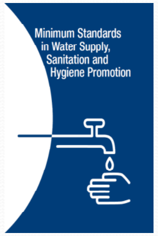
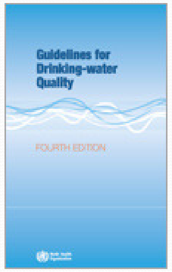
Water Quality Guidelines

by: David Banks, Hydrogeologist and thermogeologist





NORAD supported project in MRRD:
Capacity Building and Institutional Cooperation in the field of Hydrogeology for Faryab Province , Afghanistan

NORPLAN

Types of Contaminant

Unwanted substances can be

Physical

- e.g. turbidity (sediment), salinity / taste

Inorganic chemical

- e.g. nitrate, fluoride, arsenic, uranium

Organic chemical

- e.g. pesticides

Microbiological

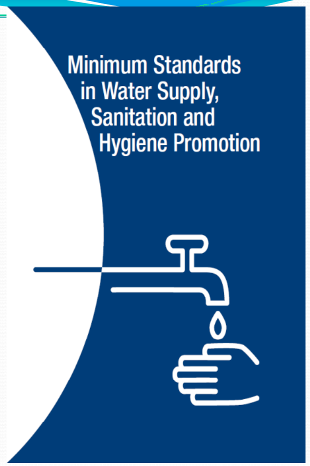
- e.g. pathogenic bacteria, viruses etc.

Radioactive

6/1/2014 2

SPHERE standards

These are minimum standards, designed to be applied in emergency or disaster situations (refugee camps, civil war, earthquake etc.)



6/1/2014 3

SPHERE Water Supply Standards

- **Access and water quantity:** All people have safe and equitable access to a sufficient quantity of water for drinking, cooking and personal and domestic hygiene. Public water points are sufficiently close to households to enable use of the minimum water requirement.
  - Indicators: 15 L per person per day
  - Maximum distance to water point = 500 m
  - Queuing time < 30 mins
- **Water quality:** Water is palatable and of sufficient quality to be drunk and used for cooking and personal and domestic hygiene without causing risk to health.
  - Indicators: No faecal coliforms per 100 mL at point of delivery or use
  - People use treated in preference to untreated sources
- **Water facilities:** People have adequate facilities to collect, store and use sufficient quantities of water for drinking, cooking and personal hygiene, and to ensure that drinking water remains safe until it is consumed.

6/1/2014 4

SPHERE Water Supply Standards

Key action

For piped water supplies, or all water supplies at times of risk of diarrhoeal epidemics, undertake water treatment with disinfectant so that there is a chlorine residual of 0.5mg/l and turbidity is below 5 NTU (nephelolometric turbidity units) at the tap. In the case of specific diarrhoeal epidemics, ensure that there is residual chlorine of above 1mg/l (see guidance notes 5–8).

6/1/2014 5

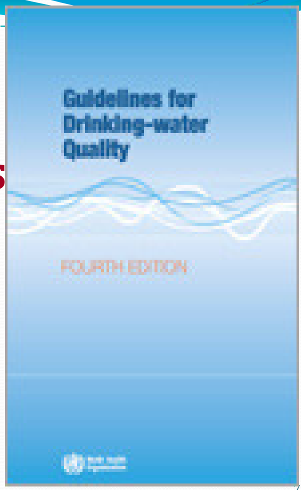
SPHERE Excreta disposal Standards

- **Environment free from human faeces**: The living environment in general and specifically the habitat, food production areas, public centres and surroundings of drinking water sources are free from human faecal contamination.
  - Indicators: All excreta containment measures, i.e. trench latrines, pit latrines and soakaway pits, are at least 30 metres away from any groundwater source. The bottom of any latrine or soak-away pit is at least 1.5 metres above the water table.

6/1/2014 6

WHO standards

WHO guidelines



6/1/2014 7

World Health Organisation

The WHO Drinking Water Guidelines (4th Edition) are non-binding...but form the background and scientific consensus for most national drinking water legislation.

In recent editions, the WHO Guidelines have moved away from highly prescriptive norms...

...and towards risk assessment health-based targets and water safety plans

6/1/2014 8

National standards

?

6/1/2014 9

Physical Quality

Salinity / Total dissolved solids (TDS)

The WHO (2011) drinking water guidelines suggest that water typically becomes significantly and increasingly unpalatable at TDS levels greater than about **1000 mg/L**.

The EU Drinking Water Directive recommends a maximum electrical conductivity of 2500 µS/cm

Remember: **TDS (mg/L) = EC (µS/cm) x f**

- where f = 0.55 for a water dominated by sodium chloride
- f = 0.75 for a water dominated by calcium bicarbonate

6/1/2014 10

Turbidity (WHO 2011)

Turbidity is measured by nephelometric turbidity units (NTU) and can be initially noticed by the naked eye above approximately 4.0 NTU. However, to ensure effectiveness of disinfection, turbidity should be no more than 1 NTU and preferably much lower. Large, well-run municipal supplies should be able to achieve less than 0.5 NTU before disinfection at all times and should be able to average 0.2 NTU or less. Surface water (and groundwater under the influence of surface water) treatment systems that achieve less than 0.3 NTU prior to disinfection will have demonstrated that they have significant barriers against pathogens that adsorb to particulate matter. Of particular importance is the fact that this will be a good indicator that they are removing chlorine-resistant pathogens such as *Cryptosporidium*.

Small water supplies where resources are very limited and where there is limited or no treatment may not be able to achieve such low levels of turbidity. In these cases, the aim should be to produce water that has turbidity of at least less than 5 NTU and, if at all possible, below 1 NTU. For many of these small and usually rural supplies, measuring turbidity below 5 NTU may present a significant cost challenge, and thus providing low-cost measuring systems that can measure lower turbidities is an important requirement.

6/1/2014 11

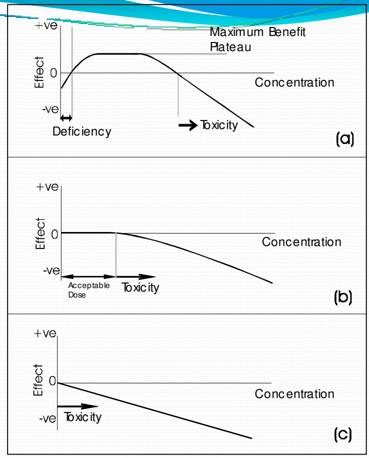
Chlorination (WHO 2011)

are also used in some household water treatment technologies. Proper dosing of chlorine for household water treatment is critical in order to provide enough free chlorine to maintain a residual during storage and use. Recommendations are to dose with free chlorine at about 2 mg/l to clear water (< 10 nephelometric turbidity units [NTU]) and twice that (4 mg/l) to turbid water (> 10 NTU). Although these free chlorine doses may lead to chlorine residuals that exceed the recommended chlorine residual for water that is centrally treated at the point of delivery, 0.2–0.5 mg/l, these doses are considered suitable for household water treatment to maintain a free chlorine residual of 0.2 mg/l in stored household water treated by chlorination. Further information on point-of-use chlorination can be found

6/1/2014 12

Chemical Quality

Hydrogeochemistry and Health



6/1/2014 13

Fluoride

- Typical drinking water limit = 1.5 mg/l
- Excessive consumption can lead to dental or skeletal fluorosis in humans or cattle
- Common in granitic and volcanic areas, geothermal areas, or in arid areas with high evaporation
- Solubility can be limited by high concentrations of calcium

6/1/2014 14

Fluoride effects

Level in water	Effects
0.8–1.2 mg/l	Prevention of tooth decay, strengthening of skeleton
Above 1.5 mg/l	Fluorosis: pitting of tooth enamel and deposits in bones
Above about 10 mg/l	Crippling skeletal fluorosis

From WHO
http://www.who.int/water_sanitation_health/naturalhazards/en/index2.html

6/1/2014 15

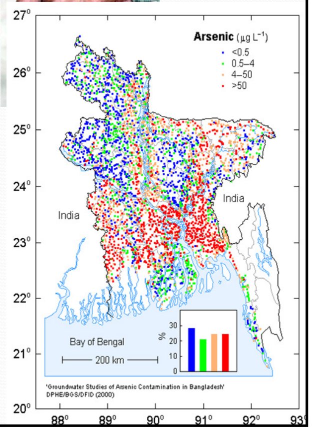
Fluoride – water treatment

- Change of usage habits: avoid F-rich water for young children, avoid supplements
- Low tech: Adsorption onto laterite-based ceramics, fish bone-ash
- Small scale: Reverse osmosis, anion exchange
- Large scale: co-precipitation with alumina / Nalgonda method

6/1/2014 16

Arsenic

- WHO provisional guideline = 10 µg/l = 0.01 mg/L
- Excessive consumption leads to skin lesions, hyperpigmentation and other symptoms
- Coagulation may remove some Arsenic



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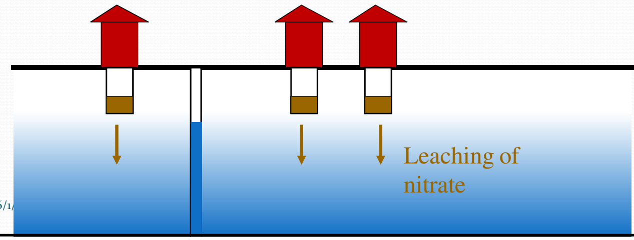
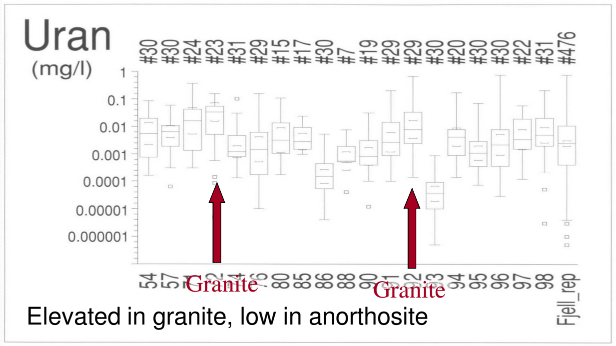
Nitrate and nitrite

- Can be derived from farming and fertilisers
- Also caused by run-in of manure to rivers and wells
- Or, over a longer period, by leaching of pit latrines to groundwater
- Typical drinking water limit = 50 mg/l nitrate (as NO_3^-)
- High concentrations can be acutely toxic to infants (blue baby syndrome), especially if also diarrhoeal risk
- Can be concentrated by evaporation



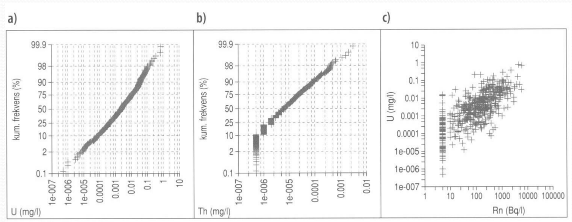
18

Uranium: displays a geological dependence – e.g. uranium in bedrock groundwater in Norway



6/1/2014 19

Uranium & Thorium

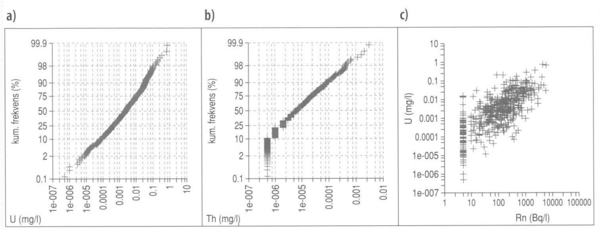


- Uranium:
- Very soluble under oxidising conditions.
- Can be evapoconcentrated
- Chemotoxicity probably exceeds radiotoxicity

Uranium Drinking water limits:

- No limit in EU
- 20 µg/l in Canada
- 30 µg/l in USA
- 30 µg/l = WHO provisional guideline

Uranium & Thorium



Thorium:
Rather insoluble under most conditions.
Chemotoxicity probably exceeds radiotoxicity
Toxicity in water poorly quantified
Drinking water limits:
- None set

Uranium & Thorium

- **Uranium,** Norway:
- 12 % exceedence in bedrock wells (n = 476) of USA norm of 30 µg/l.
- Worst in granite
- Median = 2.5 µg/l
- Maximum 749 µg/ (n = 476)
- Has been known at up to 2 mg/l elsewhere in Norway and 14 mg/l in Finland

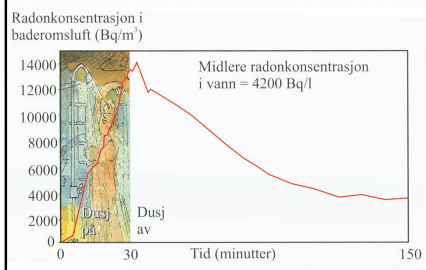
- **Thorium,** Norway:
- Worst in granite
- Median = 0.006 µg/l
- Maximum 3.1 µg/l (n = 476)

Thallium and Beryllium

Thallium
- Highly toxic (rat poison) but not routinely analysed
- No EU standard
- USEPA = 2 µg/l
- Soviet GOST = 0.1 µg/l
- In Norway, 0 % exceedence of US norm
- Median = 0.007 µg/l
- Maximum = 0.25 µg/l (n=476)

Beryllium
- Highly toxic (bone tissue, lungs, carcinogenic?) but not routinely analysed
- No EU standard
- USEPA = 4 µg/l
- Soviet GOST = 0.2 µg/l
- In Norway, 0.2-0.4% exceedence of US norm
- Median = 0.012 µg/l
- Maximum = 6.6 µg/l (n=476)

Radon



De-gasses inside the home via showers, washing machines etc.

- Inert, odourless, soluble gas
- Radioactive, derived from radium and ultimately uranium
- Half life 3.9 days
- Norwegian domestic water limit = 500 Bq/l

Radon

Norway:

13.9 % exceedence in bedrock wells (n = 1601).

Worst in granite & gneiss.

Maximum 31,900 Bq/l

0% exceedence in Drift (Quaternary) wells (n = 72)

Treatment

Relatively simple:
•Aeration plus storage to allow radon and its daughters to decay
•Better ventilation of house

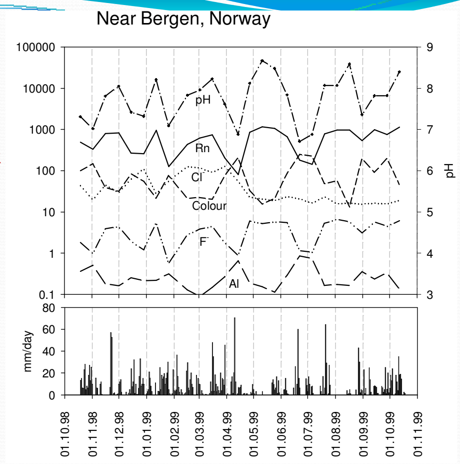
Remember that groundwater quality changes with time

Especially in fractured rock aquifers

In some boreholes, episodes of rain were accompanied by

•low pH, alkalinity, F^-, EC and radon

•high Al, colour, and sometimes turbidity and chloride (from road salt)



Many parameters are indicators of pollution

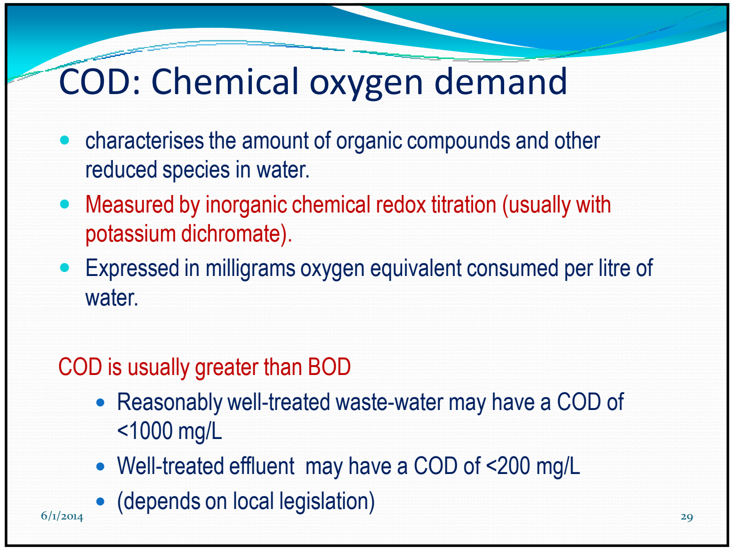
- High concentrations of **ammonium (NH_4^+)** can be an indication of contamination from sewerage. (Elevated **potassium, chloride** and **phosphorus** can also be indicators of contamination by organic wastes)
- **Biological oxygen demand (BOD)** and **chemical oxygen demand (COD)** are also indicators of contamination by organic wastes (e.g. sewers)
- Low concentrations of **dissolved oxygen** (measured by simple probe) may indicate contamination by organic wastes (e.g. sewers). (Fully oxygenated water typically has 10-12 mg/L O_2)
- **But you should also use your eyes and do a WALKOVER SURVEY**

6/1/2014 27

BOD: Biological oxygen demand

- is the amount of dissolved oxygen required by aerobic biological organisms in water to metabolise organic material present in the water at a certain temperature in a given specific time period.
- High values mean that oxygen will be consumed by microbes in metabolising organic matter, leaving none left over for aquatic life.
- Measured by a biological titration...i.e. incubating the water samples and measuring the reduction of dissolved oxygen in a given period
  - Clean rivers should have a BOD < 1 mg/L.
  - Polluted rivers may have BOD of 2 to 8 mg/L.
  - Well-treated sewage may have BOD < 20 mg/L
  - Untreated sewage may have BOD 200- 600 mg/L

6/1/2014 28


COD: Chemical oxygen demand
characterises the amount of organic compounds and other reduced species in water.
Measured by inorganic chemical redox titration (usually with potassium dichromate).
Expressed in milligrams oxygen equivalent consumed per litre of water.
COD is usually greater than BOD
Reasonably well-treated waste-water may have a COD of <1000 mg/L
Well-treated effluent may have a COD of <200 mg/L
(depends on local legislation)
6/1/2014
29