GEUS

dNmark research alliance

AARHUS UNIVERSITY
DEPT. OF PUBLIC HEALTH,
SECT. OF ENVIRONMENT, OCCUPATION & HEALTH

Groundwater N-Pollution and Public Health Effects (RC4.7)

The Example of Gastrointestinal Cancer

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Background

- M.Sc. in Environmental Engineering
- Studied at ETH Zürich and DTU Lyngby
- Focus on water pollution/treatment, GIS and interdisciplinary topics
- PhD project started September 2013

Epidemiology

"The study of the distribution and determinants of disease frequency"

- Does the exposure to a certain environmental factor increase the risk of getting a certain disease?
- Closely related to statistics

Earlier studies

- Widely different and contradicting results *(Ward et al., 2005)*
- Some positive indication has been found, e.g. for colon cancer, no firm conclusions *(De Roos et al., 2003)*
- DK study Aalborg vs. Aarhus: weak role of nitrate in DW in etiology of stomach cancer *(Jensen, 1982)*

Objectives of the project

- Use unique possibility of Danish registers for an epidemiologic study
- Assess the association between nitrate in drinking water and diseases using advantages of GIS
- Quantify health related social costs of N-pollution

Nitrate-Health Effects

- 50 mg/L fixed for acute exposure
  (methemoglobinemia = blue baby syndrome)

- In saliva: NO_3 converted to NO_2
- In stomach: NO_2 to *N*-Nitroso compounds
  (induces DNA damage → carcinogenic)

➢ Chronic effects

Cancer development

- Lag time due to a two tiered proces
  - Initiator induces DNA damage
  - Promotor
    - Induces inflammation ➔ Cell turnover ↑
- Lag time for colon cancer
  - from initiation 20 years

Register Based Epidemiologic Study

Exposure	Effect
• N-intake by drinking water → Drinking water quality data & groundwater data (JUPITER)	• Cases of disease e.g. colon cancer, other diseases → Health register data (National Cancer Register)

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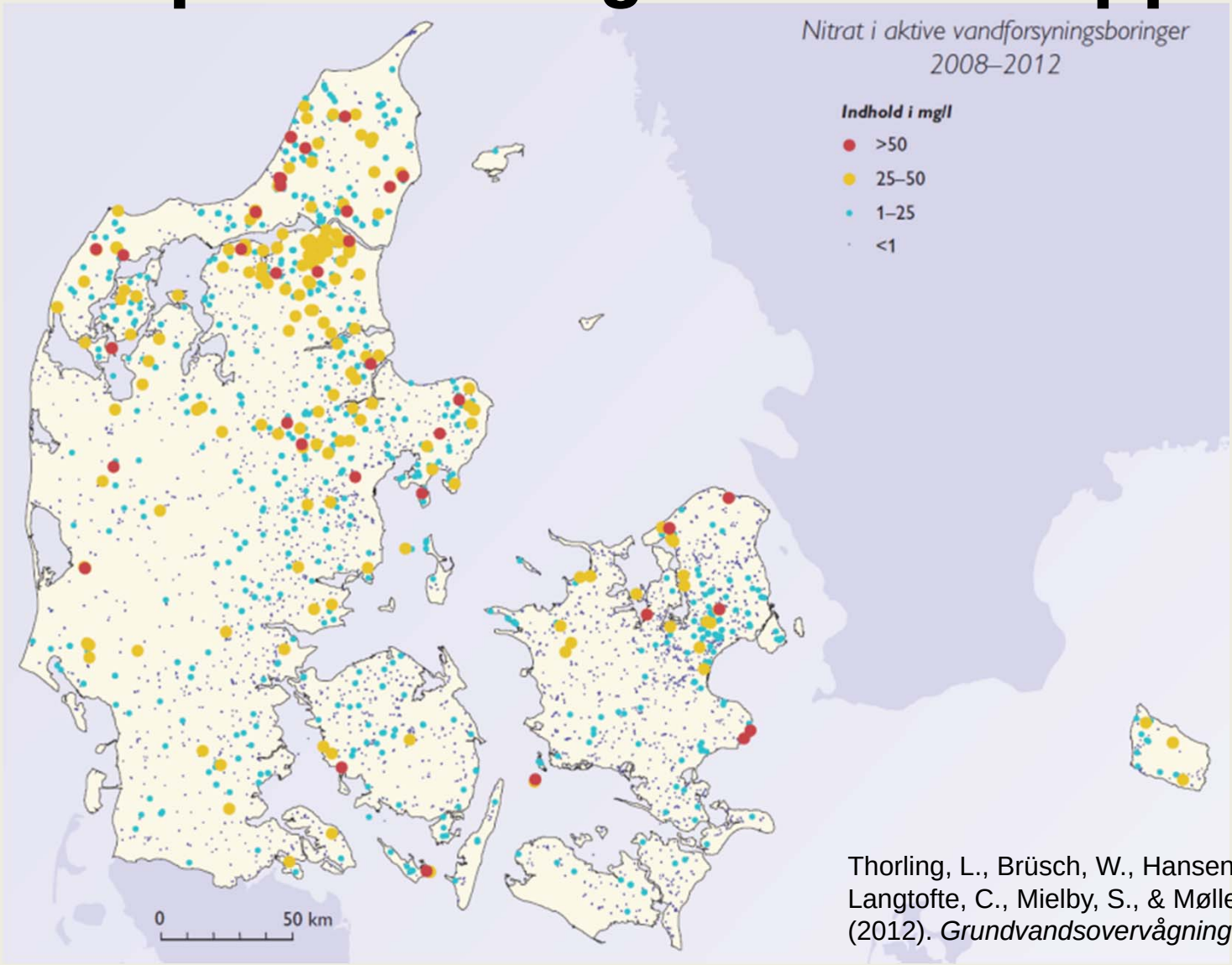
Link: Location, e.g. by CPR nr

Exposure

- Acc. to van Grinsven et al, 2010:
  - DK highest percentage of exposed population to > 25 mg/L nitrate (16.2%)
  - Mainly due to private well users
  - Based on assumptions for NL

➢ Objective 1: Make a better estimation of nitrate exposure in DK, based on data from JUPITER

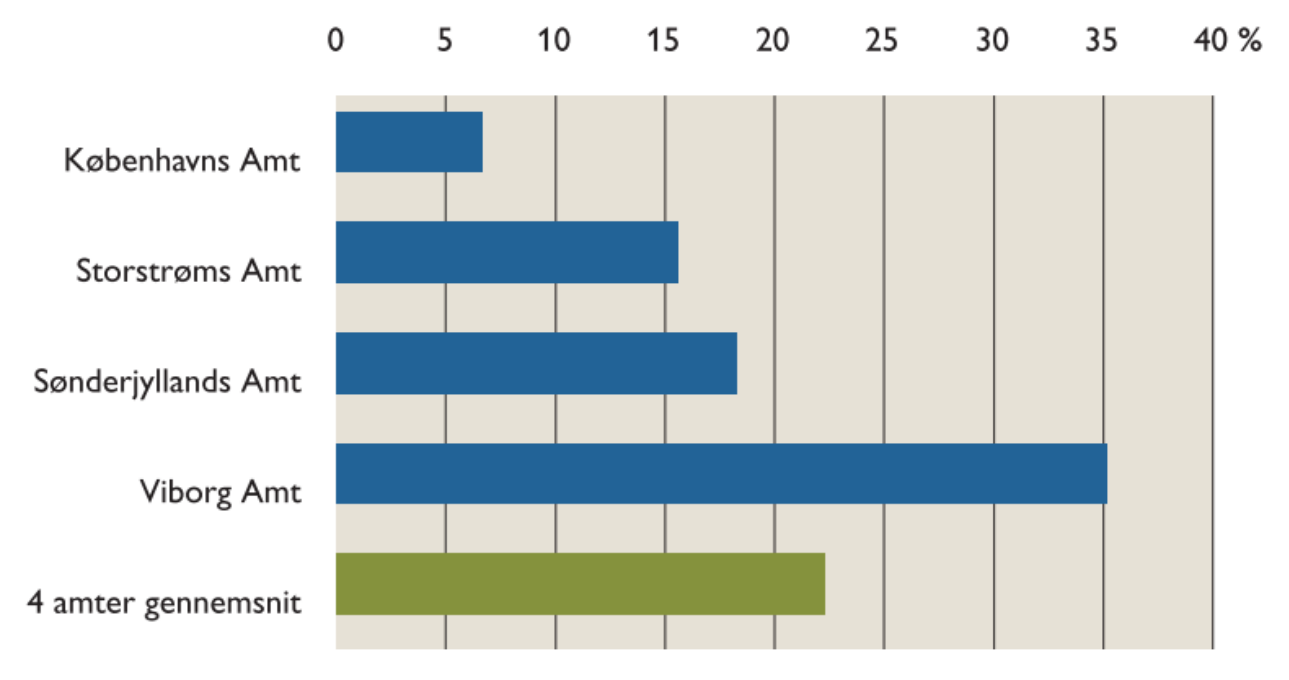
Exposure Large Water Supplies



Thorling, L., Brüsch, W., Hansen, B., Langtofte, C., Mielby, S., & Møller, R. R. (2012). *Grundvandsovervågning 2012*.

Exposure Private Wells

Nitrate in private drinking water wells exceeding 50 mg/L



Brüsch, W., Stockmarr, J., von Platen-Hallermund, F., & Rosenberg, P. (2004). *Pesticidforurenet vand i små vandforsyninger*.

Effect - Health Register

- Combination National Cancer/CPR-Register:
  - all persons residing in DK and alive on 02. April 1968 and thereafter
  - Age, sex (CPR no.)
  - Residential history:
    - Municipality and street code from 1968
    - Exact address geocoded from 1978 until last week (CIRRAU)
- Control group
  - Cohort: DK population?

Epidemiologic Study

- Approx. 25'000 cases colon cancer
- 1st step: case study compare cities with known WW supplied areas

NCR CPR JUPITER

Case	Year	Address	NO_3 Exposure
1	1994	Aalborg	42
1	1995	Aalborg	35
1	1996	Aarhus	0.3
1	1997	Aalborg	32

Issues for further steps

- Health register data
- Quality and exposure data for private well users
- Case study for certain areas: Large enough population vs. exposure information

Thank you for your attention.

References:

Ward, M. H., deKok, T. M., Levallois, P., Brender, J., Gulis, G., Nolan, B. T., & VanDerslice, J. (2005). Workgroup Report: Drinking-Water Nitrate and Health—Recent Findings and Research Needs. *Environmental Health Perspectives*, *113*(11), 1607–1614.

De Roos, A. J., Ward, M. H., Lynch, C. F., & Cantor, K. P. (2003). Nitrate in public water supplies and the risk of colon and rectum cancers. *Epidemiology*, *14*(6), 640–649.

Jensen, O. M. (1982). Nitrate in Drinking Water and Cancer in Northern Jutland, Denmark, with Special Reference to Stomach Cancer. *Ecotoxicology and Environmental Safety*, *6*(1973), 258–267.

Van Grinsven, H. J. M., Rabl, A., & de Kok, T. M. (2010). Estimation of incidence and social cost of colon cancer due to nitrate in drinking water in the EU: a tentative cost-benefit assessment. *Environmental health*, *9*(1), 58.

Extra slides (not for dNmark meeting)

Exposure

- Yearly averaged time series of nitrate (nitrite, pesticides…)
- Connect water quality from water works to supplied area
- Private wells: less data

Effect

- Why is drinking water important, if higher NO_3 intake from food?

In saliva (bacterial nitrate reductase):

$$NO_3^- + e^- + H^+ \rightarrow NO_2^- + H_2O$$

In the acidic stomach:

$$NO_2^- + H^+ \rightarrow HNO_2$$

Fate of Nitrous acid

Dinitrogen trioxide (nitrosating compound)

$$2HNO_2 \rightarrow 2N_2O_3 + H_2O$$

Nitrosation of amines:

$$R_2NH + N_2O_3 \rightarrow \boldsymbol{R_2NH \cdot NO} + HNO_2$$

Carcinogenic nitrosamine

Formation of DNA adducts

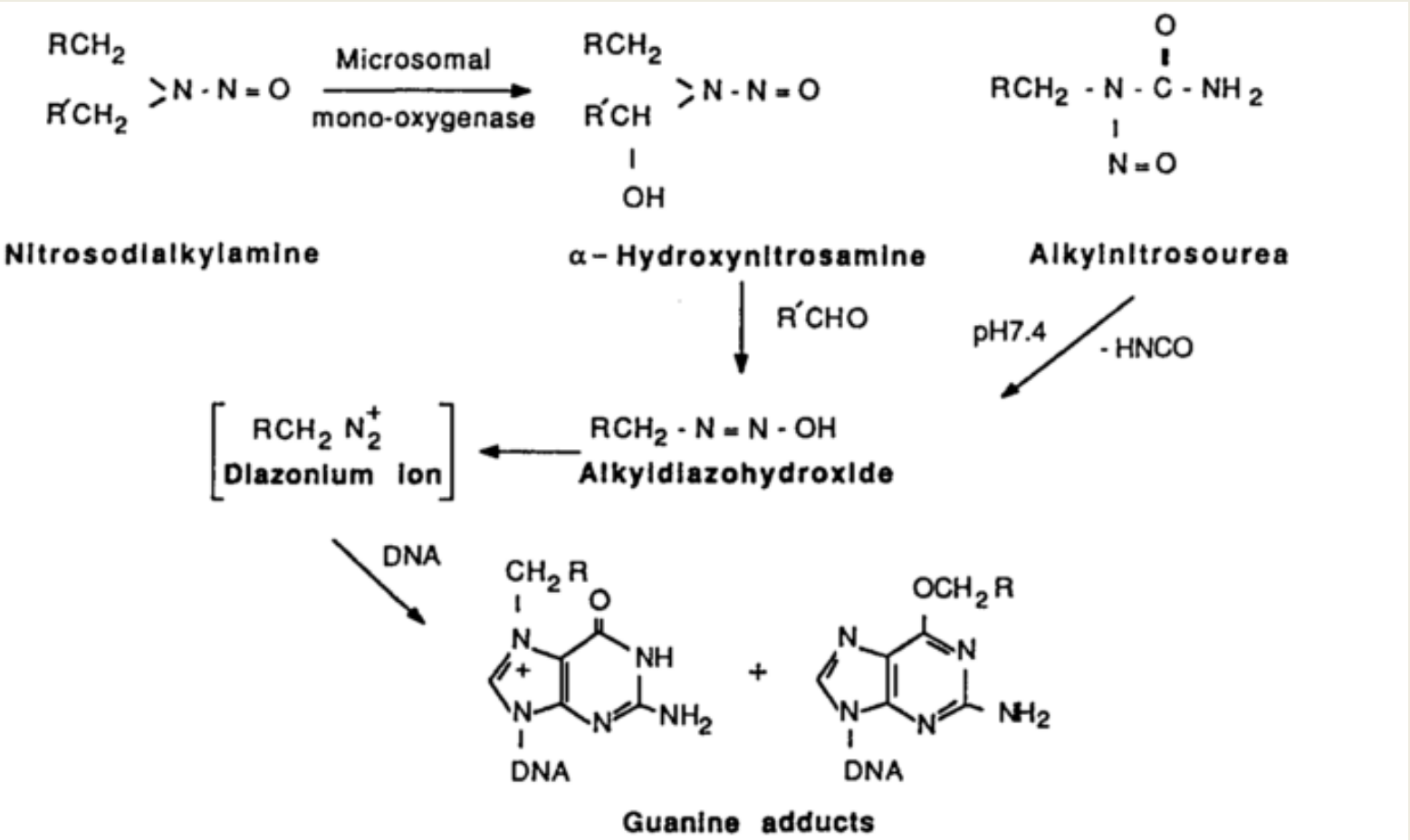


Fig. 1. Metabolic activation of *N*-nitroso compounds.

Fate of Nitrous acid

- Competition from food ingredients:
  - Vitamin C and Polyphenols bind HNO_2