Tires and tire wear particles as source of 1,3-diphenylguanidine and other organic micropollutants in the aquatic environment

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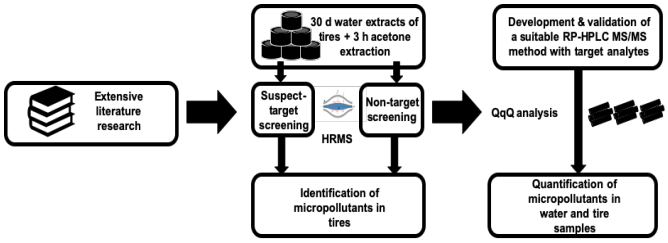
Introduction

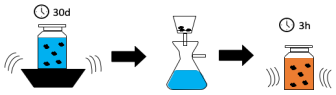
The global emission of tire wear particles (TWPs) was estimated at approx. $6 \cdot 10^6$ t/a[1]. When rain events occur these TWPs may **enter the water cycle** either directly or as part of the combined urban effluent. Tires are chemically complex and various additives like **vulcanization agents or anti-oxidants** are used in their production. The discussion about the hazardous potential of TWPs is so far predominantly focused on volatile chemicals and thiazoles[2], while **chemicals that leach out of TWPs** and their environmental impact is yet scarcely discussed. The recent discovery of **1,3-diphenylguanidine (DPG)** as environmental contaminant potentially originating from tires[3] and the chemically complex make-up of tires suggest that various other chemicals may also be introduced into the aquatic environment through tires and tire wear paricles[4].

Workflow

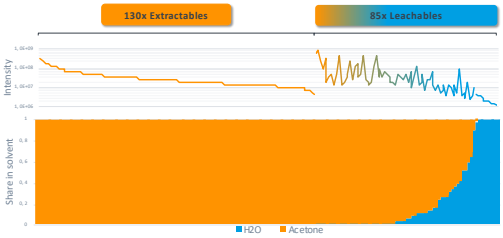


Results

Extraction of TWPs



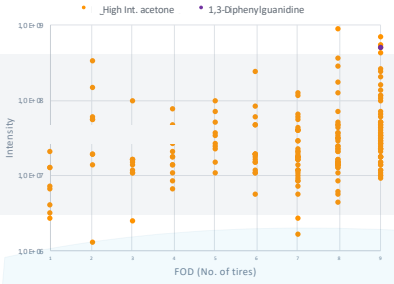
- TWPs were extracted for 30 days in fresh artificial water
- The leachate was separated and the TWPs extracted in acetone for 3 hours



Prioritization for high intensities

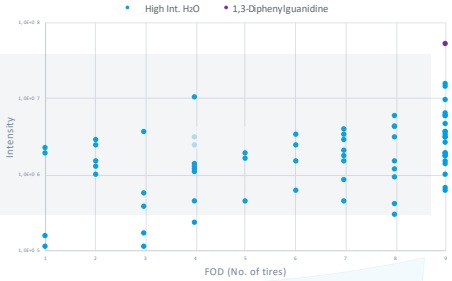
- Non-target screening with > 40,000 signals obtained
- Data processing with enviMass lead to 215 signals with intensities > 10^6 separated into 130 extractables and 85 leachables
- Further structure elucidation for both conducted

Extractables



- 130 extractables with intensities > 10^8 in acetone extracts detected
- Many candidates with high frequencies of detection (FOD) and high intensities
- Extractables may be utilized as tire markers
- Structure elucidation of high priority extractables still in progress

Leachables



- 85 leachables with intensities > 10^6 in water extracts detected
- Intensities generally lower than after acetone extraction
- 1,3-diphenylguanidine prioritized as highest intensity leachable present in all tires
- Structure elucidation still in progress

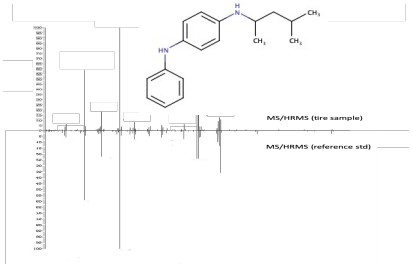
Conclusion

- **Thousands of signals detected in non-target screening of tire extracts and leachates (215 with intensities > 10^6)**
- **85 high intensity leachables may be environmental water contaminants**
- **The leachable DPG was detected in 27 surface waters with an average concentration of 0.2 µg/L**
- **130 high intensity extractables were detected**
- **Extractables generally showed higher concentrations than leachables**
- **Extractables may be utilized as chemical markers for TWP analysis**

Next steps

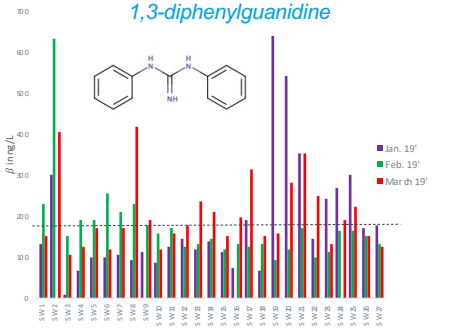
- **Further structure elucidation of leachables and extractables**
- **Investigation of environmental presence of the the 85 detected leachables**
- **Investigation of DMB-PD and other extractables as markers for tire wear particles analysis**

Structure elucidation of N-(1,3-dimethylbuthyl)-N-phenyl-1,4-phenylenediamine (DMB-PD)



- Structure of DMB-PD confirmed with reference standard
- Only minor leaching in water (ca. 5 ng/L) and high concentrations in extracts (ca. 0.25 g/L)
- Present in all tires
- Potential chemical marker for TWP analysis

Environmental occurrence of 1,3-diphenylguanidine



- A quantitative method for DPG was developed and validated
- DPG was quantified in 27 surface water samples
- Concentration range from 6 ng/L to 640 ng/L
  ➡ Ø 186 ng/L

Acknowledgement

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References

[1] Kole, Pieter Jan, *et al. Int. J. Env. Res. Public Health* **2017**, *14*, 1265
[2] Llompart et. al, *Chemosphere*, **2013,** 90, 423-431
[3] Zahn et. al, *Water Research,* **2019,** 150, 86-96
[4] Zahn et. al, **2019**, in preparation