

Policy-letter: Elevated Levels of Anthropogenic Chemical Pollutants in Coastal Ecosystems of the Caribbean Netherlands: A Case Study of Bonaire

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The United Nations Environmental Programme, as a lead agency of the Global Environmental Facility Islands Programme, emphasizes the importance of mitigating marine litter and ensuring the sustainable management of hazardous chemicals and waste in small island developing states (SIDS) [1]. Chemical pollution has been a largely overlooked threat in the Caribbean Netherlands (Bonaire, Sint Eustatius, and Saba). In contrast, the Netherlands adheres strictly to European regulations based on the OSPAR Convention, the Water Framework Directive (WFD), and the Marine Strategy Framework Directive (MSFD) [2, 3]. These regulations require monitoring priority substances—typically prohibited or strictly limited

due to their persistence, bioaccumulative nature, and high toxicity—to **safeguard human health and preserve environmental integrity.**

A Case Study of Bonaire:

Our case study was conducted at distinct locations around Bonaire to understand the impact of chemical pollutants on the island's ecosystems (Fig. 1). We analysed sediment and water samples for substances typically monitored under European guidelines [4]. The study revealed **alarming levels** of certain chemicals, exceeding the thresholds set by OSPAR for sediments, beyond which detrimental effects on aquatic ecosystems cannot be ruled out.

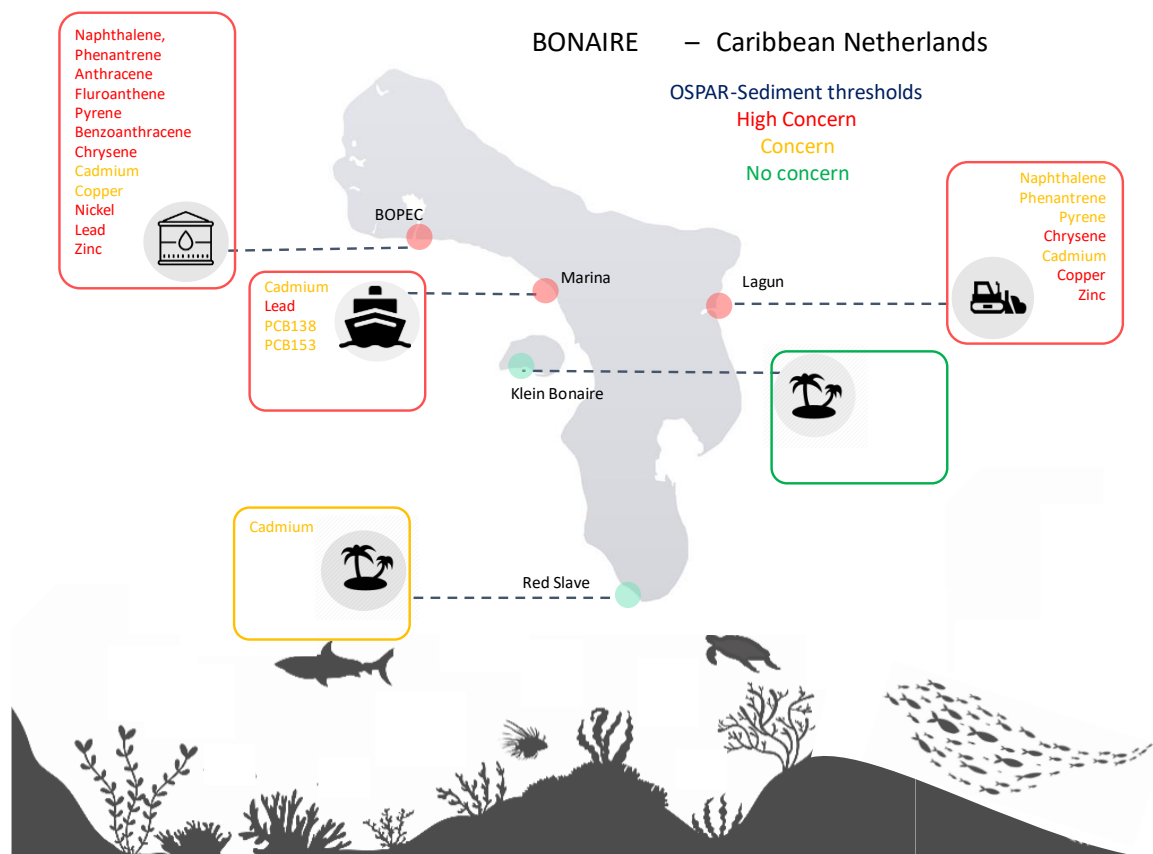


Figure 1 shows chemicals detected in sediment samples collected monthly between November 2022 and January 2023 (mean concentrations) in Bonaire exceeding the sediment quality thresholds of OSPAR. Only compounds with a threshold are displayed. Orange-coloured chemicals exceed the BAC (Background concentrations), and red-coloured chemicals indicate the exceedance of the ERL (Effect-Range-Low) for metals/EAC (Environmental Assessment Criteria) for organic chemicals. PCB = Polychlorinated biphenyls.

Sediment samples from **BOPEC**, an oil storage platform on the island's northwestern coast, showed elevated levels of polycyclic aromatic hydrocarbons (PAHs), substances commonly associated with oil emissions and known to be extremely harmful to coral reefs [5]. In the **Marina**, a harbor area, polychlorinated biphenyls (PCBs) and lead concentrations exceeded OSPAR thresholds. PCBs, oily substances with various industrial uses like lubrication, electrical insulation, flame-retardants, and paint additives, are carcinogenic and are known to induce endocrine disruption, neurotoxicity, and immunotoxicity in aquatic animals [6]. Lead can reduce coral fertilization success and symbiont density [5]. **Lagun**, a semi-enclosed bay on the eastern side adjacent to the landfill, is known as a seagrass foraging ground for sea turtles. In corroboration with the sediment results [4], cadmium concentrations in seagrass leaf tissues that were collected in Lagun [7] also exceeded the sea turtle-specific threshold level [8] and showed elevated levels of cobalt, a metal linked to fibropapilloma, a tumor-like growth on the skin inside the mouth or in the eyes of sea turtles [9]. The presence of this disease was hitherto only observed in this specific location (STCB, *pers. Comm.*). Furthermore, levels of copper and zinc in seagrass tissues collected in Lagun exceeded seagrass-specific threshold levels, suggesting the detrimental effects of these chemicals on the seagrasses [7].

Water samples were analyzed using passive sampling techniques to determine average chemical concentrations over time (approx. six weeks). The findings reveal the consistent presence of specific organic chemicals in dissolved form, such as PAHs and PCBs, during the dry season (May-June 2022) in BOPEC, Marina, and Lagun. These chemicals are readily available for uptake by benthic communities and other marine species. Specifically, in Marina, PCB concentrations exceeded the California Ocean Plan's 30-day average discharge limit of 0.019 ng/L [10], detected to be 0.027 ng/L in this study.

The accumulation of some contaminants within species increases along food chains, highlighting the environmental risks posed by these chemical pollutants, especially at higher trophic levels. The EU has established standardized practices for monitoring specific contaminants in biota to protect ecosystems and human health. However, the only existing study monitoring contaminants in biota from the BES islands dates back to 2013 in Bonaire, focusing on screening mercury levels in barracuda, wahoo, mahi-mahi, and blackfin tuna [11], whereby

the latter three species exceeded the current OSPAR threshold in marine fish.

Conclusion

Detecting chemicals exceeding OSPAR protective limits in coastal sediment during the 2022-2023 rainy season highlights a potential threat to marine ecosystems and human health. Our study also emphasizes the importance of researching contaminant levels, particularly in long-lived marine species like green turtles and higher-trophic fish. Therefore, we recommend implementing controls and monitoring initiatives across the Dutch Caribbean similar to those in European aquatic ecosystems.

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