Environmental Product Declaration (Self-Declared)

Desk Top Furniture Linoleum

Forbo Flooring Systems

Forbo Furniture Linoleum is the finishing touch for everyone who wants to create breath taking beautifully designed and functional furniture that will stand out from the crowd while also standing the test of time. A high-quality material with a proven pedigree, Furniture Linoleum is renowned for its elegance and durability and is suitable for countless stunning decorative surfacing applications.

Forbo was the first flooring manufacturer to publish a complete Life Cycle Assessment (LCA) report verified by CML in 2000.In addition Forbo is now to publish Environmental Product Declarations (EPD) for all products including full LCA reports. This EPD is using all recognized flooring Product Category Rules and is including additional information to show the impacts on human health and eco-toxicity. By offering the complete story we hope that our stakeholders will be able to use this document as a tool that will translate the environmental performance of Furniture Linoleum into the true value and benefits to all our customers and stakeholders alike.

For more information visit;

www.forbo-flooring.com

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This declaration is a self-declared environmental product declaration in accordance with ISO 14025 and EN15804 that describes the environmental characteristics of the aforementioned product. It promotes the development of sustainable products. This is not a third party certified declaration and all relevant environmental information is disclosed. This EPD may not be comparable to other declarations if they do not comply with ISO 14025, EN 15804 and the reference PCR.

PROGRAM OPERATOR	NA
DECLARATION HOLDER	Forbo Flooring B.V. Industrieweg 12 P.O. Box 13 NL-1560 AA Krommenie
DECLARATION NUMBER	NA
DECLARED PRODUCT	Desk Top Furniture Linoleum
REFERENCE PCR	Flooring: Carpet, Resilient, Laminate, Ceramic, and Wood (NSF 2012)

DATE OF ISSUE	16 September 2016
PERIOD OF VALIDITY	5 Years

CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications

Product Definition

Product Classification and description

This declaration covers Desk Top Furniture Linoleum consisting of 21 unadorned, elegant colors that add a distinctive touch to any piece of furniture. Furniture Linoleum is manufactured from renewable, natural raw materials. Basic ingredients include natural linseed oil, rosin, wood flour and natural pigments. Because of this, Furniture Linoleum is biologically degradable and doesn't harm the environment at any stage in its life. Linoleum is produced by Forbo Flooring for more than 150 years and our well-known brand Desk Top Furniture Linoleum is sold worldwide. This declaration refers to Desk Top Furniture Linoleum sheet of 2.0 mm nominal thickness.

Desktop Furniture Linoleum is build up in 3 layers as illustrated in figure 1.These three layers form one homogeneous product by the cross linking bonding's formed during the oxidative curing process :

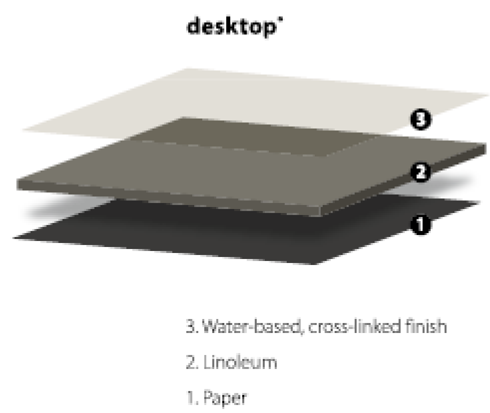

Figure 1: Illustration of Desk Top Furniture Linoleum

1. **Backing:** Impregnated paper, giving the product its flexibility to be used to curved surfaces.
2. **Intermediate layer:** This layer gives Desktop its design and color and is calendared on the paper backing.
3. **Surface layer:** After finishing the product at the trimming department a factory finish is applied to protect the surface layer.

Range of application

Furniture Linoleum can be applied as a surface on furniture in numerous areas such as offices and similar work environments, kitchens, shops and leisure centres. Furniture applications include:

• Desktops
• Shop and reception counters
• Cupboards
• Interior doors
• Chairs
• Cupboard panels
• Dividing walls (movable and fixed)
• Wall panelling

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Product Standard

The products considered in this EPD have the following technical specifications:

Technical specifications

		desktop®
Total thickness	EN-ISO 24346	2.0 mm
Roll width	EN-ISO 24341	1.83 m
Roll length	EN-ISO 24341	≤ 30 m
Weight	EN-ISO 23997	2.1 kg/m^2
Indentation-residual	EN-ISO 24341-1	< 0.20 mm
Light fastness	EN-ISO 105-B02	Method 3: blue scale minimum 6.
Gloss level	ISO 2813	< 5
Flexibility	EN-ISO 24344	ø 50 mm
Resistance to chemicals	EN-ISO 26987	Resistant to diluted acids, oils, fats and to the conventional solvents. Not resistant to prolonged exposure to alkalis.
Heat resistance		70° C
Body voltage	EN 1815	< 2 kV
Life Cycle Assessment		LCA is the foundation for securing the lowest environmental impact.

Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SA 8000 Social Accountability Standard

ISO 9001 ISO 14001 OHSAS 18001 SA 8000

Delivery Status

Table 1: Specification of delivered product

Characteristics	Nominal Value	Unit
Product thickness	2.0	mm
Product Weight 2.0 mm	2100	g/m^2
Rolls Width Length	1.83 or 2.00 (4023) ≤ 30	meter meter

Material Content

Material Content of the Product

Table 2: Composition of Desktop Furniture Linoleum

Component	Material	Availability	Amount [%]	Origin
Binder	Linseed oil Gum rosin Resin	Bio based crop Bio based crop Non Renewable	24% 1% 5%	USA/Canada/Europe Indonesia/China Europe
Filler	Wood flour Calcium carbonate	Bio based waste product from wood processing Mineral abundant	27.5% 14%	Germany Germany
Pigment	Titanium dioxide & Various other pigments	Limited mineral	4%	Global
Backing	Felt paper	Bio based crop (Cellulose 90%)	23.5%	Germany
Finish	Lacquer		1%	Netherlands

Production of Main Materials

Linseed oil : Linseed oil is obtained by pressing the seeds of the flax plant. After filtering a clear golden yellow liquid remains.
Gum rosin : Rosin is obtained by wounding pine trees. The crude gum is collected and is separated into turpentine and rosin by distillation.
Wood flour : Postindustrial bio based soft wood waste from the wood industry, which is milled into flour.
Resin : A cationic polymerization reaction converts the hydrocarbon resin oil into a hard resin.
Calcium carbonate : An abundant mineral found in all parts of the world as the chief substance in rocks (i.e., marble and limestone). It can be ground to varying particle sizes and is widely used as filler.
Titanium dioxide : A white pigment produced from the mineral rutile, a naturally occurring form of titanium dioxide. The production of the pigment is a large-scale chemical process
Various other pigments : The vast majority of the used color pigments are iron oxide based.
Felt Paper : Natural fiber (Cellulose) fleece, reinforced with an aqueous polymer dispersion.
Lacquer : The factory applied lacquer is a water-based, cross-linked acrylic finish.

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Production of Furniture Linoleum

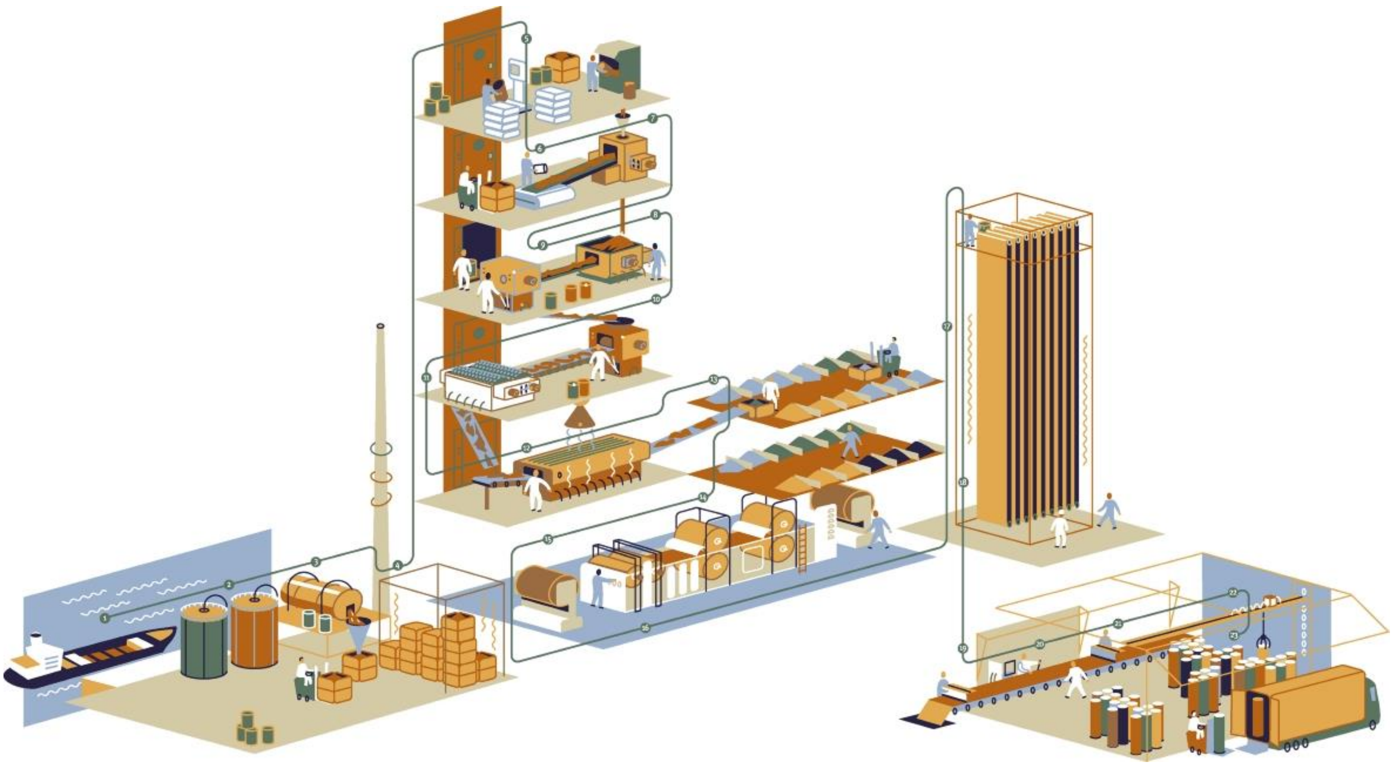

Figure 2: Illustration of the Production process

Furniture Linoleum is produced in several stages starting with the oxidation of linseed oil mixed with rosin. With the influence of oxygen from the atmosphere a tough sticky material is obtained called linoleum cement. The linoleum cement is stored in containers for a few days for further reaction and after this it is mixed with wood flour, calcium carbonate, resin, titanium dioxide and pigments. This mixture is calendared on a paper backing and stored in drying rooms, to cure till the required hardness is reached. After approximately 7 days the material is taken out from the drying room to the trimming department where the factory finish is applied on the surface of the product and the end inspection is done. Finally the edges are trimmed and the sheet is cut to length into rolls of approximately 30 meter. The trimmings and the rejected product are reused.

Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems

Production Waste

Rejected material and the cuttings of the trimming stage are being thermally recycled in a waste incineration plant. Packaging materials are being collected separately and externally recycled.

Delivery and Installation of the Floor Covering

Delivery

A worldwide distribution by truck and container ship is considered. On average every square meter of Desktop is transported as follows:

- Transport distance 40 t truck 615 km
- Transport distance 7.5t truck (Fine distribution) 123 km
- Capacity utilization trucks (including empty runs) 85 %
- Transport distance Ocean ship 0 km
- Capacity utilization Ocean ship 48%

Installation

Because of the specific techniques used during the installation of Desktop Furniture Linoleum 1% of the material is cut off as installation waste. For installation of Desktop on the carrier material, e.g.: MDF, chipboard, multiplex or pressed Plates, a scenario has been modeled assuming 0.280 kg/m^2 of adhesive is required.

Health, Safety and Environmental Aspects during Installation

Forbo flooring recommends to use (low) zero emission water based PVA adhesives for installing Desktop Furniture Linoleum.

Waste

Waste during the installation process can be thermally recycled in a waste incineration plant. Since the major part of Desktop Furniture Linoleum is sold in Europe the European electricity grid mix is used in the calculations for the energy recovery during incineration.

Packaging

Cardboard tubes and packaging paper can be collected separately and should be used in a local recycling process. In the calculation model 100% incineration is taken into account for which there is a credit received.

Use stage

The service lifetime of a Furniture Linoleum for a certain application is too widespread to give one common number. For this EPD model the reference service lifetime (RSL) is set to one year. This means that all impacts for the use phase are based on the cleaning and maintenance model for one year. Depending on the area of use, the technical lifetime advised by the manufacturer and the estimated time of use by the customer, the service lifetime can be determined. The use phase impacts should be calculated with the foreseen service life to arrive at the total environmental impact.

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Cleaning and Maintenance

For the calculations the following cleaning regime is considered:

- Dry cleaning with a dust wiper, twice a week.
- Once a week wet cleaning with a damp cloth using 0.062 l/m^2 water and 0.0003 kg/m^2 neutral cleaner. This result in the use of 3.224 l/m^2*year water and 0.016 kg/m^2*year neutral cleaner. The wet cleaning takes place without power machine usage. Waste water treatment of the arising waste water from cleaning is considered.

The cleaning regime that is recommended in practice will be highly dependent on the use of the premises where the Furniture Linoleum is installed.

Prevention of Structural Damage

Preventive measures and stain removal :

• Sharp items may cause scratches, use soft protection in case of doubt.
• Remove stains immediately after spillage (such as ink, coffee, tea, red wine).
• Prevent stubborn stains from forming; use coasters under flowerpots, vases, cups etc.
• Desk Top: for stubborn stains such as ink and pencil, use a clean cloth and neutral cleaner.

End of Life

The deconstruction of installed Desktop Furniture Linoleumcan be done mechanically and the electrical energy needed for this is estimated to be 0.03 kWh/sqm. This amount of energy is taken into account for the calculations.
For the end of life stage no landfilling is taken into account, since the vast majority of the countries in which Desktop Furniture Linoleum is sold are having a non landfill policy. Because of the high calorific value of Desktop the incineration is very profitable as a waste to energy conversion.

Life Cycle Assessment

A full Life Cycle Assessment has bee carried out according to ISO 14040 and ISO 14044.

The following Life Cycle Stages are assessed :

- Production Stage (Raw material acquisition, transportation to Manufacturing and Manufacturing)
- Transport Gate to User
- Installation Stage
- Use Stage
- End of Life Stage

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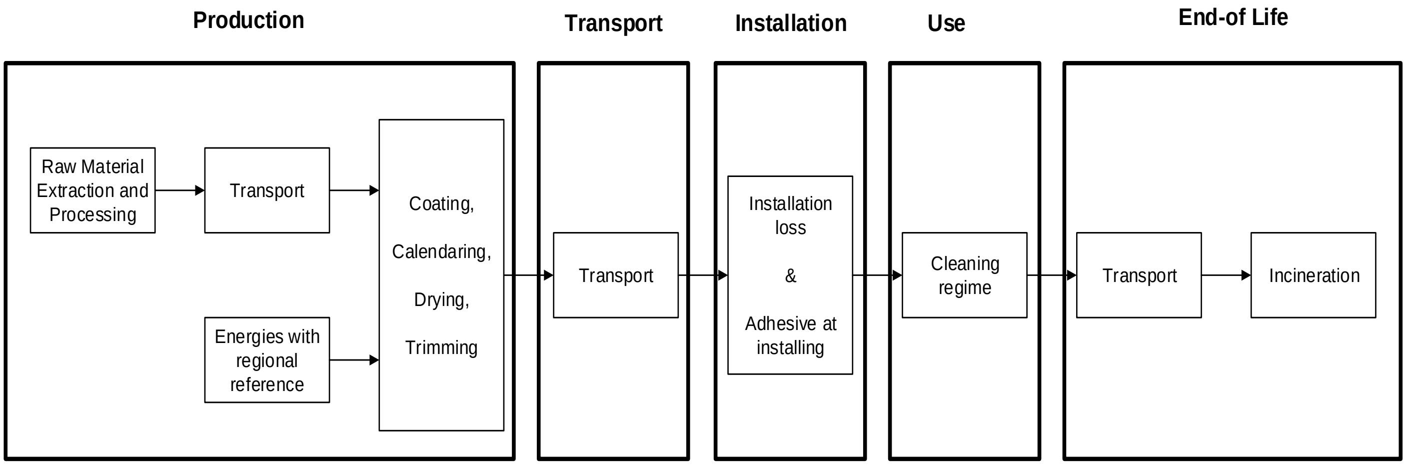


Figure 3: Flow chart of the Life Cycle Assessment

Description of the Declared Functional Unit

The functional unit is one square meter of installed product and the use stage is considered for one year of service life.

Cut off Criteria

The cut-off criteria shall be 1% of renewable and non-renewable primary energy usage and 1% of the total mass of the unit process. The total neglected input flows per module shall be a maximum of 5% of energy usage and mass.

In practice, in this assessment, all data from the production data acquisition are considered, i.e. all raw materials used as per formulation, use of water, electricity and other fuels, the required packaging materials, and all direct production waste. Transport data on all considered inputs and output material are also considered.

Allocations

In the present study some allocations have been made. Detailed explanations can be found in the chapters below.

Co-product allocation

No co-product allocation occurs in the product system.

Allocation of multi-input processes

The Production and End of Life stage include incineration plants. In these processes different products are treated together within a process. The allocation procedures followed in these cases are based on a physical classification of the mass flows or calorific values.

Credits from energy substitution are allocated to the production stage, because the gained energy from energy substitution is lower than the energy input in this stage. The same quality of energy is considered.

Allocation procedure of reuse, recycling and recovery

The installation waste and end of life waste is fed into incineration processes. Incineration processes include cogeneration processes which give thermal and power energy as outputs. It is assumed that this recovered energy offsets that produced by the European average grid mix and thermal energy generation from natural gas.

The LCA dataset used to model the incineration of Desktop is based on data developed by European Resilient Flooring Manufacturers' Institute (ERFMI) and is specific to linoleum flooring products. This indicates that 250 kWh/tonne electricity and 9744 MJ/tonne thermal energy is recovered during incineration. This model is part of the ERFMI 2008 LCA study on resilient floorings; critical reviewed by Dr ir Jeroen Guinée (Institute of Environmental Sciences CML) /ERFMI 2008/.

Description of the allocation processes in the LCA report

The description of allocation rules in of this LCA report meets the requirements of the PCR.

LCA Data

As a general rule, specific data derived from specific production processes or average data derived from specific production processes have been used as the first choice as a basis for calculating an EPD.

For life cycle modeling of the considered products, the GaBi 6 Software System for Life Cycle Engineering, developed by Thinkstep has been used. All relevant LCA datasets are taken from the GaBi 6 software database. The datasets from the database GaBi are documented in the online documentation. To ensure comparability of results in the LCA, the basic data of GaBi database were used for energy, transportation and auxiliary materials.

Data Quality

The requirements for data quality and LCA data correspond to the specifications of the PCR.

Foreground data are based on 1 year averaged data (year 2015). The reference ages of LCA datasets vary but are given in the table in the Appendix. The time period over which inputs to and outputs from the system is accounted for is 100 years from the year for which the data set is deemed representative. The technological LCA of the collected data reflects the physical reality of the declared product. The datasets are complete, conform to the system boundaries and the criteria for the exclusion of inputs and outputs and are geographical representative for the supply chain of Forbo flooring.

For life cycle modeling of the considered products the GaBi 6 Software System for Life Cycle Engineering, developed by ThinkStep, is used. All relevant LCA datasets are taken from the GaBi 6 software database. The last revision of the used data sets took place within the last 10 years.

System Boundaries

Production Stage includes provision of all materials, products and energy, packaging processing and its transport, as well as waste processing up to the end-of waste state or disposal of final residues during the product stage.

Transport and Installation Stage includes provision of all materials, products and energy, as well as waste processing up to the end-of-waste state or disposal of final residues during the construction stage. These information modules also include all impacts and aspects related to any losses during this construction stage (i.e. production, transport, and waste processing and disposal of the lost products and materials). For the transportation a worldwide distribution is considered.

Use Stage includes provision and transport of all materials, products and related energy and water use, as well as waste processing up to the end-of-waste state or disposal of final residues during this part of the use stage. These information modules also include all impacts and aspects related to the losses during this part of the use stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

End of Life Stage includes provision and all transports, provision of all materials, products and related energy and water use. It also includes any declared benefits and loads from net flows leaving the product system that have not been allocated as co-products and that have passed the end-of-waste state in the form of reuse, recovery and/or recycling potentials.

Power mix

The selection of LCA data for the electricity generation is in line with the PCR.
The products are manufactured in Assendelft, the Netherlands. The GaBi 6 Hydropower dataset has therefore been used (reference year 2012). The energy supplier is providing Forbo with a certificate every year.

CO_2-Certificates

No CO_2-certificates are considered in this study.

Life Cycle Inventory Analysis

The total primary energy for one square meter installed Desktop Furniture Linoleum 2.0 mm is presented in table 3 with their specific energy resources.

Table 3: Primary energy for all life cycle stages for Desktop Furniture Linoleum 2.0 mm for one year

Non-renewable primary energy by resources	Unit	Total Life cycle	Total Life cycle (%)	Production	Transport	Installation	Use (1 yr)	End of Life
Total non-renewable primary energy	MJ	45,84	100	49,25	2,95	9,14	1,19	-16,69
Crude oil	MJ	23,06	50%	14,81	2,7	4,6	0,4	0,55
Hard coal	MJ	3,06	7%	3,52	0,01	0,16	0,05	-0,68
Lignite	MJ	1,59	3%	1,85	0	0,18	0,05	-0,5
Natural gas	MJ	16,33	36%	26,16	0,23	4,21	0,61	-14,87
Uranium	MJ	1,81	4%	2,91	0,01	-0,01	0,08	-1,18
Renewable primary energy by resources	**Unit**	**Total Life cycle**	**Total Life cycle (%)**	**Production**	**Transport**	**Installation**	**Use (1 yr)**	**End of Life**
Total renewable primary energy	MJ	68,7	100	69,3	0,06	0,17	0,01	-0,85
Geothermical	MJ	0	0%	0,01	0	0	0	-0,01
Hydro power	MJ	9,72	14%	9,95	0	-0,01	0,01	-0,23
Solar energy	MJ	58,75	86%	58,91	0,06	0,14	0	-0,37
Wind power	MJ	0,23	0%	0,42	0	0,04	0,01	-0,24

Waste and non-renewable resource consumption

In the table 4 the non-renewable resource consumption and waste production are shown for all life cycle stages for a one year usage.

Table 4: Waste categories and non-renewable resources for Desktop 2.0 mm (one year)

Wastes	Unit	Total Life cycle	Production	Transport	Installation	Use (1yr)	End of Life
Hazardous waste	[kg]	9,66E-07	7,70E-07	7,92E-08	4,97E-09	3,11E-10	1,12E-07
Non-hazardous waste	[kg]	5,55E+00	3,87E+00	8,38E-03	4,72E-01	6,84E-02	1,13E+00
Radioactive waste	[kg]	1,97E-03	1,13E-03	3,82E-06	1,10E-04	2,63E-05	6,96E-04
Resources	**Unit**	**Total Life cycle**	**Production**	**Transport**	**Installation**	**Use (1yr)**	**End of Life**
Non-renewable resources	[kg]	4,82	5,13	0,01	0,37	0,07	-0,76

Life Cycle Assessment

In table 5 the environmental impacts for one lifecycle is presented for Desktop 2.0 mm. In table 6 the environmental impacts are presented for all the lifecycle stages.

Table 5: Results of the LCA – Environmental impacts one lifecycle (one year) – Desktop 2.0 mm

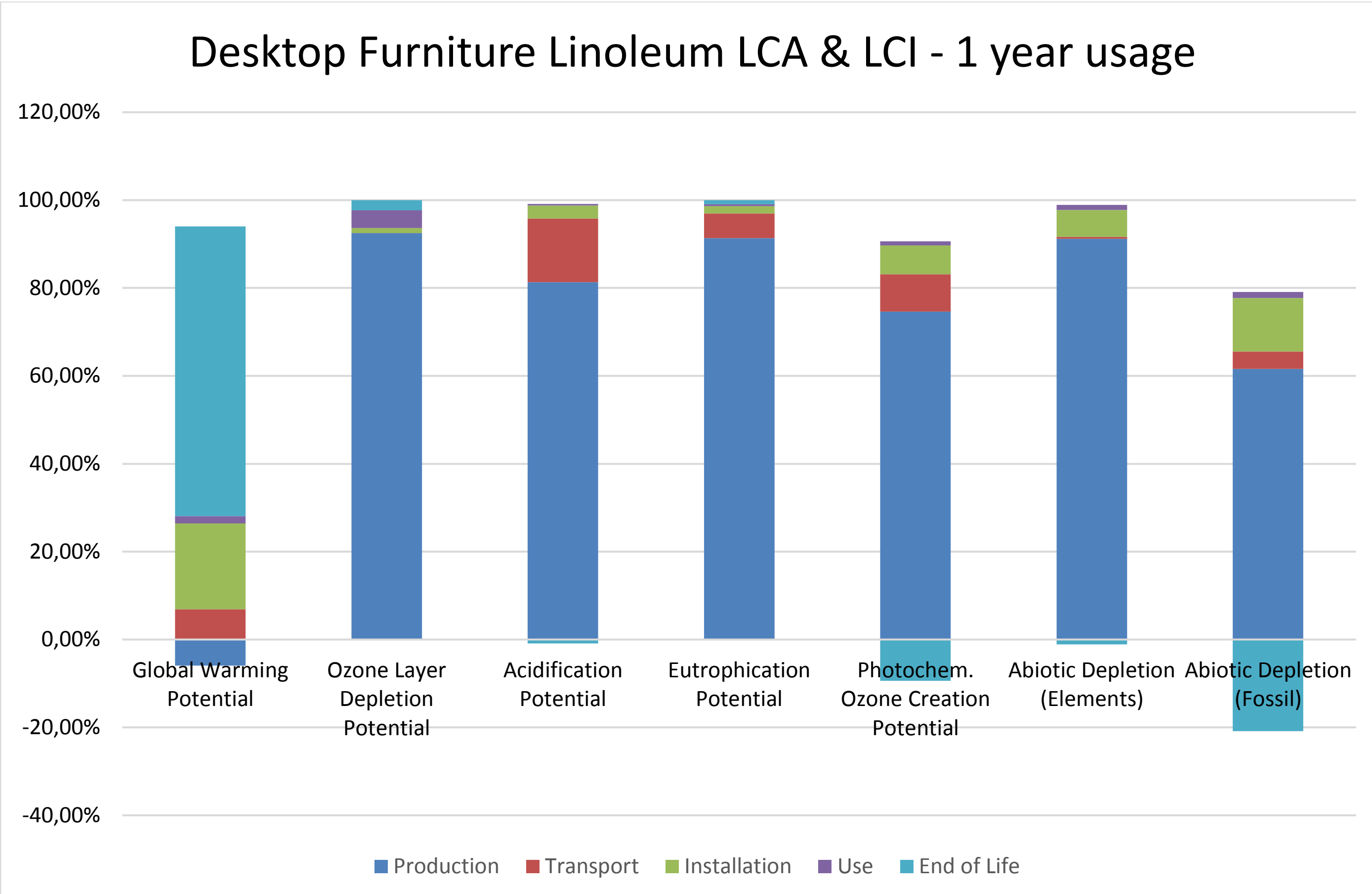
Impact Category : CML 2001 – Nov. 2010	Desktop 2.0 mm	Unit
Global Warming Potential (GWP 100 years)	3,83E+00	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	5,09E-08	kg R11-Equiv.
Acidification Potential (AP)	3,39E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	9,67E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	1,62E-03	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	2,24E-06	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	4,37E+01	[MJ]

Table 6: Results of the LCA – Environmental impact for Desktop 2.0 mm (one year)

Impact Category : CML 2001 – Nov. 2010	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	-2,59E-01	3,00E-01	8,46E-01	7,35E-02	2,86E+00
Ozone Layer Depletion Potential	kg R11-Equiv.	4,71E-08	8,94E-13	5,79E-10	2,06E-09	1,19E-09
Acidification Potential	kg SO2-Equiv.	2,81E-02	4,98E-03	1,04E-03	1,10E-04	-3,06E-04
Eutrophication Potential	kg PSO4-Equiv.	8,83E-03	5,48E-04	1,59E-04	4,09E-05	9,10E-05
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	1,49E-03	1,71E-04	1,30E-04	1,88E-05	-1,88E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2,09E-06	9,07E-09	1,41E-07	2,63E-08	-2,52E-08
Abiotic Depletion Fossil	MJ	4,62E+01	2,94E+00	9,14E+00	1,06E+00	-1,57E+01

The relative contribution of each process stage to each impact category for Desktop 2.0 mm is shown in figure 4.

Figure 4: relative contribution of each process stage to each impact category for Desktop 2.0 mm for a one year usage.



Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

In most impact categories (ODP, AP, EP, POCP, ADPE, ADPF) the production stage has the main contribution to the overall impact. For these categories the main contributor in the production stage is the Raw material supply with a share of 64-87% of total impacts from the production stage.

For GWP, ADPE, and ADPF the adhesive for the installation has a significant impact. The LCA for the installation is based on a conservative assumption of 280 g/m² adhesive. In practice this amount will almost always be lower depending on the application of the material.

Forbo declares in the EPD a worldwide distribution by truck (951km) and container ship (4916 km). For this scenario the transport has a relevance of 6%-15% in the impact categories GWP, AP, EP, POCP and ADPF.

The LCA for GWP reflects the use of renewable raw materials for the production of Desktop (linseed oil and Felt paper backing). Carbon dioxide, a greenhouse gas, is locked in from the atmosphere in the course of the plant growth via photosynthesis and stored during the use stage. This carbon dioxide is not released until the end of life when it is incinerated with energy recovery – this process accounts for the greatest emission of greenhouse gases in the life cycle of the product.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for GWP, POCP and ADPF as reported in the End of Life stage.

Additional Environmental Information

To be fully transparant Forbo Flooring does not only want to declare the environmental impacts required in the PCR, but also the impacts on human health and eco-toxicity. Furthermore the outcome of the calculations according to the european Standard EN15804 are published in this section.

Toxicity

For this calculations the USEtoxTM model is used as being the globally recommended preferred model for characterization modelling of human and eco-toxic impacts in LCIA by the United Nations Environment Programme SETAC Life Cycle Initiative.

According to the "ILCD Handbook: Recommendations for Life Cycle Impact Assessment in the European context" the recommended characterization models and associated characterization factors are classified according to their quality into three levels:

- Level I (recommended and satisfactory),
- level II (recommended but in need of some improvements)
- level III (recommended, but to be applied with caution).

A mixed classification sometimes is related to the application of the classified method to different types of substances. USEtoxTM is classified as Level II / III, unlike for example the CML impact categories which are classified as Level I.

Table 7: Results of the LCA – Environmental impacts one lifecycle (one year) – Desktop 2.0 mm

Impact Category : USEtox	Desktop 2.0 mm	Unit
Ecotoxicity	6,85E-01	PAF m3.day
Human toxicity, cancer	2,91E-09	Cases
Human toxicity, non-canc.	4,29E-07	Cases

In the following table the impacts are subdivided into the lifecycle stages.

Table 8: Results of the LCA – Environmental impact for Desktop 2.0 mm (one year)

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Ecotoxicity	PAF m3.day	6,28E-01	1,75E-02	2,72E-02	1,14E-02	8,51E-04
Human toxicity, cancer	cases	2,33E-09	7,34E-11	3,11E-10	2,83E-10	-8,89E-11
Human toxicity, non-canc.	cases	3,84E-07	1,02E-08	2,95E-08	1,91E-09	4,02E-09

Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

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The Eco-toxicity is predominated by the production stage in which the raw materials are having a big impact with a share of around 89% of the total impact category. Other small contributors are the transport to the customer and the adhesive used for installing the material.

In the Human toxicity (cancer) the largest contribution is coming from the production stage where the raw material extraction is contributing 71% to the total impact, where the manufacturing is accountable for 8.5%. Other significant contributions come from the Installation (Adhesive) with 11.5% and Use stage (Waste water treatment and electricity) with 9%.

Also for Human toxicity (non-canc.) by far the biggest impact is coming from the production stage, where the contribution of the raw material extraction with 85% is predominating this life cycle stage. A small but significant contribution to the total impact is coming from the installation stage. The other impact categories are all scoring less than 2%.

EN15804 Results

In this section the calculations have been conducted and verified according to the requirements of the European Standard EN 15804. In addition, calculations followed the document "Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report", however, Part A was not included as a part of the verification.

Table 9: Results of the LCA – Environmental impact for Desktop 2.0 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
GWP	[kg CO2-Eq.]	-2,59E-01	3,00E-01	6,53E-01	7,35E-02	1,39E-02	6,08E-02	4,34E+00	-1,36E+00
ODP	[kg CFC11-Eq.]	4,71E-08	8,94E-13	4,87E-10	2,06E-09	9,89E-12	1,25E-13	1,45E-09	-1,73E-10
AP	[kg SO2-Eq.]	2,81E-02	4,98E-03	1,17E-03	1,10E-04	3,88E-05	2,35E-04	5,75E-04	-1,29E-03
EP	[kg PO43-- Eq.]	8,83E-03	5,48E-04	1,62E-04	4,09E-05	3,47E-06	6,00E-05	1,78E-04	-1,54E-04
POCP	[kg Ethen Eq.]	1,49E-03	1,71E-04	1,58E-04	1,88E-05	2,67E-06	-8,32E-05	7,58E-05	-2,11E-04
ADPE	[kg Sb Eq.]	2,09E-06	9,07E-09	1,54E-07	2,63E-08	4,32E-09	4,57E-09	6,85E-08	-1,15E-07
ADPF	[MJ]	4,62E+01	2,94E+00	1,17E+01	1,06E+00	1,51E-01	8,24E-01	1,55E+00	-2,07E+01

GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

Table 10: Results of the LCA – Resource use for Desktop 2.0 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	3,91E+01	-	-	-	-	-	-	-
PERM	[MJ]	3,04E+01	-	-	-	-	-	-	-
PERT	[MJ]	6,95E+01	6,34E-02	3,80E-01	1,36E-02	6,80E-02	5,61E-02	6,43E-03	-1,19E+00
PENRE	[MJ]	3,98E+01	-	-	-	-	-	-	-
PENRM	[MJ]	9,47E+00	-	-	-	-	-	-	-
PENRT	[MJ]	4,93E+01	2,95E+00	1,19E+01	1,19E+00	2,43E-01	8,26E-01	1,76E+00	-2,23E+01
SM	[kg]	4,09E-01	-	-	-	-	-	-	-
RSF	[MJ]	1,47E-03	0,00E+00	2,71E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	[MJ]	1,45E-02	0,00E+00	2,84E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	[kg]	2,74E+01	1,59E-01	2,06E+00	1,14E-01	1,05E-01	8,48E-02	-2,09E-02	-1,89E+00

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

Table 11: Results of the LCA – Output flows and Waste categories for Desktop 2.0 mm (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	7.12E-06	7.96E-07	1.32E-06	2.29E-06	1.24E-07	9.44E-07	0.00E+00	-5.76E-06
NHWD	[kg]	4.92E+00	1.26E-02	4.67E-01	1.16E+00	5.86E-02	7.87E-03	4.16E-02	-1.46E+00
RWD	[kg]	1.30E-03	5.78E-06	1.25E-04	7.19E-04	3.78E-05	1.56E-06	2.43E-05	-9.36E-04
CRU	[kg]	-	-	-	-	-	-	-	0
MFR	[kg]	-	-	-	-	-	-	-	0
MER	[kg]	-	-	-	-	-	-	-	1.60E+00
EE Power	[MJ]	-	-	1,91E-02	-	-	-	2,07E+00	-
EE Thermal energy	[MJ]	-	-	2,07E-01	-	-	-	2,24E+01	-
HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EE = Exported energy per energy carrier									

Interpretation

The interpretation of the environmental impacts of the EN 15804 results are similar to the interpretation found on pages 13 and 14.

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ISO 14040 2006	Environmental management - Life cycle assessment - Principles and framework (ISO 14040); German and English version EN ISO 14040
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Description of Selected Impact Categories

Abiotic Depletion Potential

The abiotic depletion potential covers all natural resources such as metal containing ores, crude oil and mineral raw materials. Abiotic resources include all raw materials from non-living resources that are non-renewable. This impact category describes the reduction of the global amount of non-renewable raw materials. Non-renewable means a time frame of at least 500 years. This impact category covers an evaluation of the availability of natural elements in general, as well as the availability of fossil energy carriers.

ADP (elements) describes the quantity of non-energetic resources directly withdrawn from the geosphere. It reflects the scarcity of the materials in the geosphere and is expressed in Antimony equivalents. The characterization factors are published by the CML, Oers 2010.

Are fossil energy carriers included in the impact category, it is ADP (fossil). Fossil fuels are used similarly to the primary energy consumption; the unit is therefore also MJ. In contrast to the primary fossil energy ADP fossil does not contain uranium, because this does not count as a fossil fuel.

Primary energy consumption

Primary energy demand is often difficult to determine due to the various types of energy source. Primary energy demand is the quantity of energy directly withdrawn from the hydrosphere, atmosphere or geosphere or energy source without any anthropogenic change. For fossil fuels and uranium, this would be the amount of resource withdrawn expressed in its energy equivalent (i.e. the energy content of the raw material). For renewable resources, the energy-characterised amount of biomass consumed would be described. For hydropower, it would be based on the amount of energy that is gained from the change in the potential energy of water (i.e. from the height difference). As aggregated values, the following primary energies are designated:

The total **"Primary energy consumption non-renewable"**, given in MJ, essentially characterises the gain from the energy sources natural gas, crude oil, lignite, coal and uranium. Natural gas and crude oil will both be used for energy production and as material constituents e.g. in plastics. Coal will primarily be used for energy production. Uranium will only be used for electricity production in nuclear power stations.

The total **"Primary energy consumption renewable"**, given in MJ, is generally accounted separately and comprises hydropower, wind power, solar energy and biomass. It is important that the end energy (e.g. 1 kWh of electricity) and the primary energy used are not miscalculated with each other; otherwise the efficiency for production or supply of the end energy will not be accounted for. The energy content of the manufactured products will be considered as feedstock energy content. It will be characterised by the net calorific value of the product. It represents the still usable energy content.

Waste categories

There are various different qualities of waste. For example, waste can be classed according to German and European waste directives. All LCA data sets (electricity generation, raw material etc.) already contain the treatment of the waste with very low waste output at the end of the stage. So the amount of waste is predominantly caused by foreground processes during the production phase. This is important for the interpretation of waste amounts.

From a balancing point of view, it makes sense to divide waste into three categories. The categories overburden/tailings, industrial waste for municipal disposal and hazardous waste will be used.

Overburden / tailings in kg: This category consists of the layer which must be removed in order to access raw material extraction, ash and other raw material extraction conditional materials for disposal. Also included in this category are tailings such as inert rock, slag, red mud etc.

Industrial waste for municipal disposal in kg: This term contains the aggregated values of industrial waste for municipal waste according to 3. AbfVwV TA SiedlABf.

Hazardous waste in kg: This category includes materials that will be treated in a hazardous waste incinerator or hazardous waste landfill, such as painting sludges, galvanic sludges, filter dusts or other solid or liquid hazardous waste and radioactive waste from the operation of nuclear power plants and fuel rod production.

Global Warming Potential (GWP)

The mechanism of the greenhouse effect can be observed on a small scale, as the name suggests, in a greenhouse. These effects are also occurring on a global scale. The occurring short-wave radiation from the sun comes into contact with the earth's surface and is partly absorbed (leading to direct warming) and partly reflected as infrared radiation.

The reflected part is absorbed by so-called greenhouse gases in the troposphere and is re-radiated in all directions, including back to earth. This results in a warming effect on the earth's surface.

In addition to the natural mechanism, the greenhouse effect is enhanced by human activities. Greenhouse gases that are considered to be caused, or increased, anthropogenically are, for example, carbon dioxide, methane and CFCs. *Figure A1* shows the main processes of the anthropogenic greenhouse effect. An analysis of the greenhouse effect should consider the possible long term global effects.

The global warming potential is calculated in carbon dioxide equivalents (CO_2-Eq.). This means that the greenhouse potential of an emission is given in relation to CO_2. Since the residence time of the gases in the atmosphere is incorporated into the calculation, a time range for the assessment must also be specified. A period of 100 years is customary.

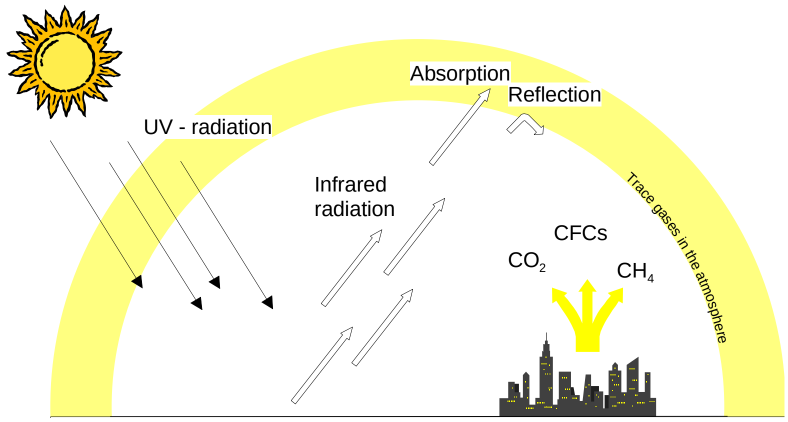

Figure A1: Greenhouse effect (KREISSIG 1999)

Acidification Potential (AP)

The acidification of soils and waters predominantly occurs through the transformation of air pollutants into acids. This leads to a decrease in the pH-value of rainwater and fog from 5.6 to 4 and below. Sulphur dioxide and nitrogen oxide and their respective acids (H_2SO_4 and HNO_3) produce relevant contributions. This damages ecosystems, whereby forest dieback is the most well-known impact.

Acidification has direct and indirect damaging effects (such as nutrients being elutriated from soils or an increased solubility of metals into soils). But even buildings and building materials can be damaged. Examples include metals and natural stones which are corroded or disintegrated at an increased rate.

When analysing acidification, it should be considered that although it is a global problem, the regional effects of acidification can vary. *Figure A2* displays the primary impact pathways of acidification.

FLOORING SYSTEMS

Desk Top Furniture Linoleum **According to ISO 14025 & EN 15804**

The acidification potential is given in Sulphur dioxide equivalents (SO2-Eq.). The acidification potential is described as the ability of certain substances to build and release H+ - ions. Certain emissions can also be considered to have an acidification potential, if the given S-, N- and halogen atoms are set in proportion to the molecular mass of the emission. The reference substance is Sulphur dioxide.

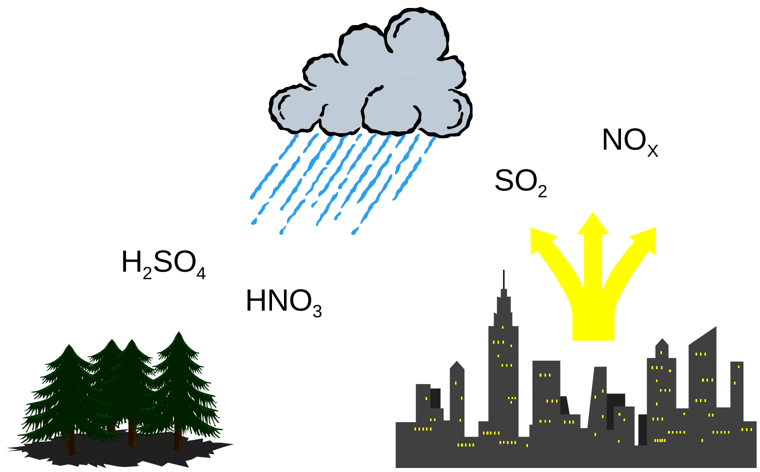

Figure A2: Acidification Potential (KREISSIG 1999)

Eutrophication Potential (EP)

Eutrophication is the enrichment of nutrients in a certain place. Eutrophication can be aquatic or terrestrial. Air pollutants, waste water and fertilization in agriculture all contribute to eutrophication.

The result in water is an accelerated algae growth, which in turn, prevents sunlight from reaching the lower depths. This leads to a decrease in photosynthesis and less oxygen production. In addition, oxygen is needed for the decomposition of dead algae. Both effects cause a decreased oxygen concentration in the water, which can eventually lead to fish dying and to anaerobic decomposition (decomposition without the presence of oxygen). Hydrogen sulphide and methane are thereby produced. This can lead, among others, to the destruction of the eco-system.

On eutrophicated soils, an increased susceptibility of plants to diseases and pests is often observed, as is a degradation of plant stability. If the nutrification level exceeds the amounts of nitrogen necessary for a maximum harvest, it can lead to an enrichment of nitrate. This can cause, by means of leaching, increased nitrate content in groundwater. Nitrate also ends up in drinking water.

Nitrate at low levels is harmless from a toxicological point of view. However, nitrite, a reaction product of nitrate, is toxic to humans. The causes of eutrophication are displayed in Figure A3. The eutrophication potential is calculated in phosphate equivalents (PO4-Eq). As with acidification potential, it's important to remember that the effects of eutrophication potential differ regionally.

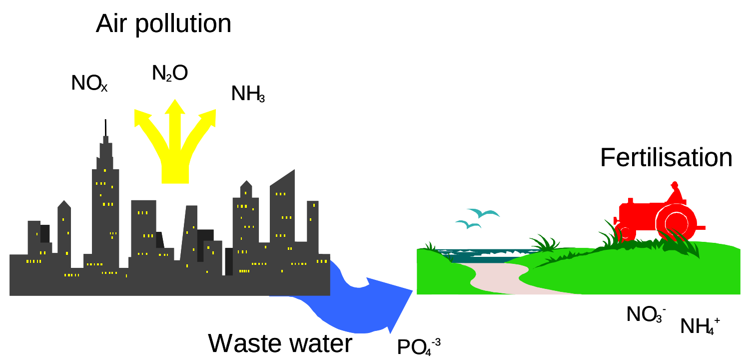

Figure A3: Eutrophication Potential (KREISSIG 1999)

Photochemical Ozone Creation Potential (POCP)

Despite playing a protective role in the stratosphere, at ground-level ozone is classified as a damaging trace gas. Photochemical ozone production in the troposphere, also known as summer smog, is suspected to damage vegetation and material. High concentrations of ozone are toxic to humans.

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Radiation from the sun and the presence of nitrogen oxides and hydrocarbons incur complex chemical reactions, producing aggressive reaction products, one of which is ozone. Nitrogen oxides alone do not cause high ozone concentration levels. Hydrocarbon emissions occur from incomplete combustion, in conjunction with petrol (storage, turnover, refueling etc.) or from solvents. High concentrations of ozone arise when the temperature is high, humidity is low, when air is relatively static and when there are high concentrations of hydrocarbons. Today it is assumed that the existence of NO and CO reduces the accumulated ozone to NO_2, CO_2 and O_2. This means, that high concentrations of ozone do not often occur near hydrocarbon emission sources. Higher ozone concentrations more commonly arise in areas of clean air, such as forests, where there is less NO and CO (*Figure A4*).

In Life Cycle Assessments, photochemical ozone creation potential (POCP) is referred to in ethylene-equivalents (C_2H_4-Equiv.). When analyzing, it's important to remember that the actual ozone concentration is strongly influenced by the weather and by the characteristics of the local conditions.

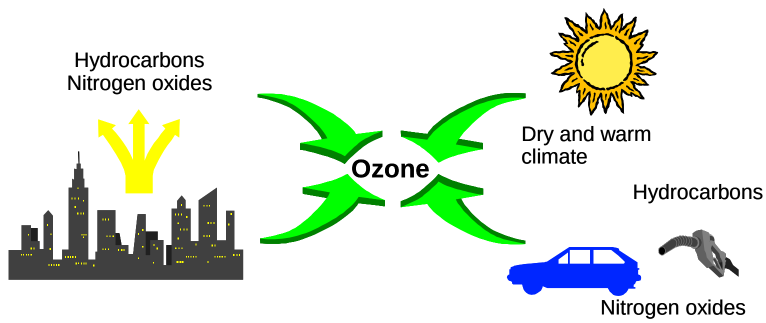

Figure A4: Photochemical Ozone Creation Potential

Ozone Depletion Potential (ODP)

Ozone is created in the stratosphere by the disassociation of oxygen atoms that are exposed to short-wave UV-light. This leads to the formation of the so-called ozone layer in the stratosphere (15 - 50 km high). About 10 % of this ozone reaches the troposphere through mixing processes. In spite of its minimal concentration, the ozone layer is essential for life on earth. Ozone absorbs the short-wave UV-radiation and releases it in longer wavelengths. As a result, only a small part of the UV-radiation reaches the earth.

Anthropogenic emissions deplete ozone. This is well-known from reports on the hole in the ozone layer. The hole is currently confined to the region above Antarctica, however another ozone depletion can be identified, albeit not to the same extent, over the mid-latitudes (e.g. Europe). The substances which have a depleting effect on the ozone can essentially be divided into two groups; the fluorine-chlorine-hydrocarbons (CFCs) and the nitrogen oxides (NOX). *Figure A5* depicts the procedure of ozone depletion.

One effect of ozone depletion is the warming of the earth's surface. The sensitivity of humans, animals and plants to UV-B and UV-A radiation is of particular importance. Possible effects are changes in growth or a decrease in harvest crops (disruption of photosynthesis), indications of tumors (skin cancer and eye diseases) and decrease of sea plankton, which would strongly affect the food chain. In calculating the ozone depletion potential, the anthropogenically released halogenated hydrocarbons, which can destroy many ozone molecules, are recorded first. The so-called Ozone Depletion Potential (ODP) results from the calculation of the potential of different ozone relevant substances.

This is done by calculating, first of all, a scenario for a fixed quantity of emissions of a CFC reference (CFC 11). This results in an equilibrium state of total ozone reduction. The same scenario is considered for each substance under study whereby CFC 11 is replaced by the quantity of the substance. This leads to the ozone depletion potential for each respective substance, which is given in CFC 11 equivalents. An evaluation of the ozone depletion potential should take the long term, global and partly irreversible effects into consideration.

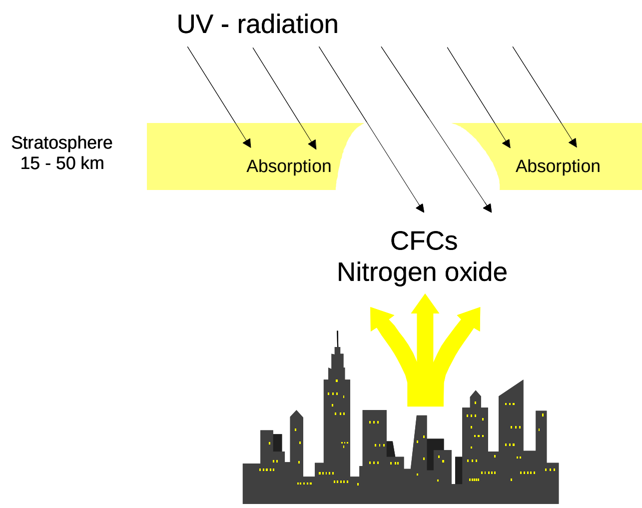

Figure A5: Ozone Depletion Potential (KREISSIG 1999)