

November 2022

The Environmental Footprint of Soileos



Lucent Bio



Science Driven. Field Proven. Bio-Activated.

Increase microbial biomass with Soileos bio-available micronutrients

TABLE OF CONTENTS

Executive Summary	3
Sustainable Solutions for Agriculture	4
We Have a Plan	4
Emissions Reductions Across the Entire Value Chain	4
Good for the Farmer and Good for the Environment	6
Expert Input	7
Environmental Footprint Analysis	8
Assessment Scope	8
How Does Soileos Stack Up to Conventional Products?	9
Carbon Emission Offset Potential	10
Assessment Scope	10
How Does Using Soileos Create GHG-Related Benefits?	11
Our Approach	12
Acronyms	13
Appendix	14
About This Whitepaper	14
Caveats	14
Reporting Period	14
Performance Data	15

Executive Summary

Lucent BioSciences, Inc. (“Lucent Bio”) aims to accelerate sustainable agriculture by delivering crop nutrition that improves yield and soil health while sequestering carbon.

Lucent Bio's flagship product—Soileos[®]—is a soil-applied, smart crop nutrition delivery system. It enhances yields, crop resilience, and soil health with on-time nutrient delivery and sustained bioavailability, allowing the crop to maximize its genetic potential. Our patented technology binds micronutrients to cellulose fiber and uses the soil's natural biological activity to release nutrients to the crops. Soileos is made from repurposed cellulose derived from crop processing, such as pea or lentil hulls or rice husks. Unlike conventional products, Soileos's organic substrate improves microbial biomass in the soil and enhances soil organic carbon levels. The net result is higher crop yields, improved nutrient density, and healthier soils.

In early 2022, Lucent Bio contracted two independent consulting firms, Viresco Solutions and SAISS Consulting, to provide insight into the environmental benefits of manufacturing and using Soileos Zinc and Soileos Iron and the carbon emissions offset potential of using Soileos Zinc.¹

Key Findings:

1. The GHG manufacturing footprint of Soileos is about 1/4th of the footprint of Zinc EDTA and about 1/6th of the footprint of Iron EDTA.
2. The manufacturing process of Soileos requires around 1.5x less water usage, 4x less energy and generates 5x fewer air pollutants than does the manufacture of EDTA.
3. Increases in soil organic carbon (SOC) levels and land use-related benefits far outweigh the GHG manufacturing footprint of Soileos.

Currently, Soileos is used on roughly 6,000 acres in Canada and the US. Soileos production capacity will significantly increase in 2023 with the completion of our new 7,000 tonnes per year manufacturing facility in Rosetown, Saskatchewan. This facility, which operates as AGT Soileos², will manufacture enough product to treat 1.5 million acres of cropland.



Soileos Pellets

- 1 Note that the potential emissions offset potential has only been assessed to date for Soileos Zinc to-date.
- 2 This \$19 million project is a partnership between Lucent Bio and AGT Food and Ingredients, with additional funding from Protein Industries Canada.



Sustainable Solutions for Agriculture

We Have a Plan

In the upcoming decades, global food systems will profoundly change as we adapt to more sustainable food production and distribution approaches. Farmers are currently being challenged to meet the needs of the present without compromising the ability of future generations to meet their own needs.

Vancouver-based Lucent Bio is looking to mitigate these challenges by delivering a climate positive and bio-activated crop nutrition system that improves yield and soil health while sequestering carbon.



Soileos

Emissions Reductions Across the Entire Value Chain

Innovation at Lucent Bio focuses on how we can better use resources and minimize our environmental footprint to support the sustainable development of climate-smart agriculture. We connect with food processors to convert low-value residues into higher revenue streams while providing an innovative plant nutrient delivery system for use at their partner farms.

Lucent Bio's flagship product—Soileos®—is a soil-applied, smart crop nutrition delivery system. It enhances yields, crop resilience, and soil health with on-time nutrient delivery and sustained bioavailability, allowing the crop to maximize its genetic potential. Our patented technology binds micronutrients to cellulose fiber and uses the soil's natural biological activity to release nutrients to the crops instead of synthetic molecules like EDTA and oxysulphates. Soileos is made from repurposed cellulose derived from crop processing residues such as pea or lentil hulls or rice husks. Unlike conventional products, Soileos' organic substrate means soil organic carbon levels are enhanced through its use. The net result is higher crop yields, improved nutrient density, and healthier soils with higher carbon.

Application of Soileos to farm soils promotes the activity and growth of native soil microorganisms. Lucent's research with Agriculture and Agri-Food Canada has shown that Soileos triggers an increase in microbial biomass due to the biologically available carbon in Soileos. The microbial community consumes the bioavailable carbon and begins to cycle, releasing the micronutrients back into the ecosystem in a bioavailable form and on time for crop uptake. Nutrients are delivered from Soileos to the crop using the symbiotic relationships between soil microbes. This is why we call Soileos "Bio-Activated."

Soileos helps farmers produce more crops with better nutrition and creates an avenue for the agri-food community to enhance nutrient stewardship, improve resource management, and contribute to a circular economy.



Good for the Farmer and Good for the Environment

Climate-positive crop nutrition, delivered by Soileos, helps farmers boost their short-term profitability and facilitate long-term stewardship of farmland and natural resources.

TABLE 1.
Sample yield increases stemming from three years of field trials with Soileos

CROP	YIELD INCREASE
Soybeans	7-10%
Wheat	5-10%
Corn	5-12%

Farmers don't have to choose between profitability and sustainability. A farmer who grows with Soileos has an environmentally sound bottom line. Soileos is strategically designed to increase yields with no run-off pollution and to stay in the soil for long-term benefits that boost return on investment (ROI) by three times or better. Check out our website's [ROI calculator](#).



The Soileos crop nutrition system has several positive environmental attributes, such as:



Climate Positive

Soileos goes beyond net-zero. The GHG benefits from its use far outweigh its manufacturing GHG footprint.



Non-Leaching and Non-Polluting

Using patented cellulose-based technology, Soileos is water-insoluble and does not leach through the soil profile like EDTA products.



Improved Soil Health

Soileos rebuilds soil by adding carbon, increasing microbial activity and enhancing nutrient cycling.



Part of the Circular Economy

By upcycling low-value food processing co-products into a climate-positive fertilizer, these materials become fertilizer that creates the next harvest, providing the next batch of co-products, and so on.



Expert Input

In early 2022, Lucent Bio contracted two independent consulting firms, Viresco Solutions and SAISS Consulting, to provide insight into the carbon emissions offset potential of using Soileos Zinc and the environmental footprint of manufacturing Soileos Zinc³ and Soileos Iron.⁴ These studies used ISO-compliant standards to compare traditional micronutrient fertilizers based on EDTA to the Soileos delivery system. The results of these studies support Lucent Bio's efforts to develop products that enhance crop production and soil carbon sequestration.



Life Cycle Analysis/Assessment (LCA) is a tool used to support decision-making for sustainable development as it evaluates the environmental impacts associated with all stages of a product or process.⁵ SAISS used a "cradle-to-gate" analysis which examined the production of Soileos from resource extraction (cradle) to the factory gate. This LCA approach is grounded in international standards and science-based quantifiers, making it a reliable and consistent means of evaluating the impact of products such as Soileos.

³ "Environmental Benefits Assessment of Soileos Zinc Delivery System in Comparison to Two Alternative Baselines," SAISS Consultants, Toronto, June 2022.

⁴ "Environmental Benefits Assessment of Soileos Iron Delivery System in Comparison to an Alternative Baseline," SAISS Consultants, Toronto, July 2022.

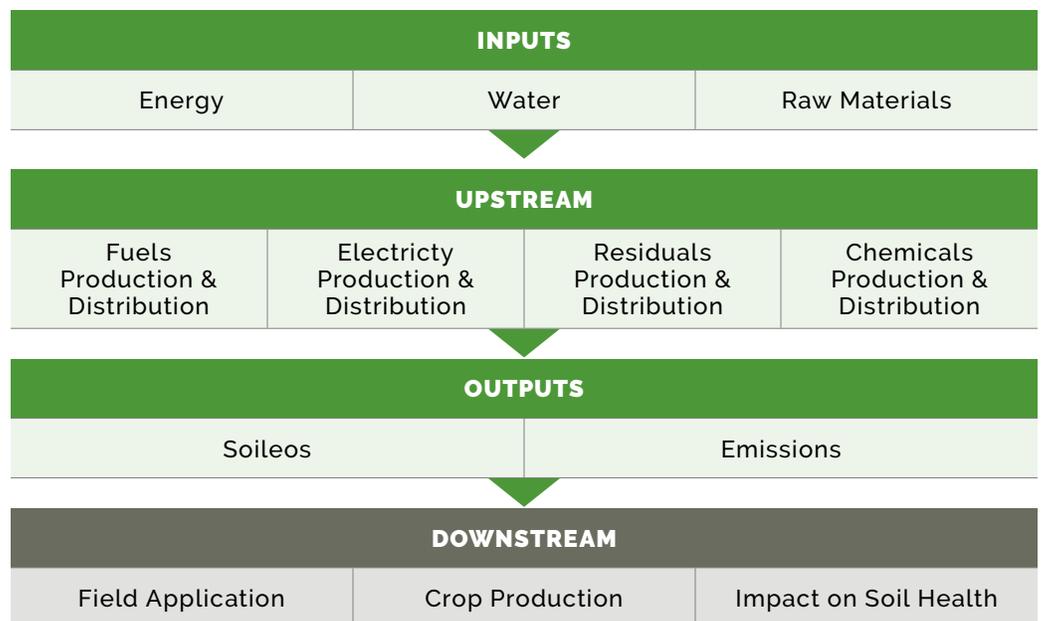
⁵ Brusseau, M. L. (2019). Sustainable development and other solutions to pollution and Global Change. *Environmental and Pollution Science*, 585–603. <https://doi.org/10.1016/b978-0-12-814719-1.00032-x>

Environmental Footprint Analysis

Key Findings:

1. The environmental footprint of manufacturing Soileos Zinc is estimated to be 1.6 t CO₂e/t of Soileos produced, about 1/4th of the footprint of Zinc EDTA.
2. The environmental footprint of manufacturing Soileos Iron is estimated to be 1 t CO₂e/t of Soileos produced, about 1/6th the footprint of Iron EDTA.
3. The manufacturing process of Soileos Iron requires 1.5x less water usage, 5x less energy and generates 5.5x fewer air pollutants than EDTA
4. The manufacturing process of Soileos Zinc requires 1.5 less water usage, 3.5x less energy and generates 4x fewer air pollutants than EDTA

Assessment Scope



Lucent Bio commissioned an assessment of the environmental footprint of manufacturing Soileos Zinc and Soileos Iron, comparing them to conventional EDTA-based micronutrient fertilizers. The environmental dimensions examined were Global Warming Potential (GWP)⁶, air pollution, primary energy use, and water use. This cradle-to-gate life cycle analysis assessed all aspects of manufacturing and found that both Soileos Zinc and Soileos Iron have lower environmental footprints than conventional EDTA products.

⁶ The Global Warming Potential metric examines the ability of each greenhouse gas to trap heat in the atmosphere. The higher the GWP, the more heat a specific gas can keep in the atmosphere.

Soileos is an innovative crop nutrient delivery system that solves current micronutrient delivery problems while improving the land. The proprietary technology behind the Soileos crop nutrition system binds micronutrients such as zinc, iron, and manganese to the cellulose fibre instead of synthetic chelating agents such as EDTA. The Soileos formulations also deliver macronutrients, specifically potassium and sulphur.

How Does Soileos Stack Up to Conventional Products?

On a per tonne of fertilizer produced basis, Soileos has a lower environmental footprint than both iron and zinc EDTA.

FIGURE 1.

GHG Footprint from Manufacturing a Metric Tonne of Product

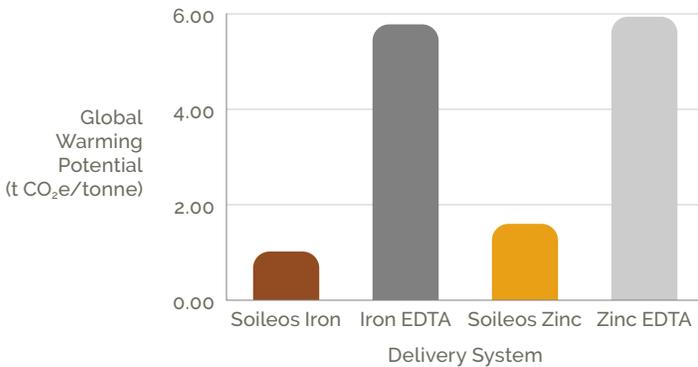


FIGURE 2.

Water Use from Manufacturing a Metric Tonne of Product

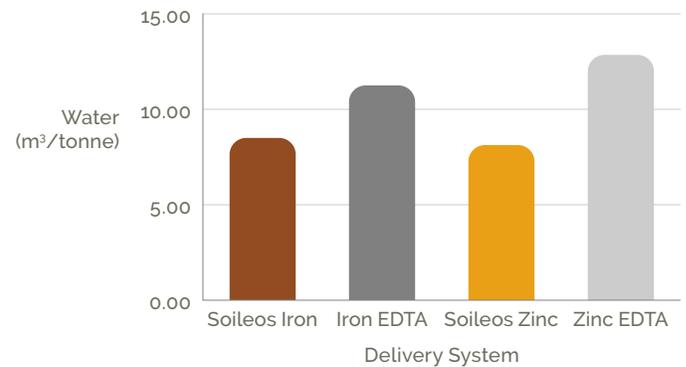


FIGURE 3.

Total Air Contaminants from Manufacturing a Metric Tonne of Product⁷

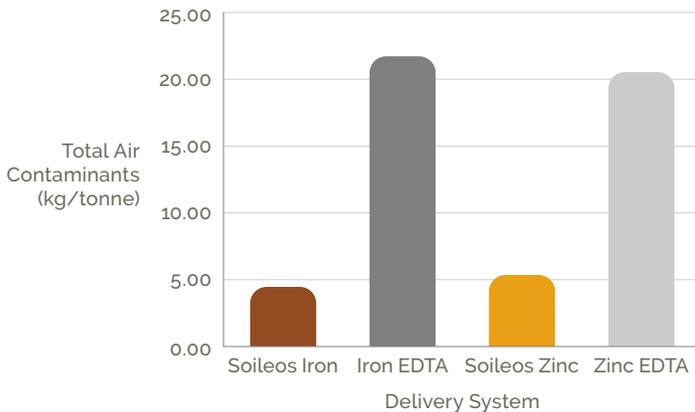
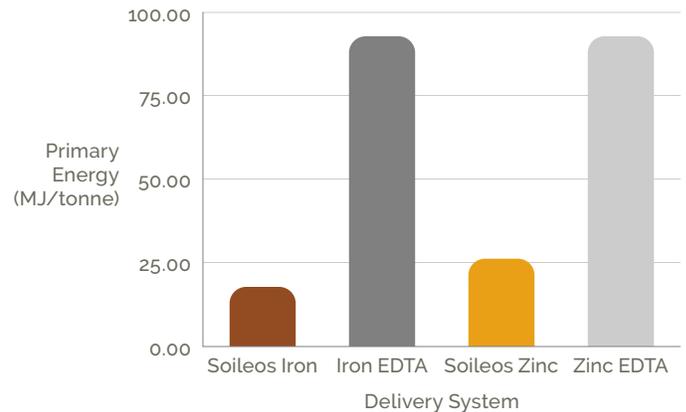


FIGURE 4.

Primary Energy from Manufacturing a Metric Tonne of Product



⁷ This chart is the sum of Total Particulate Matter (TPM), Nitrogen oxide (NO_x) and Sulphur oxide (SO_x).

Carbon Emission Offset Potential

Key Findings:

1. Soil organic carbon levels (SOC) and land use related benefits far outweigh the GHG manufacturing footprint of Soileos.
2. The degree of benefit will depend on crop, soil type, weather, etc.

Assessment Scope

The second study that Lucent Bio commissioned investigated the carbon emission offset potential of Soileos.⁸ The Greenhouse Gas (GHG) Impact of redirecting food processing residuals from being used as animal feed (the base case) to manufacturing and applying Soileos Zinc (the project case) formed the basis of this study. Three scenarios were examined: soybeans grown in Ontario, corn grown in Manitoba, and canola grown in Saskatchewan.

It was found that crop production using the Soileos delivery system has excellent potential for offsetting GHG emissions as a result of soil organic carbon sequestration through:

- Increased biomass from aboveground biomass (straw)
- Root biomass resulting from increased crop yields
- Biomass from Soileos itself



⁸ "Exploring the Carbon Emission Offset Potential of Soileos," Viresco Solutions, Calgary, July 2022.

How Does Using Soileos Create GHG-Related Benefits?

Soileos is more than carbon neutral; it's a climate-positive crop nutrition system. Using Soileos creates significant climate change related benefits through increasing soil organic carbon levels and through its ability to grow more on the same land base, thereby helping avoid negative land use changes. A GHG net benefit occurred in each crop/location scenario examined.

GHG OFFSET POTENTIAL (t CO ₂ e / t of Soileos ⁹)			
CROP	SOC INCREASE	LULUCF BENEFIT	TOTAL POTENTIAL GHG BENEFIT NET OF MFG. EMISSIONS
Corn Manitoba	3.3	5.5	7.2
Soybean Ontario	3.6	6.8	8.8
Canola Saskatchewan	6.2	4.3	8.9

For example, the benefits of applying 1 tonne of Soileos annually to canola grown in Saskatchewan is equivalent to the carbon sequestered by 150 tree seedlings grown for ten years.¹⁰



⁹ Assumptions (the following information was provided by Lucent Bio): Application rate of Soileos for all crops is 22.42 kg/ha; therefore, the total biomass input for every 1 tonne of Soileos application results from 44.6 hectares; based on soil carbon remaining in soils after 100 years; Normal yields for corn, soybean and canola are 10.65 t/ha, 4.31 t/ha and 2.09 t/ha, respectively; Increases resulting from Soileos application for corn, soybean and canola are 4.3%, 6.2% and 10.0%, respectively.

¹⁰ This equivalency is based on the US EPA Greenhouse Gases Equivalencies Calculator. This calculator uses Global Warming Potentials (GWPs) reported as CO₂e and are calculated using GWPs from the Intergovernmental Panel on Climate Change's Fourth Assessment Report. They can be retrieved from: www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references#seedlings

Our Approach

Lucent Bio demonstrates stewardship of all resources by operating with an environmental, social and governance (ESG) strategy. Our team seeks continuous improvement by examining how we can become better value creators, suppliers, employers and partners. From cradle to gate, we are working to minimize adverse environmental impacts and maximize the value of our products.

We are committed to learning more about how these potential benefits take place in situ and will measure these outcomes to verify the potential outlined in these reports. Lucent Bio is also developing conceptual carbon offset projects with several partners to begin investigating the monetization of the significant environmental benefits of Soileos.

Currently, Soileos is used on roughly 6,000 acres in Canada and the US. Soileos production capacity will significantly increase in 2023 with the completion of our new 7 tonnes per day manufacturing facility in Rosetown, Saskatchewan. This production level will enable Soileos to be applied to 1.5 million acres of cropland. Other North American manufacturing facilities are in the planning stage. These planned expansions will enable Lucent and its partners to bring the business and environmental benefits of Soileos to more and more farmers.



Acronyms

CAC	Criteria Air Contaminant(s) - air emissions most commonly used to evaluate air quality or pollution levels.
EDTA	Ethylenediamine Tetraacetic Acid , a synthetic amino acid, is widely used as a chelating agent.
GHGs	Greenhouse Gases - gases that trap heat in the atmosphere and warm the planet. The leading gases responsible for the greenhouse effect include carbon dioxide, methane, and nitrous oxide.
GWP	Global Warming Potential - a measure of the degree to which a specific compound or substance contributes to climate change.
LCA	Life Cycle Analysis - a method used to evaluate the environmental impact of a product through its life cycle, encompassing extraction and processing of raw materials, manufacturing, distribution, use, recycling, and final disposal.
LCI	Life Cycle Inventory - the data collection portion of LCA. Here the straightforward accounting of everything involved in the "system" of interest occurs.
LCIA	Life Cycle Inventory Analysis - the analysis of the data collected in the LCI.
NOx	Oxides of Nitrogen - gases known to contribute to smog and acid rain. They are typically produced from the reaction between nitrogen and oxygen during combustion.
SOx	Oxides of Sulphur - gases known to contribute to poor air quality, related health impacts, and acid rain. The combustion of fuels containing sulphur creates these oxides.
TPM	Total Particulate Matter - describes the mixture of solid particles and liquid droplets in the air. TPM includes soot, dust, dirt, smoke and can be emitted by industrial operations, fossil fuel combustion, fires, etc.
VOC	Volatile Organic Compounds - these carbon-containing chemicals have compositions that enable them to evaporate under normal indoor atmospheric pressure and temperature. VOCs are part of the photochemical reaction that leads to smog formation and, on their own, can adversely impact human health.

Appendix

About This Whitepaper

This whitepaper on environmental benefits expresses our commitment to continuous improvement. As a data-first company, we value transparency and disclosure as the groundwork for presenting our commitments to our stakeholders.

Caveats

The benefits described in this paper are predicated on an annual application of Soileos.

The values in this paper are illustrative. The degree of environmental benefit achieved will vary by such factors as crop type, soil type, other fertilizer treatments, weather, etc..

The complete Viresco and SAISS reports are not available to the public due to the proprietary nature of Lucent Bio's manufacturing process. If you wish to have a more in-depth discussion about any of the attributes of Soileos presented here, please [contact us](#) directly.

Reporting Period

Data presented in this paper reflect activities from Spring 2021 to July 2022.



Performance Data

TABLE 2

SAISS Life Cycle Inventory Analysis Results

Production of zinc and iron delivery systems (Cradle-to-Gate) per tonne fertilizer compared to EDTA-based products

INDICATOR	SOILEOS ZINC	SOILEOS IRON	ZINC EDTA	IRON EDTA	SOILEOS ZINC BENEFITS vs ZINC EDTA	SOILEOS IRON BENEFITS vs IRON EDTA
GWP (kg Co ₂ -e/tonne)	1,653	990	5,936	5,858	4,283	4,868
CAC (kg/tonne)						
SOx	2.92	2.37	9.77	11.60	6.85	9.23
NOx	1.85	1.30	8.33	8.36	6.48	7.06
TPM	0.72	0.31	2.26	1.92	1.54	1.61
CO	0.52	0.27	3.48	6.21	2.96	5.94
VOC	0.12	0.06	0.68	1.06	0.56	1.00
Primary Energy (MJ/tonne)						
Renewable	6,377	5,956	1,514	1,981	-4,862	-3,975
Non-Renewable	20,215	12,314	88,838	88,976	68,623	76,662
Total	26,592	18,270	90,353	90,957	63,761	72,687
Water (m ³ /tonne)	8.41	8.40	12.9	11.1	4.44	2.69

TABLE 3

Summary of the Total Biomass Input Source Due to the Increased Crop Yields

LOCATION	CROP	INCREASE YIELD AND BIOMASS (T/ha)				
		YIELD	STRAW	ROOT BIOMASS	SOILEOS	TOTAL
Manitoba	Corn	0.463	0.769	0.150	0.017	1.399
Ontario	Soybean	0.267	0.912	0.250	0.017	1.445
Saskatchewan	Canola	0.210	0.897	0.150	0.017	1.274

TABLE 4
Summary of Soil Input Data for the Modelling

LOCATION	CROP	SOIL CODE	CLAY %	SILT %	SAND %	SOC %	BULK DENSITY (g/cm ₃)
Manitoba	Corn	DCS ¹¹	50	39	11	3.0	1.2
Ontario	Soybean	BKN ¹²	37	47	16	2.0	1.27
Saskatchewan	Canola	RAA ¹³	62	30	8	2	1.2

¹¹ Dencross series (DCS) consists of imperfectly drained Gleyed Rego Black Chernozem soil developed on (<1 m) of moderately to strongly calcareous, shallow clayey, lacustrine, deposits over very strongly to extremely calcareous, silty, lacustrine deposits.

¹² Brookston series (BKN) consists of very deep, poorly drained soils formed in as much as 51 cm (20 inches) of silty material and the underlying loamy till in depressions on till plains and moraines. Slope ranges from 0 to 3 percent.

¹³ Regina Orthic Vertisol (RAA) consists of well drained soils formed in (< 1m) of sediment, generally consisting of either stratified fine sand, silt, and clay deposited on till plains either settled from suspension in bodies of standing freshwater or accumulated at their margins through wave action.