

Ah receptor-mediated activity of chemicals adsorbed to 4 different polymer types deployed in San Diego Bay, CA

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Introduction

In the early 1970s plastic particles were detected in the marine system for the first time¹ and by the late 1990s over 180 species were reported to ingest plastic particles². The occurrence of plastic litter in the marine environment poses not only a physical threat to organisms via entanglement and ingestion, it might also presents a toxicological threat to wildlife. In recent years it has been demonstrated that various anthropogenic environmental pollutants can be found on different types of marine plastic debris³. Most of these pollutants are considered as harmful to humans and wildlife. They can act as mutagens, cancerogens and endocrine disruptors and exert adverse health effects to organisms. The transfer of chemicals from ingested plastics into organisms and the potential toxic effects of such compounds is yet poorly understood.

Results

- 20 deployed samples and 4 blanks were tested in H4IIE luc assay
- Bio-TEQ_{EC25} ranged from **2.7 pg/g** (PVC NMF 12) up to **327 pg/g** (LDPE HE 9)
- Highest potential for Aryl hydrocarbon receptor (AhR) -mediated effects in extracts from virgin **LDPE > PP > PVC, PET**
- Blank samples of all polymers demonstrated no detectable AhR-mediated effect
- Chemical Analysis of 19 deployed polymers and 4 blank samples
- Concentrations of Σ 23 PAHs ranged from **6.6 ng/g** (PVC HE 9) up to **982 ng/g** (LDPE HE 12)

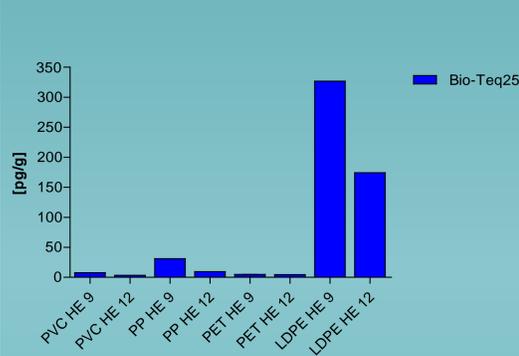


Figure 4: Comparison of Bio-TEQ_{EC25} values for four plastic polymers deployed at Harbor Excursion for 9 and 12 months.

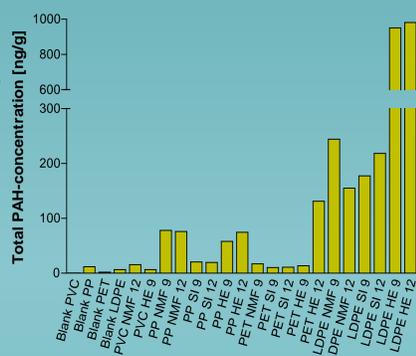


Figure 5: Total PAH concentrations (ng/g) of 23 PAHs on four different plastic polymers deployed for 9 and 12 months at three different locations. Blank is the respective virgin polymer and equals time 0 before deployment.

Conclusions

- ❖ All deployed virgin polymers demonstrated measurable Aryl hydrocarbon receptor-mediated activities
- ❖ Deployed LDPE polymers contained highest amount of Ah receptor agonists, followed by PP > PVC, PET
- ❖ Among the polymers highest sorption potential for the 23 individual PAHs in LDPE due to structure of polymer, e. g. greater surface area
- ❖ Decrease in Ah receptor-mediated activity after 12 months compared to 9 months of deployment could be due to desorption of other compounds that are able to activate the Ah receptor such as PCBs or the colonization with hydrocarbon-degrading bacteria⁵
- ❖ Mass balance analysis revealed that other compounds than the analyzed PAHs must be present on the polymers as well, e. g. PCBs were found to be present in the samples⁴ but calculations demonstrated that PCBs can not explain all of the remaining AhR-mediated activity, thus compounds such as PCDDs and PCDFs might be present

Methods

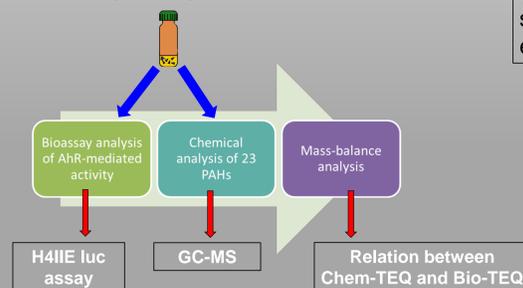
- ❖ Deployment of 4 different virgin polymers in the San Diego Bay Harbor for 9 and 12 months
- ❖ Three sites: Nimitz Marine Facility, Shelter Island and Harbor Excursion
- ❖ Extraction of plastics with hexane and ultrasonication
- ❖ Splitting of extract for chemical and bioassay analysis



Figure 2: Map of the 3 study sites (Rochman et al. 2013).



Figure 1: Picture of four virgin plastic polymers used in this study (Rochman et al. 2013).



- ❖ Analysis of 16 priority PAHs and 7 additional PAHs (4H-cyclopenta(d,e,f)phenanthrene, benzo(a)fluorene, naphthalene, benzo(e)pyrene, perylene, dibenz(a)anthracene, naphtho(2,3-a)pyrene)
- ❖ Calculation of toxicity equivalent values (TEQ) with derived chemical data and respective relative effect potency factors (REP)

- Mass balance analysis showed that in 9 out of 17 samples analyzed PAHs contributed to more than 50% to the overall Ah receptor-mediated activity

Table 1: Derived Bio-TEQ_{EC25} and Chem-TEQ_{EC25} values and the calculated mass balance between these two values.

Sample	Bio-TEQ _{EC25} [pg/g]	Chem-TEQ _{EC25} [pg/g]	Mass balance [%]
PVC NMF 12	2.7	3.6	133
PVC HE 9	7.8	1.5	19
PP NMF 9	36	13	36
PP NMF 12	14	12	86
PP SI 9	10	5.2	52
PP SI 12	8.8	4.8	55
PP HE 9	31	12	39
PP HE 12	9.4	16	170
PET NMF 9	2.8	3.0	107
PET SI 9	6.9	2.1	30
PET HE 9	4.7	2.7	57
LDPE NMF 9	33	16	48
LDPE NMF 12	231	13	6
LDPE SI 9	55	26	48
LDPE SI 12	39	39	100
LDPE HE 9	327	94	29
LDPE HE 12	174	98	56

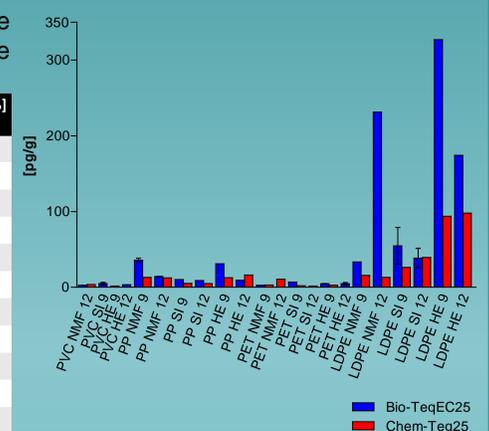


Figure 6: Comparison of calculated Bio-TEQ_{EC25} vs. Chem-TEQ_{EC25} in pg/g for four plastic polymers deployed for 9 and 12 months at three different sites.

References

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