Wastewater as a Resource

Institute of Sanitary Engineering and Water Pollution Control

Erasmus+ Cooperation

University of Prishtina & University of Natural Resources and Life Sciences, Vienna

March 21 - 29, 2023, Prishtina

Wastewater as a Resource - Lecture Program

Day 1:
Theory Framework & Legal Framework of the EU

Day 2:
Wastewater as a Resource for Process Water, Energy, Nutrients and Information

Day 3:
Integrated Wastewater Management

Lecture Format:
Not “classic” but “interactive”!
Slides are consciously very text-intensive, as they should also serve as a self-explanatory after course overview and reference book!

Theory Framework & Legal Framework of the EU

Wastewater as a Resource - Theory Framework

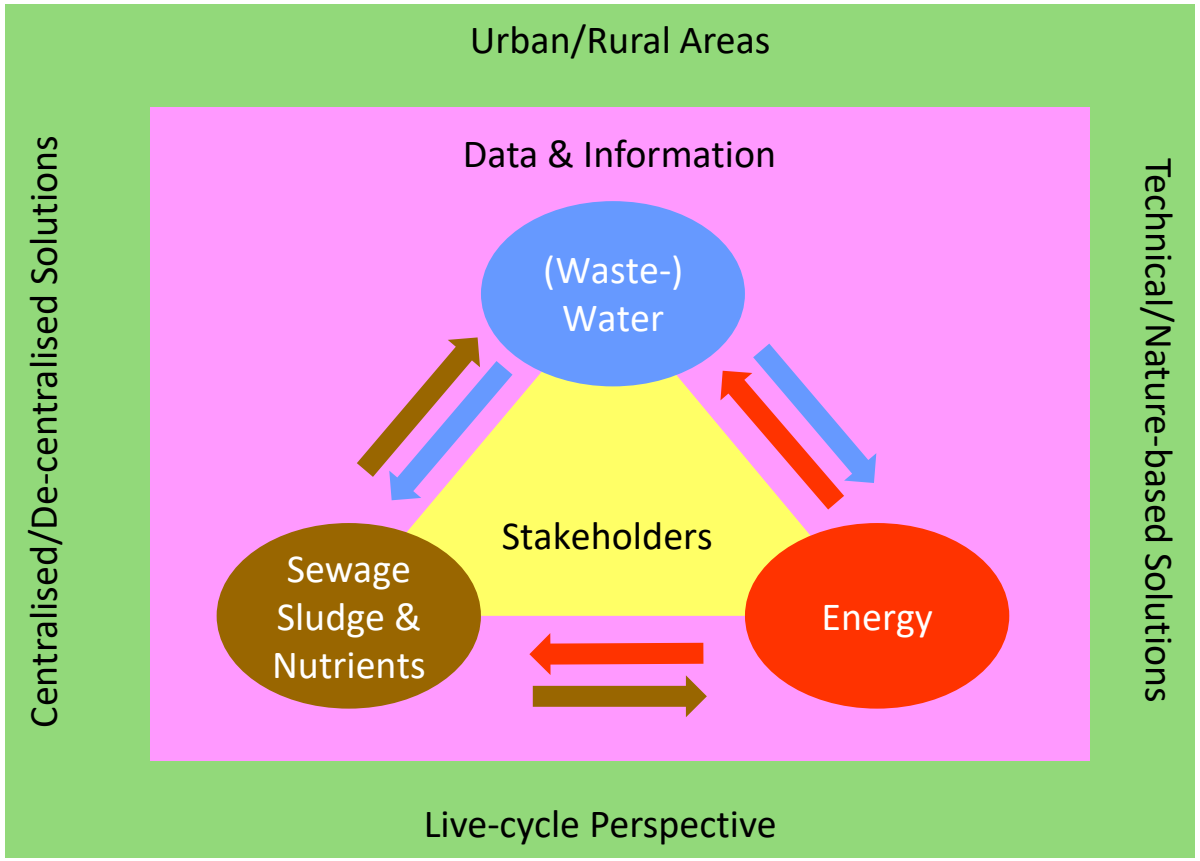


Figure: Wastewater as a Resource - Theory Framework (own presentation,
based on: Kretschmer, F. (2021): Wastewater as a Resource - Water Reuse, Energy Extraction and Nutrient Recovery. Oral presentation at ICOALS III, Nov. 1-3, 2021, Tirana.

Wastewater as a Resource - Legal Framework of the EU

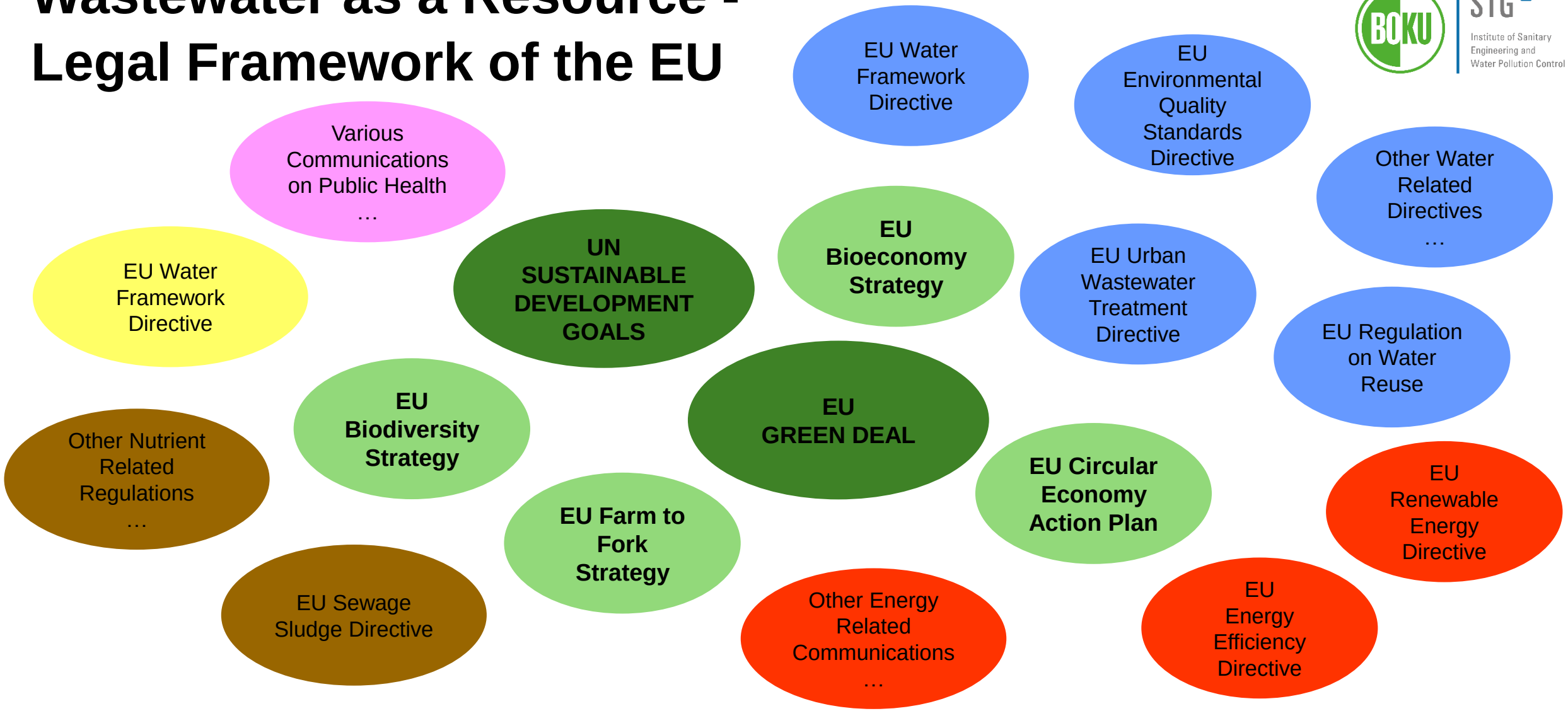


Figure: Overview/Excepert on EU Legal Framework - Background, Strategies and Directives (own presentation)

Wastewater as a Resource - Useful EU Websites

European Commission

https://commission.europa.eu/index_en

EUR-Lex - Access to European Union Law

https://eur-lex.europa.eu/homepage.html?locale=en#

European Environmental Agency

https://www.eea.europa.eu/

Wastewater as a Resource - Legal Framework of the EU

General Background - Commission Priorities

UN Sustainable Development Goals (2015)

https://sdgs.un.org/goals

The EU 2030 Agenda for Sustainable Development and the SDGs (2016)

https://ec.europa.eu/environment/sustainable-development/SDGs/index_en.htm

EU Green Deal (2020)

https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Delivering the EU Green Deal „Fit for 55“ (2021)

https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en

Wastewater as a Resource - Legal Framework of the EU

Strategies and Action Plans

EU Bioeconomy Strategy (2012)

https://research-and-innovation.ec.europa.eu/research-area/environment/bioeconomy/bioeconomy-strategy_en

EU Circular Economy Action Plan (2020)

https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

EU Farm to Fork Strategy (2020) - partly

https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

EU Biodiversity Strategy (2021) - partly

https://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm

Wastewater as a Resource - Legal Framework of the EU

(Waste-)Water

EU Water Framework Directive (2000)

https://environment.ec.europa.eu/topics/water/water-framework-directive_en

EU Urban Waste Water Treatment Directive (1991) & Proposal for Revision (2022)

https://environment.ec.europa.eu/topics/water/urban-wastewater_en

EU Regulation on Water Reuse (2020)

https://ec.europa.eu/environment/water/reuse.htm

EU Environmental Quality Standards Directive (2008) - partly

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0105-20130913

Wastewater as a Resource - Legal Framework of the EU

(Waste-)Water - further related legislation

Communication - addressing water scarcity and droughts in the EU (2007)

EU Nitrates Directive (1991)

EU Groundwater Directive (2006)

EU Drinking Water Directive (2020)

Communication - Pricing and sustainable management of water resources (2000)

EU Directive on Flood Risk Assessment and Management (2007)

EU Bathing Water Directive (2006)

EU Marine Strategy Framework Directive (2008)

Wastewater as a Resource - Legal Framework of the EU

Energy

EU Renewable Energy Directive (2018) & Amendment to new targets (2021)

https://energy.ec.europa.eu/topics/renewable-energy_en

EU Energy Efficiency Directive (2018)

https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en

Communication - REPowerEU Plan (2022)

https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en

Communication - An EU Strategy on Heating and Cooling (2016)

https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52016DC0051

Wastewater as a Resource - Legal Framework of the EU

Sewage Sludge & Nutrients

EU Sewage Sludge Directive (1986)

https://environment.ec.europa.eu/topics/waste-and-recycling/sewage-sludge_en

Regulation on EU fertilizing products (2019)

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R1009

Wastewater as a Resource - Legal Framework of the EU

Stakeholders

EU Water Framework Directive (2000)

https://environment.ec.europa.eu/topics/water/water-framework-directive_en

Wastewater as a Resource - Legal Framework of the EU

Data & Information

Recommendation on SARS-CoV-2 surveillance (2021)

https://ec.europa.eu/environment/pdf/water/recommendation_covid19_monitoring_wastewaters.pdf

European Health Emergency preparedness and Response Authority (HERA): Getting ready for future health emergencies (2021)

https://joint-research-centre.ec.europa.eu/jrc-news/coronavirus-response-monitoring-wastewater-contributes-tracking-coronavirus-and-variants-across-all-2022-03-17_en

https://ec.europa.eu/commission/presscorner/detail/en/IP_21_4672

Wastewater as a Resource - Legal Framework of the EU

Take-home Messages

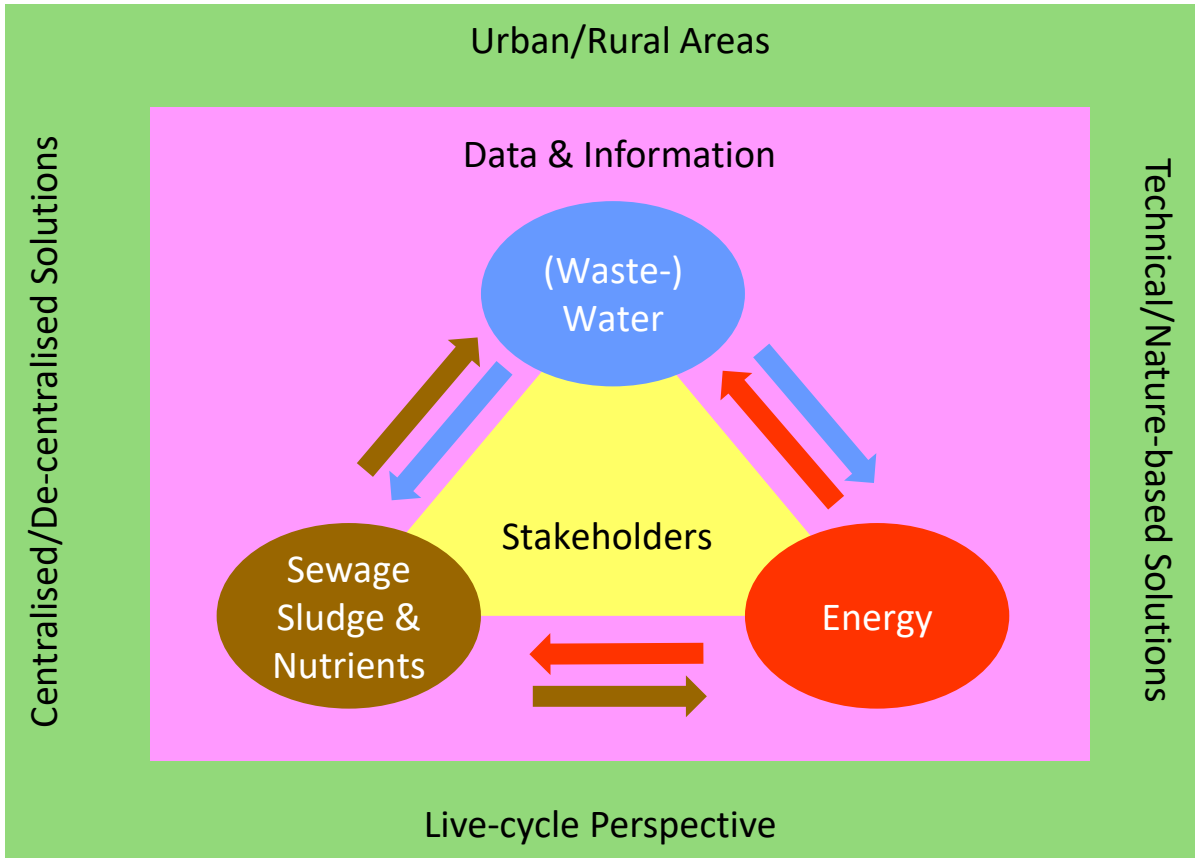
UN SDGs and EU Green Deal provide basis for future development in Europe.

EU strategies favour circular economy, climate protection and mitigation, human and environmental welfare.

Legal framework of the EU (Commission Priorities, Strategies, Communications, Directives) provide boundary conditions for related implementations in member and candidate countries.

Wastewater as a Resource for Process Water, Energy, Nutrients and Information

Wastewater as a Resource - Theory Framework



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Wastewater as a Resource for Process Water, Energy, Nutrients and Information

Relevant Approaches

Water Reuse

Energy Recovery

Sewage Sludge Management & Nutrient Recovery

Stakeholder Management (Participation)

Data & Information Management

Wastewater as a Resource - Integrated Wastewater Management

Water reuse

Reuse of treated wastewater, stormwater, and grey water for irrigation purposes and process water (incl. storage, surface and groundwater issues).

Water quantity and quality issues depending on type of reuse.

Application of classic (technical) and innovative (nature-based) approaches.

Continuous operation and maintenance of installations is crucial (live-cycle).

Core challenge: green needs blue!

Wastewater as a Resource - Integrated Wastewater Management

Water reuse

EU Regulation on Water Reuse (2020)

https://ec.europa.eu/environment/water/reuse.htm

Urban Heat Island Strategy - City of Vienna (website in German, document in English)

https://www.wien.gv.at/umweltschutz/raum/uhi-strategieplan.html

Circularity Challenges in Cities with Nature-Based Solutions (Journal Paper, 2021)

https://www.mdpi.com/2073-4441/13/17/2355

https://circular-city.eu/

Wastewater as a Resource - Integrated Wastewater Management

Energy Recovery

Electric and thermal energy generation from wastewater: biogas (sewage sludge, manure) and wastewater heat recovery (heat exchangers and heat pumps).

Electric and thermal energy generation from alternative sources: photovoltaics, solar thermal, hydropower and wind power, etc.

On-site use of energy generated or feed-in to public grids (e. g. electricity, district heating).

Application in settlements as well as in agriculture, hydroculture and forestry.

Wastewater as a Resource - Integrated Wastewater Management

Energy Recovery

EU Renewable Energy Directive (2018) & Amendment to new targets (2021)

https://energy.ec.europa.eu/topics/renewable-energy_en

Energy/heat recovery (from wastewater): Sustainable Sanitation Practice (SSP) Journal, Issue 22 (Jan. 2015)

http://www.ecosan.at/ssp/ssp-journal

Interreg Central Europe REEF 2W project (2017-2020): Renewable energy and energy efficiency in urban wastewater systems.

https://programme2014-20.interreg-central.eu/Content.Node/REEF-2W.html

Wastewater Treatment Plants as Local Thermal Power Stations (Journal Paper, 2021)

https://www.mdpi.com/2227-9717/9/11/1981

Wastewater as a Resource - Integrated Wastewater Management

Sewage Sludge Management & Nutrient Recovery

Direct reuse of sewage sludge in agriculture (today a much-discussed topic in several EU countries).

Nutrient recovery (especially phosphorous) from sewage sludge and/or sewage sludge (mono-) incineration ashes.

Application of centralized and decentralized solutions important.

Wastewater as a Resource - Integrated Wastewater Management

Sewage Sludge Management & Nutrient Recovery

EU Sewage Sludge Directive (1986)

https://environment.ec.europa.eu/topics/waste-and-recycling/sewage-sludge_en

Austrian Factsheet Recast EU Wastewater Treatment Directive (website in German, document in English, not only on sewage sludge)

https://info.bml.gv.at/themen/wasser/wasser-eu-international/europaeische-und-internationale-wasserwirtschaft/berichte/factsheet-uwwtd.html

Wastewater as a Resource - Integrated Wastewater Management

Stakeholder Management (Participation)

The wastewater sector involves people from different disciplines and with different educational levels (operational staff, planners, etc.).

The wastewater sector interacts with other disciplines in urban and rural areas (underground infrastructures, city planning, agriculture, etc.).

The upcoming challenges (climate change, renewable energy, smart cities, etc.) cannot be solved with a mono-disciplinary perspective and must involve the public.

Stakeholder management is a full-time and not a side job.

From government towards governance approach (vertical vs. horizontal view).

Wastewater as a Resource - Integrated Wastewater Management

Stakeholder Management (Participation)

EU Water Framework Directive (2000)

https://environment.ec.europa.eu/topics/water/water-framework-directive_en

Participation as a Key Aspect for Establishing Wastewater as a Source of Renewable Energy (Journal Paper, 2018)

https://www.mdpi.com/1996-1073/11/11/3232

Smart Climate City Strategy Vienna

https://smartcity.wien.gv.at/en/strategy/

Wastewater as a Resource - Integrated Wastewater Management

Data & Information Management

Wastewater carries different information on the discharged area.

- Health status of the population (e. g. Covid)

Wastewater related information is also important for other sectors in a smart city.

- Location of drainage network for other operators of underground infrastructure
- Building information (e. g. roof area) for wastewater utilities
- Wastewater flow and temperature for energy suppliers

Digitalisation (digital water, water 4.0) as an appropriate tool to tackle future challenges.

Wastewater as a Resource - Integrated Wastewater Management

Data & Information Management

European Health Emergency preparedness and Response Authority (HERA): Getting ready for future health emergencies (2021)

https://joint-research-centre.ec.europa.eu/jrc-news/coronavirus-response-monitoring-wastewater-contributes-tracking-coronavirus-and-variants-across-all-2022-03-17_en

Europe's Digital Decade: digital targets for 2030

https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en

IWA Digital Water

https://iwa-network.org/programs/digital-water/

Wastewater as a Resource for Process Water, Energy, Nutrients and Information

Take-home Messages

Technologies/concepts for the presented approaches are already available, they just need to be implemented. Digital concepts still need to be further evolved.

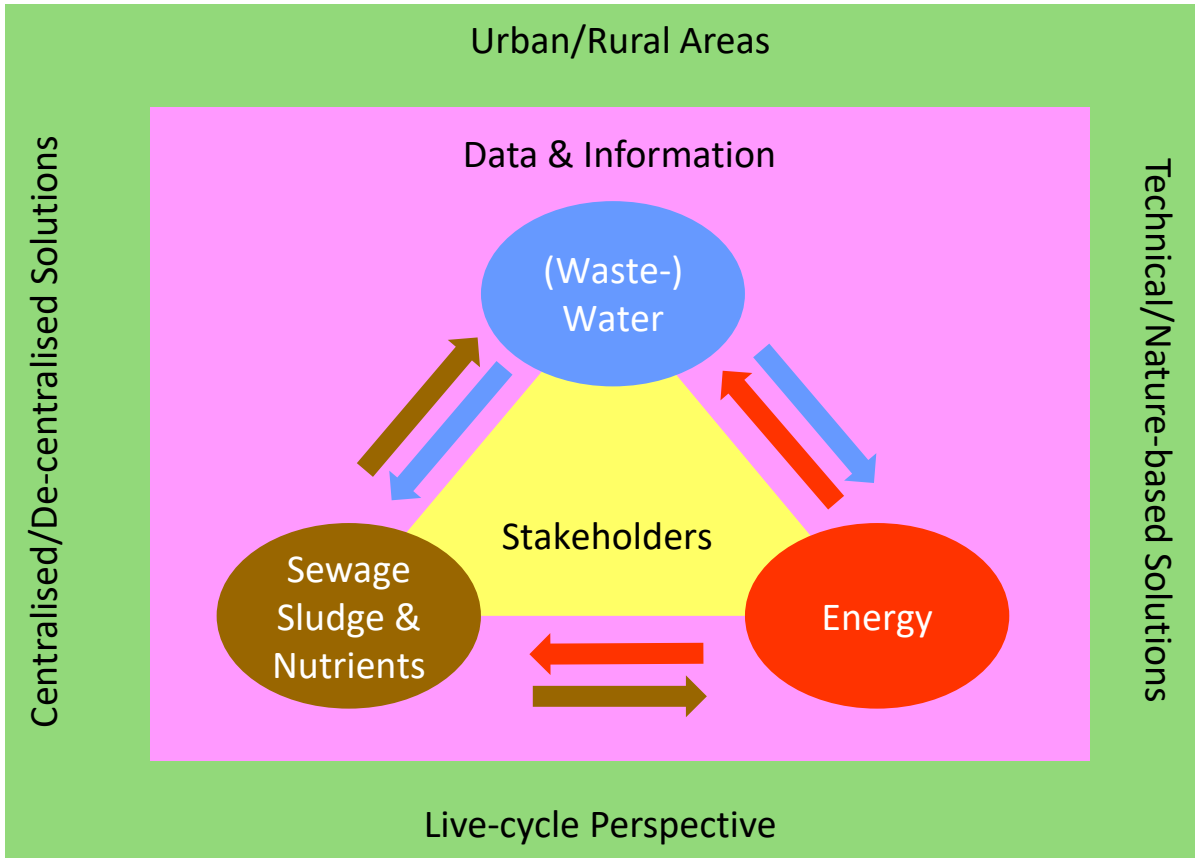
Bottom-up (local actors) approaches are valuable, but top-down (regional/national authorities) approaches are essential.

Therefore, an institutional framework is important (financial incentives, legal regulations, education and knowledge building, demonstration sites).

Early and targeted involvement of all stakeholders (incl. the public) to provide most sustainable and best accepted solutions.

Integrated Wastewater Management

Wastewater as a Resource - Theory Framework



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Wastewater as a Resource - Integrated Wastewater Management

Relevant Aspects
(when considering wastewater as a resource)

System interactions

Human resources

Different perspectives

Multidisciplinary benefits

Wastewater as a Resource - Integrated Wastewater Management

System interactions (excerpt)

Interactions between (waste-)water and energy:

- Wastewater and sewage sludge/manure treatment require energy.
- Wastewater can be used to generate related energy.

Interactions between energy and nutrients:

- Recovery of nutrients require energy.
- Wastewater contents can be used for energy generation.

Interactions between (waste-)water and nutrients:

- Wastewater and/or sewage sludge contains various valuable substances.
- Wastewater and or sewage/sludge contents determine wastewater treatment requirements.

Wastewater as a Resource - Integrated Wastewater Management

Human resources

Human expertise is being involved in all three resource-orientated aspects/fields.

Stakeholders have to be well educated and continuously trained.

Collaboration in an inter- and transdisciplinary way is essential.

Related activities might even involve the public.

Wastewater as a Resource - Integrated Wastewater Management

Excursus: Austrian Sewer Training Courses - Background

- Sewer training courses started in 1997 - 25 years ago (55th basic course in Feb. 2023).
- Organized by the Austrian Water and Waste Association (ÖWAV).
- ÖWAV expert committee on “Sewer Operation and Maintenance” defines course contents.
- Course locations are spread across Austria (hosted by wastewater utilities, mainly located in seminar hotels today).
- Speakers/trainers come primarily from wastewater utilities, companies, engineering offices and universities (theoretic issues).
- (Majority of) Courses are led by BOKU and local wastewater utilities.

Wastewater as a Resource - Integrated Wastewater Management

Excursus: Austrian Sewer Training Courses - Current Courses

- **Primarily for technicians (sewer workers)**
  - Training courses over min. 3 years along with working at the own utility
- **Sewer fundamentals (pre-qualification)**
  - Introductory internship (1 week)
  - Basic course (1 week)
- **Mandatory courses (consolidation)**
  - Cleaning and entering of sewers (4 days)
  - Sewer condition and rehabilitation (1 week)
  - Sewer operation and maintenance (1 week)
  - Electrical engineering (1 week)
- **Elective course (specialisation)**
  - Sewer inspection and condition assessment (1 week)
  - Sewer leak testing (3 days)
  - Mechanical engineering (1 week)
  - Operation and maintenance of pumping stations (4 days)
- **Board examination** for qualified sewer worker (1 day)

Figure: Sewer Training Courses (ÖWAV, n. d.)

Wastewater as a Resource - Integrated Wastewater Management

Excursus: Austrian Sewer Training Courses - Additional Course & Events

- **Qualified sewer rehabilitation manager/consultant (2 weeks)**
- **Sewer inspection**
  - for inspectors (1 week)
  - for inspectors - refresher training (2 days)
  - for rehabilitated sewers (2 days)
  - for demand-orientated sewer management using an electronic mirror (2 days)
- **Sewer system neighborhoods**
  - for sewer operators
  - exchange of knowledge and experiences
  - regular meetings in the “neighborhood”
  - about 330 utilities
- **Annual/periodic seminars**
  - for consultants, planners, decision makers
  - on sewer operation and maintenance
  - on newly released ÖWAV guiding documents

Wastewater as a Resource - Integrated Wastewater Management

Excursus: Austrian Sewer Training Courses - Stakeholder Interaction

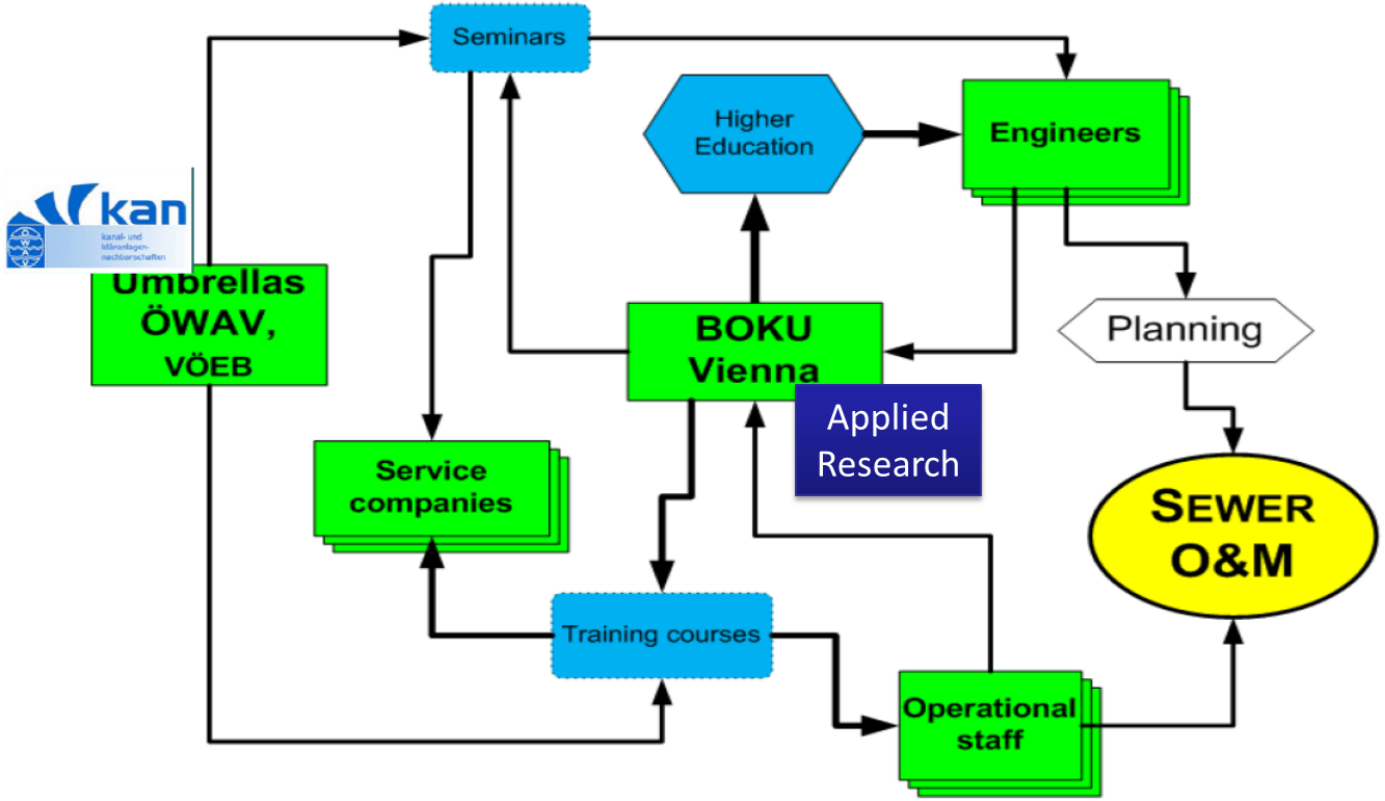


Figure: Sewer Training Courses and Stakeholder Interaction (Ertl, n. d.)

Wastewater as a Resource - Integrated Wastewater Management

Perspectives - Urban and rural areas

All three resource-orientated aspects (water reuse, energy recovery, nutrients) can be relevant for rural and urban areas.

A sharp distinction between urban and rural areas is in contradiction to integrated management, both areas have close interrelations

- Rural areas provide resources for urban ones (food, recreational activities, etc.) and vice-versa (e. g. wastewater).
- Urban areas are processing sites and markets for rural products.

Wastewater as a Resource - Integrated Wastewater Management

Perspectives - Centralised and de-centralised solutions

All three resource-orientated aspects can involve centralised and/or de-centralised solutions.

Centralised solutions are usually “bigger” and thus more complex than de-centralised ones.

A mix of applications can be favourable compared to “monocultural” ones in regard to the resilience of the related system (water, energy, nutrients).

Wastewater as a Resource - Integrated Wastewater Management

Perspectives - Technical and nature-based solutions

For decades, technical (grey) solutions have been the systems of choice (sewer systems, activated sludge plants, etc.).

In recent times nature-based (blue-green) solutions are evolving (treatment wetlands, local stormwater infiltration, etc.).

Technical solutions are considered high-maintenance, nature-based ones low-maintenance (but both approaches serve their objective).

Technical solutions often are an adequate option for centralised approaches, nature-based solutions often are considered a more de-centralised option.

Wastewater as a Resource - Integrated Wastewater Management

Perspectives - Live-cycle

Today, building implementation has a strong focus on the planning and construction phase (investment cost).

Aspects of operation and maintenance often are neglected (operational costs, services, availability of trained staff, etc.)

The entire lifespan of an installation must be considered

- Planning
- Construction
- Operation & Maintenance
- Demolition

Wastewater as a Resource - Integrated Wastewater Management

Benefits (excerpt)

Technical

- improved planning due to early and targeted involvement of stakeholders
- pluvial flood protection due to on-site water management

Economic

- additional income and local/regional welfare due to sales and new business models
- possible benefits of nature-based solutions compared to technical solutions in terms of operation and maintenance

Wastewater as a Resource - Integrated Wastewater Management

Benefits (excerpt)

Environmental

- local water cycle due to on-site water management
- climate mitigation due to renewable energy generation
- increased biodiversity due to blue-green infrastructure

Social

- human welfare due to blue-green infrastructure
- capacity building due to adequate education and training
- increased resilience of local/regional structures/system

Wastewater as a Resource - Integrated Wastewater Management

Take-home Messages

Wastewater should be seen as resource rather than just (useless) waste.

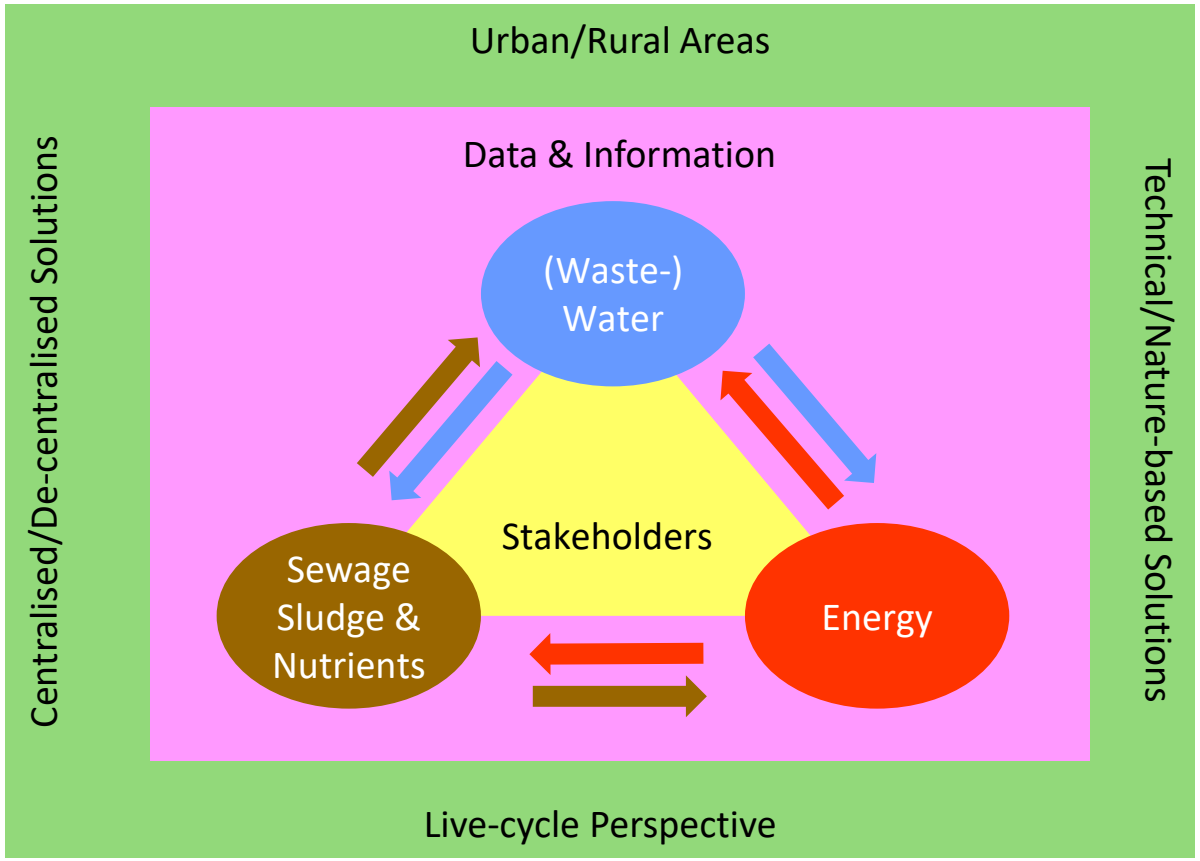
Transition will not happen overnight, but even “smaller” applications are a piece in the puzzle of more sustainable development.

An appropriate framework and political will would motivate for-runners to tackle practical realizations.

Universities can play an active and important role:

- pioneers of experimental/practical implementation
- education and training of academic and non-academic stakeholders

Wastewater as a Resource - Theory Framework



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