Marine Pollution Bulletin 86 (2014) 539–546

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Assessment of contamination, distribution and chemical speciation of trace metals in water column in the Dakar coast and the Saint Louis estuary from Senegal, West Africa

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ARTICLE INFO

Article history:
Available online 16 July 2014

Keywords:
Trace metals
Speciation
Water column
Coast
Estuary
Senegal

ABSTRACT

The water column from Dakar coast and Saint Louis estuary in Senegal, West Africa, was sampled in order to measure the contamination level by trace metals. The speciation of metals in water allowed performing a distribution between dissolved and particulate trace metals. For the dissolved metals, the metallic concentration and repartition between the organic fraction and the inorganic fraction were performed. The results show that the pollution of the estuary was more serious than in Dakar coast for Co, Cr, Ni, Pb and Zn; while, Cd and Cu were higher in Dakar coast. A strong affinity between metals and suspended particles has been revealed. Dissolved metals that have a tendency to form organic metal complexes are in decreasing order: Cd, Zn, Pb, Co = Cr = Mn, Cu and Ni. The results showed that the mobility of trace metals in estuary is controlled by dissolved organic carbon, while in coast it depends on chlorides.

Marine coast and estuary environments are increasingly affected by human activity because of urban, industrial, mineral and agricultural waste. So, the use of the ocean as a dumping ground could lead to high levels of pollution (Bramha et al., 2014; Bodin et al., 2013; Memet and Bülent, 2012; Sultan et al., 2011; Xuelu and Chen-Tung, 2012). Both natural and anthropogenic factors are considered as a major environmental concern for marine ecosystems. They can impact the aquatic environment by producing polluting components which may enter into the human food chain and result in health problems (Kerambrun et al., 2012). Indeed, metallic contamination in aquatic environments has received huge concern due to its toxicity.

The Senegalese coast is one of the most productive in the world due to the presence of permanent and temporary rise of deep water; it is also cold and rich in nutrients (Sidoumou et al., 2006). Despite the relatively heavy level of industrial activity in the less developed region, there is a growing need to control the quality of coastal waters that may be influenced by waste tips from different sources into the seawater. Very few papers (Biney et al., 1994; Sidoumou et al., 2006; Diop et al., 2012) concern heavy metal concentrations in the Senegalese coast. This study conducts a preliminary investigation of pollution in the Senegalese coastal environment with focus on heavy metals in water column.

Since a long-time, it has been established that the toxicity, bioavailability and mobility of heavy metals depend on their speciation rather than their only total concentrations (Florence, 1986). Thus to fully understand the environmental chemistry of an element in a given system, it is important to identify and quantify the various species (forms) that make up its total concentration. Dissolved trace metals in water can exist as free hydrated ions, inorganic complexes as well as various organic complexes. A recent review by Pesavento et al. (2009) details the traditional methods as well as the emerging ones. In speciation studies, the distinction between the 'inorganic' and 'inert' metal fractions is especially important. The inorganic fraction includes the free forms and simple complexes characterized by fast rates in dissociation, while inert fraction represents the strongly bound metal complexes (Mota and Correia, 1995). The inorganic fraction would indicate the bioavailability and toxicity of heavy metals (Brown and Markich, 2000). For this reason it is useful to estimate the composition of inorganic metallic forms as a measure of the potential risk posed by heavy metals in environmental water systems.

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http://dx.doi.org/10.1016/j.marpolbul.2014.06.051
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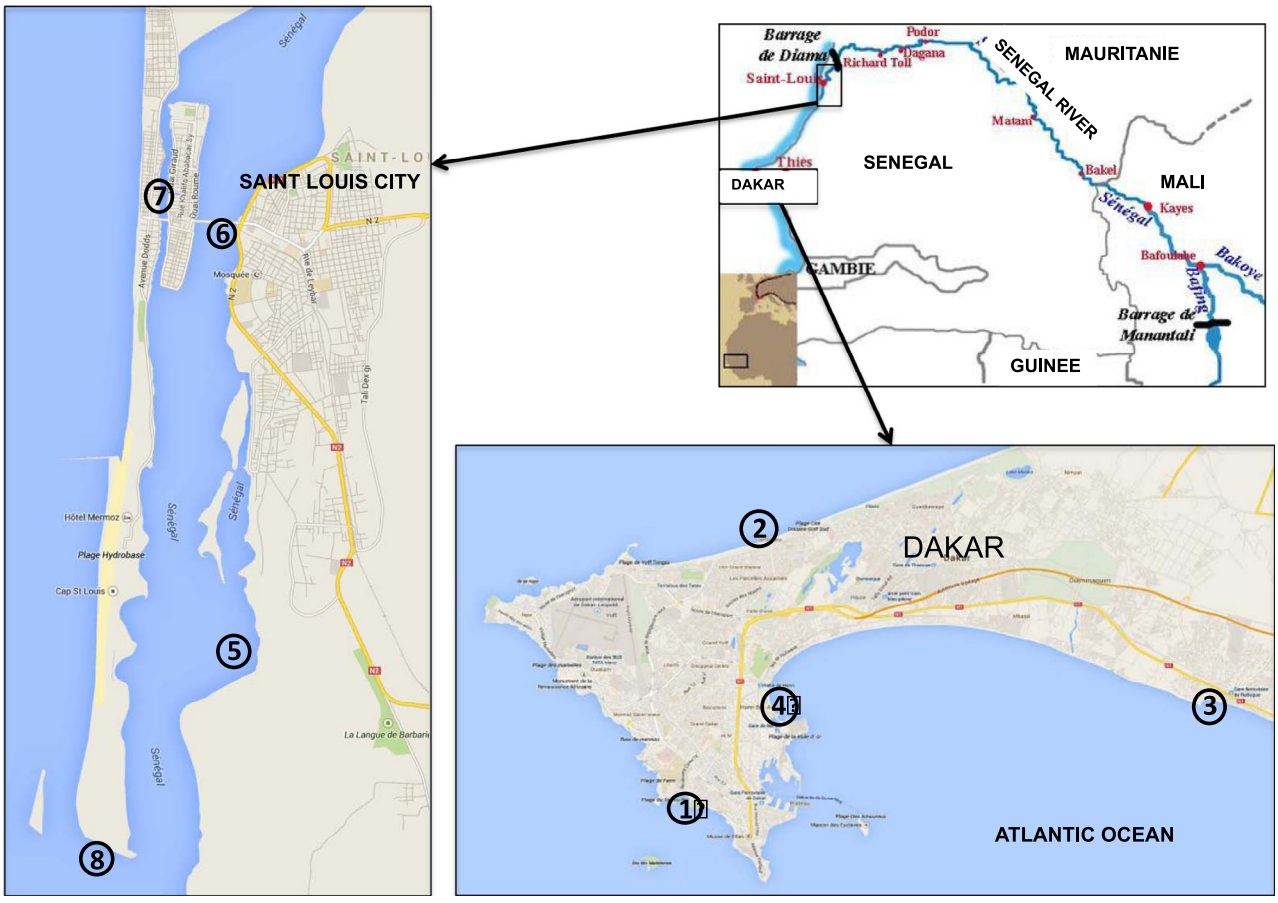

Fig. 1. Map of the sampling sites in Dakar and Saint Louis (Senegal, West Africa).

The objective of this work is to investigate the contamination status of trace metals in the Saint Louis estuary in the North of Senegal and along the Atlantic Ocean at Dakar in the Western part of Senegal. C18 cartridges were used to evaluate the inorganic fraction of trace metals, and thus the relationships between the variations in the dissolved organic carbon and the bioavailability of heavy metals.

Senegal is a coastal country located in the West of Africa between 12°80 and 16°41 N and 11°21 and 17°32 W. Its coast includes the most Western part of the African continent. In this area, the climate is characterized by an extended dry season, cool from November to March and warm from April to June, and by a short wet and warm season from July to October (Simier et al., 2004).

Fig. 1 shows the locations of the sampling sites. Water samples were collected from eight stations, namely in the Dakar coast: Soumbedioune (site 1); Camberene (site 2); Rufisque (site 3) and Hann (site 4) and in the Saint Louis estuary: Laybar (site 5); Sore (site 6); Guet Ndar (site 7) and Hydrobase (site 8). The brief description of sampling sites selected for this study is reported in Table 1.

To study the seasonal variability, three sampling campaigns were realized from June 2012 to January 2013: one sampling during the dry and warm season (June 2012), another during the wet and warm season (September 2012) and the third one during the dry and cool season (January 2013). Surface water samples were collected using two litres polyethylene bottles, which were rinsed with 10% HNO_3 and Milli-Q water three times, and stored in polyethylene bags until required. In the studied area, the bottles were rinsed twice with the water and then filled with running water. The method of collecting water followed those reported by APHA (1995).

We used a rapid and simple method described by Abbasse et al. (2002) and Romani et al. (2005) for the metallic concentration (preconcentration) and discrimination between the organic fraction and the inorganic fraction of the metals from sea and river waters. In this method we use 8-hydroxyquinoline, which forms neutral complexes with the metals. These letters were thus adsorbed on C18 cartridges bonded silica gel for metallic concentration (preconcentration) and determination after elution in smal-

Table 1
Locations and description of sampling sites in the coast and the estuary from Dakar and Saint Louis (Senegal).

Area	Site N°	Name site	Coordinates	Description type of pollution sources
Dakar coast	1	Soumbedioune	14°40′42″N 17°27′39″W	Important discharge of urban wastewater without any treatment
	2	Camberene	14°46′16″N 17°25′54″W	Discharge of urban wastewater with treatment plant
	3	Rufisque	14°42′42″N 17°16′54″W	Intensive fishing and industrial activities (cement factory, oil refinery)
	4	Hann	14°42′54″N 17°25′51″W	Mix urban and industrial wastewater directly discharged, location near Dakar harbour
Estuary Saint Louis	5	Laybar	15°58′56″N 16°29′09″W	Urban wastewater and agricultural runoff
	6	Sore	16°01′17″N 16°29′56″W	Urban wastewater discharge
	7	Guet Ndar	16°01′35″N 16°30′26″W	Location near rubbish dump, discharge of urban wastewater, fishing activities
	8	Hydrobase	15°57′53″N 16°30′43″W	No anthropogenic pollution source