A preliminary study of tire-derived chemicals (6PPD-Q) in river sediment in Tamsui river

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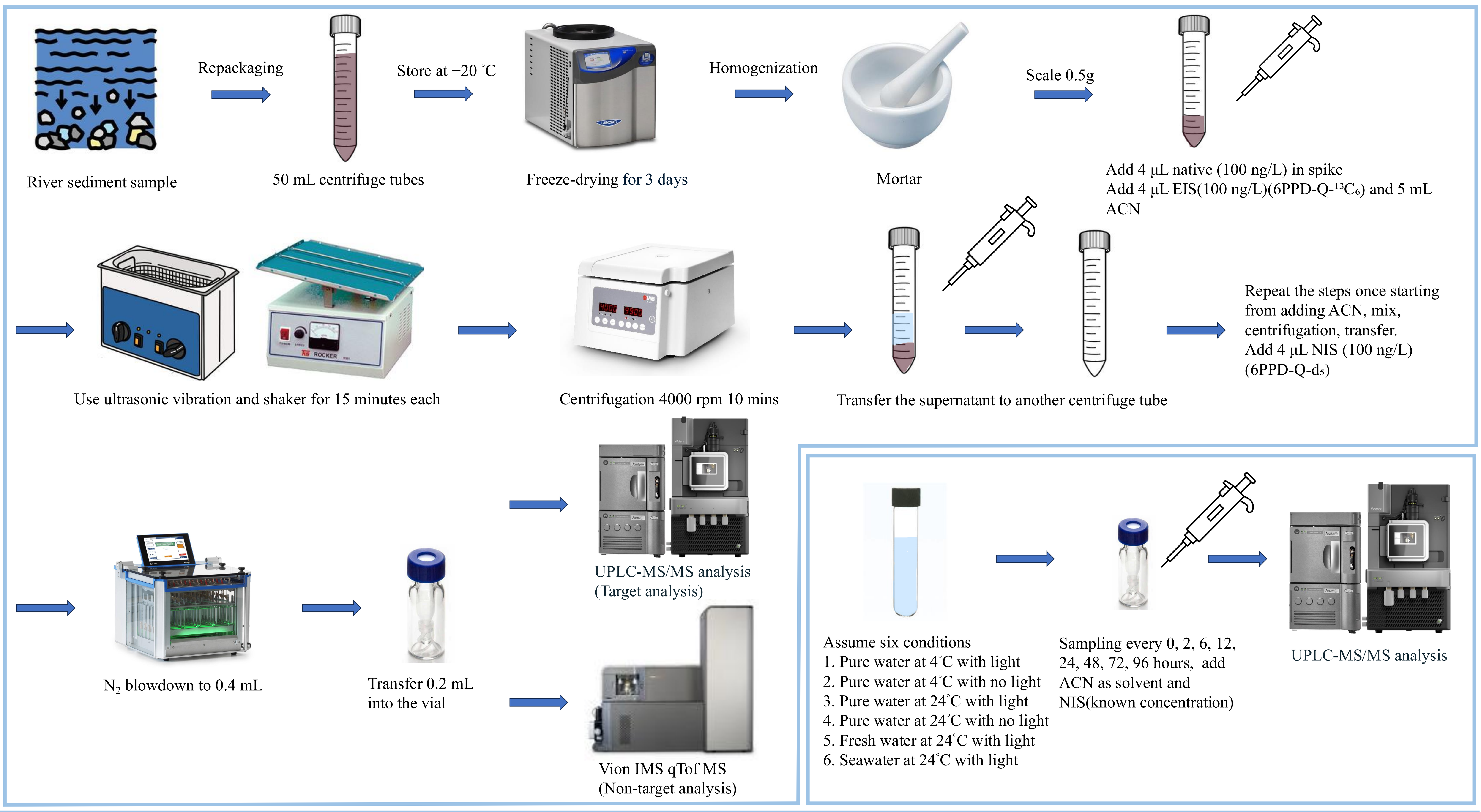
Introduction

The global increase in tire demand and production has raised concerns over tire-derived chemicals (TDCs) in urban environments. TDCs include preservatives, antioxidants, and vulcanization accelerators. An antioxidant, N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD), is widely added to tires to prevent ozone-induced cracking of rubber. However, when exposed to ozone (O_3) or other oxidants, 6PPD rapidly transforms into 6PPD-quinone (6PPD-Q), a compound with high toxicity. Studies have shown that 6PPD-Q can cause acute mortality to certain fish species, such as coho salmon (*Oncorhynchus kisutch*), at low concentrations (LC_{50} < 1 μg/L). During vehicle operation, tire wearing releases particles containing 6PPD-Q, which can enter ecosystems and humans through atmospheric transport, or aquatic pathways. Due to its hydrophobicity (log $K_{ow} \approx 3.5$), 6PPD-Q can accumulate in sediments and biota, raising significant concerns about its potential long-term impacts on human health and ecological safety. However, our understanding regarding the fate of 6PPD-Q in the environment is very limited. In this study, we conduct a preliminary survey to collect sediment samples from the Tamsui River tributaries in northern Taiwan for 6PPD-Q analysis. Our research objectives are (1) to understand the occurrence and distribution of 6PPD-Q and other TDCs in the Tamsui River watershed, and (2) the stability of 6PPD-Q in natural waters.

Materials and Methods



Results

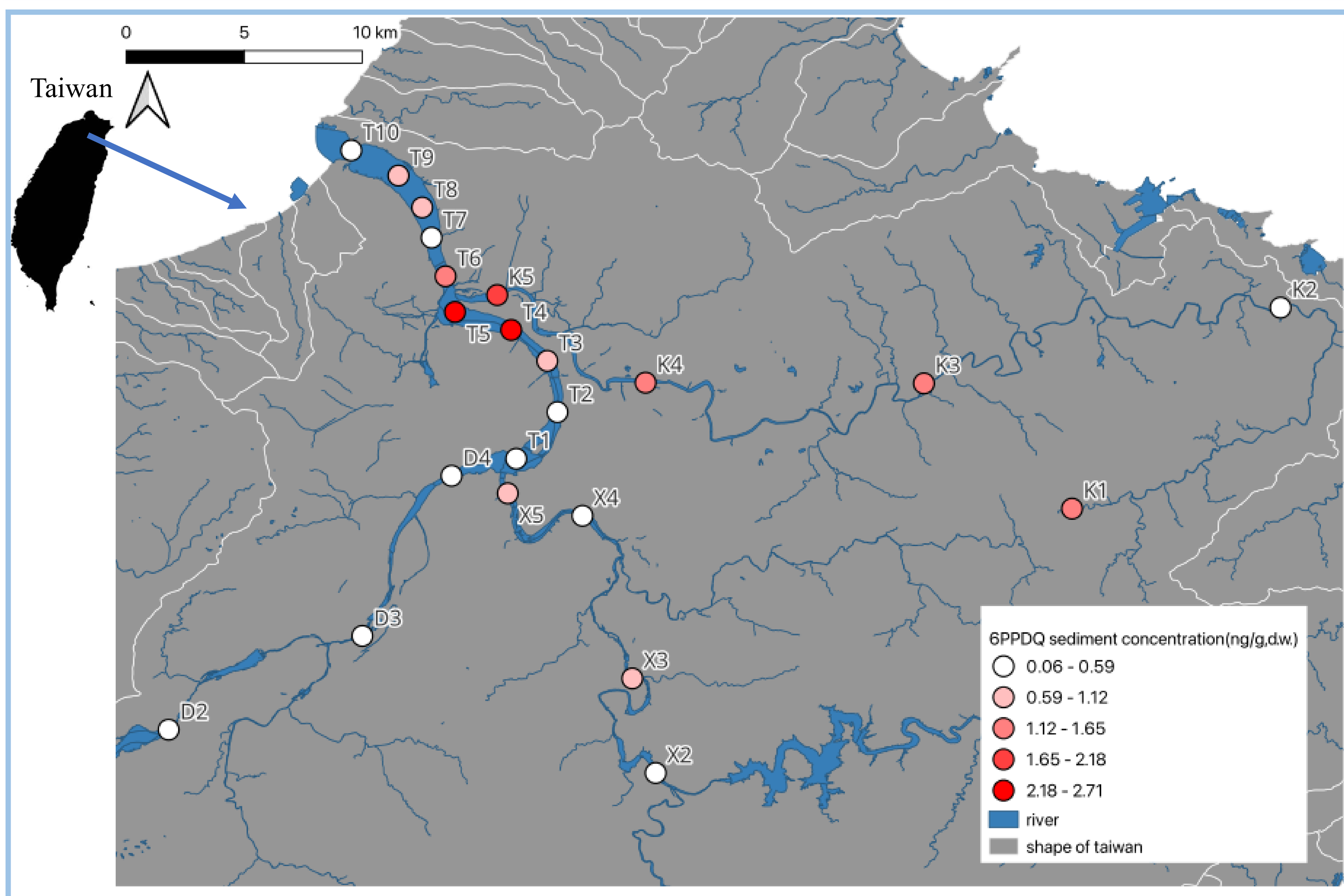


Figure 1. Sampling sites in Taiwan

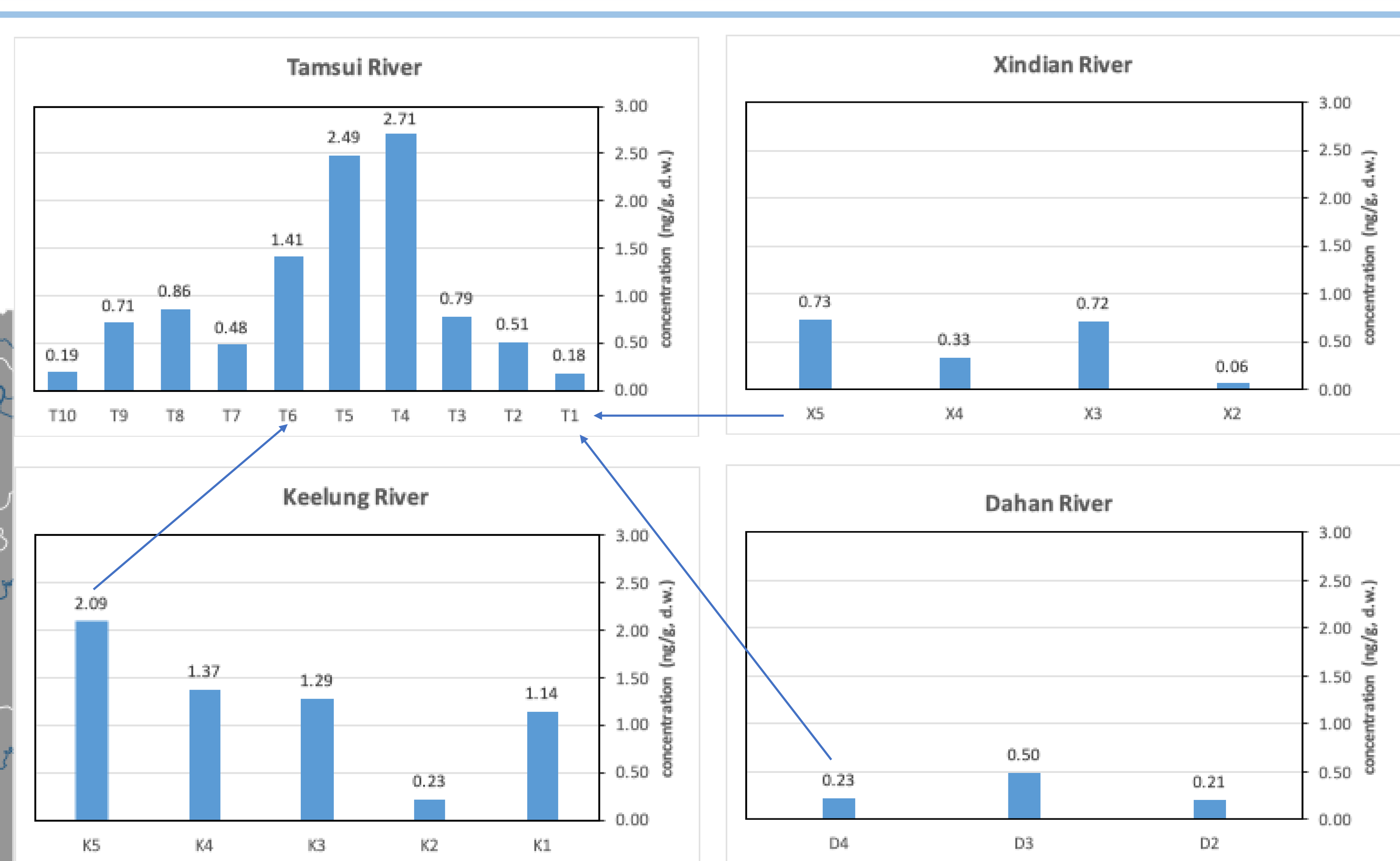


Figure 2. 6PPD-Q concentrations in sediments across stations

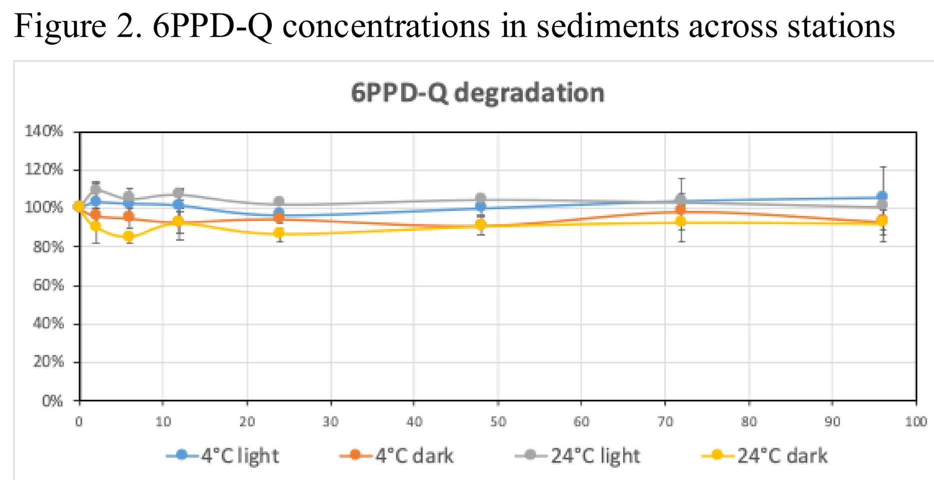


Figure 3. 6PPD-Q degradation in pure water under different conditions

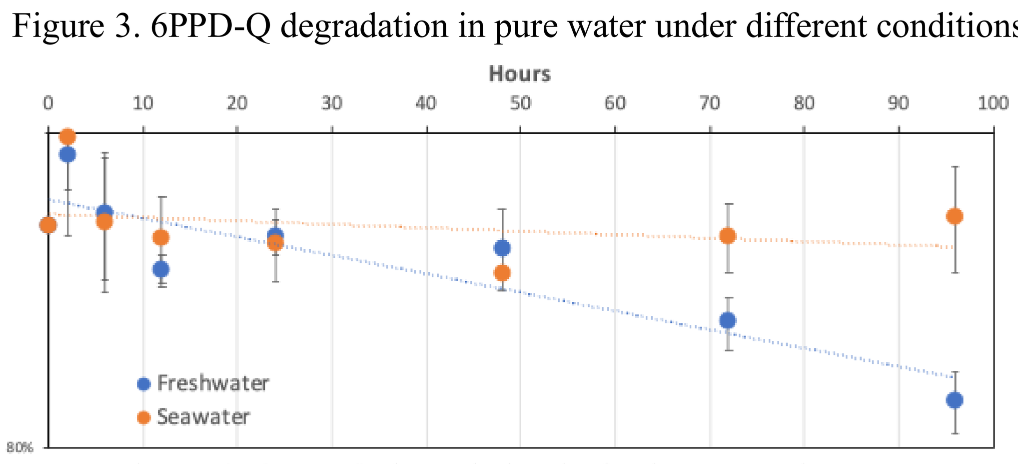


Figure 4. 6PPD-Q degradation in freshwater and seawater

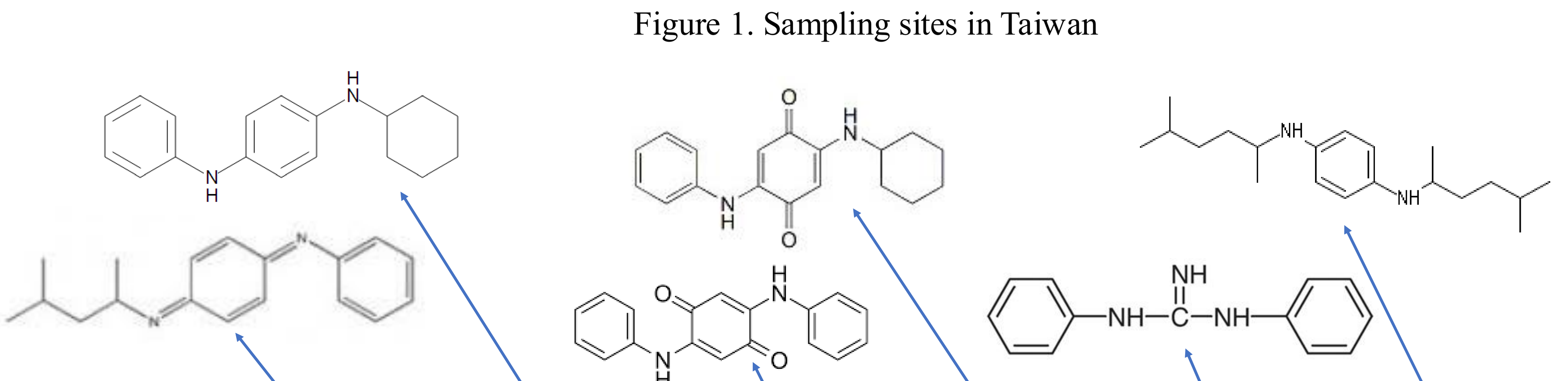


Table 1. Other TDCs in sediment

Name	6QDI	CPPD	DPPD-Q	CPPD-Q	DPG	77PD
Detected Frequency	72.7%	13.6%	63.6%	9.1%	36.4%	9.1%
Semi-quantitative concentration (ng/g, d.w.)	0.16~8.41	0.16~0.91	0.19~1.87	0.16~0.20	0.16~2.28	0.19~0.36

Conclusions

6PPD-Q was detected in all sediment samples collected from Keelung, Dahan, Xindian, and Tamsui Rivers, suggesting that urban runoff from the densely populated Taipei metropolitan area contributed substantial inputs of 6PPD-Q derived from tire wearing particles. The highest concentration of 6PPD-Q was at station T4. This area is strongly influenced by tidal salinity fronts, which create a “trap” and promote the accumulation of contaminant-enriched sediments, explaining why T4 exhibited the highest concentration among all sampling stations. In the degradation experiments, we found that under most conditions, the concentration of 6PPD-Q did not change much, except for the freshwater with natural occurring microbes at 24°C with light, and the degradation rate was about 4.8% per day. Using non-target analysis, we found other tire-derived chemicals (TDCs) such as 6QDI and DPPD-Q in our samples. Some of them are known to be persistent in the environment and could be toxic in aquatic life. Our results suggest that TDCs are prevailing in the Tamsui River watershed. Future studies are needed to further investigate the fate of TDCs in Tamsui River and assess their potential impacts on the Tamsui River ecosystem.