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Life-cycle impact assessment of end-of-life reverse osmosis membranes: method selection

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Abstract: To help move desalination closer to more sustainable practices, this work aimed at comparing 6 different life-cycle impact assessment methods to understand which of them would be more representative to further compare the impacts of disposing of end-of-life reverse osmosis membranes in the Brazilian context. This step was necessary because methods are mainly focused on developed countries, and their use might bring mislead conclusions in other realities. Among the six compared methods, two converged to the same results according to statistical tests, and CML-IA Baseline was chosen over ILCD Midpoint because it has already been amongst the recommended methods to the assessed context.

Keywords: Life-cycle analysis; end-of-life reverse osmosis membranes; method selection.

INTRODUCTION

Desalination has become an integral part of water management worldwide. As any other process, it causes environmental impacts, including the disposal of end-of-life reverse osmosis (EoL-RO) membranes. To move desalination towards more sustainable practices, life cycle impact assessment (LCIA) is an important tool to compare different disposal options for of EoL-RO and their associated impacts. This allows organizations to use that information to intervene in positive ways in the membrane life-cycle, and also invest into new processes.

However, the vast majority of LCIA models were developed in European countries, USA, and Canada, which prevents countries outside those regions from producing LCIA results with specific characteristics. Hence, the present study aims to analyse different models in the Brazilian LCA context, in order to help understand how this regionalization sets specific to which model.

MATERIAL AND METHODS

To perform the LCIA, Open LCA was used and six different methods were first compared. This stage was added because the vast majority of LCIA models were developed in European countries, USA, and Canada. This might prevent countries outside those regions from producing LCIA results with specific characteristics. Hence, a way to diminish such biases is to test which methods converge to the same result.

To this, ReCiPe 2016, IMPACT 2002+, IMPACT World +, EDIP 2003, CML-IA Baseline, and ICLD Midpoint 2011+ were compared in terms of common categories. To evaluate if there

was any significant difference between the methods, the Monte Carlo simulation (1000 runs) was applied, creating distribution functions for each of them. Functions were plotted in box plot form for exploratory data analysis (EDA), where the Shapiro-Wilk test verified the non-parametric distribution. After, they were pairwise compared using the non-parametric Anderson-Darling test (AD Test) at a confidence level of 95%.

RESULTS AND CONCLUSIONS

To define the LCIA method to be used, the tested ones were compared in terms of common categories. Despite not having the exact same name, by comparing their description and unit of reference, it was seen that ozone layer depletion and global warming were present across all six methods. The EDA performed started comparing the global warming category, where all 6 distributions did not follow a normal distribution, as confirmed by the Shapiro-Wilk test. For that reason, further statistical tests were applying considering non-parametric distribution.

Samples were then plotted in box plot form, as shown in Figure 1a. It was possible to notice that apart from Impact 2002+, at first the results seemed to converge, reason why the Anderson-Darling test was applied to the remaining group. However, the visual comparison was not confirmed by the statistical test, and the null hypothesis of the samples being originated from the same population was rejected. The AD test was also used to pairwise comparison, and the null hypothesis was continuously being rejected. This means that, for the global warming category, each method presented a different impact result, and the analysis was not able to indicate alone which method(s) could lead to better results.

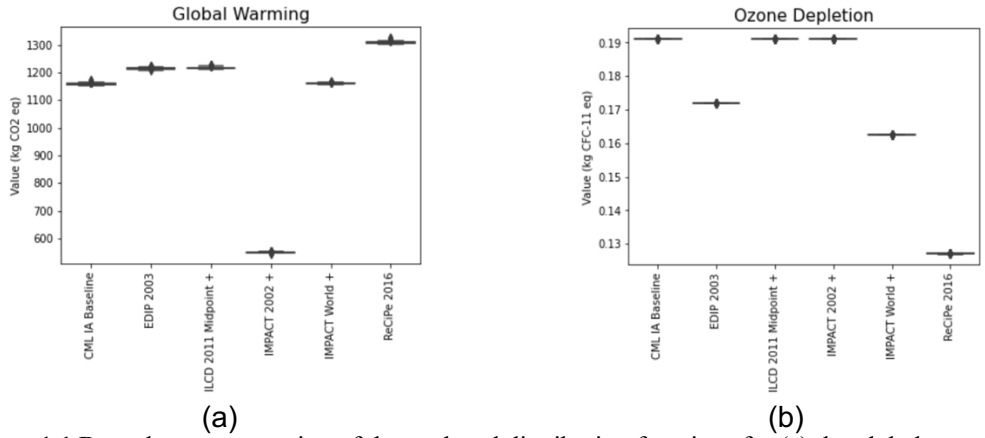

Figure 1.1 Box-plot representation of the analysed distribution functions for (a) the global warming category and (b) ozone depletion

The same methodology was applied to the ozone depletion category. In this case, the box plot showed that CML IA Baseline, Impact 2002+ and ILCD Midpoint seemed to converge to the same population, as shown in Figure 3b. This was statistically confirmed by the AD-test, where the null-hypothesis was confirmed at a confidence level of 95%. However, when crossing information between both categories – global warming and ozone depletion, it was possible to notice that Impact 2002+ presented a higher deviation from the other two for global warming, narrowing down the selection. In this case, since CML IA Baseline was one of the methods recommended by Mendes, Bueno and Ometto (2015) for the Brazilian context, it was chosen to perform further experiments.

REFERENCES

Mendes, N. C.; Bueno, C.; Ometto, A. R. (2015). Life-cycle Impact Assessment: a review of the main methods. Production, 26, 160-175.