



Aalto University  
School of Engineering

# Drinking water management in the Nordic countries

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**This presentation is dedicated to Mr. Tapio Ala-Peijari, who passed away on March 15th, 2014.**

**He was a great person and a water professional and also an advisor of my research.**



# Content

- **History**
  - **Access to public water supply**
  - **Drinking water policy and legislation**
  - **Raw water sources and water quality**
  - **Drinking water treatment**
  - **Waterborne outbreaks**
  - **Ownership**
  - **Distribution system characteristics**
  - **Tariffs**
  - **Research and development**
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# History

- **In Sweden, up to the mid and late 19<sup>th</sup> century, the primary reason for water supply in the urban areas was its use for combating fire. During the middle of that century some bad outbreaks of cholera in Stockholm and Gothenburg killed a large number of inhabitants.**
  - **In Denmark, more than 5 000 deaths in Copenhagen in 1853 due to cholera outbreak => first water utility in Odense in the same year (Copenhagen 1859)**
  - **In Norway, the first waterworks was established in Bergen in 1854**
  - **In Finland, Helsinki established water utility in year 1876**
- => Large fires and waterborne diseases major drivers for launching public water supply in urban areas**

# Access to public water supply

	DK	FI	IS	NO	SE
Population (million)	5.6	5.5	0.3	5.1	9.6
Area (million km <sup>2</sup> )	43	338	103	324	450
Population density (inh./km <sup>2</sup> )	129	18	3.1	16	24
Population served by public water supply (%)	96	90	95	90	87
Proportion of rural population (%)	13.4	15.4	6.6	20.3	14.9
Proportion of rural population served by the public water supply (%)	70	35	24	51	13

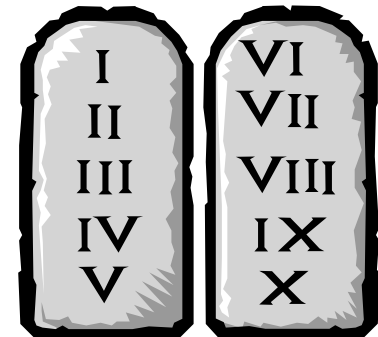
# Access to public water supply

- **Access to drinking water is at high level in all the Nordic countries despite of the low population density (except in Denmark) and large proportion of rural population (except in Iceland)**
- **Denmark's water quality challenges require public water services also at the rural areas, while Sweden prefers private wells for single houses**

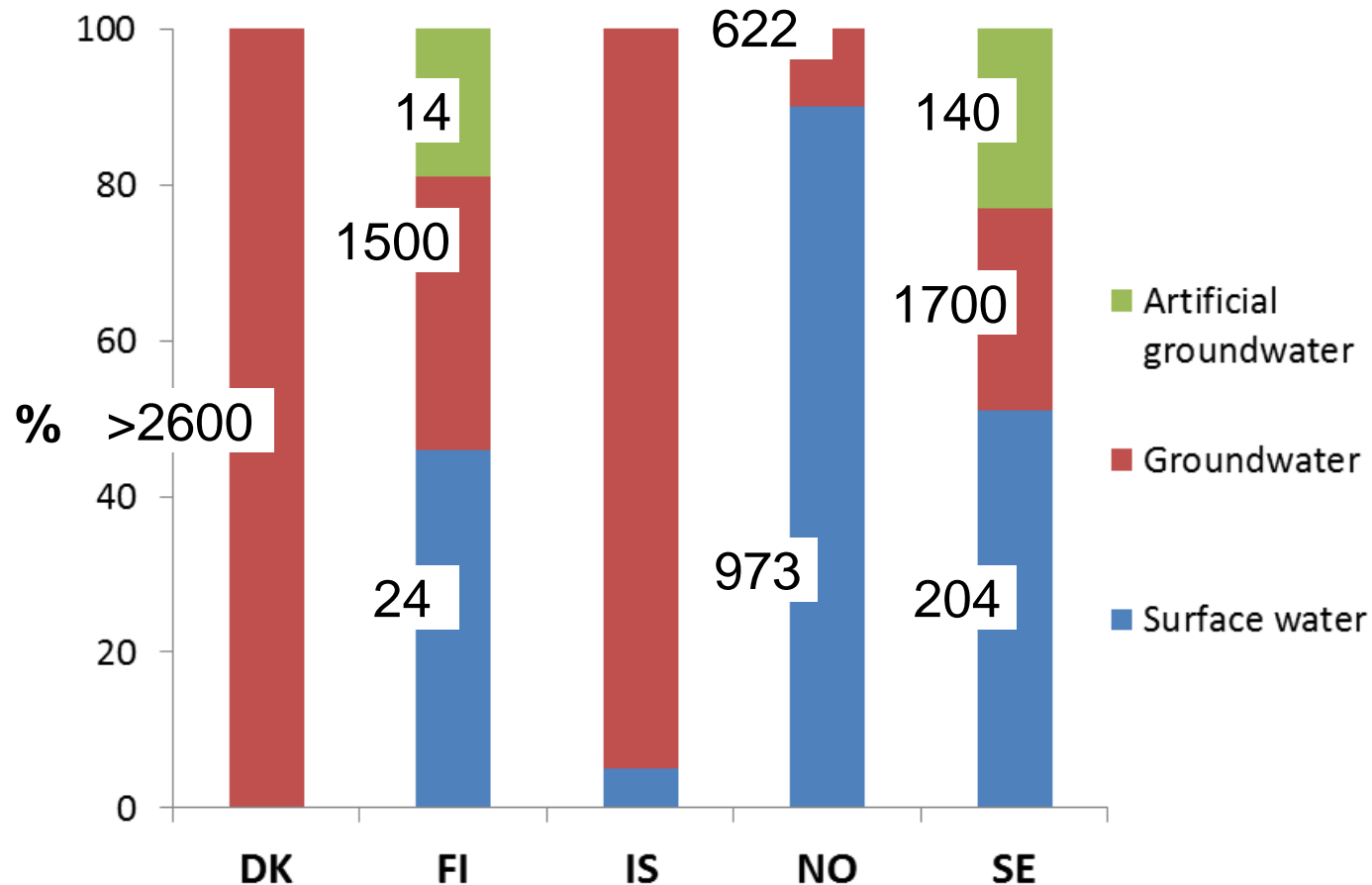


# Implementation of drinking water directive

- All the Nordic countries have implemented Drinking Water Directive (98/83/EC) in their national legislation, Norway and Iceland being members of European Economic Area (EEA)
- In Denmark >40 and in Sweden < 20 additional/or stricter parameters has been set into national legislation
- Finland has set 2 additional parameters
- In Sweden, Norway and Iceland drinking water is considered as a food product, not in Finland and Denmark



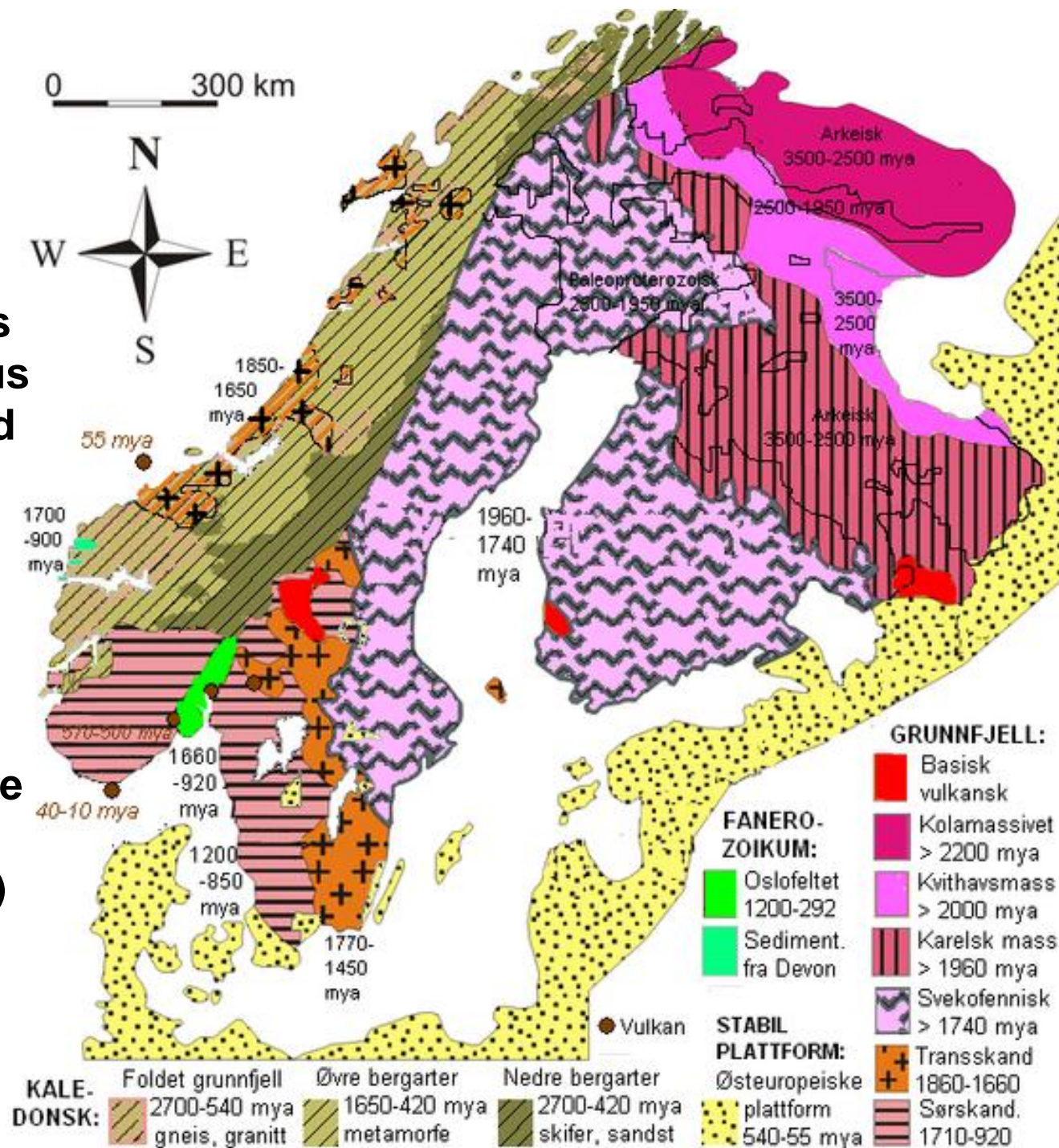
# Raw water sources and the number of the plants





# Geology

- Most of Denmark consists of Quaternary deposits overlying Cretaceous chalk, limestone and Tertiary sand and clay => easily accessible groundwater resource.
- In Finland and Sweden, aquifers are typically small and shallow (vulnerable)



# Major water quality challenges

DK*	FI	IS	NO	SE
pesticides	NOM	pathogens	NOM	NOM
nitrates ammonia	fluoride		pathogens	fluoride
chloride	iron		pH	iron
nickel arsenic	manganese		color	manganese
organic pollutants	pathogens			pathogens
pathogens	pH			pH

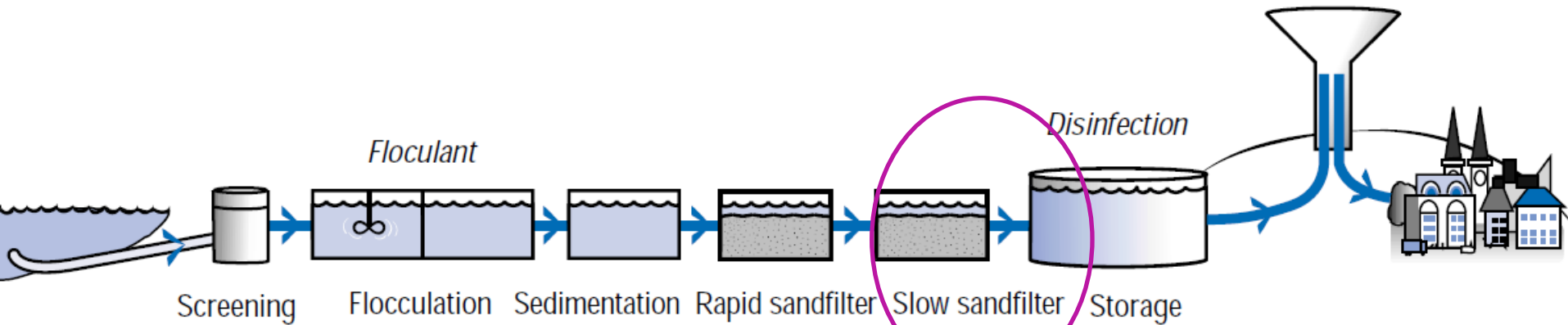
\* Problems occur mainly in shallow aquifers

# Groundwater treatment

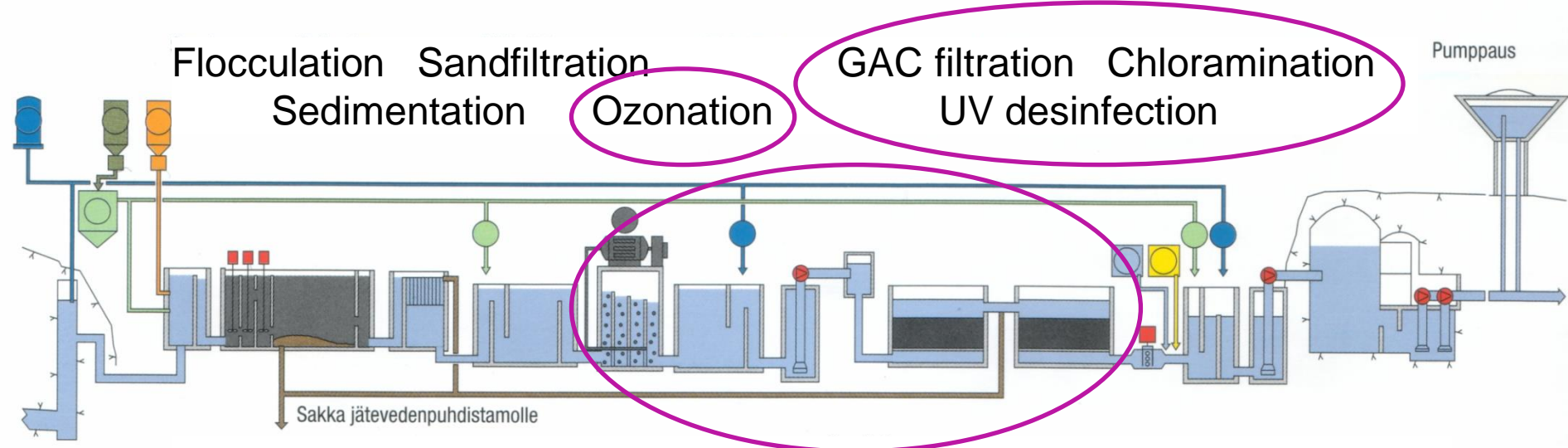
- In Denmark simple treatment with aeration, pH adjustment and filtration
- In Sweden and Finland mostly no treatment (sometimes iron removal, alkalisation and/or UV radiation)
- In Iceland no treatment, separate hot water system directly from the geothermal sources (smell of hydrogen sulfide)



# Surface water treatment



## Sweden



## Finland

# Surface water treatment

Norway (Meyn 2011)

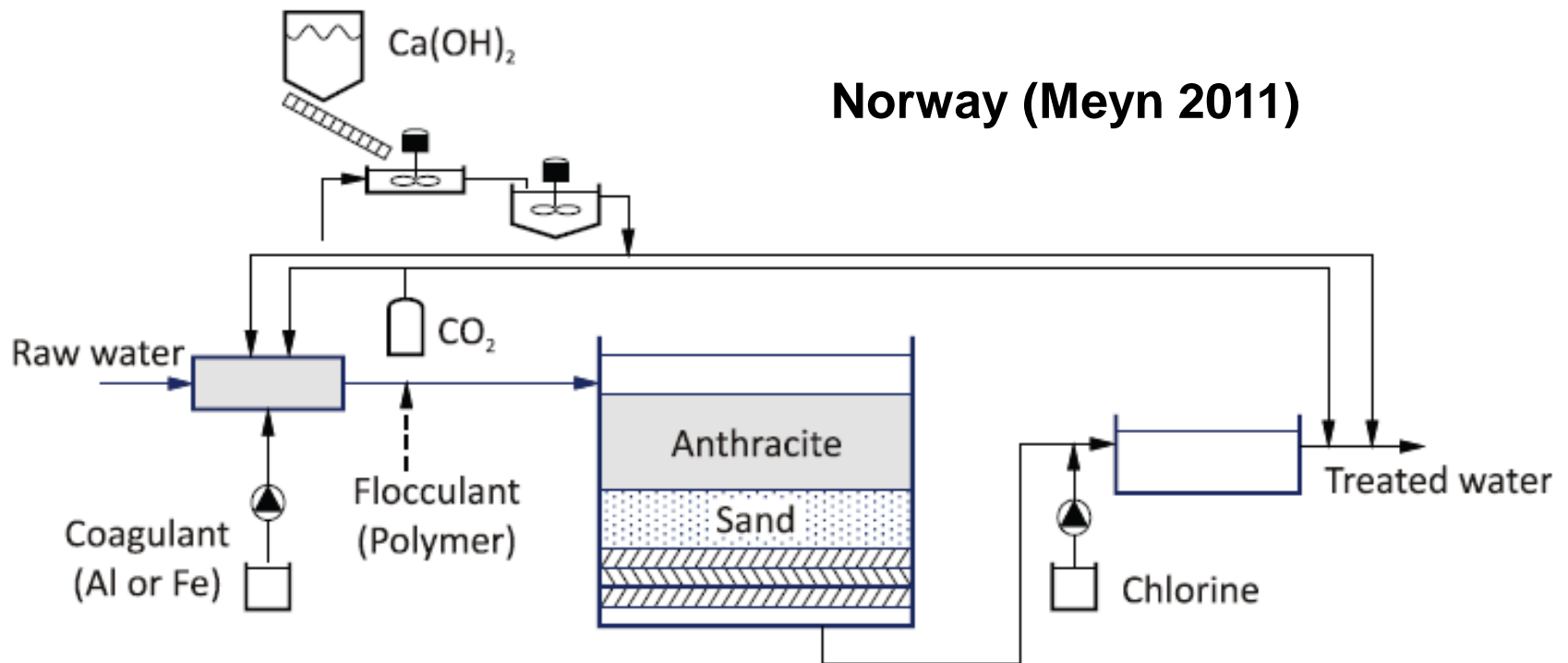


Figure 4.2: Typical flow scheme for a contact filtration plant for NOM removal in Norway including pH adjustment, corrosion control and disinfection, adapted from Ødegaard et al. (1999)

# Disinfection

- **Practically in all the Nordic countries all the large surface water treatment plants apply disinfection**
- **Groundwater is not disinfected in Denmark**
- **UV radiation is increasingly applied in Finland**
- **In Norway, UV radiation is the most frequent disinfection method (902 plants serving 3 million people). However, 177 plants serving 3 million people use chlorination.**

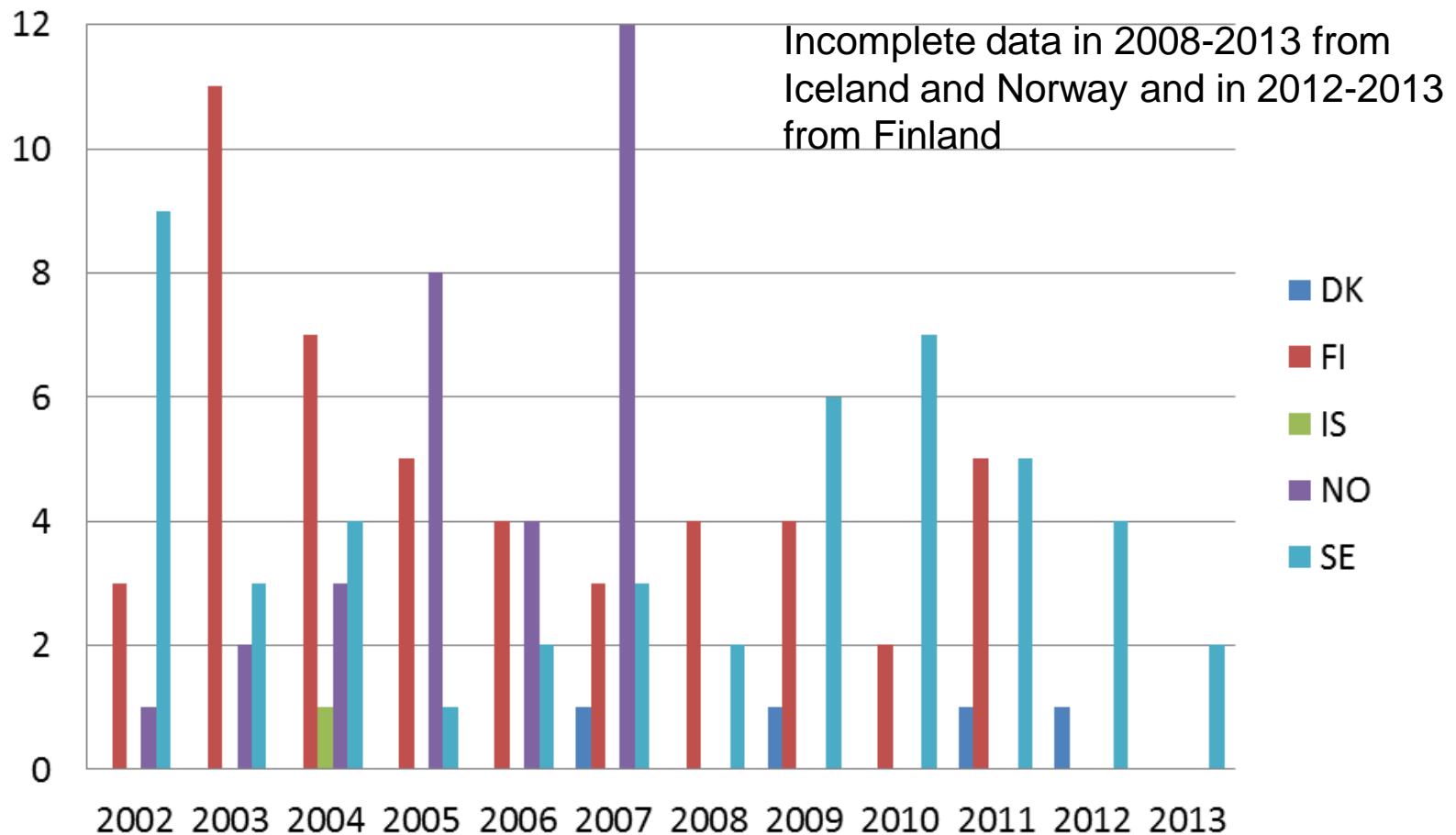


# Drinking water treatment

- A special feature of Norway is a high number of small surface water treatment plants, where membrane technology is a promising alternative to current technologies (contact filtration, Molde-process, ozonation-biofiltration etc.)
- Finland and Sweden have fairly similar water quality challenges and a conventional approach to manage with them
- Iceland has challenges mostly in the small settlements, where animal manure poses a threat to drinking water quality
- Denmark has extensive agriculture being a major challenge for groundwater abstraction

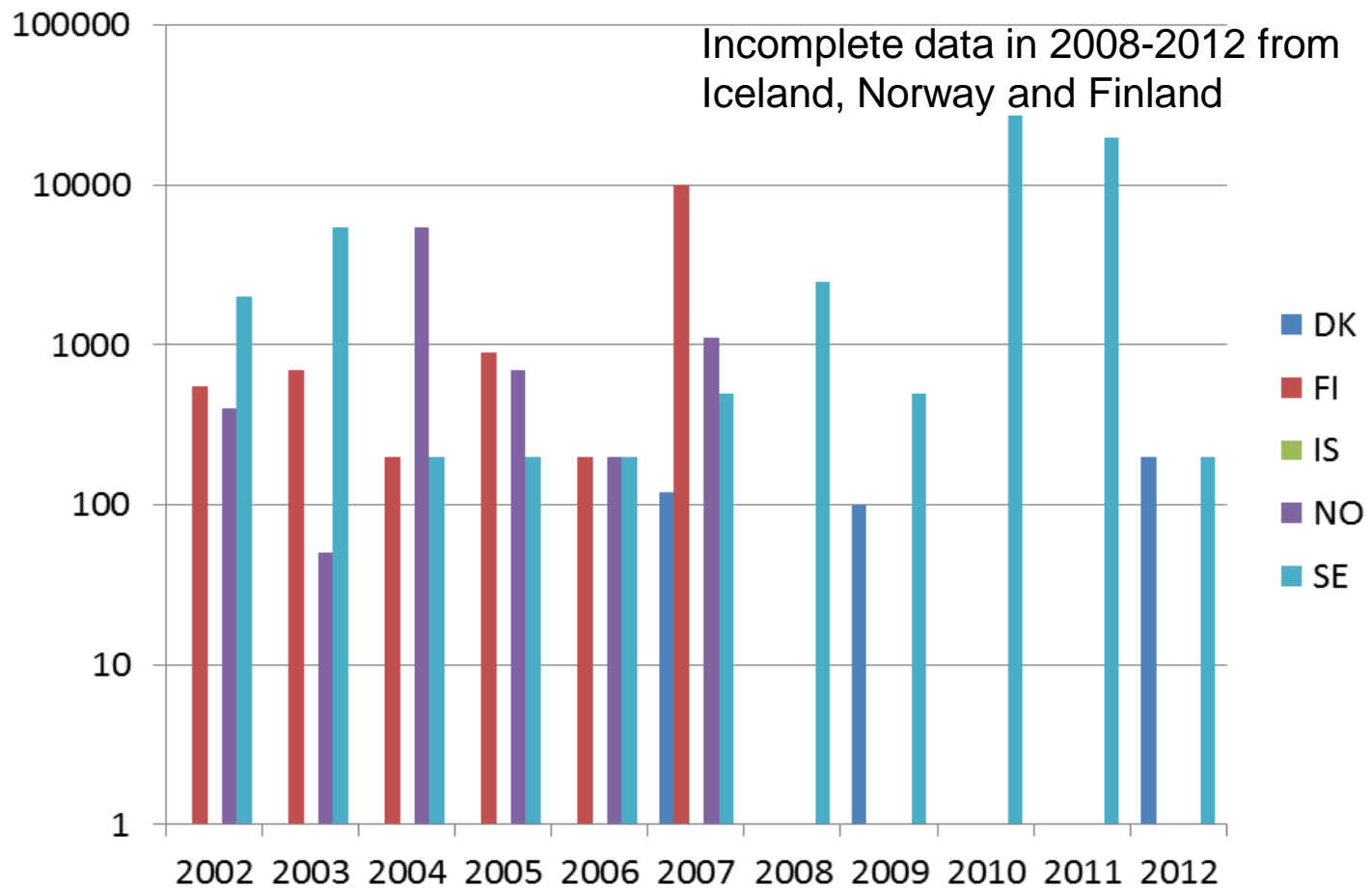


# Number of waterborne outbreaks





# Number of episodes of illness



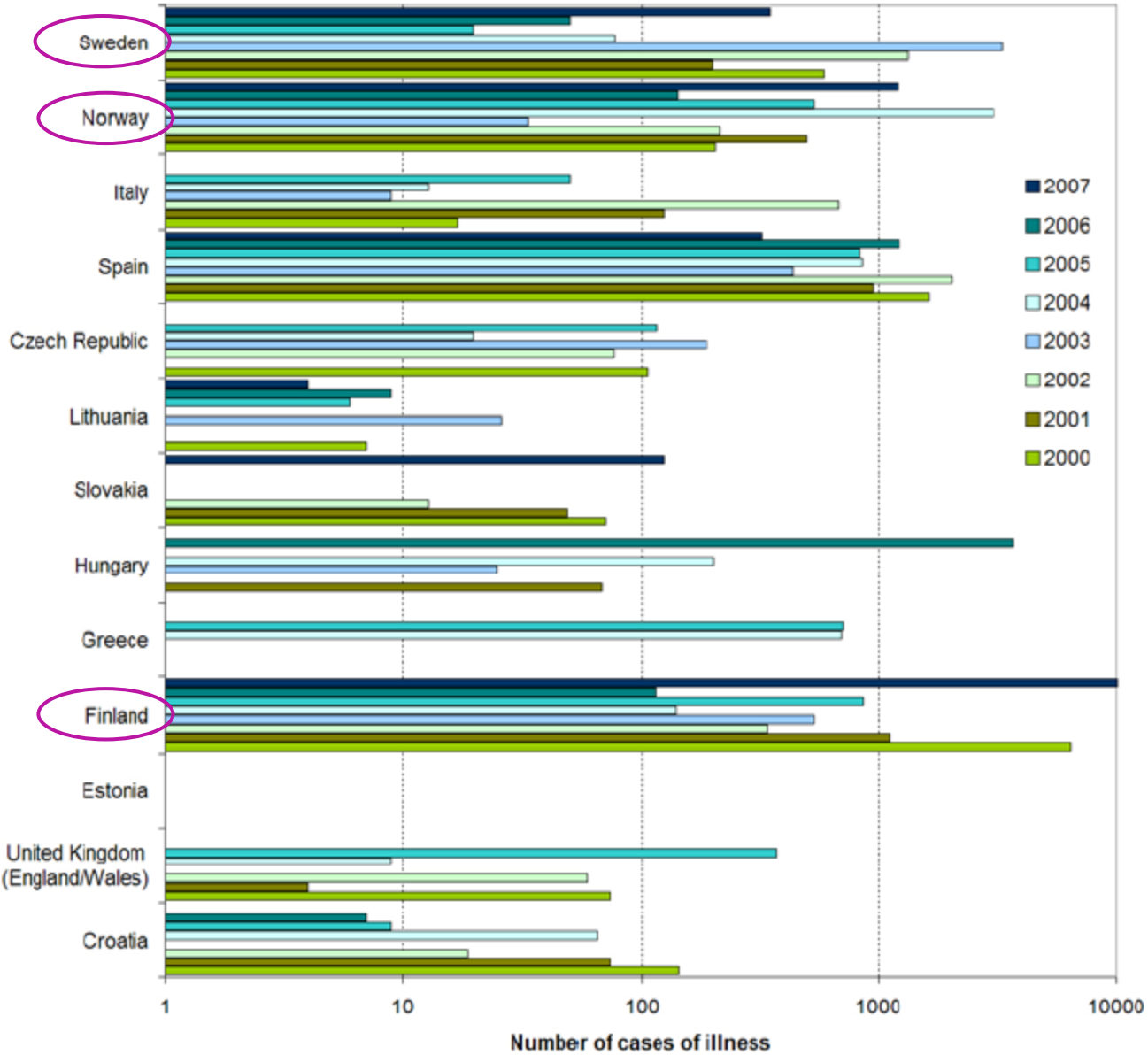
# Some recent waterborne outbreaks

- In 2007 the largest waterborne outbreak in Finland for the last 20 years took place in the City of Nokia: a population survey revealed a total of 8 450 cases of gastroenteritis during the outbreak
- In 2010 a confirmed outbreak of *Cryptosporidium* infection affected at least 27 000 inhabitants of Östersund, Sweden, which represents the largest known outbreak in Europe and the second largest worldwide after the Milwaukee outbreak.
- In 2011 a confirmed outbreak of *Cryptosporidium* infection affected about 20 000 inhabitants of Skellefteå, Sweden

**(More in Guzman-Herrador's presentation)**

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**Fig. 2. Number of reported episodes of illness attributable to diseases carried in drinking-water in selected countries, 2000–2007**

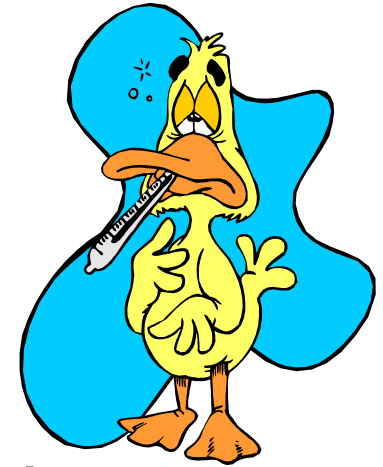


# Some preventive policy approaches that have been taken or are under preparation

- Requirement of two hygienic barriers in Norway (more in prof. Ødegaard's presentation this afternoon), readiness to start disinfection within 4 hours in Finland
- Water safety plan and quality management (ISO 22000) requirement for large utilities in Denmark
- Obligatory certificate of all personnel working in close contact with drinking water in Finland
- Introduction of risk management approach instead of increasingly excessive water quality standards, in preparation in Finland



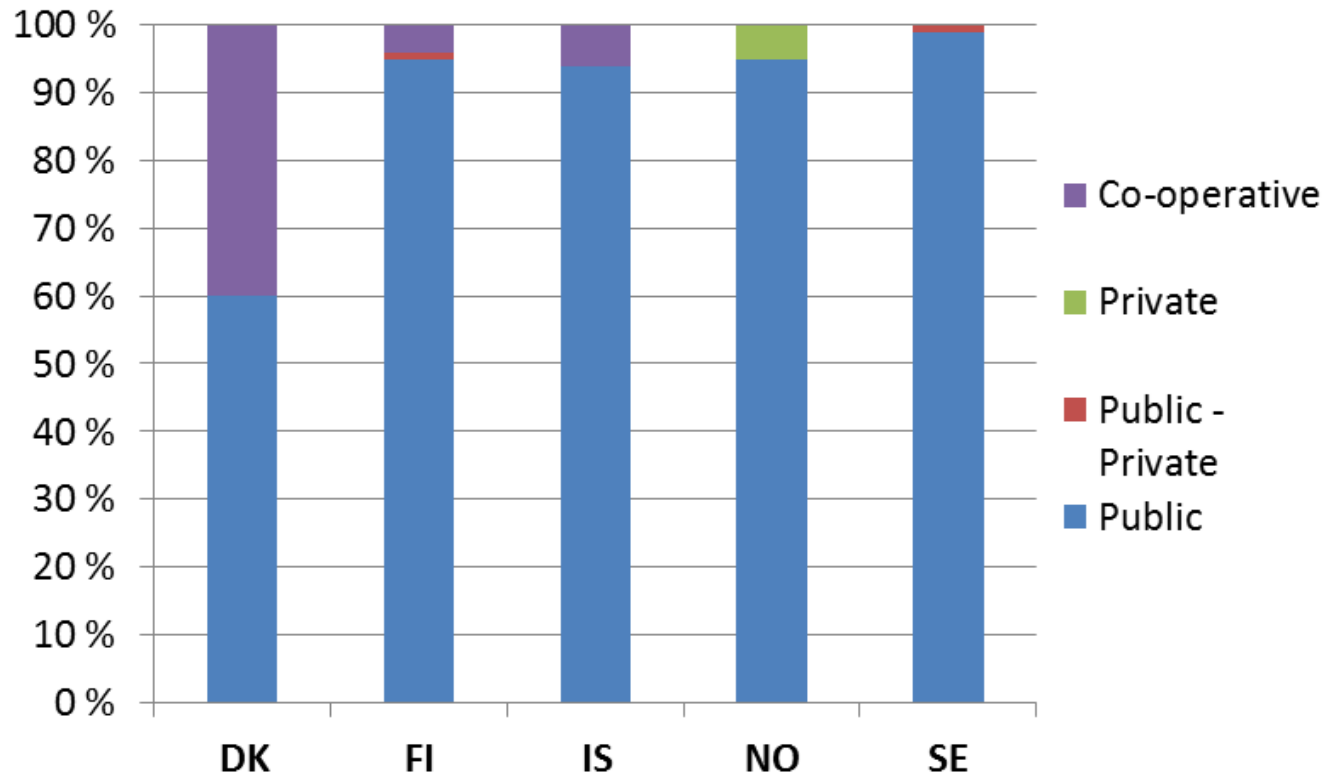
# Waterborne outbreaks



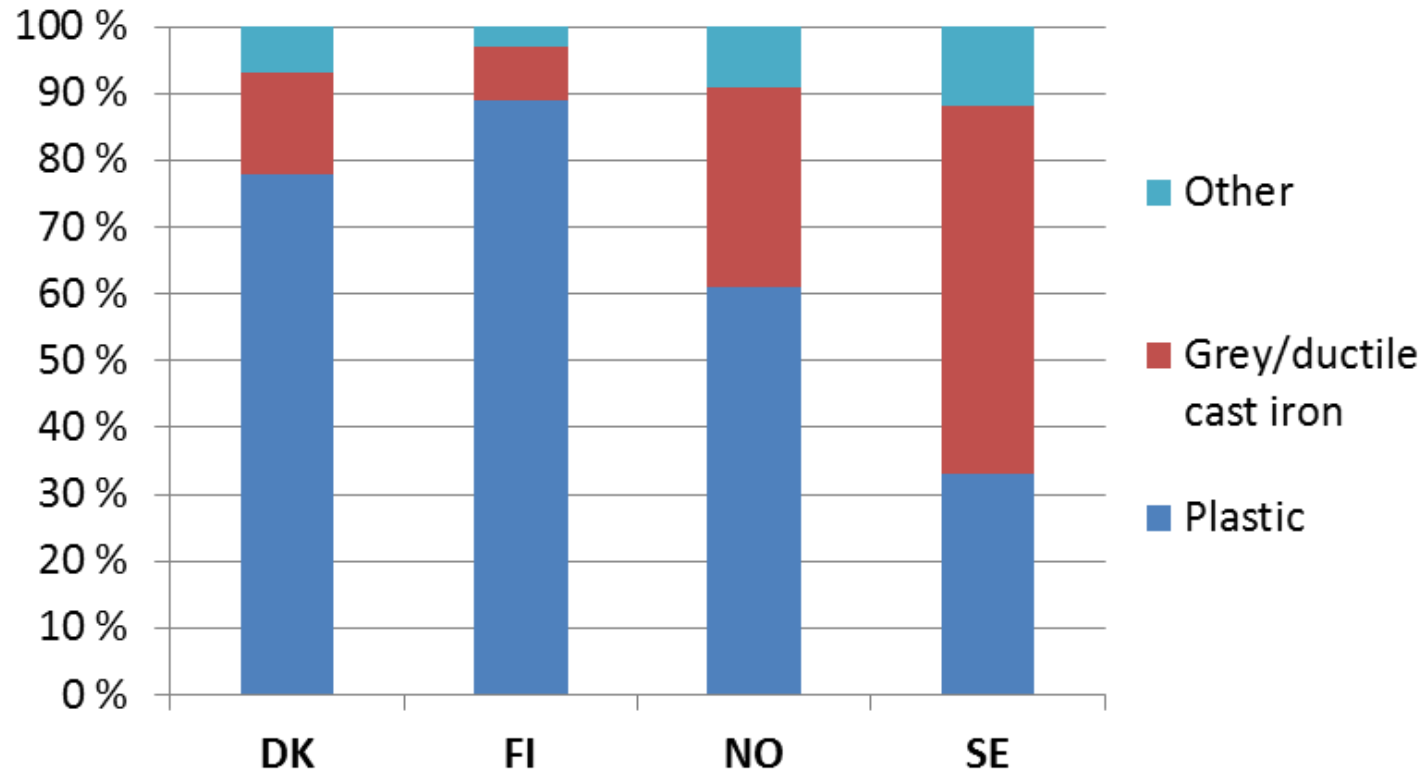
- **Sweden, Norway and Finland have all faced serious waterborne outbreaks**
- **The number of waterborne outbreaks in Denmark is relatively small compared to the fact that most of the supplied water is non-disinfected groundwater. This can be partly explained by deep aquifers in Denmark.**
- **The number of waterborne outbreaks in Finland, Sweden and Norway is high in international comparison, which can be partly explained by a well-functioning reporting system, shallow aquifers and lack of groundwater disinfection  
=> drinking water quality management needs to focus on microbial safety**

# Ownership

## Mostly publicly owned utilities



# Material of the distribution pipes (excl. connections)



# Distribution systems and water use

	DK	FI	IS	NO	SE
Length of the distribution system excl. connections (km)	49 000	92 000	2 700	47 000	71 000
Length/population served (m/inhabitant)	9.1	18.6	9.5	10.2	8.5
Leakage rate (%)	8.6	17	n.a	15-50	15-20
Annual renovation rate (%)	1.0	< 0.4	n.a	0.6	0.7-0.8
Abstraction for public water supply (l/inhabitant/day)*	190	210	740	450	270
Average household consumption (l/inhabitant/day)	107	138	283	195	160
Share of household consumption from supply (%)	56	66	38	43	59
Metering rate of households (%)	100	100	n.a	29	98



# Average tariffs for the household

	DK	FI*	IS	NO	SE**
Connection fee (€)					
- drinking water only	3 706	1 720		1 653	
- including wastewater		3 895			12 200
Fixed fee (€/year)					
- drinking water only	75	58		213	
- including wastewater		113			335
Consumption fee (€/m <sup>3</sup> )					
- drinking water only	1.93	1.40		1.84	
- including wastewater		3.61			2.45

\* Based on the annual consumption of 180 m<sup>3</sup>

\*\* Based on the annual consumption of 150 m<sup>3</sup>



# Asset management

- **Longest distribution systems per inhabitant are in Finland, where the renovation rate is lowest  
=> need to raise tariffs and start extensive renovation programs in the future**
- **High consumption rates of drinking water as well as low proportion of abstracted water compared to consumption take place in Norway and Iceland, where all the consumption is not metered  
=> improved demand management and leakage control is needed**

# Research and development

- **Sweden is putting biggest efforts in drinking water research at the moment, total budget of the running projects > 18 M€**
- **Current hot topics are:**
  - **SmartWater (e.g. ROSAVAND)**
  - **Sensor development (e.g. AQUATARIUM)**
  - **Natural organic matter (e.g. DOMAqua, NOMiNOR)**
  - **Membranes (e.g. ADWATEC, GenoMembrane)**
  - **Risk-based approach in drinking water management**

**=> Early results will be presented during this conference 😊**



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