Accelerating Sludge Management towards Sustainability

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WEBINAR

30 November 2022 | 14:00 GMT

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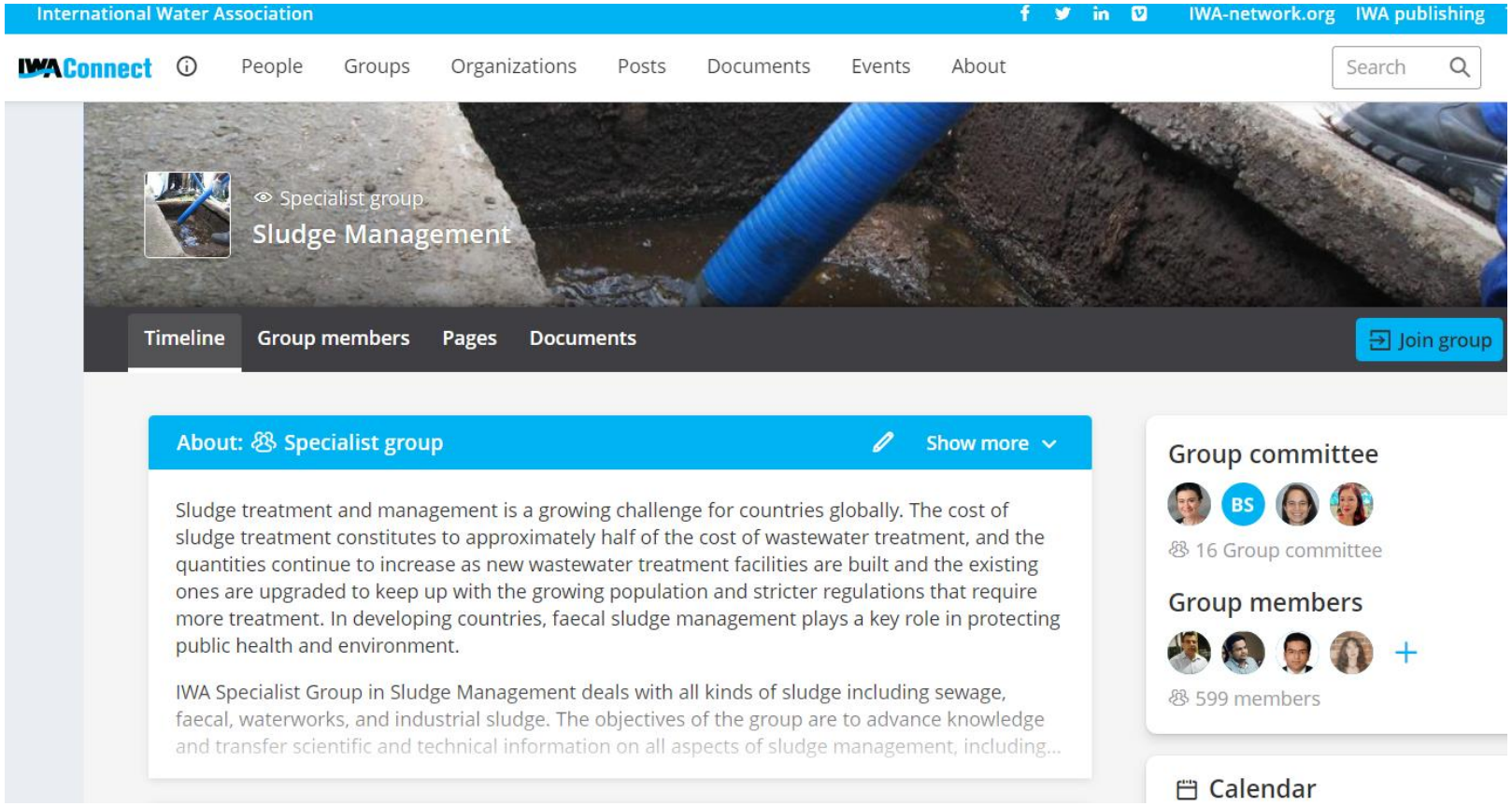
IWA SLUDGE MANAGEMENT SG



The IWA Specialist Group in Sludge Management deals with all kinds of sludge including sewage, faecal, waterworks, and industrial sludge.

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WEBINAR INFORMATION

- **'Chat' box**: please use this for general requests and for interactive activities.
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Please Note: *Attendees' microphones are muted. We cannot respond to 'Raise Hand'.*

MODERATOR & SPEAKERS

Richard Tsang, CDM Smith, USA

Puja Doshi, Engineers without borders, Germany

Ludovico Spinosa, CEN and ISO Expert/Officer, Italy

AGENDA

- Welcome, introduction & housekeeping rules
  Richard Tsang
- Accelerating Sludge Management towards Sustainability – Technical aspects
  Ludovico Spinosa
- Accelerating Sludge Management towards Sustainability– Institutional aspects
  Puja Doshi
- Conclusions
  Richard Tsang
- Q&A discussion moderated by
  Richard Tsang
- Final remarks
  Richard Tsang

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Accelerating Sludge Management towards Sustainability - Technical Aspects

LUDOVICO SPINOSA, CEN AND ISO EXPERT/OFFICER, ITALY

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Accelerating Sludge Management towards Sustainability

- To comply with the Target 6.3 of the SDGs of UN Agenda 2030 aimed to:

  "…improve water quality by reducing pollution...
  ...and substantially increasing
  recycling and safe reuse globally"

  it is necessary to push ever more decisively towards the achievement of sustainability objectives in the governance of wastewater and sludge management systems.

- It must also not be forgotten that an effective and real achievement of sustainability objectives cannot disregard respect for Circular Economy and Thermodynamic principles.

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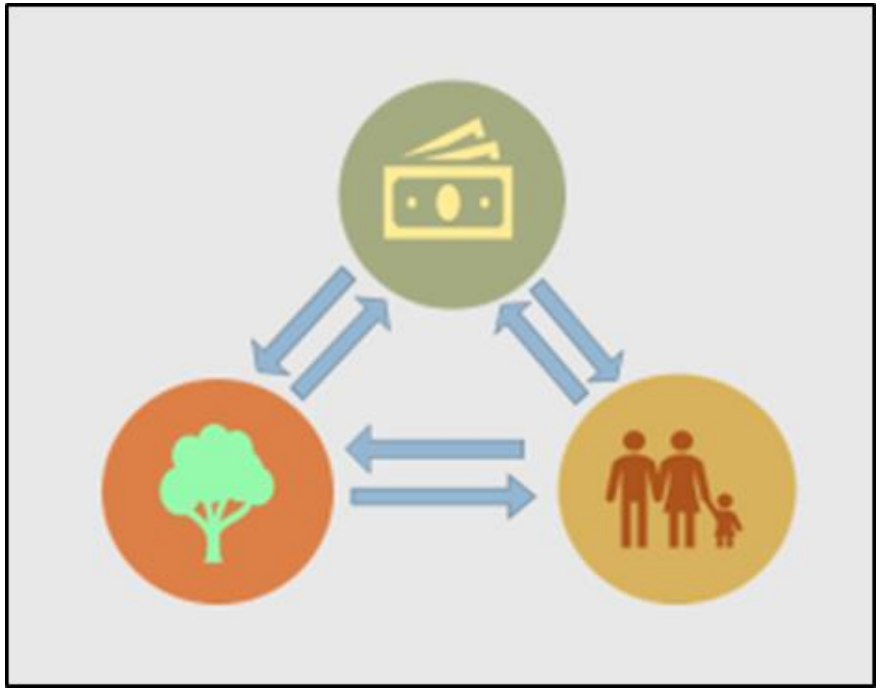
SUSTAINABILITY

- A sustainable situation occurs when consumption of renewable resources does not exceed nature's ability for their replenishment, i.e. the natural resources are not consumed faster than they can be naturally replenished.

- Sustainable systems must be:
  - environmentally bearable;
  - economically convenient;
  - socially acceptable.

- Sustainability must be seen from a relative, not absolute, point of view because it strictly depends on how the boundaries are set.



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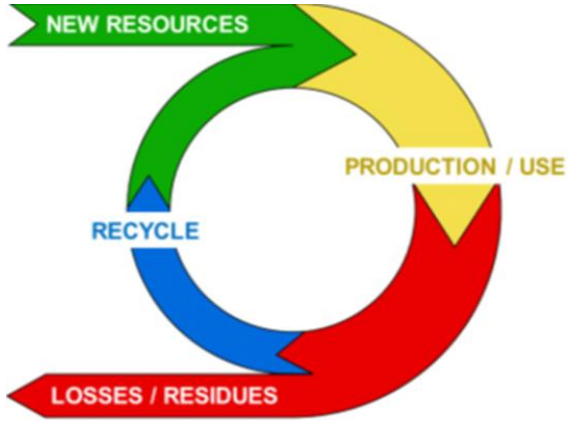
CIRCULAR ECONOMY

- This term defines an economic system designed to regenerate itself.
- This conceptual definition can be represented, for a single process not for a system, by a closed circle including some *"losses"* to be replaced by *"new resources"*.
- Considering that wastewater treatment and sludge management systems consist of a sequence of a finite number of single processes and/or sub-processes, challenge is to reduce the total amount of losses and subsequently the need of new resources, quantitatively re-establishing the "*mass/energy balance*".
- In practical reality a circle can only be approximated with an n-sided polygon: the greater the number of sides (i.e. single processes), the greater the approximation of the system to a circle.
- However, the social dimension of sustainability is only marginally addressed.



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THERMODYNAMIC LAWs

- All human-operated transformations are "*not perfect or fully reversible*" and are subject to the 3 Laws of Thermodynamics.

- It follows that:

1) **Energy** is invariably conserved, but assumes different forms some of which cannot be conveniently recovered, so energy/material losses are always occurring (1st Law).

2) **Entropy**, which is a measure of the disorder in an isolated system, constantly increases, thus meaning that a worse state than before is involved (2nd Law).

3) **Absolute zero** value is impossible to be reached by finite processes, so that perpetual motion, i.e. infinite recycling, is impossible (3rd Law).

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SLUDGE FACTs

- Sludge is the unavoidable by-product of a water/wastewater treatment system.
- In Europe, average generation rate is of about 59 g/cap/day, ranging ≈20 in Greece to ≈108 in Portugal, being these differences be explained in terms of water availability, population served, and type of wastewater treatment.
- Although sludge accounts for only about 1–2% (in volume) of the treated wastewater, it contains most of the pollution and is both difficult and expensive to be handled, often requiring over 50% of the operating budget for the wastewater treatment plant.

However, sludge treatment and disposal often plays a minor role during the planning/design phase of water and wastewater treatment systems, as its physical location at the end of the water cycle incorrectly leads to its underestimation.

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ACCELERATION

From what has been previously said and in compliance with the SDGs of the UN 2030 Agenda, the need emerges to look at sludge management from a different perspective aiming at accelerating the development of more sustainable strategies oriented towards maximizing recovery benefits instead of simply disposing it.

Way to accelerate sludge management sustainability includes:

- Considering sludge management as the Locomotive, not the Last wagon, of water/wastewater systems.
- Taking into account both **Technical** actions (…aimed at improving sustainability by maximizing the recovery benefits) and **Institutional** actions (…aimed at implementing sustainability by overcoming barriers).

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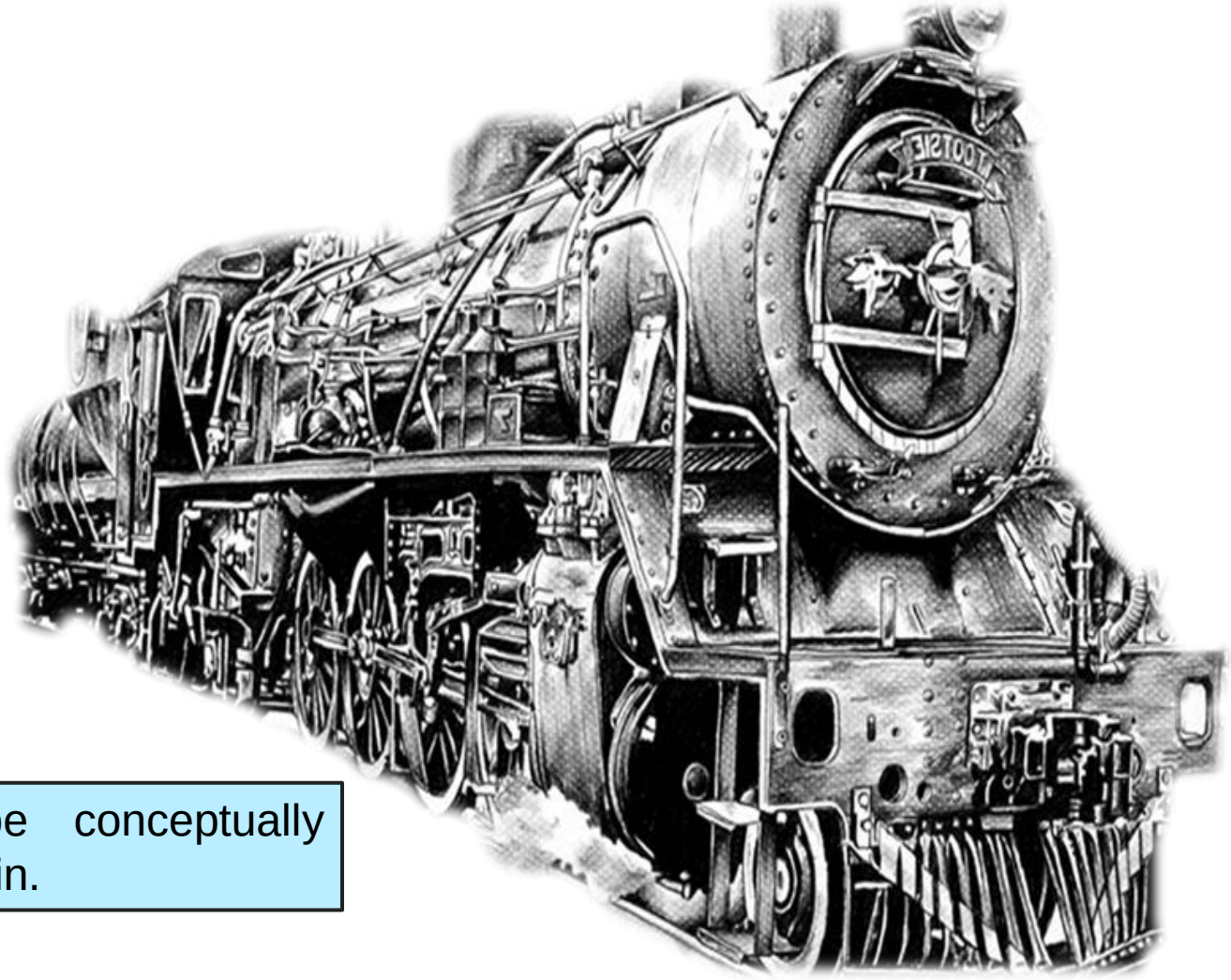
LAST WAGON → LOCOMOTIVE

As mentioned, the treatment and disposal of sludge often plays a secondary role during the design/planning phase of wastewater treatment plants, as it is considered the "terminal" due to its physical location, but forgetting that the most appropriate sequence to adopt for wastewater treatment is strongly driven by the sludge reuse/disposal options available in the specific local context.



Consequently, sludge management should be conceptually considered as the locomotive of the water cycle train.

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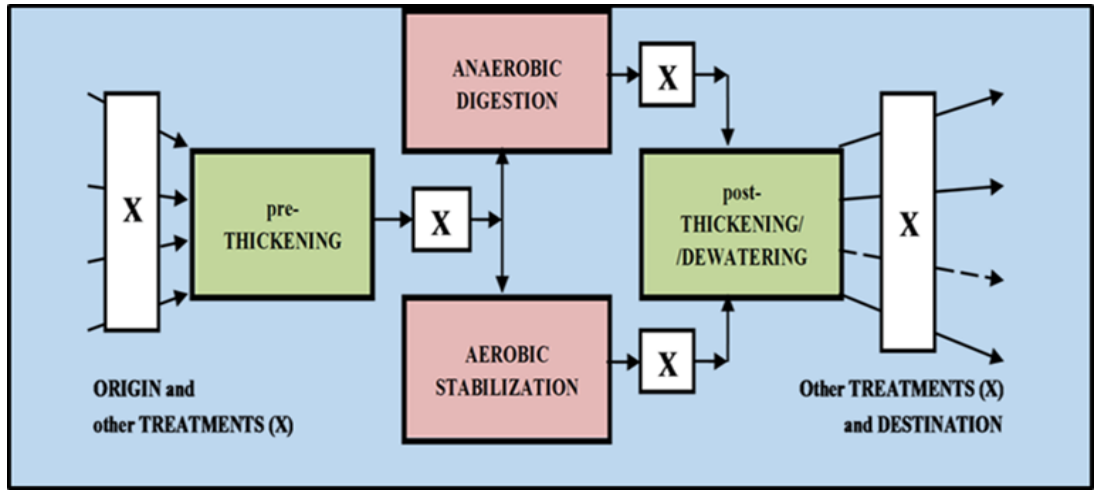
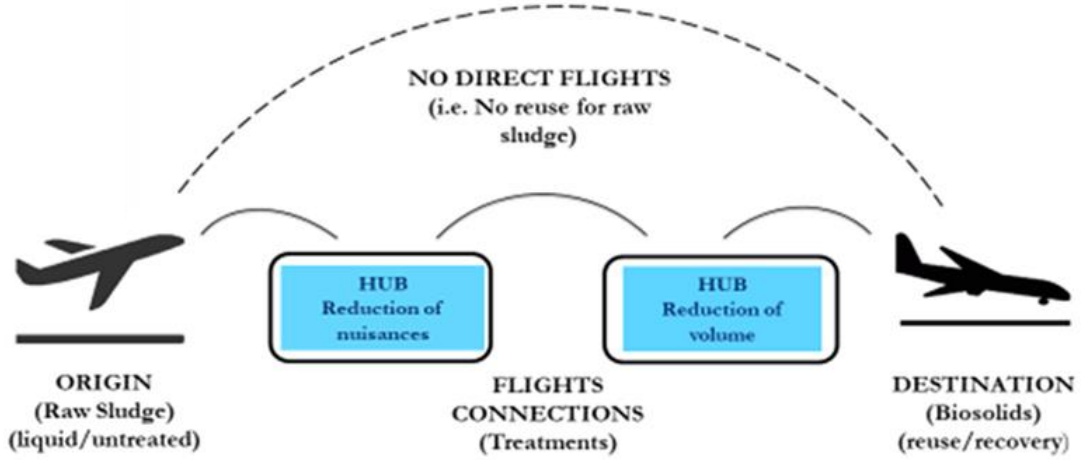
TECHNICAL ASPECTS - 1

- In a sustainable sludge management network, no direct flights are available in the "*Journey to recovery*" from Origin (i.e. production) to Destination (i.e. utilisation/disposal).
- Within this context, several treatment options are available, but the "*Reduction of nuisances*", through stabilization/digestion, and the "*Reduction of volume*", through thickening/dewatering, represent two unavoidable hubs.
- Further, most of the stabilization/digestion methods also reduce the sludge amount by degrading volatile solids.





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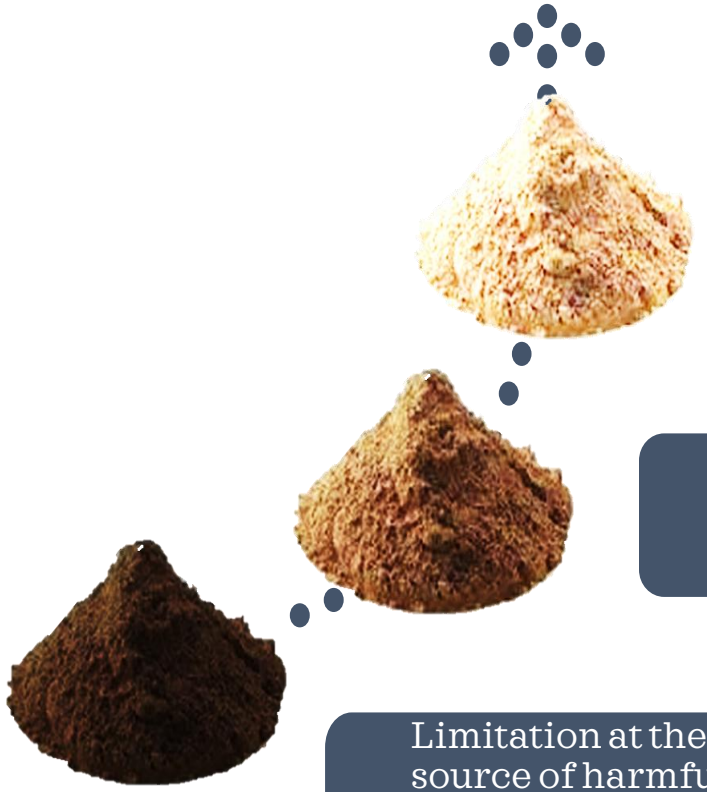
TECHNICAL ASPECTS – 2
Reduction of nuisances (Stabilization / Digestion)

- Improvements for Anaerobic digestion include pre-treatment (e.g. disintegration processes), more efficient mixing, increased reactor load and heat recovery, biogas retraining/upgrading.
- Developments of Aerobic stabilization include thermophilic conditions or a primary thermophilic aerobic phase followed by anaerobic mesophilic digestion.

Research areas include:
- presence and fate of estrogenic compounds;
- enzyme treatment;
- molecular methods on microbial populations.



Reduced nuisances, health risks and handling costs

Several strategies and technologies are available to improve sludge quality

Limitation at the source of harmful substances entering the wastewater treatment plant.

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TECHNICAL ASPECTS – 3
Reduction of volume (Thickening/Dewatering)

Two options are available:

- Reduction in the water treatment line: cellular lysis, increased age of sludge, ozonization, membrane technology, thermal hydrolysis process.
- Reduction in the sludge treatment line: more effective chemicals to make easier the solid/liquid separation, use of biopolymers to decrease the environmental impact, new technologies based on combination of mechanical and other forces (electrical field, thermal supply, ultrasounds), drying, thermal processes.

The goal is not pushing sludge production towards an "absolute minimum"…

…but, making sludge amount/volume "compatible" with its final destination/outlet and the best overall energy/material balance.

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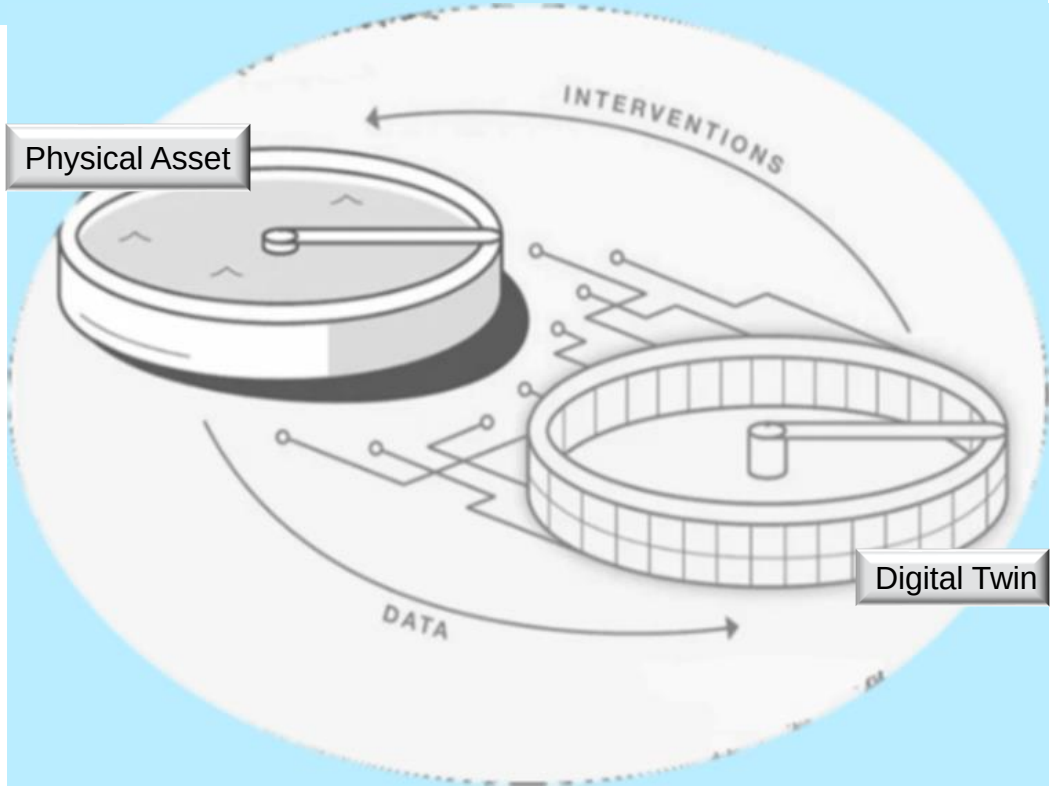
DIGITALIZATION - 1

Digitalization can affect both Technical and Institutional aspects of wastewater/sludge management.
On the side of Technical aspects, Digitalization could be of great help as it allows greater operational capacity and control to be obtained through "*real time monitoring*".

- Digitalization can be mainly described as the convergence from Operational Technology (OT) to Information Technology (IT).
- It is the integration of manufacturing systems controlling physical events and processes with back-end hardware and software for conveying and processing information.
- OT/IT convergence supports systems optimization with the help of data from digital twins by combining all processes and operations in centralized information systems, thus steering wastewater/sludge treatment operations



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DIGITALIZATION - 2

Examples of Processes that can be coupled to a "*digital twin*" within a wastewater/sludge treatment plant

Stabilization/Digestion:

- Monitoring of the biogas composition to control digester process instabilities.
- Continuous monitoring of odours with consequent modification of operating parameters.
- Installation of foam sensor to activate surface discharge or removal option, trap on gas line and protection to the pressure release valves.

Thickening/Dewatering:

- Gravity thickener: adapting polymer dosage to settling velocity.
- Centrifuge: adapting polymer dosage, differential speed and conveyor torque to cake/centrate suspended solids content and flow rate of incoming sludge.
- Filter press: regulating volume/mass rates, pressure rise and mixing energy to optimize the filtration results and minimize requirement of conditioning agent.
- Polymer consumption: monitoring polymer dosing through zeta potential and streaming current detector measurements, direct measurements by spectrophotometry or rheology, use of an inert trace electrostatically bound to the flocculant.

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CONCLUSIONS

- To accelerate Sludge Management towards Sustainability in compliance with the SDGs (Target 6.3 in particular) of UN Agenda 2030, it is necessary to approach the wastewater/sludge management systems with respect for criteria of greater responsibility in social, environmental and economic terms (Sustainability principles) without disregarding respect for Circular Economy and Thermodynamic principles.

- Sludge Management should be conceptually considered as the Locomotive of the water cycle train because the most appropriate sequence to adopt for wastewater treatment is strongly driven by the sludge reuse/disposal options available in the specific local context.

- Technical actions aimed at improving sustainability by maximizing recovery benefits, instead of just disposal, must be adopted.

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Accelerating Sludge Management towards Sustainability - Institutional Aspects

PUJA DOSHI, IWA-IGR SECRETARY, ENGINEERS WITHOUT BORDERS, GERMANY

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BARRIERS

Endogenous factors are tied to local economic, political, and cultural priorities. Distinction between rural, peri-urban and urban areas, formal and informal settlements, i.e. slums

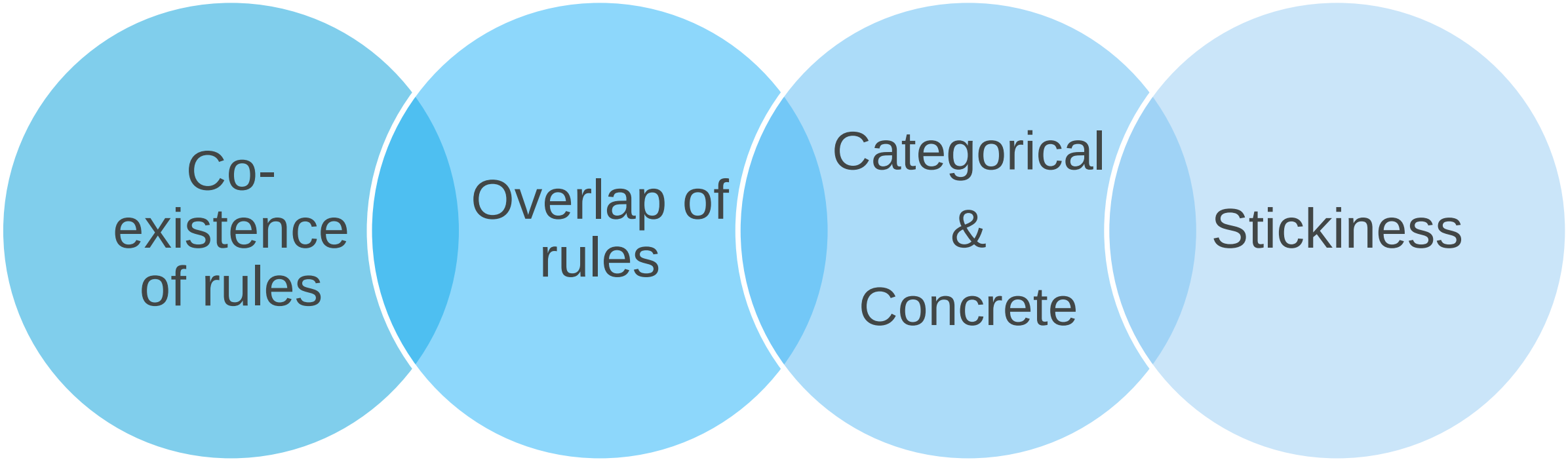
Exogenous factors are mainly related to the economic access to public systems, and include water poverty, socially disadvantaged groups or low-income households

Legal Pluralism: Legal practices and norms are not monolithic entities but are in fact multi-layered and subject to negotiation and enforcement, gap between rules and behavior

PRICING MECHANISMS

Pricing mechanisms can help to diminish barriers, being able to act as		
A fine-tuning instrument **Social Aspects**	A revenue raising instrument **Covering O&M**	Polluter-pays-principle **Long term investment**

LEGAL PLURALISM



FORMS OF INSTITUTIONAL CHANGE

Path dependency: historical-cultural traditions and policy legacies influence actual actions and tend not to adapt towards new circumstances

Institutional bricolage: new elements are simply mixed or added to traditional local elements thus possibly colliding with modern ideas

Institutional syncretism: old and new, traditional and modern, informal and formal elements are interwoven in a creative process thus forming a completely new type of institution.

FORMS OF INSTITUTIONAL CHANGE

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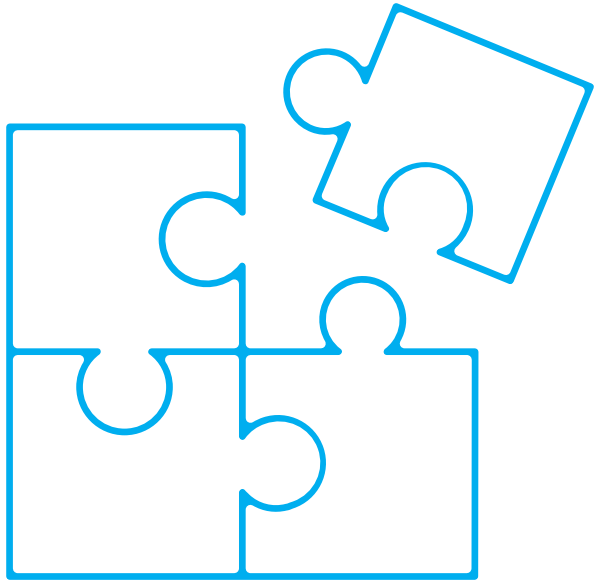
The institutional syncretism is the right answer to the re-conceptualization of wastewater treatment

FORMS OF INSTITUTIONAL CHANGE

….To continue old institutions under new conditions while acknowledging endogenous (embedded social norms) and exogenous (costs, poverty etc.) access barriers.



REGULATION

Compliance	• Bridging the gap of compliance with existing legislation and regulations
Providing	• Providing capacity and resources to ensure implementation at the local/municipal level
Enforcing	• Enforcing and following up on existing legislation and strengthen the political will to do so
Updating/Harmonizing	• Updating legislation and harmonize legislation relevant to sludge management
Changing Perception	• Changing perception about waste
Society's interest	• Putting society's interest above political interest by accordingly setting the rules of the game

REGULATION

Within this framework, regulation, including clear rules for penalties and sanctions, needs to be adapted to the local context, and issued to avoid imposition of:

GENERIC and not numerically quantified limits, which may have general applicability but are difficult to be widely applied and prosecuted

UNJUSTIFIED although numerically quantified limits, which could become dangerous in certain situations

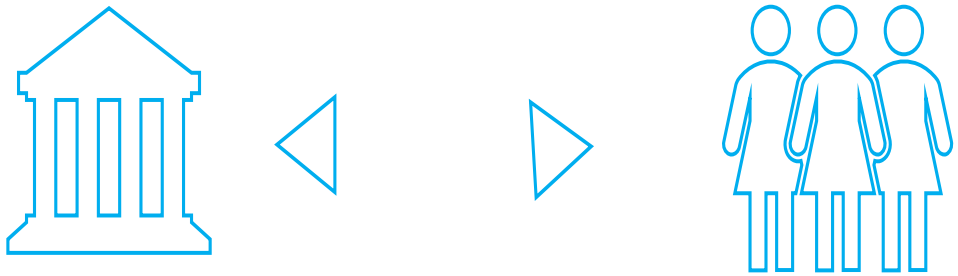
STANDARDIZATION

1

Each laboratory may utilize different equipment and accessories, so results cannot be reliably compared since they are obtained under different circumstances and conditions.

2

The development of “standardized characterization methods” is a necessary support to the development of regulation, since well-defined procedures allow legal requirements to be fulfilled in a correct and uniform manner, thus building stakeholder and public confidence.



DIGITALIZATION

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Goals of digitalization in sludge management are

(i) controlling energy

(ii) reducing toxicity

(iii) optimizing sludge transport

This digital concept is defined

by

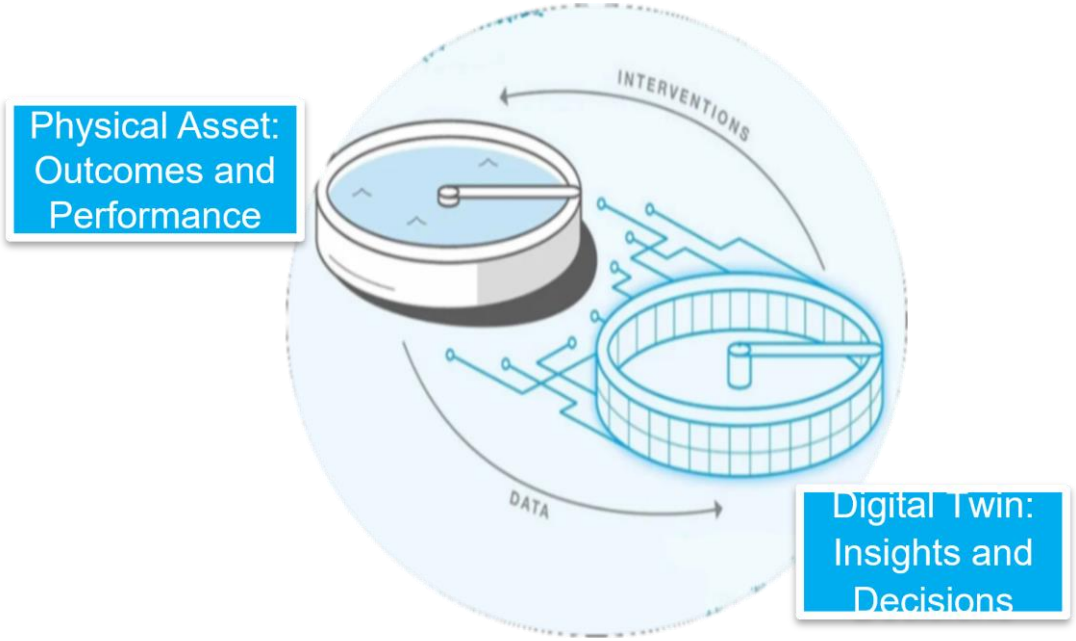
system optimization

above

process optimization

DIGITALIZATION

- Real time data obtained by digital twins provide a firm information base on the quantity and characterization of sewage sludge.



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Wastewater treatment plants tend to be highly energy consumptive and are ranked as one of the most important energy consumers managed by municipalities.

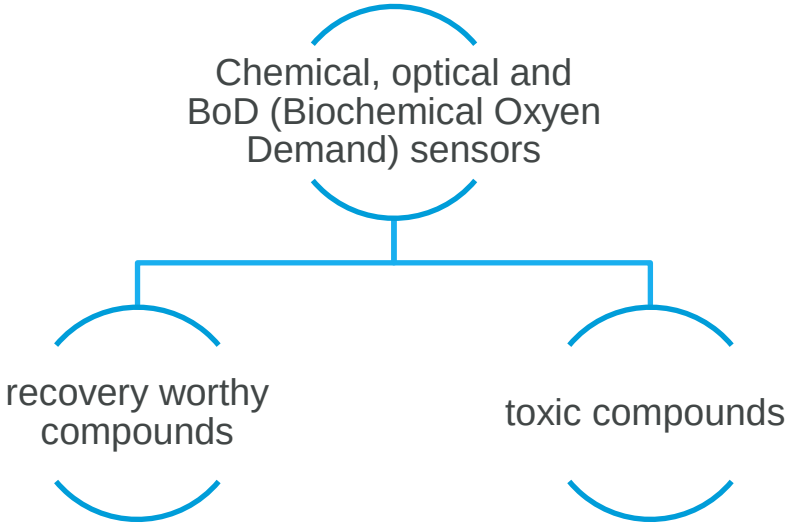
Short term fluctuations i.e., seasonal, in sludge production can be levelled out.

Controlling Energy reduction (i)

Depending on the quantity of sludge that is produced on a daily or short-term basis energy and chemical input for treatment can be regulated.

Toxic reduction (ii)

- To ensure that the presence of toxic chemicals is below the specified concentration
- Sensor Technology & Artificial Intelligence (AI) provide for an low cost & effective solution



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(iii) Optimizing Sludge Transport

Sludge Management cannot be seen in a silo, and it involves the transportation towards its destination either as	
(i) waste towards a waste depot or landfill	(ii) product/commodity for agricultural use or cement plants

CONCLUSION

- Creating the right base for institutional environment that enables
  - Regulation
  - Standardization
  - Digitalization

CONCLUSION

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The institutional environment enables to set up appropriate regulation (via institutional syncretism)

Regulatory methods and appropriate business models that make sludge an attractive commodity including supply chain mechanisms towards the destination incentivize the industry to produce fewer toxic compounds.

Digitalization allows obtaining greater operational capacity of wastewater and sludge management systems through real time monitoring and building stakeholder confidence and reducing barriers between citizens and institutions through web/apps connection.

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Conclusions

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Q&A Panel Discussion

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Final Remarks

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