LIFE BIOREPEM

LAYMAN'S REPORT

Summary and results of the LCA study

Project Details

PROJECT TITLE: Progetto LIFE19 ENV/IT/000358 BIOREPEM - BIOcide REduction in PEst Management

DURATION: 52 months

EU FINANCIAL CONTRIBUTION: tot. Project cost 1'525'713 €, UE contribution 813'839 € (55%)

SECTOR: LIFE Environment and Resource Efficiency - Environment and Health, including chemicals and noise

PROJECT COORDINATOR: Municipality of Fiumicino

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1 Executive Summary

This report presents the results of a Life Cycle Assessment (LCA) comparing traditional pest control methods to innovative, low-impact alternatives developed by the LIFE BIOREPEM project for managing rodent and mosquito populations in Fiumicino, Italy. Conducted according to the Product Environmental Footprint (PEF) 3.1 guidelines, this LCA examines the environmental impacts associated with each approach across their full life cycles, including raw material extraction, usage phase and direct emissions into environmental matrices.

The LIFE BIOREPEM project aims to address the ecological and health risks associated with conventional rodenticide and insecticide methods. Traditional pest control methods typically rely on chemical agents, such as Difenacoum for rodents and TETRAPERM ABD for mosquitoes, which pose risks to non-target species, contribute to pollution of air, soil, and water, and may lead to increased resistance in pest populations. By contrast, the BIOREPEM methodology emphasizes a non-toxic approach, employing mechanical and biological control mechanisms such as the EKOMILLE trap for rodents and CULINEX larvicide combined with AQUALAB ovitraps and MOSQUITO MAGNET traps for mosquitoes.

The LCA results reveal substantial environmental benefits in favor of the BIOREPEM methods. Key findings include:

- **reduced emissions and toxicity:** the BIOREPEM approach results in significantly lower toxic emissions in both rodent and mosquito control compared to traditional chemical methods. The EKOMILLE and MOSQUITO MAGNET traps avoid the use of harmful rodenticides and insecticides, effectively reducing air, water, and soil pollution;
- **improved ecosystem health and biodiversity protection:** traditional methods carry substantial risk of secondary poisoning for non-target species, such as predators of rodents and aquatic organisms impacted by larvicides. In contrast, BIOREPEM's non-toxic alternatives protect biodiversity and minimize unintended ecological damage;
- **energy and resource efficiency:** the BIOREPEM devices demonstrate durability and lower material turnover. With longer operational lifespans, these methods show lower resource consumption, aligning with sustainable resource management goals.

Overall, the findings support the adoption of BIOREPEM's alternative control methods in sensitive urban environments. Through a significant reduction in environmental footprint and ecological disturbance, these innovative methods align with the objectives of sustainable pest management and could serve as a model for urban pest control initiatives.

The following chapters will provide a detailed analysis of the LCA methodology, impact categories, comparative results, and specific environmental benefits associated with the BIOREPEM methods.

2 Introduction

The LIFE BIOREPEM project aims to address the pressing environmental and health challenges posed by traditional pest control practices. Rodent and mosquito control measures often rely on chemical agents that can lead to ecosystem degradation, pollution, and resistance development in target species. As urban and suburban communities seek sustainable alternatives, the need for low-impact pest management solutions has become critical.

The LIFE BIOREPEM approach introduces innovative methods that minimize ecological harm through non-toxic mechanical and biological controls. These methods include the EKOMILLE system for rodent control and an integrated mosquito management system combining CULINEX larvicide, AQUALAB ovitraps, and MOSQUITO MAGNET traps. This report evaluates these methods' environmental impacts against traditional rodenticide and insecticide applications through a comprehensive Life Cycle Assessment (LCA) analysis.

This study uses the Product Environmental Footprint (PEF) 3.1 methodology to provide a standardized and thorough assessment of each method's environmental footprint across various impact categories. By assessing each stage of the life cycle, including raw material extraction, usage phase and direct emissions into environmental matrices, the LCA aims to quantify and compare the environmental impacts of each approach, guiding stakeholders toward environmentally responsible pest management decisions.

3 Methodology Overview

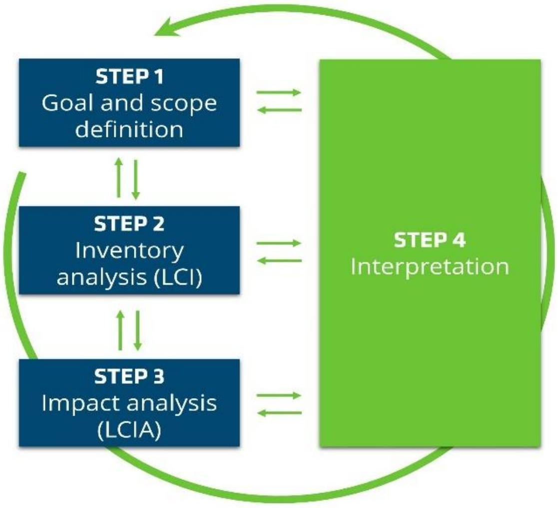
The LCA methodology was applied in accordance with PEF (*Product Environmental Footprint*) 3.1 guidelines to evaluate the environmental impacts associated with the traditional and BIOREPEM methods. The LCA follows four main stages:

1. **Goal and scope definition**: this study aims to assess and compare the environmental impacts of conventional and BIOREPEM approaches for rodents and mosquitoes captures within Fiumicino. The scope includes all lifecycle stages for each method, raw material extraction, usage and direct emissions. The functional unit used for the comparison of the scenarios is the murid and culicides disinfestation in five schools of the Municipality of Fiumicino for the period of one year (2023).

2. **Life Cycle Inventory (LCI)**: data was collected on the resources, energy, and emissions associated with each pest control device and chemical used. Primary data was gathered from on-site usage and monitoring in 2023 in five schools in the municipality of Fiumicino, supplemented by secondary data from the Ecoinvent 3.10 database where needed.

3. **Life Cycle Impact Assessment (LCIA)**: the impact categories considered include greenhouse gas emissions, toxicity, resource use, and pollution across air, water, and soil. The PEF 3.1 method provides a robust framework for assessing and comparing each method's environmental footprint.

4. **Interpretation**: Results are evaluated to identify the environmental benefits and trade-offs associated with each pest control method, with recommendations aimed at promoting sustainable pest management practices.



The PEF 3.1 methodology assesses impacts across 16 categories, but this study focuses on those most relevant to pest control, including:

- **Climate Change**: assesses greenhouse gas emissions.
- **Resource Use (Fossils and Minerals)**: evaluates depletion of natural resources.
- **Ecotoxicity**: measures potential harm to ecosystems from chemicals.
- **Human Health Impacts**: considers toxicity impacts on human health.
- **Particulate Matter**: assesses pollution related to airborne particulates.

These categories provide a comprehensive view of each method's environmental and ecological footprint, helping to identify areas where improvements can reduce impact.

4 Results

The LCA results reveal marked differences between traditional and BIOREPEM pest control methods, particularly in the categories of ecotoxicity, climate change, and human health impacts. Below, the results for each pest type—rodents and mosquitoes—are discussed separately.

Rodent Control:

- **traditional method**: the traditional approach uses rodenticides, specifically Difenacoum, which has significant ecotoxicity impacts due to its persistence in the environment and potential for secondary poisoning. Emissions data indicate notable pollution in air, soil, and water matrices, with risks for non-target species such as predatory birds and mammals.
- **BIOREPEM method:** the BIOREPEM method uses electromechanical traps (EKOMILLE) that offers a non-toxic alternative that reduces risks to non-target species and eliminates residual contamination in soil and water. This method's long-lasting, mechanical design leads to a lower resource footprint and reduced greenhouse gas emissions.

Mosquito Control:

- **traditional method**: the standard method for mosquito control relies on TETRAPERM ABD, an insecticide that poses ecotoxicity risks to aquatic organisms and contributes to air and soil pollution. Frequent applications are required, leading to cumulative emissions and potential resistance development in mosquito populations.
- **BIOREPEM method (CULINEX, AQUALAB, and MOSQUITO MAGNET)**: BIOREPEM's integrated mosquito management system leverages biological controls and CO_2-based traps, which avoid the use of persistent insecticides. This approach greatly reduces ecotoxicity impacts and protects aquatic and terrestrial ecosystems. The lower emissions of pollutants in air, soil, and water demonstrate this method's compatibility with biodiversity conservation and human health protection goals.

The comparison of traditional and BIOREPEM methods shows a clear advantage for the latter in several impact categories:

- **reduced Greenhouse Gas Emissions**: BIOREPEM's methods have lower emissions associated with the life cycle of the equipment, as mechanical and biological controls reduce the need for energy-intensive chemical production;
- **lower ecotoxicity**: BIOREPEM's methods avoid the environmental risks of chemical pesticides and rodenticides, resulting in significantly lower ecotoxicity impacts across air, water, and soil matrices;
- **biodiversity and ecosystem protection**: by avoiding secondary poisoning and chemical pollutants, BIOREPEM's methods promote ecosystem health and reduce collateral damage to non-target species, particularly in sensitive urban environments.

The findings demonstrate the efficacy of BIOREPEM methods in reducing environmental impacts compared to traditional pest control practices, underscoring their suitability for broader adoption.

5 Comparative Analysis

Below is a comparison of the impact categories considered most significant.

1. **Greenhouse Gas Emissions**

Greenhouse gas emissions were evaluated for each method over their life cycle, from production to direct emissions into environmental matrices. The BIOREPEM methods demonstrated a marked reduction in emissions compared to traditional chemical approaches.

- **Traditional methods**: the use of chemical rodenticides and insecticides contributes to greenhouse gas emissions, not only from the production of active substances like Difenacoum and TETRAPERM ABD but also from the transportation and frequent application of these substances. The need for periodic replenishment amplifies the carbon footprint, as new supplies are frequently manufactured and distributed;
- **BIOREPEM methods**: by using mechanical and biological controls, such as the EKOMILLE trap for rodents and the CULINEX, AQUALAB, and MOSQUITO MAGNET systems for mosquitoes, BIOREPEM minimizes emissions linked to frequent production cycles. The durability of the devices, coupled with lower maintenance requirements, further reduces greenhouse gas contributions. Quantitatively, BIOREPEM methods for rodents demonstrate a reduction in carbon emissions by 1'116 kg $CO_{2,e}$ for traditional up to 1.41 kg $CO_{2,e}$, and for mosquitoes from 524 kg $CO_{2,e}$ to 1.67 kg $CO_{2,e}$ for CULINEX and AQUALAB integrated system.

2. **Ecotoxicity and Environmental Health**

The ecotoxicity impact category assesses the potential harm of each method to ecosystems and biodiversity, particularly due to chemical pollutants released into air, water, and soil.

- **Traditional methods**: the use of Difenacoum in rodent control and TETRAPERM ABD in mosquito control introduces significant ecotoxicity. These chemicals can contaminate soil, air and water, impacting non-target species and increasing the risk of secondary poisoning among predators that consume affected rodents or mosquitoes. Additionally, the persistence of these chemicals in the environment exacerbates the risk, as their toxicity can affect local flora and fauna long after initial application;
- **BIOREPEM methods**: BIOREPEM's reliance on non-toxic mechanical and biological controls eliminates chemical pollutants, thereby drastically reducing ecotoxicity impacts. The EKOMILLE traps use attractants rather than poisons, and the CULINEX larvicide is microbiological, targeting mosquito larvae without harming other aquatic species. Quantitatively the ecotoxicity impacts were reduced by more than 70% for rodents and up to 100% for mosquitoes.

3. **Human Health Impacts**

- **Traditional methods**: chemical rodenticides and insecticides can lead to various health risks due to their toxic nature. Pest control operators face potential exposure to harmful substances such as Difenacoum and TETRAPERM ABD, which require protective equipment and careful handling to mitigate risks. Additionally, residual traces of these chemicals can persist in treated areas, potentially posing a risk to bystanders, particularly in public areas such as schools. Prolonged exposure to these chemicals is associated with adverse effects, including respiratory issues and allergic reactions;

- **BIOREPEM methods**: the BIOREPEM approach prioritizes non-toxic solutions, significantly reducing health risks for both operators and the public. The EKOMILLE system for rodents, along with the CULINEX, AQUALAB, and MOSQUITO MAGNET devices for mosquito control, do not rely on chemical agents, eliminating the risk of chemical exposure during application. Consequently, the human health impact of BIOREPEM methods is considerably lower, providing a safer alternative for pest management in urban and sensitive areas.

The comparative analysis clearly demonstrates the environmental and health advantages of the BIOREPEM pest control methods over traditional chemical approaches. Key benefits include:

- environmental impact reduction: BIOREPEM methods reduce greenhouse gas emissions, ecotoxicity, and waste generation, contributing to a significantly lower environmental footprint;
- improved human health safety: the absence of toxic chemicals in BIOREPEM methods reduces health risks for operators and nearby communities, particularly in public spaces such as schools;
- resource efficiency: durable and reusable BIOREPEM devices promote resource efficiency and waste reduction, supporting sustainability in urban pest management;
- biodiversity conservation: BIOREPEM methods mitigate risks to non-target species and contribute positively to local biodiversity and ecosystem health.

The findings from this study indicate that BIOREPEM’s low-impact, sustainable approach to pest control not only aligns with environmental protection goals but also presents a viable and effective alternative for urban areas seeking to manage pest populations responsibly**.**

While the BIOREPEM approach offers numerous environmental benefits, some impact indicators reveal areas where the methods may perform less favorably compared to traditional pest control techniques. These differences primarily arise from the unique operational and material demands of the BIOREPEM devices, which, although non-toxic, involve specific trade-offs in terms of production and energy use.

The worsening impacts are due to the production of brass and electronical components for EKOMILLE rodent traps and due to the LGP production for the MOSQUITO MAGNET units for mosquitoes. Unlike traditional chemical methods, which are relatively simple to produce, BIOREPEM devices require a variety of durable materials (metals, plastics, and electronic components) to ensure long-term operation.

The area where BIOREPEM methods show a potentially higher environmental concern the use of minerals and metals for EKOMILLE trap and for mosquitoes’ system are related to climate change, the use of fossils resource, the formation of particulate matter and photochemical ozone, due to the use of MOSQUITO MAGNET units. In the case where MOSQUITO MAGNETS are not used, the impacts of the BIOREPEM method are all lower than those of the traditional methodology.

6 Conclusions

The Life Cycle Assessment (LCA) conducted for the LIFE BIOREPEM project provides a clear perspective on the environmental, health, and resource impacts associated with traditional and BIOREPEM pest control methods for rodents and mosquitoes. This study demonstrates the effectiveness and sustainability of the BIOREPEM approach, underscoring its suitability for implementation in urban and sensitive environments.

The comparative LCA study reveals substantial benefits associated with BIOREPEM's non-toxic, durable devices, particularly when evaluated against conventional chemical-based pest control. The primary findings of this study include significant reduction in environmental impact, enhanced human health and safety, resource efficiency and waste reduction, biodiversity and ecosystem protection.

The findings from this LCA study indicate that BIOREPEM's low-impact pest control methods align well with policy initiatives focused on sustainable urban management and environmental conservation. Governments and regulatory agencies could consider promoting or mandating non-toxic alternatives in urban pest control, providing subsidies or incentives for adopting environmentally friendly practices.

The LIFE BIOREPEM project exemplifies how innovative, non-toxic pest control methods can meet ecological and public health objectives while effectively managing rodent and mosquito populations. This study's results underscore BIOREPEM's value as a model for sustainable pest management, offering a viable alternative to traditional chemical-based methods.

By substantially reducing greenhouse gas emissions, eliminating toxic pollutants, and conserving resources, the BIOREPEM approach aligns with the principles of environmental stewardship and responsible urban management. The findings support the recommendation for broader adoption of BIOREPEM's non-toxic methods in urban settings, contributing to a healthier, more sustainable future for communities.

7 Supplementary technical infomation

This final chapter includes supplementary information, data tables, and references that support the findings presented in the main body of this report. These resources provide transparency for the data sources and methodology used and offer additional insights into the details of the comparative analysis.

To provide a comprehensive view of the Life Cycle Assessment (LCA) results, the following tables and figures are included as appendices:

- **Table A1**: summary of impact categories assessed by PEF 3.1

Name	Unit	Decription
Acidification	mol H+ eq	Assesses acidification potential due to substances like NO_x and SO_2, which can harm ecosystems and biodiversity
Climate change	kg CO2 eq	Measures greenhouse gas emissions and their global warming potential
Ecotoxicity freshwater	CTUe	Measures the potential toxicity of chemical compounds for aquatic organisms
Eutrophication freshwater	kg P eq	Assesses nutrient accumulation in freshwater, evaluating nutrient oveload
Eutrophication marine	kg N eq	Assesses nutrient accumulation in marine waters, often due to phosphates and nitrates, promoting algae growth
Eutrophication terrestrial	mol N eq	Measures nutrient accumulation in terrestrial ecosystems that can damage flora
Human toxicity cancer	CTUh	Evaluates cancer risk from exposure to toxic substances
Human toxicity non-cancer	CTUh	Assesses non-cancer health risks from toxic substance exposure
Ionising radiation (human health)	kBq U235 eq	Assesses the potential human health impact of ionizing radiation, such as from nuclear fuel cycles
Land use	dimensionless (pt)	Measures the effects of direct or indirect land use on ecosystems, biodiversity, and soil-related environmental services
Ozone depletion	kg CFC11 eq	Evaluates the impact of ozone-depleting substances like CFCs and HCFCs on the stratospheric ozone layer
Particulate matter	disease incidence	Considers the impact of fine particles (PM2.5 and PM10) on respiratory and cardiovascular health
Photochemical ozone formation (human health)	kg NMVOC eq	Assesses smog formation from ozone precursors (NO_x, VOCs)
Resource use fossils	MJ (net calorific)	Measures fossil fuel consumption (coal, oil, gas), expressed in MJ
Resource use minerals and metals	kg Sb eq	Examines non-renewable resource extraction of minerals and metals
Water use	m3 world eq	Analyzes freshwater consumption with consideration for local water scarcity

- **Table A2**: Comparative summary of LCA results for rodents' methods

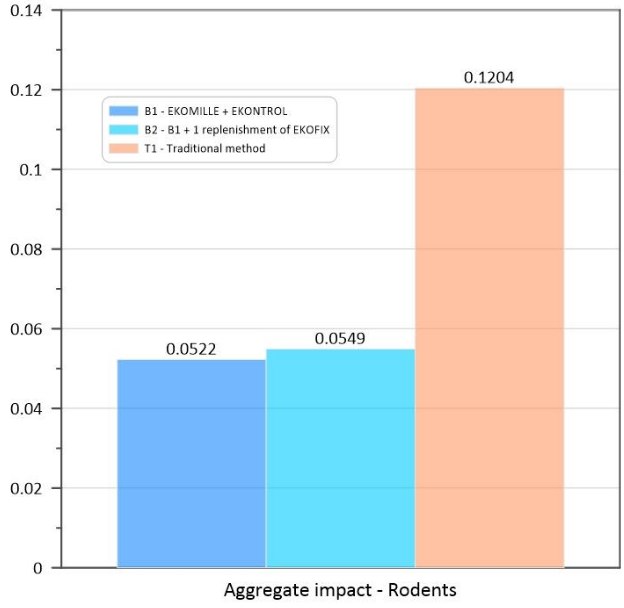
Impact category	Unit of Measure	B1[1]	B2[1]	T1[1]	B1 Vs T1	B2 Vs T1
Acidification	mol H+ eq	1.26	1.41	4.17	INF	INF
Climate change	kg CO2 eq	135.39	162.37	1115.70	INF	INF
Ecotoxicity freshwater	CTUe	3149.94	3365.93	11777.10	INF	INF
Eutrophication freshwater	kg P eq	0.121	0.132	0.246	INF	INF
Eutrophication marine	kg N eq	0.17	0.20	0.81	INF	INF
Eutrophication terrestrial	mol N eq	1.77	2.06	8.34	INF	INF
Human toxicity cancer	CTUh	4.68E-07	5.28E-07	1.13E-05	INF	INF
Human toxicity non-cancer	CTUh	5.62E-06	5.76E-06	8.56E-06	INF	INF
Ionising radiation (human health)	kBq U235 eq	7.60	8.75	41.73	INF	INF
Land use	dimensionless (pt)	594.44	748.99	2943.83	INF	INF
Ozone depletion	kg CFC11 eq	2.38E-06	2.73E-06	4.01E-05	INF	INF
Particulate matter	disease incidence	8.31E-06	9.54E-06	4.91E-05	INF	INF
Photochemical ozone formation (human health)	kg NMVOC eq	0.65	0.83	4.58	INF	INF
Resource use fossils	MJ (net calorific)	2304.20	2756.42	26049.17	INF	INF
Resource use minerals and metals	kg Sb eq	0.03	0.03	0.01	SUP	SUP
Water use	m3 world eq	73.22	91.99	411.37	INF	INF
[1]B1: EKOMILLE + EKONTROL; B2: EKOMILLE + EKONTROL + EKOFIX, T1: standard						

- **Table A3**: Comparative summary of LCA results for mosquitoes' methods

Impact category	Unit of Measure	B1[2]	B2[2]	T1[2]	B1 Vs T1	B2 Vs T1
Acidification	mol H+ eq	4.57	0.01	1.97	SUP	INF
Climate change	kg CO2 eq	813.71	1.67	524.37	SUP	INF
Ecotoxicity freshwater	CTUe	2622.34	29.47	2993289.64	INF	INF
Eutrophication freshwater	kg P eq	0.05	0.00	0.10	INF	INF
Eutrophication marine	kg N eq	0.77	0.00	0.36	SUP	INF
Eutrophication terrestrial	mol N eq	8.25	0.03	3.74	SUP	INF
Human toxicity cancer	CTUh	3.10E-06	1.03E-08	8.24E-06	INF	INF
Human toxicity non-cancer	CTUh	3.67E-06	1.51E-08	1.49E-05	INF	INF
Ionising radiation (human health)	kBq U235 eq	14.12	0.06	15.70	INF	INF
Land use	dimensionless (pt)	2716.23	48.42	1162.23	SUP	INF
Ozone depletion	kg CFC11 eq	5.26E-05	4.35E-08	1.63E-05	SUP	INF
Particulate matter	disease incidence	3.55E-05	9.15E-08	2.33E-05	SUP	INF
Photochemical ozone formation (human health)	kg NMVOC eq	7.30	0.01	1.95	SUP	INF
Resource use fossils	MJ (net calorific)	41503.22	31.27	10460.88	SUP	INF
Resource use minerals and metals	kg Sb eq	0.00	0.00	0.00	INF	INF
Water use	m3 world eq	80.37	2.71	175.62	INF	INF

[2] B1:CULINEX TAB + AQUALAB + MOSQUITO MAGNET; B2: CULINEX TAB + AQUALAB+ EKOFIX, T1: standard

- **Figure A1**: Aggregated impact[1] for rodents' methods



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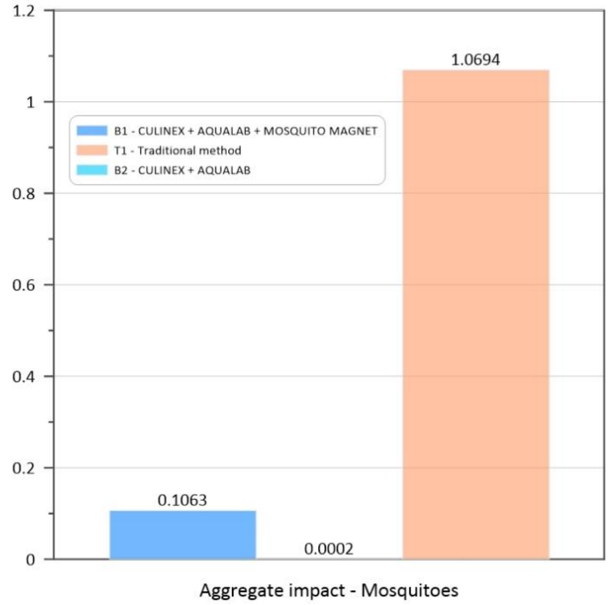
- **Figure A2**: Aggregated impact[1] for mosquitoes' methods



[1] "*Aggregated impact"* refers to the combined effect of multiple environmental impacts across categories, providing a single, comprehensive measure. By consolidating indicators like climate change, resource use, and toxicity, the aggregated impact helps assess overall environmental performance and compare product sustainability across lifecycle stages.

8 References

This section lists all sources referenced throughout the report, including scientific articles, LCA guidelines, and environmental databases:

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