Environmental Product Declaration (EPD)

of secondary raw materials or aggregates of industrial origin

SAND MATRIX

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EPD

1 DESCRIPTION OF THE COMPANY AND THE PRODUCT

1.1 The company

Officina dell'Ambiente S.p.A, located in the municipality of Lomello in Pavia province, performs the treatment and recovery process of special hazardous and non-hazardous wastes, mainly bottom ashes derived from municipal incineration plants to be re-used as secondary raw material for the production of cement and other building materials. Since November 2015 a new plant was put into operation in Conselice (Ravenna province).

Thousands of tonnes of bottom ashes from incineration, instead of being disposed in landfill, are treated in a controlled manner through a treatment/recovery cycle which generates a secondary raw material, named Matrix®, as substitute of primary raw material for cement production and other building products.

Today, Matrix® has become a family of products with different characteristics, particle size and application ranging over almost all building sectors. At the moment, representatives of the Matrix® Family are:

- Matrix® Standard, with a particle size between 0 and 10 mm;
- AGMatrix®, with a particle size between 2 and 10 mm; this product has been EC-labelled as aggregate for concrete in 2008;
- Sand Matrix®, a group of sands that can be produced in particle size of 0-2 mm, 0-4 mm and 2-4 mm.

The recovery of incineration bottom ashes, otherwise disposed in landfill, allows to conserve resources mitigating the demand for raw materials and the depletion of natural resources.

Officina dell'Ambiente complies with European Union Directives that provide a management policy aimed at minimizing waste production, focusing on their recovery rather than their disposal.

Officina dell'Ambiente supplies several cement plants and producers of concrete with a wide range of products as substitutes of primary raw materials with the dual purpose of removing a considerable flow of waste from landfill and to preserve the reserves of natural materials.

Officina dell'Ambiente holds the Environmental Management System certificate according to the scheme of UNI EN ISO 14001:2015, which has the following scope: *treatment and recovery of specific hazardous and non-hazardous waste through the phases of weighing, unloading, storage and physical-mechanical separation.*

The headquarters of Officina dell'Ambiente, which corresponds to the production site, is in Strada Provinciale 193bis – Tenuta Grua LOMELLO (PV). The other plant, where only Sand Matrix is produced, is located in Via Selice, Conselice (RA).

This site of Lomello is ISO 14001 certified and EMAS registered from 2006. The Conselice site has received ISO 14001:2015 certification in September 2016 and EMAS registration in 2018. In all cases, the certification body is DNV Italy.

1.2 Sand Matrix®

In Lomello, the main process is aimed to obtain the product named Matrix® Standard, starting from bottom ashes derived from municipal incineration plants. The process involves a set of physical-mechanical treatments, without the addition of chemical reagents, consisting of a screening, crushing and separation of ferrous and non-ferrous metals. More in detail, the main production process of Officina dell'Ambiente consists of the following phases:

- acceptance of the waste;
- unloading of the waste in specific areas of the production site;
- waste maturation process;
- loading of the waste through loading hoppers and transferring to the treatment plant;
- screening and separation of the waste;
- crushing and separation of ferrous metals from unscreened waste;
- storage of Matrix® Standard in specific areas of the production site;
- picking and selling of the finished product.

Following the production of Matrix® Standard, Officina dell'Ambiente has built in the external area of the plant a system of vibrating sieves working without the use of water, which separates Matrix® Standard into the fractions with particle size 0-4 mm, 2-10 mm and >10 mm (which is sent back to the crushing system). The fraction with particle size 0-4 mm (Sand Matrix® 0-4 mm) is further separated into the fractions with particle size 0-2 mm (Sand Matrix® 0-2 mm) and 2-4 mm (Sand Matrix® 2-4 mm) using the vibrating sieves.

In Conselice, after the first phase of acceptance and maturation, the waste goes through the refining phase to produce the fractions with particle size 0-2 mm, 0-4 mm and 2-4 mm.

All Sand Matrix® products (0-2, 0-4, 2-4 mm) own characteristics and specific EC marking for various sectors, such as the production of concrete, pre-measured mortars, bituminous conglomerate, brick and cement mixtures.

As required by PCR document 2012:01, in Matrix® products there are no substances with a high degree of concern (SVHC) provided in the ECHA Candidate List with a concentration greater than 0,1%.

Table 1: Quantity of Sand Matrix® produced in 2019

Product	U.M.	Lomello Site	Conselice Site
Sand Matrix® 0-2 mm	ton	30.662	54.284
Sand Matrix® 2-4 mm	ton	11.714	18.368
Sand Matrix® 0-4 mm	ton	61.840	30.256

Declared Unit
1000 kg of Matrix product
The phases of distribution, use and disposal of the product are not included in the study.

1.3 Composition of the product

***Table 2**: Average chemical composition of Sand Matrix® produced in 2019 in Lomello (*standard deviation of average)*

Parameter	U.M.	2019	SD*
Humidity	%	11,69	1,77
SiO_2	%	41,16	2,24
Al_2O_3	%	8,53	0,45
Fe_2O_3	%	9,86	0,84
CaO	%	20,33	2,04
MgO	%	2,71	0,14
Na_2O	%	2,74	0,24
K_2O	%	1,02	0,07
TiO_2	%	0,91	0,05
Mn_2O_3	%	0,16	0,03
Cr_2O_3	%	0,03	0,00
S (total)	%	0,48	0,08
SO_3	%	1,18	0,19
P_2O_5	%	1,21	0,08
Cl	%	0,45	0,07
$CaCO_3$	%	8,21	2,01
Loss on ignition	%	5,84	0,69

Parameter	U.M.	2019	SD*
As	mg/kg	8	2
Cd	mg/kg	9	10
Cr total	mg/kg	230	28
Cr (VI)	mg/kg	< 1	
Cu	mg/kg	2657	308
Hg	mg/kg	< 5	
Mn	mg/kg	1085	219
Ni	mg/kg	152	60
Pb	mg/kg	1050	384
Sb	mg/kg	72	10
Se	mg/kg	< 5	
V	mg/kg	24	2
Zn	mg/kg	3604	619

***Table 3**: Average chemical composition of Sand Matrix® produced in 2019 in Conselice (*standard deviation of average)*

Parameter	U.M.	2019	SD*
Umidità	%	12,82	1,77
SiO_2	% s.s.	42,37	2,24
Al_2O_3	% s.s.	8,07	0,45
Fe_2O_3	% s.s.	9,26	0,84
CaO	% s.s.	20,56	2,04
MgO	% s.s.	2,51	0,14
Na_2O	% s.s.	3,08	0,24
K_2O	% s.s.	1,04	0,07
TiO_2	% s.s.	0,87	0,05
Mn_2O_3	% s.s.	0,11	0,03
Cr_2O_3	% s.s.	0,02	0,00
S totale	% s.s.	0,42	0,08
SO_3	% s.s.	1,03	0,19
P_2O_5	% s.s.	1,18	0,08
Cl	% s.s.	0,46	0,07
$CaCO_3$	% s.s.	9,31	2,01
Perd.peso	% s.s.	5,52	0,69

Parameter	U.M.	2019	SD*
As	mg/kg	4	2
Cd	mg/kg	15	10
Cr totale	mg/kg	126	28
Cr (VI)	mg/kg	< 1	
Cu	mg/kg	3219	308
Hg	mg/kg	< 1	
Mn	mg/kg	714	219
Ni	mg/kg	89	60
Pb	mg/kg	656	384
Sb	mg/kg	36	10
Se	mg/kg	< 1	
V	mg/kg	17	2
Zn	mg/kg	2269	619

1.4 System boundaries

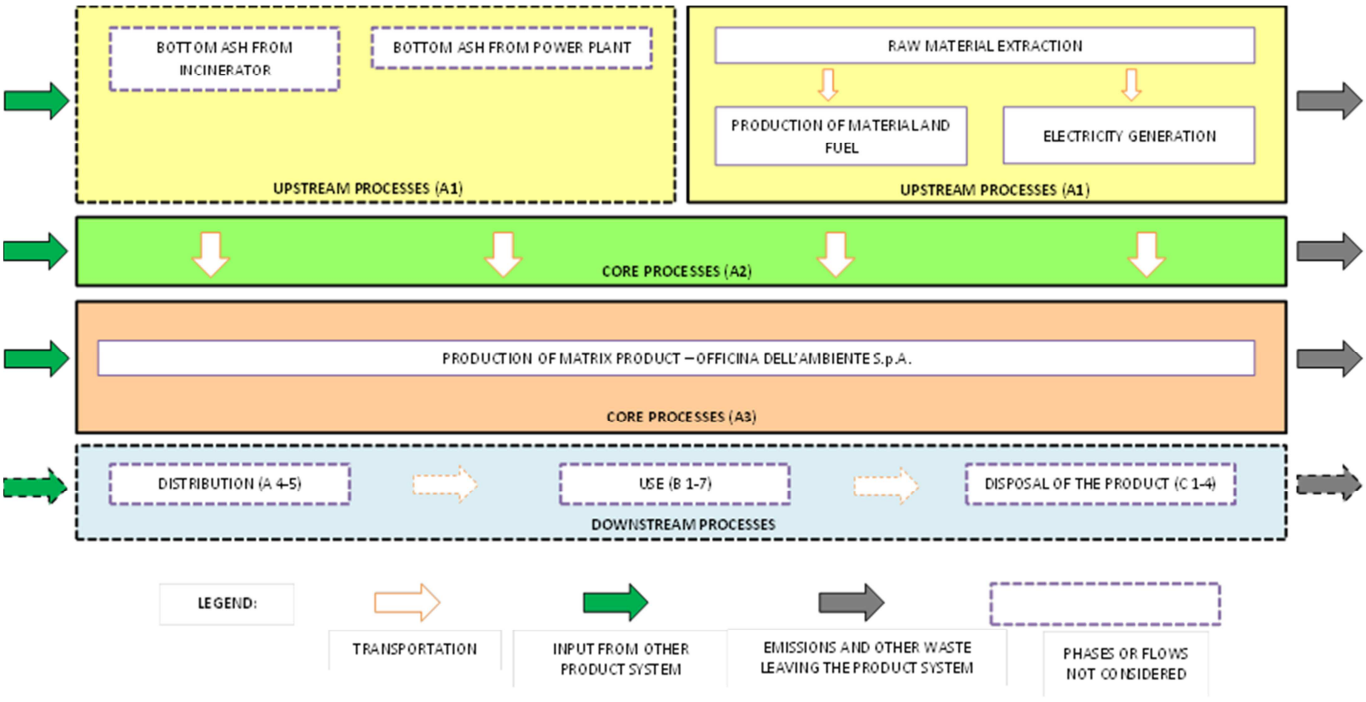
System boundaries determine the unit processes to be included in LCA study and which data as "input" and/or "output" to/from the system can be omitted. According to the PCR 2012:01 and to the EN 15804:2012, the life cycle of Matrix® products is divided into upstream and core phases, as specified below.
The upstream phase (A1) comprises the supply of raw materials and specifically:

- the extraction and processing of raw materials and recycling processes of the secondary raw materials from the previous product system (with the exception of the processes which are part of the waste treatment of the previous product system);
- the electricity generation from primary energy sources, including their extraction, refining and distribution;
- energy recovery from secondary fuels (with the exception of processes which are part of the waste treatment in the system of the previous product).

The core phase, divided in two parts, includes the following processes:

- external and internal transport between processes belonging to the core phase (A2);
- production of Matrix® products and treatment of waste derived from the production of Matrix® products (A3).

The downstream phase is not included in the system boundaries. In the figure below it is shown the schematic diagram of the life cycle of the product and the table regarding life cycle stages according to the PCR and to the EN 15804.



GPI module	Comparability basis: Asset life cycle stages	Within the product group Information module	Performance in a construction application EPD type Declared unit: Cradle-Gate
UPSTREAM	A1) RAW MATERIAL SUPPLY	A1-3) PRODUCTION PHASE	MANDATORY
CORE	A2) Transport		
	A3) Manufacturing		
DOWNSTREAM	A4) TRANSPORT	A3-4) MANUFACTURING PHASE	Optional
	A5) Construction, installation process		
	B1) Material emission from usage*	B) Usage stage	Optional
	B2) Maintenance		
	B3) Repair		
	B4) Replacement		
	B5) Refurbishment		
	C1) Deconstruction, demolition	C) End of life	Optional
	C2) Transport		
	C3) Waste processing		
	C4) Disposal		
Other environmental information	D) Reuse, recycle or recovery	D) Recyclability potentials	Optional
Inclusion of reference service life (RSL)	B)1-5	B) Usage stage	Mandatory if all life stages included

** Named 'Use' in ISO 21930*

1.5 Data quality and cut-off

The inventory analysis was conducted using specific data provided by Officina dell'Ambiente concerning the consumption of raw materials and electricity, the production of Matrix® products and related waste. All data refer to the year 2019. The electricity consumed by Lomello is produced from hydroelectric and solar power (74%) and photovoltaic sources (26%), while the electricity consumed by Conselice comes from hydroelectric (76%) and photovoltaic sources (24%).
Selected generic data was used from international databases (in particular Ecoinvent 3.5) regarding the production processes of the auxiliary materials used for the production of Matrix® products, the processes of generation and distribution of electricity, the means of transportation and waste treatment processes related to the production of Matrix® products. Furthermore, the distances of transportation were calculated using Google Maps online calculator. Generic data was not used.
According to the PCR 2012:01 and to the cut-off rules, flows lower than 1% of the total inventory were excluded; in particular the following processes were excluded: the packaging of auxiliaries; the maturation process of the bottom ash, the accumulation and the process of natural weathering of the Matrix® Standard; the consumption of natural gas for heating offices, the travels of workers to and from work and the construction of machinery and plants, as not directly related to the product.

1.6 Distribution, use phase and disposal of the product

The distribution of the product, use phase and disposal of Matrix® products were not considered ("cradle-to-gate" LCA study, i.e. from cradle to the gate of the company).

1.7 Comparison of EPD within the same product category

This EPD meets the requirements of ISO 14025 and EN 15804. The EPD within the same product category but which refer to different programs cannot be compared. EPD of construction products may not be comparable if they do not comply with the requirements of comparability set in EN 15804.
AGMatrix® product described in this document is based on specific PCR 2012:01 version 2.3.

1.8 Validity of EPD

This EPD refers to the geographical area of Italy and remains valid until the 11th of April 2024.

2 ENVIRONMENTAL PERFORMANCE

The environmental performance of Sand Matrix® products, as described below, is based on the methodology of Life Cycle Assessment (LCA) and it was calculated in accordance with ISO 14040 and 14044, the International EPD system, PCR 2012:01 and EN 15804:2012. The management and update of environmental data concerning EPD products are regulated by a specific procedure in the manual for the management systems of safety and the environment (complying with EMAS Regulation). The radioactivity of bottom ash from incineration of municipal waste is monitored before sending to Officina dell'Ambiente in order to exclude the delivery of radioactive bottom ash.

2.1 Assessment methodology

The calculation method adopted for the LCA study of the present EPD is described in the document "GPI for an International EPD® System" and the characterization factors used to convert the data deriving from the inventory analysis of the life cycle into impact categories are listed in the web-site www.environdec.com and described in the PCR. In addition to the impact categories required by PCR, the impact categories related to aquatic and terrestrial ecotoxicity, human toxicity and land use were also considered; these impact categories taken from the CML 2001 method developed by the Center of Environmental Science (CML) of Leiden University in the Netherlands (http://cml.leiden.edu/software/data-cmlia.html).

2.2 Environmental profile of Sand Matrix®

The impact categories, which characterize upstream and core phases and the life cycle of Sand Matrix® 0-2 mm, Sand Matrix® 0-4 mm e Sand Matrix® 2-4 mm, refer to one (1) tonne of product. The results for all fractions of Sand Matrix® are the weighing average of both plants. Resources whose contribution is greater than 5% of the total impact of one (1) ton of Sand Matrix® are also shown.

***Table 4**: The environmental impacts of 1 tonne of Sand Matrix® 0-2mm*

Impact categories	Unit	Upstream (A1)	Core (A2)	Core (A3)	A1_A3
Global warming 100 years	kg CO_2 eq	0,463	28,670	19,501	48,635
Ozone layer depletion	mg CFC-11 eq	0,459	5,401	2,413	8,603
Photochemical oxidation	g C_2H_4	0,230	3,662	1,876	5,769
Acidification	g SO_2 eq	4,151	119,823	72,399	196,373
Eutrophication	g PO_4--- eq	0,622	19,689	15,154	35,466
Depletion of abiotic resource (element)	kg Sb eq	6,89E-09	5,72E-08	4,35E-07	4,99E-07
Depletion of abiotic resource (fossil)	MJ	35,816	416,998	184,384	637,199
Human toxicity 100 years	kg 1,4-DB eq	0,092	7,654	4,451	12,196
Freshwater aquatic ecotoxicity 100 years	kg 1,4-DB eq	0,046	0,473	2,953	3,472
Marine aquatic ecotoxicity 100 years	kg 1,4-DB eq	2,02E+02	1,92E+03	3,80E+03	5,93E+03
Terrestrial ecotoxicity 100 years	kg 1,4-DB eq	0,000	0,022	0,009	0,031
Land use	m^2a	0,015	0,058	0,033	0,105
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ	39,912	1,071	1,035	42,018
Use of renewable primary energy resources used as raw materials	MJ	0,007	0,026	0,015	0,048
Total use of renewable primary energy resources	MJ	39,919	1,097	1,050	42,066
Use of non-renewable primary energy excluding nonrenewable primary energy resources used as raw materials	MJ	37,538	427,730	190,285	655,553
Use of non- renewable primary energy resources used as raw materials	MJ	0,000	0,001	0,225	0,227
Total use of non-renewable primary energy resources	MJ	37,538	427,731	190,510	655,779
Use of secondary material	kg	0,000	0,000	1,175	1,175
Use of renewable secondary fuels	MJ	0,000	0,000	0,000	0,000
Net use of water	m^3	0,002	0,015	0,193	0,210
Non-hazardous waste	kg	0,001	0,006	4,672	4.679
Hazardous waste	kg	0,000	0,005	0,002	0,007
Radioactive waste	kg	0,000	0,000	0,000	0,000

***Table 5**: Consumption of renewable and non-renewable resources of 1 ton of Sand Matrix® 0-2mm*

Use of renewable primary energy excluding renewable primary energy resources used as raw materials	Unit	A1-A3
Hydroelectric energy	MJ	31,271
Solar energy	MJ	9,557
Other resources	MJ	1,190
Total resources	**MJ**	**42,018**

Use of renewable primary energy resources used as raw materials	Unit	A1-A3
Hard wood in forest	MJ	0,030
Soft wood in forest	MJ	0,018
Other resources	MJ	0,000
Total resources	**MJ**	**0,048**

Use of non-renewable primary energy	Unit	A1-A3
Oil	MJ	617,356
Natural gas	MJ	24,592
Coal	MJ	7,784
Other resources	MJ	6,047
Total resources	**MJ**	**655,756**

Use of non- renewable primary energy resources used as raw materials	Unit	A1-A3
Inert	kg	0,112
Sodium chloride	kg	0,066
Calcite	kg	0,036
Other resources	kg	0,009
Total resources	**kg**	**0,222**

***Table 6**: The environmental impacts of 1 tonne of Sand Matrix® 2-4mm*

Impact categories	Unit	Upstream (A1)	Core (A2)	Core (A3)	A1-A3
Global warming 100 years	kg CO_2 eq	0,463	29,934	19,981	50,378
Ozone layer depletion	mg CFC-11 eq	0,458	5,639	2,506	8,603
Photochemical oxidation	g C_2H_4	0,230	3,823	1,939	5,992
Acidification	g SO_2 eq	4,147	125,104	74,336	203,587
Eutrophication	g PO_4--- eq	0,623	20,557	15,569	36,748
Depletion of abiotic resource (element)	kg Sb eq	6,89E-09	5,97E-08	4,20E-07	4,86E-07
Depletion of abiotic resource (fossil)	MJ	35,709	435,375	191,511	662,595
Human toxicity 100 years	kg 1,4-DB eq	0,091	7,991	4,566	12,649
Freshwater aquatic ecotoxicity 100 years	kg 1,4-DB eq	0,046	0,494	3,001	3,541
Marine aquatic ecotoxicity 100 years	kg 1,4-DB eq	2,03E+02	2,01E+03	3,84E+03	6,06E+03
Terrestrial ecotoxicity 100 years	kg 1,4-DB eq	0,000	0,023	0,009	0,032
Land use	m^2a	0,015	0,060	0,034	0,109
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ	40,189	1,118	1,076	42,383
Use of renewable primary energy resources used as raw materials	MJ	0,007	0,027	0,015	0,049
Total use of renewable primary energy resources	MJ	40,195	1,146	1,091	42,432
Use of non-renewable primary energy excluding nonrenewable primary energy resources used as raw materials	MJ	37,433	446,579	197,627	681,639
Use of non- renewable primary energy resources used as raw materials	MJ	0,000	0,001	0,215	0,217
Total use of non-renewable primary energy resources	MJ	37,434	446,580	197,842	681,856
Use of secondary material	kg	0,000	0,000	1,175	1,175
Use of renewable secondary fuels	MJ	0,000	0,000	0,000	0,000
Net use of water	m^3	0,002	0,016	0,204	0,222
Non-hazardous waste	kg	0,001	0,006	4,756	4,763
Hazardous waste	kg	0,000	0,005	0,002	0,007
Radioactive waste	kg	0,000	0,000	0,000	0,000

***Table 7**: Consumption of renewable and non-renewable resources of 1 ton of Sand Matrix® 2-4mm*

Use of renewable primary energy excluding renewable primary energy resources used as raw materials	Unit	A1-A3
Solar energy	MJ	31,504
Hydroelectric energy	MJ	9,652
Other resources	MJ	1,227
Total resources	**MJ**	**42,383**

Use of renewable primary energy resources used as raw materials	Unit	A1-A3
Hard wood in forest	MJ	0,031
Soft wood in forest	MJ	0,018
Other resources	MJ	0,000
Total resources	**MJ**	**0,049**

Use of non-renewable primary energy	Unit	A1-A3
Oil	MJ	642,072
Natural gas	MJ	25,502
Coal	MJ	8,028
Other resources	MJ	6,253
Total resources	**MJ**	**681,856**

Use of non- renewable primary energy resources used as raw materials	Unit	A1-A3
Sodium chloride	kg	0,115
Calcite	kg	0,067
Gravel	kg	0,036
Other resources	kg	0,009
Total resources	**kg**	**0,227**

***Table 8**: The environmental impacts of 1 tonne of Sand Matrix® 0-4mm*

Impact categories	Unit	Upstream (A1)	Core (A2)	Core (A3)	A1-A3
Global warming 100 years	kg CO_2 eq	0,464	42,463	24,738	67,665
Ozone layer depletion	mg CFC-11 eq	0,444	8,000	3,421	11,864
Photochemical oxidation	g C_2H_4	0,224	5,424	2,565	8,213
Acidification	g SO_2 eq	4,112	177,469	93,539	275,120
Eutrophication	g PO_4--- eq	0,628	29,161	19,679	49,468
Depletion of abiotic resource (element)	kg Sb eq	6,87E-09	8,47E-08	2,69E-07	3,61E-07
Depletion of abiotic resource (fossil)	MJ	34,647	617,609	262,188	914,444
Human toxicity 100 years	kg 1,4-DB eq	0,091	11,336	5,707	17,134
Freshwater aquatic ecotoxicity 100 years	kg 1,4-DB eq	0,047	0,701	3,477	4,225
Marine aquatic ecotoxicity 100 years	kg 1,4-DB eq	2,06E+02	2,85E+03	4,23E+03	7,28E+03
Terrestrial ecotoxicity 100 years	kg 1,4-DB eq	0,000	0,032	0,013	0,046
Land use	m^2a	0,015	0,085	0,044	0,145
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ	42,928	1,586	1,481	45,995
Use of renewable primary energy resources used as raw materials	MJ	0,007	0,039	0,020	0,066
Total use of renewable primary energy resources	MJ	42,935	1,625	1,501	46,060
Use of non-renewable primary energy excluding nonrenewable primary energy resources used as raw materials	MJ	36,396	633,503	270,436	940,335
Use of non- renewable primary energy resources used as raw materials	MJ	0,000	0,002	0,117	0,119
Total use of non-renewable primary energy resources	MJ	36,396	633,505	270,553	940,454
Use of secondary material	kg	0,000	0,000	1,175	1,175
Use of renewable secondary fuels	MJ	0,000	0,000	0,000	0,000
Net use of water	m^3	0,002	0,023	0,315	0,340
Non-hazardous waste	kg	0,001	0,009	5,584	5,594
Hazardous waste	kg	0,000	0,007	0,003	0,010
Radioactive waste	kg	0,000	0,000	0,000	0,000

***Table 9**: Consumption of renewable and non-renewable resources of 1 ton of Sand Matrix® 0-4mm*

Use of renewable primary energy excluding renewable primary energy resources used as raw materials	Unit	A1-A3
Hydroelectric energy	MJ	33,813
Solar energy	MJ	10,589
Other resources	MJ	1,592
Total resources	**MJ**	**45,995**

Use of renewable primary energy resources used as raw materials	Unit	A1-A3
Hard wood in forest	MJ	0,042
Soft wood in forest	MJ	0,024
Other resources	MJ	0,000
Total resources	**MJ**	**0,066**

Use of non-renewable primary energy	Unit	A1-A3
Oil	MJ	887,175
Natural gas	MJ	34,524
Coal	MJ	10,449
Other resources	MJ	8,306
Total resources	**MJ**	**940,454**

Use of non- renewable primary energy resources used as raw materials	Unit	A1-A3
Inert	kg	0,152
Sodium chloride	kg	0,074
Calcite	kg	0,038
Other resources	kg	0,011
Total resources	**kg**	**0,274**

2.1 Additional environmental information

Comparison between Sand Matrix® and sand production

Sand Matrix® 0-2 mm was compared with sand, whose life cycle includes the extraction of the raw material, the handling inside the cave and the treatment of the extracted material; the life cycle of the sand was obtained from the Ecoinvent database (process Sand {IT}| gravel and quarry operation | Cut-off, U" modified with the Italian energy mix), ETH database (process "Sand ETH U") and ELCD database (process "Sand 0/2, wet and dry quarry, production mix, at plant, undried RER S"). The following table presents the results of the comparison relative to 1 ton of product.

Table 10: *Results of the comparison between Sand Matrix® 0-2 mm (without and with avoided impacts) and sand*

Impact category	Unit	Sand Matrix® 0-2 mm	Sand Matrix® 0-2 mm with avoided impacts of slag disposal	Sand Matrix® 0-2 mm with avoided impacts of slag disposal and primary production of iron and aluminium	Sand (Ecoinvent)	Sand (ETH)	Sand (ELCD)
Global warming potential 100 years	kg CO_2 eq	48,635	-682,752	-737,025	2,594	9,786	2,457
Ozone depletion	mg CFC-11 eq	8,274	5,861	2,071	0,406	12,094	0,383
Photochemical smog formation	g C_2H_4	5,769	-149,483	-230,112	0,507	0,879	1,077
Acidification	g SO_2 eq	196,373	-95,945	-556,074	22,228	31,030	20,376
Eutrophication	g PO_4--- eq	35,466	-2941,891	-3031,546	4,443	5,967	2,027
Human toxicity	kg 1,4-DB eq	12,196	-210,921	-240,939	0,378	0,981	0,112
Water ecotoxicity	kg 1,4-DB eq	3,472	-2276,674	-2296,381	0,353	0,149	0,003
Marine water ecotoxicity	kg 1,4-DB eq	5,93E+03	-1,10E+06	-1,16E+06	1,69E+03	1,84E+03	6,10E+02
Soil ecotoxicity	kg 1,4-DB eq	0,031	-1,592	-1,978	0,001	0,005	0,001
Land use	m^2a	0,105	-0,061	-1,139	0,433	4,625	0,000
Water consumption	m^3	0,210	0,189	0,080	0,011	0,093	-0,011
Non renewable resources without energy content	MJ eq	42,018	16,860	-8,079	5,273	2,918	2,358
Non renewable resources with energy content	MJ eq	0,048	-0,044	-0,507	0,076	0,037	0,000
Renewable resources without energy content	MJ eq	655,774	441,202	-196,709	42,675	150,554	28,831
Renewable resources without energy content	MJ eq	0,005	0,226	0,198	0,054	2,918	2,358

From the above results, it can be noted that, as regards the indicators of global warming, formation of photochemical smog, acidified cation and eutrophication, all the impact categories are higher in the life cycle of the Sand Matrix® (compared to the process database Ecoinvent): that is due to the higher consumption of fossil fuels. Only the indicator depletion of the ozone layer for the process of extracting the sand of the database ETH is greater than Sand Matrix®.
Concerning the indicators of toxicity, all impact categories are higher in the life cycle of Sand Matrix® due to increased consumption of fossil fuels and processes for waste disposal.
The consumption of non-renewable resources as raw material in the Sand Matrix® results to be higher than other extraction processes of the sand, as well as the consumption of non-renewable resources of Sand Matrix®, mainly due to the transport of waste incinerators to Officina dell'Ambiente; consumption of renewable resources as raw material is not particularly significant as it is related to the biomass used for the production of electricity in the energy mix of European countries. Instead, the consumption of renewable energy resources indicates that the extraction of sand used traditional resources (fossil fuels). It should be emphasized that for the production of Sand Matrix is used only electricity from renewable sources. The water consumption is higher than in the production of the Sand Matrix® because it refers the water used to wet the heaps.

With regards to the comparison between the scenarios of Sand Matrix® with and without avoided impacts of bottom ash, the greatest benefit is evident in the indicator of ecotoxicity in water and the indicator of eutrophication as a result of avoided emissions into water of toxic substance, phosphate and COD released by bottom ash.
With regards to the comparison between the scenarios of Sand Matrix® with and without avoided impacts of bottom ash disposal in landfill (calculated modifying process "Municipal solid waste (waste treatment) {CH} | treatment of municipal solid waste, sanitary landfill | Cut-off, U" of Ecoinvent database) and the primary production of iron and aluminium (calculated with processes "Sinter, iron {GLO} | production | Cut-off, U" and "Aluminium production | Cut-off, U" of Ecoinvent database), the greatest benefits are evident in the indicators of non-renewable resources, with and without energy content, due to the avoided supply of raw materials and fossil fuels (the latter contributes to the reduction of global warming potential); water consumption remains almost constant because it is related to the production of Sand Matrix®; also in the indicator of formation of photochemical smog, due to the avoided emission of carbon monoxide derived from primary production of iron; also in the indicator of acidification, due to the avoided emission of sulphur dioxide derived from the primary production of iron; and also in the indicator of eutrophication, toxicity and ecotoxicity, due to the avoided emissions derived from landfill.

Quality of Matrix® products

Officina dell'Ambiente S.p.A. applies a production cycle that includes a series of self-limitations with the aim to further increase the level of assurance of the already high technical standards of the Matrix ®. In particular, bottom ashes produced by incinerators that treat special industrial waste are never delivered to Officina dell'Ambiente, even if that bottom ash could be theoretically compatible for its chemical and physical properties; other types of waste are never delivered and treated, even if Officina dell'Ambiente is authorized to receive different EWC waste code, therefore mixing of wastes does not occur; waste from storage centres is never delivered to Officina dell'Ambiente but only ash produced by individual furnaces is accepted, so as to maintain a clear traceability and specificity of the incoming material. Environmental controls on Matrix ® Family are performed to ensure products with consistent quality and environmental characteristics compatible with the limits of the law and regulations. All Matrix® products are subject to strict controls: analysis includes the major inorganic constituents and heavy metals and are carried out on samples that represent the average production of the plant. Main organic pollutants are regularly measured on a monthly basis in the Matrix ® Standard and their values are always equal to zero or extremely low.

Officina dell'Ambiente has set up a chemical laboratory equipped with modern instrumentation and directed by a chemist regularly enrolled with the professional Order. The instrumental equipment is able to realize inorganic analysis with particular reference to complex mineralogical matrices such as slag from incineration (ball mills, digester oven, muffle for mergers alkaline, inductively coupled plasma spectrometer for the determination of metals). In addition physical and mechanical tests are performed, as required to maintain the EC labels, and the same laboratory is suitable for carrying out independently mixtures of concrete and mortar together with a number of measurements according to the UNI EN rules. Alternatively, highly qualified external laboratories are employed.

Product certification

According to Regulation 305/2011/CE, building materials may be sold only if they possess EC marking in accordance to the corresponding technical standard. For almost all of the applications of Matrix® products, EC marking is required.
Obtaining this marking requires the existence of the Quality Control System, known as FPC (Factory Production Control) that once implemented is subject to certification by an independent body (ICMQ, certificate number 1305-CPD-0661). Officina dell'Ambiente S.p.A. has been certified at the beginning of 2008 and the FPC system covers five products for a total of eleven EC marking in accordance with the technical standard.

All products of the Matrix® Family play an important role in the LEED certification scheme as they contribute to the achievement of credits related to the section "Materials and resources" either for category 4 (recycled content) and category 5 (regional materials) . To facilitate the acquisition of credits by customers working in eco-sustainable building, the recycled content in Matrix® products, which is equal to 100% post-consumer waste, has been established using the requirements of the standard ISO 14021. The result is a self-declared environmental statement (in accordance with ISO 14021) whose accuracy has been subjected to independent validation of ICMQ certification.

Improvement strategy

Based on the results of the LCA study and maintaining what has already been reported in the EMAS Environmental Declaration, improvement goals set by Officina dell'Ambiente for Matrix® products include the extension of the CE marking to at least one more Matrix® product and the reduction of environmental impacts of Matrix® products through the review of the logistics of transporting of waste input.

Differences of the environmental performance versus previous versions of the EPD

Officina dell'Ambiente, always attentive to environmental issues, since 2011 has verified its impacts through the life cycle analysis of its products and the preparation and publication of the Environmental Product Declaration within the International EPD® System. Over the years, it has improved its analysis, implementing the collection of primary data and specific information, deepening the assessment of all the processing phases.
This year a new version of the database was used, from Ecoinvent in version 3.3 to version 3.5. Also the software was updated (from SimaPro version 8.5 to SimaPro version 9).

Analyzing the main environmental impacts (global warming, depletion of the ozone layer, formation of photochemical smog, acidification and eutrophication), in 2019 they increase compared to the previous year for Sand Matrix 2-4 and 0-4 while they decrease for Sand Matrix 0-2: the variability is linked to the percentage of material produced in one site rather than another, knowing that the impact of the Sand Matrix produced at Conselice is less than that one produced at Lomello, due to the efficiency of the plant (better in Conselice).

3 REFERENCES

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- *PCR 2012:01 version 2.3 valid until 2020-03-03*; Group CPC: Construction products
- *UNI EN 15804:2014 Sostenibilità delle costruzioni - Dichiarazioni ambientali di prodotto - Regole chiave di sviluppo per categoria di prodotto*
- *ISO 14040:2006 Environmental management – Life cycle assessment - Principles and Framework*
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International EPD® system http://www.environdec.com

EPD from the same product category but referring to different programmes cannot be compared.

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Geographic Area: Italy

CEN EN 15804 was used as a basic PCR.

PCR and PCR BASIC MODULE: Construction products and Construction services; version 2.3 valid until 2020-03-03, 2012:01
The revision of the PCR was conducted by: Technical Committee of the International EPD® System (president: Massimo Marino). email: info@environdec.com

Independent verification of the declaration and data, according to ISO 14025
The third-party verification was conducted by Vito D'Incognito Via Vallazze 95 Milano tel. +39 335 6004199 email vdincognito@take-care.it accredited by the Technical Committee of the International EPD® System.

The certification body Bureau Veritas Italia is the manager of the contract with Officina dell'Ambiente.