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Microbiological and physicochemical characterization of water and sediment of an urban river: N'Djili River, Kinshasa, Democratic Republic of the Congo

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ABSTRACT

Microbial and toxic metals contamination of freshwater resources is still a major problem in many parts of the world. In this study, water and sediment samples ($n = 9$) were subjected to the microbiological and some physicochemical analysis to assess the water quality of the N'Djili River (Kinshasa, Democratic Republic of Congo). Microbiological analysis was performed for faecal indicator bacteria (FIB) including *Escherichia coli* (*E. coli*) and *Enterococcus* (ENT). The FIB characterization was performed for general *E. coli*, *Enterococcus faecalis (E. faecalis)* and human-specific *bacteroides* by PCR, using specific primers. The physicochemical parameters including pH and electrical conductivity were measured in water samples, and grain size distribution, organic matter and total mercury (Hg) were measured in sediments samples. The results revealed high concentration of FIB, with the maximum values of 1.6×10^3 and 2.7×10^3 CFU 100 mL^{-1} for *E. coli* and ENT, respectively. The FIB in sediment samples present higher concentration than in water, with maximum values of 9.4×10^5 and 1.2×10^5 for *E. coli* and ENT, respectively. The PCR assays for human-specific *bacteroides* HF183/HF134 indicated that more than 90% of bacteria were from human origin. The Hg concentration in sediment samples reaches the values of 0.5 mg kg^{-1}. Thus, our results indicate that the uncontrolled landfills and mixing of untreated urban and industrial effluents lead to the deterioration of the water quality of the rivers traversing the economically important cities. This study represents useful tools to evaluate water and sediment quality in river systems which can be applied to similar aquatic environments.

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1. Introduction

In many parts of the world, the discharge of untreated hospital and industrial effluents, agricultural and urban activities, domestic wastewater and uncontrolled landfills constitute the main contamination sources of aquatic environments. The deterioration of water quality, especially in developing countries pose tremendous effects and human health risks (Kambole, 2003; Pritchard et al., 2008; Key et al., 2004; Mubedi et al., 2013; Atibu et al., 2013). The urban river systems receive various types of contaminants including toxic metals, persistent organic pollutants, pathogenic organisms and pharmaceutical drugs such as antibiotics, which constitute major environmental and human health concerns. In the aquatic environment, sediments may constitute a reservoir for these pollutants. It has been demonstrated that the sediments can accumulate contaminants and pathogenic organisms at the concentration of 10–1000 times higher than the overlying water (Davies et al., 1995; Poté et al., 2008; Haller et al., 2009a,b). Hence, the sediment represents an important compartment for the assessment of the pollution in river-reservoir systems.

Several studies have demonstrated that sediments may constitute an important reservoir of faecal indicator bacteria (FIB) in freshwater environments (LaLiberte and Grimes, 1982; An et al., 2002; Haller et al., 2009a). Accumulation of FIB and pathogenic organisms in sediments has been attributed to the sorption of the microorganisms to particles suspended in water, whereas desorption of the microorganisms from sediment can occur under changing physicochemical conditions (e.g., pH, oxygen availability, redox conditions). Faecal pollution can originate from a variety of human and non-human sources, but FIB contamination from human faecal material is generally considered to be a greater risk to human health as it is more likely to contain human enteric pathogens (Scott et al., 2003; WHO, 2004; Montgomery and Elimelech, 2007). Additionally, the use of wastewater contaminated by FIB for irrigation is widely practiced in developing countries such as in sub-Saharan Africa, but little is understood in these developing nations about the potential risks associated with its use (Ndiaye, 2009; Gemmell and Schmidt, 2012). These studies demonstrated that pathogens contained in the wastewater used for irrigation can be transferred to the raw vegetables and fresh produces.

The N'djili River is one of the tributaries of Congo River that drain the capital city of Kinshasa. Due to its position in the city, the river is used for many activities including water supply, population bathing and irrigation for urban agriculture. The

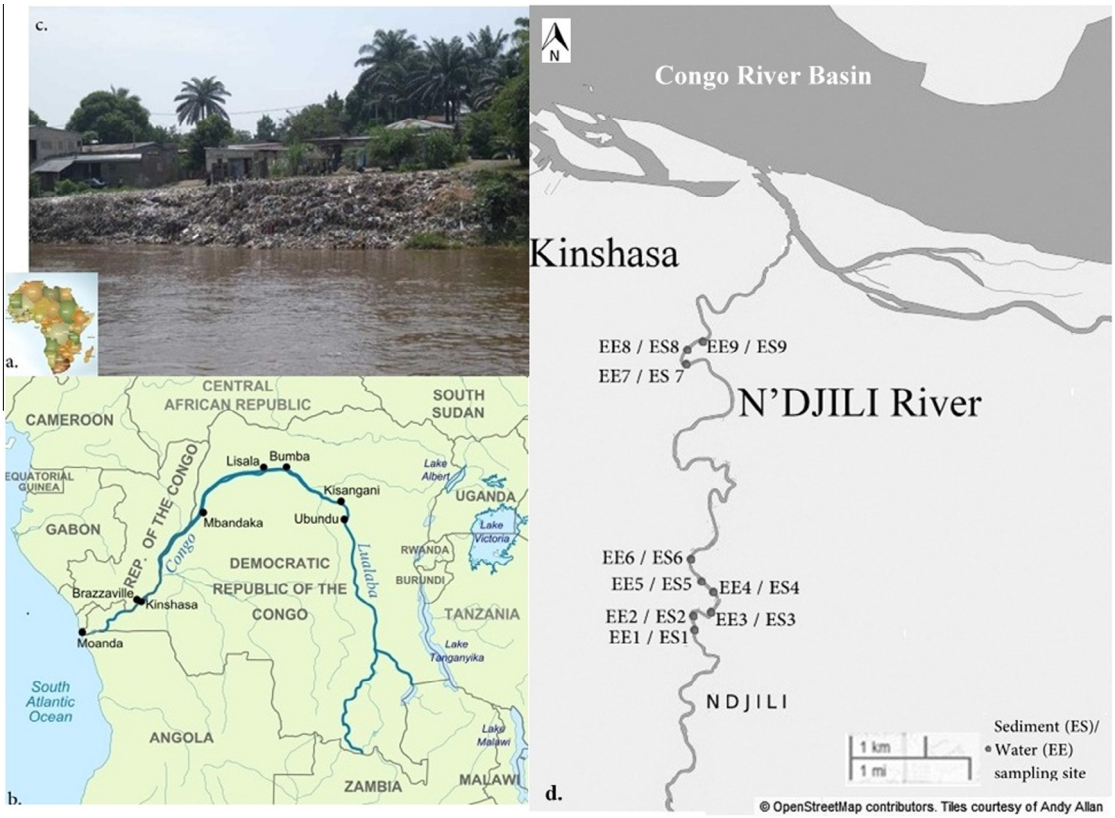

Fig. 1. Map location sampling area of the N'Djili River, capital city of Kinshasa, Democratic Republic of Congo. Republic of Congo, (a) Africa continental map, (b) Congo River map, (c) Picture of the an uncontrolled landfill near N'Djili River (Google map), (d) Flow of N'Djili River to the Congo River Basin and the sampling sites location. EE: water samples, ES: sediment samples, EE1-EE3/ES1-ES3 samples from industrial effluent discharge (IED) area, EE4-EE6/ES4-ES6 samples from presence of uncontrolled landfills (PUL) area, EE7-EE9/ES7-ES9 samples from urban agricultural and storm runoff (UAS) area.