SEASONAL DISTRIBUTION OF PHYTOPLANKTON IN A TROPICAL ESTUARY UNDER HIGH URBAN PRESSURE (SAIGON RIVER, VIETNAM)

Distribution saisonnière du phytoplancton dans un estuaire tropical sous forte pression urbaine (Rivière Saigon, Vietnam)

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RÉSUMÉ

Dans la présente étude, la qualité de l'eau et la structure de la communauté du phytoplancton ont été étudiées deux fois par mois de janvier 2017 à décembre 2020, sur trois sites d'échantillonnage de la rivière Saigon et de son estuaire traversant Ho Chi Minh-Ville (Vietnam). Des points d'échantillonnage supplémentaires ont été pris le long d'un gradient amont aval de la rivière Saigon pendant la période humide et pluvieuse (2017, 2019 et 2020). L'analyse du phytoplancton a permis d'identifier des espèces appartenant à six groupes dans lesquels les Bacillariophycées, les Chlorophycées et les Cyanobactéries représentent la diversité phytoplanctonique la plus importante. L'abondance totale du phytoplancton est plus importante dans la zone urbaine dense (environ 10 et 100 fois plus élevée qu'en amont et en aval respectivement). L'abondance du phytoplancton est plus élevée en saison sèche (jusqu'à 5×10^6 cellules L^{-1}) avec une forte dominance de Bacillariophycées (> 95 %). En saison des pluies, et malgré un niveau similaire en nutriments, l'abondance est inférieure de deux ordres de grandeur (3.10^4 cellules L^{-1}) avec une plus grande proportion de Cyanobactéries. En saison sèche, le temps de séjour moyen est d'environ 88 jours, tandis qu'en saison des pluies cette valeur est réduite à 36 jours. Une forte corrélation a été obtenue entre le temps de séjour et la chlorophylle-a (R^2=0,69). Le temps de séjour apparaît ainsi comme le principal facteur influençant la dynamique saisonnière du phytoplancton dans la rivière Saigon.

ABSTRACT

In the present study, water quality and the community structure of phytoplankton were bi-weekly investigated over four years from January 2017 to December 2020 at three sampling sites within the Saigon River and its estuary surrounding Ho Chi Minh City (Vietnam). Additional sampling points were taken along the gradient course of the Saigon River during dry and rainy periods (2017, 2019 and 2020). Phytoplankton analysis allowed the identification of species belonging to six groups in which Bacillariophyceae, Chlorophyceae, and Cyanobacteria accounted for the most important phytoplankton diversity. The total phytoplankton abundance was greater in the urban area (around 10 and 100 times higher than in upstream and downstream, respectively). The phytoplankton abundance was greatest in dry season (up to 5×10^6 cells L^{-1}) with a large dominance of Bacillariophyceae (> 95 %). In the rainy season, the abundance is two orders of magnitude smaller (3.10^4 cells L^{-1}) but with a larger proportion of Cyanobacteria. The residence time was then analyzed between the upstream and the urban area. In the dry season, the average residence time is about 88 days, while in the rainy season this value is reduced to 36 days. A high correlation was obtained between the residence time and the chlorophyll-a (R^2=0.69). The residence time appears thus to be the main factor that influences the phytoplankton dynamics in the Saigon River.

KEYWORDS

nutrients, megacities, phytoplankton, residence time, tropical estuary

1 INTRODUCTION

Phytoplankton is a major component of the food web structure in aquatic ecosystems. Their seasonal distribution and diversity are driven by the interactions between physical, chemical, and biological factors. Especially in eutrophic ecosystems, nutrients essential for the growth of algae (nitrogen, phosphorus, silica) are in excess and cause phytoplankton blooms. Limiting the availability of one of these nutrients can alter seasonal phytoplankton dynamics but also species diversity. In addition, there is the effect of environmental conditions (temperature, salinity, residence time of water). The aim of this study is to analyze the spatio-temporal distribution of phytoplankton species in a tropical estuary under high urban pressure in the light of nutrients levels and residence time fluctuation.

2 MATERIALS AND METHODS

2.1 Study site

Ho Chi Minh City (HCMC) is the economic capital of Vietnam. It is a megacity of about 9 million inhabitants in full demographic and economic expansion, like most of the biggest cities of South East Asia. The rate of collection and treatment of wastewater is very low (< 20%) before the release to the Saigon River (Nguyen et al. 2020). Downstream HCMC, Saigon River joins the Dong Nai River to form the estuarine zone about 60 km from the coastal area (figure 1). The Saigon River is influenced by tides, leading to the current flow inversion twice a day. The hydrology is also influenced by tropical climate typical of the South of Vietnam (rainy season from May to November, mean annual precipitation = 1900 mm).

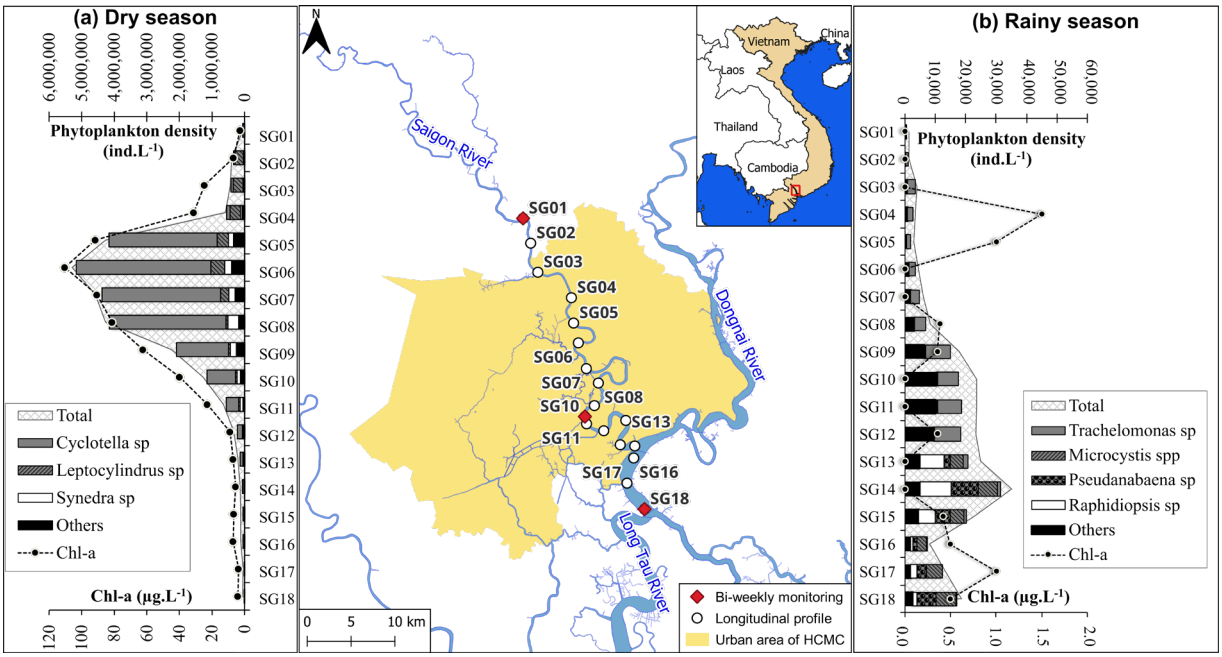

Figure 1: Map of the study site and density of phytoplankton and dominant species and chlorophyll-a along a longitudinal profile in a) dry season and in b) rain season (profiles from 2017; Nguyen et al. 2021a)

2.2 Sampling and analysis

Bi-weekly monitoring was carried out at three sites (upstream, urban area, downstream) from January 2017 to December 2020 in the Saigon River, completed by longitudinal profile in dry and rainy seasons (Figure 1). Each water sample was collected in a 5L polypropylene bottle for measurements of dissolved and total nutrients (Nitrogen, phosphorus and Silica) as well as the analysis of chlorophyll-a. A second sample of 2L and fixed to Lugol was taken for the identification and counting of phytoplankton species. Nutrients and chlorophyll-a concentrations were determined using classical colorimetric methods and phytoplankton was identified using their morphology observation through microscope (Optika150) and counted with a Sedgewick Rafter cell (PYSER-SGI, England).

2.3 Residence time calculation

The residence time (Tr) was calculated using the following equation: Tr = Q/V where Q is the upstream discharge and V is the volume of water of a given estuarine section. Monthly Q was obtained from the Center of Environmental Monitoring (Vietnamese monitoring program) and the mean estuarine volume was calculated using the estuarine geometry of the C-GEM model implemented on the studied site to model hydrodynamics and biogeochemistry (Nguyen et al 2021b). The residence time (in days) is then calculated for each month and compared with phytoplankton.

3 RESULTS AND DISCUSSION

Over the period 2017-2020 analyzed, the Saigon River experiences eutrophic status with extreme levels of nitrogen (total N > 2 mgN L^{-1}) and phosphorus concentrations (total P > 0.4 mgP L^{-1}). The chlorophyll-a regularly exceeds 40 µg chla L^{-1}, especially in the urban densely area (10 to 100 times higher than in upstream and downstream) and much higher during the dry period than the rainy season (figure 1). These results are consistent with previous study of our group leading to the main conclusion of a dominant nutrients sources from untreated domestic wastewaters (Nguyen et al, 2019). Commonly freshwater diatoms species (Cyclotella spp., Peridinium spp.) and sometimes brackish water species (Leptocylindrus spp., Skeletonema Costatum) were largely dominant. Nevertheless, Microcystis spp. (Cyanobacteria) can be observed during the rainy period. No link was found between the high abundance of phytoplankton in the dry season and the nutrients level that is always high (no limitation). This residence time fluctuates with the seasonal discharges, it is longer during the dry season (88 days in mean) and shorter during the rainy season (36 days in mean) (Figure 2a). The high abundance of phytoplankton is therefore more likely linked to the residence time rather than the availability of nutrients. Indeed chlorophyll-a correlates with residence time (R^2 = 0.685) (figure 2b)

Since the water of the Saigon River is used for the production of drinking water, the possible shift of phytoplankton diversity and the appearance of toxic cyanobacteria due to eutrophication would threat the regional water resources managements.

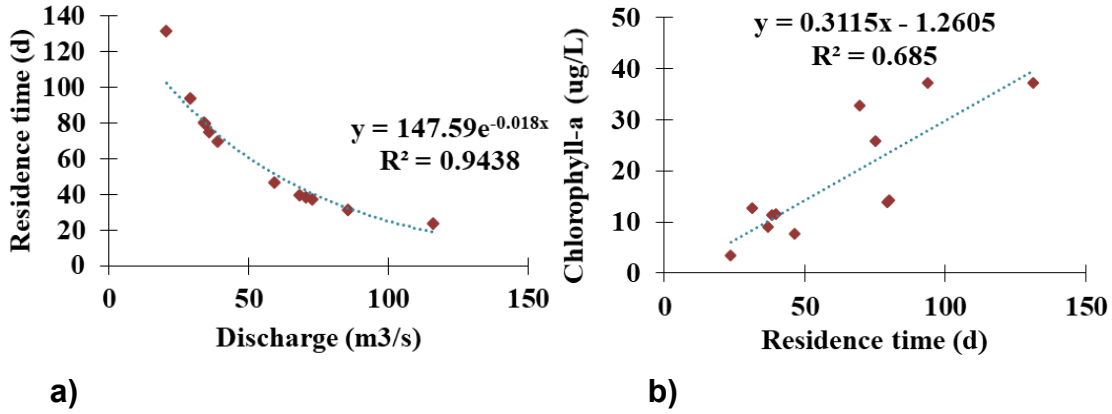

Figure 2 : Relationship between a) residence time and mean monthly discharge and b) chlorophyll-a and residence time at urban dense site (period 2017-2020)

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