TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY

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How to measure water?

Water Quality Parameters

Workshop for young water engineers

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TalTech, 2022

Why to measure?
What to measure?

- Suitability of water for different purposes (drinking water, bathing water, industry, agriculture, etc...)
- Study purposes
- Monitoring, detecting changes in quality/status of the waterbody

GOAL: → Measurement plan (where, what, how much)→ Sampling → Analyses → Discussing results → Decisions

What could be measured?

Physical parameters

- Temperature
- Color
- Taste
- Smell
- Turbidity
- Suspended solids

Chemical parameters

- Organic compounds-BOD, COD, TOC
- Nutrients (N and P compunds)
- Main cations and anions
- Soluble gases (O_2, CO_2 …)
- Hardness
- Alkalinity
- pH/Conductivity
- Etc…

- Heavy metals, Pesticides, Pharmaceuticals, Etc.

- **Biological parameters**

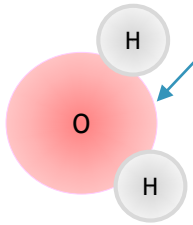
- Bacteria
- Viruses
- Parasites
- Algae
- Etc...

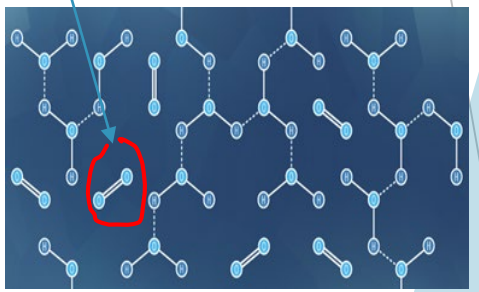
Parameters measured during the fieldwork

- Dissolved oxygen content (always measured in the sampling site)
- pH
- Conductivity

Dissolved oxygen (O_2) concentration

- **Concentration of dissolved oxygen** characterises the living conditions in the waterbody, the level of pollution and the rate of self-purification
- We are measuring the oxygen, that has been solved in the water and not all oxygen that is present as part of water molecules





https://www.fondriest.com/

O_2 – where does is come from and where does it go?

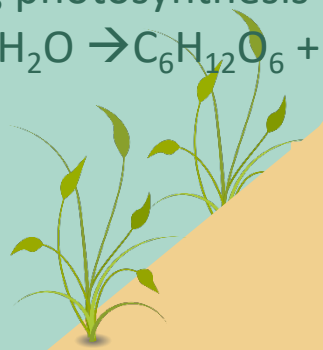
Adding/removing O_2– water and air are mixed in the upper level (equilibrium)

Removal of O_2 – respiration of aquatic organisms

$C_6H_{12}O_6 + 6O_2 \rightarrow 6\ CO_2 + 6H_2O$ + „energy“

Adding O_2 – during photosynthesis

$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$



Adding organic substances to the waterbody – organisms (plants and animals) + agricultural land + industry (wastewater)

Removal of O_2 – Decomposition of organic substances

„Organic substance“ + $O_2 \rightarrow CO_2 + H_2O$ +„nutrients“ + „energy“

O_2 units

- **Dissolved Oxygen Units**

1. usually reported in mg/L
2. or as a percent of air saturation

- $O_2\% = \frac{Cx}{Co} * 100\%$

$$O_2\% = \frac{C_x * 760}{C_0 * P_T} * 100$$

C_x – O_2 concentration measured (mg/l);
C_0 – O2 concentration at given temperatuure and airpressure 760 mmHg (from table)
P_T – air pressure at the moment of measurment

100% air saturation means that the water is holding as many dissolved gas molecules as it can in equilibrium.

O_2 units

Example:

T=25 ^oC

DO measured = 7,6 mg/l

DO saturation from table

$$O_2\% = \frac{7,6}{8,24} * 100 = 92,2\ \%$$

Maximum Dissolved Oxygen Concentration Saturation Table

Temperature (degrees C)	DO (mg/L)	Temperature (degrees C)	DO (mg/L)
0	14.60	23	8.56
1	14.19	24	8.40
2	13.81	25	8.24
3	13.44	26	8.09
4	13.09	27	7.95
5	12.75	28	7.81
6	12.43	29	7.67
7	12.12	30	7.54
8	11.83	31	7.41
9	11.55	32	7.28
10	11.27	33	7.16
11	11.01	34	7.05
12	10.76	35	6.93
13	10.52	36	6.82
14	10.29	37	6.71
15	10.07	38	6.61
16	9.85	39	6.51
17	9.65	40	6.41
18	9.45	41	6.31
19	9.26	42	6.22
20	9.07	43	6.13
21	8.90	44	6.04
22	8.72	45	5.95

Measurments (O_2)

- Always done during the sampling, as changes can occur while taking the samples to the lab and we cannot get the correct result. (The organic substance in the sample start to break down using O_2)
- Sensors (with different working principles) – results can be shown either in mg/l or in %. Temperature is measured as well.
- Titration – Winkler method (in case of low concentrations of oxygen, small amounts of water)

www.coleparmer.com


www.usgs.gov


https://niwa.co.nz

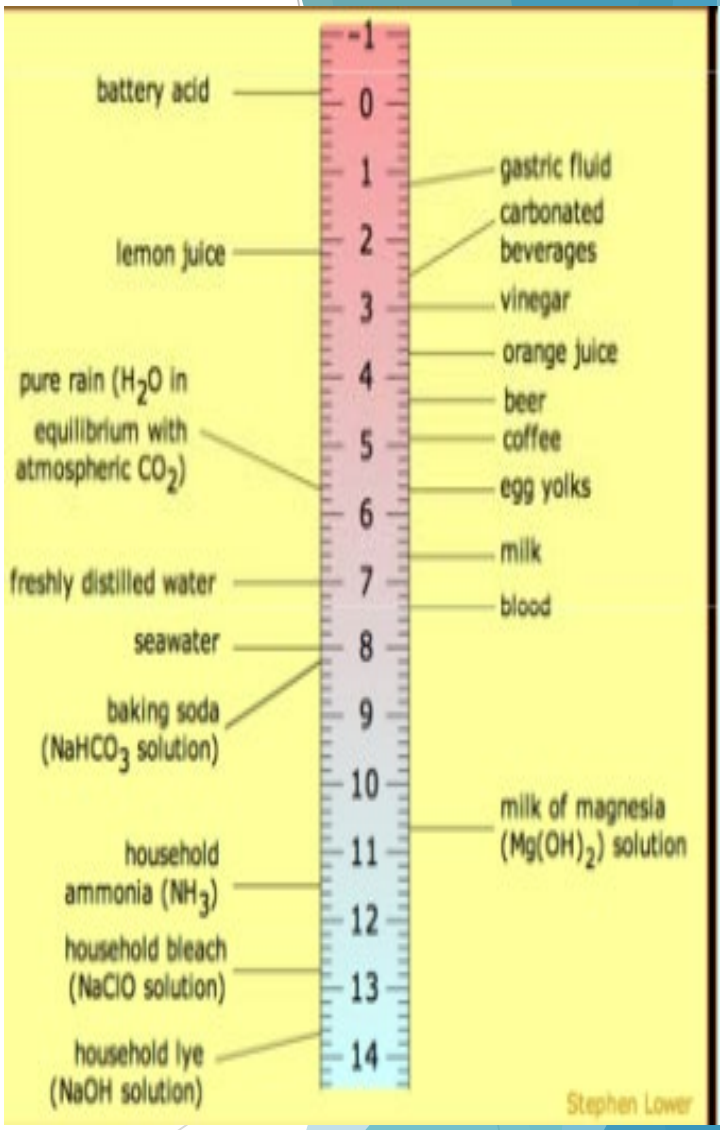
pH

- pH is a measure of how acidic/basic water is The range goes from 0 - 14, with 7 being neutral.
- The pH of water determines the solubility of many ions and biological availability of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium)

- Constant values of pH and conductivity during longer period, can be a proof that the quality of water hasn't changed

- Usually measured directly on-site, but can be measured also in the laboratory

- Surface freshwater: 6-9
- Swamps: 4-5
- Sea water: 8.1, can be as low as 7.7



The effects of pH on other chemicals in water:

- Heavy metals such as cadmium, lead, and chromium dissolve more easily in highly acidic water (lower pH). This is important because many heavy metals become much more toxic when dissolved in water
- A change in the pH can change the forms of some chemicals in the water. Therefore, it may affect aquatic plants and animals. Ammonia is quite harmless to fish in neutral or acidic water, but when the water becomes more alkaline (the pH increases), ammonia becomes progressively more poisonous to these same organisms.

Conductivity

- Conductivity is a measure of how well a solution conducts electricity. To carry a current a solution must contain charged particles , or ions.
- The major positively charged ions are sodium, (Na^{+}) calcium (Ca^{+2}), potassium (K^{+}) and magnesium (Mg^{+2}).
- The major negatively charged ions are chloride (Cl^{-}), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}), and bicarbonate (HCO_3^{-}).
- Nitrates (NO_3^{-2}) and phosphates (PO_4^{-3}) are minor contributors to conductivity, although they are very important biologically

- Conductivity is not specific. It measures the total concentration of ions in a solution. We can not differentiate one ion from another
- Salts and other substances affect the quality of water used for different purposes. They could have a critical influence on aquatic biota, as every kind of organism has a typical salinity range that it can tolerate
- **Salinity** is a measure of the amount of **salts** in the water
- Conductivity is an early indicator of change in a water system. Most bodies of water maintain a fairly constant conductivity that can be used as a baseline of comparison to future measurements

Conductivity will vary with water source: ground water, water drained from agricultural fields, municipal waste water, rainfall

Conductivity of **surface waterbodies** (rivers, streams) depends on the geology of the area that they pass through.

- Rivers in **granite** beds have lower conductivity, as granite is made of inert materials that do not break down into ions so easily

- Rivers located in areas with sandy soils have a higher conductivity as a rule, as particles falling into water are easily broken down into ions.

In case of **ground water,** conductivity depends on the character of the relevant geological layers as well.

Examples

- Distilled water ~ 0,5-10 µS/cm
- Tap water (Tallinn) ~ 400-500 µS/cm
- Tap water (Rakvere) ~ 900 µS/cm
- River water ~400-600 µS/cm
- Baltic Sea ~10 000 µS/cm
- Ocean ~ 50 000 µS/cm (50 mS/cm)
- Rain water ~ 2-40 µS/cm

Measuring devices

pH-sensor

www.priggen.com

pH-meter

Units

conductivity

- µS/cm
- mS/cm
- S/cm

0,5- 50 000 µS/cm

www.coleparmer.com

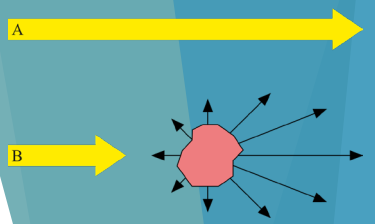
Table top pH-meter

www.mt.com

Conductivity meter and sensor

www.ysi.com

Turbidity

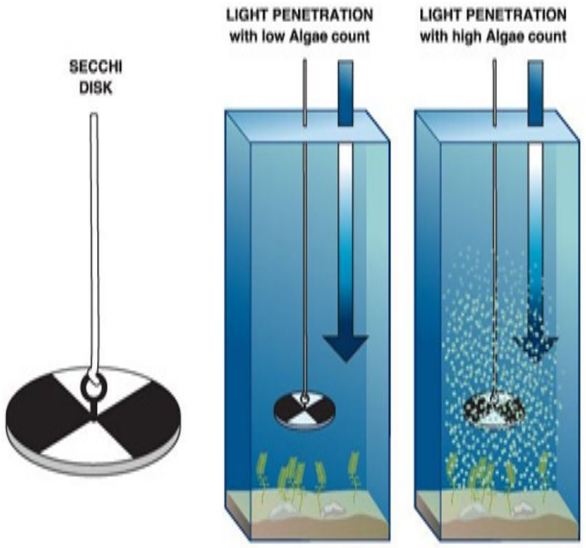


https://www.photometer.com/en/GlossaryEntry/Scattered-light/

- Turbidity measures the scattering effect suspended particles have on light
- It is caused of suspended and colloidal inorganic and organic material (soil, clay, sand) as well as plankton, microbes, etc., floating in water, which reduce the transparency of the water
- As a general rule, greater the degree of pollution, more pronounced is the turbidity. Therefore often the degree of turbidity is taken to be an approximate measure of the intensity of pollution.
- **BUT** two reservations must be made:
  - ✓ Turbidity in natural watercourses might be due to the presence of small amounts of some inert and relatively harmless minerals like clay particles. Such water is considered satisfactory for most purposes
  - ✓ Absence of turbidity doesn't necessarily mean that the water is unpolluted, because the clear water could be polluted with dissolved impurities

- Particles that cause turbidity are generally non-toxic, but
  - ✓ higher turbidity increases water temperature because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold.
  - ✓ higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO.
  - ✓ suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development.
  - ✓ as the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates

Turbidity can be measured **directly** with a turbidity meter/sensor, or **indirectly** with a Secchi disc/tube



Turbidity

Typical Values

Measured Sample	Measured Value
Waste Water	70-2000 NTU
Final outlet sewage treatment plant	4-20 NTU
Well Water	0.05 - 10 NTU
Potable water	0.05 - 1.5 NTU
Milk	> 4000 NTU
Orange juice	300 - 900 NTU
Primary sludge	6-3%(60 - 30 g/l)
Activated sludge	3-7 g/l
Recirculated sludge	6-8 g/l
Digested sludge	5-8%(50-80 g/l)

https://www.isanorcal.org/download/tech2007_presentations/turbidity.pdf