Emerging contaminants in a tropical estuary impacted by a megacity: spatial distribution and risk assessment

Contaminants émergents dans un estuaire tropical impacté par une mégacité : distribution spatiale et évaluation des risques

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RÉSUMÉ

Cette étude a pour objectif d'évaluer la distribution spatiale de micropolluants le long d'un continuum rivière-littoral impacté par une *megacity* en zone tropicale. 26 échantillons d'eau de surface ont été collectés sur la rivière Saigon-Nha Be sur 140kms à partir de l'amont de la *megacity* d'Ho Chi Minh (HCMC, 9.2 millions d'habitants) jusqu'à l'estuaire situé en mer de l'Est. Quatre échantillons supplémentaires ont été prélevés à l'embouchure de quatre canaux principaux du centre-ville chargés en eaux usées. Des analyses chimiques par dilution isotopique associée à la Chromatographie Liquide couplée à la Spectrométrie de Masse en tandem (HPLC-MS/MS) ont ciblé 259 Contaminants d'Intérêt Émergents ou CECs (produits pharmaceutiques, retardateurs de flamme, plastifiants, pesticides, etc.). Divers profils de concentration ont été observés pour chaque groupe de contaminants (produits pharmaceutiques, produits industriels, pesticides) mettant en évidence leurs différentes sources. Le centre-ville et en particulier les canaux urbains ont été identifiés comme la source principale de la plupart des contaminants quantifiés. Le risque engendré par la présence de ces contaminants a été estimé par le calcul de quotients de risque pour chaque contaminant.

ABSTRACT

This study aims to assess the spatial distribution of micropollutants in surface water along a tropical river continuum impacted by a megacity. 26 grab samples were collected along 140 km of the Saigon-Nha Be river from upstream the megacity of Ho Chi Minh (9.2 million inhabitants) to the estuary mouth in the East Sea. Four additional samples were collected in the main canals of the city center dominated by wastewater discharges. Chemical analysis was performed using isotope dilution high performance liquid chromatography - tandem mass spectrometry (HPLC-MS/MS) targeting up to 259 contaminants of emerging concern (CECs: pharmaceuticals, flame retardants, plasticizers, pesticides, etc.). Diverse concentration profiles were observed along the continuum to the estuary for the different targeted chemical groups (pharmaceuticals, industrial chemicals, pesticides) highlighting the different sources of chemicals and their attenuation. The city center and in particular the urban canals were identified as a major source of most of the contaminants quantified in the river waters. Finally, risk quotient values were estimated for each contaminant for acute and chronic effects.

KEYWORDS

Emerging contaminants, megacities, tropical estuary, water quality

1. INTRODUCTION

Contaminants of Emerging Concern (CECs) are a broad spectrum of non-regulated chemicals including pharmaceuticals and personal care products (PPCPs), flame retardants, plasticizers, among others. They are released from anthropogenic sources, especially from urban areas, wastewater treatment plants, agriculture, industry and can find their way to rivers, estuaries and coastal ecosystems. CECs have been qualified as a risk to environmental ecosystems and human health. In tropical areas, the current fast urbanization rate, illustrated by the rise of many megacities (cities of more than 10 million inhabitants), leads to important discharges of CECs to the surrounding environment. To date, very few data have been published on the occurrence, behavior and fate of CECs in tropical systems. Therefore, this study aims to investigate the impact of a tropical megacity on the spread of CECs and their spatial variation integrating the river continuum from the source down to the estuary mouth.

2. METHODOLOGY

2.1 Study site

The study site is located in the south of Vietnam: namely the Saigon river-NhaBe River and Ho Chi Minh City (HCMC), a megacity of 9.2 million of inhabitants settled on its banks. The Saigon River runs from the Dau Tieng reservoir to the East Sea for 200 km. It goes through agricultural and forest dominated lands, then crosses Ho Chi Minh's city center and in the downstream part, it flows nearby paddy and aquaculture fields and the Protected Can Gio Mangrove (UNESCO Biosphere reserve). The Saigon river is subject to a tropical monsoonal climate with strong seasonality and due to the proximity of the estuary it is also influenced by semi-tidal cycles. In the city center, around 20% of the domestic wastewater is treated by three WWTPs. Many canals connect to the river dragging runoff and untreated domestic and industrial wastewaters from the most densely populated areas.

2.2 Sampling strategy

The sampling took place during the dry season of March 2020. From upstream to downstream of HCMC megacity, 26 sites of the Saigon-Nha Be rivers were monitored over a longitudinal campaign (140 km from Cu Chi to the estuary, sample collection every 4-8 km on average). The sampling strategy was based on the collection of 500 mL grab water samples at each site. Additional four samples were collected in the main urban canals. Duplicate samples and Field Blanks were collected for quality control.

2.3 Combined analyses

The water samples were filtrated (QFA, Whatman), spiked with 60 internal standards and concentrated by a factor of 1000 via solid phase extraction (Oasis HLB 6cc cartridges). Analysis was performed using isotope dilution high performance liquid chromatography coupled with tandem mass spectrometry (HPLC-MS/MS) targeting up to 259 contaminants (SLU, Sweden and IGE, France). The contaminants were selected according to their high production volume, local use, toxicity, and possible use as markers of sources or environmental processes (photolabile, biodegradation). Risk quotients were evaluated using lowest PNECs values for freshwater and seawater (from Norman database).

3. RESULTS

3.1 Quantification frequencies and total concentrations

107 chemicals (61 PPCPs, 4 hormones, 12 industrial products, 23 pesticides, and 7 (bio)transformation products) were quantified at least once along the Saigon River. The total quantification frequencies and total concentrations calculated for each site were higher in the samples located in the city center and the city canals (Figure 1). More than 80 compounds were quantified in the canals with total concentrations for each canal ranging from 3 to 100µg/L. These results show that the urban center of the megacity is a hotspot of releases of CECs. Moreover, 50 CECs were quantified at the river mouth with a total concentration of 100ng/L. This highlights the persistence and mobility of those contaminants which can reach marine environment.

3.2 Spatial variability

In more details, the spatial profile of PPCPs displayed an increase and a peak of concentration in the city center and the canals followed by a decrease along the Nha Be river and down to the estuary. Industrial chemicals also had higher concentrations in the city center and the Van Thuat Canal which flows nearby the airport and industrial zones. These results are coherent with the fact that PPCPs and industrial chemicals are mainly released by point sources during dry seasons and are found near the densest urban and industrial areas. Pesticides had more diversified profiles showing maximums of concentrations in the upper part of the profile (diuron, azoxystrobin), the city center (propiconazole, metalaxyl) or the downstream part (atrazine). This reflects the variety of land uses and sources of the pesticides from agriculture (upper region), urban use (city center) and both agriculture and aquaculture (downstream part).

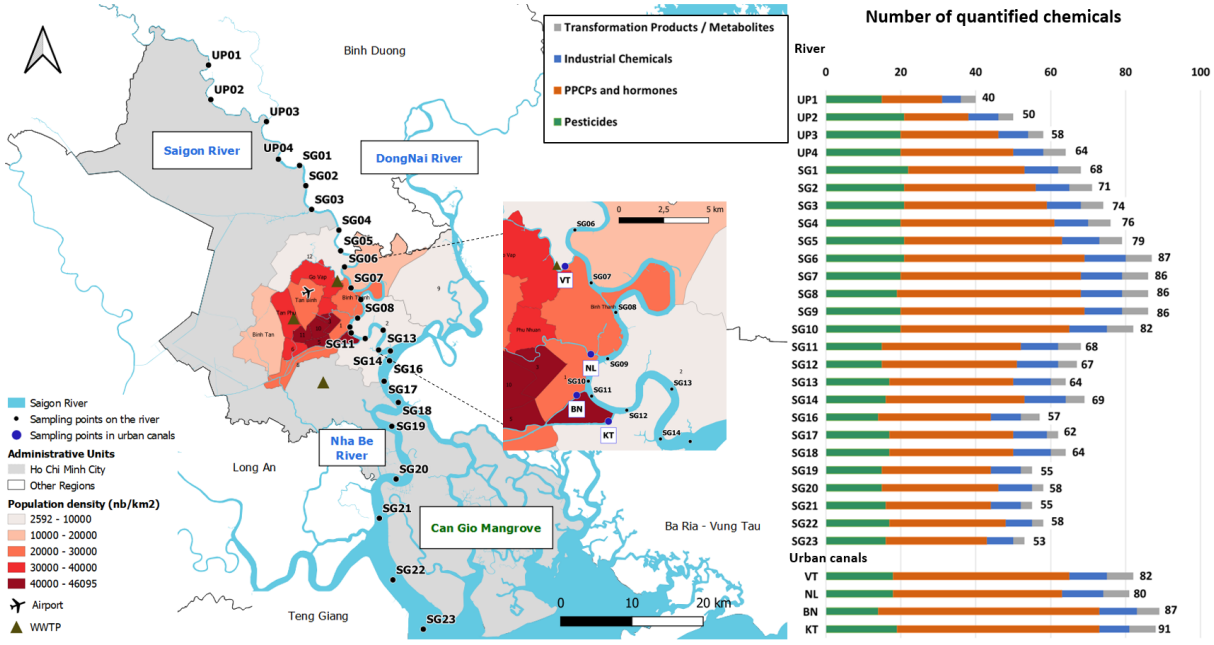

Figure 1: Map of the study site (left) and graph of the quantification frequencies measured along the Saigon River and in four urban canals of Ho Chi Minh City (right)

In conclusion, the megacity, especially its canals, releases a broad range of contaminants to the river. The different patterns of attenuation observed for individual chemicals reflect the presence of changing mixtures of CECs along the continuum and lead to complex exposure conditions for aquatic organisms.

LIST OF REFERENCES

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