Training Program on Sustainable Natural and Advance Technologies and Business Partnerships for Water & Wastewater Treatment, Monitoring and Safe Water Reuse in India

Sludge Drying Reed Bed

Prepared by:
Riccardo Bresciani
IRIDRA Srl

IRIDRA S.r.l.

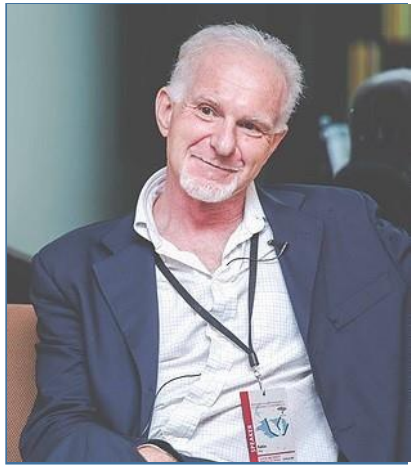
PAVITR

Copyright and Disclaimer

PAVITR

Copy it, adapt it, use it – but acknowledge the source!

Introduction to the authors



Name and Last Name
Technical director Iridra
Environmental Chemistry
Expert in nature based solutions processes and sustainable water management

Email masi@iridra.com

Name and Last Name
Project manager Iridra
Environmental Engineer
Expert in design, supervision and training on Constructed Wetland wastewater treatment plants

Email bresciani@iridra.com

Name of the organization
IRIDRA SRL
Iridra Srl founded in 1998, is a private consulting engineering firm composed by an interdisciplinary group of professionals with multi-annual experience in the water management and in wastewaters treatment with natural systems (Constructed Wetlands, CWs), where Iridra is recognized as the leader company in Italy and one of the most well-known in the world.

www.iridra.com

Learning objectives

PAVITR

At the end of this session, participants will:

- have more familiarity with Sludge drying reed beds, their functioning and the involved biological processes
- have the preliminary skills for a first assessment and sizing of Sludge drying reed beds
- know the preliminary basis for their construction and operation

Agenda of the session

PAVITR

Time	Content
5 min	Introduction to the session
25 min	Introduction to the technology (background overview, principles, performance expected, appropriateness)
60 min	Design of the technology (key considerations, basic calculations, key formulas, etc.)
15 min	Break
15 min	Operation and maintenance
15 min	Construction and/or implementation
30 min	Example: the PAVITR pilot
12 min	Homework: exercise to design/implement the technology for a case study
13 min	Final remarks

Introduction to the technology

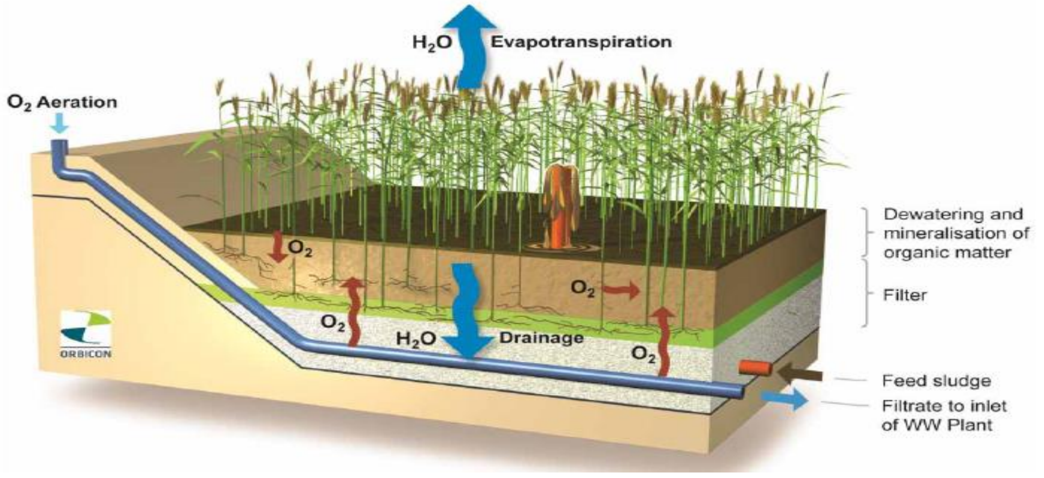
Sludge Drying Reed Beds (**SDRB**)

Sludge Drying Reed Bed (SDRB)

PAVITR

Description

Sludge Drying Reed Beds (SDRBs), or Planted Drying Beds (PDBs), have been used for over thirty years for the stabilization and dewatering of **sludge from urban wastewater treatment plants**; recently they have been applied for septage and faecal sludge in developing countries. SDRBs consist of a bed filled with a filter medium (gravel and sand) planted with reeds (e.g. Phragmites spp) or some other plant species. Faecal sludge is disposed on the surface, where evapotranspiration promotes dewatering, while the interaction between oxygen, bacteria and plant roots induces the mineralization of the organic matter. The final product is generally a **soil conditioner** usable safely in agriculture.



Processes in SDRB

source: Steen Nielsen - Orbicon, DK

IRIDRA

Sludge Drying Reed Bed (SDRB)

PAVITR

Description

Faecal sludge is loaded on the surface bed with a **Sludge Loading Rate (SLR) of 50-200 kg/m2** of TS per year, 7.5-20 cm of sludge is loaded 1-3 times a week.

Despite some authors report high SLR (up to 200 or more), the operation of the system at these challenging conditions is still to be demonstrated and it can lead to critical conditions on the short or medium period.

SLR of **50-120 kg/m2 of TS per year** are more realistic, with the higher values in tropical and hot climates.

source: Steen Nielsen - Orbicon, DK

IRIDRA

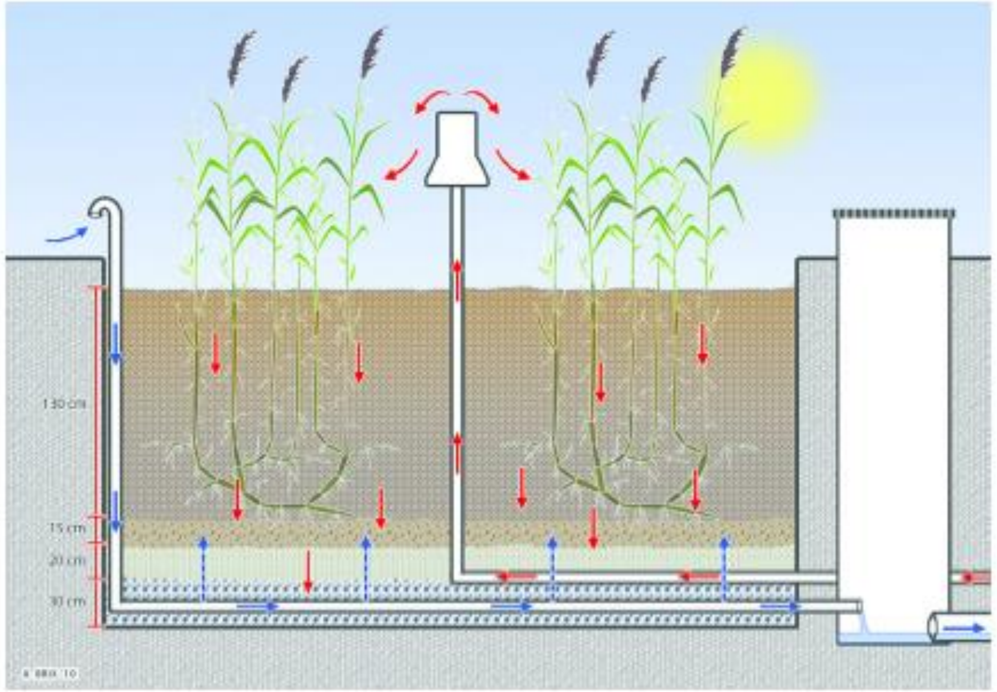
Sludge Drying Reed Bed (SDRB)

PAVITR

Description

The reduction of the liquid part of the sludge takes place due to percolation through the filter layer, evaporation or evapotranspiration, while the solid part undergoes a process of mineralization due to the interaction between oxygen, plants and bacteria.

The final treatment products are a **dried sludge** usually suitable to be used in agriculture as a **soil conditioner**, and a liquid effluent that needs further treatment.



Source: Dotro et al., 2017.

Sludge Drying Reed Bed (SDRB)

PAVITR

Description

SDRBs can work for **five to ten years** before the emptying procedure: the load in the bed to be emptied is interrupted for about 4-12 months to complete the **stabilization phase**, after which the organic top layer is excavated and the bed is re-established for the next phase.

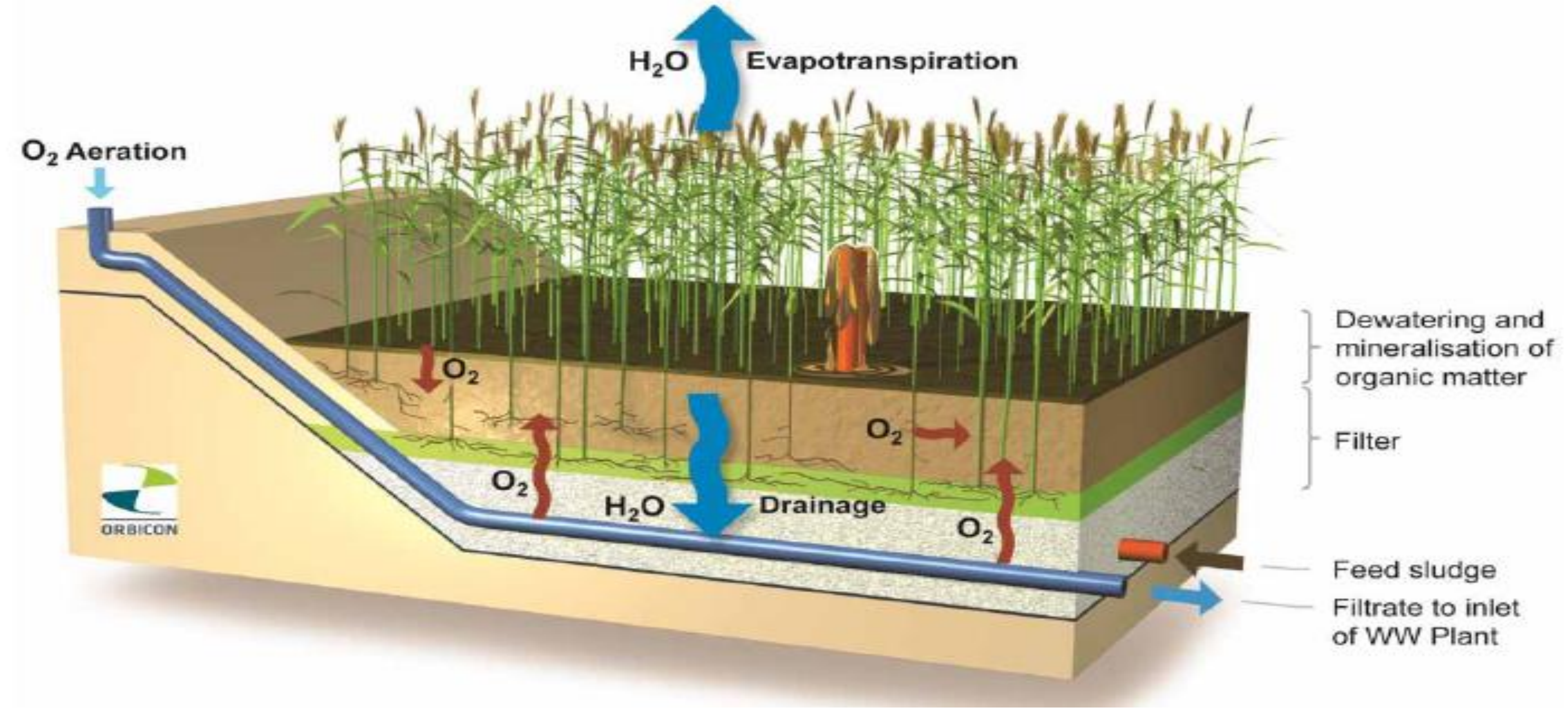
source: IRIDRA

IRIDRA

Sludge Drying Reed Bed (SDRB)

How it works

Processes are essentially dewatering, driven by evapotranspiration, and mineralization of organic matter due to complex interactions between oxygen, bact



Sludge Drying Reed Bed (SDRB)

PAVITR

Advantages

- ✓ Low CAPEX
- ✓ Low OPEX
- ✓ Low contribution in terms of CO_2 emissions
- ✓ Easy to construct
- ✓ Easy to operate and maintain, no need of skilled labour
- ✓ No chemical additives like polymers as conditioner
- ✓ No odour diffusion and no mosquito proliferation
- ✓ Low level of technological equipment (just a pump to distribute the sludge)
- ✓ High life span
- ✓ High flexibility
- ✓ High stabilization and pathogen reduction
- ✓ High mineralization of organic compounds
- ✓ High dehydration, solid content reduction up to 50%, volume reduction up to 90%
- ✓ Leachate quality better than in other sludge treatments (it can be further treated in landfill leachate treatment)
- ✓ Final sludge reusable in agriculture as soil conditioner, or for further composting, for recultivation, gardening and landscaping, landfill covering

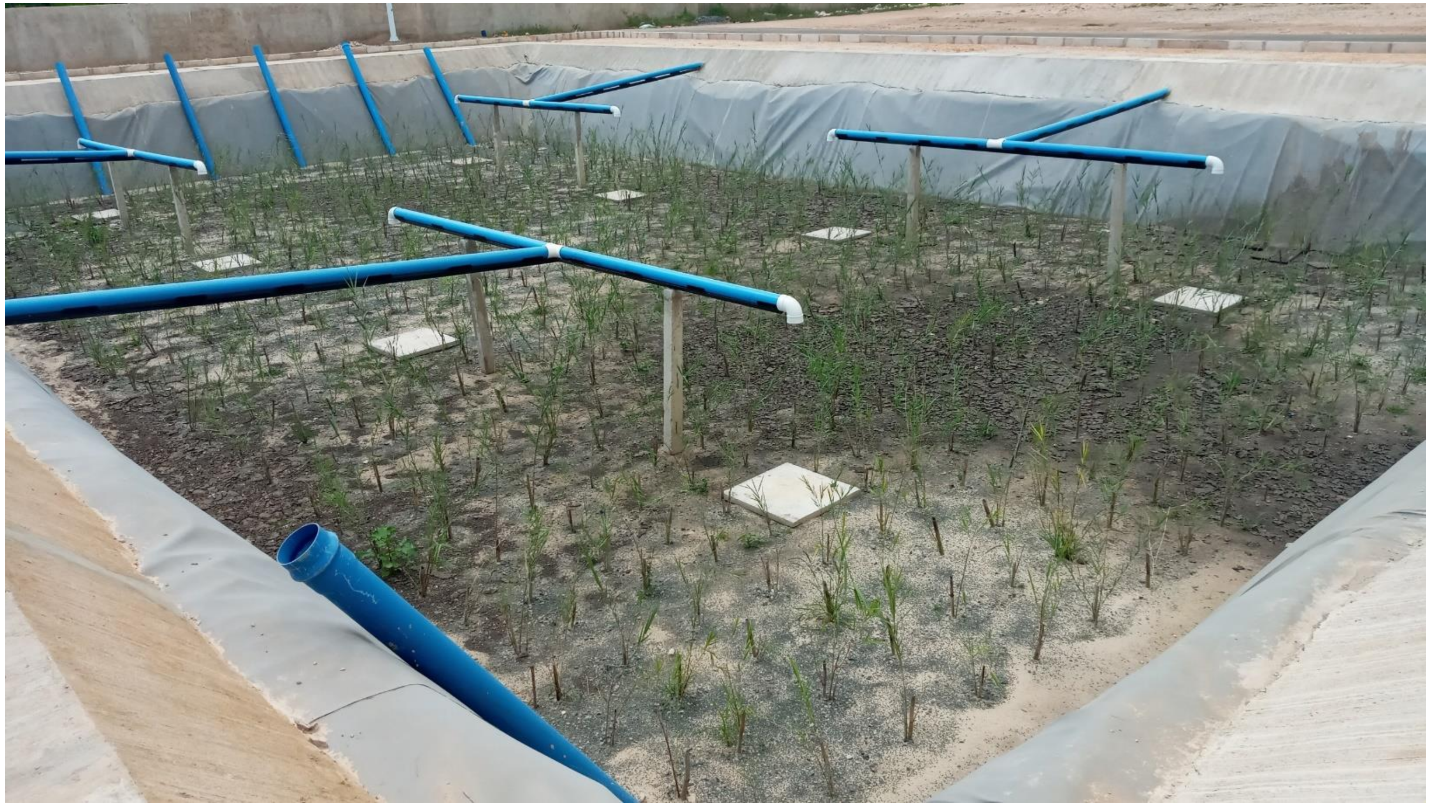
IRIDRA

Sludge Drying Reed Bed (SDRB)

Treatment efficiency

- Suspended solids: >= 95 %
- COD: 70 to 90 %
- Helminth eggs: 100 %
- NH4: 40 to 60 %

source: Dorothee Spuhler, seecon gmbh



source: IRIDRA

Sludge Drying Reed Bed (SDRB)

PAVITR

Treatment mechanisms

The treatment of sludge in SDRBs is achieved through a combination of physical and biochemical processes. In wet, rainy climates, **macrophytes** play an essential role in almost all processes, and are responsible for the higher levels of treatment in terms of stabilisation and pathogen removal in SDRBs compared to unplanted drying beds (Brix, 1997; Kadlec and Knight, 1996). Macrophytes therefore play an essential role in the following:

- **stabilizing** the beds to prevent media erosion and clogging, and improving the drainage;
- increasing **moisture loss** (through evapotranspiration, in contrast to only evaporation in unplanted drying beds);
- providing a surface area for **microbial growth** within the sludge layer;
- transferring **oxygen** to the sludge layer (i.e. within the rhizosphere); and
- **absorbing** heavy metals and nutrients.

source: Kengne et al., 2014

IRIDRA

Sludge Drying Reed Bed (SDRB)

PAVITR

Applicability

Any kind of sludge can be treated in drying beds.

It is best combined with co-composting in order to produce fertiliser.

The method is simple but requires professional design and trained manpower for the operation.

However, large land areas are required for the construction.

Drying beds are centralized treatment options and thus adapted for larger areas. The operation and maintenance requires an efficient community organization.

As odour could be an issue, they should be constructed far away from households.

The bottom needs to be sealed to prevent groundwater pollution and the percolate must be treated.

Therefore, drying beds are not adapted for areas prone to flooding.

At places with frequent rain must be roofed.

source: Dorothee Spuhler, seecon gmbh

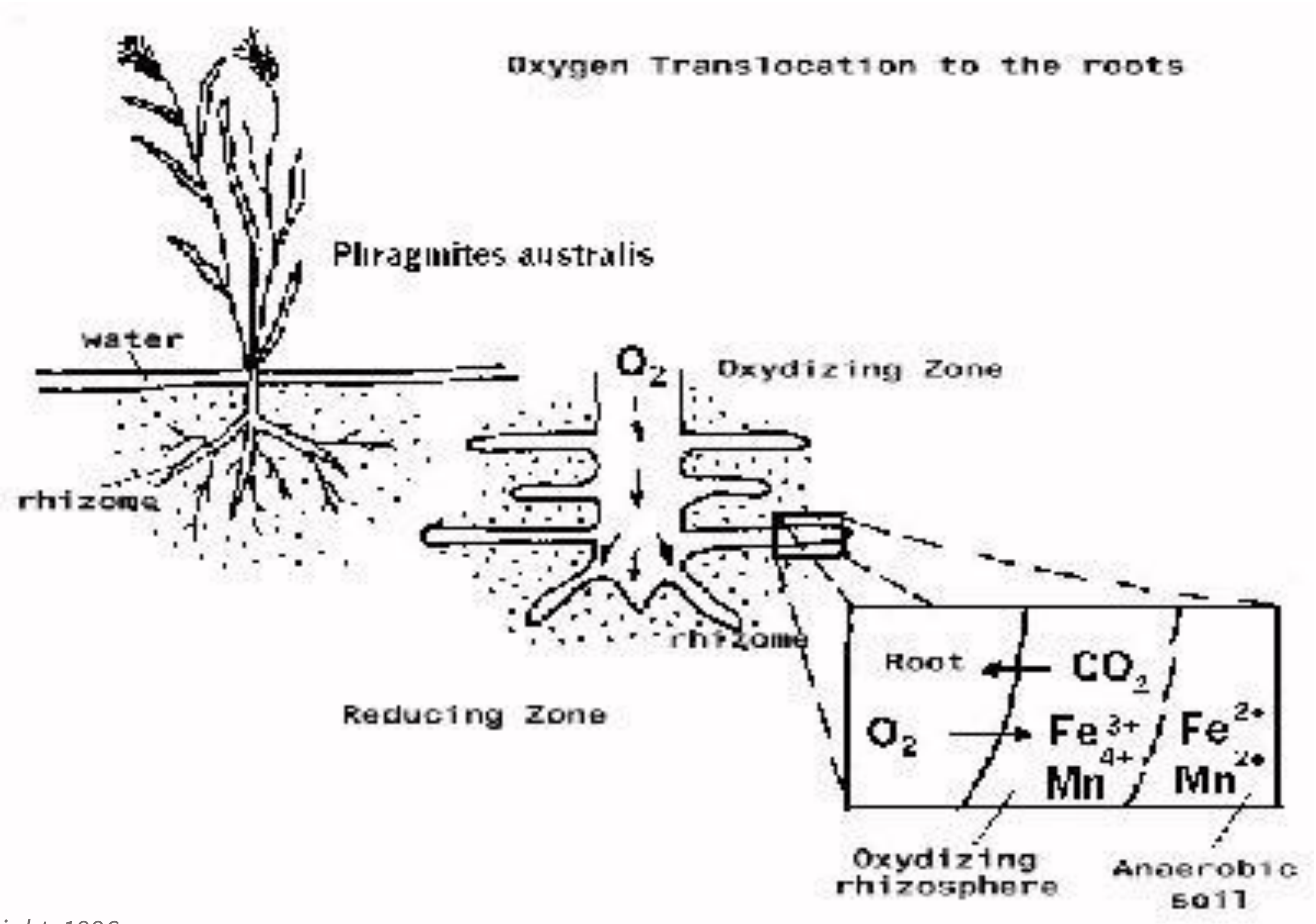
IRIDRA

The role of plants

- **Physical effects**: roots provide surface area for attached micro-organisms; root growth maintains the hydraulic properties of the substrate; vegetation cover protects the surface from erosion and shading prevents algae growth; Litter provides an insulation layer on the wetland surface (especially for operation during winter).
- **Uptake**: 1) nutrients: plays a minor role for common wastewater parameters compared to the degradation processes by micro-organisms. 2) heavy metals and special organic compounds: different plant species can play a major role to enhance the treatment efficiency.
- **Release**: plants not harvested → release during decomposition; Some plants: release of organic compounds (which can be used for denitrification) or oxygen (e.g. reeds – but too little compared to O2 demand of wastewater).
- other functions not directly related to the treatment process

source: Kengne et al., 2014

The role of plants



Source: Kadlec&Knight, 1996

Design of **the technology**

PAVITR

General CW Design

General CW Design criteria

In designing constructed wetlands, the aim is to maximize contact between the polluted water column and the various wetland components (biofilms, plants, the sediment layer, etc.).
Contact efficacy depends on the water flow path in the system, that is related to the bed size and the residence time.
It is not advisable the use of simplistic guidelines for all situations. CWs must be individually designed for a particular set of objectives and constraints.

SDRB system in northern Italy, operating since 2004

Source: IRIDRA srl

General CW Design criteria

- Hydrology
- Hydraulic Retention Time
- Hydraulic Loading Rate
- Filling Media (porosity, hydraulic conductivity kf)
- Redox conditions (aerobic, anaerobic, mix reactor)
- Geometry of the bed
- Waterproofing
- Inlet and Outlet devices
- Cells configuration (series and/or parallel)
- Choice of macrophytes
- Treatment goals (in terms of specific pollutants overall removal)

General CW Design criteria

Decisional tree: STEP 1

Determination of treatment goals

- End users analysis and characterization of faecal sludge to be treated (Total Solids, Total suspended solids, Volatile solids, Loss of ignition, organic content, nitrogen, pathogens, etc.)
- Individuation of the final discharge of treated water (e.g. superficial water, soil, reuse, sewer, co-treated in existing WWTP etc.)
- Local regulations
- Determination of the level of requested treatment

General CW Design criteria

Decisional tree: STEP 2

Choice of the most appropriate solution

- Does the constructed wetland technology fit with the objective of treatment ?
- Evaluation of project alternatives in terms of performances and technical-economic sustainability

General CW Design criteria

PAVITR

Decisional tree: STEP 3

Preliminary sizing

- Individuation of the most appropriate system design
- Outlined sizing of requested surface

IRIDRA

General CW Design criteria

PAVITR

Decisional tree: STEP 4

Identification of the intervention area

- Analysis of intervention area morphology
- Compatibility with the existing restrictions (the main restriction is usually represented by the space availability)
- Environmental impact evaluation

IRIDRA S.r.l.

General CW Design criteria

PAVITR

Decisional tree: STEP 5

System design

- Choice of the adequate pre-treatment systems
- Choice of filling medium
- Choice of the plants
- Determination of the useful surfaces
- Geometry and configuration of the beds
- Choice of the waterproofing types
- Verification of the system performances
- Constructive parameters

IRIDRA

SDRB Design

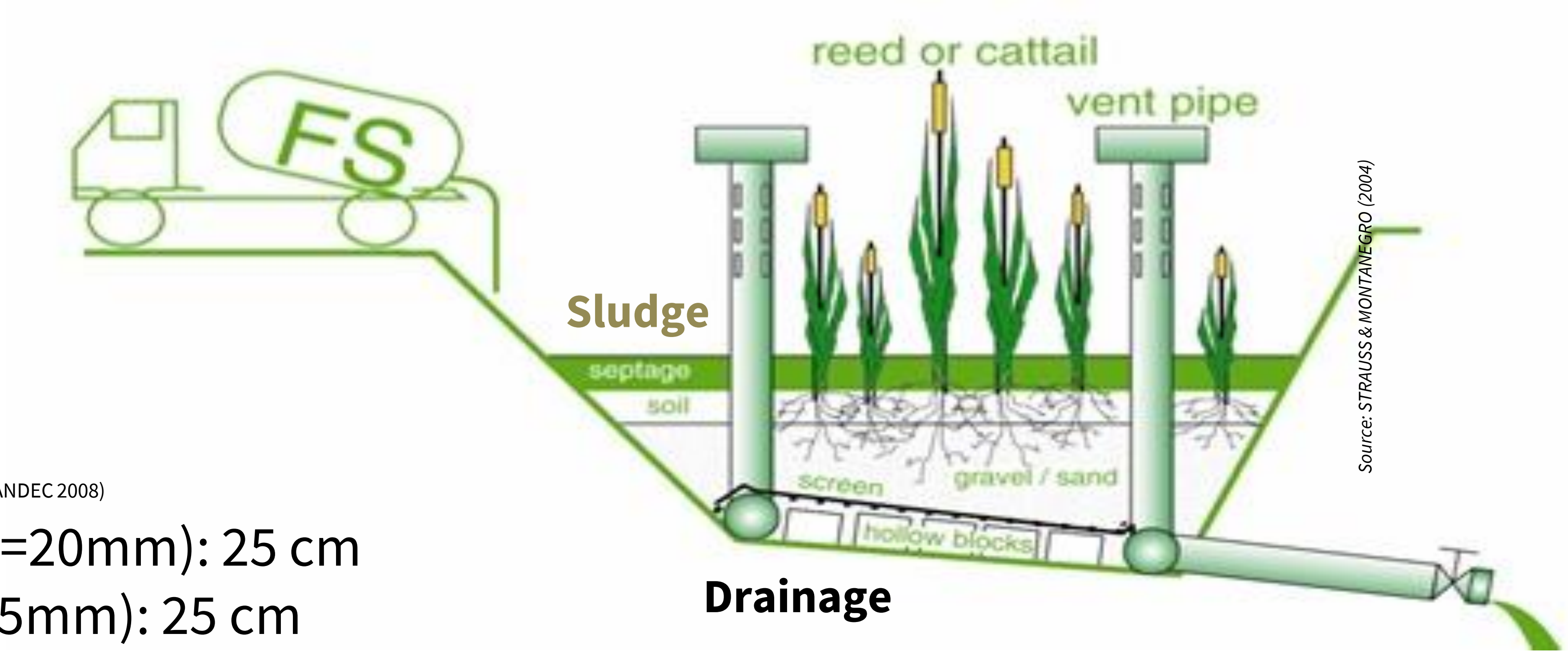
SDRB Design

General overview

- Sludge application depth: about 20 cm
- Loadings: 50-200 $KgTS/m^2/year$
- Application: Once a week; Desludging: every 5-10 years
- Achieved drying: 40 to 70 % TS

SDRB Design

General overview



Source: STRAUSS & MONTANEGRO (2004)

Filter bed (EAWAG/SANDEC 2008)
Large gravel (d=20mm): 25 cm
Fine gravel (d=5mm): 25 cm
Sand: 10 cm

source: Dorothee Spuhler, seecon gmbh

SDRB Design

General overview

Vegetation

source: Dorothee Spuhler, seecon gmbh

Plant species	Common name	Water type	Habitat	Water regime
Phragmites sp.	Reeds	Fresh to brackish	Marshes; swamps	Seasonal to permanent inundation, up to 60 cm
Typha sp.	Cattail	Fresh to marshes	Pond margins	Seasonal to permanent inundation, up to 30 cm
Cyperus papyrus	Papyrus	Fresh to marshes	Pond margins, lakes	Seasonal to permanent inundation, up to 30 cm
Echinochloa sp.	Antelope grass	Fresh to brackish	Marshes; swamps	Seasonal to permanent inundation, up to 40 cm

source: Kengne et al., 2014

SDRB Design

Faecal sludge SLR

High variation of SLR can be found in literature, depending by the climate, and also different loading and resting period strategies

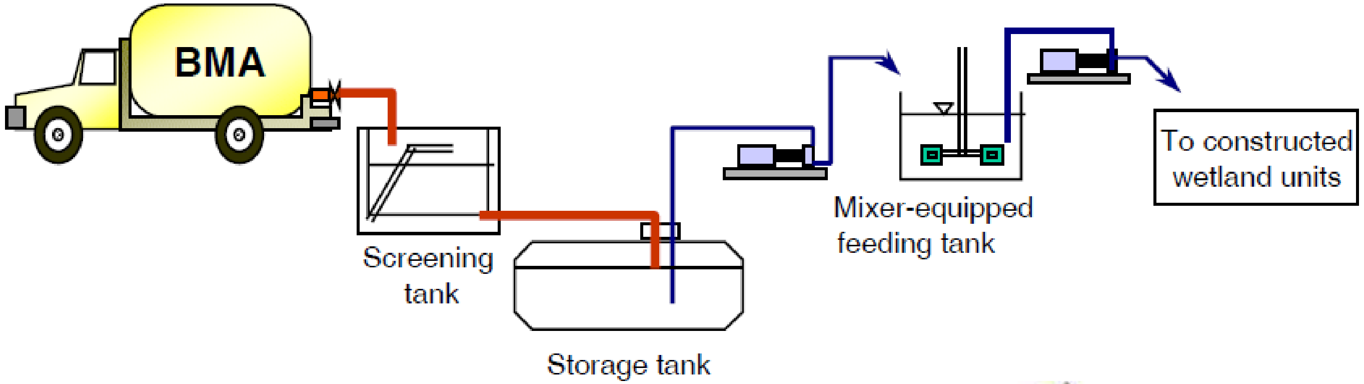
Climatic Zone	Sludge type	SLR kg /m²/year	Feeding and resting strategy	TS content of dewatered sludge (%)
Temperate	AS	50 - 60	3 days loading and 30 to 50 days rest period	≥30
	SS	25 - 30	20 days rest period in between loading	70%
	SS	46	1 week loading and 5 weeks rest period	38%
Continental	AS	85 - 90	1 week loading and 3 weeks resting in winter and 1 to 2 weeks resting in summer	50% - 64%
	AS	50 - 60	2 days loading and 10 days rest period	26% - 30%
Tropical	SS	178 - 283	7 - 12 days resting period between each dosing	40%
	SS	100 - 200	7 days of resting between each loading	≥30%
Humid sub-tropical climate	SS	100	7 days of resting between each loading	35 (±6.32)

SDRB Design

Faecal sludge SDRB – Pre-treatment

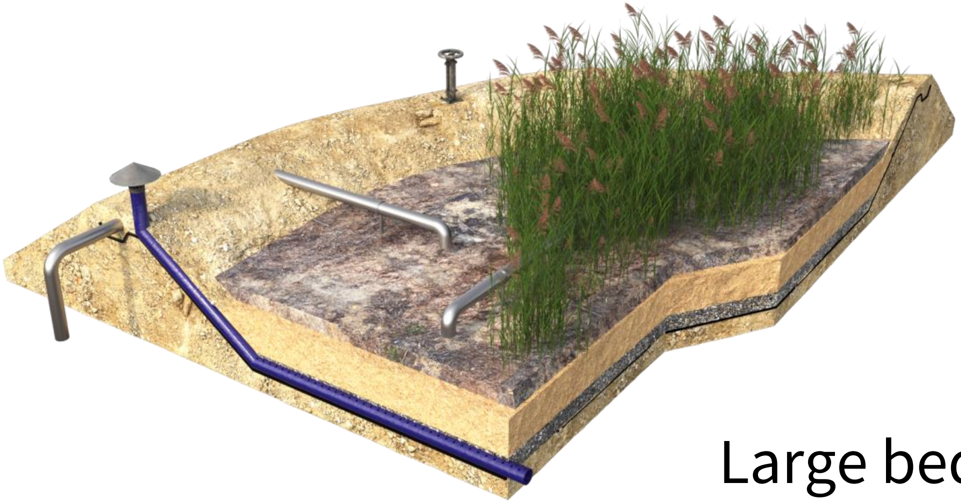
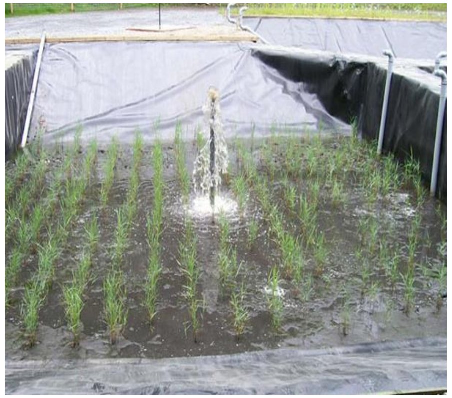
Before loading the beds, vacuum trucks should discharge the sludge into a holding-mixing tank that is fitted with a bar screen to retain coarse material and garbage, prevent clogging of reed beds and sludge contamination.

Furthermore, the tank has the benefits of acting as a buffering unit to regulate the flow of sludge onto the bed and to permit a more regular and uniform distribution; some type of holding-mixing unit should always be installed before the bed is loaded.

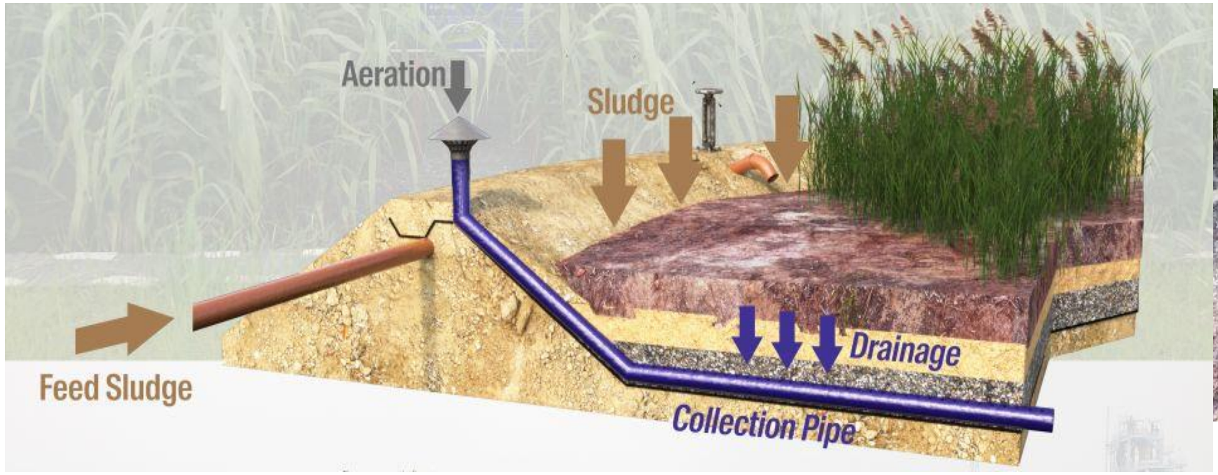


SDRB Design

Faecal sludge SDRB – distribution


Large beds

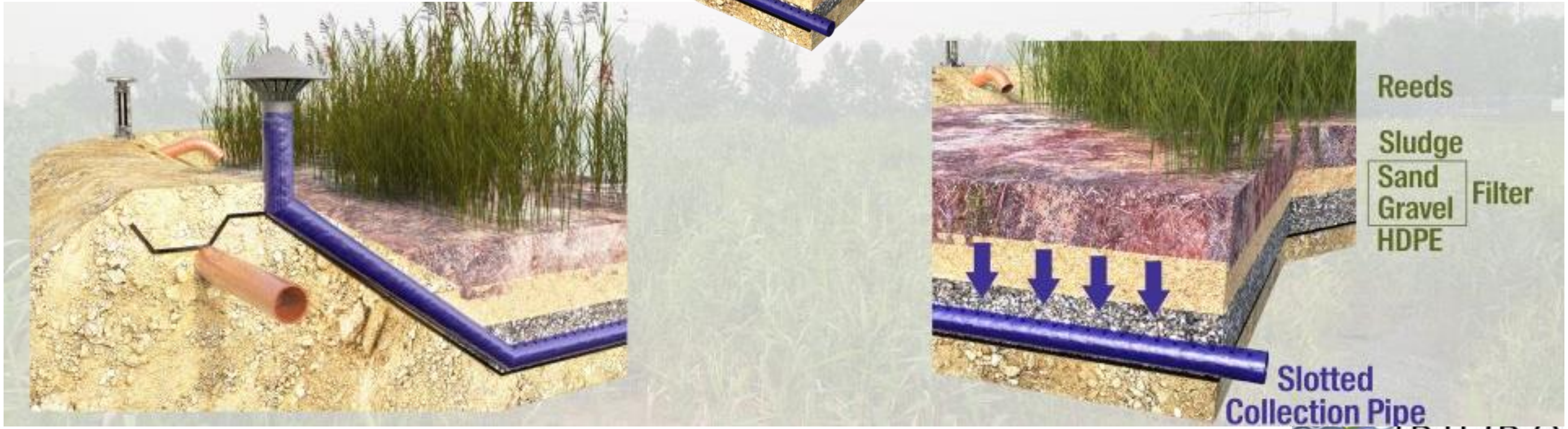


Small beds

IRIDRA

SDRB Design

Faecal sludge SDRB – drainage



Key learning points…

PAVITR

- SDRB: gravel and sand beds planted with reeds for sludge dewatering and stabilization
- Final products: stabilized sludge + leachate
- Reuse: soil conditioner
- Percolation, mineralization, evapotranspiration
- Components: inlet and outlet piping, waterproof liner, filter media, vegetation, berms
- Operation: 5-10 year; Stabilization: 4-12 months
- Pre-treatment → SDRB → discharge/reuse
- Feeding: 1-3 times a week
- SLR: 50-200 kg/m2/year
- Sludge application depth: 20 cm
- Filter: sand (5-10 cm), 5 mm gravel (15-25 cm), 20 mm gravel (25-40 cm)

Let’s have a break

We will be back in 15 min

Construction and implementation

SDRB implementation

Simple implementation

- Material easily available *in situ*
- Often few or no experience in SDRB implementation by the builder
- Need to guarantee easy operation and maintenance
- As few as possible electromechanical tools

SDRB implementation

Implementation phases

1. Earthmoving
2. Waterproofing
3. Filling beds
4. Construction details
5. Planting and starting phase

SDRB implementation

1. Earthmoving

- Area preparation: excavation and embankments
- Reed bed preparation: levelling and compacting of bottom and banks, preparation of inlet and outlet
- Excavation sections for concrete works
- Excavation sections for pipe placing
- Reshaping of the area
    - Final embankments
    - Rainwater drainage
    - Restoring existing profiles
    - Consolidation

SDRB implementation

1. Earthmoving

Site cleaning

Excavation and embankments

Source: IRIDRA

SDRB implementation

1. Earthmoving

Excavation and terracing

Excavation and embankments

Source: IRIDRA

SDRB implementation

2. Waterproofing

1st geotextile layer

Sand layer

Source: IRIDRA

SDRB implementation

PAVITR

2. Waterproofing

Geomembrane

2nd geotextile layer

Source: IRIDRA

IRIDRA

SDRB implementation

PAVITR

3. Drainage

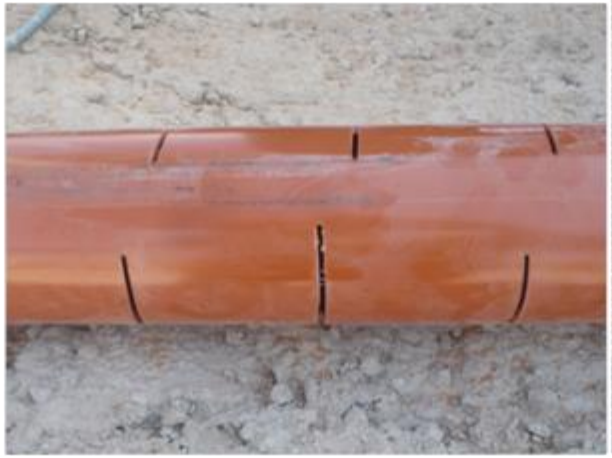
Drainage and aeration pipelines

IRIDRA s.r.l.

SDRB implementation

3. Drainage

Drainage



Source: IRIDRA

SDRB implementation

4. Filling beds

Recommendations:

- As much as possible according to literature indications
- Well cleaned
- Possible rounded grain

- Substrates can include sand, gravel (medium to coarse rock) or other coarse media
- The upper substrate layer should have a coefficient of uniformity higher than 3.5 to avoid rapid clogging (this can be achieved after sieving or washing to remove fine particles)
- A small amount of soil or organic material may be required to allow the growth of plants during the early stages
- The bed must be kept moist, but not flooded until seeds have germinated or rhizome fragments produce new shoots

source: Kengne et al., 2014

SDRB implementation

4. Drainage and Filling with gravel

Source: IRIDRA

SDRB implementation

PAVITR

4. Construction details

SDRB Feeding system

Source: IRIDRA

IRIDRA

SDRB implementation

2. Feeding distribution

By submersible pumps or slurry pump:

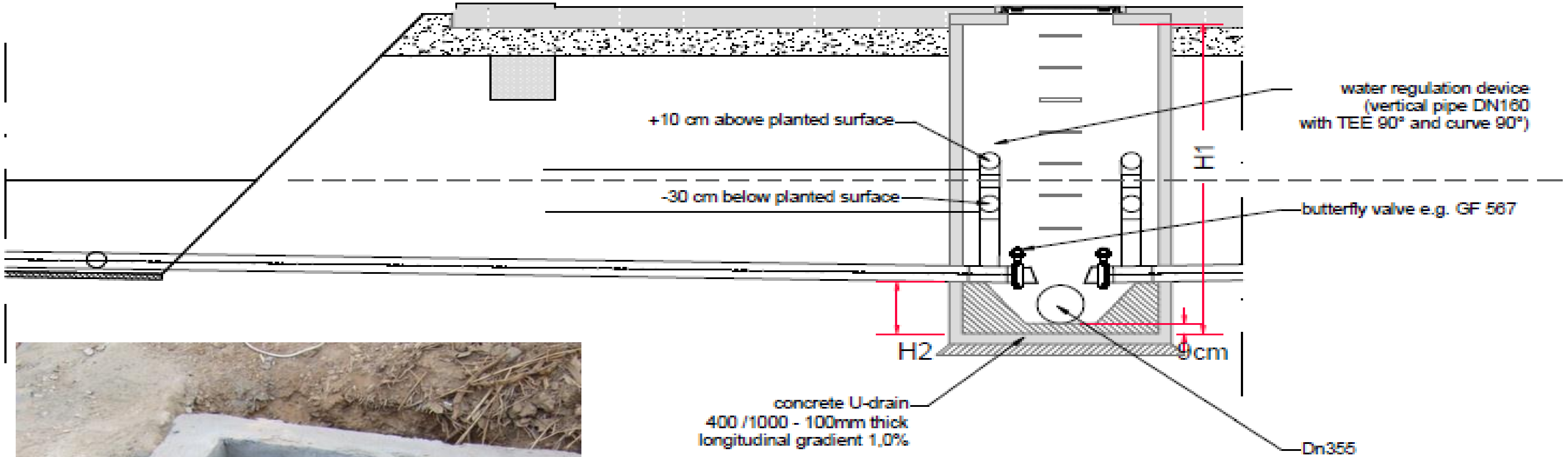
- Centrifugal for wastewater application
- High solids passage
- Implementation possible in every conditions
- High flow rate to consent uniform distribution on the beds
- Limited energy consumption

source: Xylem

SDRB implementation

4. Construction details

Regulation manhole device

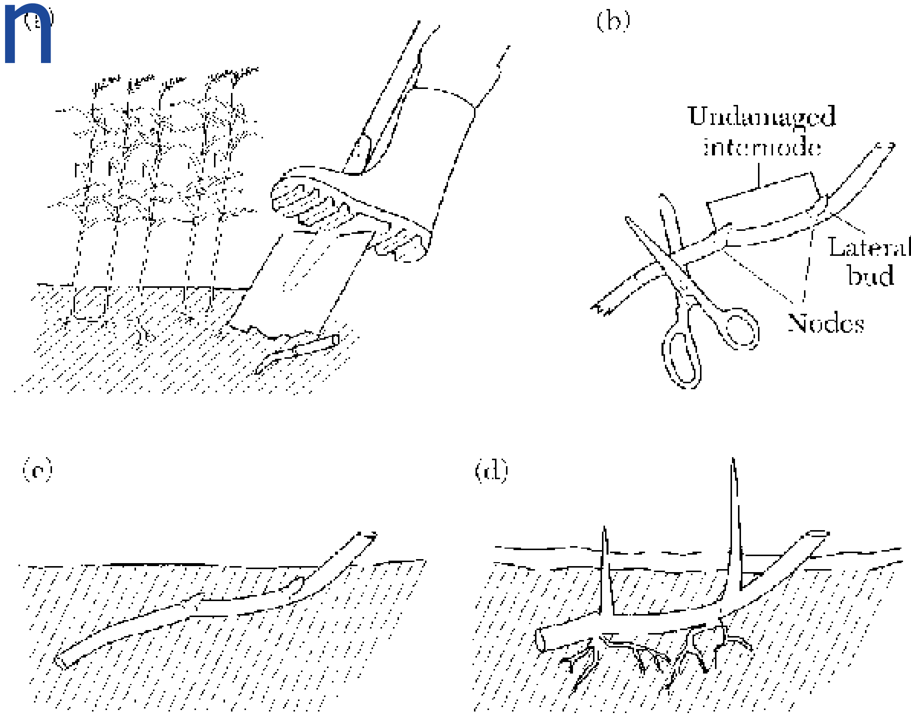


SDRB implementation

5. Planting and starting phase

Dig preparation for plants

Source: IRIDRA



Rhizome

Pot plants

SDRB implementation

5. Planting and starting phase

Plant preparation in on-site nursery

Source: IRIDRA

Key messages

- Earthmoving: reed bed, piping
- Pre-treatment
- Waterproofing: 1st geotextile layer, sand layer, geomembrana, 2nd geotextile layer
- Drainage system: slotted pipes
- Passive aeration pipes
- Bed filling: clean, round gravel
- Feeding system
- Vegetation: *Phragmites australis (some other alternatives are possible in tropical climates)*
- Dig preparation
    - Planting
    - Bed flooding

Source: IRIDRA

Operation and maintenance

Operation & Maintenance

PAVITR

The operation and maintenance of the SDRBs can be carried out by unskilled workers after an adequate training based on the **Operation and Maintenance Manual**. For larger installations, a higher level of experience is required to obtain better results.

The **leachate** must be collected and sent to an appropriate treatment; the vegetation needs to be regularly harvested. In comparison with unplanted drying beds, the quality of the leachate is much better.

IRIDRA s.r.l.

Operation & Maintenance

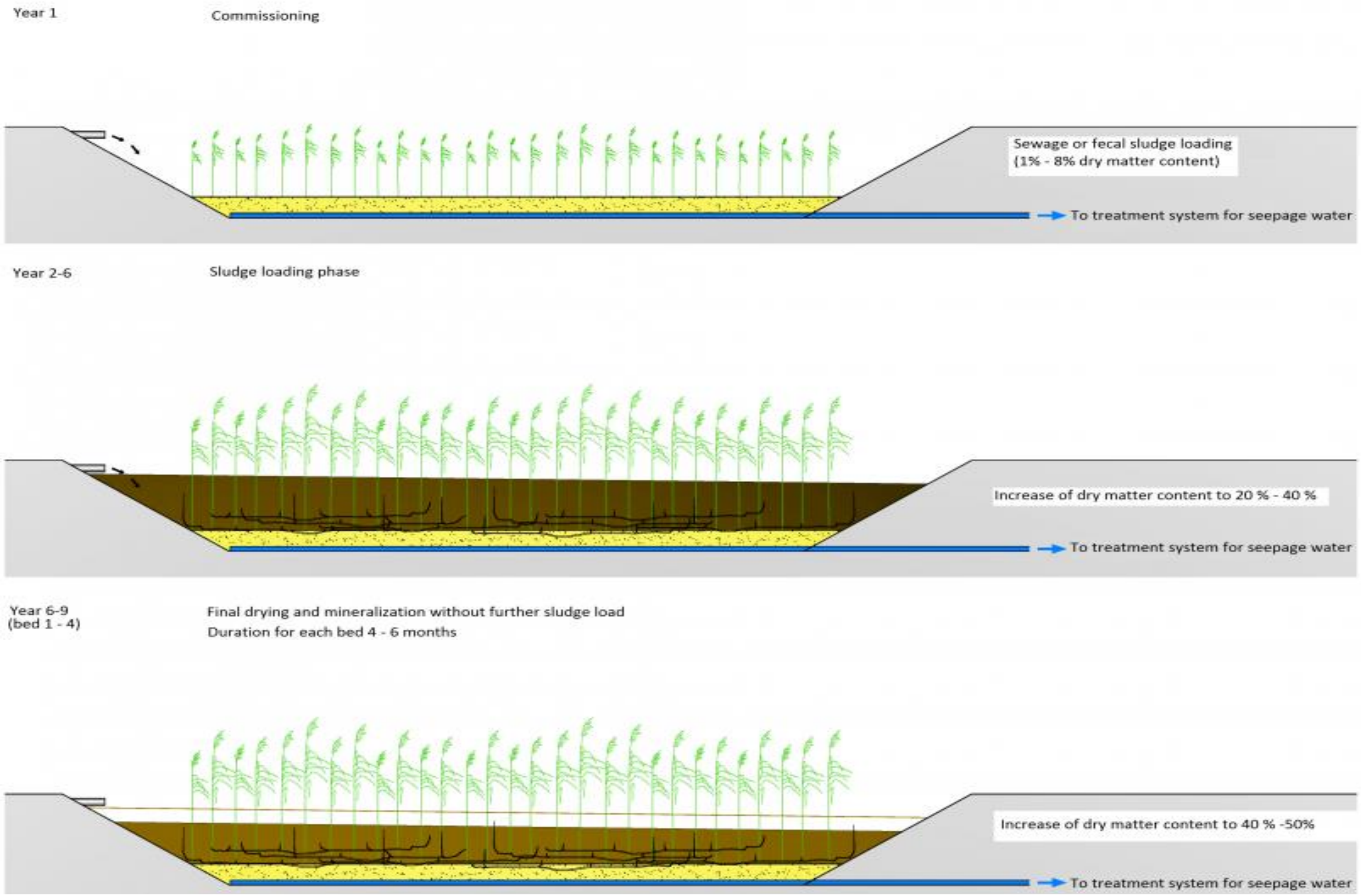
SDRB Operation

The strategy of operation is divided into different phases, depending by the type of sludge, the SLR, the climate:

- Start-up and commissioning (1-2 years) where the SLR is progressively increased until the design value;
- 5-8 years where the sludge is loaded according to the design values
- 2-3 years of decommissioning, where alternatively each reed bed is stopped for few months and the sludge is then extracted by an excavator; after the removal operations, the reed bed is again ready to begin a new cycle

Operation & Maintenance

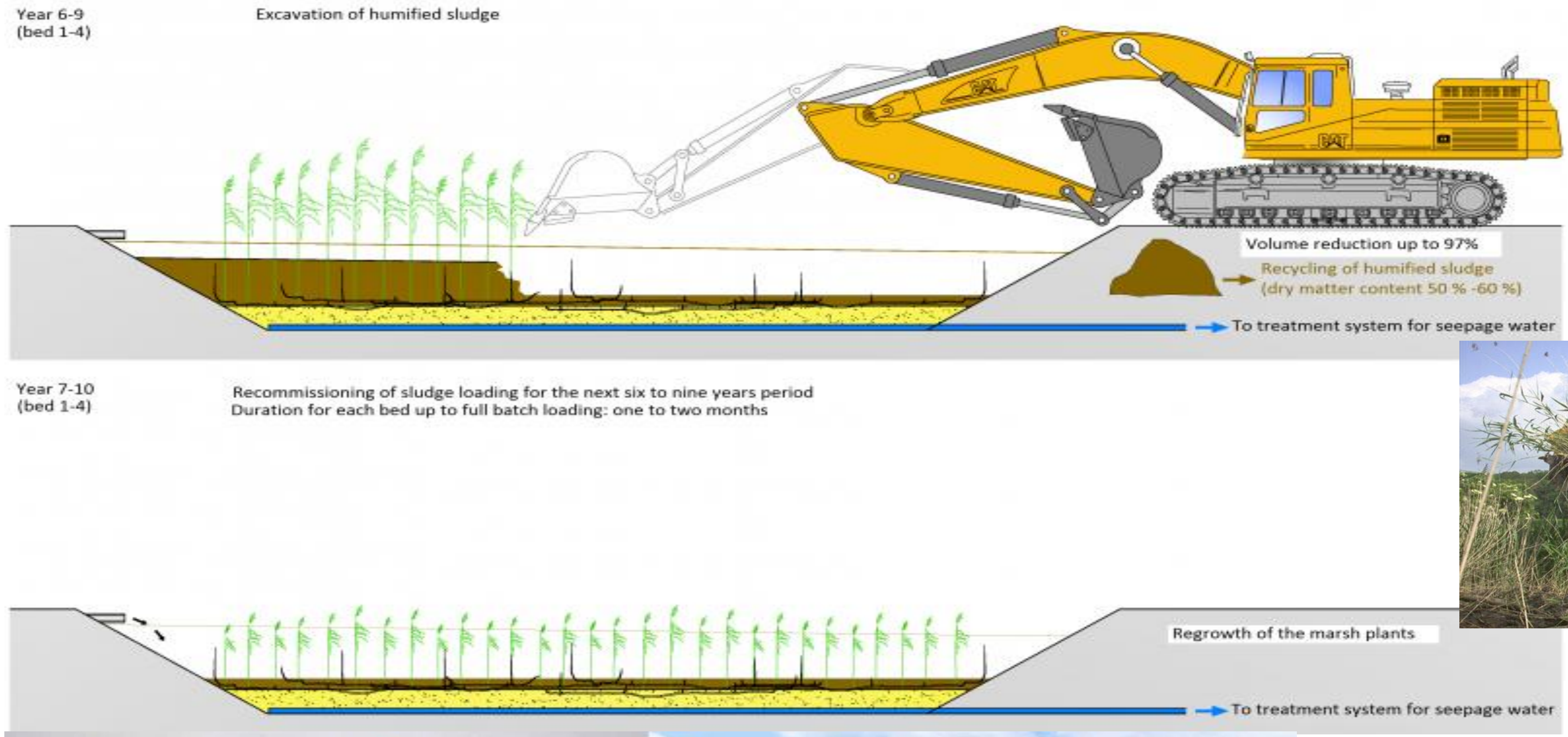
Indicative phases for faecal sludge



Source: Bloomberg

Operation & Maintenance

Indicative phases for faecal sludge



Source: Bloomberg

Operation & Maintenance

PAVITR

Start-up and commissioning: 1°-2° year

This is the most crucial phase, to avoid operational issues in the future and to reach design capacity during standard operation

- Plants adaptation: after completion of the basins, plants should be maintained in saturated condition for 1 months filling the basins, leaving the outlet closed and compensating evapotranspiration with water: the rainy season could be an optimum period to do it, having enough rainfall for ET compensation
- Open the outlets and emptying of the basins
- Start with sludge loading operation
- Load has to be progressively increased
- Rest period of each bed during the first year is generally shorter than standard operation, but it has to be adapted according to characteristics of incoming sludge, climate, growth of plants, aspect of sludge layer on the surface, percolation capacity
- THE STRATEGY HAS TO BE INCLUDED IN O&M PLAN, AND EVENTUALLY ADAPTED TO REAL CONDITIONS AND RESULTS

Operation & Maintenance

PAVITR

Standard operation

During the different phases, to avoid operational issues, it is fundamental to operate the SDRB:

- Controlling and eventually varying the SLR loading rate depending by climate, sludge quality, monitoring results
- Adopting proper resting and loading periods for each bed according to SLR loading rate, seasonality, type of phases. The shifts between loading and resting periods, are crucial to obtain a proper quality of the final sludge residue
- During standard phases, control sludge growth in each bed and SLR rate in order to not overcome design rates.
- THE STRATEGY HAS TO BE INCLUDED IN O&M PLAN, AND EVENTUALLY ADAPTED TO REAL CONDITIONS AND RESULTS: EXPECTED SLUDGE GROWTH SHOULD NOT EXCEED 1.5 CM/MONTH, FINAL GROWTH SHOULD BE LESS THAN 15 CM/YEAR

IRIDRA S.r.l.

Operation & Maintenance

The final sludge quality

The characteristics of the sludge at the end of one complete cycle (6-12 years) depends by SLR, climate conditions, operational strategies (loading and resting periods). Following the standards, a water content of 40-50% and a volume reduction of 80-90% is generally achievable.

Final sludge from urban sewage is well stabilized and a safe reuse in agriculture is possible, or for further composting, for recultivation, gardening, landscaping, temporarily covering of landfill

Operation & Maintenance

Organic load and operation problems

the most common operational problems are:

- insufficient dewatering
- poor vegetation growth

In a poorly run facility the symptoms are observed in:

- the low degree of dewatering
- the rapidly growing residual sludge layer
- the vegetation becomes stressed, fails, wilts and holes in the vegetation coverage result

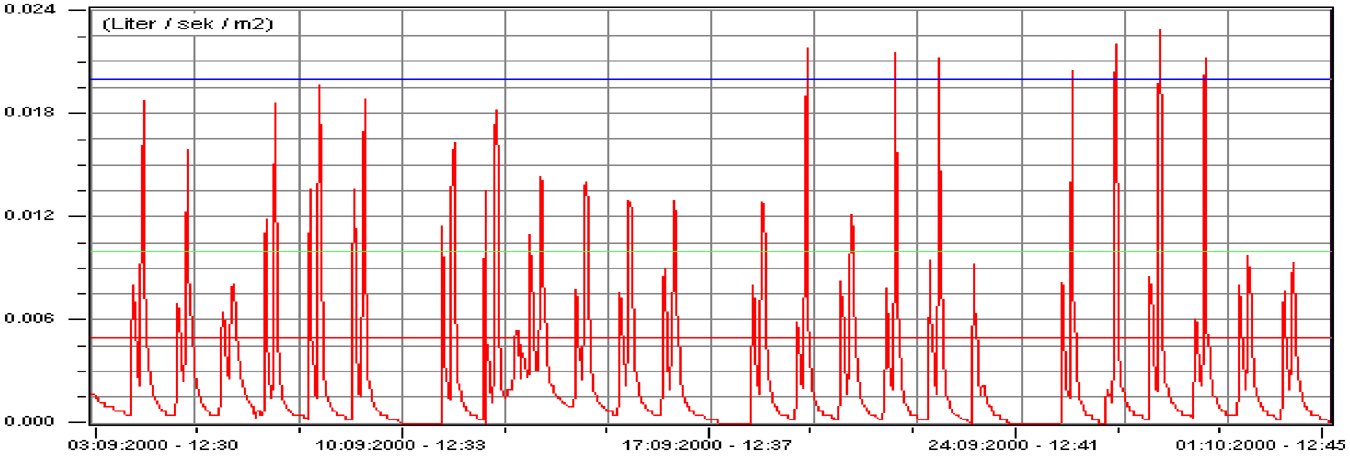
Source: Steen Nielsen, Orbicon Leif Hansen

Operation & Maintenance

Normal operation

Reeds

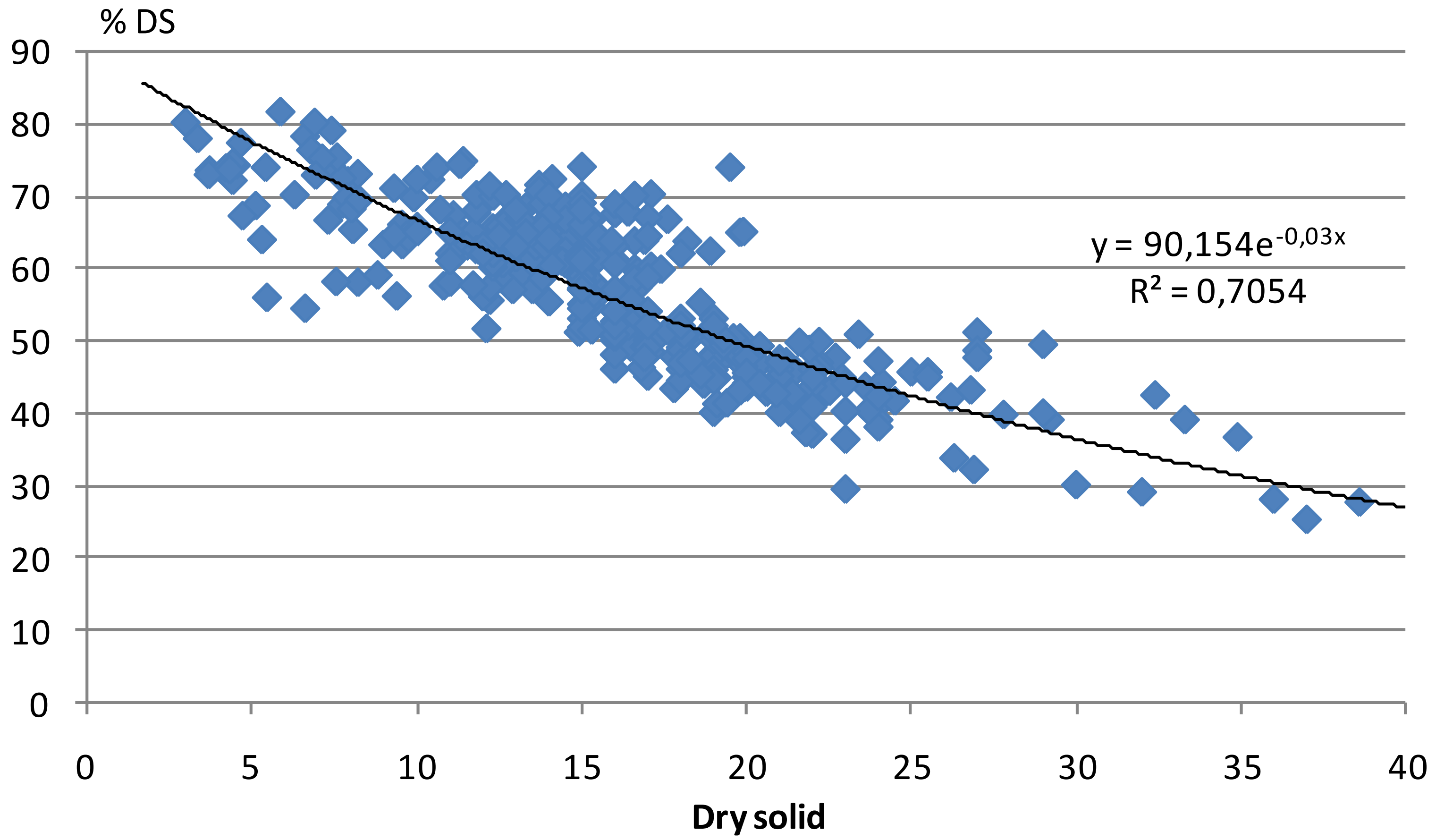
Sludge residue



Source: Steen Nielsen, Orbicon Leif Hansen

Operation & Maintenance

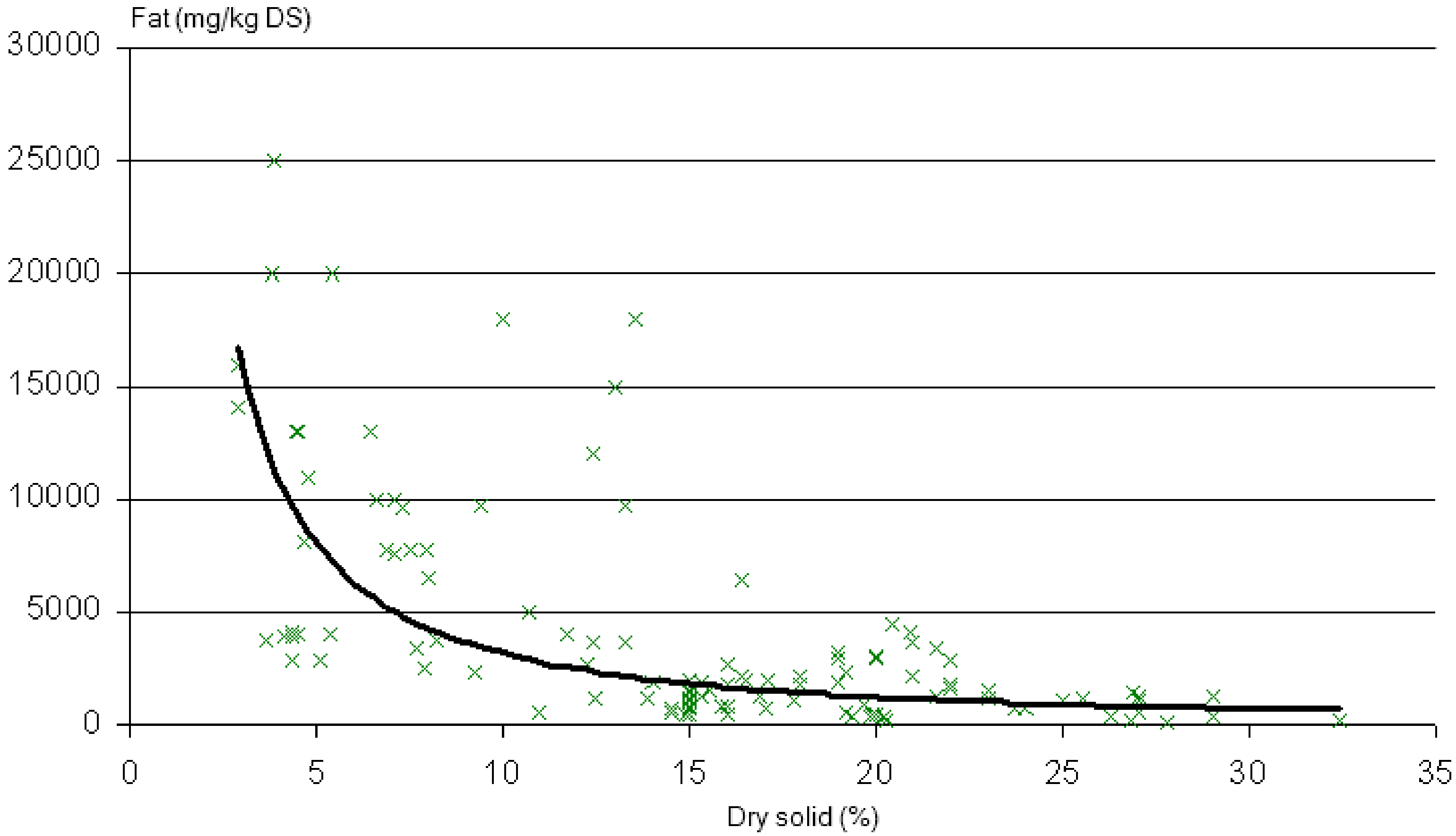
Organic - Loss on ignition



Source: Steen Nielsen, Orbicon Leif Hansen

Operation & Maintenance

Fat in the sludge



Source: Steen Nielsen,
Orbicon Leif Hansen

Operation & Maintenance

PAVITR

Systems treating sludge with high contents of:

- Loss of ignition higher than 65 % (between 65-76%)
- Fat (15,000 – 30,000 mg/kg ds)
- Oil (2,300 – 7,000 mg/kg ds)

The dewatering efficiencies only achieve **5-15 % dry solid** in the sludge residue.

Systems treating sludge with low contents of:

- Loss on ignition between 50 – 65 %
- Fat (4,000 – 8,000 mg/kg ds)
- Oil (50 – 2,000 mg/kg ds)

The dewatering efficiencies achieve **20-37 % dry solid** in the sludge residue.

Source: Steen Nielsen, Orbicon Leif Hansen

IRIDRA

End use

Key considerations

- People’s needs and preferences (socio-cultural);
- Local materials, products and skills;
- Economic viability;
- Additional barriers;
- Regulatory aspects

Source: Mr. Praveen Nagaraj, CDD Society, Bengaluru

End use

PAVITR

END - USE Methodology	DESCRIPTION
Soil Conditioner and Fertilizer in Agriculture	Treated faecal sludge and urine can be applied to soil to improve plant growth by a) increasing nutrients b) improving the physical structure of the soil.
Biogas	Faecal sludge is mixed with organic waste to produce biogas and digestate. Biogas is used as energy source for lighting and boiling
Solid Fuel	Dried faecal sludge can replace other fuels such as wood and charcoal, which are more expensive and damaging to the local environment
Protein for animal feed	Animals such as larvae feed on faecal sludge and provide a protein source for farm animals and fish
Aquaculture	Faecal sludge is fed to aquatic organisms such as fish and aquatic plants. These aquatic organisms can then be eaten directly used as animal feed or used as fertilizers

Source: Mr. Praveen Nagaraj, CDD Society, Bengaluru

Key messages

- Simple operation and management
- No high tech appliances
- No chemical additives
- Periodic control of inlet, outlet
- Check pump and siphon
- Plant harvesting
- Collection and treatment of leachate
- Start up: 1-2 years; operation: 5-10 years, decommissioning: 2-3 years
- Sludge growth ≤ 1.5 cm/month
- Final water content: 40-50%, volume reduction: 80-90%
- Common problems: insufficient dewatering, poor vegetation growth

Source: IRIDRA

Example:
the PAVITR pilot project

Introduction

Objective

To implement a replicable pilot unit of SDRB for Faecal Sludge in the region, adapted to local conditions

Location

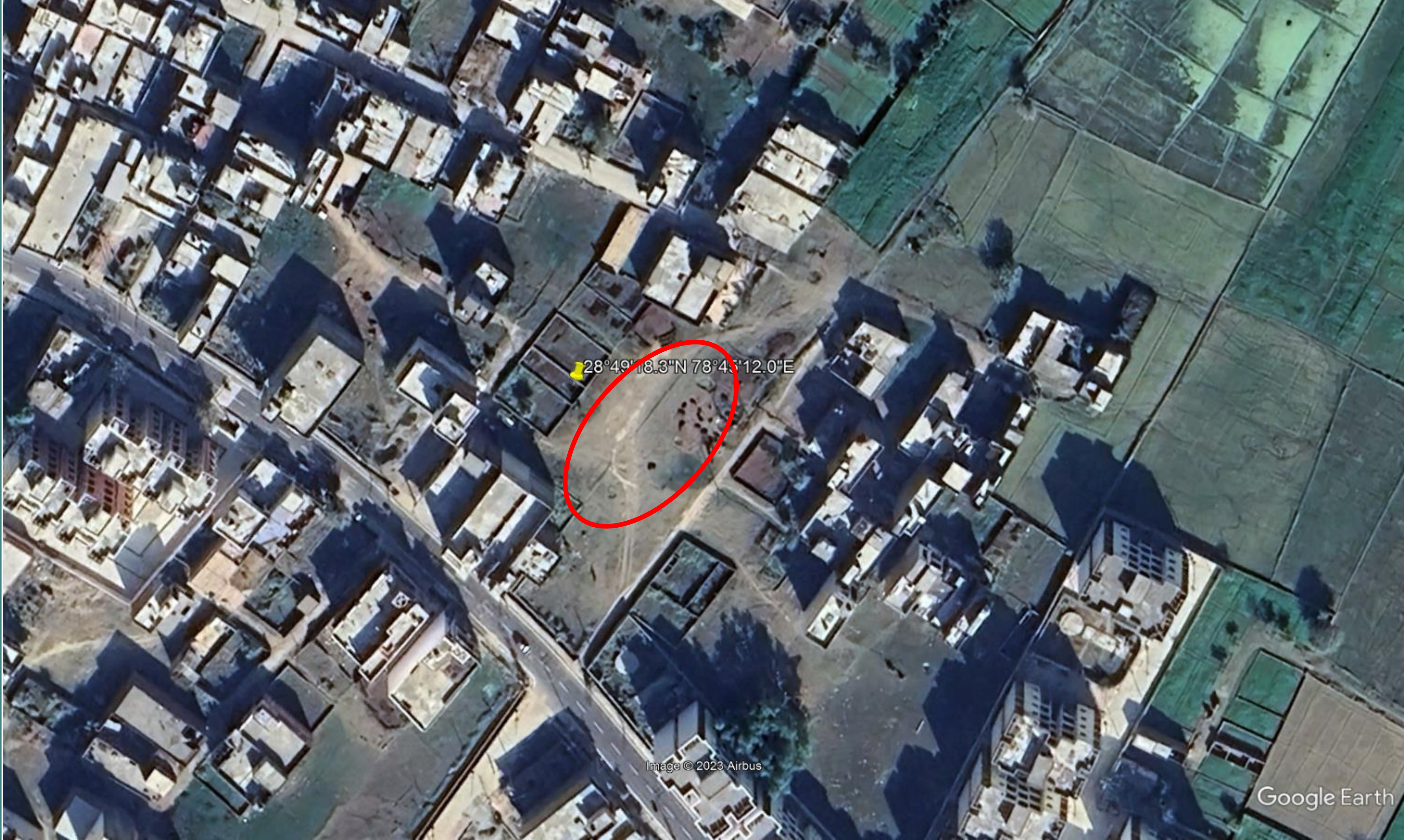
The present research will be conducted at **MORABADAD, Uttar Pradesh, India** by **Aligarh Muslim University**

Introduction

Site

The selected site by the municipality is in the peri-urban area of Morabadad. The area is property of the municipality and surrounded by poor households, which are not connected to the sewer and they are discharging in the fields at lower elevation, creating due to the claily soil wide stagnant zones.

The municipality is already constructing a small transfer station for solid waste collection and a new road, with a channel that will collect wastewater to the nearby nallah for sewer collection. They will erect also a boundary wall to limit nuisance to the inhabitants, with a gate for truck entrance.


28°49'18.3"N 78°45'12.0"E
Image © 2023 Airbus
Google Earth

Introduction

Faecal Sludge management, capacity and sludge characterization

There are large parts of the city not served by sewer and STP. Faecal sludge management in Morabadad is still to be organized in a more structured way by the municipality. Actually, they have some vacuum trucks with 5 cubic meter max capacity, transporting faecal sludge to STP or other sites.

It is intention of the municipality to develop one small pilot that can be replicated with a decentralized approach in the peri-urban areas. The FSTP will receive 1 truck per day, therefore it will be designed for **5 m3/day**, extendable with a modular approach to 10 or 15.

The most of collected faecal sludge is coming from septic tanks, where only black water is connected. Greywater are being disperded along roads and directly on the fields. There are latrine pits in the slum areas and in rural areas, by they are not collected nowadays. A monitoring of faecal sludge will be done by AMU for detailed design, in a preliminary phase we assumed **max 3% TS** according to literature per septage.

Materials & Method

PAVITR

FSTP

FS volume: 5 m^3/d@3% TS

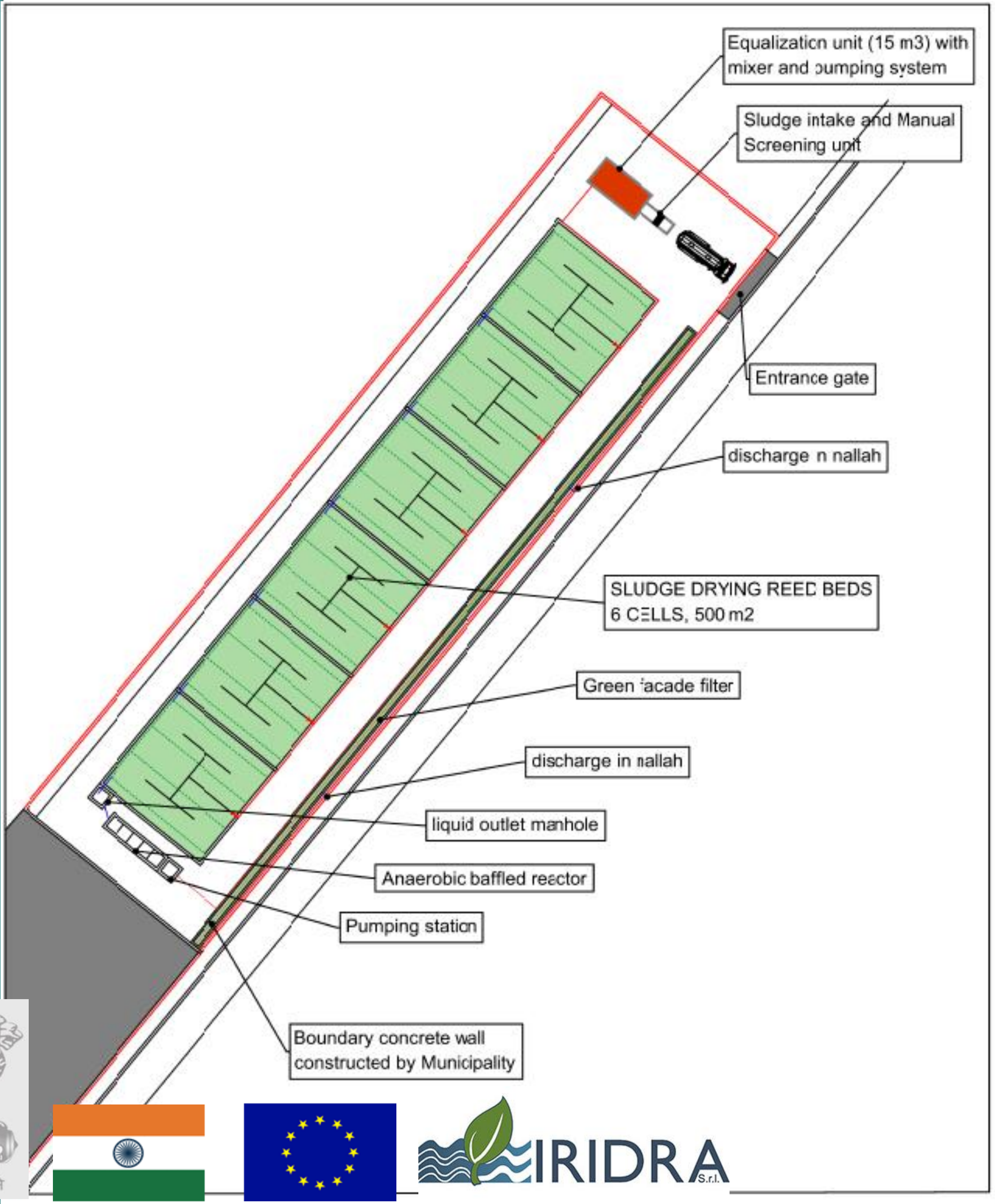
Total investment cost (CAPEX): 8,000,000.00 INDIAN RUPIAS

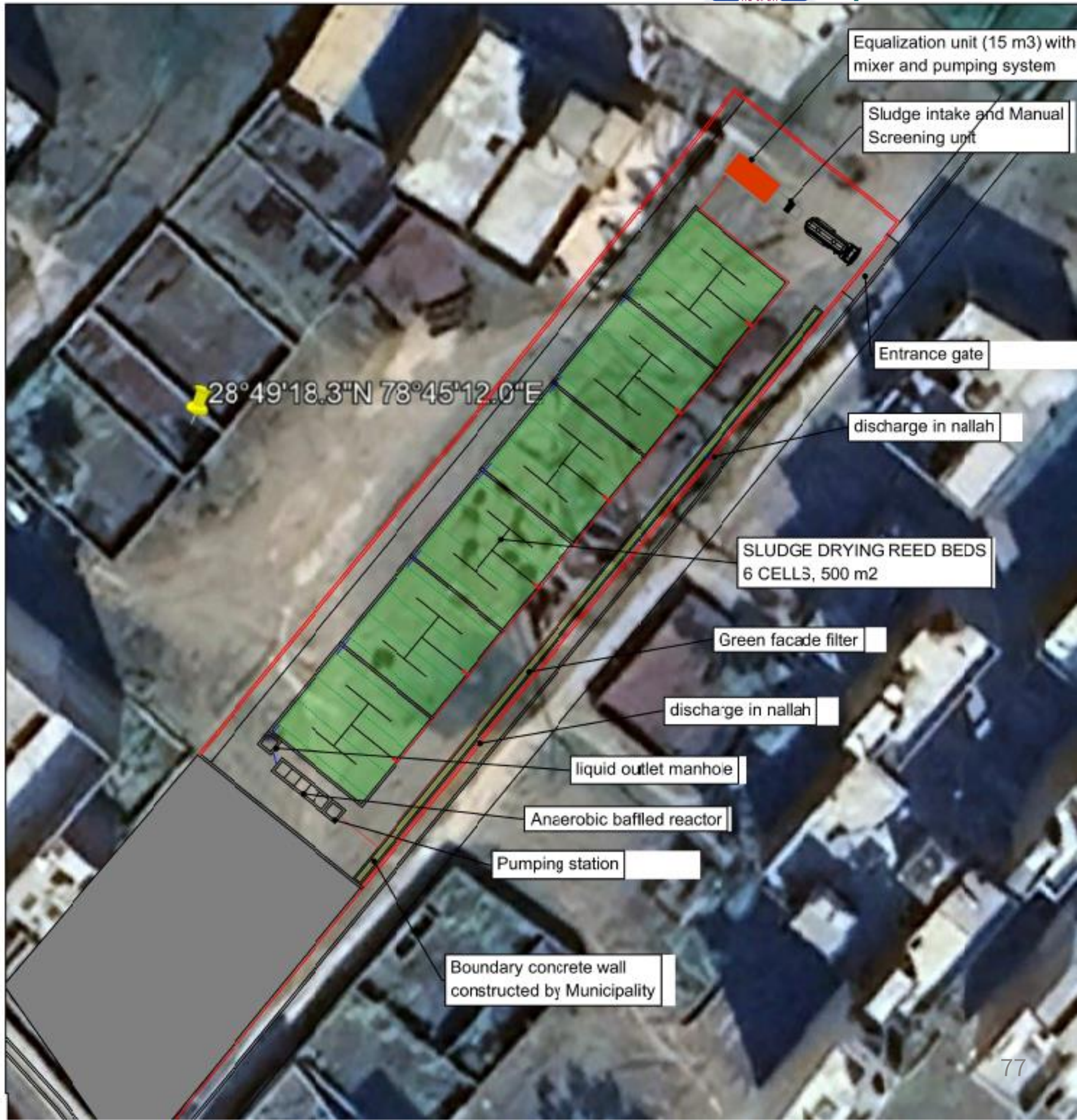
FS → **Equalization tank** With pump → **SDRB** → **Liquid treatment** ABR + GREEN FACADE → **Discharge in nallah**

सत्यमेव जयते

IRIDRA S.r.l.

Preliminary Layout





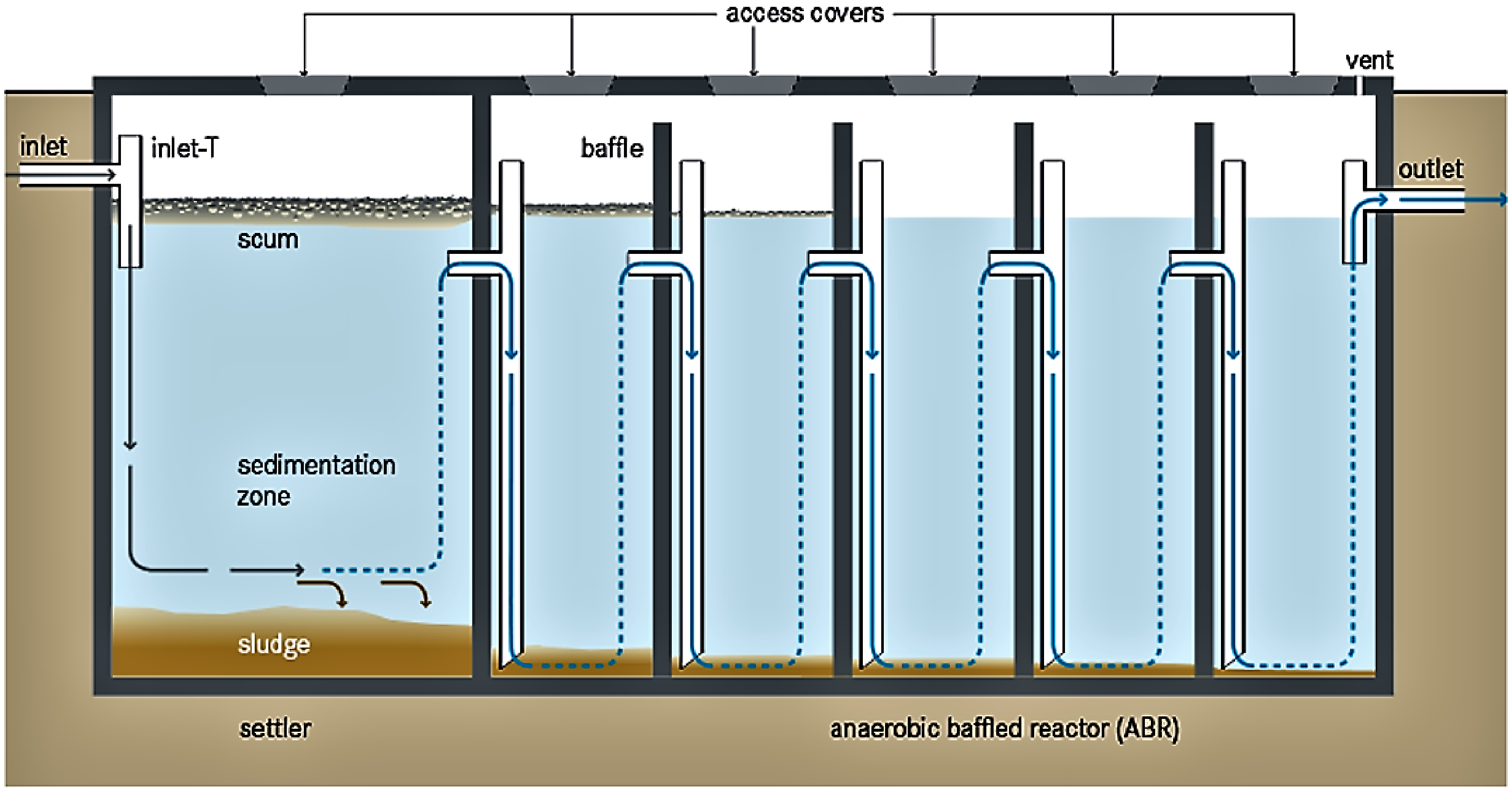
सत्यमेव जयते

IRIDRA S.r.l.

Materials & Method

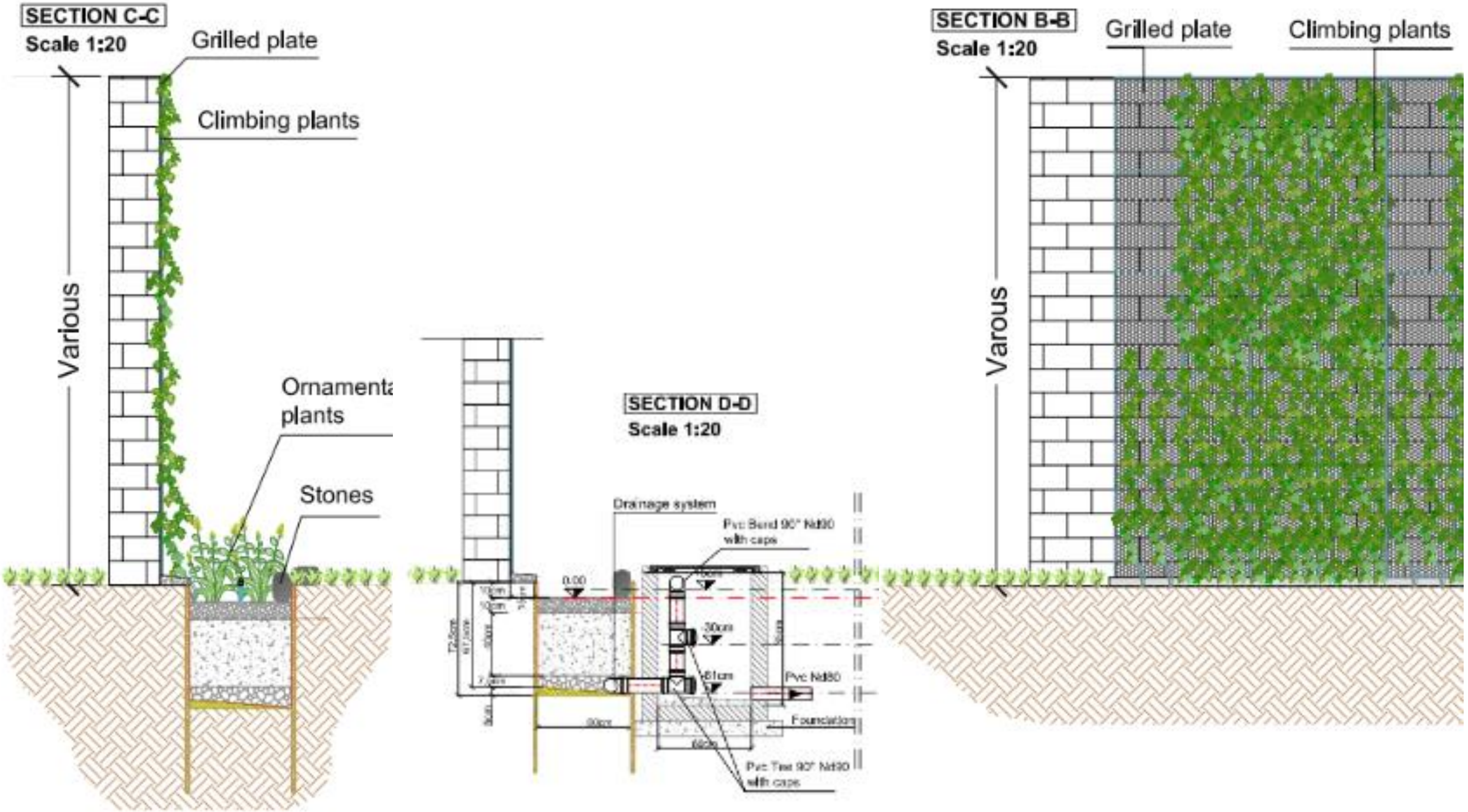
Anaerobic Baffled Reactor

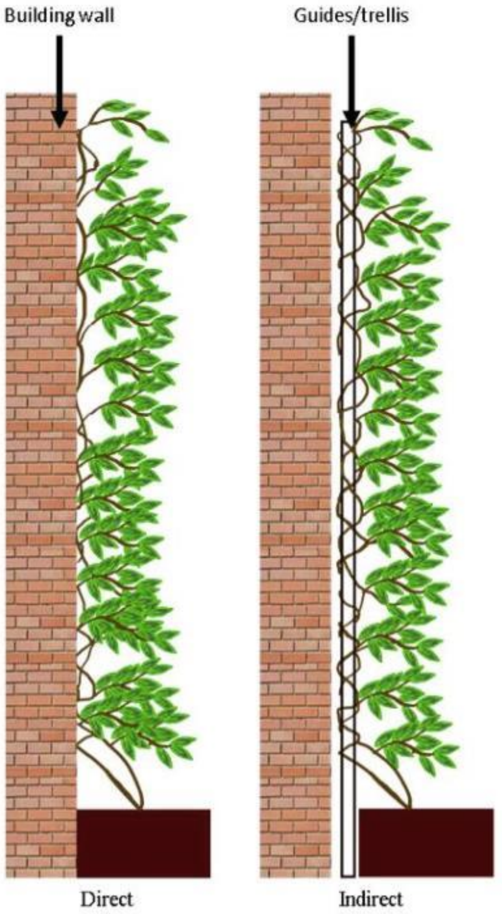
HRT 2 days



Materials & Method

Green Facade as polishing stage





(a) Green façades

Key messages

- High rate of replicability of the solution
- Sludge reuse in agriculture
- Adaptable to local conditions
- Experience of AMU in FRB construction can facilitate the process of material selection and work supervision
- Design, tendering and construction are on going, the system will be completed by the end of 2023

Homework

Introduction to the case study

After conducting a preliminary study for FS characterization, a municipality in temperate climate would like to design a SDRB to dewater FS having the following characteristics:

- Estimated annual FS emptied: **5,000 m3/year**
- Average TS content of raw FS: **30,000 mg/L** (or 3% TS)

source: Kengne et al., 2014

Your homework is

PAVITR

1. Determine the total solids of faecal sludge per year.

2. Determine the specific area required for the planted-sludge drying bed and the number of beds assuming a loading period of 2 days and a resting period of 22 days

source: Kengne et al., 2014

Solution

1. Determine the total solids of faecal sludge per year

- TS: 150.000 kgTS/year

2. Determine the specific area required for the planted-sludge drying bed

- Area: 3.000 m2 (loading rate: 50 kgTS/m2/year)
- N° of sectors: 12

source: Kengne et al., 2014

References

- BARRETO DILLON, L.; DOYLE, L.; LANGERGRABER, G.; SATISH, S.; POPHALI, G. (2013): Compendium of Natural Water Systems and Treatment Technologies to cope with Water Shortages in Urbanised Areas in India. Berlin: EPUBLI GMBH. URL: https://www.researchgate.net/publication/322725512_Compendium_of_Natural_Water_Systems_and_Treatment_Technologies_to_cope_with_Water_Shortages_in_Urbanised_Areas_in_India [Accessed: 26.07.2021]
- BORDA (2018): FSM in Leh. Bangalore: BORDA South Asia. URL: https://www.borda-sa.org/wp-content/uploads/2018/08/BORDA_FSM_for_Leh_HF.pdf [Accessed: 26.07.2021]
- DODANE, P. H., MBÉGUÉRÉ, M., KENGNE, I. M., & STRANDE-GAULKE, L. (2011): Planted drying beds for faecal sludge treatment: lessons learned through scaling up in Dakar, Senegal. In: Sandec News 12/2011, 14-15. URL: https://www.fsmtoolbox.com/assets/pdf/101.17.16_Planted_drying_beds_Dakar.pdf [Accessed: 26.07.2021]

References

PAVITR

- ENGLUND, M. AND STRANDE, L. (Editors) (2019): Faecal Sludge Management: Highlights and Exercises. Dübendorf, Switzerland: Eawag: Swiss Federal Institute of Aquatic Science and Technology. URL: https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/EWM/FSM_Book_Highlights_and_Exercises/FSM_Highlights_and_Exercises_Final-compressed.pdf [Accessed: 26.07.2021]
- HYDEA Spa (2020): https://www.hydea.it/portfolio/progetto-di-gestione-dei-rifiuti-solidi-urbani-e-trattamento-dei-reflui-da-fosse-settichezanzibar-tanzania/?portfolioCats=110%2C111%2C132 [Accessed: 26.07.2021]
- KIM, B., BEL, T., BOURDONCLE, P., DIMARE, J., TROESCH, S., & MOLLE, P. (2018): Septage unit treatment by sludge treatment reed beds for easy management and reuse: performance and design considerations. In: Water Science and Technology, 77(2), 279-285. London, UK: IWA Publishing. URL: https://iwaponline.com/wst/article/77/2/279/38438/Septage-unit-treatment-by-sludge-treatment-reed [Accessed: 26.07.2021]
- PANDEY, M. K., & JENSSEN, P. D. (2015): Reed beds for sludge dewatering and stabilization. In: Journal of Environmental Protection, 6(04), 341. SCIRP Scientific Research. URL: https://www.scirp.org/html/7-6702590_55564.htm [Accessed: 26.07.2021]

Credits

This training has been created in the framework of the EU-Indian Joint Project “PAVIRT- Potential and Validation of Sustainable Natural & Advance Technologies for Water & Wastewater Treatment, Monitoring and Safe Water Reuse in India”. This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No821410 and the Department of Sciences and Technology of India under the Grant DST/IMRCD/India-EU/Water Call2/PAVITR/2018 (G).

For more information, please visit: https://pavitr.net