Water scarcity footprint for cement production

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This study evaluates the production of cement in Lafarge-Holcim factory located in Nobsa, Colombia, corresponding to the 2013 water footprint evaluation. The study was elaborated within the frame of SuizAgua Colombia project, an Initiative of the Global Programme Water Initiatives of the Swiss Agency for Development and Cooperation that aims to improve corporate water stewardship with the use of innovative approaches including the water footprint concept.

1. Scope

1.1 **Functional unit:** The declared unit is 1000 kg (1 ton) of cement. The plant produces different types of cement, but mainly Portland cement.

1.2 System boundaries:

Geographical and temporal dimensions: The year evaluated is 2013, but estimation of captured rain water required multi-annual precipitation data. Location of cement plant is Magdalena-Cauca basin in Colombia (watershed ID: 49500).

Figure 1 presents the type of processes involved in cement production. Supply chain including limestone, gypsum and iron ore is transported to the cement plant, where they are milled and then are treated with high temperatures in a kiln to obtain a pre-product (clinker) that is milled again with gypsum to obtain cement. Water for industrial use is mainly from a river, and used for cooling. Plant recycles and reuses industrial water, also collects rain water for industrial purposes. Tap water is used for domestic purposes; this water is treated before its release to a surface water source. Direct water use's calculations employs specific data, available from water meters and water quality analysis.

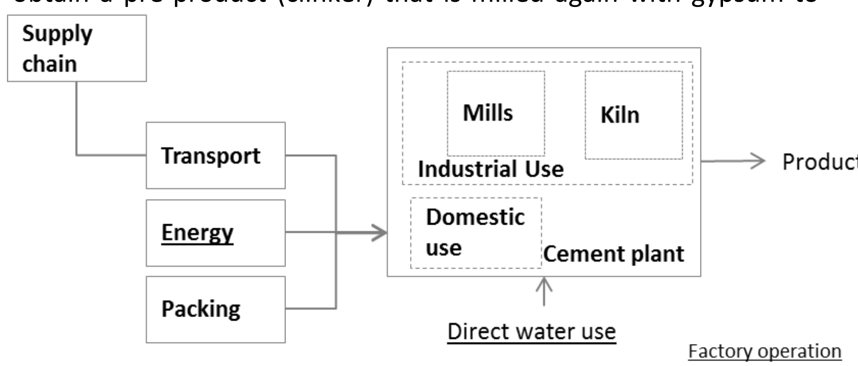

Figure 1. System Boundaries

Table 1. Cement production inventory data

		Amount	Unit
Direct water use	Rain water captured	19.2	L
	superficial water input	86.2	L
	tap water input	10.1	L
	treated domestic waste water release	9.1	L
Energy consumption	Electricity, Med Volt	84.8	kWh
	Carbón	82.9	kg
	Diesel 8% biodiesel	0.5	gal
	AFR (alternative fuel residues)	0.0	Ton
Supply chain production		1'446.3	kg
supply chain transport	transport, transoceanic freight ship	1.7	tkm
	transport, lorry >32t, EURO4	0.3	tkm
	transport, lorry 16-32t, EURO4	36.6	tkm
Packing	Bags (2 paper kraft layers)	2.2	kg
	Bags (2 paper kraft + 1 PE layers)	0.0	kg

Table 1 presents energy and material inputs and outputs for 1 ton of cement in this plant, with scope as described previously. Supply chain production includes limestone, gypsum, iron scrap and ore, and pozzolan.

Indirect water uses are modeled with Quantis Database. Electricity, Medium Voltage of origin Colombia is derived taking into account the matrix that describes the type of electricty for 2009 as follows: hydro 72%, gas 20%, oil 1%, coal 7%.

2. Water scarcity footprint results

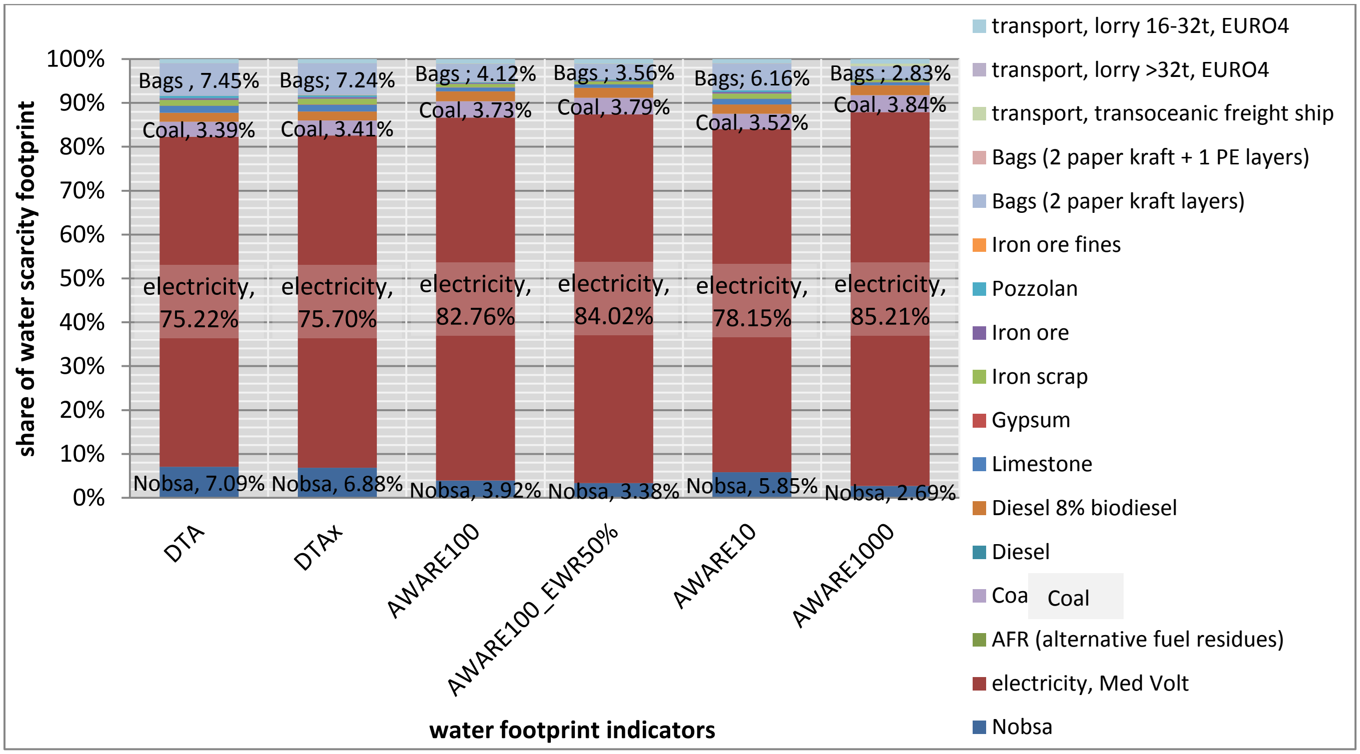

Figure 2. Water scarcity footprint comparing different indicators in percentages

Figure 2 presents results for 6 different indicators for water scarcity footprint: DTA, DTAx, AWARE100, AWARE100_EWR+50%, AWARE10 and AWARE1000. For all of them, hotspot is indirect water footprint related to electricity consumption; the largest is given by AWARE1000 (85.21%), followed by AWARE100_EWR+50% (84.02%) and AWARE100 (82.76%). After electricity, main share of water footprint is on Nobsa cement plant (whose share varies between 2.69% and 7.09% for the different indicators), Bags (varies between 2.83% and 7.45%) and coal (between 3.39% and 3.79%); however none of them goes beyond 10%. In summary, all evaluated indicators shown similar results about water scarcity footprint hotspots. This is because high indirect water consumption due to high electricity consumption per ton of cement produced, and because there is a large water consumption associated to dams of hydroelectric plants.

The largest absolute value is associated with *AWARE1000* method, 1.51 $m^3_{world\text{-}eq.}$, associated to an increased water scarcity of energy inputs (electricity, coal) of Colombian origin, because AWARE1000/AWARE100 for Colombia relation is 1.5. The difference should be associated to dry months on Caribe basin, which increases average value of scarcity for Colombia. Relationship between *AWARE10* result, 0.7 $m^3_{world\text{-}eq,}$ and AWARE100 result, 1.04 $m^3_{world\text{-}eq}$ is also explained by this reason. In this case study, AWARE increases when taking 150% of original value for Environmental Water Requirement doesn't significantly increase Water Scarcity Footprint, the increase is from 1.04 to 1.05 $m^3_{world\text{-}eq}$ per ton cement. DTAx and DTA imply a smaller absolute value by definition, and results for DTA and DTAx are close (0.58 m^3_{eq} and 0.44 $m^3_{world\ eq}$).

3. Analysis of results

- Given the scales of each method, largest absolute value for water scarcity footprint is given by AWARE1000, followed by AWARE100_EWR+50%, AWARE100, AWARE 10, DTA and DTAx. In this case study, all different water scarcity footprint methodologies gave as result that electricity consumption from Colombian matrix was the main hotspot.
- In this case, electricity water footprint was obtained from database. This procedure doesn't consider monthly variability of water consumption, which in the case of hydroelectricity varies importantly between months depending on water balance and can even be negative in some months, when more water is released than entered by precipitation or input of river flow (WD4 ISO14073, 2015).
- In terms of MJ, energy consumption on plant is 88% carbon, 10% electricity and 2% diesel8%bioldiesel. In comparison, water scarcity footprint is between 75% (DTA) and 85% (AWARE1000) due to electricity consumption. In terms of water scarcity footprint, coal is a better choice, but in terms of water availability footprint, pollution due to coal mining increases its relevance.
- The use of different thresholds may increase significantly the absolute value for average water scarcity of a country, even if it is of low water scarcity. In the case of Colombia, scarcity increased around 50% between AWARE10 and AWARE100, and between AWARE100 and AWARE1000. This increase relates to high stress Caribe basin, which is the one with areas and months of AWARE greater than 10, and even though it covers only 9% of national territory.
- For Colombia, water availability change in dry years can be pretty high; therefore it may be important to include dry scenarios in order to identify hotspots during these seasons. These results can be of mayor interest for a company if it has direct operations in areas of temporal water scarcity, because it would be more aware about needs for preparing for these seasons. The company can also work with its supplier for a better water management on hotspots watersheds.

4. Potential problems to be addressed

- For supplies for which only the country of origin is known, its AWARE indicator may be overestimated and therefore its water scarcity footprint may hinder importance as hotspots of other supplies or direct processes, for which there are water basin location available. This is true for all indicators but for AWARE may be of greater concern. Additional analysis for only processes with specific location available may be of interest, especially if company has greater potential of influence over them.
- When excluding processes for which there is not a local water basin of origin available, water scarcity footprint changed significantly when downscaling AWARE100 (increase of 41%). This result increase awareness about downscaling when possible, especially for productive processes where location is known and given that their basins have large areas and changing microclimates.

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Annex I. Used Water Scarcity Indexes

Location	DTA	DTAx	AWARE100 (1/AMD)	AWARE100_ EWR+50%	AWARE10	AWARE1000
Global Average	0.78	1.28	20.30	28.00	5.94	289.38
Colombia Av	0.39	0.30	0.77	0.79	0.49	1.15
Spain Av	0.72	1.27	31.49	37.88	5.14	263.44
Basin ID 49500	**0.38**	**0.29**	**0.38**	**0.34**	**0.38**	**0.38**
Downscaled (average year water availability)						
Cities: Nobsa, Tibasosa, Paz del río (Chicamocha River sub-basin)	0.40	0.02	0.66	0.66	0.94	0.66
Sibaté (Bogotá River sub-basin)	0.74	0.05	2.22	2.22	23.86	2.22
Villanueva (Suarez River sub-basin)	0.40	0.02	0.33	0.33	0.48	0.33
Palmira (Amaime and Cerrito rivers sub-basins)	0.55	0.03	0.73	0.73	1.25	0.73
Downscaled and with dry year water availability						
Cities: Nobsa, Tibasosa, Paz del río (Chicamocha River sub-basin)	0.7	0.0	2.7	2.7	100	2.7
Sibaté (Bogotá River sub-basin)	1.5	0.1	100	10	100	1'000
Villanueva (Suarez River sub-basin)	1.0	0.1	100	10	100	1'000
Palmira (Amaime and Cerrito rivers sub-basins)	1.1	0.1	100	10	100	1'000