May 2024

The Environmental Footprint of Nutreos

Lucent Bio

Seed Coating. Microplastic-Free.

Enhanced germination and emergence without compromise.

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Executive Summary

In a world grappling with climate change, food security challenges, and resource depletion, the urgency to adopt climate-smart agri-food systems has never been greater. Lucent BioSciences, (Lucent Bio) is committed to addressing these challenges head-on by connecting food processing to food production in a way that conserves natural resources and promotes economic and environmental prosperity.

To support the adoption of a climate-smart agri-food system, Lucent Bio created Nutreos, a non-toxic, plant-based, biodegradable micronutrient seed coating that delivers strong germination, vigour and crop establishment without microplastics.

To evaluate the environmental footprint and further confirm the climate-smart properties of Nutreos, Lucent Bio contracted third-party expert consultant SAISS[1]. Key findings of the study proved Nutreos to be climate-smart from the start, with a lower environmental footprint than conventional seed coating technologies.

Nutreos

Key Findings:

1. Nutreos has a significantly lower environmental footprint compared to conventional seed coating technologies.
2. Nutreos avoids microplastic pollution by utilizing plant-based biodegradable materials instead of fossil fuel-derived polymers.
3. Nutreos contributes to mitigating climate change and air pollution by replacing conventional plastics with natural biodegradable biopolymers.

1 Environmental Benefits Assessment for Agreos, Nutreos and Corresponding Baselines" SAISS, Toronto. April 2024.

Lucent Bio

About Us

At Lucent Bio, we en**vision** a future where a climate-positive agri-food system feeds the world sustainably.

Our **mission** is to accelerate the transition to a sustainable agri-food system through innovative crop input solutions that are climate-positive, non-polluting, and based on circular economy principles.

In today's world, the need to do more with less has never been more pressing. As we navigate the challenges of climate change, food security, and resource depletion, the transition to climate-smart agri-food systems has become more and more pressing.

At Lucent Bio, we embrace this challenge head-on. We recognize that the key to success lies in connecting food processing to food production in a way that preserves natural resources and drives economic and environmental prosperity. We are innovating climate-positive agri-food systems through sustainable circular economy solutions that support agriculture. Our dedication to environmental responsibility drives every aspect of our work, from research and development to product implementation.

Innovation in Sustainability

Our focus on innovation extends beyond product development. We continuously strive to push the boundaries of what's possible in sustainable agriculture. By leveraging cutting-edge technologies and scientific expertise, we develop crop nutrition solutions that reduce environmental impact and promote corporate responsibility in the agri-food industry.

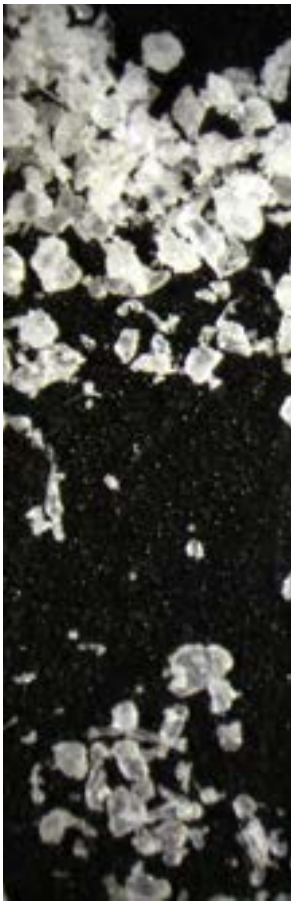
Empowering Change

Lucent Bio is dedicated to empowering growers, agronomists, manufacturers, and consumers to make informed choices that benefit their families, communities, and the planet. Through our sustainable crop nutrition solutions, we provide the tools and resources necessary to drive positive change in agriculture. By collaborating with stakeholders across the industry, we aim to build a more resilient and sustainable agri-food system for future generations.

Building Momentum for Change

In pursuit of climate-smart agriculture, the pressure to mitigate greenhouse gas (GHG) emissions is becoming increasingly important. From production to distribution, every step is an opportunity for emission reductions and can contribute to a more resilient agri-food system.

Lucent Bio's strategies for climate change mitigation include the use of a circular economy approach that upcycles food crop processing co-products into climate-smart crop inputs. We work to streamline our supply chain operations and minimize environmental impacts, Our business approach connects agri-food processors with climate-smart agricultural inputs for an increasingly localized supply chain, creating a system that maximizes local resource efficiency and minimizes environmental impact. Specifically, the bulk of the material inputs that make up our crop nutrition products are locally sourced surplus agricultural residues. Our partnerships with food processors enable us to transform these lower-value co-products into higher-value revenue streams, furthering our commitment to sustainability in agri-food systems.



Avoidance of Microplastics

Microplastics, tiny particles less than 5mm in size[2], have emerged as a serious and pervasive environmental threat. These particles, often the result of conventional plastics being degraded and fragmented over time, infiltrate various ecosystems, contaminating soil, water, and even the food chain. As awareness grows regarding the environmental impact of microplastics in agriculture, it has become imperative to adopt practices that minimize their use and release into the environment. An estimated 22,500 tonnes of microplastics were utilized in fertilizers, and an additional 500 tonnes were incorporated into seed coatings in the European Economic Area in 2019[3].

Conventional seed treatments use plastic coatings or binders based on petrochemicals, and their use introduces microplastics into agricultural ecosystems. However, with the emergence of innovative technologies like biopolymer-based crop nutrition products, we now have the opportunity to displace these harmful downstream contaminants.

By opting for bio-based alternatives free of fossil fuel-derived plastics, we can protect soil health and crop vitality while contributing to a more sustainable agricultural future.

Climate and Air Pollution Impacts

The production of crop nutrition products has a number of environmental impacts, including the release of air pollutants and GHGs. Manufacturing activities generally release Criteria Air Contaminants (CACs), such as nitrogen oxides (NOx), oxides of sulphur (SOx), and volatile organic compounds (VOCs), into the atmosphere contributing to air pollution and greenhouse gas emissions.

Emerging alternatives like natural hydrogels and starch derivatives provide biodegradable options that mitigate environmental impacts. Studies[4] suggest these alternatives enhance seedling establishment, potentially reducing fertilizer application, thereby minimizing downstream air pollution.

Furthermore, selecting products that meet or exceed air quality standards demonstrates proactive environmental stewardship, contributing to a more sustainable agri-food system. Crop nutrition systems with lower harmful air emissions benefit public health through cleaner air and healthier communities. Minimizing air pollution is key to preserving ecosystems and biodiversity, aligning with broader environmental goals.

[2] https://www.britannica.com/technology/microplastic

[3] http://apps1.unep.org/resolutions/uploads/sowing_a_plastic_planet_-_how_microplastics_in_agrochemicals_are_affecting_our_soils_our_food_and_our_future_ciel.pdf_0.pdf

[4] Solomon, Yokamo. (2023). Alternative fertilization approaches in enhancing crop productivity and nutrient use efficiency: A review. Archives of agriculture and environmental science, 8(2):244-249. doi: 10.26832/24566632.2023.0802022; Recent advances in seed coating technologies: transitioning toward sustainable agriculture. Sohail, M. et al. Green Chemistry. Issue 16, 2022.

A Paradigm Shift in Seed Coatings

Nutreos is a non-toxic, plant-based, biodegradable micronutrient seed coating that delivers strong germination, vigour and crop establishment without microplastics or petrochemical additives.

Nutrition Without Microplastics

Nutreos prioritizes the delivery of essential nutrients to crops, avoiding the use of conventional microplastics that can harm soil and the environment.

Enhancing Crop Establishment

Nutreos promotes germination, root development, strong early vigor, and optimized crop establishment. Seeds receive the nutrition they need to thrive right from the start.

Nurturing Sustainable Farming

Nutreos enhances crop stablishment, optimizes resource utilization, and aligns with 4-R principles to support climate-smart agriculture.

A Biodegradable Innovation

Nutreos coatings are made from natural biodegradable biopolymers, and do not contain petrochemicals or fossil fuel-derived microplastics.

Nutreos

Lowering Environmental Footprint

Nutreos redefines seed treatment by delivering essential nutrition directly to the seed by using biopolymers that begin releasing nutrients in response to soil biology. The approach reduces the environmental footprint of seed coatings and aligns with climate-smart agriculture. Nutreos formulations ensure germinating seeds receive essential nutrients—like copper, iron, manganese, and zinc—without introducing harmful microplastics into the soil or surrounding ecosystems.

Microplastic Free by Design

Nutreos, as an innovative, biodegradable seed coating, was designed to deliver nutrition, not microplastics. In contrast to conventional fossil fuel derived seed coating, all Nutreos formulations avoid the use of microplastics and do not contribute to microplastic contamination in soils. This attribute underscores Lucent Bio's commitment to environmental stewardship supporting soil health and ecosystem integrity.

Mitigating Climate Change and Air Pollution

By utilizing natural biodegradable biopolymers in its coatings, Nutreos reduces the amount of harmful pollutants released into the atmosphere compared to existing fossil fuel-based technologies. This results in cleaner air and reduced greenhouse gas emissions for a more sustainable agri-food system.

Building upon our understanding of Nutreos and its promise as a sustainable alternative, we use expert analysis to explore its environmental footprint further. Through this expert input, we validate Nutreos' role in advancing agricultural practices while upholding environmental stewardship.

Independent Third-Party Evaluation

Lucent Bio commissioned SAISS, an expert consulting firm with extensive experience and expertise in the clean-tech and climate change sector, to conduct an environmental footprint analysis of its seed coating technology Nutreos. This comprehensive study used ISO-compliant standards to compare conventional seed coatings based on plastics derived from fossil fuels to Nutreos products. The results of this study support Lucent Bio's effort to develop products that support climate-smart agri-food systems. This study examined the life cycle of two Nutreos products, one containing the micronutrient zinc and the other containing copper.

SAISS performed a Life Cycle Analysis (LCA) to provide further insights into the sustainability of Nutreos. LCA is a tool utilized in decision-making for sustainable development, offering an evaluation of the environmental impacts across all stages of a product or process[5]. Employing a "Cradle-to-Gate" analysis, SAISS examined the production processes of Nutreos and a variety of conventional polymer products, from resource extraction to factory gate. Grounded in international standards and science-based indicators, this LCA approach ensures a reliable and consistent assessment of Nutreos' environmental impact, further solidifying its role in climate-smart agricultural practices.

The Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA) provided by SAISS are integral components of the LCA process. The LCI involves compiling an inventory of all inputs and outputs associated with the production of Nutreos, while the LCIA evaluates the potential environmental impacts of those inputs and outputs. By conducting both LCI and LCIA, SAISS was able to comprehensively assess the environmental footprint of Nutreos, providing valuable insights into its sustainability compared to conventional seed coating methods.

[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 Insights:

1. Nutreos has a significantly lower environmental footprint compared to conventional seed coating technologies.
2. Nutreos avoids microplastic pollution by utilizing plant-based biodegradable materials instead of fossil fuel-derived polymers.
3. Nutreos contributes to mitigating climate change and air pollution by replacing conventional plastics with natural biodegradable biopolymers.

Assessment Scope

SAISS consultants conducted a lifecycle analysis of the environmental footprint of Nutreos. This study encompassed two main scopes: the evaluation of the Nutreos production process, and a comparison of Nutreos to a number of conventional seed coatings.

First, SAISS examined in detail the production of Nutreos coating materials utilized by Lucent Bio. This involved evaluating the materials and processes involved in producing Nutreos, focusing on energy consumption, resource use, and potential emissions associated with manufacturing (TABLE 1).

Secondly, SAISS performed a comparative analysis between Lucent Bio's Nutreos and conventional seed coatings made from fossil fuel-derived plastics. This comparative assessment seeks to elucidate the environmental advantages of Nutreos over traditional seed coating products, specifically polyvinyl alcohol (PVA), polyacrylate (PAA), polyacrylamide (PAM), polyethylene glycol (PEG), and butadiene styrene (BS). By comparing Nutreos to these established coating technologies, we aim to highlight the potential benefits of integrating Nutreos into climate-smart agri-food systems.

It's important to note that the impacts of the Nutreos coating process and packaging are excluded from this assessment as these activities are not expected to vary significantly between Nutreos and baselines. That is, these activities typically do not have significant environmental impacts and occur in both the baseline and study scenarios.

Overall, the LCA aims to provide a comprehensive understanding of the environmental benefits associated with Nutreos compared to conventional seed coating methods. By examining both the production phase and application phase of Nutreos, as well as comparing it to established baselines, we seek to offer valuable insights that can inform decision-making in sustainable agriculture practices.

TABLE 1. Environmental Impact Assessment Framework

INPUTS		
Energy	Water	Raw Materials

UPSTREAM			
Fuels Production & Distribution	Electricty Production & Distribution	Bio Products Production & Distribution	Chemicals Production & Distribution

OUTPUTS	
Nutreos	Emissions

DOWNSTREAM
Field Application

How Does Nutreos Stack Up to Conventional Products?

Nutreos represents a significant advancement in seed coating technology, offering tangible benefits for both the environment and agricultural productivity. Understanding the implications of adopting Nutreos over conventional alternatives is important, particularly for growers and other stakeholders seeking climate-smart agricultural solutions.

Highlighting the lower carbon footprint and reduced emissions of air pollutants of Nutreos production compared to the manufacture of conventional petrochemical-based options shows the potential to mitigate climate change and improve air quality. The use of Nutreos means fewer greenhouse gases and reduced air pollution, essential for healthier ecosystems and communities.

As Nutreos is made of plant-based biodegradable materials, microplastic pollution of the sort created by existing coatings is entirely avoided. Thus, Nutreos offers a sustainable solution aligned with environmental conservation efforts. Nutreos is a practical and impactful tool for promoting sustainable agriculture and environmental stewardship, appealing to a wide range of stakeholders invested in advancing ecological sustainability within the agricultural sector.

These findings emphasize Nutreos' environmental superiority over conventional seed coating technologies that have been made from petrochemicals. Further examination of key environmental metrics derived from the SAISS LCIA Results offers detailed insights into Nutreos' lower environmental impacts.

Global Warming Potential

The GWP contribution values of Nutreos Copper (2,117 kg CO2-e/tonne) and Nutreos Zinc (3,301 kg CO2-e/tonne) indicate a significant reduction in greenhouse gas emissions compared to those released when producing and using conventional seed coatings. Specifically, Nutreos Copper shows a reduction of approximately 65% compared to Polyacrylate (PAA), which has a GWP of 5,996 kg CO2-e/tonne. Nutreos Zinc shows a reduction of approximately 45% compared to PAA. When compared to the average GWP of conventional coatings (4,652.25 kg CO2-e/tonne), Nutreos Copper shows a reduction of approximately 55%, and Nutreos Zinc demonstrates a reduction of approximately 29%. This substantial reduction highlights the environmental benefits of using Nutreos products for seed coating applications.

Nutreos Copper cuts emissions by

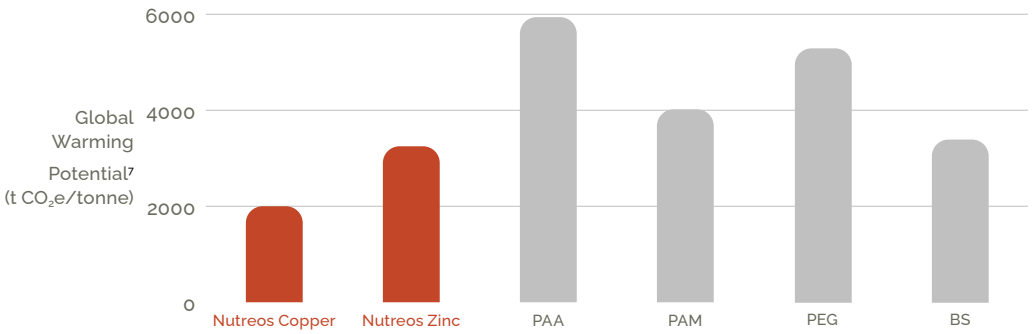
65%

Nutreos Zinc by

45%

FIGURE 1.

GHG Footprint from Manufacturing a Metric Tonne of Product



Criteria Air Contaminants (CAC)

Both Nutreos formulations exhibit notably lower CAC values across key pollutants (SOx, NOx, TPM, CO, VOC) compared to conventional coatings as shown in Figure 2, "Total Criteria Air Contaminants from Manufacturing a Metric Tonne of Product." Nutreos Copper shows an average reduction of approximately 30% compared to the average of conventional coatings (PAA, PAM, PEG, BS), while Nutreos Zinc demonstrates an average reduction of approximately 12%. This reduction suggests a potential decrease in acidification potentials within soil and water ecosystems when Nutreos products are utilized for seed coating applications.

Image: Nutreos Seed Coating. Microplastic-Free.

[7] 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.

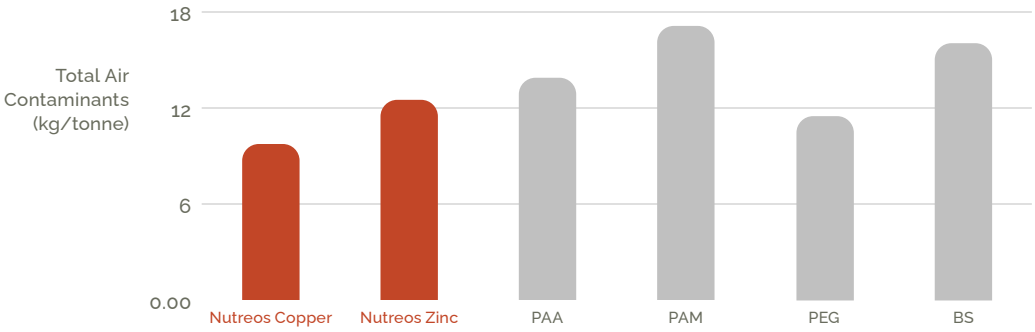
Nutreos Copper:

42%

reduction

FIGURE 2.

Total Criteria Air Contaminants from Manufacturing a Metric Tonne of Product



Primary Energy Use

Nutreos formulations demonstrate superior energy efficiency with lower total primary energy consumption for its production compared to conventional coatings. Nutreos Copper shows a total primary energy consumption approximately 54% lower than PAA, while Nutreos Zinc demonstrates a total consumption of approximately 40% lower. This outcome shows the efficacy of Nutreos in reducing energy inputs during seed coating production, contributing to overall sustainability objectives in agricultural practices. To clarify, primary energy use refers to the total amount of raw energy sources (such as coal, natural gas, and oil) used in the production process before any conversion to electricity or other secondary forms of energy. This distinction highlights the direct impact of energy efficiency improvements in the manufacturing process.

Microplastic Pollution

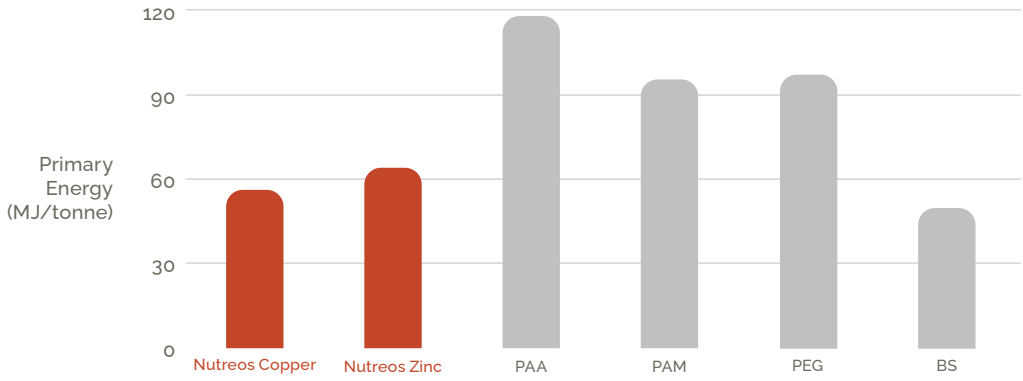
Nutreos Copper:

54%

reduction

FIGURE 3.

Primary Energy from Manufacturing a Metric Tonne of Product



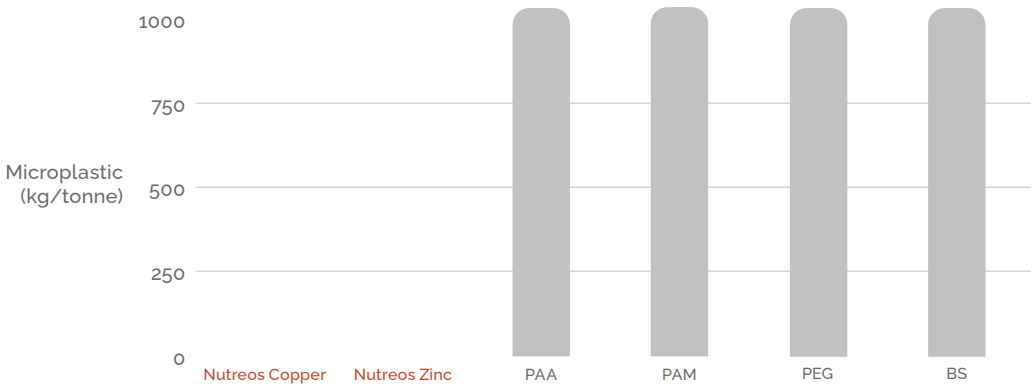
Nutreos reduces microplastic pollution

100%

A notable advantage of Nutreos formulations is that their use avoids the introduction of microplastic pollution in soil, a stark contrast to conventional seed coatings that are made from fossil fuel-derived plastics. This represents a 100% reduction in microplastic pollution compared to conventional coatings. This attribute underscores Lucent's commitment to environmental stewardship and the potential of its Nutreos technology to avoid the detrimental effects of microplastic pollution on soil health and ecosystem integrity.

FIGURE 4.

Soil Microplastics Residues by Product



Nutreos is climate-smart from the start with:

- The use of upcycled materials, encompassing circular economy principles
- A production process with reduced GHG emissions and air pollutants
- A biodegradable, microplastic-free design, not based on fossil fuels, leaving nothing behind.
- An agronomic focus to support resilient agri-food systems with improved seed germination and crop vigour

Nutreos seed coatings replace conventional materials with a microplastic-free solution. Leading climate-smart agriculture, Nutreos' reduced environmental footprint, pollution, and climate impacts ensure a win for all.

Lucent Bio

Our Approach

Lucent Bio is dedicated to creating a climate-positive agri-food system through innovative, sustainable crop inputs.

With a focus on innovation, we continually push the boundaries of sustainable agriculture, leveraging cutting-edge technologies to develop solutions that reduce environmental impact and promote corporate responsibility while improving farm profitability.

Empowering growers, agronomists, and manufacturers is central to our mission. Through sustainable crop inputs, like Nutreos, Lucent Bio provides tools and resources needed to make our agri-food systems more sustainable and to build a climate-smart future.

Acronyms

BS	**Butadiene Styrene** - synthetic rubbers derived from styrene and butadiene.
CAC	**Criteria Air Contaminant(s)** - air emissions most commonly used to evaluate air quality or pollution levels: NOx, SOx, CO, VOCs, PM.
GHGs	**Greenhouse Gases** – gasses that trap heat in the atmosphere and warm the planet. The leading gasses 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	**Nitrogen Oxides** - gasses known to contribute to smog and acid rain. They are typically produced from the reaction between nitrogen and oxygen during combustion.
PAA	**Polyacrylate** - a number of synthetic resins produced by the polymerization of acrylic esters.
PAM	**Polyacrylamide** - a water-soluble synthetic linear polymers made of acrylamide or the combination of acrylamide and acrylic acid.
PEG	**Polyethylene Glycol** - a synthetic polymer produced via polymerization of ethylene oxide molecules to make joining units of ethylene glycol by an ether linkage.
PVA	**Polyvinyl Alcohol**- a a water-soluble synthetic polymer formed by the polymerization of vinyl acetate.
SOx	**Sulphur Oxides** - gasses 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 climate-smart agri-food systems. As a data-first company, we value transparency and disclosure as the groundwork for presenting our commitments to our stakeholders.

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 SAISS report is 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 Nutreos presented here, please contact us directly.

Supporting Data

TABLE 2. Production of seed coating (Cradle-to-gate)

INDICATOR	NUTREOS COPPER	NUTREOS ZINC	POLYACRYLATE (PAA)	POLYACRYLAMIDE (PAM)	POLYETHYLENE GLYCOL (PEG)	BUTADIENE STYRENE (BS)
GWP (kg Co_2-e/tonne)						
	2,117	3,301	5,996	3,979	5,381	3,251
CAC (kg/tonne)						
SOx	4.11	4.60	1.02	2.05	1.68	2.50
NOx	3.29	4.34	5.98	3.45	5.41	4.37
TPM	0.65	1.43	0.62	0.60	0.68	1.02
CO	1.51	1.79	4.38	3.41	2.32	1.94
VOC	0.45	0.48	1.19	2.33	0.88	6.19
Total	10.01	12.64	13.19	17.24	10.97	16.02
Primary Energy (MJ/tonne)						
Renewable	29.83	30.14	0.09	3.16	2.32	0.14
Non-Renewable	24.07	39.21	115.91	91.54	89.68	44.86
Total	53.90	69.35	116.00	94.69	92.00	45.00
Water (m^3/tonne)	46.12	51.27	3.83	14.52	8.69	1.97
Microplastic in soil (kg/tonne)	0	0	1,000	1,000	1,000	1,000