Contamination Dynamic of Chlordecone in Trophic Chains of Guadeloupe Coastal Ecosystems

Dinámica de la Contaminación por Chlordecona en la Red Trófica de los Ecosistemas Costeros de la Guadalupe

Dynamique de Contamination de la Chlordécone dans les Réseaux Trophiques des Écosystèmes Côtiers Guadeloupéens

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EXTENDED ABSTRACT

Introduction

Used from 1972 to 1993 in the French West Indies, chlordecone is an organochlorine insecticide spread in banana crops. Very stable and persistent, the molecule remains in the soil for a long time and contaminate marine environments through leaching and runoff events. Very lipophilic, this organochlorine shows an important potential of penetration in living organisms and a high risk of toxicity for both man and animals. In the French West Indies, the contamination of the marine species by chlordecone was first evidenced in the early 2000. Several studies were then conducted in order to quantify and map this contamination in seafood resources. These researches led to the establishment of several areas of fishing restrictions and fishing ban along the eastern coast of Basse Terre in Guadeloupe. However, few studies were conducted on the dynamics of contamination. Studying the transfer of the molecule through trophic food webs is essential to understand how chlordecone reaches marine ecosystems and how that molecule contaminates living organisms. The principal objectives of this study were to:

i) Identify the main way for chlordecone to enter in marine trophic food-webs among the potential sources of contamination (sediments, suspended matter, biofilm, macroalgae, Magnoliophytes, turf), and
ii) Understand the mechanisms of transfer of chlordecone along the food web (bioconcentration and/or bioamplification).

Material and Methods

In order to answer these questions, a study site, located in a chlordecone contaminated area and including the three marine systems of Guadeloupe (mangroves, seagrass beds and coral reefs), was chosen in the coastal areas of Goyave. The sampling campaign was carried out from January 2014 to February 2015. 248 samples, representing different trophic levels, were collected at each site: sources of carbon (sediment, biofilm, suspended matter, macroalgae, seagrass), primary consumers (herbivores, biofilm feeders, suspended matter feeders and zooplankton), detritivores and omnivores and secondary consumers (planktivores, first and second level carnivores, piscivores). Quantitative analyses of chlordecone were measured by using both a liquid chromatography coupled to mass spectrometry (UPLC-MS/MS). These analyses were conducted by the laboratory Labocea.

Results and Discussion

Way of entrance of chlordecone in the trophic food-webs — Potential sources of contamination, such as sediment, biofilm, water suspended matter and leaf litter, as well as turf, macroalgae (10 species), and seagrass (3 species), were sampled in the three habitats (mangrove, seagrass bed and coral reef). The results are presented in Figure 1.

If the major part of the sources of carbon analyzed presents low concentrations of chlordecone, *Dictyota*, a brown macroalgae (Phaeophyceae), seems to be significantly more contaminated than the other genera (from 85 to 219 µg/kg). Several hypotheses could explain this result: a strong affinity with chlordecone due to high proportions of lipids and terpenes in *Dictyota*, or a potential analytic bias. The contribution of *Dictyota* to the diet of herbivorous fish species is very low (Dromard 2013), therefore, *Dictyota* have been excluded from the analysis. Other primary producers (macroalgae, seagrass and algal turf) present low and homogeneous levels of contamination (between 0 and 13 µg/kg), as well as biofilm and sediment (under the limit of detection). These results are globally consistent with those of previous studies carried out in Martinique and Guadeloupe (Bocquené and Franco 2005, Bouchon et al. 2010). On the contrary, the suspended matter filtered from seawater shows levels of contamination comprised between 20 and 60 µg/kg, decreasing from the shore to the open sea. These values are coherent with previous measures made in Martinique by Bocquené and Franco (2005). Accord-

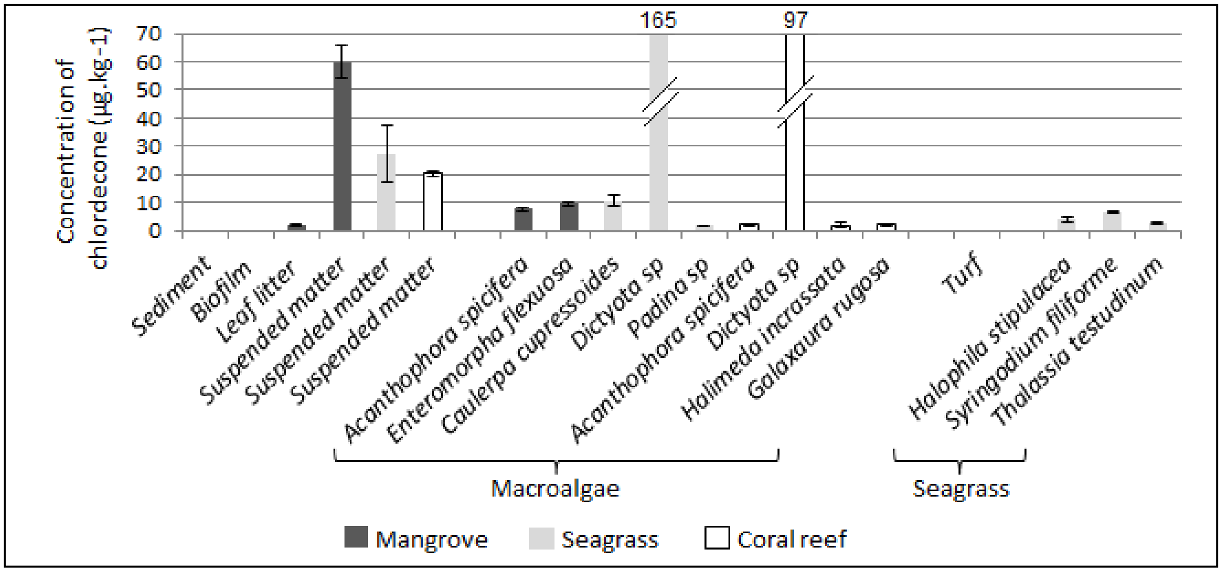

Figure 1. Concentrations of chlordecone in the main sources of carbon (µg/kg)

ing to these results, the main way for chlordecone to enter in the trophic food-web seems to be the suspended matter from the water column.

Transfer of chlordecone along the trophic food-web — In order to identify the factors influencing the contamination of marine organisms and detect a potential bioamplification of chlordecone through the food-web, the levels of contamination of both trophic levels and general compartment (primary consumers, secondary consumers, detritivores and omnivores) were studied. The results are presented in Figure 2.

Significant differences were established between the levels of contamination of the different general compartments (Kruskal-Wallis, all p-value < 0,01). According to multiple comparisons test, two groups appear: on the first hand, primary consumers with low contamination values and, on the other hand, secondary consumers and the detritivores and omnivores compartment, with the highest concentrations of chlordecone. In the same way, two groups of trophic levels stand out. The first group includes suspended matter feeders, biofilm feeders, herbivorous and hexacorallians with mean contamination values between 0,5 and 74 µg/kg. The second group, characterized by higher mean contamination values, between 35 and 524 µg/kg, includes planktivores, carnivores, piscivores, detritivores, and omnivores. This difference of contamination between primary and secondary consumers can be linked to the variations of assimilation between those two types of diet and has been already demonstrated with other pollutants (Thomann and Connolly 1984). The influence of diet in the level of contamination indicates a slight bioamplification phenomena.

Influence of the coast-open sea gradient — Mangrove, seagrass beds and coral reefs are located respectively between 0 and 50 m, 200 and 1500 m, and 800 and 4000 m from the coastline. Indeed, the contamination of samples by chlordecone according to their distance from the coast (and so from the source of pollution) was studied. The levels of contamination measured in mangrove, seagrass beds and coral reefs are presented in Figure 3.

A significant influence of the environment on the contamination of samples by chlordecone has been found (Kruskal-Wallis X^2 = 34,02, df = 2, *p*-value < 0,0001). Mangrove is the closest environment from the sources of pollution and receives the most important amount of terrigeneous inputs. Mangrove appears to be the most contaminated habitat and samples collected in the mangrove show a mean concentration of chlordecone equal to 205 µg/kg. On the contrary, samples collected on coral reefs, which receive diluted terrigenous inputs, are the less contaminated with mean concentration equal to 58 µg/kg. Finally, samples from the seagrass beds present an intermediate level of contamination with a mean value equal to 72 µg/kg. This observation, consistent with previous studies conducted in Martinique (Bodiguel et al. 2011) and in the United States of America (O'Connor and Huggett, 1988), indicates a difference of contamination according to the habitat, and so a bioconcentration phenomena, i.e. contamination "through bath".

Conclusion

Because the highest concentrations of chlordecone were noted among the potential sources (sediment, biofilm, macroalgae, seagrass, litter), the suspended matter filtered from the water column seems to be the main way for chlordecone to enter in the trophic food-web. Concerning the dynamics of contamination, both bioconcentration and bioamplification phenomena appear to influence the transfer of chlordecone through the trophic food-web. In order to have a stronger understanding of this dynamics, but also to support the fishery activities, complementary studies about the kinetic of contamination and decontamination should be conducted.

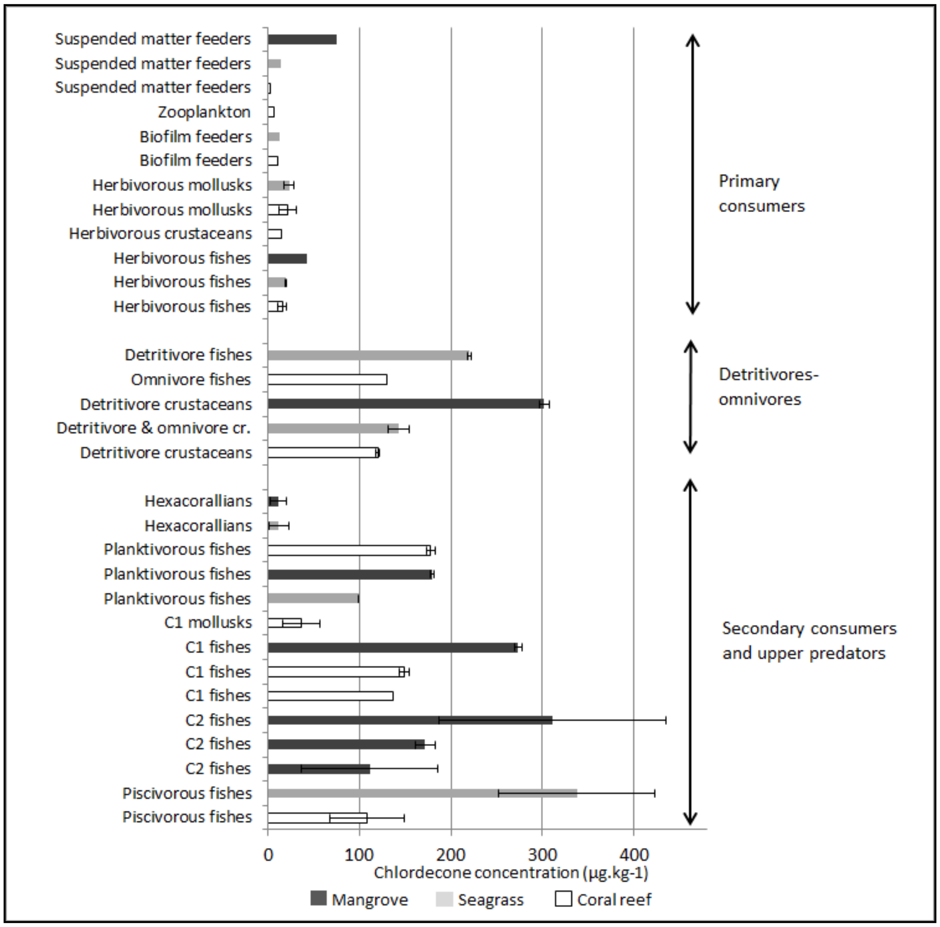

Figure 2. Concentrations of chlordecone according to trophic groups and levels (µg/kg).

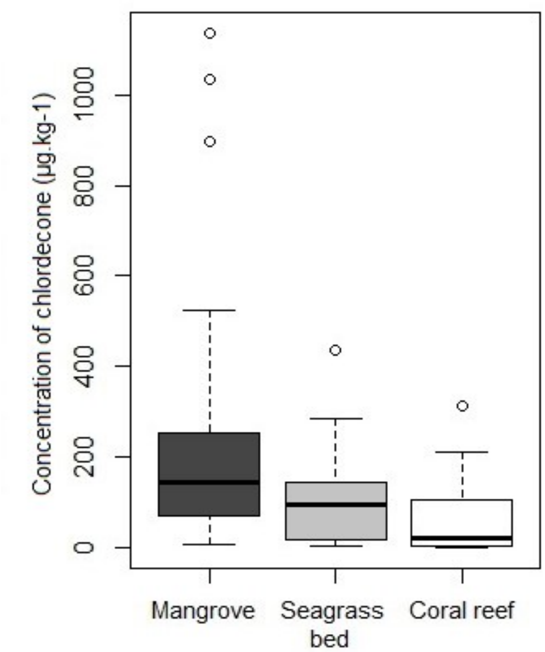

Figure 3. Mean concentrations of chlordecone (µg/kg) according to the habitats (mangrove, seagrass beds, coral reefs).

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