LIMNOTOP: Eco-remediation near Ormoz, Slovenia

Year of issue

2025

Summary

The project applied an eco-remediation methodology at the Dobrava landfill (Municipality of Ormož, Slovenia) in the Pannonian lowlands. It aimed to demonstrate a green technology that reduces landfill impacts through a closed hydrological and pollution cycle, complementing and exceeding legislation. The Limnotop approach combines a dense, high-evapotranspiration woodland cover as a water barrier with recirculation and a constructed wetland for leachate treatment, to protect surface and groundwater.

Since project completion, the landfill has been permanently closed to additional landfilling and reconstructed; the constructed wetland remains in operation for leachate treatment (as confirmed by site managers). Post-LIFE, the site has been under operational monitoring by the authorities. In 2019 the environmental permit required additional leachate treatment, and a 2020 municipal plan considered routing leachate to the Ormož wastewater treatment plant to complement the wetland. A separate collection/transfer center now operates adjacent to the closed landfill. Overall, the case shows long-term use of nature-based treatment integrated with closure works, with upgrades pursued to meet current standards.

Photo Gallery



Location

46.4127, 16.146

Project

NWRM

National ID

Slovenia_05

Sector

Forest

Installation Date

2006-10

Implementation status

Completed

Contact

REC

Overview

Location of the project

At Dobrava, NW of Ormož. The site lies north of the state road G1-2 (Ormož western bypass), west of local road LC 302-021 Ormož–Koračice, and south of local road JP 804-391 Dobrava; the Lešnica stream runs along the western edge.

Country

Slovenia

NUTS2 Code

Vzhodna Slovenija

Sponge measures implemented in the case study

Afforestation

Wetland restoration and management

Objectives

The demonstrated approach allows a landfill site to become a bioreactor by permitting controlled infiltration and consequently further decomposition of the degradable part of the waste. This results in a quicker stabilization of a landfill site as the water in the bioreactor stimulates anaerobic microbes to mineralise organic waste. Fast growing trees with high evapotranspiration are used, which additionally contributes to leachate treatment and evapotranspiration of excess water to the atmosphere. Due to the closed hydrological and pollution cycle, the negative impact on the environment is reduced and the landfill site is lastingly rehabilitated.

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility
Other	Municipality Ormož	Initiation of the measure	Project beneficiary	Responsible
Other	University of Ljubljana	Monitoring	Faculty for Chemistry and Chemical Technology, Department for chemistry and biochemistry, Laboratory for inorganic chemistry	Supporting
Architects / Engineers	LIMNOS, Company for applied Ecology	Implementation	Private company, subcontractor	Supporting
Architects / Engineers	Communal company Ormož	Implementation	Municipal communal service provider - public institute	Supporting
Research institute / University	Institute for physical biology	Monitoring	Private company	Supporting

Site Information

Climate Zone

Cool temperate dry

Precipitation

800.00 mm

Temperature (°C)

10.00 °C

Elevation range

223

Slope range

gentle slope

Vegetation class

Surroundings are mapped as agricultural land (kmetijska zemljišča); within the rehabilitated landfill cover the dominant plantings were willow (Salix sp.), grasses, and white clover.

WFD Ecological status

Moderate

WFD Chemical status

Failing to achieve good

Design and Implementation

Project scale

Micro

Project scale specifications

A single landfill site (Dobrava, Ormož) with a localized eco-remediation system (constructed wetland and evapotranspiration cover) and site-specific monitoring network.

Area subject to Land use change or Management/Practice change (ha)

4.00 ha

Size

4.00

Size unit

ha

Favourable preconditions

The LIMNOTOP project demonstrates an innovative technique of landfill rehabilitation which enables further waste degradation after the landfill closure, thus attaining stabilization of waste before the end of the useful life of liner materials. A closed hydraulic and pollution cycle was applied in the system of the landfill. The rehabilitation process includes natural systems which enable leachate treatment with stabilization and detoxification of pollutants, as well as extraction of residual nutrients in leachate for the growth of the wood biomass.

Financing

Total cost

594721.00 €

Total cost information

Total budget for the project.

Financing authorities

Authority name	Type of funding	Comments	Financing share
European Union	EU-funds: LIFE+	€267,624	55 %
—	National funds	€327,097	45 %
Municipality of Ormož	Local funds	In 2020, the Municipality approved an upgrade of the Dobrava collection centre and leachate conveyance. Estimated value €969,309.22 (with VAT); financing source: entirely the municipal budget (€887,198.01 excluding refundable VAT).	additional investments

Compensations

Non

Policy and Governance

Policy description

Land-filling is still the most common form of final waste disposal. The permanent control of emission of leachate and biogas presents a major environmental problem of the landfills. The common approach toward elimination of the negative emissions from landfills on the environment is the use of physical barriers (mineral, synthetic liners), which prevents the formation of landfill leachate and gasses. Surface isolation of the deposited wastes at the same time prevents their further degradation and disables their final stabilization. As the duration of the isolation materials is limited, in spite of their high quality, the long-term solution of these existing techniques is environmentally questionable.

Land ownership

Municipality of Ormož

Policy targets

Pollutants Removal

Oher Societal Benefits

Part of a wider plan

Oui

Wider plan

Comments
The need for the reclamation of landfill sites to avoid long-term contamination is widely recognized in the EU countries. According to Slovene and EU Directives, old landfill sites have to be rehabilitated and there is a strong need for the protection of drinking water sources near landfill sites.

Public consultation

Non

Has contractual arrangements

Non

Impacts and Monitoring

Monitoring System

Monitoring requirements

Groundwater operational monitoring is mandated under the amended permit (2023) at five observation wells plus two dug wells, with Lešnica stream water level measurements and an exceedance-response plan.

Monitoring parameters

The performance of a prototype was monitored throughout a two and a half year period. Monitoring of leachate composition was performed and the contribution of constructed wetland to leachate purification was evaluated. The accumulation of leachate contaminants was followed in all of the subunits of the remediation system; in plant and soil material.

Maintenance

Maintenance requirements

The operator maintains the monitoring network and site through routine inspections, periodic cleaning/reactivation of wells, and other upkeep required by the environmental permit.

Impact Assessment Methodology

Performance impact assessment method

Edge of Field/Plot

Performance impact estimation information

Laboratory analyses of the samples, Soil samples preparation, BOD analysis of leachate, ICP-MS analiysis of leachate and soil samples

Socio-economic Impacts

Direct benefits information

The project results suggest savings are as high as 51% compared to leachate treatment systems and 31% for the final cover of landfill sites with synthetic layers.
Revenue potential from biomass: Establishment of woodland/energy crops was intended to generate income to offset maintenance & construction costs (target: ~25%); the Layman report also lists “renewable energy (wood biomass) 10–25%” among direct benefits.
Operational efficiencies: The approach reduces the need to maintain airtight caps and shortens the time needed for after-care and for required environmental monitoring, Public acceptance & secondary use: Rehabilitation with vegetated cover improves landscape acceptance and enables secondary/public uses of revitalised landfill land; the project also included guided site visits for dissemination.due to faster waste stabilisation.

Biophysical impacts: Biodiversity

Information on improved biodiversity

This new method of landfill management enables the secondary use of revitalized landfill sites improving biodiversity and increasing their public acceptance.

Biophysical impacts: Water & Soil Quality

Water quality overall improvements

Positive impact-WQ improvement

Information on water quality overall

Reduction of the contamination of surrounding waters with nutrients and toxic compounds, elimination of offensive odors, reduction of uncontrolled emission of gasses, final degradation of wastes with controlled infiltration of water into the landfill body.
No accumulation of heavy metals found in the landfill cover material; metals largely retained in the anaerobic landfill body, with part removed via plant uptake (notably Cd, Zn).
Boron (site study on leachate reuse): Leachate B = 0.8–3.83 mg/L; bioavailable B in soil increased over the 10-month study; leaf B (mean) clover 23.9 mg/kg, grasses 4.5 mg/kg, willow (new cover) 41.3 mg/kg, willow (old cover) 81.8 mg/kg; vegetation showed no visible toxicity in the monitoring period. (Notes that continued inputs could risk accumulation over longer terms.)

Water quality improvements - Phosphorus (P)

80.00

Water quality improvements - Phosphorus (P) - Unit

% reduction pf pollutant

Water quality improvements - Nitrogen (N)

80.00

Water quality improvements - Nitrogen (N) - Unit

% reduction pf pollutant

Biophysical impacts: Others

Ecosystem impact climate regulation

Not relevant for the specific application

Information on ecosystem impact GHG soil carbon

Offensive odors are eliminated and the emission of greenhouse gases reduced through a gas drainage system and the increased assimilation of CO2 and the oxidation of methane by the vegetative growth.

Information on other biophysical impacts

Odour elimination and reduced GHG emissions cited for the system (gas drainage + CO_2 assimilation and CH_4 oxidation by vegetation).

Lessons Learned

Key lessons

The “closed loop” concept—constructed wetland pre-treatment + recirculation under a high-ET vegetated cover; works as a landfill bio-reactor: monitoring during the LIFE project showed effective leachate pre-treatment, vigorous plant growth on the cover, no heavy-metal build-up in cover soils, and faster waste stabilisation signals (high leachate temperature/flows).

Nature-based treatment can remain part of after-care but may need to be complemented. After the landfill closed (end-2015), the 2023 permit records that leachate is now routed to the public sewer and treated at Ormož WWTP, with the constructed wetland kept as pre-treatment; a 2020 municipal investment paper had already noted the wetland alone was not sufficient.

Long-term performance depends on structured monitoring and maintenance. The 2023 decision sets 30-year after-care obligations (groundwater status monitoring, leachate monitoring at the outlet to sewer, gas/air checks, regular site inspections) and quantifies the associated monitoring/O&M cost items.

Where leachate is reused for irrigation, some constituents (e.g., boron) can accumulate in soil/plant tissue - even without short-term phytotoxicity - so targeted parameters must be tracked over time.

The eco-remediation elements are durable: managers confirm the constructed wetland remains in operation post-closure, illustrating persistence of NBS infrastructure alongside conventional upgrades. (Site managers, 2025, pers. comm.) See also the operator’s listing of the Dobrava constructed wetland.

Barriers

Barrier type	Barrier role	Comments
Expected maintenance needs	Main barrier	Risk of gradual accumulation of certain constituents (e.g., boron) under leachate irrigation, requiring vigilance.

Drivers

Driver type	Driver role
Legal obligations	Main driver

Success factors

Success factor type	Success factor role	Comments
Existing staff and consultant knowledge	Main factor	—
Attitude of decision makers	Main factor	Strong local ownership and operator capacity (Municipality of Ormož; Komunalno podjetje Ormož) with clear permit responsibilities.

Success factor type	Success factor role	Comments
Other	Main factor	Appropriate plant choices and demonstrated cover performance enabling nutrient uptake and ET.

Transferability

Highly transferable to small closed landfills needing leachate control: the Limnotop combo (evapotranspiration cover + recirculation + constructed wetland) works and can persist post-closure. But check leachate loads/variability, groundwater setting, and permit after-care. Expect CW alone may be insufficient (as in Ormož: sewer/WWTP back-up), and plan long-term monitoring (e.g., NH4, AOX, boron) plus regular upkeep of wells and wetland.

Sources

Sources

LIMNOTOP - The sustainable rehabilitation of the landfill site

Sustainable Rehabilitation of the Landfill Site

Trajnostna sanacija odlagališÄ a odpadkov

Ecoremediation of degraded soils and sediments

Partial decision amending the environmental permit for Dobrava landfill (11 Apr 2023)

The sustainable rehabilitation of the landfill site (LIMNOTOP) – LIFE03 ENV/SLO/000557

Ekoremediacije kot priložnost za inovativni regionalni razvoj (conference paper; “20. Zborovanje slovenskih geografov”)

Zbirni center Dobrava – Komunalno podjetje Ormož

Sustainable reclamation of landfill sites

Odlok o OPPN za ureditev zbirnega centra in odlagališča komunalnih odpadkov Dobrava (OPPN Dobrava) – Predlog (kartografski del)

Boron in irrigation water and its interactions with soil and plants: an example of municipal landfill leachate reuse