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# Morpho-granular approach to characterize harbour sediments and their agglomeration/dispersion behaviour

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ABSTRACT

An exhaustive physico-chemical and morpho-granular characterization of sediments collected in Port-Camargue harbour was investigated to improve marine sediment knowledge and to study inter-particle phenomena (granular properties and agglomeration/dispersion state). In the context of dredging framework, these phenomena could lead to disperse pollution in water column through chemical mobilization (dissolution or sorption phenomena) and/or physical mobilization (dispersion/agglomeration phenomena). Moreover they could disturb sedimentation behaviour which may lead to take pollution away from harbour. This work was focused on particle solid phase of sediment. Granular aspects were jointly studied with laser granulometry, electrophoresis measurements and Scanning Electron Microscopy (SEM). Chemical and mineralogical properties were mainly characterized with X-ray Diffraction (XRD) and Scanning Electron Microscopy with Energy Dispersive X-ray spectroscopy (SEM–EDX). These analyses were performed on bulk sediments and size fractioned sediments (<20 μm; 20–40 μm; 40–63 μm; 63–80 μm; >80 μm). Results showed that sediments can be differentiated by their granular properties (different in size distribution, shape and inter-particle interactions). A classification was proposed in function of their particle size distribution and silt percentage (very low proportion of clay is neglected): silty, silty sand and sand sediments. Furthermore, due to the presence of agglomeration/aggregation and dispersion behaviours, a morpho-granular approach was used to identify different types of agglomerates/aggregates. To minimize the impact of these phenomena on separation process of size fraction, often needed to investigate these systems, an optimized method was developed for sieving with a mechanical agitation and rinsing.
This experimental work could therefore supplement and enrich the chemical and biological approaches of marine sediments observed in the more conventional pollution mobilization studies.
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## 1. Introduction

Dredging of marine sediments is required in many ports, to deepen and to maintain depth of the shipping channel. However, dredging activities, and especially the release of sediments during dredging and the disposal of dredged material, can impact marine habitats [1–5]. Among other things, dredging and marine disposal activities can contribute to remobilize fine sediment-associated contaminants [6,7].

Sediments in estuaries and harbour areas are complex mixtures composed of solid and liquid phases with different characteristics and compositions. The liquid phase is predominately water with ions and molecules such as organic matter [8]. The solid phase consists of granular inorganic and organic materials that present many physical and geochemical properties (particle size distribution, water content, cohesive nature, mineralogical and geochemical compositions), responsible for biochemical and physicochemical interactions such as agglomeration/dispersion (weak physical bond), aggregation (strong chemical bond), dissolution/precipitation and sorption phenomena [9–11].

Moreover, these interactions can lead to trap organic or metallic contaminants in fine fraction (<80 μm) of sediments [12–16]. Generally literature presents studies on adsorption/desorption and precipitation/dissolution phenomena that contribute to pollution mobilization [1,9,10,17]. But dispersion/agglomeration phenomena can also mobilize molecule or particle pollutants adsorbed or agglomerated on mineral fractions (Fig. 1). Therefore pollutants can be transferred between granulometric fractions (smaller or bigger) and, for that reason, to be transported or to settle.

In dredging framework, agglomeration/dispersion interactions could therefore lead to disperse pollution in water column which could lead to transport it outside the harbour, and/or to impact particle settling at the bottom of the harbour. Then, the aim of this work is to have a better knowledge of solid fraction of sediment, and to investigate agglomeration/dispersion state of harbour sediment particles. An exhaustive characterization of physicochemical and granular aspects has been carried out on bulk and size fractioned sediments. Data published in the literature are focused on chemical distribution of contaminants, and biological or physicochemical properties of marine sediments.

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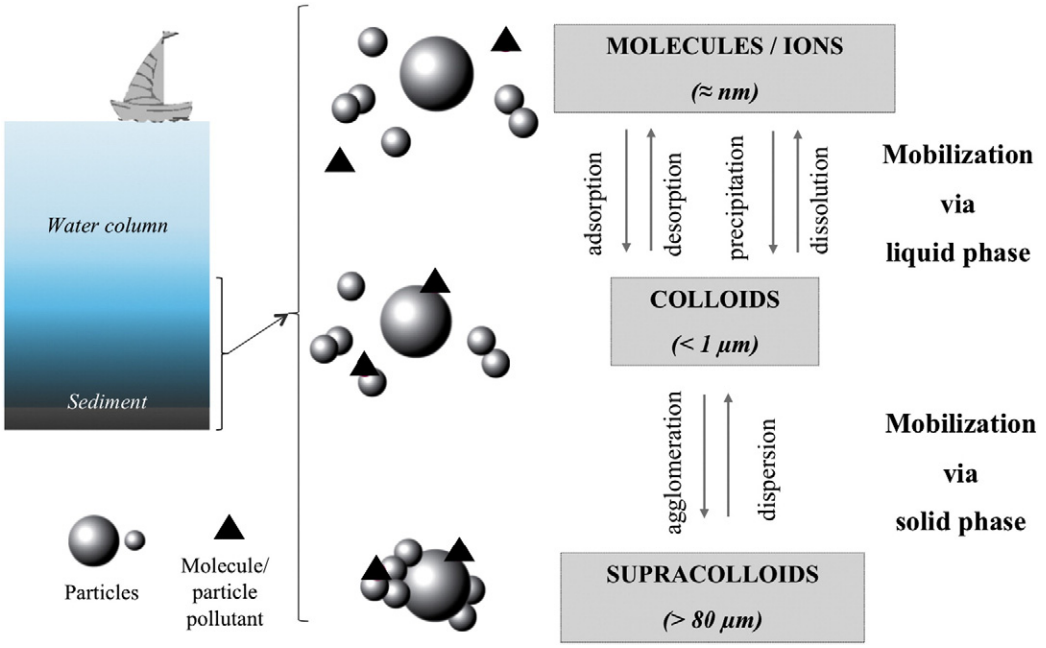


**Fig. 1.** Particle interactions and pollutant mobilizations.

Some other studies introduce sediment/contaminant interactions in various solid fraction phases (organic and mineral) and the liquid phase (water and pore water) [7,18–23]. But few studies carry out morphogranulometric characterization of sediment particles and agglomeration/dispersion behaviours.

The first part of this paper concerns granular and physicochemical characterization of bulk sediments. Firstly, chemical and mineralogical composition and physicochemical characteristics were determined. Then population identification and granular characteristics of particles were discussed in detail. The granulometric distributions can also permit classification of the sediments, according to standard US Department of Agriculture Soil Textural Classification Triangle [24]. Finally, a study has been achieved combining laser granulometry, ultra-sonification and zeta potential measurements in order to characterize agglomeration/dispersion state of sediments and to identify the different agglomerate/aggregate types. The second part is focused on characterization of size fractioned sediments (<20 µm; 20–40 µm; 40–63 µm; 63–80 µm; 80–100 µm) that requires an optimized granulometric separation despite agglomeration/dispersion phenomena existence and their impact on separation process.

## 2. Material and methods

### 2.1. Field sites and sampling

Study area is the Port-Camargue harbour localized in South France, in the Gulf of Lion that is a wide embayment of Mediterranean coastline. This is one of the largest marinas in Europe and is close to Natura 2000 sites that are protected nature reserves. It has not been dredged since 1969 (date of its construction) because of a low sedimentation rate, a characteristic of Mediterranean Sea [25]. Several sediment samples were taken into the harbour in order to observe and to characterize sediments by descriptive criteria (i.e. texture, structure, and colour related to rate of mud). But only three of them have been chosen for this work (Fig. 2); one is located in the outer-harbour zone (Sampling 1) with a muddy material, one is situated in an old technical zone

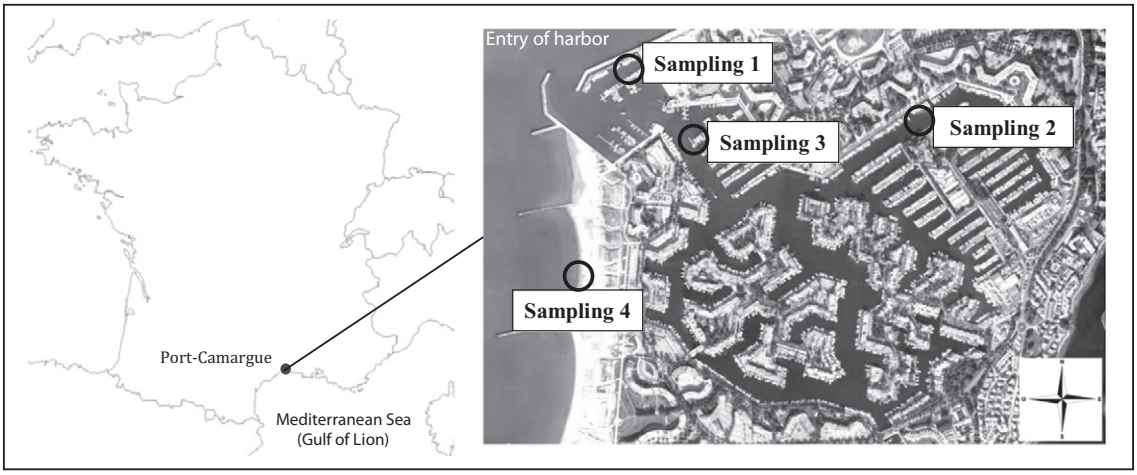


**Fig. 2.** Locations of sampling stations.

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