Glyphosate in aquatic systems: global exposure distributions and probabilistic risk assessment

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Introduction and Objectives

- Glyphosate is the world's best-selling herbicide;, 8.6 billion kg of glyphosate had been applied to agricultural fields as of 2016[1]
- The Canadian Council of Ministers of the Environment (CCME) freshwater chronic guideline for the protection of aquatic life is 800 µg/L for Glyphosate[2]
- The Environmental Protection Agency (EPA) acute toxicity benchmark is 249500 µg/L for AMPA, the main metabolite of Glyphosate[4]
- Currently there are studies available that examine the concentrations of glyphosate and AMPA. However, to our knowledge, a comprehension global exposure assessment for freshwater has not been conducted.
- Therefore our objective is to conduct such assessment for both glyphosate and it's main metabolite AMPA and conduct a probabilistic risk assessment
- Furthermore, we will attempt to answer a number of questions regarding seasonal patterns, temporal trends, geographical location, and relationships between glyphosate and AMPA.

Methods

Literature Search

- A general search was conducted using the Web of Knowledge database and PubMed using the search term "glyphosate + concentration + water"
- Papers were screened on established criteria including : freshwater samples; excluding salt water and soil), non-experimental; reporting glyphosate values that truly exist in the environment, and reporting real values; excluding calculated or estimated values (e.g., means)
- Initially 1809 Records were found, and were screened following the flow displayed in *Figure 1*

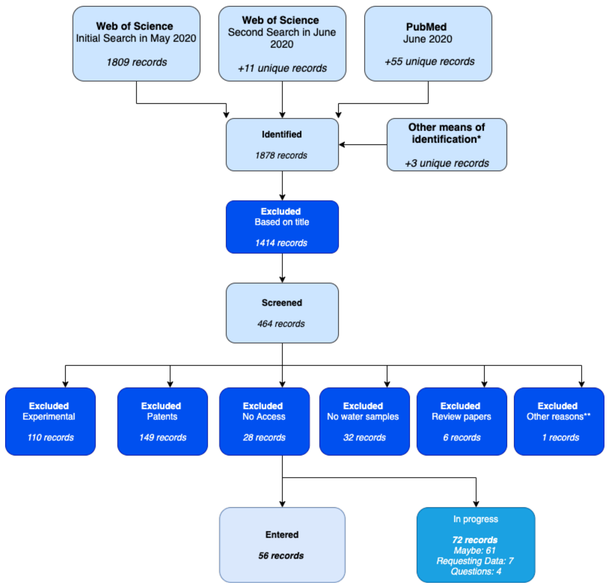

Figure 1. Flow chart of the literature search process. Currently, this project is still in progress, 61 (maybe) records are currently requiring further criteria review, 7 papers data is being requested from the authors and 4 we still have additional question prior to data entry. *Found from being referenced in other sources and from previous knowledge. **Paper was in another language

Data Collection

- Meta data collected from available studies included geographical and temporal information (X and y coordinates, date sampled, season, uses of glyphosate such as agricultural or urban.
- All non-quantified concentration data was recorded as a range in respect to the reported limit of detections (LOD) and limit of quantifications (LOQ), e.g., 0 – LOD, LOD – LOQ
- All samples were characterized as "Not Detected," "Detected" or "Quantified" based on where they fell in the detection/quantification spectrum displayed in *Figure 2*.
- 56 papers were included in this review, from these 56 papers 6342 data points were pulled for glyphosate and 3990 points were pulled for AMPA

Figure 2. Detection and Quantification spectrum. Values that are reported during a chemical analysis all fall along a spectrum. The limit of quantification (LOQ) is the smallest concentration that can be reliably measured, limit of detection (LOD) is where the presence can be distinguished from the blank[3]. Values below this point are reported as "Not Detected" but can exist anywhere between 0 and the LOD. "Detected" samples can exist between LOD and LOQ when they fall below the LOQ.

Preliminary Results: Environmental Exposure

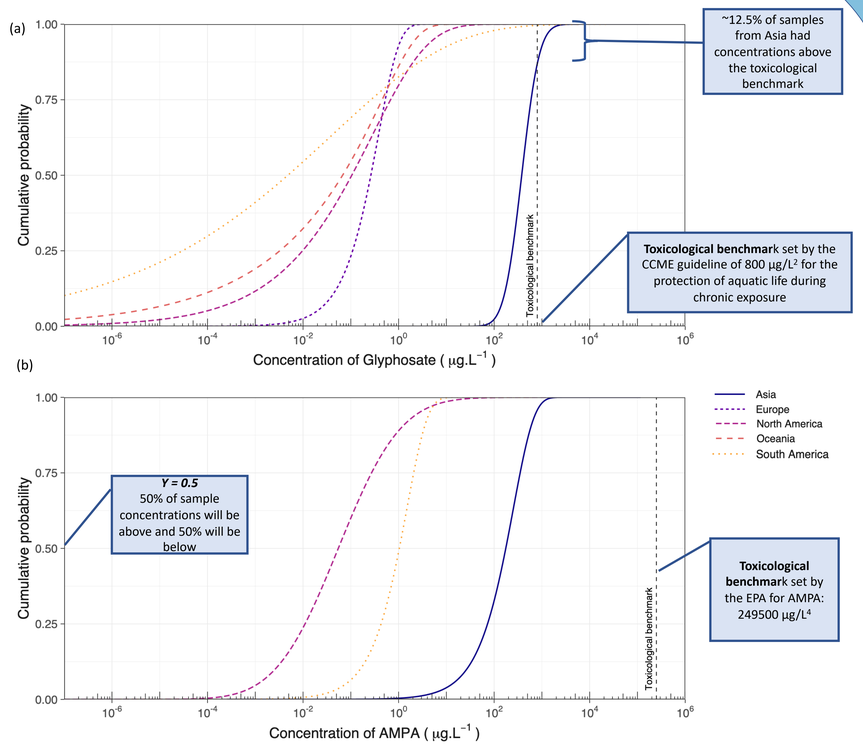

Figure 3. Environmental exposure distributions for (a) glyphosate and (b) AMPA by region. Comparison of glyphosate and AMPA concentrations in rivers and streams in five different geographical regions: Asia, Europe, North American, Oceania, and South America. The Middle East and Africa did not have enough sampling data for the creation of a exposure distribution model. For AMPA our model could only be fit for Asia, North America and South America.

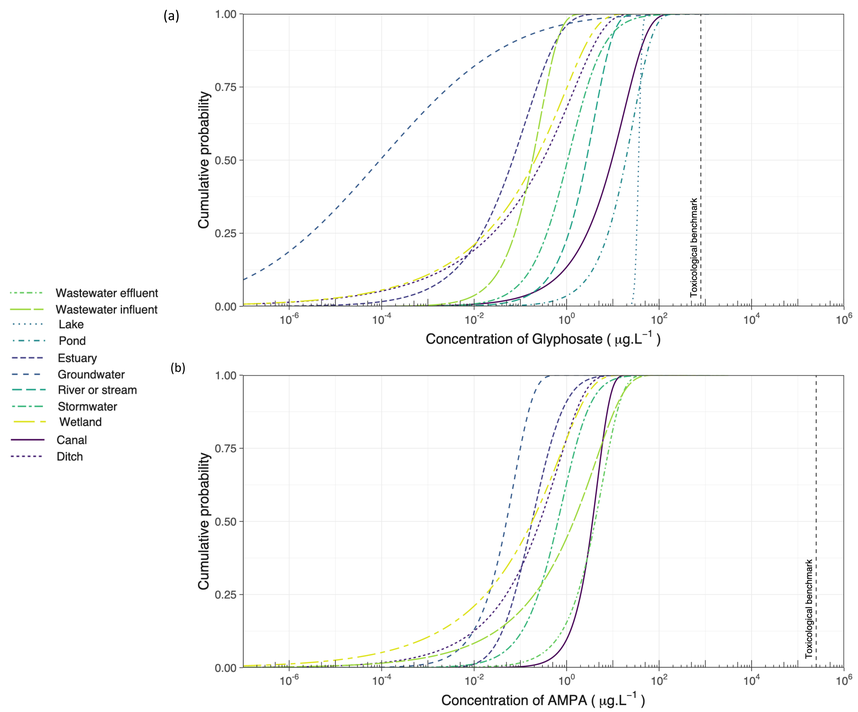

Figure 4. Environmental exposure distributions for (a) glyphosate and (b) AMPA by water matrix. When compared by water matrix there is no overlap between the probability curves and the toxicological benchmarks

Preliminary Results: Summary of Samples

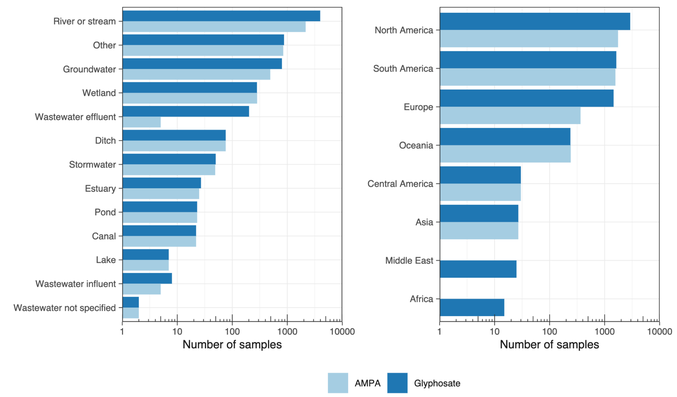

Figure 7. Number of samples by water matrix and region. The majority of water samples for both glyphosate and AMPA were taken from rivers or streams, with 3957 glyphosate samples (62.4% of total) and 2143 AMPA samples (54.7% of total). The best represented regions were North American and South America, with the majority of South American samples originating from Brazil and Argentina. The Middle East and Africa were the regions with the least amount of data available and no reported data for AMPA

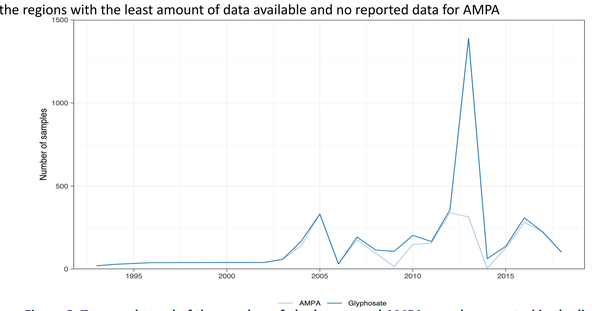

Figure 8. Temporal trend of the number of glyphosate and AMPA samples reported in the literature. There are three peaks in number of samples at 2005, 2013 and 2016. The 2013 spike is largely attributed to a very large study that was released that year.

Main Conclusions

Risk Assessment

- Overall glyphosate and AMPA concentrations fell below our benchmarks (Glyphosate: 800 µg/L², AMPA: 249500 µg/L⁴) , suggesting that the risk from glyphosate exposure to aquatic life is minimal as diaplyed in *Figure 3* and *Figure 2*
- One exception displayed in *Figure 3*, is the higher-end of concentrations from Asia. However, Asia was one of the regions that was underrepresented in terms of reported glyphosate concentrations in the literature.

Regional Presence

- The most well represented geographical location was North America, followed by South America, Europe and Oceania.
- Regions that were underrepresented included Asia, the Middle East and Africa.
- Rivers or streams had the largest number of glyphosate and AMPA samples.

Water Matrix

- Higher concentrations of glyphosate trended to be found more often in ponds, lakes and canals. Lower concentrations trended to be found more often in Groundwater and Estuaries
- AMPA concentrations trended to higher in both effluent and influent wastewater and canals.

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