

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

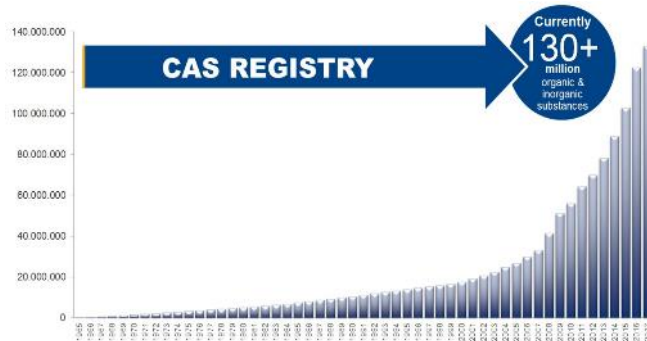
- Other domestic sources

(laundry, personal care, medication, ...)

- Industrial

(production processes, cleaning, ...)

Why Wastewater Treatment?

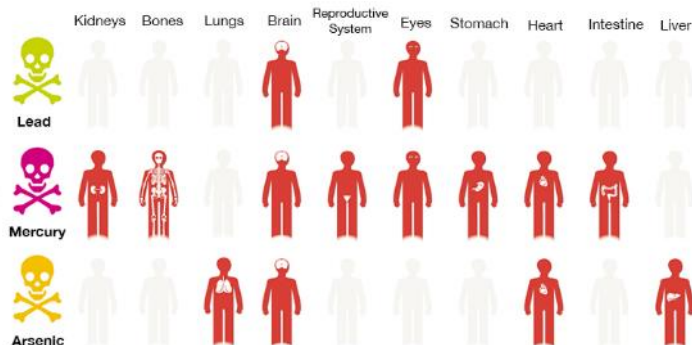


Source: CAS

Bacteria commonly found in the human colon^[29]

Bacterium	Incidence (%)
<i>Bacteroides fragilis</i>	100
<i>Bacteroides melaninogenicus</i>	100
<i>Bacteroides oralis</i>	100
<i>Enterococcus faecalis</i>	100
<i>Escherichia coli</i>	100
<i>Enterobacter sp.</i>	40–80
<i>Klebsiella sp.</i>	40–80
<i>Bifidobacterium bifidum</i>	30–70
<i>Staphylococcus aureus</i>	30–50
<i>Lactobacillus</i>	20–60
<i>Clostridium perfringens</i>	25–35
<i>Proteus mirabilis</i>	5–55
<i>Clostridium tetani</i>	1–35
<i>Clostridium septicum</i>	5–25
<i>Pseudomonas aeruginosa</i>	3–11
<i>Salmonella enterica</i>	3–7
<i>Faecalibacterium prausnitzii</i>	?common
<i>Peplostreptococcus sp.</i>	?common
<i>Peptococcus sp.</i>	?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 chronic 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 chronic 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

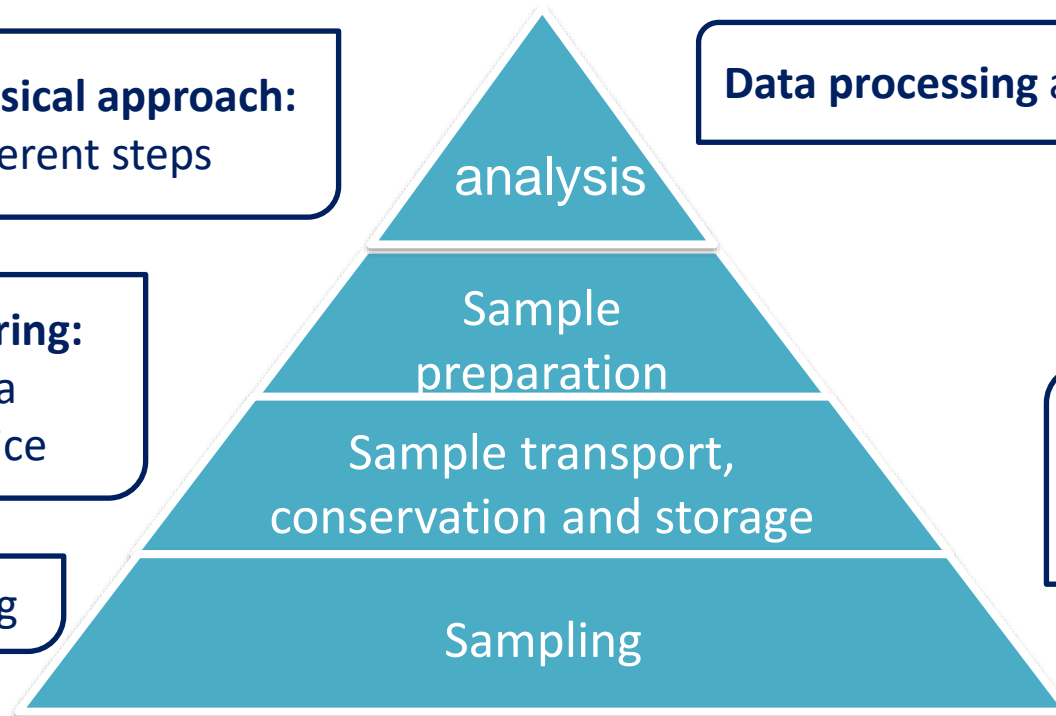
Monitoring describes the processes and activities that need to take place to characterize and monitor the quality of the waters.

Classical approach:
different steps

Data processing and storage

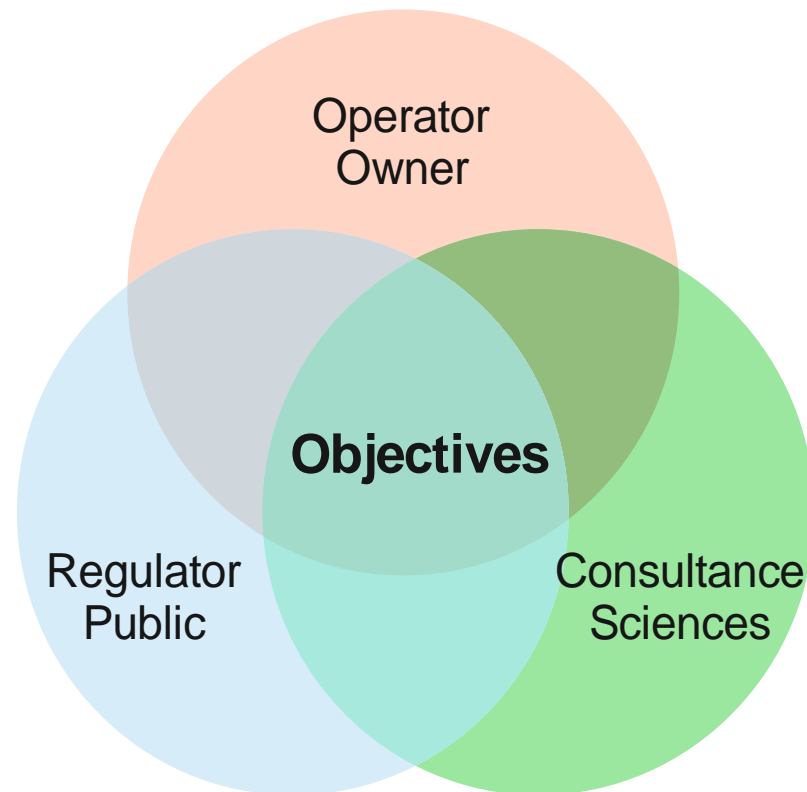
On-site monitoring:
integrated into a
monitoring device

Representativeness of sampling



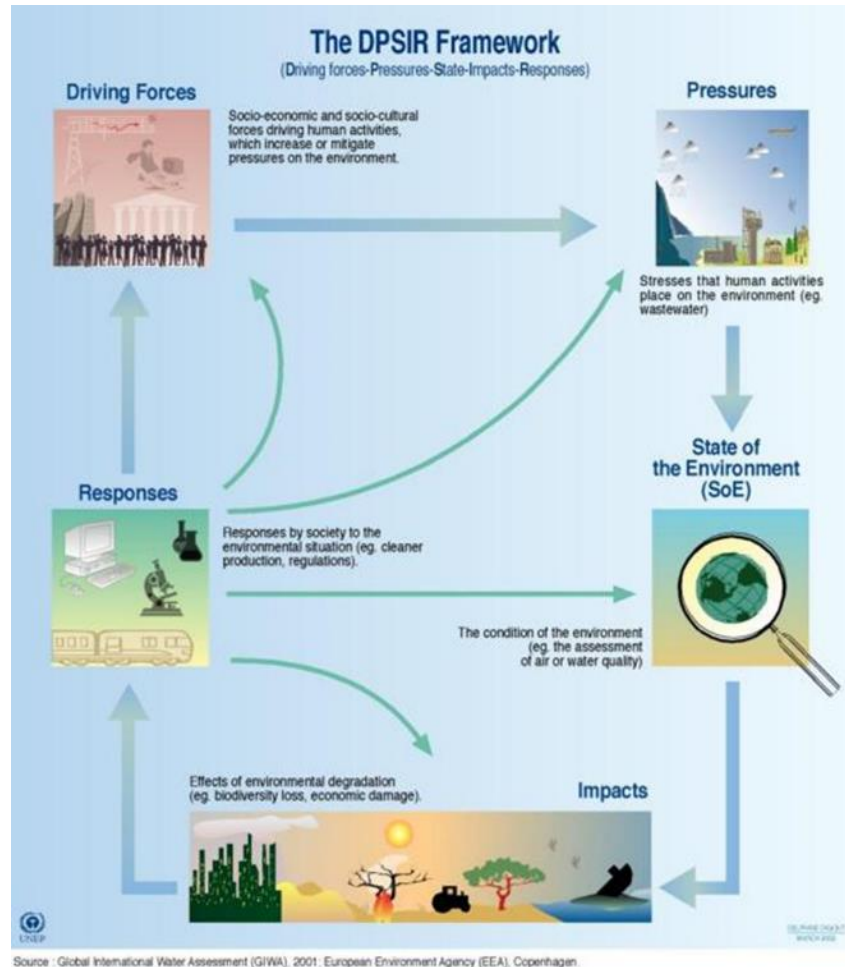
Each step needs to consider **parameters of interest**

Monitoring - why?



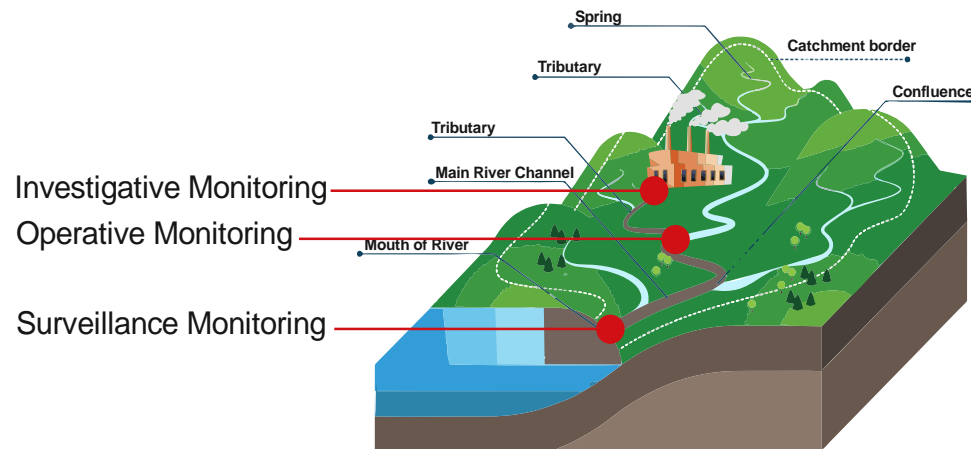
- Monitoring for
 - Performance indication
 - Assessment of treatment efficiency
 - Efficient operation & optimization
 - Identifying problems
 - Planning and upgrading
 - Compliance with regulations
- Monitoring Objectives
 - Have to be defined
 - Best case: broad overlap of different objectives
 - 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

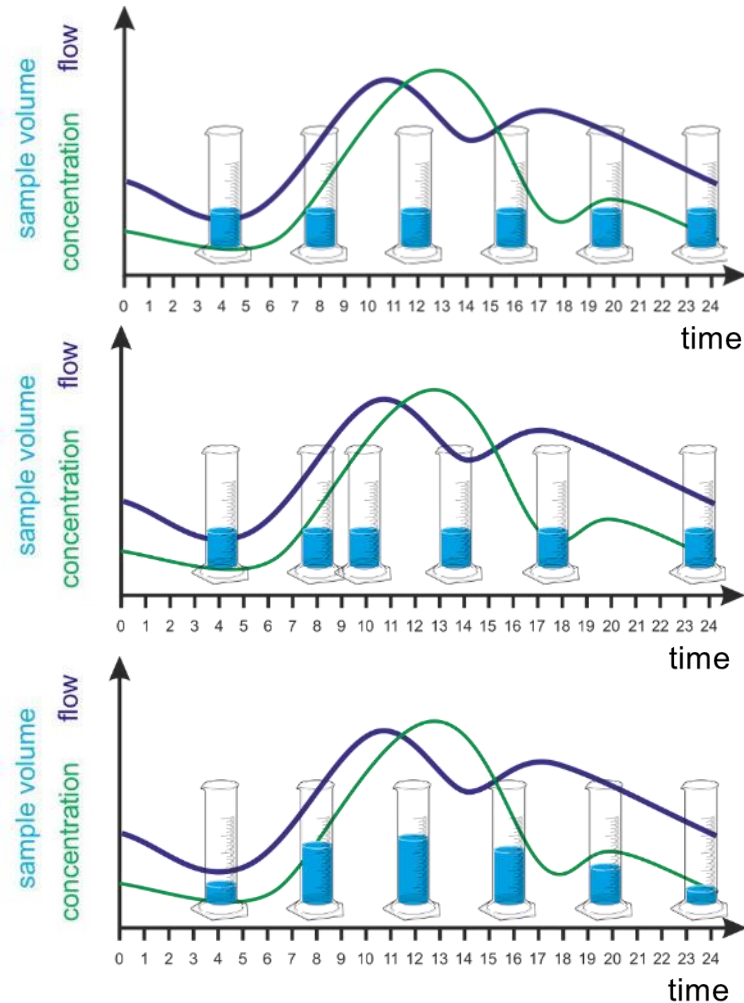
- Inflow of WWTP
- Effluent
- Along treatment train
- Indirect dischargers
- Sewer-(sub)catchment

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)

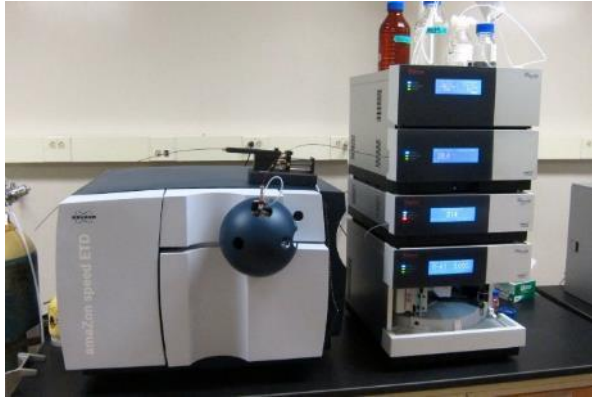
Monitoring - how?



• 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

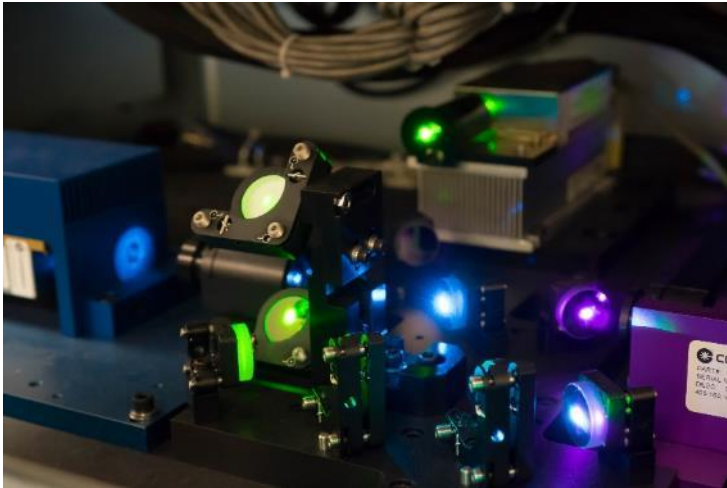
Monitoring - how?



- 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?



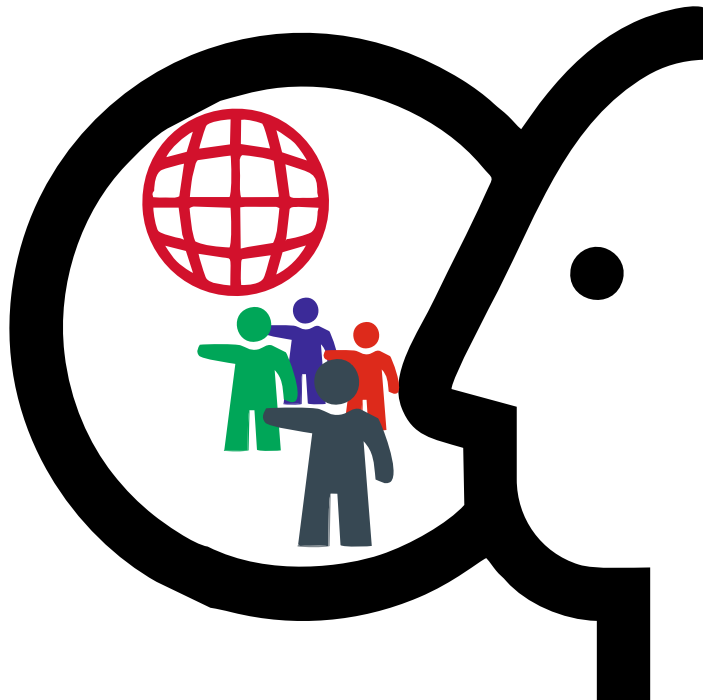
- Education and training
- Test Kit / cuvette based systems
 - Photometric tests
 - Available for a broad range of parameters
 - Easy to use and robust
 - From many suppliers
- Simple parameter set
 - Physical parameters
 - T, pH, Cond, O₂
 - Carbon parameters
 - BOD & COD (test Kit)
 - Nutrients
 - 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 Oxygen, pH, conductivity
 - Microscope
- Fridge, sink, ...
- (field kits available for operation with car battery)

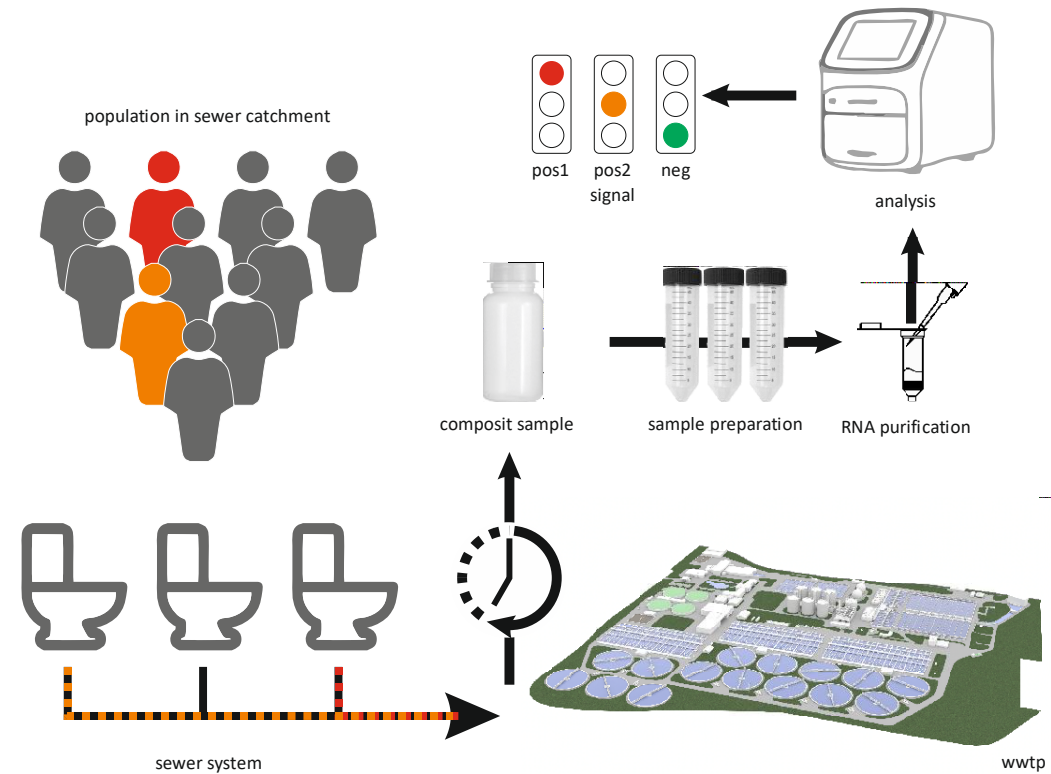
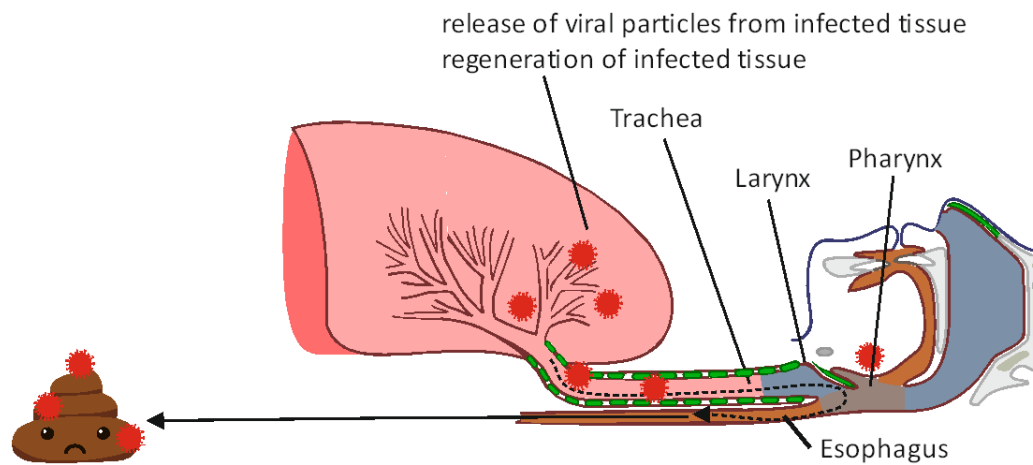
SARS-CoV2 / COVID



- Wastewater as mirror of the society
 - Nutrition behaviour
 - Personal care behaviour
 - Drug consumption
 - Diseases
 - ...
- Anonymous picture integrating over a larger 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

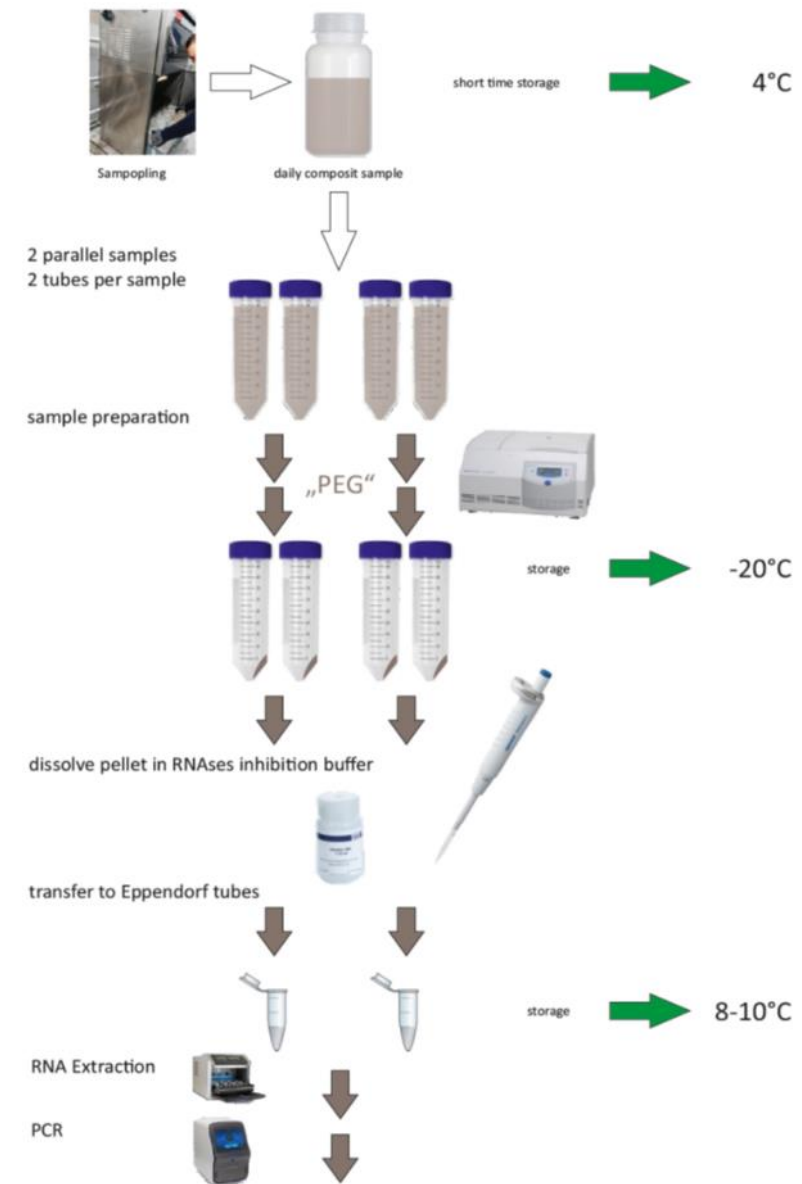
SARS-CoV2 / COVID

- Why does it work



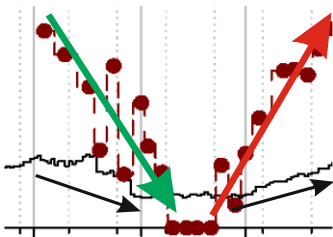
SARS-CoV2 / COVID

- 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)

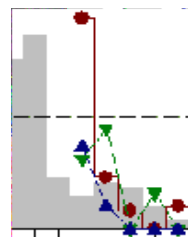


SARS-CoV2 / COVID

decreasing - increasing
trend

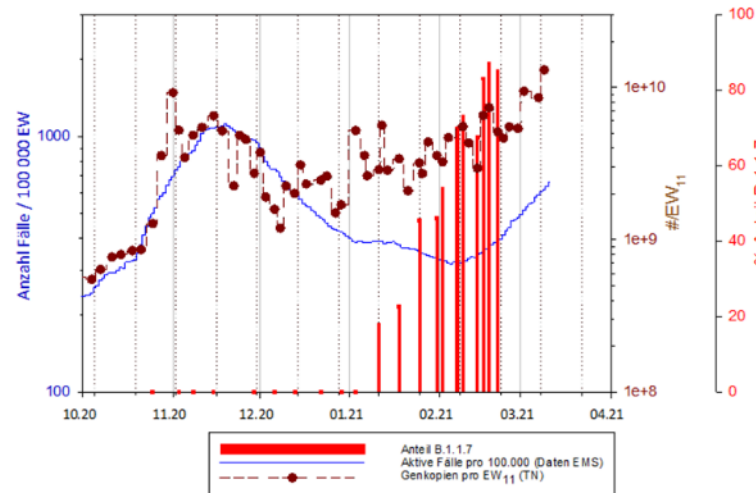
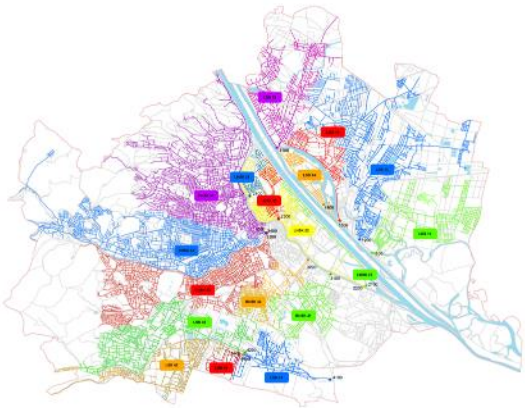
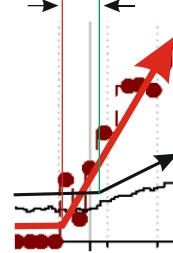


effect of local
lock-down



early warning

7-10 days



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

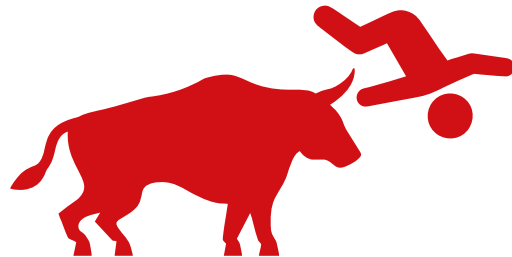
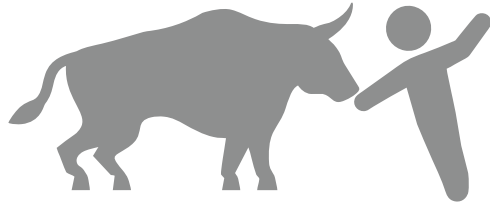
- If noticeable signal in wwtp inflow
- Clusters of mutation spreading persons
- Going into details by iterations
- Time proportional sampling

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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