Life Cycle Assessment (LCA) of the Sprout pencil

GREEN SURVEY

Provider
Green Survey
Skovgaardsgade 5C, 8000 Aarhus C
CVR-nr. 41873574

This environmental assessment has been developed in accordance with ISO 14040 and 14044

What is Life Cycle Assessment?

A life cycle assessment (LCA) is a standardized method to quantitatively assess the environmental performance of a product, service, or material. An LCA evaluates a product's impact across its whole life cycle and considers all aspects of a product's fabrication, including raw material extraction, manufacturing, transportation, distribution, usage and disposal, and even material recycling and new life.

An LCA identifies opportunities for improvement by localizing environmental hot spots in the life cycle by studying the contribution of the different life stages on the overall environmental impact. The results of an LCA can further be used for internal or external communication and can serve as the basis for life cycle management and support decisions.

An LCA study consists of four stages:

Firstly, the scope and goal of the study need to be stated. In this stage, the reason for executing the LCA is defined. Furthermore, a precise definition of the product is needed in addition to a description of data and requirements, assumptions, and limitations.

Secondly, the inputs and outputs in the product's life cycle are modelled. This system is usually referred to as life cycle inventory (LCI) and is often illustrated and shows system boundaries and the flows like inputs of raw materials and outputs to air, land, and water.

Thirdly, the life cycle impact assessment (LCIA) is studied, and the environmental relevance of the inputs and outputs are addressed.

And fourthly, the study needs to be interpreted.

Why Life Cycle Assessment?

Due to our still-growing population, global production is reaching new heights every year. As a result, we use and consume more resources than our planet can replenish, and we must restructure our consumption, production, and way of life to reverse this trend. Therefore, life cycle assessment is now essential if we want to exploit our resources responsibly, as it is a powerful tool to support sustainable development, production and decisions. It can be difficult for the individual consumer to weigh the actual environmental impacts of a product or service. Therefore, by applying the assessment and quantifying inputs and outputs in a product system, the life cycle assessment method will allow us to make better decisions based on actual environmental impacts.

By utilizing life cycle assessment as a business, you can begin to understand your production and supply chain processes better. You may be comparing different ways of creating products or providing services and are thereby able to see if changes need to be made to improve overall results. Your goal can also be to achieve total transparency in your production and let your consumers know that you are obtaining more knowledge and taking steps in a green transition to becoming more sustainable.

The three keywords for an efficient, value-creating and credible green transformation are action, documentation, and transparency. Well-documented initiatives and green steps are also the way to combat greenwashing. Greenwashing is a phenomenon where companies misuse green statements without documentation to support their words. If green objectives are merely ideas without action, they will have no climatic or economic significance. Green actions must be documented and validated to build a credible green transition. Companies can use an LCA to avoid any distrust in the green agenda.

The Paris Agreement and European Climate Law

In December 2015, 196 countries, part of the UN Climate Convention, entered the legally binding treaty, The Paris Agreement. The goal of the Paris Agreement is to limit global warming, with the long-term goal to limit the rising global temperature to below 2 degrees Celsius and preferably below 1.5 degrees Celsius. To achieve this goal all involved countries are required to prepare a national plan, stating how the individual countries will contribute to reducing greenhouse gasses. Furthermore, this national plan contains target goals for how much the country will reduce its emissions.

Based on the Paris agreement, the EU has chosen to raise the level of ambition. Shortly after, the framework concerning climate and energy policies leading up to 2030 was introduced by the EU. The goal states that countries in the EU have to achieve a 30% reduction of greenhouse gases than in 1990 by 2030. Since then, the ambitions have been raised even further, and the EU announced a new goal in 2020. The new goal specifies that we must reduce the emissions of greenhouse gases by 55% compared to 1990 by 2030. If we are to reach these goals, we must all take responsibility and begin to take steps in the right direction.

Life Cycle Assessment (LCA)

In accordance with ISO standards 14040 and 14044.

Sprout®Pencil

From

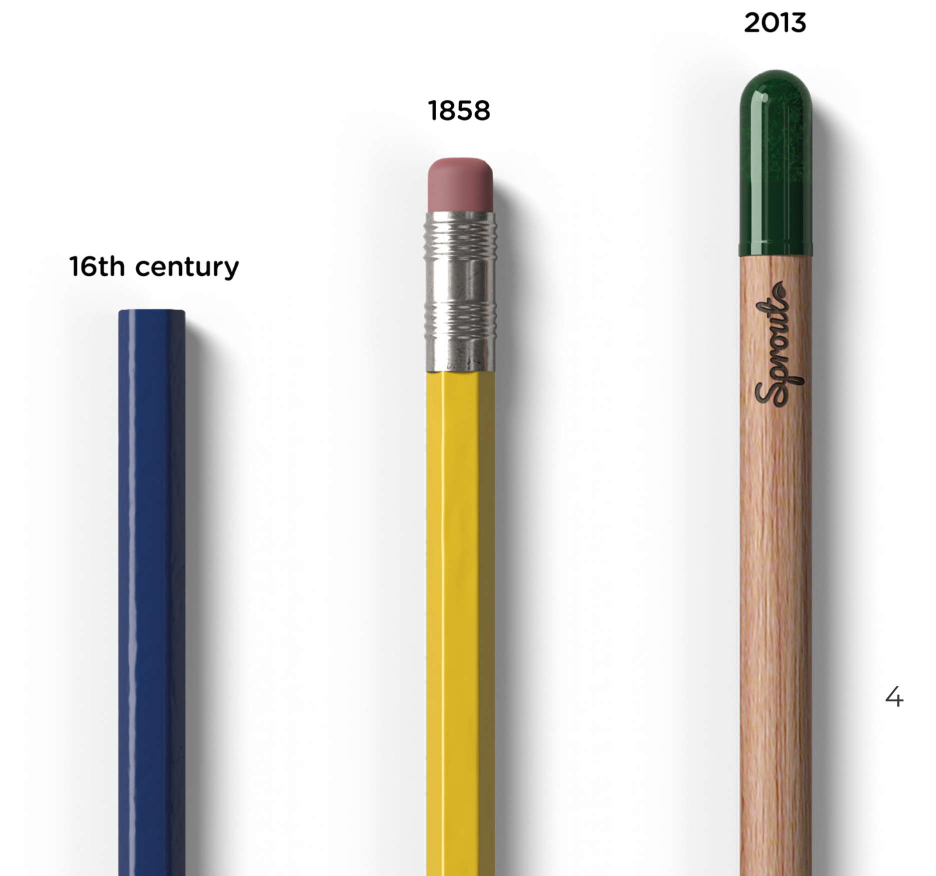
Green Survey ApS

Issued
September, 2021

Valid until
September, 2026

Owner of declaration
Sprout Europe ApS
Lersø Parkallé 107
2100 Copenhagen
Denmark
CVR: DK35418148

Third party verifier
Green Survey
Skovgaardsgade 5C
8000 Aarhus C
Denmark
CVR-nr. 41873574



Sprout and Life Cycle Assessment

Sprout is a Danish brand that operates on a global scale and produces plantable pencils, among other products. Sprout has their main production in Europe and delivers to 60 countries worldwide. Their hero product is the innovative wooden pencil with a second life as it contains plant seeds and can be planted after use.

Sprout strives to achieve total transparency in the production of their hero product, the Sprout pencil. It is Sprout's goal to become carbon neutral in 2022 and carbon positive in 2024, and the team behind Sprout has already taken several steps toward sustainable production (you can find more info about Sprout, their green profile, and their future goals in Sprout Transparency Report 2021).

Sprout is now applying a life cycle assessment to the production of their Sprout pencil to map and quantify inputs and outputs of the production system. By doing this, Sprout creates transparency and shows how they take their environmental responsibilities seriously by documenting their work and efforts. Sprout is also always looking for opportunities for improvement. In addition, Sprout hopes to motivate other companies to take action through complete transparency in sustainable work and, as a result, help to combat greenwashing.

Sprout

Third-party verifier

Green Survey performs life cycle assessment and is an independent consultant company located in Aarhus, Denmark. Green Survey specializes in helping companies document the environmental footprints of a product or service and create transparency by verifying and validating production based on well-documented climate calculations. Green Survey is driven and motivated by making a difference in the green transition for both small and big companies.

GREEN SURVEY

LCA information

Goal and scope

This assessment is a complete LCA done accordingly with ISO standards 14040 and 14044. Therefore, the study includes the definition of objectives and scope, life cycle impact inventory, and impact assessment followed by an interpretation of the results. The results of the LCA will be accurately reported with the intensions to both be used in Sprout's internal and external communication. The results, data, methods, assumptions, and limitations will be transparent and presented in sufficient detail to allow the reader to understand any limitations and trade-offs inherent in the LCA study.

The assessment is a stand-alone LCA and studies the different parts of a single product system intending to create transparency and knowledge about the production of the Sprout®Pencil. as well as to assess, mitigate and monitor for significant impacts on the environment. The assessment includes all production steps, starting with raw material extraction and subsequently manufacturing, fabrication, transportation, distribution, usage, and disposal.

Product information

Product name:
Sprout®Pencil

Product description:
The product consists of a wooden graphite pencil with an average weight of 4.6 grams and a length of 17.5 cm. The pencil used in the LCA is unsharpened with a body made of certified sustainable linden wood and a 100% natural graphite/clay core. The pencil furthermore has a biodegradable cellulose cap encasing sawdust and plant seeds. The pencil is available with 10 different plant seeds; however, the body and cellulose cap remain the same in all versions. The different seeds available are; sunflower, basil, thyme, forget-me-not, cherry tomato, chia, carnation sage, daisy and coriander. The main analysis in this report is done with the sunflower seed, however, a further impact analysis concerning all the different seeds are also present.


Make the world Sprout

Life Cycle Inventory and system boundaries

A production and life cycle assessment system boundaries determine what processes and inputs are included in the assessment. In figure 1, the system boundaries for the directly involved processes in the life cycle of the Sprout pencil are illustrated. The life cycle assessment for the Sprout pencil is based on a cradle-to-grave LCA. Therefore, all relevant processes during the product's life cycle have been accounted for, and no life cycle stages have been omitted, in which significant environmental impacts are taking place.

As shown in figure 1, the life cycle of the Sprout pencil consists of 5 main stages: 1) acquisition of raw materials, 2) Fabrication, 3) Distribution, 4) Usage, and 5) End of life. In addition to the production flow, an array of inputs factors are also shown in figure 1. The list of input factors (figure 1) has all (once or more) contributed to the environmental impact of each step in the supply chain of the Sprout pencil. These input factors cover the use of materials, transport, process emissions, etc., and have all been incorporated in the calculations of the total environmental impact for the final product.

Acquisition of raw materials, manufacturing, and fabrication

The first product stages comprise the acquisition of all raw materials, energy, and transport to the production site, fabrication, and packaging. In the case of the Sprout pencil, the raw materials are extracted from respective forestry (the wooden body of the pencil), mining (the graphite core of the pencil), and from the field (seeds for the capsule). This stage includes inputs like extraction, and transportation of sawlogs and veneer logs, minerals, and plant material. In the manufacturing, and fabrication stage of the Sprout pencil, global values for the use of a sawmill, and other fabrication installations were included. Here inputs like the use of diesel, oil, organic compounds, and energy during production were added.

Transport and distribution

Transportation includes transport to, within, and from the main and smaller production sites. The main manufacturing of the Sprout pencil takes place in Poland, located in Central Europe, and the pencil is then transported to Denmark. An additional transportation value for the average customer is added in the end. Figure 2 shows which parts of the Sprout pencil come from were. The parts of the Sprout pencil are mainly transported using EURO5 freight lorries (16-32 metric tons). However, a few parts, including the graphite and cellulose capsule, are also transported by water. In these cases, global values for freight container ships were used.

Use, new life, and disposal

These stages include the usage and the possibilities for reuse, recovery, and/or recycling potentials. The wooden body, cellulose capsule, and sawdust of the pencil are biodegradable. The graphite in the pencil is not biodegradable, however, no dangerous chemical compounds are present in the graphite/clay mixture that makes up the core or in any part of the pencil. A more complete review of the disposal scenario can be found on page 19.

Data quality, limitations, and assumptions

All significant impacts from inputs and processes have been taken into account in the assessment of the Sprout pencil. The emission conversion factors are provided SimaPro containing industry values. Values specific to the country were used when available, and for other processes, global and European values were applied. The environmental cost of the product is expressed in CO_2 emissions, nutrient emissions, and the use of the earth's resources. These impact factors are further explained on pages 22 and 23.

Except for the graphite input, all inputs and processes entered in the system are transformation processes that contain all process inputs and inputs from associated emissions and resource extractions while excluding transport processes. Transportation data were afterward added accordingly to each process and supplier process. The specific transport from the graphite supplier is unknown because of trait confidentiality. In this case, global values for graphite mining, production, and transportation were used.

The modeling of the life cycle assessment was carried out using Ecoinvent 3.5, SimaPro 9.1.1.1, ReCiPe 2016 v1.1 while applying the midpoint method, Hierarchist version. The assessment has been developed per ISO 14040, ISO 14044, and then additional necessary ISO guidelines.

ReCiPe 2016 v1.1. A harmonized life cycle impact assessment method at midpoint and endpoint level Report I: Characterization. RIVM Report 2016-0104a M.A.J. Huijbregts et al.: http://www.rivm.nl/en/Topics/L/Life_Cycle_Assessment_LCA/Downloads/Documents_ReCiPe2017/Report_ReCiPe_Update_2017

Huijbregts M.A.J., Steinmann Z.J.N., Elshout P.M.F., Stam G., Verones F., Vieira M., Zijp M., Hollander A., van Zelm R. ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level. Int J Life Cycle Assess (2017) 22: 138: https://link.springer.com/article/10.1007/s11367-016-1246-y

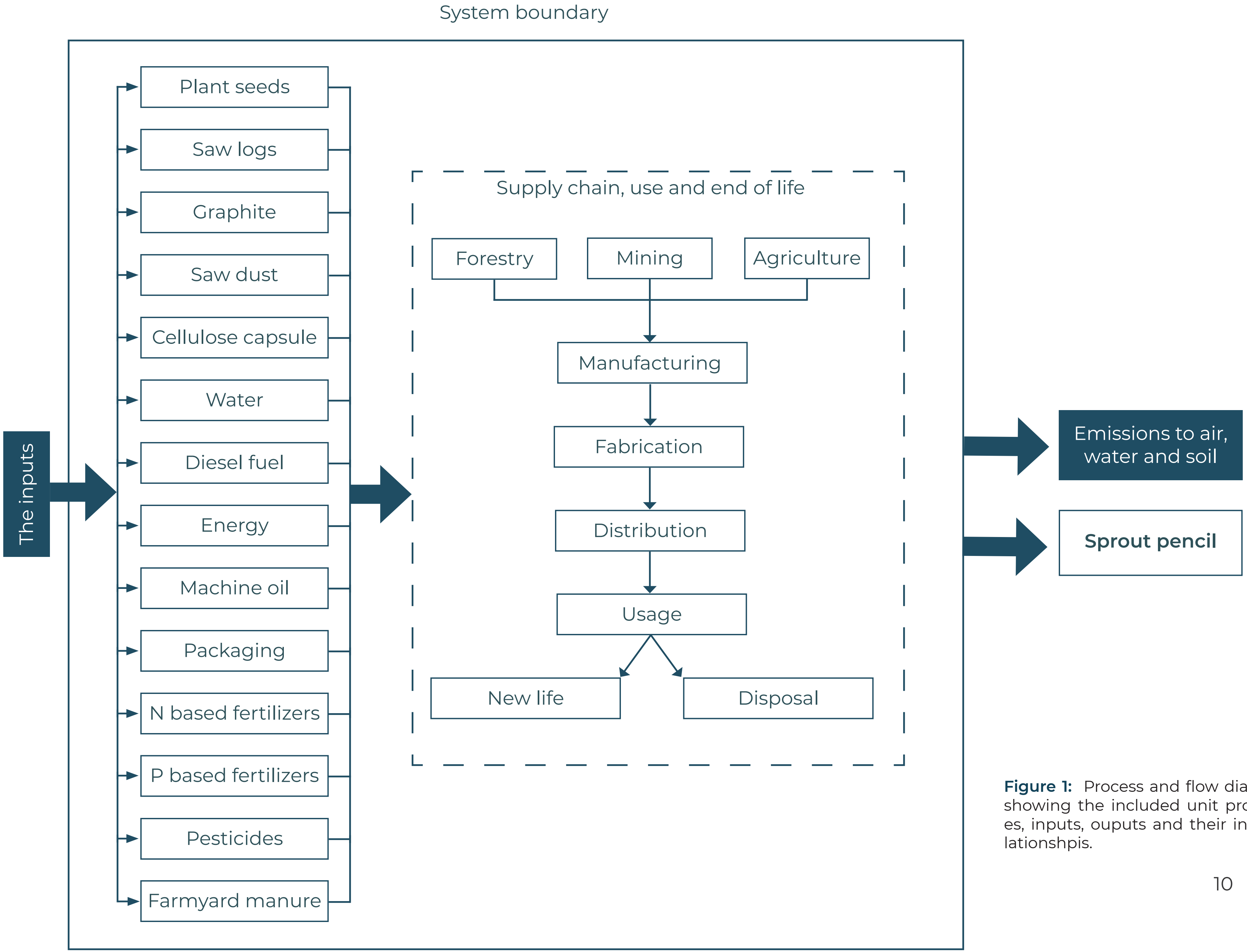


Figure 1: Process and flow diagram showing the included unit processes, inputs, ouputs and their interrelationshpis.

Sprout pencil map

1. Pencil wood
2. Cellulose capsule
3. Graphite
4. Sunflower seeds
5. Thyme seeds and sawdust
6. Basil, Chia, and Carnation seeds
7. Corriander, Sage, Daisy, and Cherry Tomato seeds
8. Forget me not and Cherry tomato seeds

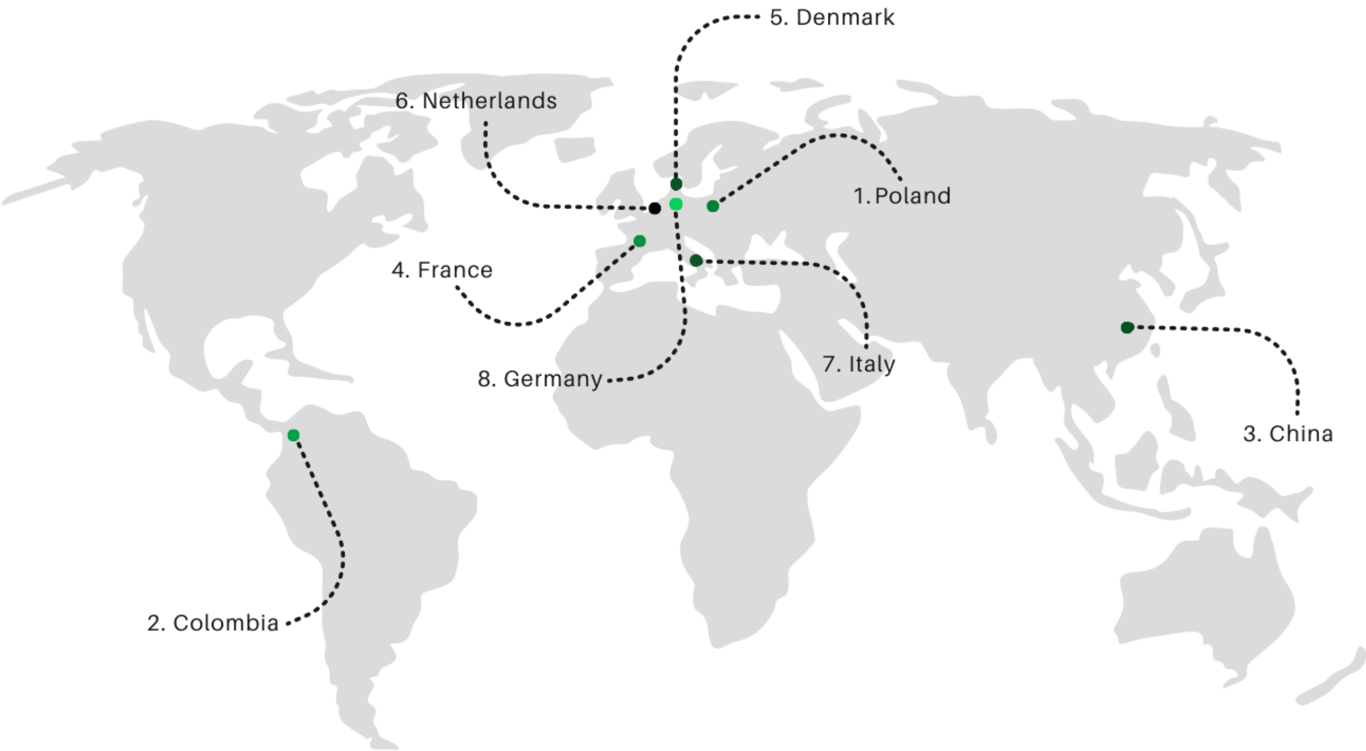


Figure 2: Displays a world map that provide information about the origins of the different Sprout pencil components .

Life Cycle Impact Assessment (LCIA)

The Sprout pencil and the Enviromental Impact results

Table 1: The table below provides an overview of the total impact for all impact categories and how much each component contributes to the total impact for each category of the final product. The impact results refer to the impact of producing one Sprout pencil. For further information and specifications regarding the different types of impact categories, please see references and impact category explanations

	Impact category	Sprout pencil (total)	Sunflower seed	Graphite	Saw dust	Cellulose Capsule	Packeing	Wood body	Additional transport
Global warming	kg CO_2 eq	3.64 E-3	5.81 E-5	7.05 E-5	2.78 E-5	0.00042	0.00139	0.00039	0.00127
Stratospheric ozone depletion	kg CFC-11 eq	4.90 E-9	1.83 E-9	3.85 E-11	2.06 E-11	1.86 E-10	1.61 E-9	2.63 E-10	9.60 E-10
Freshwater eutrophication	kg P eq	1.12 E-6	4.73 E-8	2.04 E-8	2.75 E-9	1.56 E-7	7.31 E-7	7.68 E-8	9.15 E-8
Marine eutrophication	kg N eq	1.50 E-6	1.15 E-6	1.54 E-9	3.04 E-10	1.25 E-8	3.15 E-7	8.32 E-9	8.94 E-9
Land use	m^2 a crop eq	1.33 E-2	0.0043	2.97 E-5	4.95 E-5	0.0001	0.0055	0.0034	0.0001
Mineral resource scarcity	kg Cu eq	1.95 E-5	3.61 E-7	2.07 E-7	1.02 E-7	1.05 E-6	1.17 E-5	1.57 E-6	4.54 E-6
Fossil resource scarcity	kg oil eq	1.11 E-3	5.32 E-8	1.97 E-5	9.36 E-6	0.0001	0.0004	0.0001	0.0004
Water consumption	m^3	3.08 E-5	1.66 E-6	3.36 E-7	6.55 E-8	5.36 E-6	1.99 E-5	1.32 E-6	2.21 E-6

Table 1 displays an overview of the environmental impact results as a result of the production of one Sprout pencil. The table describes the impact of each component in addition to the total environmental impact of the final product during the production.

For example, the global warming impact of producing one Sprout pencil is 0.00364 kg. CO_2 eq. or 3.64 g. CO_2 eq. The component of The Sprout Pencil contributing the most to this result is packaging during production when the different components are shipped to the production site and the transport to Denmark from the production site in Poland (additional transport). Another example could be that the largest contributor to mineral resource scarcity (kg. Cu eq.) is the Pencil graphite core.

It can be difficult to get the full picture of the environmental impact of the Sprout Pencil from this table. The numbers are therefore converted into percentages of the total impact for each category and displayed in a bar graph (figure 3) on page 14.

The Sprout pencil's components and their respective impacts

The bar graph in figure 3 displays the percentage distribution of the Sprout pencil components to the total impact for all categories. The components contribute differently to each impact category. For example, the sunflower seed component has the largest contribution to the marine eutrophication category, with almost 80% of the total impact coming from this component. The large percentage is explained by the use of fertilizers on the field. Another component that has little to no effect on the total results is sawdust. Natural products often contribute the least. However, the amount and short transportation also have a lot to say regarding the results.

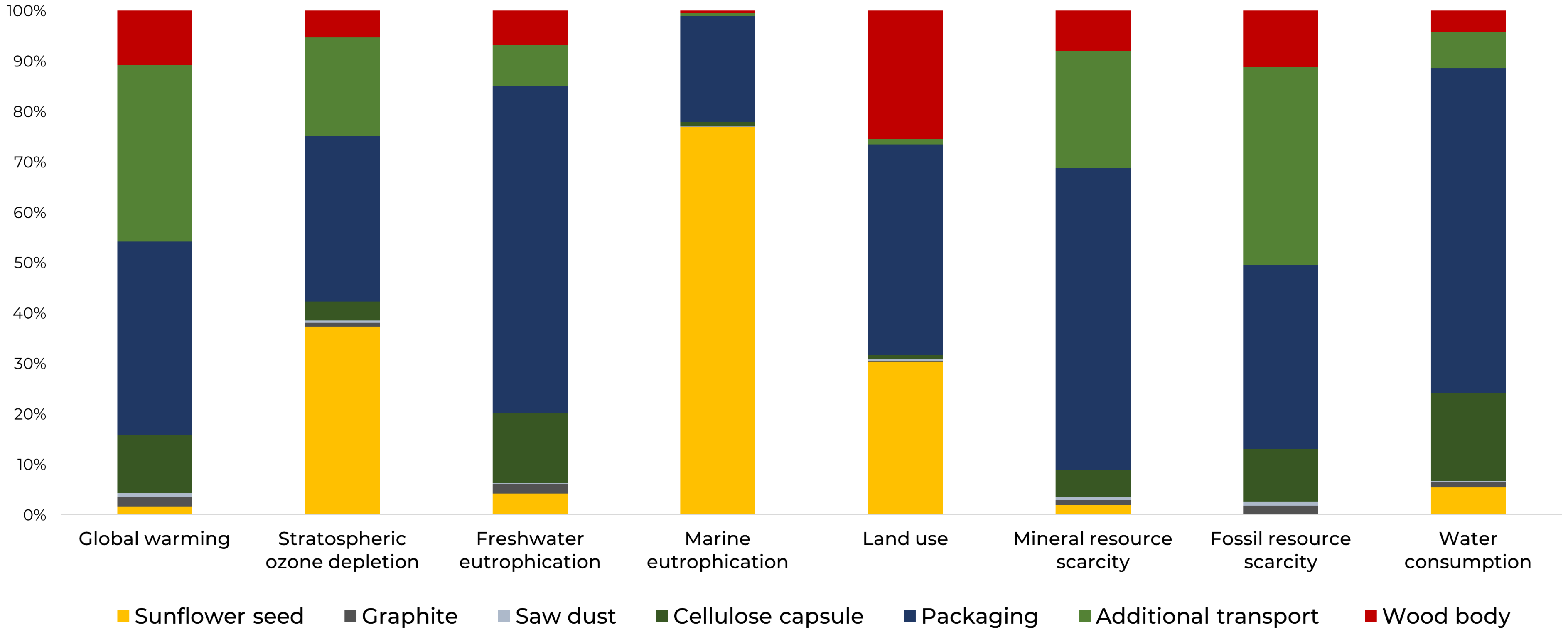


Figure 3: The bar graph displays the contribution of each component of the Sprout pencil to the total impact results in percentages for respectively Global warming (kg CO_2 eq), Stratospheric ozone depletion (kg CFC-11 eq), Freshwater eutrophication (kg P eq), Marine eutrophication (kg N eq), Land use (m^2 a crop eq), Mineral resource scarcity (kg Cu eq), Fossil resource scarcity (kg oil eq) and water consumption (m^3). For further information and specifications regarding the different types of impact categories, please see references and impact category explanations

The Sprout pencil and Global Warming Impact

The characterization factor of climate change is the category; global warming impact. This is the most common impact category when analyzing, comparing, and documenting the environmental impact of products in literature and everyday occurrences. An even clearer picture of the Sprout pencil's global warming impact (kg CO_2 eq) is provided in the pie chart below (figure 4). This chart makes it possible to see the allocated percentages of the different components in more detail.

Because the Sprout pencil is mainly made with natural components, we avoid chemical compounds that usually have a high impact. Other factors like transportation and packaging during transportation will therefore have a more significant influence on the results like those in figure 4.

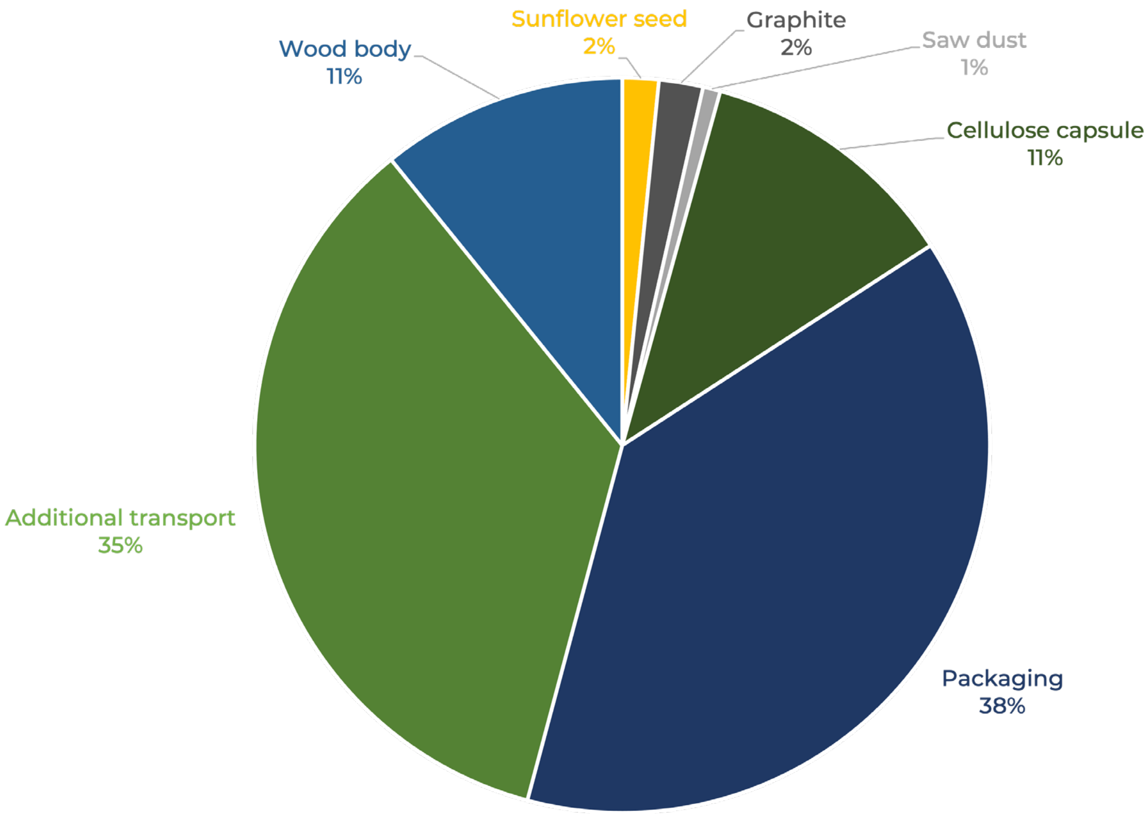


Figure 4: The pie chart illustrates the contribution of each component of the Sprout pencil to the total global warming impact category (kg CO_2 eq) in percentages.

The Sprout pencil and different seeds

Table 2: The table below provides an overview of the different versions of the Sprout pencil (10 different seeds) and their respective values for all impact categories. The impact results refer to the impact of producing one Sprout pencil with the respective seed type. For further information and specifications regarding the different types of impact categories, please see references and impact category explanations

	Impact category	Sunflower	Basil	Thyme	Forget me not	Cherry tomato	Chia	Carnation	Sage	Daisy	Coriander
Global warming	kg CO_2 eq	5.81 E-5	1.51 E-5	4.43 E-6	6.09 E-6	6.22 E-6	1.33 E-5	1.06 E-5	4.56 E-5	3.11 E-6	5.60 E-5
Stratospheric ozone depletion	kg CFC-11 eq	1.83 E-9	1.68 E-10	4.94 E-11	6.91 E-11	6.00 E-11	1.48 E-10	1.19 E-10	4.40 E-10	3.00 E-11	5.40 E-10
Freshwater eutrophication	kg P eq	4.73 E-8	6.65 E-9	1.96 E-9	2.73 E-9	2.41 E-9	5.87 E-9	4.70 E-9	1.77 E-8	1.21E -9	2.17 E-8
Marine eutrophication	kg N eq	1.15 E-6	2.46 E-7	7.22 E-8	1.01 E-7	8.67 E-8	2.17 E-07	1.73 E-7	6.35E-7	4.33 E-8	7.80 E-7
Land use	m^2a crop eq	0.0043	0.0002	6.13 E-5	8.58 E-5	7.37 E-5	0.0001	0.0001	0.0005	3.68 E-5	0.0006
Mineral resource scarcity	kg Cu eq	3.61 E-7	8.54 E-8	2.51 E-8	3.48 E-8	3.34 E-8	7.54 E-8	6.03 E-8	2.45 E-7	1.67 E-8	3.00 E-7
Fossil resource scarcity	kg oil eq	5.32 E-8	3.31 E-6	9.73 E-7	1.32 E-6	1.48 E-6	2.92 E-6	2.33 E-6	1.08 E-5	7.38 E-7	1.33 E-5
Water consumption	m^3	1.66 E-6	5.58 E-6	1.64 E-6	2.30 E-6	1.97 E-6	4.92 E-6	3.94 E-6	1.45 E-5	9.85 E-7	1.77 E-5

The Sprout pencil is available with 10 different kinds of seeds; sunflower, basil, thyme, forget me not, cherry tomato, chia, carnation, sage daisy, and coriander. The table above provides an overview of the different seeds' influence on the Sprout pencil environmental impact.

All seeds originate from Europe and have similar growing conditions with fertilizers, irrigation, manure, and other factors, and all avoid the use of greenhouses. Therefore the main differences in the output from the assessment stem from the transportation and the weight of the seeds. Again we use a graphic illustration to explore the different seeds' impact on global warming on the next page in figure 5.

The Sprout pencil and the different seeds' Global Warming Impact

The bar graph in figure 5 displays the global warming impacts (kg. CO_2 eq) of each version of the Sprout pencil. The sunflower, coriander, and sage seeds have the largest contribution to global warming, whereas the daisy seeds have the smallest impact. It is important to emphasize that although the differences look drastic in the graph, these are very low values concerning the production of the Sprout pencil. For example, when we look at the pie chart in figure 4, the sunflower seeds only account for only 2% of the total global warming impact. The differences in the values are most likely the result of the different weights of the seeds and transportation distance. Figure 2 provides information about the origins of the different types of seeds.

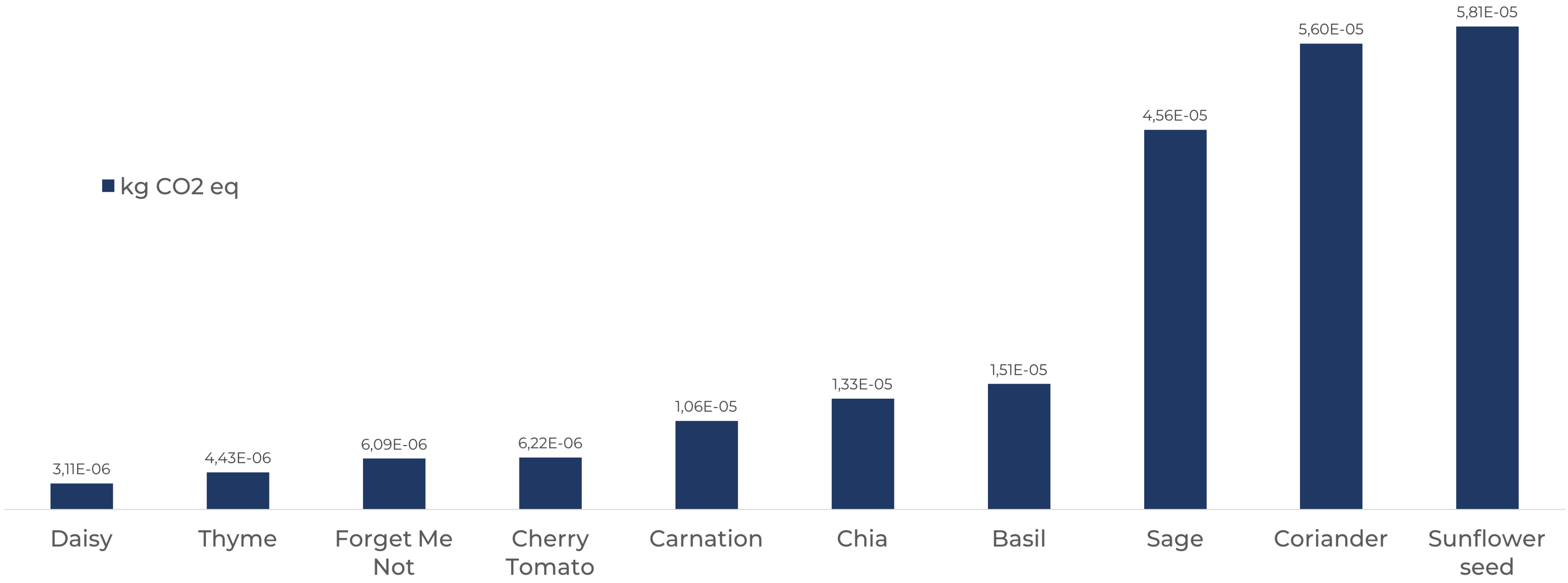


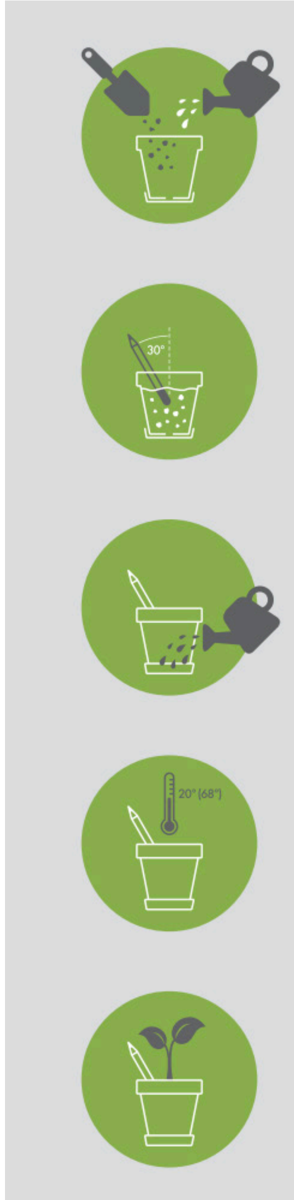
Figure 5: The bar graph illustrates the global warming impact of each version of the Sprout pencil (10 different seeds) in kg. CO_2 eq. The impact results refer to the global warming impact of producing one Sprout pencil with the respective seed. For further information and specifications regarding the different types of impact categories, please see references and impact category explanations.

Waste and disposal scenario

One of the world's biggest problems today is waste. Our way of living produces more waste globally than we know what to do with. We must start thinking of ways to start bringing down our waste amount, and one way that benefits the situation is to start using more products made of natural materials that are more easily biodegradable.

The main thought behind the Sprout pencil is that it is possible to plant the stub after use. Wood is biodegradable and will, although slowly, start to decompose in the soil. The same goes for the sawdust and the cellulose capsule. The seeds contained in the capsule will begin to sprout, and new life will show itself. The core of the pencil is non-toxic and made of natural materials consisting of a mixture of clay and graphite. This part of the pencil is not biodegradable and will eventually need to go to waste management1. Moreover, the pencil shavings from the use of the Sprout pencil can be added to compost or even be added to the same plant pot as the stub, where it would act as mulching and act as a pest deterrent.

During the life of the trees that make up the sawdust and body of the pencil, carbon dioxide (CO_2) is naturally captured and fixated from the atmosphere and stored in the plant tissue. Normally this CO_2 will be realized again. However, by planting the remaining stub and adding the shavings, up to 70% of the CO_2 becomes naturally stored in the soil[2,3]. However, it does put the responsibility on us as consumers to think about how we correctly can handle our waste. By following the advice from Sprout, we can minimize our waste, and by following this process, we also greatly reduce the need for transport or energy for the end-of-life phase. In addition, a new plant will sprout and the cycle will begin again..



[1]Devadula S., Ramani K., Uchil P., Kota S., Mani M., Chakrabarti A. (2013) An Action Effectiveness Measure for Manufacturing Process Performance. In: Chakrabarti A. (eds) CIRP Design 2012. Springer, London. https://doi.org/10.1007/978-1-4471-4507-3_3
[2]Zeng, N. Carbon sequestration via wood burial. Carbon Balance Manage 3, 1 (2008). https://doi.org/10.1186/1750-0680-3-1
[3]Scholtens, F. Carbon sequestration by biomailer wood compost (2017. https://biomeiler.nl/

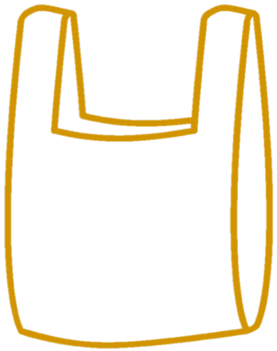
Concluding remarks

The overall aim of this environmental assessment was to assess, mitigate and monitor for significant impacts on the environment and create total transparency in the production of the Sprout pencil. The Sprout pencil is a relatively simple product made of natural materials. In products like the Sprout pencil, the most significant influences on the product's environmental impact often come from transport and packaging. This is also true in the assessment of the Sprout pencil.

The total global warming impact of producing one Sprout pencil is 3.64 g. CO_2 eq. You can compare this to the average new car that emits approximately 120.1 g. of CO_2 eq. every kilometre it drives[1] or to a single use plastic bag that emits 1580 g. CO_2 equivalents during production and its life[2].

It is crucial that we start paying attention to our emissions and furthermore the 17 sustainable development goals. If we are to reach the new goal EU announced in 2020, we are to reduce the emissions of greenhouse gases by 55% compared to 1990 by 2030. Therefore, we must as consumers, private companies, and as the public sector all take responsibility and begin to make informed decisions in our everyday life and work life.

[1]https://www.smmt.co.uk/wp-content/uploads/sites/2/DEF571-SMMT-Co2-report-2017.pdf
[2]http://www.co2everything.com/co2e-of-plastic-bag



Single use plastic bag?
1580 g. CO_2 eq.

Driving a new car?
120.1 g. CO_2 eq. every kilometre.

One Sprout pencil?
3.64 g. CO_2 eq.


Basil

References and impact category explanations

Global warming - Climate change (kg CO_2 eq)
The characterization factor of climate change is the global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as kilograms of carbon dioxide equivalents; abbreviated kg CO_2 eq. The CO_2 eq is calculated by converting amounts of other gases into the equivalent amount of carbon dioxide.

IPCC 2013 supplementary material chap. 8 tab 8SM15 - https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/supplementary/WG1AR5_Ch08SM_FINAL.pdf

Stratospheric ozone depletion (kg CFC-11 eq)
Due to stratospheric ozone depletion, a greater proportion of UV-B radiation reaches the earth's surface. The characterization factor for ozone layer depletion accounts for the destruction of the stratospheric ozone layer by anthropogenic emissions of ozone depleting substances (ODS). The characterization factor was developed by the World Meteorological Organization (WMO) and defines the ozone depletion potential for different gases expressed in kg trichlorofluoromethane equivalents (kg CFC-11 eq).

Scientific Assessment of Ozone Depletion: 1998. Global Ozone Research and Monitoring Project - Report No. 44, ISBN 92-807-1722-7, Geneva. Undefined Report no. 4 by WMO (1999).

Freshwater eutrophication (kg P eq)
The characterization factor of freshwater eutrophication accounts for the environmental persistence (fate) of the emission of P containing nutrients. The unit is kg phosphor to freshwater equivalents (kg P eq).

Struijs, J., Beusen, A., van Jaarsveld, H. and Huijbregts, M.A.J. (2008b). Aquatic Eutrophication. Chapter 6 in: Goedkoop, M., Heijungs, R., Huijbregts, M.A.J., De Schryver, A., Struijs, J., Van Zelm, R. (2008).

ReCiPe 2008 A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level. Report I: Characterisation factors, first edition. Chapter in anthology Chapter on aquatic eutrophication in the ReCiPe report (report I: characterization factors, 2008).

Marine eutrophication (kg N eq)
The characterization factor of marine eutrophication accounts for the environmental persistence (fate) of the emission of N containing nutrients. The unit is kg nitrogen to freshwater equivalents (kg N eq).

Struijs, J., Beusen, A., van Jaarsveld, H. and Huijbregts, M.A.J. (2008b). Aquatic Eutrophication. Chapter 6 in: Goedkoop, M., Heijungs, R., Huijbregts, M.A.J., De Schryver, A., Struijs, J., Van Zelm, R. (2008). ReCiPe 2008 A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level. Report I: Characterisation factors, first edition. In press. Chapter in anthology Chapter on aquatic eutrophication in the ReCiPe report (report I: characterization factors, 2008)

Land use (m^2 a crop eq)
Land use indicates the area of land, either transformed or occupied in a given time, which is the corresponding extent of resource consumption and/or emissions. The unit is m^2 pr. year.

Bos U., Horn R., Beck T., Lindner J.P., Fischer M. (2016). LANCA® Characterization Factors for Life Cycle Impact Assessment. Version 2. Franhofer Verlag, Stuttgart, DE. http://publica.fraunhofer.de/eprints/urn_nbn_de_0011-n-3793106.pdf

Mineral resource scarcity (kg Cu eq)
Mineral resource scarcity is calculated by converting amounts of minerals to the equivalent amount of copper. The unit is kg copper equivalents (kg Cu eq).

van Oers, L, Koning, A, Guinée, JB, Huppes, G (2002) Abiotic resource depletion in LCA. Road and Hydraulic Engineering Institute, Ministry of Transport and Water, Amsterdam http://www.leidenuniv.nl/cml/ssp/projects/lca2/report_abiotic_depletion_web.pdf

Fossil resource scarcity (kg oil eq)
The characterization factor for the use of fossil resources is expressed as the equivalent amount of oil used in kg (kg oil eq).

van Oers, L, Koning, A, Guinée, JB, Huppes, G (2002) Abiotic resource depletion in LCA. Road and Hydraulic Engineering Institute, Ministry of Transport and Water, Amsterdam http://www.leidenuniv.nl/cml/ssp/projects/lca2/report_abiotic_depletion_web.pdf

Water consumption (m^3 eq)
The factor for the freshwater depletion is the amount of freshwater consumption (m^3 eq).

Boulay A.M., Bare J., Benini L., Berger M., Lathuillière M.J., Manzardo A., Margni M., Motoshita M., Núñez M., Pastor A.V., Ridoutt B., Oki T., Worbe S., Pfister S. (2016). The WULCA consensus characterization model for water scarcity footprints: Assessing impacts of water consumption based on available water remaining (AWARE)