LCA of PVC and HDPE pipes for drinking water distribution networks in cities

David Sanjuan-Delmás[a]; Anna Petit-Boix[a]; Carles M. Gasol[b]; Gara Villalba[a,c]; María Eugenia Suárez-Ojeda[d]; Xavier Gabarrell[a,e]; Alejandro Josa[f,g]; Joan Rieradevall[a,c]

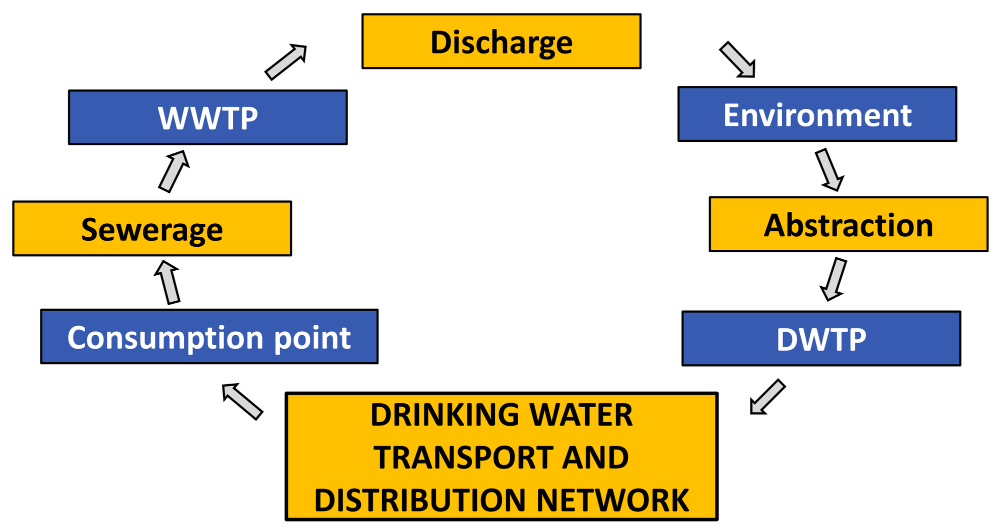
[a]Sostenipra, Institute of Environmental Sciences and Technology (ICTA), School of Engineering, Universitat Autònoma de Barcelona (UAB), Campus UAB, 08193 Bellaterra, Barcelona, Spain. 2014 SGR 1412.
[b]Inèdit innovació. Spin off of UAB Research park. Cabrils Road Km 2(IRTA) 08348, Cabrils, Barcelona, Spain.
[c]Department of Chemical Engineering, School of Engineering, Edifici Q, Universitat Autònoma de Barcelona (UAB), 08193 Bellaterra, Barcelona, Spain.
[d]GENOCOV. Department of Chemical Engineering, School of Engineering, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain.
[e]Department of Chemical Engineering, (Catalan Biotechnology Reference Network -XRB-), School of Engineering, Edifici Q, Universitat Autònoma de Barcelona (UAB), 08193 Bellaterra, Barcelona, Spain.
[f]Department of Geotechnical Engineering and Geosciences, School of Civil Engineering, Technical University of Catalonia – Barcelona Tech, Campus Nord, C/Jordi Girona 1-3, Building D2, 08034 Barcelona, Catalonia, Spain
[g]Institute of Sustainability (IS.UPC), Technical University of Catalonia—Barcelona Tech, UPC, Campus Nord, Building VX. Pl. Eusebi Güell, 6, 08034 Barcelona, Catalonia, Spain

* *Corresponding author*: **david.sanjuan@uab.cat**; Tel. (+34)935813760

1 INTRODUCTION

The drinking water distribution network (DWDN) includes the necessary infrastructure to transport water from the drinking water treatment plant to the consumption point (excluding buildings) (Figure 1).

The present contribution analyses the environmental impacts derived of the construction of 1 m of DWDN with a pipe made of poly vinyl chloride (PVC) or high density polyethylene (HDPE), which are two commonly installed materials in small to medium cities. DWDN life cycle phases have been identified (Figure 2). The use and maintenance phase has been excluded due to the huge variations in the environmental impacts, which depends on case-specific variables such as the location of the elements over topography (for instance, the drinking water treatment plant location).



DWTP: Drinking Water Treatment Plant
WWTP: Waste Water Treatment Plant

Fig 1 The drinking water distribution network within the urban water cycle. The orange boxes represent water transport phases.

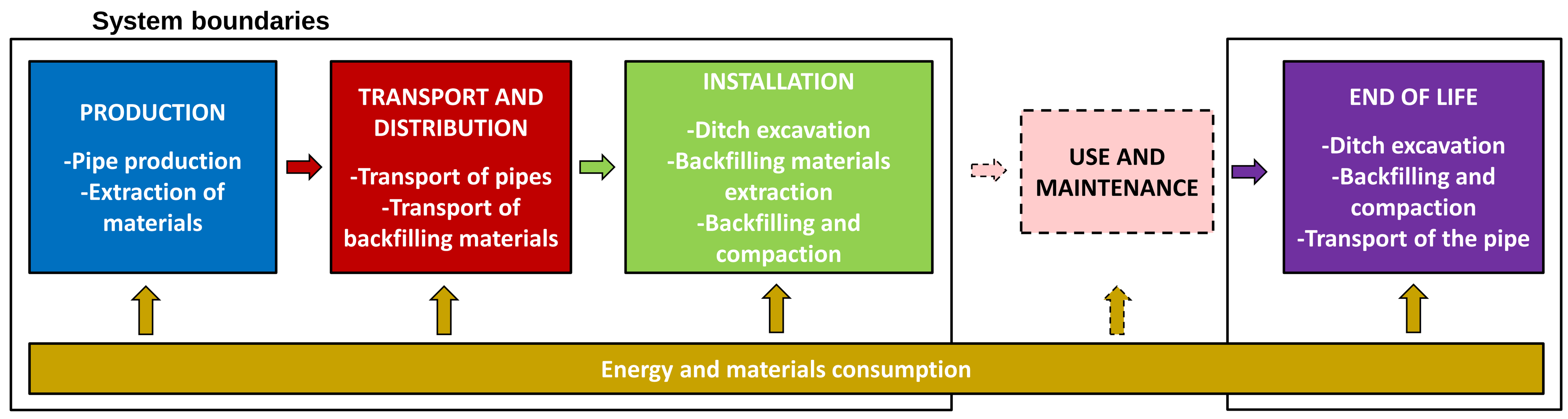


Fig 2 Life cycle and system boundaries of the drinking water distribution network. Discontinuous line boxes are not included in the assessment.

2 METHODOLOGY

The LCA methodology has been applied following the ISO 14040 [1] and using the software Simapro 7.3, the CML 2 baseline 2000 V2.05 method and the ecoinvent 2.2 [2] database for the environmental information. In order to obtain the required quantity of materials and energy consumptions, the database Itec Metabase [3] was used.

The functional unit (FU) considered for comparison is 1 m of DWDN for the transport of water during 60 years considering the phases of production, transport, installation (including the ditch, Figure 3) and end of life.
The same technical conditions have been considered for the 2 pipes made of different materials: 315 mm diameter (the largest used pipe diameter in DWDN) and 6 bars of maximum pressure. Also, sand has been considered as backfilling materials and gravel as bedding material for both constructing solutions (Figure 3). Regarding the life expectancy of the pipes, experts declare that both HDPE and PVC pipes could reach life expectancies of between 50 and 100 years [5, 6]. For this reason, the same life expectancy was assumed for the 2 options.

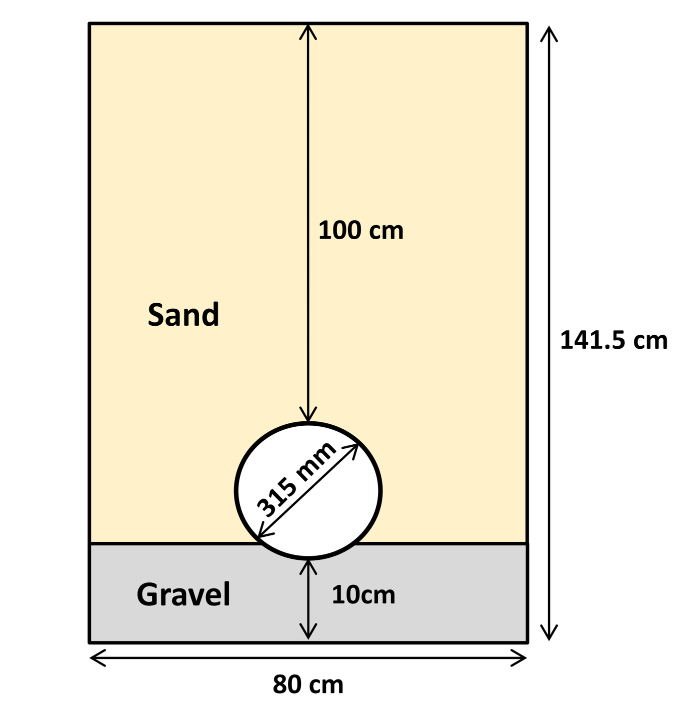


Fig 3 Dimensions of the ditch considered for the installation of the network. Source: [4]

3 RESULTS AND CONCLUSIONS

Regarding the contribution of each life cycle phase to the environmental impact of the DWDN (Figure 4), the results show that production is the main contributor to the impacts of both HDPE and PVC (between 30 and 65% of the environmental impact in 6 out of 7 midpoint impact categories analysed), followed by installation (between 13 and 36%).
Since the same ditch dimensions were considered for the installation the environmental impacts of installation, transport and end of life are similar in both cases. Thus, the differences observed between HDPE and PVC are derived of the pipe production.

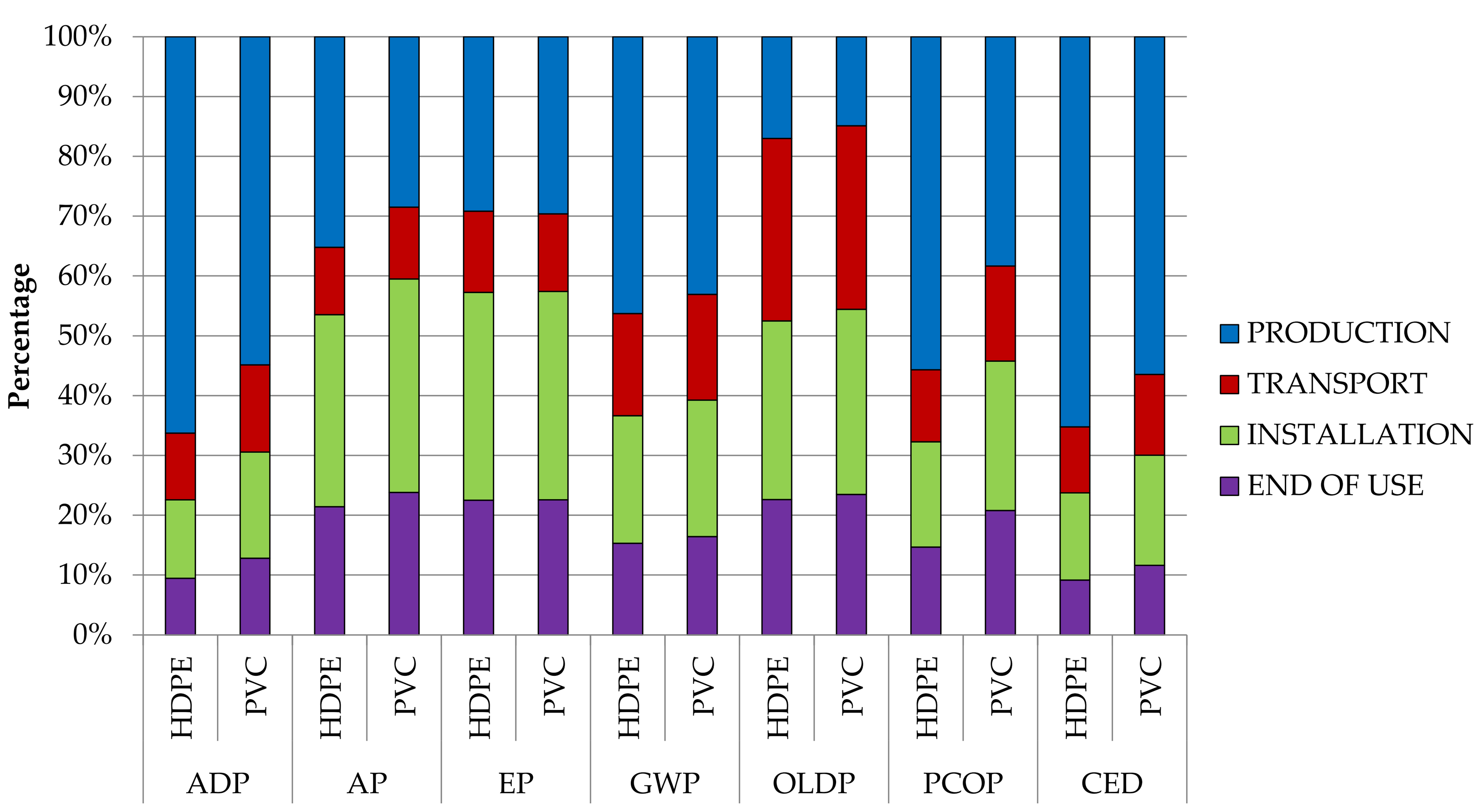


Fig 4 Contribution of each life cycle phase to the environmental impact of the HDPE and PVC pipes

The comparison of the HDPE and PVC pipes (Figure 5) shows that PVC presents between 10 and 30% lower environmental impacts in 4 out of the 7 categories.
Although the selection of PVC pipes might reduce the environmental impacts, the ditch dimensions optimization might be the priority, since it is linked with the environmental impacts derived of transport, installation and end of use phases (through the volume of soil excavated, transported and backfilled), which together account for 33 to 85% of the impacts.

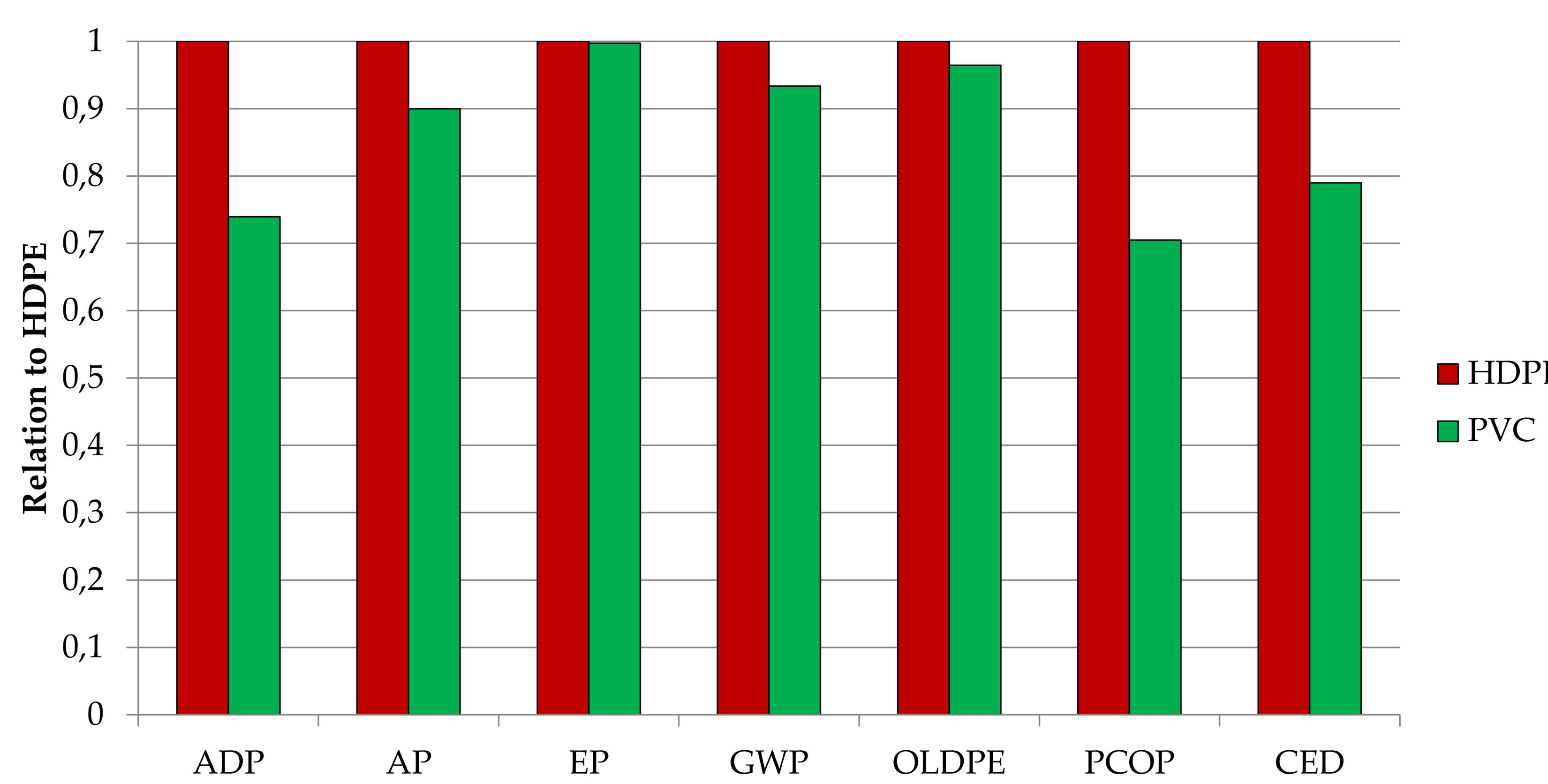


Fig 5 Comparison of the environmental impacts derived from the HDPE and PVC pipes.

ADP=Abiotic Depletion Potential, AP=Acidification Potential, EP=Eutrophication Potential, GWP=Global Warming Potential, OLDP=Ozone Layer Depletion Potential, PCOP=Photo Chemical Oxidation Potential, CED= Cumulative Energy Demand, PVC=poly vinyl chloride, HDPE=high density polyethylene

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