Environmental Product Declaration

In accordance with ISO 14025 and EN 15804:2012+A2:2019 for:

Average Ceramic Product

from

Villeroy and Boch AG.
Saaruferstraße, 66693 Mettlach (Germany)

Programme:	The International EPD® System, www.environdec.com
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General information

Programme information

Programme:	The International EPD® System
Address:	EPD International AB Box 210 60 SE-100 31 Stockholm Sweden
Website:	www.environdec.com
E-mail:	info@environdec.com

CEN standard EN 15804 serves as the Core Product Category Rules (PCR)
Product category rules (PCR): *Construction products, 2019:14, version 1.0*
PCR review was conducted by: Martin Erlandsson, IVL Swedish Environmental Research Institute, martin.erlandsson@ivl.se
Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification ☒ EPD verification
Third party verifier: *Manfred Russ* *Senior Sustainabilty Consultant Quantis* *Accredited Verifier* *International EPD® System* *E-Mail: Manfred.russ@quantis-intl.com*
Procedure for follow-up of data during EPD validity involves third party verifier: ☒ Yes ☐ No

Villeroy & Boch 1748	Owner of the declaration Villeroy & Boch AG Saaruferstraße, 66693 Mettlach (Germany) https://www.villeroyboch-group.com/
ERM	EPD prepared by ERM LTD. Exchequer court, 33 St Mary Axe, Lime Street, London EC3A 8AA www.erm.com

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EPDs within the same product category but from different programmes may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804. For further information about comparability, see EN 15804 and ISO 14025.

Company information

Owner of the EPD:

Villeroy & Boch AG

Contact:

Giuseppe Noto,

Noto Giuseppe Noto.Giuseppe@villeroy-boch.com

Mobile: +49(0) 151 162 665 86

Description of the organisation:

This EPD study on ‘Sanitary Ceramics,’ specifically focussing on average ceramic sanitary products was commissioned by Villeroy & Boch (V&B), one of the largest providers of “Bathroom and Wellness and Tableware” related products in Europe. With its head office based in Germany (Saaruferstraße,66693 Mettlach) V&B is a major manufacturer of ceramics with 13 manufacturing facilities in Europe. Its products are sold in around 125 countries.

Product-related or management system-related certifications:

DIN EN ISO 9001:2015 – Quality Management System

DIN EN ISO 14001:2015 – Environmental Management System

DIN EN ISO 50001 :2015 – Energy Management System

Name and location of production site(s):

Villeroy & Boch S.A.S., Avenue du 11 Novembre, F-82400 Valence d`Agen, France

Villeroy & Boch AG sanitary factory Mettlach, Britterstraße 1, 66689 Mettlach, Germany

Villeroy & Boch Magyarország Kft., Erzsébeti út. 7, HU-6800 Hódmezővásárhely, Hungary

Mondial SA, Str. Timişorii, Nr. 149-151, RO-305500 Lugoj, Jud. Timiş, Romania

Villeroy & Boch (Thailand) Co. Ltd., 58 Moo 6 Nogplamoe, Nongkhae, Saraburi, 18140, Thailand

Product information

Product name:

Average sanitary ceramic product

Product identification:

Table 1: Technical construction data – representative dimensions for each product category

Category	Dimension	Unit
Washbasins	800*450*170	mm
Bidets	540*360*400	mm
Toilets	600*360*400	mm
Urinals	600*300*350	mm
Kitchen Sinks	1000*510*225	mm
Cisterns	390*165*300	mm

UN CPC Code:

37210 Ceramic sinks, baths, water closet pans, flushing cisterns and similar sanitary fixtures

Product description:
This report describes the environmental impact of the ceramic component of a range of products, including baths, wash basins, WCs, urinals, etc made by Villeroy & Boch ('V&B'). These products all undergo the same manufacturing process and will therefore have equivalent impacts per kg of product, regardless of the actual end-use application.

V&B manufacture sanitary ceramic products at five locations as noted in name and locations of production sites. All these sites are used to supply products for the European market. The results presented in this report are the weighted average products from these five production locations.

Table 2 shows the weighted production volumes from each manufacturing site for 2019.

Table 2: Weighted contribution of ceramic from the 5 production sites.

Country	Total Production (Tonnes)	Weighted Contribution (%)
France	5,526	8.87
Germany	10,436	16.75
Hungary	18,353	29.45
Romania	15,884	25.49
Thailand	12,124	19.45
Total	62,323	100.00

Table 3 indicates the typical composition of sanitary ceramic products made by V&B.

Table 3: Typical composition of sanitary ceramic products

Material	Content
Clay and Chamotte	48%
Kaolin	14%
Feldspar	24%
Quartz	4%
Zirconia	2%
Chalk/ limestone	2%
Others	1%
Recycling (internally recycled fired scrap)	5%

Packaging
No packaging has been modelled for the final product.

Recycled material:
The production site in Valence d`Agen, France, uses some scrap material sourced from V&B's other operations in Chateauroux.

LCA information

Functional unit / declared unit:
The declared unit quantifies and describes the product and is used as the basis for reporting results. This EPD relates to an average sanitary ceramic product sold in the European market.

The declared unit for the study is:
"1 kg average sanitary ceramic product, excluding packaging and additional fittings (eg valves, screws, taps, etc)."

Reference service life:
This is a 'cradle-to-gate study with modules C and D (A1-A3+C+D)' study so steps A4-5 and B1 – B7 are not included. As such, declaration of the reference service life (RSL) is not applicable.

Time representativeness:
LCA calculations were subject to client-specific data from 2019 and based on one-year averaged data. Supply of products from each V&B manufacturing site is relatively stable, there are no large scale changes in supply location from year to year.

Geographic representativeness:
The upstream supply chain has been modelled based on production from the specific various V&B manufacturing sites used to manufacture ceramic sanitary ware products for the EU market. It has been assumed that the product will be sold in the EU and the end of life stage will also take place in the EU.

Databases and LCA software used
All primary data used was based on the manufacturer's specific data inventory. Modelling was carried out using GaBi software (version 9.5.2.49). Background life cycle inventory data were primarily sourced from the GaBi 2020 databases, supplemented with data from ecoinvent v3.6, where this was deemed more representative. Country specific data for fuels and energy were used where possible. For raw materials it was more challenging to find country-specific data; if this could not be obtained, European average data were used where available. If the country specific data was not available, the most representative dataset from another location was used.

Description of system boundaries:
System boundary: cradle-to-gate study (A1-A3+C+D).

The LCA addresses the environmental aspects and potential environmental impacts from the point at which raw materials are extracted from the environmental through to final production of the ceramic product. The end of life stage is also considered, from removal of the used ceramic product through to the final disposal along with and the benefits and loads beyond the system boundary.

Life cycle stage descriptions are shown in Table 4 and Figure 1.

Table 4: Description of the system boundary according to the PCR

Life cycle stage	Individual stages	Module	Use	Geography	Specific data	Variation – sites
Product stage	Raw material	A1	X	DE,FR,HU, RO,TH	V&B manufacturing data (accounting for raw materials, energy and waste which is >90% of total)	GWP-GHG Min: -25% Max: +29% compared to average
	Transport	A2	X	GLO		
	Manufacturing	A3	X	EU-28		
Construction process stage	Transport	A4	MND	EU-28		
	Construction Installation	A5	MND	EU-28		
Use stage	Use	B1	MND	EU-28	-	-
	Maintenance	B2	MND	EU-28	-	-
	Repair	B3	MND	EU-28	-	-
	Replacement	B4	MND	EU-28	-	-
	Refurbishment	B5	MND	EU-28	-	-
	Operational energy use	B6	MND	EU-28	-	-
	Operational water use	B7	MND	EU-28	-	-
End of life stage	De-construction & demolition	C1	X	GLO	-	-
	Transport	C2	X	GLO	-	-
	Waste processing	C3	X	GLO	-	-
	Disposal	C4	X	EU-28	-	-
Resource recovery stage	Reuse-Recovery-Recycling-potential	D	X	GLO	-	-

X = declared modules, MND = module not declared, Note country abbreviations: DE (Germany), FR (France), GLO (Global), HU (Hungary), RO (Romania) & TH (Thailand)

The system boundaries considered in this study are presented in Figure 1 and include A1, A2, A3, C1, C2, C3, C4 and D from above:

Figure 1: System Diagram

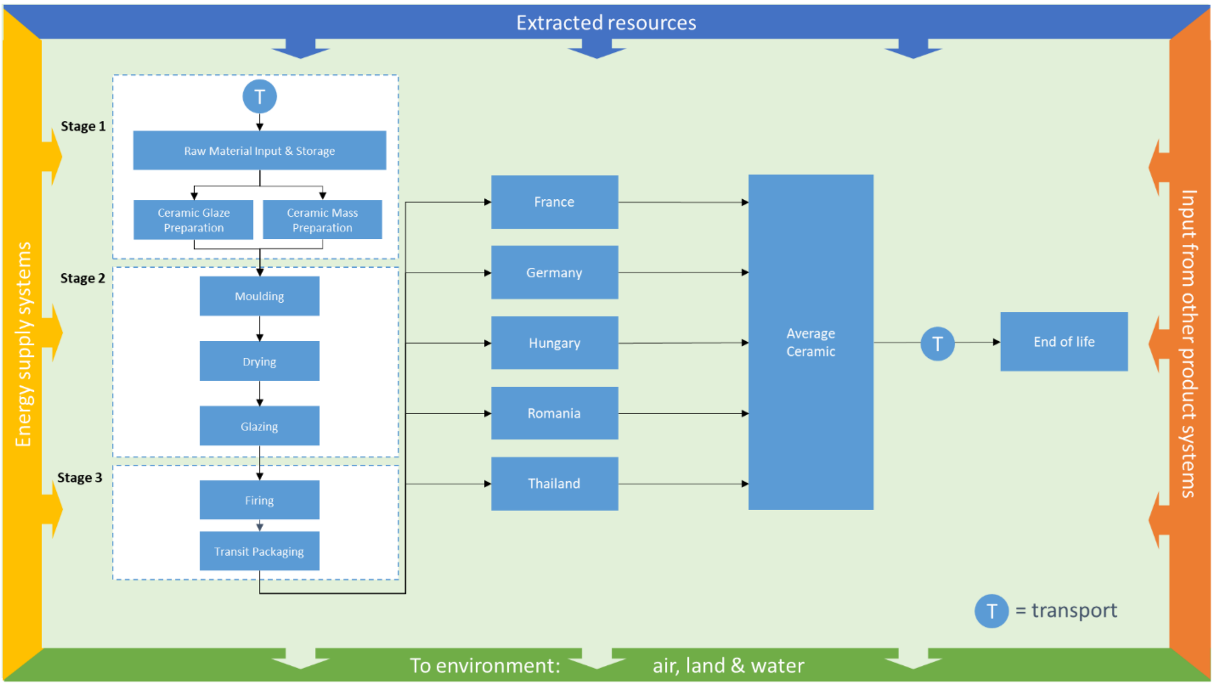


Table 5 summarises those life cycle aspects that have been included within and excluded from the study.

Table 5: Components inclusion/ exclusion

Included	Excluded
▪ Raw material acquisition ▪ Processing of raw materials ▪ Transport of raw materials to V&B manufacturing sites ▪ Energy used in production at manufacturing facilities ▪ Assembly of finished product ▪ Transport and disposal/recycling of wastes ▪ Transportation of components to assembly site	▪ Production, transportation and disposal of the packaging used for raw materials ▪ Construction activities, capital equipment and infrastructure ▪ Human labor, employee commute and business travel

Description of production process

The production process includes the following steps:

Raw Material Preparation
For 'mass' preparation (comprising the material bulk of the ceramic product) the hard materials (feldspar, quartz and internally crushed, fired sanitary ware) are ground with water while the clays are separately dissolved in water with stirrers. Both suspensions are then mixed together with kaolin and conveyed through sieves and filters to a vessel, where the liquid fresh mass ('casting slip') is mixed with recycled mass from the production process. After a few days of rest the slip can be processed in the production facilities.

In case of glaze preparation (providing the surface coating of the product), the raw materials are ground together with water and, if necessary, desired colour bodies and mixed with recycled glaze from the production. After filtration and the addition of levelling agents, the glaze can be used in the glazing area.

Gypsum casting

In the plaster casting process, a plaster mould is filled with casting slip. Due to the capillary force of the absorbent material plaster, water is removed from the slurry to yield a thicker, more uniform, homogeneous material. This process can take 70-90 minutes depending on environmental conditions and the consistency of the casting compound. When the desired thickness is reached, the plaster mould is removed. The remaining slip is emptied and it is left to dry for approximately 60 minutes.

High pressure casting

During the moulding process, a high pressure system removes a large part of the water from the slurry in the porous plastic mould. After a certain amount of standing time, any residual slurry that is not required is returned to the working tank, then the blank of the sanitary article is released from the die-casting mould with the help of water and air. The moulds are then rinsed with water and air to prevent the capillaries from clogging.

After demoulding, the blanks (‘green bodies’) are processed by hand. The casting seams are deburred and the assembly, flushing and overflow holes are formed with special tools. Uneven areas are then smoothed out with the help of different sponges and water. Defective parts are removed from the process and made available to the mass preparation for recycling.

Drying

The blanks are dried before firing. During the drying process the moisture in the blank is reduced to a minimum. Integrated measuring and testing methods are used to detect defects in the articles at an early stage, to remove irreparable parts from the process and, if necessary, to recycle them back into the mass preparation stage.

Firing

The glazed blanks are placed on kiln cars with refractory base (fireclay). The supporting surface of the tunnel kiln car is coated with a release agent, which prevents the ceramic parts from sticking to the surface. The blanks are then fired in a gas-powered tunnel kiln.

Waste disposal:

The ceramic manufacturing processes generates process wastewater that is sent to a municipal waste water process. Additionally there is a minimal amount of scrap that is either internally or externally recycled or sent to landfill.

End of life scenario

It has been assumed that, at end of life, the ceramic product would be manually dismantled from where it has been installed during the use stage. Hence no burdens have been allocated to module C1.

It is considered very unlikely that post-consumer ceramic ware would be recycled due to the low value and high mass of the product, and to the limited locations where recycling could actually take place. Therefore it has been assumed that no recycling takes place at end of life but that the ceramic product is all sent to landfill, 50 km from where the product was installed.

Ceramic is inert in landfill (not producing landfill gas that can be burnt to produce electricity). As such, no potential benefits or loads beyond the system boundary have been modelled in module D.

Data Quality

Data collection followed the guidance provided in ISO 14044:2006, clause 4.3.2. All producer-specific data are from 2019 and are based on one-year averaged data.

ERM collected site-specific data from V&B's operations using structured questionnaires. The data received were cross-checked for completeness and plausibility using mass balances and stoichiometry, as well as internal and external benchmarking.

All background data were obtained from the databases contained within the Gabi 9.5.2.49 software: most data were sourced from the Gabi 2020 database from Sphera, supplemented with data from ecoinvent v3.6. Datasets from these databases have been used worldwide for several years in LCA models of many critically reviewed studies in industrial and scientific applications. All data were sourced from 2016-2019.

Cut-off criteria

EN 15804 requires that where there are data gaps or insufficient input data for a unit process, the cut-off criteria shall be 1% of renewable and non-renewable primary energy usage and 1% of the total mass of this unit process. The total neglected flows from a product stage must be no more than 5% of product inputs by mass or 5% of primary energy contribution.

All emissions and their environmental impact contributing greater than 1% to the total must be recorded.

In this assessment, all information gathered from data collection for the production of the WC has been modelled, i.e. all raw materials used, the electrical energy and other fuels used, use of ancillary materials and all direct production waste. Transport data on input and output flows have also considered.

Assumptions and Limitations

This EPD does not assess the installation and use stages associated with the life cycle of the ceramic product. The end of life has been modelled based on what is currently the most likely scenario, but this may not be representative of the end of life of a newly installed product that would be disposed of some years in the future, eg if recycling of post-consumer ceramics were to become more widespread. Packaging of the finished product has also not been considered.

Allocation

Most scrap generated during production of the ceramic components is internally recycled. A small amount is sent for external recycling. No impacts have been allocated to this scrap, all burdens associated with the production process have been assigned to the main ceramic product.

LCA Additional Technical Information

The results shown in this EPD are an average across five different production locations, which all produce ceramic sanitary ware for the European market. Each production location was assessed individually and the weighted average resuilts are presented. The environmental impact results table includes the co-efficient of variation (CV)—the ratio of the standard deviation to the mean—which is a measure of the dispersion of results among each site. The CV has been calculated based on 1 kg ceramic production from each site (ie not weighted by production volume). The higher the CV the greater the variation in results observed across the different production locations.

Further Information

Additional information on sanitary ware ceramic products can be found at www.villeroy-boch.com

Environmental Information

Potential environmental impact

	A1	A2	A3	C1	C2	C3	C4	D	TOTAL	Co-efficient of variation
GWP - total [kg CO2 eq.]	2.22E+00	1.96E-01	1.17E-01	0.00E+00	1.41E-02	0.00E+00	1.47E-02	0.00E+00	2.57E+00	0.28
GWP - fossil [kg CO2 eq.]	2.21E+00	1.94E-01	1.08E-01	0.00E+00	1.40E-02	0.00E+00	1.51E-02	0.00E+00	2.54E+00	0.28
GWP – biogenic [kg CO2 eq.]	8.76E-03	9.56E-04	9.32E-03	0.00E+00	-1.80E-05	0.00E+00	-4.39E-04	0.00E+00	1.86E-02	0.46
GWP - luluc [kg CO2 eq.]	1.33E-03	1.38E-03	4.22E-05	0.00E+00	1.15E-04	0.00E+00	4.44E-05	0.00E+00	2.92E-03	0.50
ODP [kg CFC-11 eq.]	1.99E-08	2.19E-17	2.59E-16	0.00E+00	1.80E-18	0.00E+00	5.87E-17	0.00E+00	1.99E-08	0.67
AP [Mole of H+ eq.]	2.95E-03	3.16E-04	2.48E-04	0.00E+00	1.26E-05	0.00E+00	1.08E-04	0.00E+00	3.63E-03	0.43
EP - freshwater [kg P eq.]	3.33E-05	5.02E-07	8.07E-06	0.00E+00	4.18E-08	0.00E+00	2.54E-08	0.00E+00	4.19E-05	0.66
EP - marine [kg N eq.]	1.07E-03	1.05E-04	1.38E-04	0.00E+00	3.64E-06	0.00E+00	2.80E-05	0.00E+00	1.34E-03	0.48
EP - terrestric [Mole of N eq.]	1.16E-02	1.20E-03	1.18E-03	0.00E+00	4.50E-05	0.00E+00	3.07E-04	0.00E+00	1.43E-02	0.49
POCP [kg NMVOC eq.]	2.94E-03	2.87E-04	2.85E-04	0.00E+00	1.05E-05	0.00E+00	8.47E-05	0.00E+00	3.61E-03	0.48
ADPF [MJ]	3.75E+01	2.28E+00	3.09E-01	0.00E+00	1.87E-01	0.00E+00	2.01E-01	0.00E+00	4.05E+01	0.24
ADPE [kg Sb eq.]	2.32E-06	1.29E-08	3.77E-09	0.00E+00	1.07E-09	0.00E+00	1.43E-09	0.00E+00	2.34E-06	0.55
WDP [m³ world equiv.]	1.08E-01	1.47E-03	1.21E-02	0.00E+00	1.22E-04	0.00E+00	1.62E-03	0.00E+00	1.23E-01	0.53

Caption: GWP - total = global warming potential; GWP - fossil = global warming potential (fossil fuel only); GWP - biogenic = global warming potential (biogenic); GWP - luluc = global warming potential (land use only); ODP = ozone depletion; AP = acidification terrestrial and freshwater; EP - freshwater = eutrophication potential (freshwater); EP - marine = eutrophication potential (marine); EP- terrestric = eutrophication potential (terrestrial); POCP = photochemical ozone formation; ADPE = abiotic depletion potential (element), ADPF = abiotic depletion potential (fossil) WDP = water scarcity.

Potential environmental impact – GWP-GHG based on EN 15804:2012+A1:2013 (previous version of the standard)

	A1	A2	A3	C1	C2	C3	C4	D	Total
GWP-GHG	2.17E+00	1.92E-01	1.16E-01	0.00E+00	1.37E-02	0.00E+00	1.43E-02	0.00E+00	2.51E+00

Use of resources

	A1	A2	A3	C1	C2	C3	C4	D	TOTAL
PERE [MJ]	2.80E+00	1.26E-01	8.24E-02	0.00E+00	1.05E-02	0.00E+00	2.70E-02	0.00E+00	3.05E+00
PERM [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT [MJ]	2.80E+00	1.26E-01	8.24E-02	0.00E+00	1.05E-02	0.00E+00	2.70E-02	0.00E+00	3.05E+00
PENRE [MJ]	3.75E+01	2.29E+00	3.09E-01	0.00E+00	1.88E-01	0.00E+00	2.01E-01	0.00E+00	4.05E+01
PENRM [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT [MJ]	3.75E+01	2.29E+00	3.09E-01	0.00E+00	1.88E-01	0.00E+00	2.01E-01	0.00E+00	4.05E+01
SM [kg]	1.17E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-02
RSF [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW [m3]	5.05E-03	1.44E-04	3.25E-04	0.00E+00	1.20E-05	0.00E+00	4.95E-05	0.00E+00	5.58E-03

Caption: 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

Waste production and output flows

	A1	A2	A3	C1	C2	C3	C4	D	TOTAL
HWD [kg]	7.39E-09	1.14E-10	5.91E-11	0.00E+00	9.45E-12	0.00E+00	2.13E-11	0.00E+00	7.59E-09
NHWD [kg]	2.04E-02	3.38E-04	5.05E-01	0.00E+00	2.79E-05	0.00E+00	1.00E+00	0.00E+00	1.53E+00
RWD [kg]	8.69E-04	2.77E-06	1.81E-05	0.00E+00	2.27E-07	0.00E+00	2.10E-06	0.00E+00	8.92E-04
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR [kg]	0.00E+00	0.00E+00	4.18E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.18E-02
EEE [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EET [MJ]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Caption: 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; EEE = Exported electrical energy; EET = Exported thermal energy

Information on biogenic carbon content

	A1	A2	A3	C1	C2	C3	C4	D	TOTAL
Biogenic carbon content in product [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Biogenic carbon content in packaging [kg]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

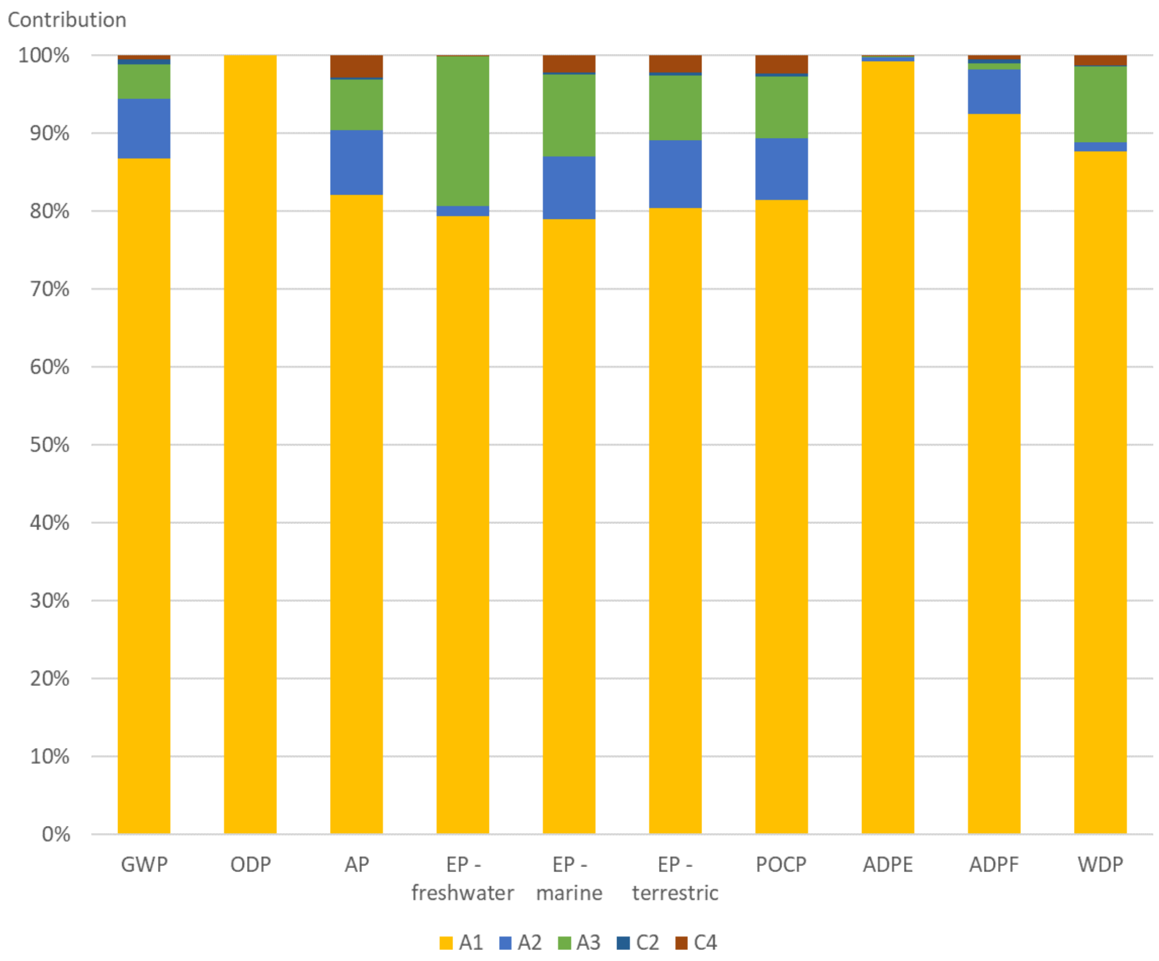
Other environmental indicators

	A1	A2	A3	C1	C2	C3	C4	D	TOTAL
PM [Disease incidences]	3.69E-08	3.21E-09	1.44E-09	0.00E+00	7.95E-11	0.00E+00	1.34E-09	0.00E+00	4.30E-08
IR [kBq U235 eq.]	1.23E-01	3.96E-04	2.69E-03	0.00E+00	3.25E-05	0.00E+00	2.21E-04	0.00E+00	1.27E-01
ETF-fw [CTUe]	1.37E+02	1.65E+00	6.04E-01	0.00E+00	1.35E-01	0.00E+00	1.14E-01	0.00E+00	1.40E+02
HTP-c [CTUh]	3.81E-10	3.33E-11	2.38E-11	0.00E+00	2.73E-12	0.00E+00	1.69E-11	0.00E+00	4.57E-10
HTP-nc [CTUh]	2.12E-08	1.74E-09	1.50E-09	0.00E+00	1.41E-10	0.00E+00	1.86E-09	0.00E+00	2.65E-08
SQP [Pt]	3.22E+00	7.72E-01	9.39E-02	0.00E+00	6.43E-02	0.00E+00	4.05E-02	0.00E+00	2.35E+00

Caption: PM = Particulate matter emissions; IR = Ionizing radiation, human health; ETF-fw = Eco-toxicity (freshwater); HTP-c = Human toxicity, cancer effects; HTP-nc = Human toxicity, non-cancer effects, SQP = Soil quality potential/ Land use related impacts

Interpretation

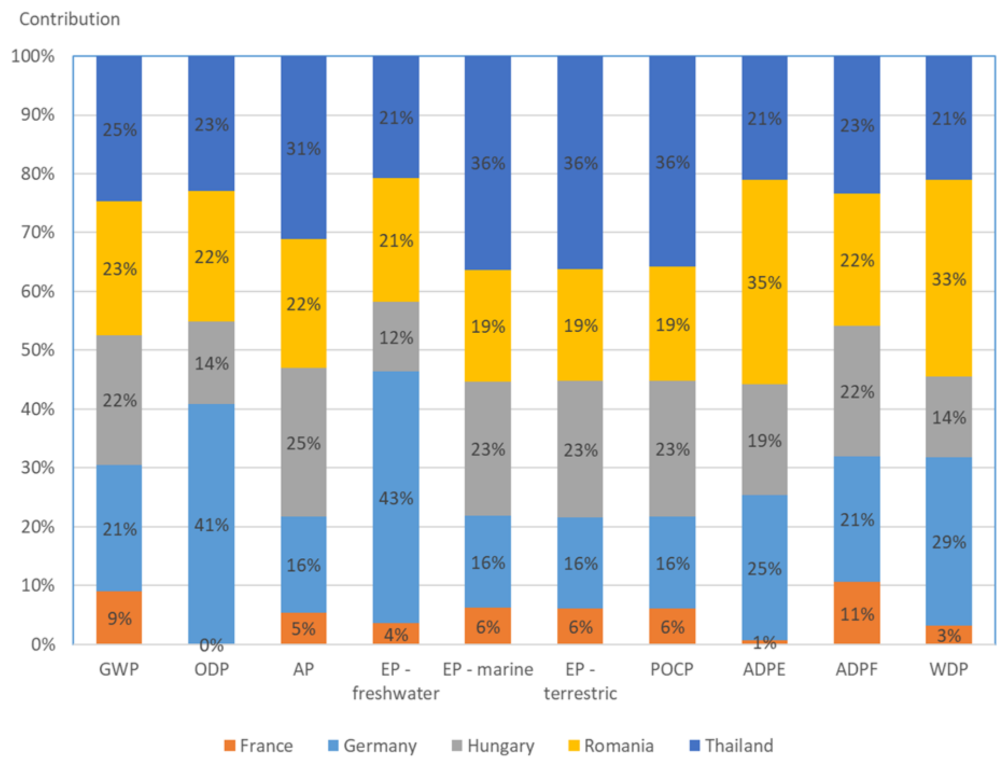
Figure 2: Contribution of modules (A1, A2, A3, C2 and C4) to environmental impact categories for sanitary ceramic products



The results in Figure 2 show that module A1 (raw material supply) is the dominant contributor to the majority of environmental impact categories, accounting for almost more than 80% of burdens for every impact category. Burdens associated with module A2 are the next most significant, but to a much lesser extent than A1, and is negligible for several impact categories. Similarly, Module A3, also has a reasonable contribution to some impact categories but a minor contribution in others.

Modules associated with end of life have a negligible contribution to the overall life cycle burdens.

Figure 3: Contribution of individual manufacturing facilities to environmental impact categories for sanitary ceramic products



The results from Figure 3 show that Hungary and Thailand tend to account for the largest contributions to the total impact. This is due to a combination of factors including production volume (Hungary is the biggest producer), production efficiency (significantly more waste is generated in Thailand than in other locations), raw material and fuel mix.

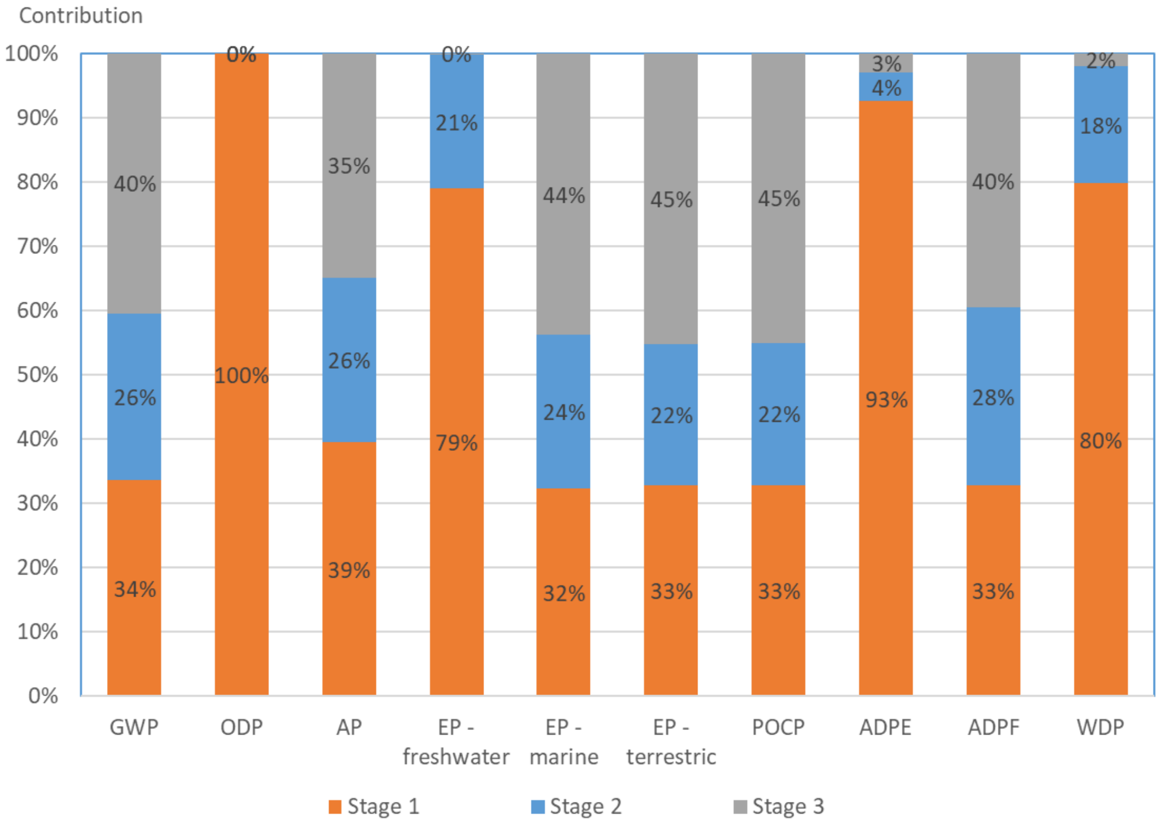
The co-efficient of variation has been reported alongside the EPD results for the environmental impact categories. The degree of difference in co-efficient of variation varies greatly depending on the metric assessed. For some, such as climate change and use of fossil resources, the different production sites are reasonably well-aligned, while for others, such as freshwater eutrophication and use of metal and mineral resources, the differences are much greater. These differences are due to a number of factors including fuel mix, country-specific electricity grid mix, particular selection of raw materials, loss rates during manufacturing, etc.

The high relative burdens associated with ozone depletion, freshwater eutrophication and water scarcity in Germany are due to outsized contributions from production of zirconium silicate and barium carbonate minerals. The larger than expected burdens for marine and terrestrial eutrophication and photochemical ozone formation in Thailand is mainly due to the high electricity usage and the specific grid mix in this region. The high contribution to mineral and metal resource depletion in Romania is mostly due to burdens associated with frit production.

Overall, compared to production volumes from each site, it can be seen that ceramic manufactured in Thailand generally has proportionally higher burdens than expected for most impact categories. German production also has higher burdens for some indicators. In contrast, production in Romania and France shows lower relative impacts for most categories.

Figure 4 shows the contribution to the total impact from A1-3 from each production stage (stage 1 = raw materials preparation, stage 2 = casting and drying, stage 3 = firing). For most impact categories there is a relatively even split between each stage, but ODP, EP (freshwater), ADPE and WDP are all dominated by impacts associated with raw material acquisition).

Figure 4: Contribution of individual processing stages to environmental impact categories for sanitary ceramic products



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