Marine Pollution Bulletin 136 (2018) 322–333

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Levels and ecological risk assessment of heavy metals in surface sediments of fishing grounds along Algerian coast

Inal Ahmed[a,b,*], Boulahdid Mostefa[a], Angelleti Bernard[c], Radakovitch Olivier[c,d]

[a] Ecole Nationale Supérieure des Sciences de la Mer et de l'Aménagement du Littoral, (ENSSMAL), BP19, Campus universitaire de Dely Ibrahim, Bois des Cars, Alger, Algeria
[b] Centre National de Recherche et de Développement de la Pêche et d'Aquaculture, (CNRDPA), 11, Bd Colonel Amirouche, PO Box 67, Bou-Ismaïl, 42415, Tipaza, Algeria
[c] Aix-Marseille Univ., CNRS, IRD, INRA, Coll France, CEREGE, Aix-en-Provence, France
[d] Institut de Radioprotection et de Sureté Nucléaire (IRSN), PSE-ENV/SRTE/LRTA, BP3, 13115 Saint-Paul-Lez- Durance, France

ARTICLE INFO

Keywords:
Ecological risk assessment
Trace metals
Sediment
Fishing grounds
Algerian coast

ABSTRACT

The level and the ecological risk assessment of heavy metals (Zn, Cu, Mn, Fe, Ni, Cr, V, As, Pb, Cd and Co) were evaluated in surface sediments from fifty-one stations along the Algerian coast. The main objective was to evaluate the risk that such metals may cause to the ecosystem, and thus the stations were choose in relation with the fishing trawlable areas of Algeria. The usual chemical indexes Geoaccumulation index (Igeo), Enrichment factor (EF) and Pollution Load Index (PLI) as well as potential ecological risk index reveal that the metal pollution along this coast is low, and is only related to As contents. Nevertheless, the concentrations of Ni, Cr and As exceed their respective ERL values (Effect range low) usually applied for Sediment Quality Guideline. However, Cr and Ni are mainly natural and cannot be related to anthropogenic inputs and their ecotoxicological levels as to be questioned.

1. Introduction

Heavy metals are one of the most important pollutants in our environment due to their bioconcentration and their various form of toxicity (Liu et al., 2003; Gonzalez- Macias et al., 2006; Fang and Hong, 1999; Klavins et al., 2000; Tam and Wong, 2000; Yuan et al., 2004; Chakraborty et al., 2014). Because of their numerous anthropogenic uses and their persistence, they represent a risk at long-term scale in many areas of the world.

In the coastal environments, marine sediments have often been regarded as the ultimate reservoir for trace metals issued from anthropic inputs (Sin et al., 2001; Santos et al., 2005), because most of these metals are effectively adsorbed onto the surface of the mineral phases. Sediments play thus an important role in the transport and storage of potentially hazardous metals (Guevara et al., 2005; Masson et al., 2006), but in the same time they constitute the habitat necessary for aquatic organisms to grow, evolve and establish in the ecological system. Furthermore, they may also constitute a secondary source of pollution if the sediment is resuspended (Kalnejais et al., 2010) or through the releasing of non-residual or dynamic metal complexes (Chakraborty et al., 2012). Therefore, sediment contamination is a parameter used for the prediction of potential ecological risks in aquatic systems.

Since the beginning of the industrial revolution and the subsequent increase of industrial development, very large amounts of toxic pollutants have been discharged into coastal environments and estuaries, contaminating marine sediments with metals (Farmer, 1991; Liu et al., 2003; Perkins et al., 1973, Durrieu de Madron and MERMEX group, 2011). Local contaminations are thus usual and can be due to several factors including pipeline construction, wastewater treatment and disposal, runoff, mining, industrial activities, ports, urban development (Balls et al., 1997; Morton and Blackmore, 2001; Nriagu, 1996; Taylor and McLennan, 1995; Zingde et al., 1988). Rivers are also a major source of particulate metals to the continental shelves (Roussiez et al., 2006; Radakovitch et al., 2008).

Like in many developing countries, the Algerian coastal zone has experienced severe deterioration as a result of growing population and industrialization. Great industrially settlements in some areas (Skikda, Arzew, Algiers and Annaba) have been discharging their solid and liquid wastes into the sea directly or after a limited treatment. The maritime traffic and untreated domestic discharges from 16 million inhabitants along the Algerian coast are other factors influencing sea

* Corresponding author at: Ecole Nationale Supérieure des Sciences de la Mer et de l'Aménagement du Littoral, (ENSSMAL), BP19, Campus universitaire de Dely Ibrahim, Bois des Cars, Alger, Algeria.
E-mail address: a.inal@enssmal.dz (I. Ahmed).

https://doi.org/10.1016/j.marpolbul.2018.09.029
Received 5 April 2018; Received in revised form 15 September 2018; Accepted 17 September 2018

contamination.

Despite of this increasing pressure, only few researches concerning metal concentrations in the surface sediments of the Algerian coast were published (MPRH, 2010; Inal et al., 2014; Bachouche et al., 2017) and none of them discussed the associated ecological risks and biological effects. Belhadj and Aubert (2017) shows that the sediments of the Ghazaouet Bay (western Algeria) are highly polluted by Zn, Cd, Cu and Pb issued from a large industrial complex of zinc electrolysis as well as from leaching of tailings disposal from ore exploitation, but their data was restricted to the bay area. These four works focused on the estimation of the pollutant load in some hot spots, and they do not give a comprehensive view of the entire Algerian coast. However, the needs to better know the ecological risk associated to the surface sediments was recently emphasized by the aquaculture and fisheries development program: "AQUAPECHE 2020" and the wholesomeness of fishing areas and products must be now integrated. In this objective, our work presents and discusses for the first time the ecological risk that could be associated to heavy metals in surface sediments of the Algerian coast. It aims at helping managers from the fishing sector to evaluate the quality of the main fishing areas, and to facilitate decisions regarding the quality control of fishery products.

2. Study area

The Algerian coast along the southwestern side of the Mediterranean Sea is 1300 km long and receives several rivers, the most important being Seybousse, Lekbir and Soumam on the east, Yesser, Sebaou, Harrach and Mazafran in the centre and Chelif, Tafna on the west (Fig.1). This coast presents a variety of morphological forms with a majority of rocky shores, sometimes with high cliffs, but also sandy beaches and dunes. The distribution of soft-bottom sediments shows an increasing inshore silt gradient characterized by a succession of fine sand, muddy sand, sandy mud and pure mud (Bakalem, 2008).

The watersheds along this coast drain sedimentary rocks from Cenozoic and Cretaceous except in the area of Skikda (Fig. 1, C) where volcanic structures exist as well as Silurian deposits.

Algeria's population increased by 95% over the last thirty years, from 22 million inhabitants in 1985 to 40.4 million in 2015 (ONS, 2016). About 45% of this population is concentrated on a very narrow strip along the littoral, especially in industrial and harbor zones, such as Algiers, Annaba, Arzew, Oran and Skikda (Grimes, 2003). The coast has a population density of 281 inhabitants/km^2 whereas the national one is 12 inh./km^2 (Grimes, 2005). This situation exerts great pressure on the coastal marine ecosystem, and worsening conditions can be observed on large sections of the coast, particularly in the gulfs close to the biggest agglomerations, such as Algiers, Oran and Annaba (Grimes, 2003) and near the industrial-harbor complexes, like Arzew, Bejaia, Ghazaouet and Skikda (Belhadj and Aubert, 2017). Grimes (2003) showed that several pollution sources are concentrated in these areas: i) domestic waste; ii) chemical and petrochemical industrial discharges, including heavy metals, hydrocarbons and organic compounds; iii) discharge from thermal power stations, including hot water and chlorine.

In this work, we were not interested by looking at hot spots of contamination but by evaluating the heavy metals contamination of the sediments at the large scale. Our objectives were to produce the first national dataset and overview of the ecological risk for the ecosystem. For this, the sampling stations were choose in relation with fishing grounds, which constitute the main trawlable areas surveyed during the scientific surveys of the demersal resources of Algerian coast.

3. Material and methods

3.1. Sediment collection and pre-treatment

Fifty-one surface sediment samples were collected between 18 m and 562 m water depth using a Van Veen grab. They were taken during one oceanographic survey aboard of the Research Vessel "Grine Belkacem" from 20 May to 10 June 2015. The survey covered the entire Algerian coast, and the geographical position and characteristics of each station are reported in Table 1. The large range of water depths is related to our interest onto fishing ground areas, and the fifty-one stations constitute the fishing hauls that were explored during this oceanographic survey. The sampling period was recommended by the MEDITS program (Mediterranean International bottom Trawl Survey) for demersal ressources evaluation.

The sub-samples selected for heavy metals and organic matter analysis were homogenized and placed into sealed polyethylene bags

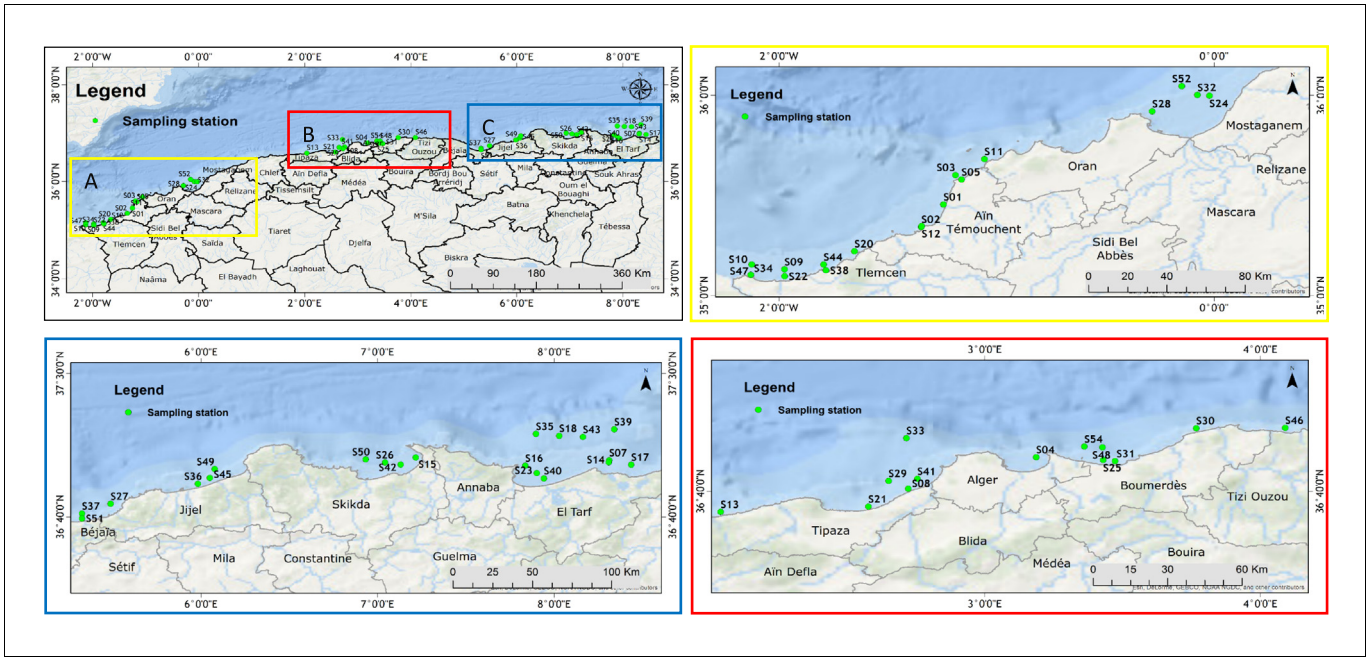

Fig. 1. Location of Algerian coast and sampling stations. A: West coast, B: Centre coast, C: East coast.