INNOQUA
LUMBRIFILTER TECHNOLOGY DEMONSTRATION SITE OVERVIEW

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(on behalf of the consortium who carried out the work!)

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 689817

Introduction

Prototype Site Implementation

2 x Controlled Demonstration Sites:
National University of Ireland, Galway,
University of Girona, Spain.

Prototype Optimizations

- ✓ *Reduced Active Layer Hgt*
- ✓ *Simplified Dosing System*
- ✓ *Stress Testing*
- ✓ *Integration*
- ✓ *Validate Local Material Species*

Demonstration Site Implementation

10 x Uncontrolled Demonstration Sites Worldwide
representing a variety of applications

Demonstration Applications

- ✓ *Agriculture*
- ✓ *Residential*
- ✓ *Commercial - Office*
- ✓ *Educational Buildings*
- ✓ *Tourism – Buildings*
- ✓ *Aquaculture*

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The Challenge – Diverse Influent Characteristics

Selected wastewater characteristics for the demonstration sites (on a mg / L basis, unless otherwise specified)

Country	Flow Volume (m^3/day)	pH	Suspended Solids	COD	BOD_5	Ammonium (as N)	Total Nitrogen (as N)	Total Phosphorus (as P)
Ireland 1	0.2	7.5	**5483**	**8148**	**6000**	57.6	252	-
Ireland 2	1.4	7.8	115	601	375	33	51	9
France	0.6	7.5	609	1313	495	164	-	-
Italy	0.5	7.1	325	1016	380	161	145	13
Scotland	2.00	-	**68**	**335**	**147**	**32**	-	-
Turkey	1.50	7.5	595	772	261	53.8	-	7
Romania	2.40	-	324	857	395	36.7	103	8
Ecuador	2.00	7.2	164	506	298	62	-	-
Peru	2.5	8.2	134	872	511	**180**	-	-
Tanzania	1.40	-	95	511	-	78	-	-
India	1.2	7.5	2644	2036	1217	117	-	-

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The Challenge – Varying Effluent Quality Requirements

Selected treated effluent limits, where discharged to surface water body (on a mg / L basis if not stated otherwise)

Country	pH	Temperature (°C)	Suspended Solids	COD	BOD_5	Total nitrogen	Total phosphorus
Ireland*	-	-	-	-	-	-	-
UK	8	20	35	125	25	25	-
Romania	7.5	35	60	125	25	15	2
Italy	8	-	25	100	20	15	2
France	-	-	25	-	35	-	-
Turkey	9	-	30	-	30	-	-
Ecuador	-	-	100	250	100	-	-
Peru	8.5	+-3*	-	**40**	**15**	-	-
Tanzania	8	20-35	100	60	30	35	6
India	9.5	+5**	**20**	50	10	**10**	**1**

%removal efficiency in some countries varying between 70-85% for TSS/COD/N removal

*Under the Nitrates Regulations farmers must not apply more than 170 kgs of nitrogen from livestock manure per ha per year (with some additional caveats).

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The Challenge – Diverse Climatic Conditions

Country	Min Temp (observed) (°C)	Max Temp (observed) (°C)	Annual Rainfall (mm)	Maximum Rainfall in Wettest Month (mm)
Ireland	-7.9	25.6	1,400	350 (Dec/Jan)
Spain	5	26	737	110 (Oct)
Ireland-Agri	-7.9	25.6	1,400	350 (Dec/Jan)
France	-0.5	26.6	697	73 (May)
Italy	0.3	37	697	73 (Oct)
France-NBK	5	27	1,200	120 (Nov)
Scotland	-10	25	750	76 (Oct)
Turkey	-24	41	669	89 (Oct)
Romania	-30	32	600	100 (June)
Ecuador	9	21	1,013	149 (Apr)
Peru	5	27	95	40 (Feb)
Tanzania	18	32	1,145	270 (April)
India	20	38	839	241 (Sept)

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Lumbrifilter (Ireland & Ecuador)

Ireland (Craughwell) – agricultural demo-site

Dairy washwater - 0.2 m^3/day

	Inlet (mg/L)	Outlet LBF (mg/L)	Removal efficiency (%)
TSS	1,483	469	63
COD	6,378	2,587	44
BOD	3,457	1,278	28
NH4-N	60	12	77
pH	7.5	8	-

Challenge:
- Very high strength wastewater

Ecuador (Quito) – domestic

Challenge:
- Space!

Domestic washwater - 0.4 m^3/day. 0.75 m active layer

	Removal rate (%)			
	BOD_5	**COD**	**TSS**	**NH_4-N**
Average	53.5	60.5	63.9	26.9
Standard deviation	±29.0	±19.9	±22.6	±26.6
Median	64	68	72	25

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Lumbrifilter + UV system (Italy - Vasto)

Domestic washwater - 0.4 m^3/day.

Challenge:
- Align with construction project
- Lower than expected hydraulic loading

	Removal rate (%)						
	BOD_5	**COD**	**TSS**	**TN**	**NH_4-N**	**TP**	**Turbidity**
Average	96.1	84.3	89.8	49.2	92.5	9.2	92.4
Standard deviation	±3.1	±13.7	±9.7	±28.7	±7.0	±45.4	±7.0
Median	97.2	89.9	93.3	56.8	94.2	18.7	95.3

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Lumbrifilter +DF (France - Anglet)

Challenge:
- Experimentation with preliminary & primary treatment

Office wastewater - 0.6 m^3/day.

	Removal rate (%)						
	TSS	**BOD_5**	**COD**	**NH_4-N**	**TP**	**PO_4-P**	**Turbidity**
Average	78.0	89.5	70.8	72.3	36.7	25.3	77.9
Standard deviation	±21.8	±8.9	±20.9	±16.3	±18.7	±12.5	±16.3
Median	88.7	92.6	76.4	78.3	40.0	23.0	82.5

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Romania demo-site - Ilişeşti

Considerations:
- Change of use of building from tourist residence to business
- Low winter temperatures

Office wastewater – 1.6 m^3/day.

Removal rate (%)								
	TSS	BOD_5	COD	NH_4-N	TP	PO_4-P	Turbidity	TN
Average	64.1	77.2	70.9	66.0	35.8	25.4	73.4	55.4
Standard deviation	±20.5	±15.2	±13.9	±18.5	±15.9	±15.6	±14.9	±20.4
Median	69.3	83.4	73.1	70.2	32.9	23.1	78.3	61.9

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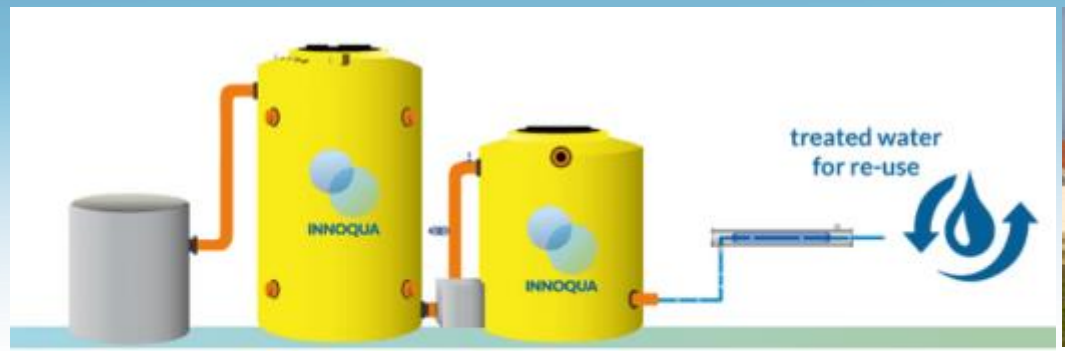
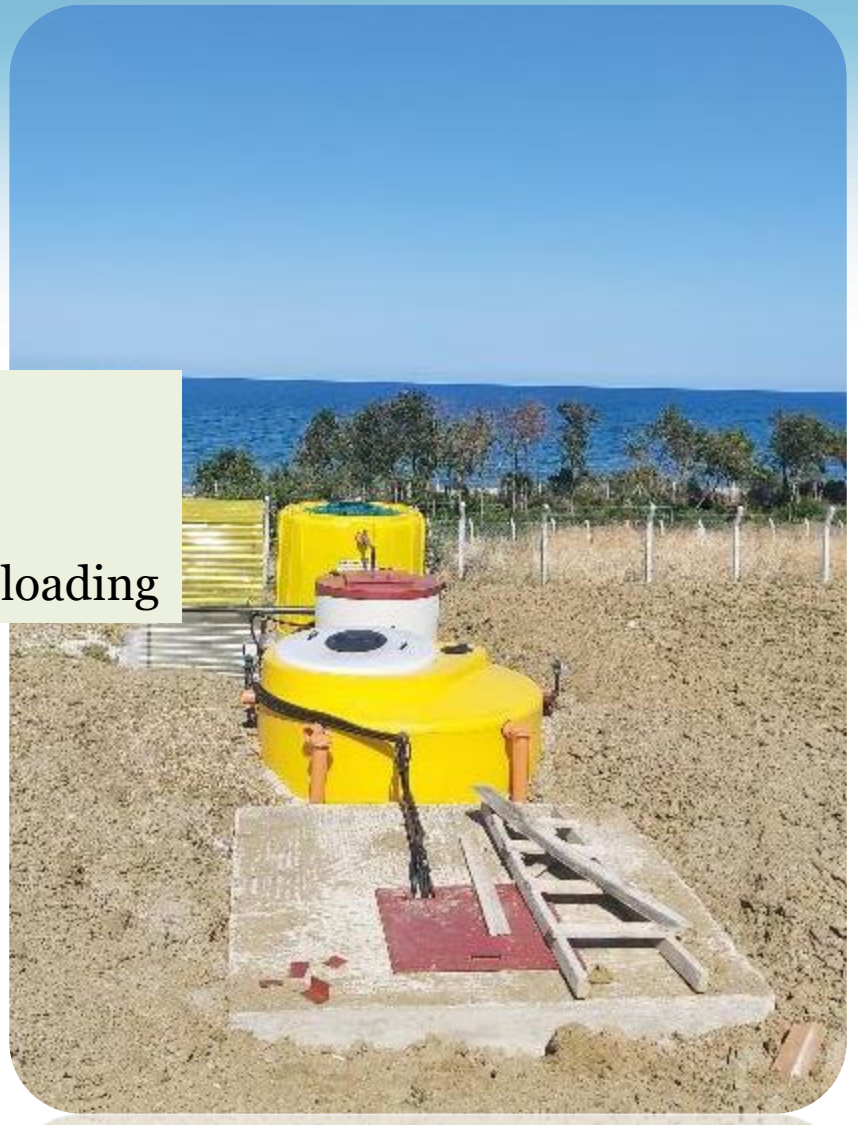
Lumbrifilter +DF +UV system (Turkey - Sinop)





Domestic wastewater – 1.3 m^3/day.

Considerations:
- Single extreme rainfall event
- Low biological load
- Lower than expected hydraulic loading

	Removal rate (%)					
	TSS	BOD_5	COD	NH_4-N	TP	Turbidity
Average	39.5	37.6	33.7	63.7	39.1	49.7
Standard deviation	±32.6	±27.0	±28.7	±23.1	±22.4	±25.9
Median	42.8	35.0	32.7	63.5	40.9	51.4

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Lumbrifilter +DF +UV system (Tanzania Mlalakuwa)

Domestic wastewater – 1.4 – 3.7 m^3/day.

	% removal						
	TSS	**Turbidity**	**COD**	**NH_4-N**	**TP**	**PO_4-P**	**TN**
Average	25.0	74.9	64.0	65.4	35.7	19.1	36.5
Standard deviation	±20.4	±16.6	±18.9	±32.0	±13.8	±17.5	±23.8
Median	29.2	77.0	71.5	80.0	34.3	20.0	33.0

Considerations:
- Local custom/policy in terms of dealing with complaints/public
- Intermittent electricity supply
- Initial load to the system

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Lumbrifilter +DF +UV system
Lumbrifilter +BSP

(India - Bengaluru)

Demo-site INDIA

Considerations:
- High temperature
- Intermittent electricity supply
- Erratic loading

Domestic wastewater – 0.99 m^3/day.

	% Removal rate			
	TSS	**BOD_5**	**COD**	**NH_4-N**
Average	80.8	89.4	79.1	82.4
Standard deviation	±20.8	±10.0	±15.1	±11.2
Median	88.0	92.8	82.7	84.6

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Lumbrifilter +DF +UV system
Lumbrifilter +BSP

(Peru - Arequipa)

University campus building– 1.3 m^3/day.

Challenge:
- High temperatures coincided with low season/campus closure

	Removal rate (%)							
	TSS	**BOD_5**	**COD**	**NH_4-N**	**TP**	**PO_4-P**	**Turbidity**	**TN**
Average	73.2	77.7	42.2	73.1	20.6	12.1	81.8	44.3
Standard deviation	±32.8	±19.43	±22.	±20.4	±13.4	±11.2	±16.1	±22.7
Median	88.9	86.4	46.4	77.8	20.7	7.3	88.5	40.2

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Other sites

Carnogue, France (lumbricomposting – aquaculture facility)

Littlemill, Scotland (small village)

Tuam, Ireland (municipal)

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KEY COMMENTS & LESSONS (AMONGST OTHERS)

- **Good organic and solids loading rate design is key**
- **Worm densities (5000/m^3 (mature worms upwards)**
- **Coordination, planning & customs!!**
- **Active layer of 1000 mm used (but keep topped up – below 700 - 750 mm potential performance degradation)**
- **Intermittent loading** at each site (e.g. 1 dose per hour)
- **Primary settlement** used in almost all sites
- **Energy costs measured for most sites***
- **Temperature** generally not an issue on any site
- **Maintenance** - occasional raking of the top surface; Occasional top-up of woodchip has been required in the Lumbrifilter—perhaps 100 mm over 4–6 months. No further maintenance was required.
- **Locally sourced material** - coconut husk to replace woodchip & pea gravel to replace pozzolana.
- The **Lumbrifilter is very robust** and recovers quickly even when flows have stopped for several weeks—providing the **woodchip remains damp and does not freeze**.
- Where wastewater volumes are low periodically the Lumbrifilter dosing system can be adjusted to maintain a good worm population.

*data available

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Thank you for your attention!

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