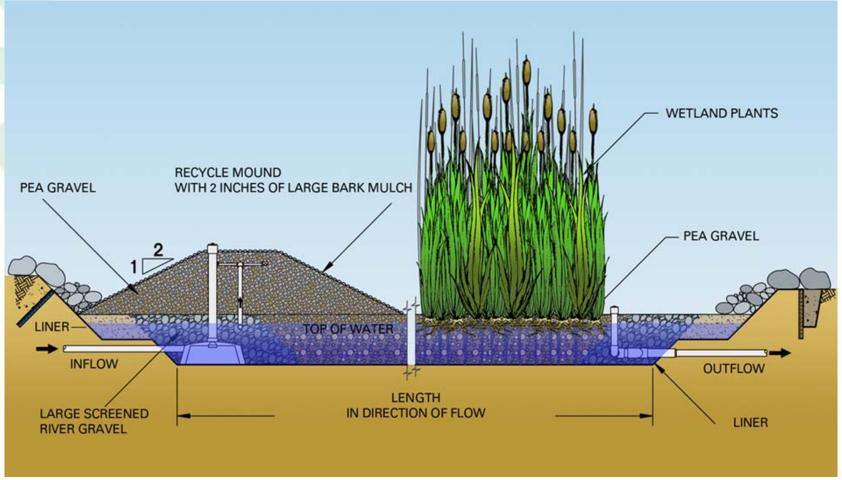


Mechanisms:

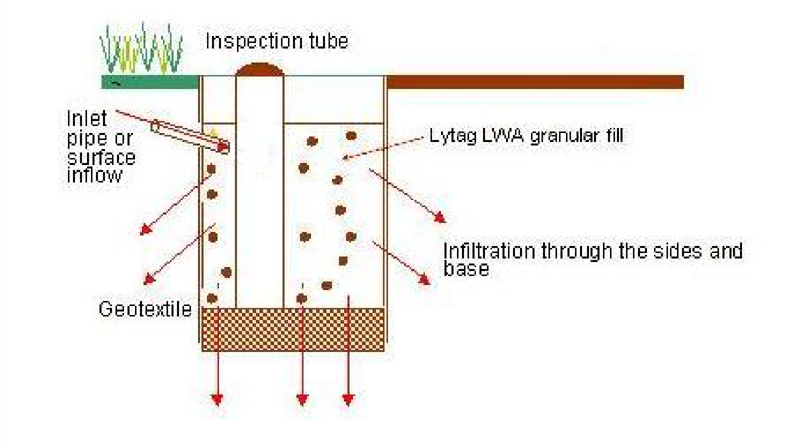
- Settling
- Coalescence
- Adsorption
- Ion exchange
- Biodegradation
- Bioaccumulation
- Retention

Source picture: Contech Engineered Solutions

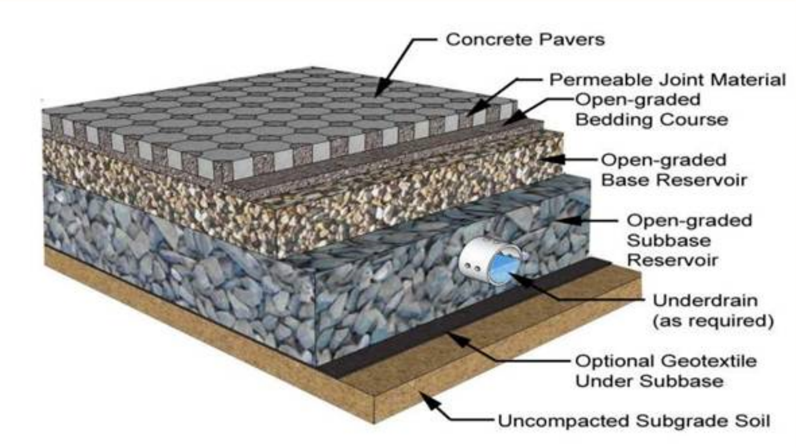
Some SUDS



Subsurface Constructed Wetlands
(source: www.natsys-inc.com)



Cross-Section through a traditional soakaway
(source: www.lytag.co.uk)



Permeable paving
Source: Smith, 2009

Filterra Bioretention Systems
Source picture: Contech Engineered Solutions

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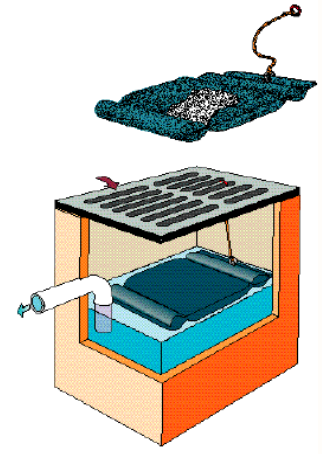
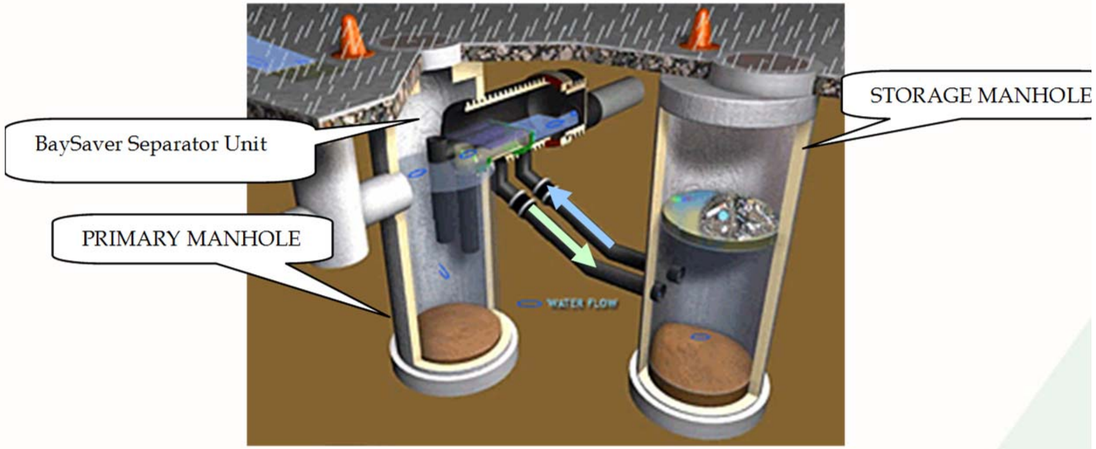
Examples of commercial units

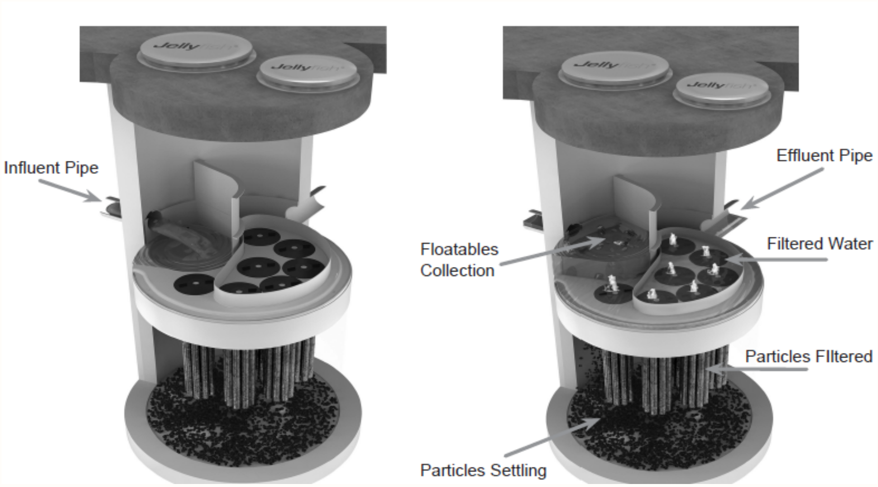
Ecol High efficiency coalescence separator ESK



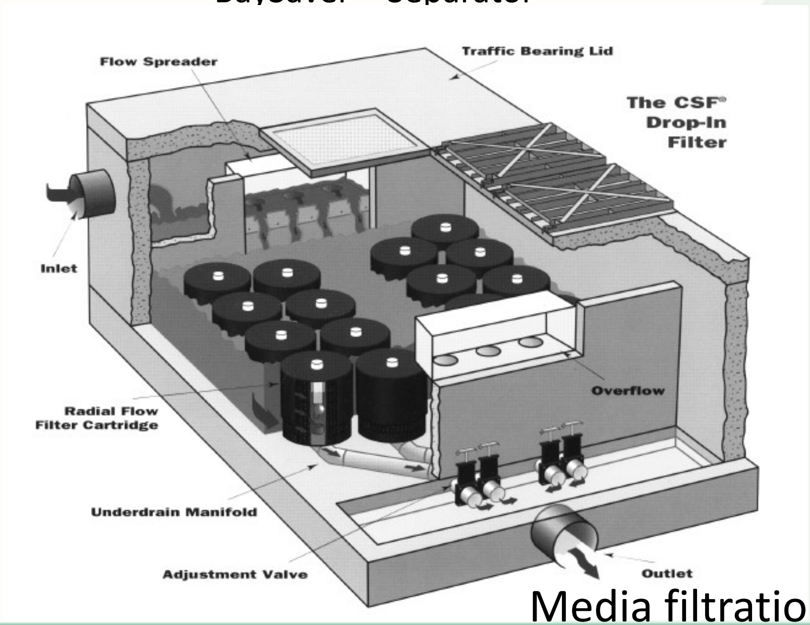
oil separation by adsorbing pillow



BaySaver® Separator



Jellyfish® Stormwater Treatment
Contech Engineered Solutions



Media filtration

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Future Stormwater Management has to be <u>sustainable</u>

Technical functionality:
- Document performance
- Understand mechanisms
- Design criteria
- Models for dimensioning

NOU 2015:16

Holistic assessment of systems:
- Tools for implementation
- Tools for operation and maintenance
- Co-benefits, including environmental, economic and social

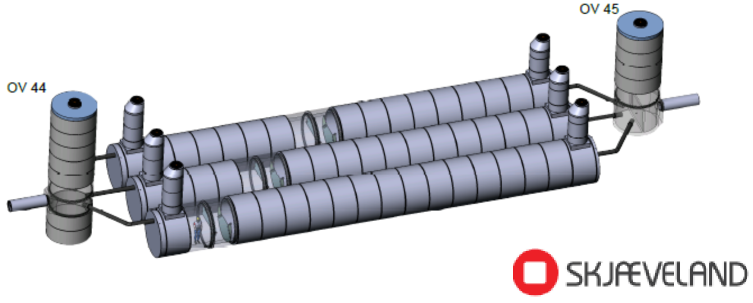
Klima 2050:
- Decision support tools
- Data structure for NBS
- Ovase.no
- Practical design criteria and models

FV505

Clean-up of stormwater from bridge and road

INNOVATION POTENTIAL

Stormwater management is set high on the agenda in Norway, especially through the work of NOU2015: 16 Stormwater in cities and towns - As a problem and resource. The innovation potential lies in the development and testing of new solutions and combinations of solutions for treatment of stormwater from roads under real operation and maintenance conditions.



STAVANGER AIRPORT

Measures for de-icing chemicals in stormwater

INNOVATION POTENTIAL

The innovation potential lies in the development and testing of new solutions for the management of stormwater that may contain de-icing chemicals, focusing on the following elements:

- Method (s) for the real-time detection and monitoring of the concentration of de-icing chemicals in stormwater
- Solution (s) for the collection and infiltration of stormwater along the runway
- Solution (s) for treating stormwater when a high concentration of de-icing chemicals is discovered

Laboratory test on media biofilter (Filtralite media)

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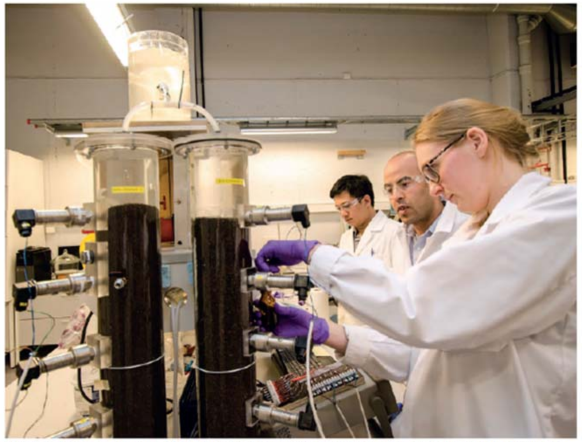

HOLDER VANN. Masterstudent Hanna Lindset tapper filtrert vann fra den ene testsylinderen. Kamal Azrague (i midten) og Gema Raspati bistår og følger med på instrumentene.

Forsker for en våtere hverdag

Med nøyaktige målinger og praktisk eksperimentering håper forskerne å løse utfordringene som et villere og våtere klima fører med seg.

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I et kjellerlaboratorium på Gløshaugen i Trondheim sildrer forurenset vann gjennom rør og ned i to lange gassylindere fulle av spesialgrus i leire. Vannet kommer fra Værnes lufthavn, og er mettet med avisingskjemikalier. Når det kommer ut av sylindrene skal det være rent og trygt å tilbakeføre til naturen.

– Disse løsningene brukes til å behandle drikkevann i dag, forteller mastergradsstudent Hanna Lindset.

Overvann kan ofte være forurenset, og må dermed renses før det sendes ut til nærliggende elver og innsjøer. Mer ekstremnedbør og tettere overflater vil gi større mengder vann som må behandles, og lokale rensetiltak som dette kan være en god løsning. Løsningene som utvikles kan brukes både på veier, bane og tomt.

Partnerprosjekt

Hanna Lindset jobber sammen med SINTEF-forskere Kamal Azrague og Gema Raspati, og nå er overvannsprosjektet inn i en fase hvor de prøver å finne ut av det naturlige filterets levetid.

Forskningen er en del av Klima 2050-satsingen, og er et resultat av møtet mellom de forskjellige partnerne i forskningssenteret.

– Dette er et godt eksempel på hvordan ulike aktører kan gå sammen for å løse et problem. Akkurat i dette tilfellet var det Avinor som hadde en utfordring med forurenset overvann, og lurte på hva som kunne gjøres med det. Klima 2050-partnerne Weber Saint-Gobain og Isola kom opp med en løsning, forteller NTNU-professor Tore Kvande.

Tverrfaglig samarbeid om overvannsproblem

Renskes av bakterier

Nå jobber SINTEF og universitetet sammen om å forske på overvannfiltrering ved hjelp av leirpartikler og kjemikalienedbrytende mikroorganismer.

– Bakteriene vi bruker, er lokale til jordsmonnet, men vi gir dem bedre leveforhold, og vi sørger for at de får mye næring for å skape høyere konsentrasjoner enn det man ville hatt til vanlig. Resultatet er et selvrensende filter, sier Kamal Azrague til Byggeindustrien.

Filteret kan, ifølge forskerne, legges inn i grøfter eller i kummer hvor overvannet kan samles for filtrering.

– Med morgendagens vær vil vi få langt mer nedbør enn nå, og vi forventer at det også vil være behov for økt bruk av kjemikalier på for eksempel flyplasser på grunn av været. Ved å filtrere forurenset overvann på stedet, blir problemet mye mindre, sier Azrague.

water MDPI

Article

Potential of Biofilters for Treatment of De-Icing Chemicals

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Received: 20 March 2018; Accepted: 8 May 2018; Published: 10 May 2018

check for updates

Abstract: Organic de-icing chemicals, such as propylene glycol and potassium formate, cause environmental degradation in receiving water if left untreated, due to the high organic load resulting in oxygen depletion. Biofilters are commonly used for the treatment of biodegradable organic carbon in water treatment. This study investigated the potential for using biofilters for treating organic de-icing compounds. Lab-scale adsorption tests using filter media made of crushed clay (Filtralite) and granular activated carbon were conducted. Further, a column filtration experiment testing two different crushed clay size ranges was carried out investigating the effect of filter media depth, nutrient addition, and filtration rate. The surrogate parameter used to monitor the removal of de-icing chemicals was dissolved organic carbon (DOC). The adsorption test showed no significant adsorption of DOC was observed. The column test showed that the most active separation occurred in the first ~20 cm of the filter depth. This was confirmed by results from (1) water quality analysis (i.e., DOC removal and adenosine tri-phosphate (ATP) measurement); and (2) calculations based on a filtration performance analysis (Iwasaki model) and filter hydraulic evaluation (Lindquist diagram). The results showed that, for the highest C:N:P ratio tested (molar ratio of 24:7:1), 50–60% DOC removal was achieved. The addition of nutrients was found to be important for determining the biofilter performance.

Keywords: biofilter; de-icing chemicals; filtration performance; nutrients; stormwater

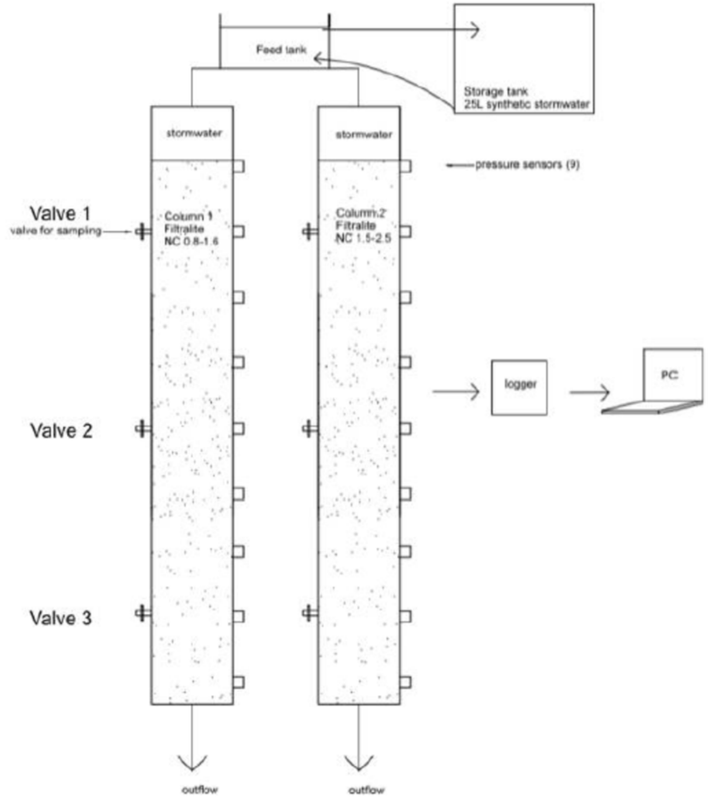
1. Introduction

Air travel during winter months is made safer owing to the de-icing practices in place. In most cases, low molecular weight alcohols are used for de-icing the airplanes, whereas for the runways, alcoholic compounds are often combined other non-corrosive deicers. Consequently, the run-off water from airplanes and runways contains high concentrations of the aforementioned chemicals. These chemicals infiltrate into the soil or are released into water bodies around the airports when the snow melts. Even though the de-icing chemicals are readily biodegradable, the degradation requires a high oxygen demand and this may affect the natural state of the soil [1,2].

For airports in Norway, propylene glycol (PG, $C_3H_8O_2$) is the main component of aircraft de-icing fluids and potassium formate (PF, HCO_2K) is used for de-icing of runways and taxiways. Studies were conducted investigating the infiltration of such chemicals into groundwater during the development of Gardermoen Airport in Oslo. At low concentrations, these chemicals are readily biodegradable over a wide range of temperature, but exhibit inhibitory behavior at higher concentrations, i.e., in the order

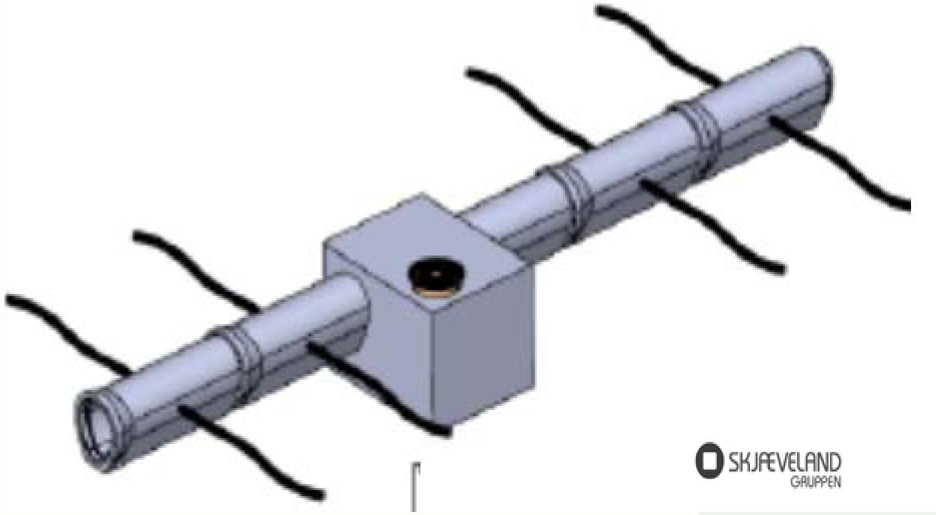
Results from the lab tests

- Filter media made of Filtralite and granular activated carbon
- Effect of filter media depth, nutrient addition, and filtration rate
- The most active separation occurred in the first ~20 cm of the filter depth.
- The results showed that, for the highest C:N:P ratio tested (molar ratio of 24:7:1), 50–60% DOC removal was achieved
- The addition of nutrients was found to be important for determining the biofilter performance
- Higher removal may be obtained with oxygenation



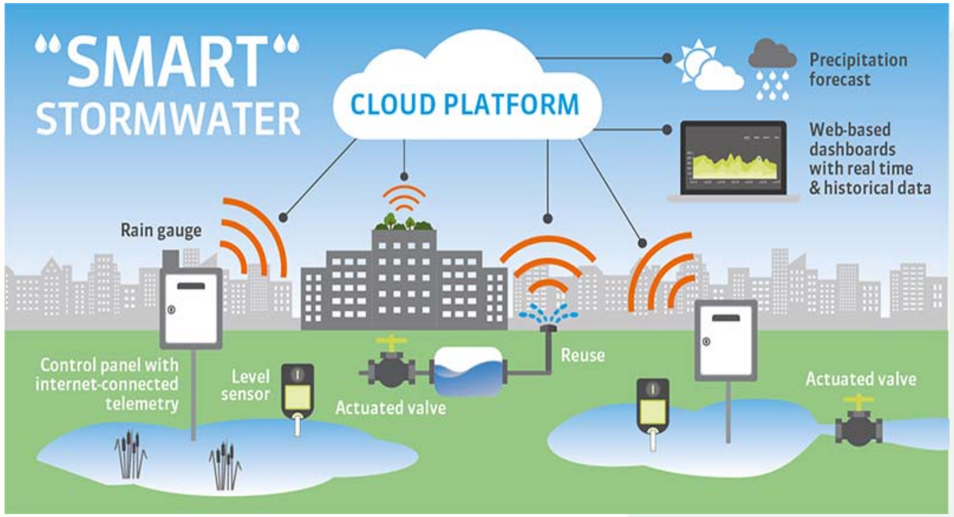
Stavanger Airport Sola - Possible technical solution for collecting and infiltration of overvann

- Separation of Avinor and municipal discharge point in the eastern part of Sømmevågen
- Development of shallow infiltration system with decomposition of de-icing chemicals with microorganisms
- Installation of infiltration system along runway 18/36 for collection and infiltration of overflow with de-icing chemicals
- Degradation in unsaturated zone



Online monitoring for de-icing chemicals - Some facts

- Online monitors are devices designed to sample and analyse onsite
- Characterise unpredictable changes
- Take real-time decisions such as stormwater flow diversion
- Often allows reduction in both capital and operating costs
- Online monitors require maintenance, periodic calibration, and checks by personnel



Online monitoring of de-icing chemicals

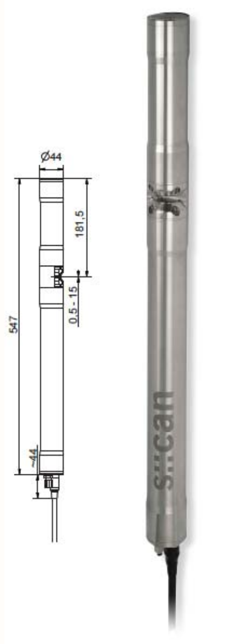
- Direct measurement of de-icer constituents (e.g., glycol, formate, or acetate) in stormwater is not possible
- Instead, on-site monitoring of surrogate* parameter
- Common surrogates for the primary de-icer constituents include biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total organic carbon (TOC)

Analytical methods by parameter and type of monitoring

Monitor Type	Parameter			
	BOD	COD	TOC	BOD/COD/TOC by correlation
Online	Biochemical oxidation (58)	Photochemical oxidation (59)	Thermal catalytic combustion (63)	Refractometry (66)
		Electrochemical oxidation (60)	UV/persulfate oxidation (64)	Optical/absorbance (67)
			UV/ozone oxidation (65)	Optical/absorbance, reflectance, and fluorescence (68)

Screening outcomes

- S::can is not able to analyze formate and glycol due to no direct absorbance
- BioTector (HACH), PeCOD , Innovox (Sue/GE) are able to provide accurate analyze
- BioTector has been already used in several airports Worldwide



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Status

- The pilot study is postponed due complex installation
- A manual sampling and laboratory analysis is on-going to evaluate the discharge and the potential and need for the on-line monitoring

Conclusions

- Both quantity and quality needs to be managed
- Current practices (sedimentation/detention ponds) may often not be sufficiently protecting the receiving water bodies
- Two or more treatment steps are required on critical locations
- Decision support tools (e.g. LCA, LCC, and social assessment) should be used prior any installation
- Shallow infiltration system together with media filter and online monitoring show a large potential for airport stormwater management – To be confirmed in a pilot study