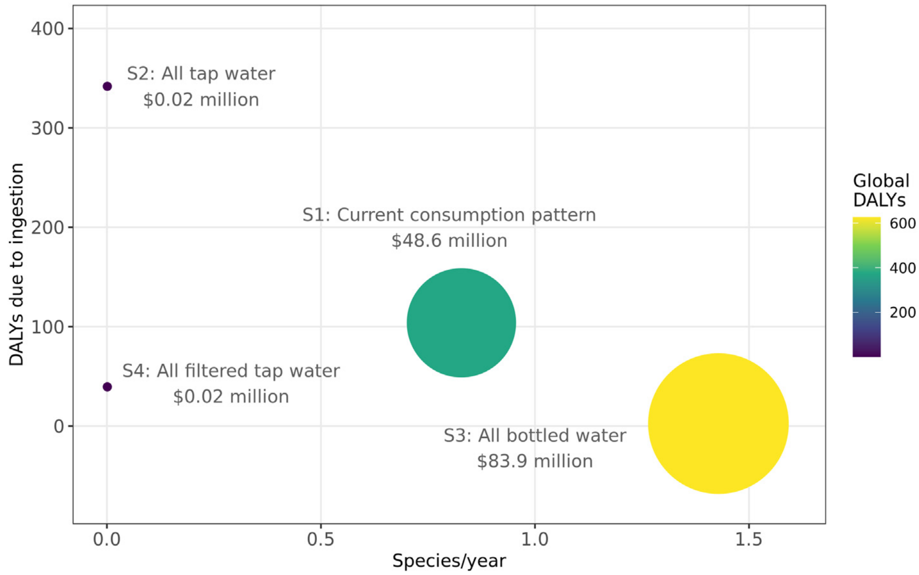

Fig. 3. Integrated health and environmental impacts of drinking water source scenarios in Barcelona.*
*Dot plot size proportional to value of raw material costs in $. Two measures of health impacts (in DALYs are shown). DALYs due to ingestion refer to bladder cancer in the Barcelona population. Global DALYs refer to human health impacts in the global population due to emissions in the production of drinking water to supply the Barcelona population.

among domestic filter users in the study area (March et al., 2020). However, different filters may have different THM removal efficacies (Carrasco-Turigas et al., 2013), which is not reflected in our estimates. Second, given the lack of specific input data for the LCA, we have equated domestic filter use with tap water use, which ignores the materials and energy used for the production of the filters. Although these results should be cautiously interpreted, our findings suggest that domestic filters reduce both local health and global environmental impacts compared to other drinking water options, and appear as a compromise option between bottled and tap water. However, correct maintenance of domestic filters is an important issue, given that a number of studies raised issues on microbiological safety for membrane filters (Zhang et al., 2013) and jar-type filters (Daschner et al., 1996).

Our estimates provide the first comparative data of the health and environmental impacts of different water consumption choices; however, interpretation of our findings should take into account several limitations of our study. We consider a limited set of scenarios, including extreme scenarios that may not be probable. Nonetheless, these scenarios provide a useful envelop of potential impacts related to changing drinking water source. Our HIA is based on a number of assumptions. We applied the national bladder cancer incidence to the city of Barcelona, given that local statistics were not available. There is very limited evidence on the relative contribution of each exposure route (ingestion, inhalation, dermal) for THMs, and we used estimates from the only single study that was identified. Our estimates of exposure relied on the limited available evidence regarding the prevalence of specific types of filters, the reduction of THM levels, and the THM concentrations in bottled water, highlighting an important data gap. We assumed that the exposure-response relationship was the same for the different exposure routes (ingestion, non-ingestion) and applied the available exposure-response function that is estimated based on total THM levels in tap water, regardless of personal behaviour. The exposure-response function is estimated based on bladder cancer incidence, which do not fully correspond to DALYs. In addition, the burden of disease attributable to THMs is interpreted as future projections over each individual's lifespan assuming the current disease incidence, population and age distribution. Our HIA relies on the assumption that the association between THM exposure and bladder cancer is causal; however, several uncertainties about this relationship remain such as the mechanisms of action, difference in risk between men and women, among others. Our models are based on individuals' primary drinking water source, and do not take into account variability in individuals' drinking water source (e.g. at residence, work, in restaurants). Finally, we considered the local health impacts from a single exposure pathway (THMs), with substantial epidemiological evidence linking it to health. There may be other contaminants relevant for health that we have not included due to lack of available epidemiological evidence.

Similarly, several limitations are involved in the application of LCA and the ReCiPe2016 endpoint (H) method to our research question. In general, impacts are not spatially-resolved in ReCiPe2016, which is a major limitation to integration with HIA. We did not have sufficient data to quantitatively account for uncertainties across impact categories. We considered global DALYs in the LCA as a secondary impact category due to several important uncertainties including the lack of spatial resolution needed to identify which population is exposed, and lack of documentation of the selection of potentially toxic substances that are modelled and which health endpoints are included in the DALYs. Limitations and target areas for methodological improvements in LCA have been reviewed by others (Finkbeiner et al., 2014). Key limitations relevant to our analysis include lack of specificity regarding time horizon and level of certainty in the calculation of characterisation factors for some impact categories (e.g. photochemical ozone formation, terrestrial acidification, freshwater eutrophication, land use and fossil resource scarcity) (Huijbregts et al., 2016). Inclusion of emerging activities and substances, such as nanoparticles, are important areas for future development (Huijbregts et al., 2016). Considering these limitations, we draw our conclusions based on comparisons across scenarios, rather than on the absolute values of impacts, consistent with recommendations in the literature (Golsteijn, 2016). Other limitations of LCA make comparisons across studies challenging: studies can have different system boundaries, thereby including different impacts or processes (Curran, 2014; van der Meer, 2018). Nonetheless, LCA is the best available tool to provide a comprehensive, holistic, and complete understanding of the potential impacts generated across all stages of production (van der Meer, 2018).

5. Conclusions

Our study provides the first attempt to compare health and environmental impacts of individual water consumption choices through the integration of HIA and LCA. Our findings suggest that the sustainability gain from consuming water from public supply relative to bottled