TECHNISCHE UNIVERSITÄT WIEN
Vienna | Austria

Introduction to Water Quality Monitoring

incl. COVID in the sewage, public health impacts and environmental performance requirements

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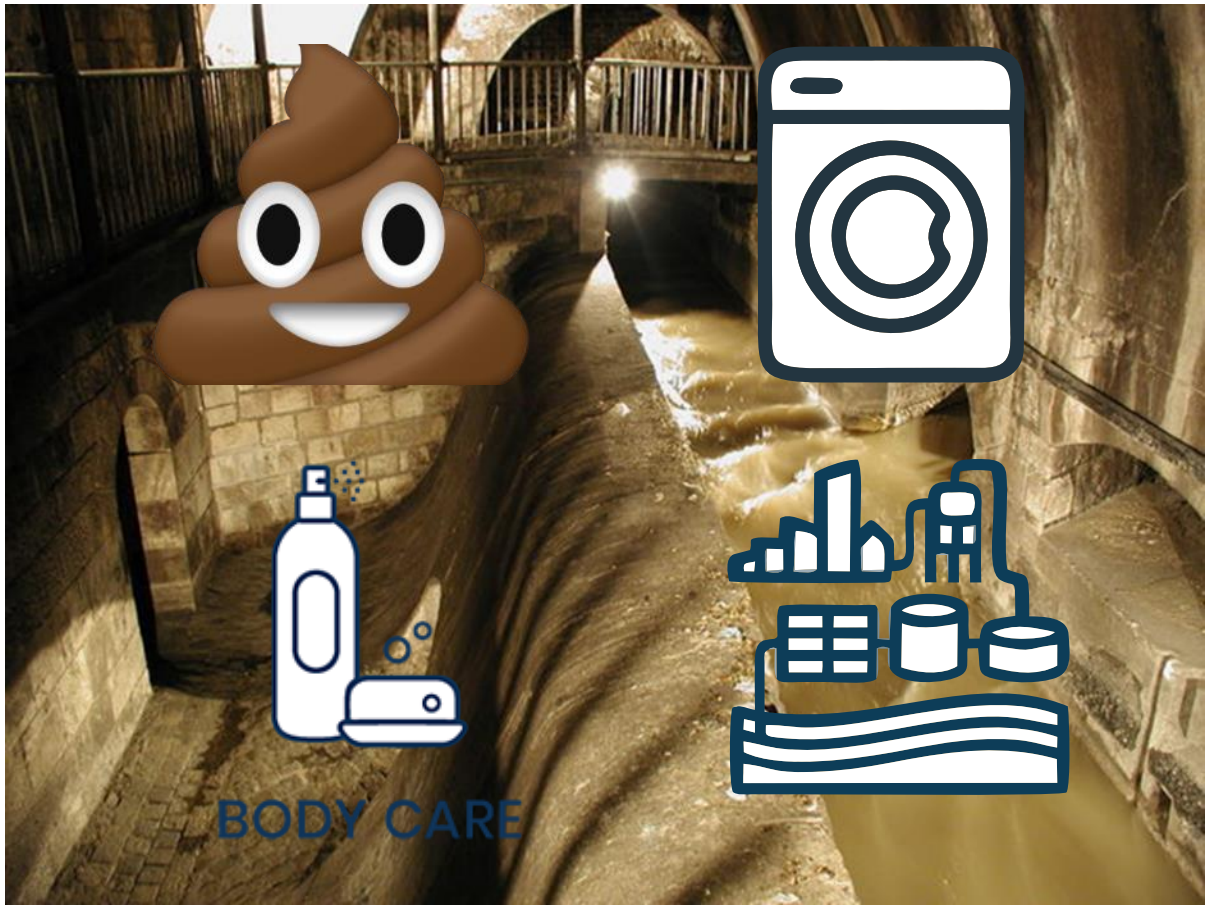
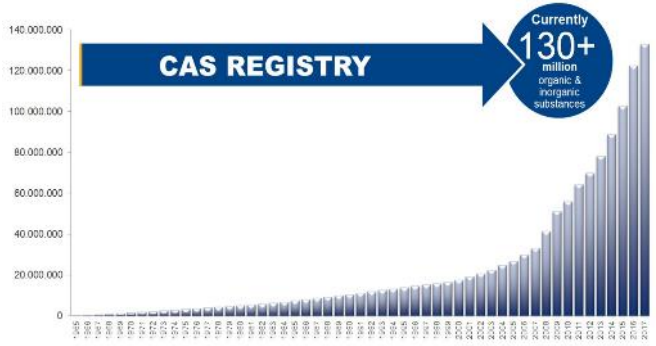
Why Wastewater Treatment?



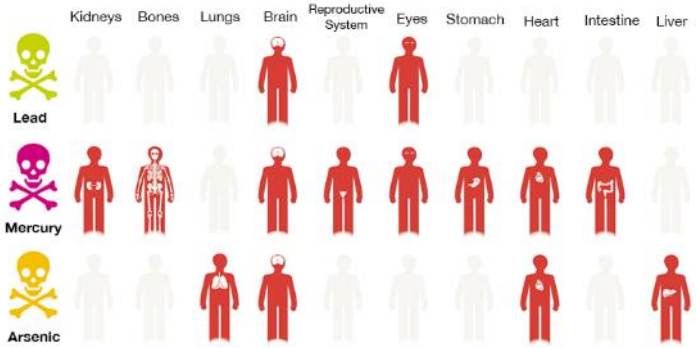
- Wastewater
  - Human faeces
    - On average 128 g / p / d
    - 75% water
    - 84 - 93% organic solids
      - 25 - 54% bacterial biomass
      - 2 - 25% protein (N)
      - 25% carbohydrate / undigested food
      - 2 - 15% fat
  - Urine
    - On average 1.4 L / p / d
    - 91 - 96% water
    - 65 - 85% organic matter
    - 6.87 g/L C, 8.12 g/L N
  - Other domestic sources
    (laundry, personal care, medication, …)
  - Industrial
    (production processes, cleaning, …)

Why Wastewater Treatment?



Source: CAS

Bacteria commonly found in the human colon[29]	
Bacterium	Incidence (%)
Bacteroides fragilis	100
Bacteroides melaninogenicus	100
Bacteroides oralis	100
Enterococcus faecalis	100
Escherichia coli	100
Enterobacter sp.	40–80
Klebsiella sp.	40–80
Bifidobacterium bifidum	30–70
Staphylococcus aureus	30–50
Lactobacillus	20–60
Clostridium perfringens	25–35
Proteus mirabilis	5–55
Clostridium tetani	1–35
Clostridium septicum	5–25
Pseudomonas aeruginosa	3–11
Salmonella enterica	3–7
Faecalibacterium prausnitzii	?common
Peptostreptococcus sp.	?common
Peptococcus sp.	?common



- Wastewater as mixture of
  - Organic chemicals
    - Macro concentrations (mg / L range)
      Fats, lipids, sugars, …
    - Micro concentrations (µg / L range)
      hormones, pharmaceuticals, food additives, …
  - Inorganic compounds
    - Nutrients (mg / L range)
      nitrogen, phosphorous, potassium, …
    - Heavy metals
      Cu, Cn, Pb, …
  - Microorganism
    - Commensal intestinal bacteria
      (GI ~250–400 m²)
    - Pathogenic organisms
      bacteria (Shigella, …), viruses (Hep-A, …), protozoa, …
- High dynamic composition
- Reflects characteristic of discharging person & society

Why Wastewater Treatment?

- Consequences of release of untreated wastewater
  - Human as protection target
    - Uptake of pathogenic organisms
      - Consumption of polluted drinking water
      - Recreational use
      - Agricultural reuse
    - Intoxication by chemicals
      - Organic & inorganic substances
      - Dose-response relationship
      - Acute and chronical effects
  - (aquatic) environment as protection target
    - Deterioration of habitats and ecofactors
      - Lack of oxygen
      - Increased availability of nutrients
      - pH and T shifts
      - …
    - Intoxication by chemicals
      - Organic & inorganic substances
      - Acute and chronical effects

Why Wastewater Treatment?

- Increasing pressure on water resources
  - Availability
    - Quantitative & qualitative aspects
    - Temporal & spatial distribution
  - Demand
    - Increasing population
    - industrialisation
- Downstream use
  - Direct reuse
    - Agriculture
    - Industry
    - Municipal
  - Indirect reuse
    - After returning to natural water cycle

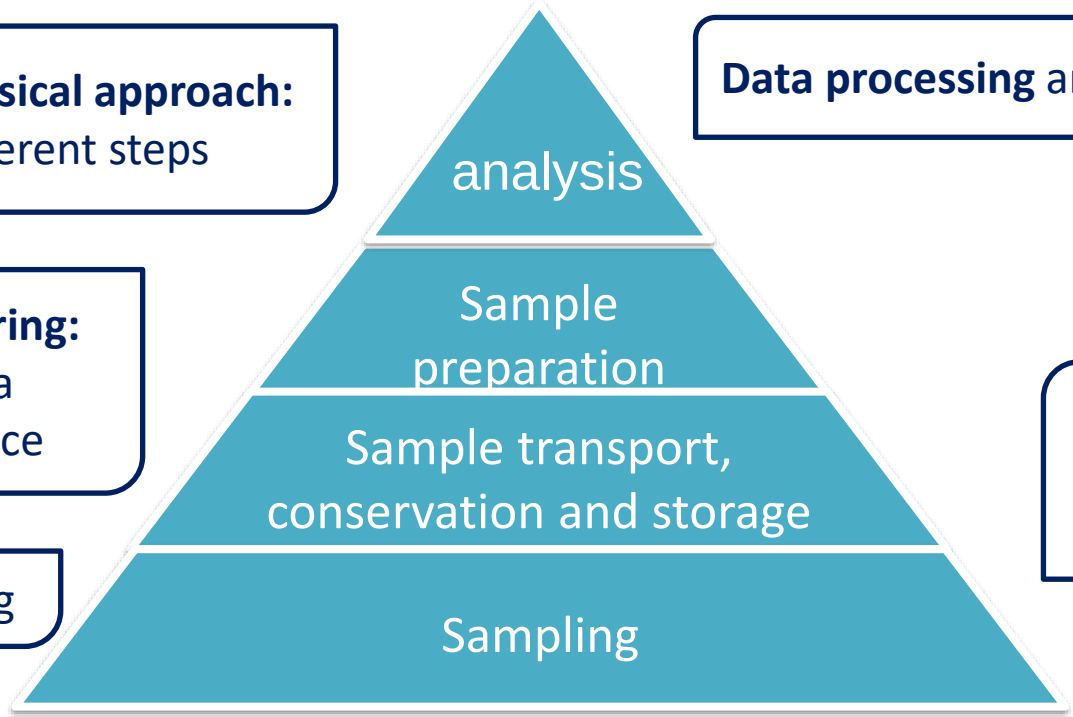
Monitoring

Monitoring describes the processes and activities that need to take place to characterize and monitor the quality of the waters.

Classical approach: different steps

On-site monitoring: integrated into a monitoring device

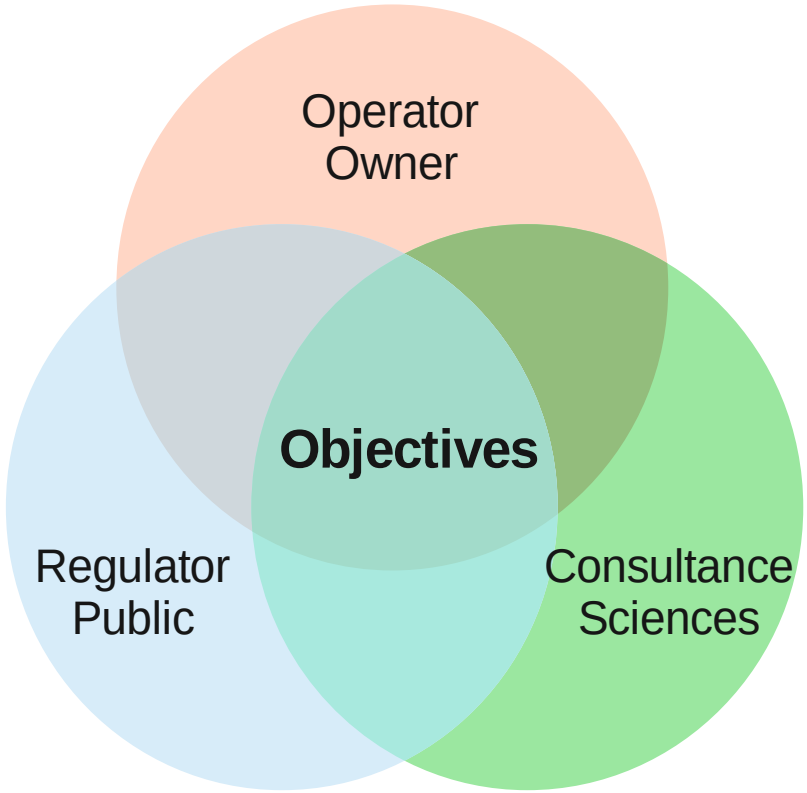
Representativeness of sampling



Data processing and storage

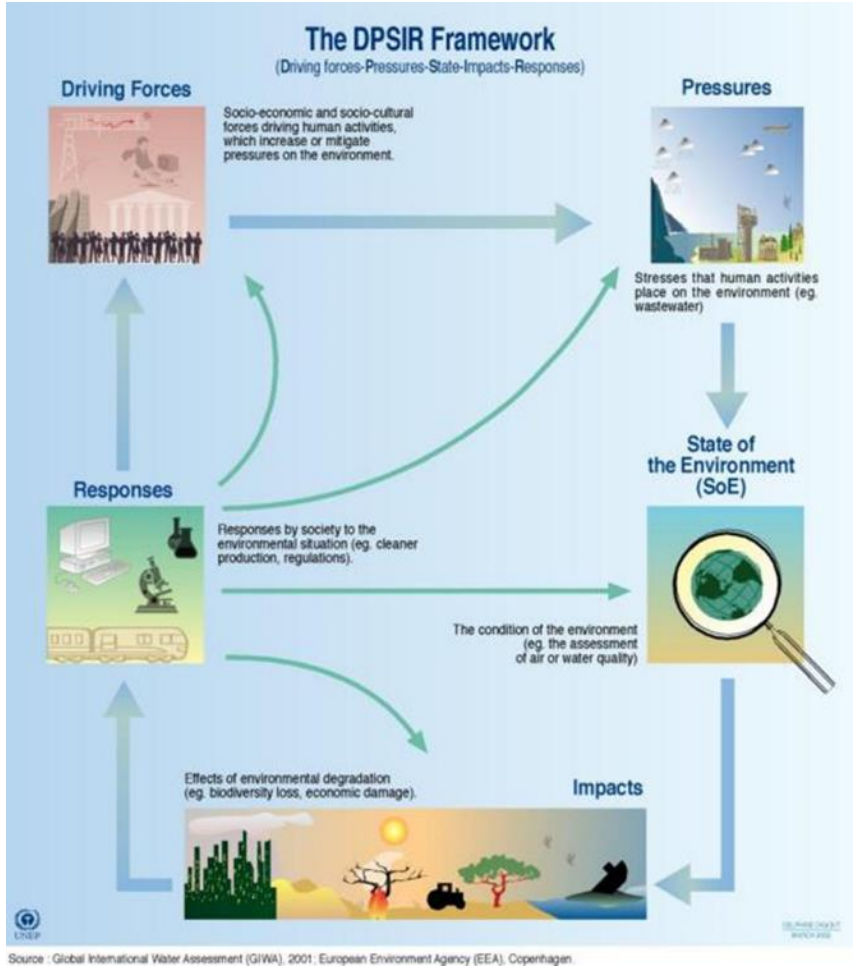
Each step needs to consider **parameters of interest**

Monitoring - why?



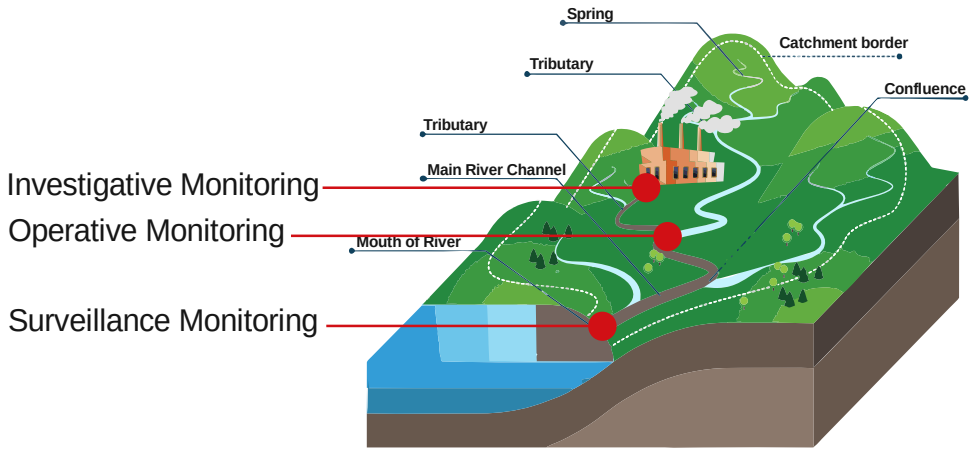
- Monitoring for
  - Performance indication
  - Assessment of treatment efficiency
  - Efficient operation & optimization
  - Identifying problems
  - Planning and upgrading
  - Compliance with regulations
- Monitoring Objectives
  - Have to be defined
  - Best case: broad overlap of different objectives
  - Cost - benefit
- More is not better!

Monitoring - why?



- Water quality assessment
  - based on regulations
  - environmental quality standards
- Pollution screening
- Trend analyses
  - long term programs required
- Event/Process monitoring (high frequency)
- Load assessment
  - e.g. emissions
  - cross border transport
  - flow and concentration
- Calibration and validation of models

Monitoring - where?



Surveillance	Operative	Investigative
small	larger	as necessary
extended	reduced	specific
long	gaps allowed	short
Monthly or bi-weekly	monthly	events

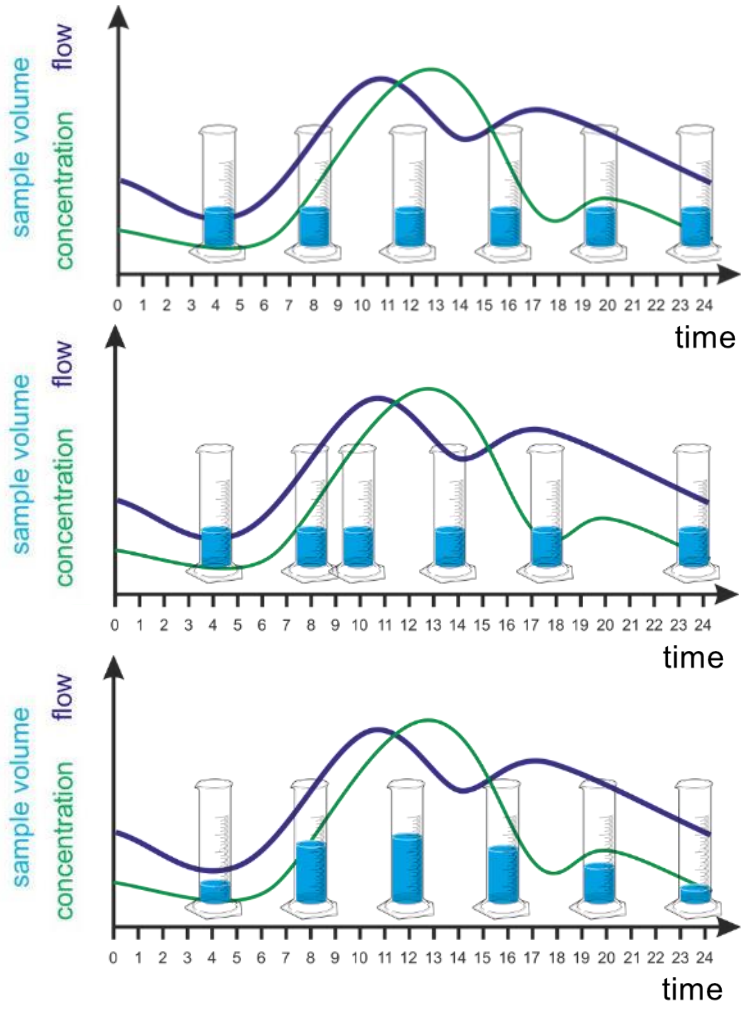
- Depending on monitoring Objectives
  - Environmental Monitoring
    - Surveillance monitoring
    - Operative monitoring
    - Investigative monitoring
    - Differences in
      - Number of sites
      - Parameter set
      - Time series
      - Time resolution
      - Costs !
  - WWTP Monitoring
    - Inflow of WWTP
    - Effluent
    - Along treatment train
    - Indirect dischargers
    - Sewer-(sub)catchment

Monitoring - what?

- Depending on monitoring objectives und guidelines

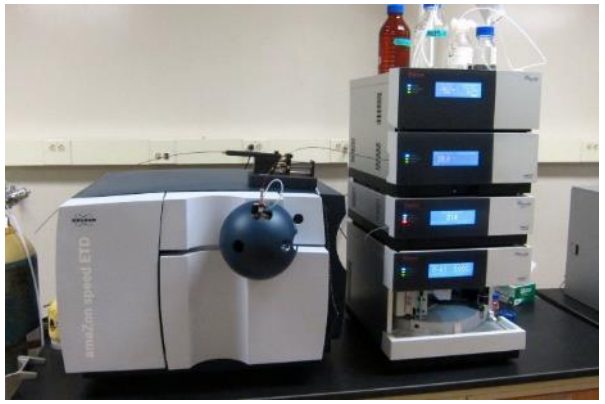
- Physical-chemical parameters
  - Temperature, pH, Conductivity
  - Online probes available
- Macronutrients (C/N/P) & TSS
  - Traditional and meaningful parameter set
  - Base for most guidelines and KPIs
- Flow
- Energy
- Other process relevant parameters
  - Sludge settling properties
- (investigative parameters as e.g. heavy metals)

Monitoring - how?



- Sampling
  - Grab samples
    one sample at one place one time
  - **Semi-continuous and continuous sampling**
    automated sampling station or monitoring sensors
    e.g. 24h volume proportional sampling for WWTPs
    - Time proportional, CTCV (Constant Time - Constant Volume)
    - Volume proportional, CVVT (Constant Volume - Variable Time)
    - Flow proportional: CTVV (Constant Time - Variable Volume)
  - Passive sampling
    Adsorption of substances on sampling media
  - Remote surveillance
    on-site monitoring equipment to be connected to a base station via e.g. telemetry network
  - Remote sensing
    e.g. satellites for monitoring using multi-channel sensors
  - Bio-monitoring
    use of living organisms as monitoring tools

Monitoring - how?

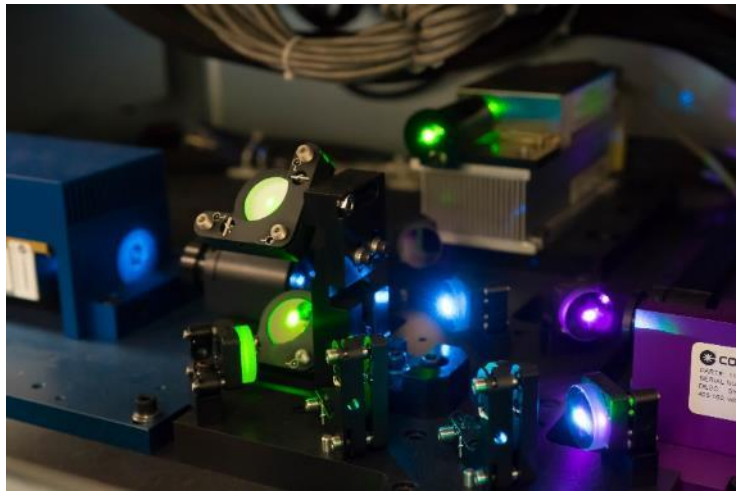


- Equipment
  - Broad variety of options (& price range)

  - Manual lab methods
  - (semi-)automated lab methods
  - Onsite continuous online measurement

- Education & training
  - More important then type equipment!!!

Monitoring - how?



- Above slide applies to
  - all parameters (chemistry & biology)
  - Environmental monitoring
  - Wwtp KPI monitoring
- Different equipment level at different organisational levels
  - Field level (no power supply, …)
  - Treatment plant level
  - Authority level
  - Provider of analytical monitoring
- Solutions for all complexity levels available

Where to start?

- Education and training
- Test Kit / cuvette based systems
  - Photometric tests
  - Available for a broad range of parameters
  - Easy to use and robust
  - From many suppliers
- Simple parameter set
  - Physical parameters
    - T, pH, Cond, O_2
  - Carbon parameters
    - BOD & COD (test Kit)
  - Nutrients
    - Different N specied; P

Where to start?

- For wwtps
  - World wide wwtps have similar analytical equipment
  - In 98% of cases this is a basic but targeted and efficient “low cost” equipment

  - Basic equipment
    - Sludge property measurement
    - Photometer for C/N/P measurement
    - Handprobe for Oxyhen, pH, conductivity
    - Microscope

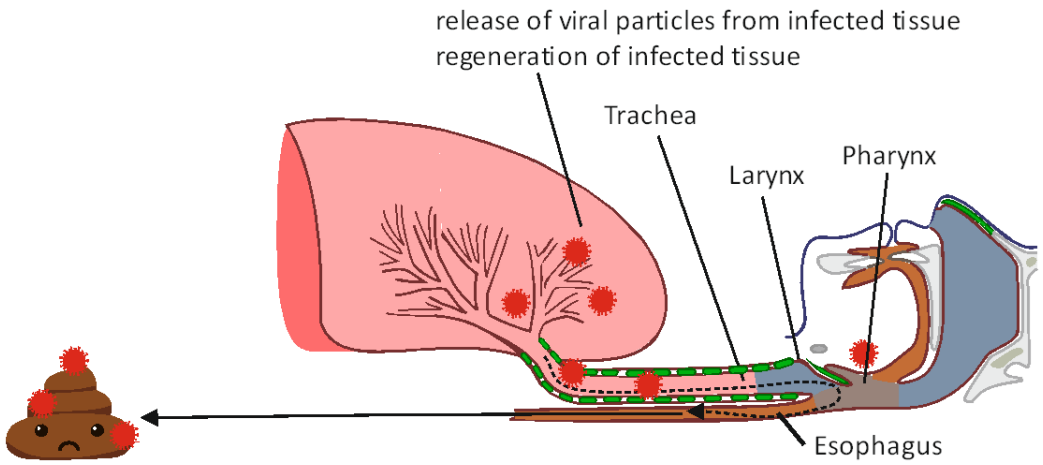
  - Fridge, sink, …
  - (field kits available for operation with car battery)

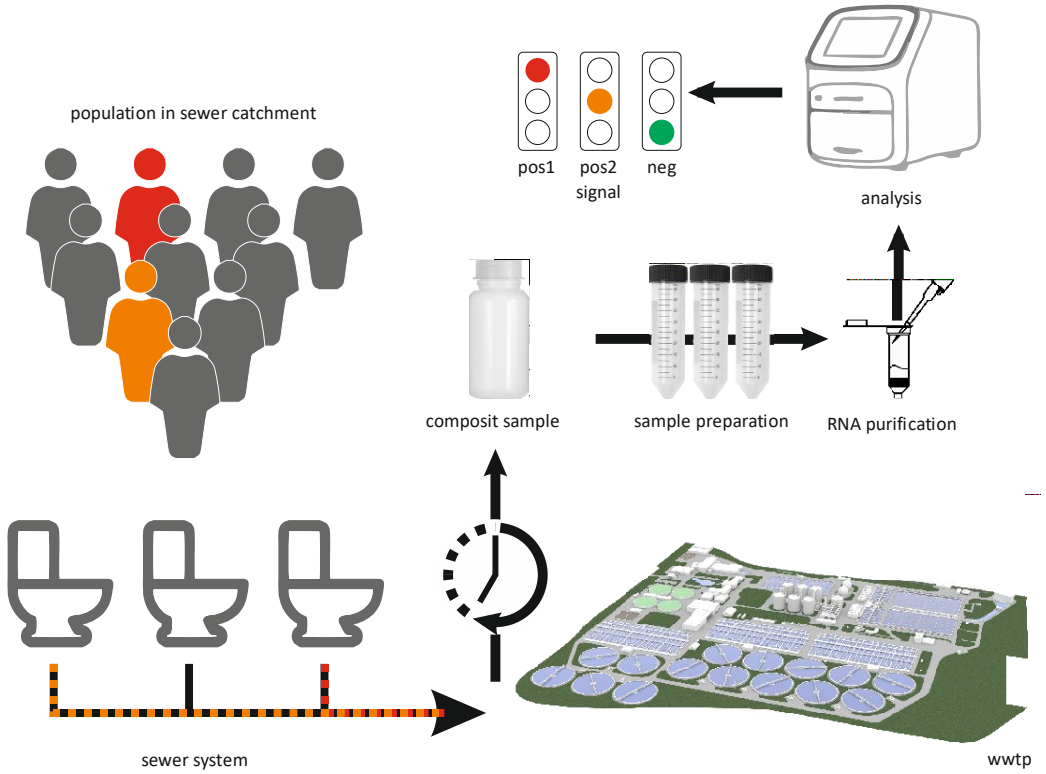
SARS-CoV2 / COVID

- Wastewater as mirror of the society
  - Nutrition behaviour
  - Personal care behaviour
  - Drug consumption
  - Diseases
  - …
- Anonymous picture
  integrating over a lager amount of people
- Wastewater as valuable source of information
- Wastewater based epidemiology (WWBE)
- Direct link to ww monitoring!
  - WW monitoring as basic requirement
  - Sampling
  - Metadata

SARS-CoV2 / COVID

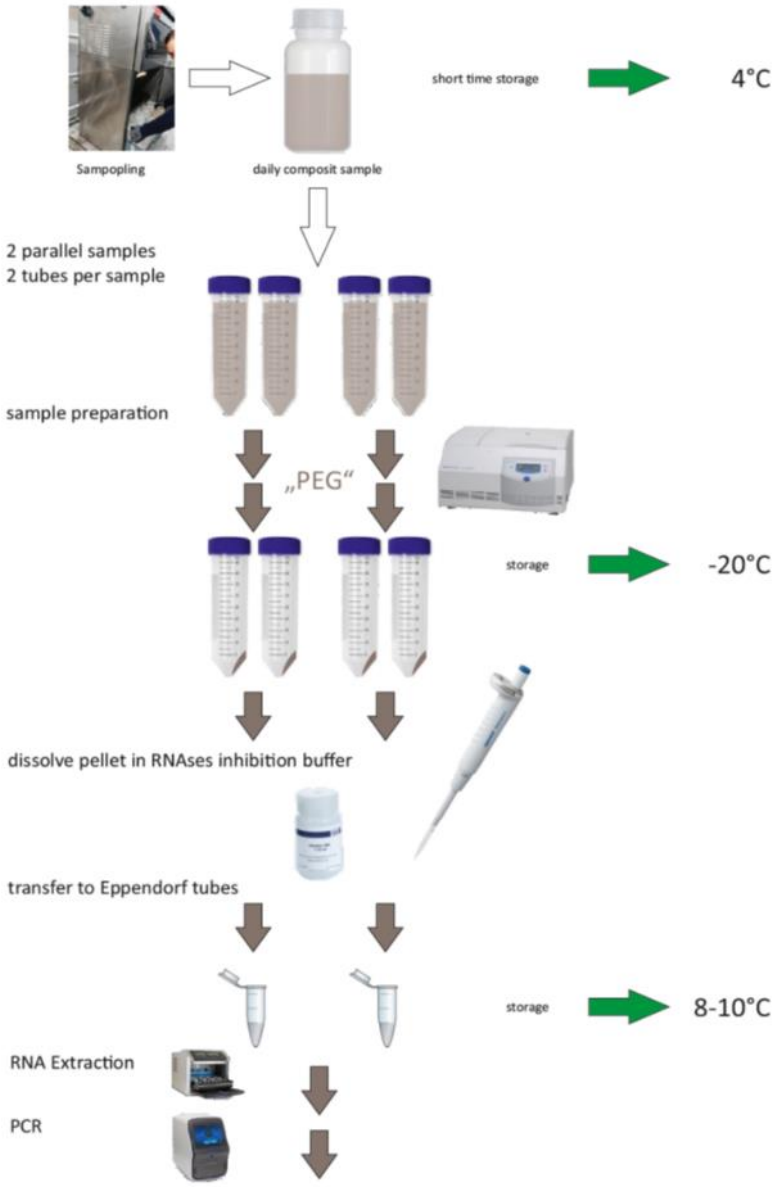
- Why does it work



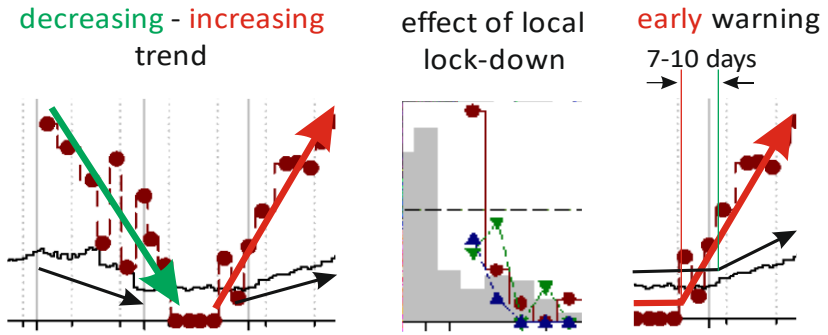


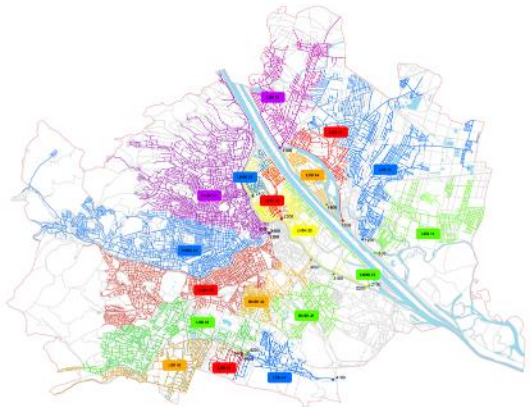
SARS-CoV2 / COVID

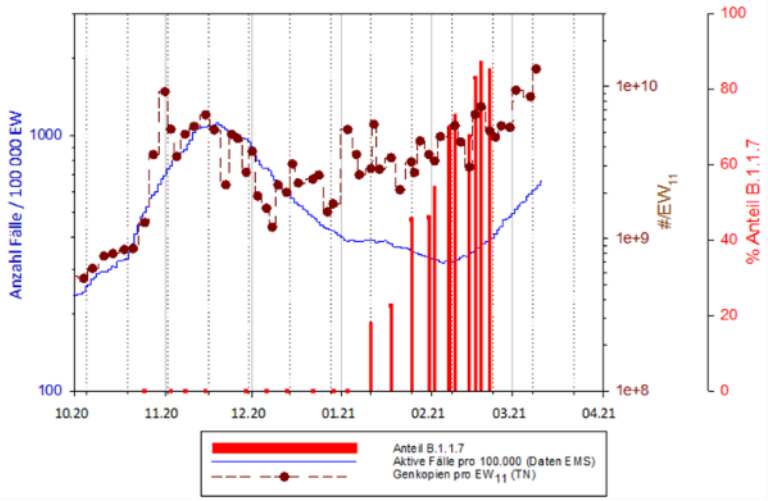
- Genetic region of 1 or more functional / structural genes amplified via quantitative PCR
- Protocol:
  - Sample pretreatment (= enrichment of virus)
  - Destroying physical integrity of cells (RNAses quickly degrade RNA!)
  - RNA purification (not only from virus!) (= getting rid of other stuff)
  - Reverse transcription (converting RNA to DNA for PCR)
  - quantitative RT PCR (Target specific quantification of copy number)
- (Mutation detection & Sequencing)



SARS-CoV2 / COVID







- Trend analysis
  - De-Warning
    - Monitoring of management measures
  - Warning
    - Sudden occurrence (pos signals) after stagnation period (neg signal)
    - ~ early warning with 7-10 days in advance

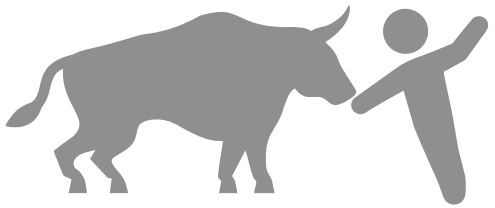
Identification of hot-spots

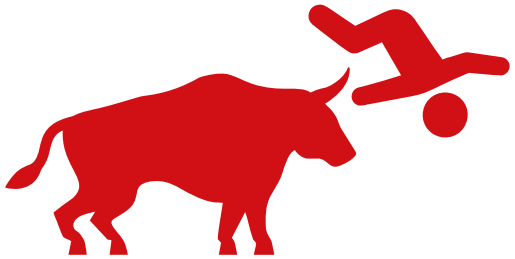
- If noticable signal in wwtp inflow
- Clusters of mutation spreading persons
- Going into details by iterations
- Time proportional sampling

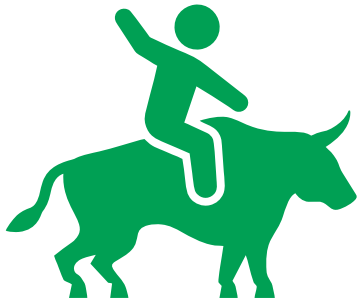
Mutation detection

Monitoring & WWBE for SARS-CoV-2 (3; 4; …)

- Mutual effects between COVID monitoring & WWT
- Provision of metadata for normalization of SARS measurement in ww
  - Estimation of people in sewer catchment
  - Elimination of dilution effects due to storm water
  - Comparability between wwtps
  - Average expulsion per person connected
  - Estimation of share of excreting persons (additional info needed!)
- Perception of wwt in general public and among health authorities!!!







Monitoring – an attitude!?

- Monitoring should not be considered
  - a nasty task!
  - only expensive and without benefit for the operator!
  - to be done for “the others”!

- “Quick wins” do not require high sophisticated (and expensive) equipment
- Overlap between target protection monitoring and PIs
- Education, skills and improvisations are a good start and a necessary base (Brain over equipment)

Thank you for your attention

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