11-12 FEBRUARY 2025

RABAT, MOROCCO

Institut Agronomique et Vétérinaire Hassan II

BONEX

SURE NEXUS

WEFE NEXUS INTERNATIONAL CONFERENCE

EXPLORING AND BRIDGING NEXUS FOR A SUSTAINABLE FUTURE

PRIMA

IN THE MEDITERRANEAN AREA

These projects are part of the PRIMA programme supported by the European Union.

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Day 1 – 11th February 2025

KEYNOTE SPEECH

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Smart Wastewater Treatment to support WEFE Nexus

Prof Laila Mandi

Professor of Water & Environmental Sciences- Cadi Ayyad University of Marrakech- Morocco

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Smart Wastewater Treatment to support WEFE Nexus

Prof. Dr. Laila MANDI,
Faculty of Sciences Semlalia, Cadi Ayyad University
Marrakech, Morocco

كليـــة العلوم السملالية - مراكش
FACULTÉ DES SCIENCES SEMLALIA - MARRAKECH

AFRICA TRANSITION INSTITUTE
المعهد الدولي للانتقال المستدام في إفريقيا
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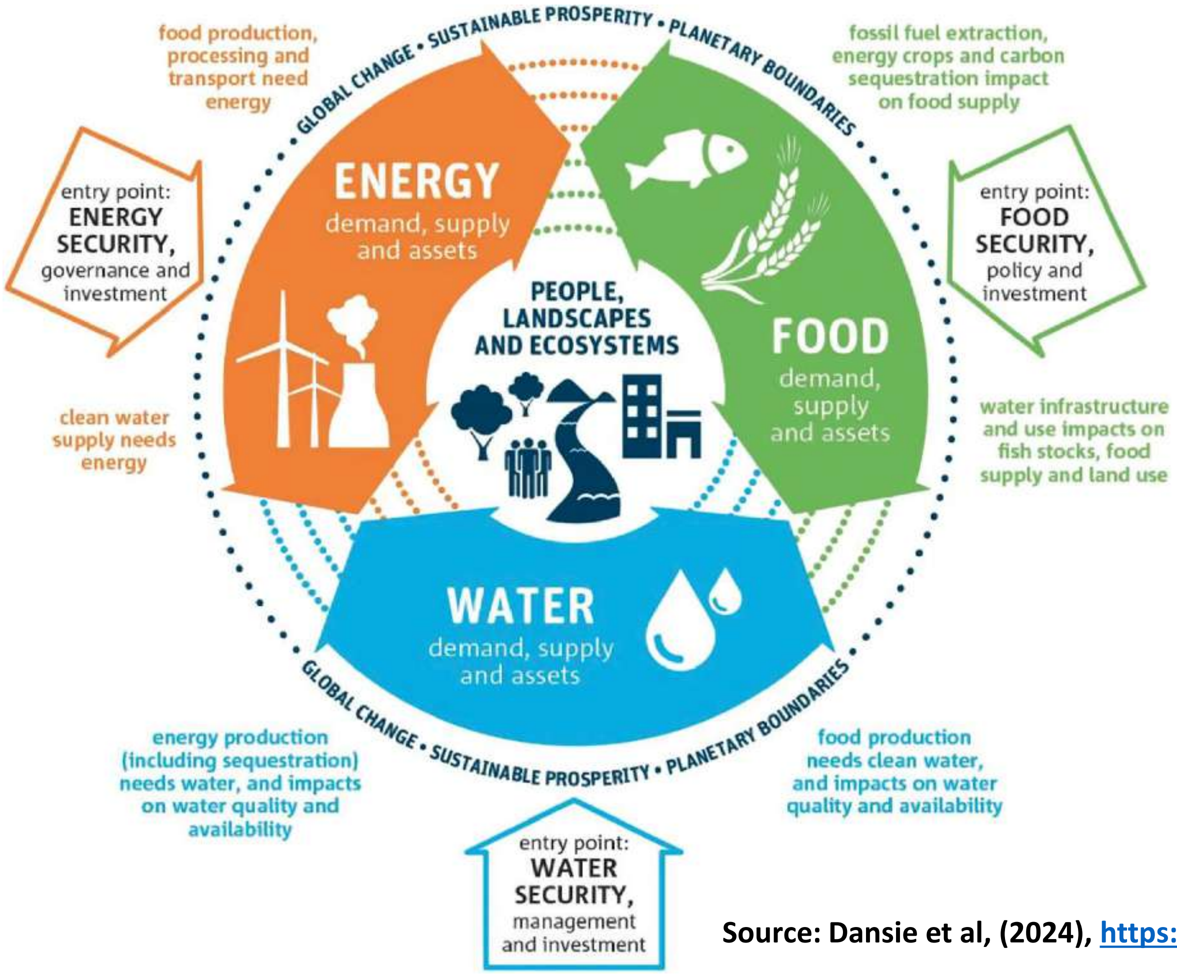
1. Water: The Foundation of the WEFE Nexus



Source: Dansie et al, (2024), https://doi.org/10.1007/978-3-031-25463-5_1

Water: **Essential for food production, energy generation, and ecosystem health.**

🌾 **Food**: Agriculture consumes ~70% of global freshwater; inefficient irrigation wastes water & energy.

⚡ **Energy**: Water is needed for hydropower, cooling thermal plants, and producing biofuels.

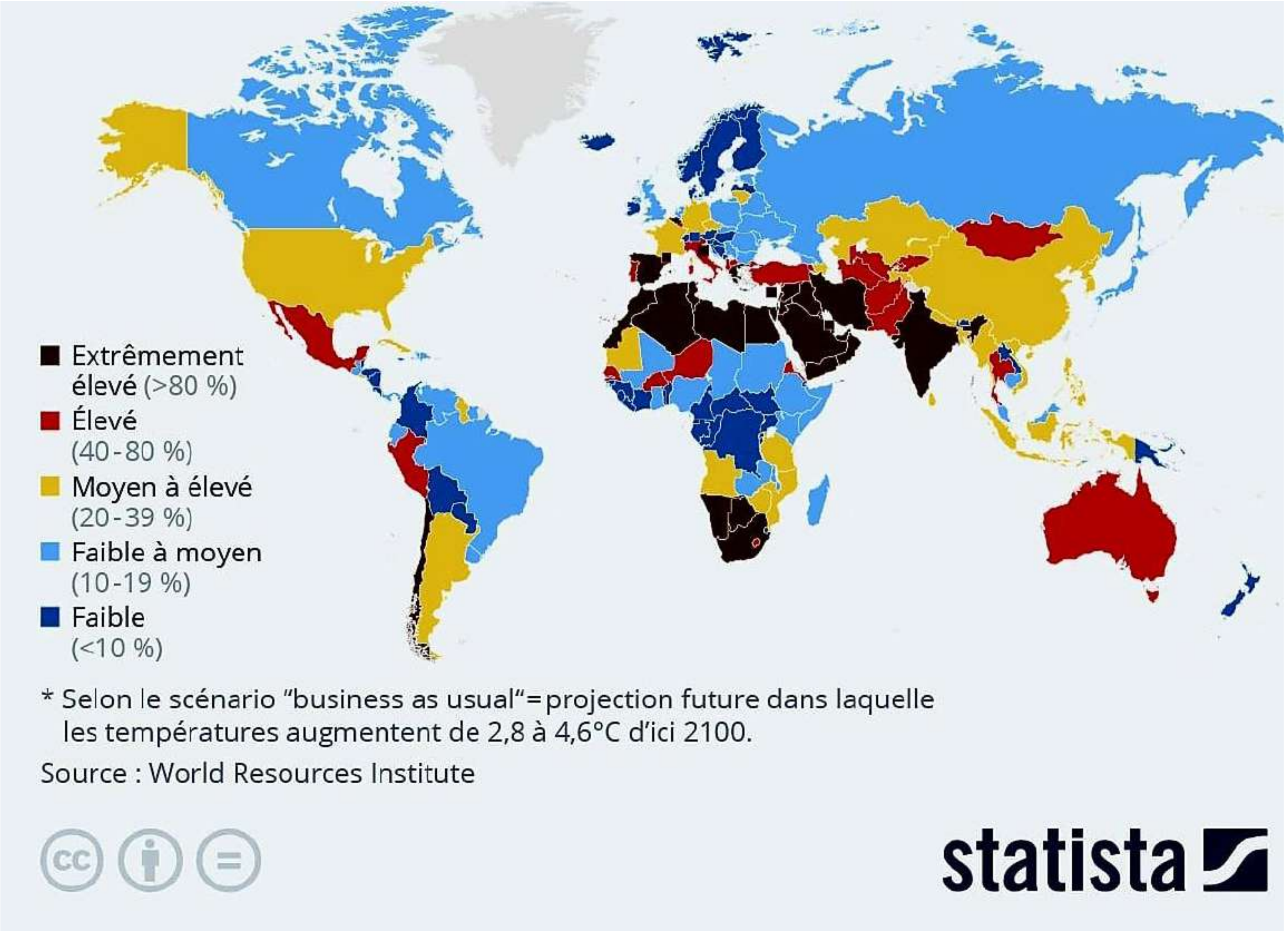
🌱 **Ecosystems**: Polluted water destroys biodiversity, while healthy ecosystems naturally purify water.

2. Growing Water Crisis: Where Water Stress Will Be Highest by 2050

Projected water ratio of human water demand to water availability

(Water Stress Level in 2050)

Population growth → Urbanization → Climate change → Intensifying pressure on water resources



3. Efficient Wastewater Treatment and Reuse: A Necessity

What is the situation of wastewater treatment in the world?

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4. Why Conventional Wastewater Treatment Falls Short

Challenges	Issues in Conventional Wastewater Treatment	Impact on WEFE Nexus
High Energy Consumption	Requires intensive aeration, pumping, and chemical treatments.	Increases energy demand, contributing to carbon footprint.
Costly Infrastructure	Expensive to build, operate, and maintain, especially in rural areas.	Limits widespread adoption, leaving many without treatment access.
Unsuitable for Rural/Peri-Urban Areas	Large centralized plants require extensive piping & maintenance.	Decentralized areas lack access to proper sanitation.
Limited Pollutant Removal	Struggles with emerging contaminants (microplastics, pharmaceuticals).	Pollutants remain in water, harming ecosystems & food safety.
Low Reuse Potential	Treated water often does not meet reuse standards for irrigation.	Wasted opportunity to support agriculture & water security.
Environmental Pollution Risks	Discharge of partially treated water causes eutrophication & waterborne diseases.	Affects aquatic life, drinking water sources, and ecosystem health.

Without sustainable wastewater treatment, we lose an opportunity to recover water, nutrients, and energy, weakening the WEFE Nexus.

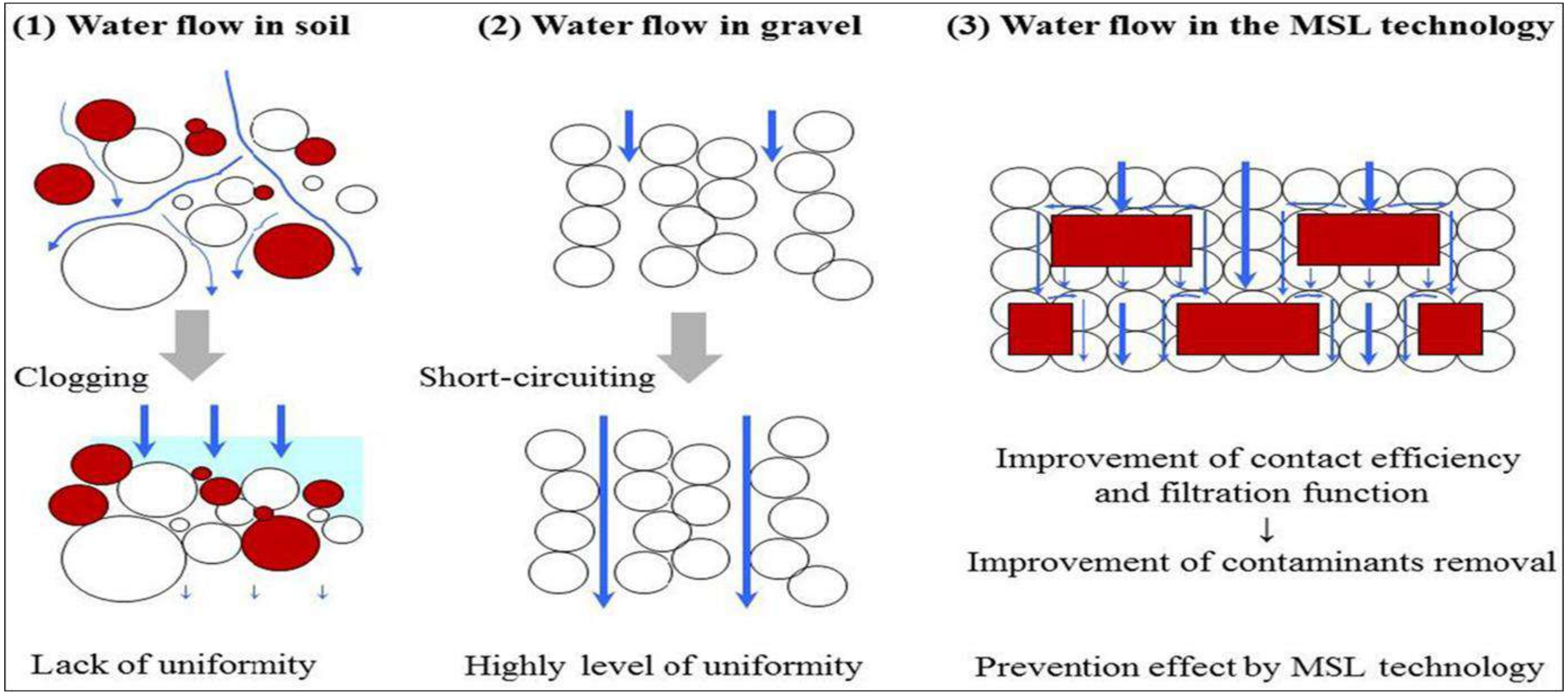
5. Multi-Soil-Layering Technology(MSL): An Eco-friendly solution for WEFE Nexus

- Innovative wastewater (WW) treatment technology Developed in the 1990 by Pr. Wakatsuki in Japan

- Filtration of WW using a porous medium (Permeable layers+ Soil mixture layers)

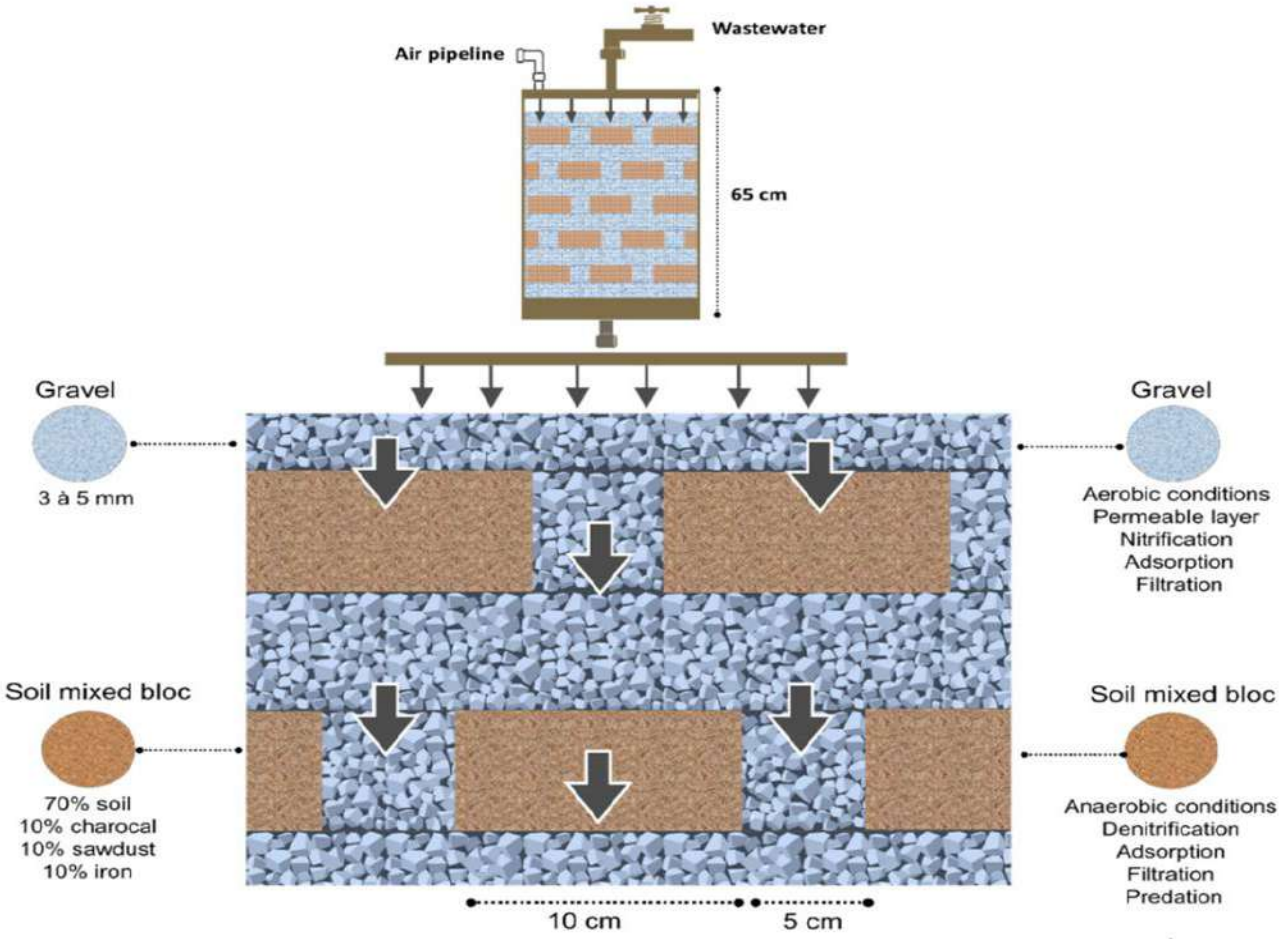
Source: Wakatsuki et al.1990. Jpn. J. Soil. Sci. Plant Nutr, 61, 74-84

5.1. Prevention mechanisms of clogging and short-circuiting in MSL technology

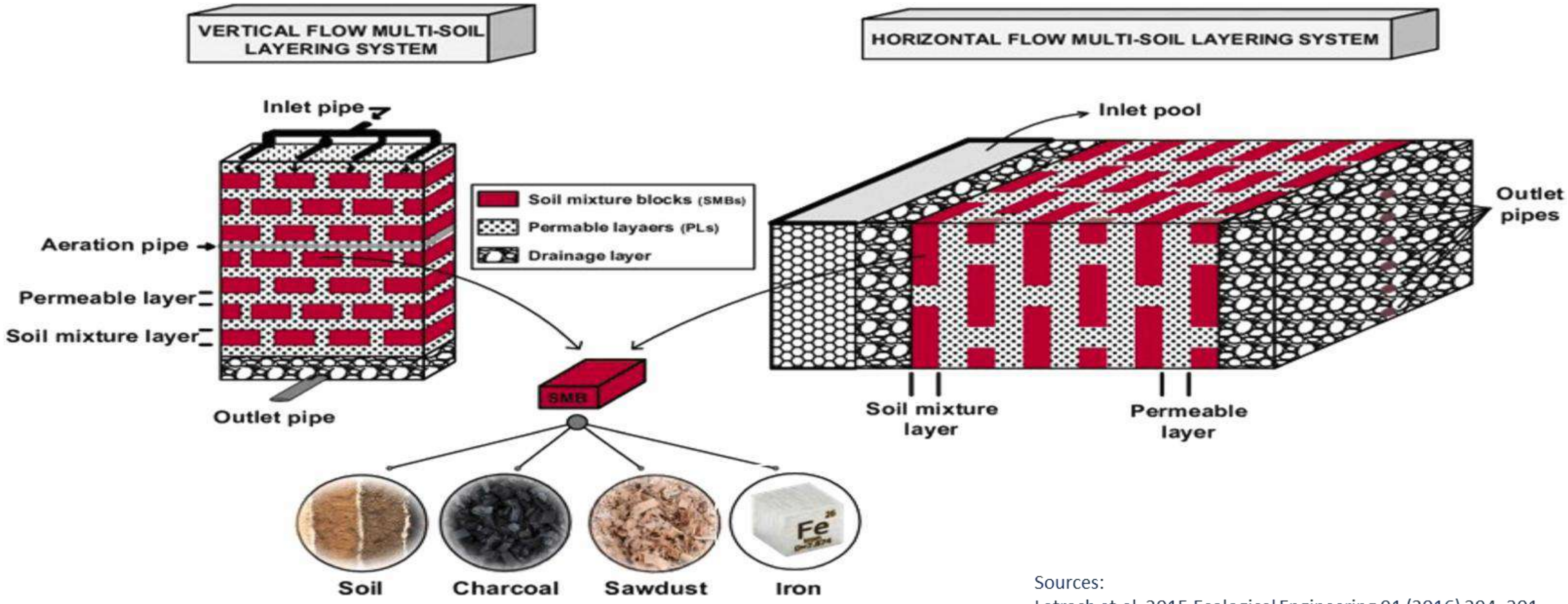


Source:
Latrach et al. Ecological Engineering 117 (2018) 140–152

5.2.Experimental model of a multi-soil-layering system with the major removal mechanisms.



5.3. Different categories of MSL



Sources:
Latrach et al. 2015.Ecological Engineering 91 (2016) 294–301
Zhang et al. 2015. Bioresource Technology 193 (2015) 424–432
Mohssine et al, (2023) Process Safety and Environmental Protection, 178, 1045-1082.

5.4. Case study at Cadi Ayyad University (Marrakech)

Parameter	Removal
TSS	99%
COD	84%
BOD	86%
TN	44%
NH_4	87%
TP	86%
FC	2.5-3Log

Purifying performances

Operating conditions
Sewage : domestic WW
PL: gravel HLR: 250 L m^{-2} d^{-l}

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5.5. Case study at Tlat Merghen village (Haouz province)

Source : Lamzouri K. 2018. PhD thesis, IAV Hassan II, pp 242

Operating conditions
Sewage : domestic WW
PL: gravel
HLR: 250 L m^{-2} d^{-l}

Purifying performances

Parameter	Removal
TSS	97 %
BOD	98 %
COD	94 %
TN	94 %
TP	91 %
FC	3.15 Log

5.6. New Applications of MSL Technology: Removal of toxic cyanobacteria and their Cyanotoxins from Surface Water

Toxic cyanobacteria bloom at the Lake Lalla Takerkoust (Morocco) (16/09/2019)

Anthropogenic activities and global warming

↓

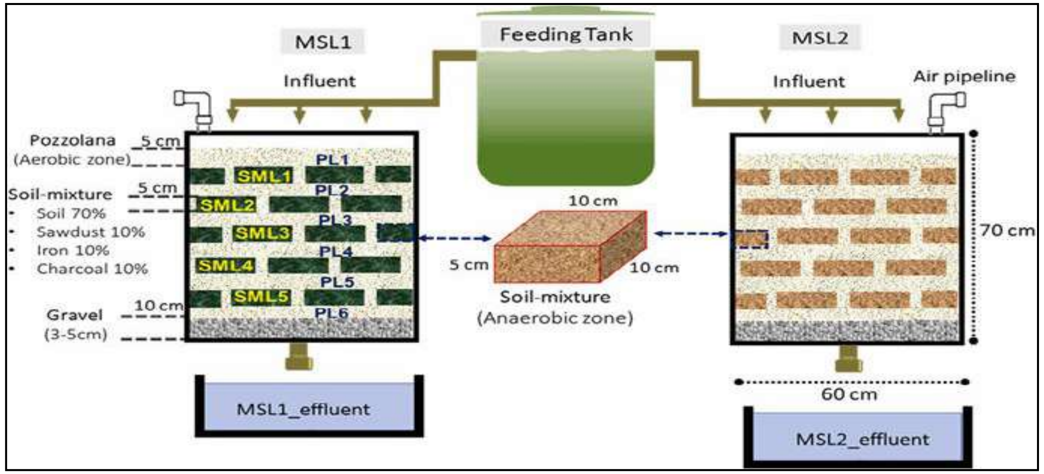
Eutrophication

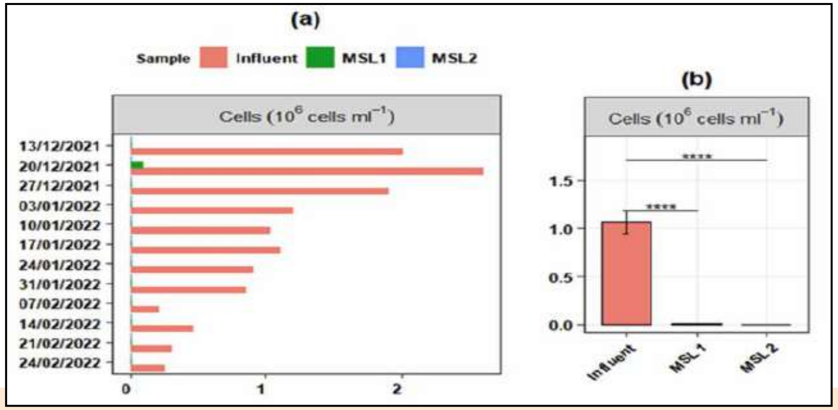
↓

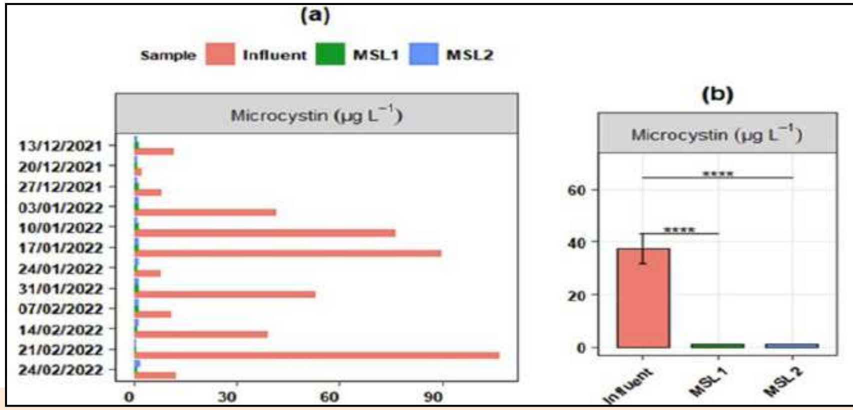
Harmful Algal Blooms

5.6.1. Eco-friendly management of harmful cyanobacterial blooms in eutrophic lakes through vertical flow MSL

- Cyanobacterial cell removal by MSL ranged from 99 % to 100 %
- Greater degradation capacity of MC-LR in MSL1 (sandy soil) and MSL2 (clay soil)
- MC-YR variant was most persistent in substrate of both MSL systems

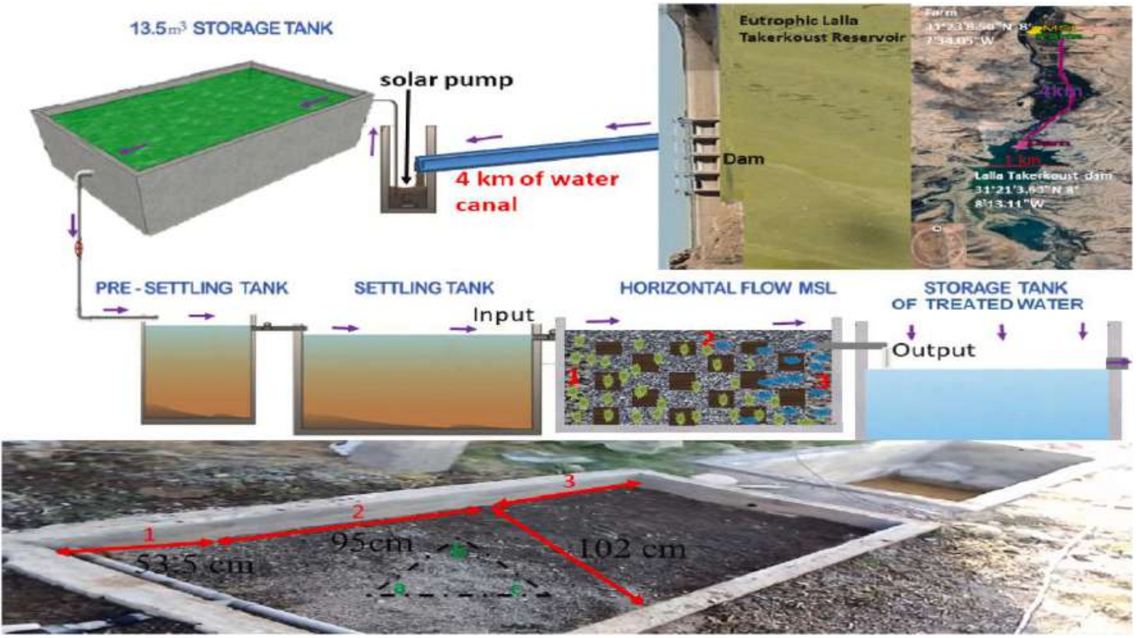




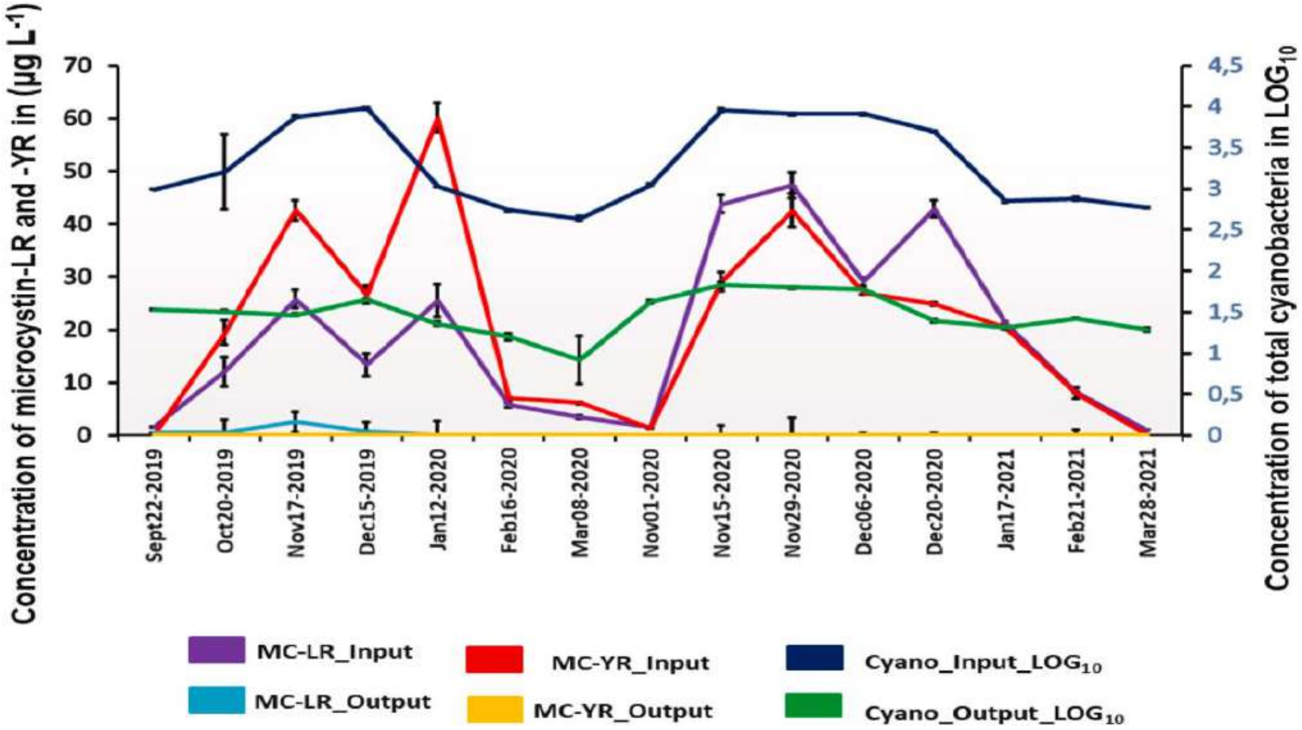


statistical significance: * ** *: $p < 0.0001$

5.6.2. Eco-friendly management of harmful cyanobacterial blooms in eutrophic lakes through horizontal subsurface flow MSL



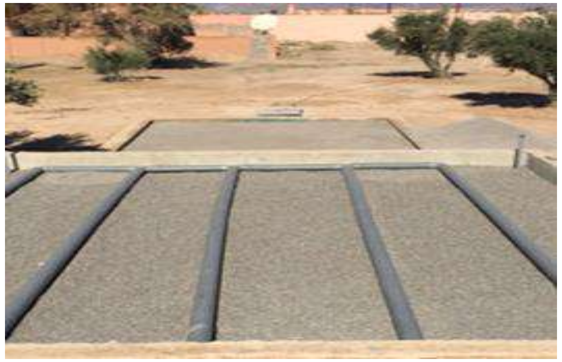
Mugani et al, (2024). Innovative approaches for Microcystin removal: Bacterioplankton biodegradation and multi-soil-layering system performance assessment. Journal of Cleaner Production, 452, 142187.



Kinetics of MC concentration (MC-LR and MC-YR) and cyanobacteria abundance in water treated by the MSL system at inlet and outlet,

5.7. Treatment applications of MSL Eco-technology

- Treatment of domestic wastewater
- Teatment of river polluted water
- Treatment of livestock wastewater
- Treatment of leachates
- Treatment of industrial wastewater (OMWW, textile, tannery, etc.)



5.8. Benefits of Multi-Soil-Layering Technology

- Low cost (<40 $/Inhab)
- Local material
- Simple O&M
- Small area (0.3 m²/Inhab)
- No energy demand
- Remove > 90 % of pollutants & pathogens
- Lifespan : 20 years

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6. How Can Smart Solutions Strengthen Treated Wastewater?

Smart Solution	How It Works	WEFE Nexus Benefit
AI & Sensors	Real-time monitoring of water quality, predictive maintenance, automated treatment adjustments	**Water:** Optimized treatment efficiency reduces water loss
Solar Energy	Powers decentralized wastewater treatment plants, reducing reliance on fossil fuels	**Energy**: Lowers treatment costs and carbon footprint
Nutrient Recovery	Extracts nitrogen and phosphorus from treated wastewater for use as fertilizers	**Food:** Supports sustainable agriculture and soil health
Water Reuse	Treated water is reused for irrigation, industry, or groundwater recharge	**Ecosystem:** Reduces freshwater extraction, preventing depletion

7. Conclusions

- Treated wastewater is a key solution for securing water, food, energy, and ecosystems.
- Smart, nature-based solutions like MSL technology enhance efficiency, affordability, and sustainability.
- Investing in wastewater reuse strengthens agriculture, reduces energy demand, and protects ecosystems.

"Wastewater is not waste—it's a resource.

By integrating smart solutions, we close the WEFE Nexus loop for a sustainable future."

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