

Response to Reviewer 2

### **R2-C1**

***High quality thoughtful effort to produce HydroWASTE. Review link works, data download and open easily.***

We thank the reviewer for their thoughtful comments on our manuscript and our database. The suggestions have helped to create a more concise and transparent manuscript. Please note that our comments to the other reviewers are now also available at the ESSD website. Any references to line numbers in our response relate to the original manuscript.

Please also note the supplement to this comment:

### **R2-C2**

***Do the authors correctly describe a database, or more properly a dataset. From looking at other recent examples in ESSD, this reviewer understands a database as open, accessible, recruiting (sometimes in easy automated fashion) additional incoming data (often from individuals as data providers), searchable through a variety of database fields, adopting and promoting novel community definitions, etc. Here a reader finds a static product (will the post-review version be on-line in interactive form?), with inputs entirely and solely at the discretion of the authors via ‘official’ national reports. Nothing in text about adding new data? Very good product, but probably more a dataset than a database? Produced with persistent skill but - even compared to HydroATLAS - this product seems more limited? Perhaps necessarily given the topic but authors provide no justification?***

We understand that there are varying definitions of “dataset” and “database”. In general terms (see e.g. <https://www.usgs.gov/faqs/what-are-differences-between-data-a-dataset-and-a-database?>), “a database is an organized collection of data stored as multiple datasets.” As HydroWASTE in its current version is stored as a single file, it could indeed be called a dataset. However, a dataset is also often considered to be a simple collection of data (in a table or spreadsheet) that is not intended to be updated, extended beyond its original intention, or manipulated by multiple users. HydroWASTE has been created by collating and curating multiple source datasets (i.e., it is a collection of different datasets, where several analyses were performed to include originally missing features). Also, it is designed to be expandable in the future, either through new data integration or inclusion of model results and relationships, and it has been enhanced by adding a linkage to the river network of HydroATLAS. We thus believe that our design and vision of HydroWASTE, starting with this version, fits more with that of a database than a dataset. However, we refrained from including more explanations on these intentions in the manuscript as we cannot ensure future updates at this point and do not want to raise false expectations. We hope that with these explanations the use of the term ‘database’ is acceptable in the case of HydroWASTE.

### **R2-C3**

***Lines 54, 55: exposure to chemicals from dense populations “which at a regional level can help prevent negative effects and determine hotspots of contamination.” This in a discussion of importance of dilution factors but “prevent negative effects” requires higher dilution factors while “determine hotspots” implies lower dilution factors. Perhaps authors mean ‘or’ rather than ‘and’?***

We understand the reviewers point. However, we find that one outcome is resulting from the other. For example, if we determine a hotspot using the model, we can prevent negative effects by avoiding further

contamination. To make this sentence clearer, we changed it to: “..., which at a regional level can help prevent negative effects by identifying zones of high contaminant concentrations (i.e., “hotspots”)”.

#### **R2-C4**

***Line 126: “basis for calculating the contaminant loads” but authors already informed readers that for many so-called contaminants of emerging concern, WWTP accumulate but do not ameliorate contaminants of concern. Level of treatment irrelevant in that case? Authors could write here ‘loads of treated or untreated contaminants’?***

WWTPs are typically not designed to treat emerging contaminants, but different types and levels of treatment still might have an effect on any contaminant. But we agree that the reviewer’s suggestion helps to avoid any confusion for the reader and we thus revised the text as suggested.

#### **R2-C5**

***Line 335: “underestimations” of population served, of WWTP spatial density, of? A reader needs clarification here?***

Thank you for identifying this ambiguity. We changed the text to specifically say “underestimations of population served”.

#### **R2-C6**

***In Fig 3, underestimation refers to population served, e.g. number of WWTP must be underestimated in view of population served? Where are the missing WWTP? Not addressed in uncertainty discussion, e.g. “reflecting the incompleteness of WWTP records” but no attribution noted or solutions proposed?k Authors tend to consider weaknesses in data sources (e.g. OSM) or in European methods for estimating populations served, but fundamental question of missing (or absent) WWTP not addressed?***

We agree that this discussion is missing in the original manuscript. We thus added a new paragraph after line 452:

*“Besides the incompleteness of the OSM-sourced records, the national datasets may not include all facilities or may not have been updated recently. For example, the available datasets from the United States and China were last updated in 2012 and 2010, respectively, leaving around 10 years of new WWTP developments unaccounted for. This uncertainty could imply an underestimation of risk caused by missed WWTP effluents, and/or an overestimation of risk caused by an exaggeration of unserved populations in environmental assessments; although concurrent changes in total population numbers and/or treatment levels add to the complexity of recent developments.”*

#### **R2-C7**

***If comparison data products (e.g. Jones 2021, and note they describe their product as ‘results’ or as a ‘study’) come from same sources and therefore propagate same weaknesses, authors have no alternate forms of validation? Given variations among countries in terminology and reporting, basing comparisons on only South Africa seems very weak?***

Unfortunately, we are not aware of any other validation data at the global level, and any national statistics that we know of typically are based on the same (or very similar) sources. So, the propagation of errors indeed remains a problem. However, a main goal of developing HydroWASTE was the linkage of

WWTPs to the river network (by using ‘official’ WWTP data sources wherever possible) rather than improving upon or quantifying the limitations of these ‘official’ data sources. Note that the mentioned analysis using South African data was only performed to evaluate the use of Open Street Map data as a valid source where no official sources were available. That being said, the OSM dataset was used for less than 10% of the HydroWASTE records.

## **R2-C8**

***Line 363: here reader finds that “10,445” (20% of total WWTP in HydroWASTE) WWTP discharged into large (lake or ocean) bodies of water. But, back at line 326, readers learned that 224 (of 58,500 WWTP in HydroWASTE) discharged into oceans or lakes. Why this apparent discrepancy. If this reviewer missed the reason, other readers will likewise miss?***

As explained in original lines 326-327, the “224” WWTPs are located on small islands or in small coastal basins which do not have a river network, hence they are assumed to discharge directly into the ocean. In contrast, the “10,445” are connected to the river network, but were assumed to discharge into large lakes or the ocean for the calculation of dilution factors, due to their close vicinity to the lake or the ocean. To clarify this, we updated the sentence at original line 362:

*“The dilution factors (DFs) were calculated for every WWTP record using Eq. (2), except for: (1) WWTPs that have their outfall location less than 10 km from large lakes or the ocean ( $n = 10,445$ ), for which we assigned an infinite DF (see section 2.2 for more details);...”*

Furthermore, we added the following explanation behind the related statement at line 314:

*“This conservative assumption was made to avoid the potentially erroneous assignment of very low DF values for WWTPs located near a large waterbody (but on a small stream) given the plausible option that the WWTP can discharge its effluents directly into the lake or ocean, e.g., by artificial over- or underground drainage, to increase dilution and ensure regulatory compliance.”*

## **R2-C9**

***Line 706, Figure 6: Here authors show waste water fractions whereas throughout most of the manuscript they a focused on dilution ratios. If the latter represent the most-preferred regulatory factor, why not adopt them consistently. Or, if national reports differ, explain the difference? Not clear to this reader why we confront both DF and % WW fractions?***

The concepts of dilution factors and wastewater ratios are not the same and are not interchangeable. The dilution factor is used as a regulatory factor for WWTPs, i.e., it is determined for the WWTP itself by relating its effluent amount to the natural discharge right below the outfall location. In contrast, the wastewater ratios are calculated along the entire river system, based on the accumulated sum of upstream effluents, with 0% where there are no WWTPs upstream. We understand that Keller (2014) uses dilution factors as proxy for concentrations of contaminants, however the study works at a grid level, and does not consider the exact location of WWTPs, rendering the distinction of both metrics unnecessary.

Nonetheless, to avoid confusion we added/modified the following sentence at line 285:

*“Finally, since dilution factors are used only as a regulatory compliance factor for WWTP effluents, i.e., determined for each WWTP location individually, we also assessed the distribution of treated wastewaters throughout the entire global river network by calculating the ratio of accumulated upstream wastewater to natural discharge in every river reach.”*

## R2-C10

*Line 752, Figure 3: Reference at top of column 7 should be Jones et al. 2021? Authors of this manuscript have taken global treated wastewater total from Jones et al. of  $188.1 \times 10^9$ , converted to daily average to get 514? (I get 515?)*

The reviewer is correct about the citation and the total daily average, which is 515.3 million  $\text{m}^3 \text{ day}^{-1}$  instead of 514.4 million  $\text{m}^3 \text{ day}^{-1}$ . Sorry for this error; it was caused by eliminating a few small (island) nations for which our own data (HydroWASTE) does not have any values. This error is now corrected, and the manuscript has been updated with the value 515. We also corrected the same error for the population served from the JMP. For this reason, Tables 1, 3, 4 and S5 were updated accordingly, as well as two locations in the manuscript where these numbers were referred to (original lines 343 and 345).

This correction did not affect the database or any conclusions made in the manuscript.

### Reference:

Keller, V. D., Williams, R. J., Lofthouse, C., & Johnson, A. C. (2014). Worldwide estimation of river concentrations of any chemical originating from sewage-treatment plants using dilution factors. *Environmental toxicology and chemistry*, 33(2), 447-452.