Physicochemical characteristics of port dredging sediments and of the brick slip used in the manufacture of bricks: a comparative study

D. Benyerou, N. Boudjenane & M. Belhadri
Rheology Laboratory, Transportation and Handling of Complex Fluids (LRTTFC), Department of Hydraulics, Faculty of Architecture and Civil Engineering, University of Science and Technology of Oran (USTO-MB), Algeria

Abstract

The dredging practices are a major challenge for the development and maintenance of port activities. Millions of cubic meters are extracted regularly from Algerian ports, it is necessary to value them. This study focuses on the development of marine sediments from the port of Bethioua for making bricks. A physicochemical, mineralogical and fine microscopic characterization was done with great care for these marine sediments and for the slip brick at several laboratories in our university (USTO-MB). The physicochemical, mineralogical and microscopic characterization of materials shows a similarity between these sediments. They can be a very useful source of local raw materials, particularly for the building sector such as bricks.
Keywords: marine sediments, dredging, recycling, brick slip, characterization, port.

1 Introduction

In recent decades, the manufacture of bricks was assessed using the marine and river sediments worldwide [1–10]. The objective of this work is to characterize the physicochemical properties of marine sediments in the port of Bethioua and to examine two research issues applied to reduce the tonnage of dredged materials and to promote them in the brick manufacturing research.

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Most building materials are heterogeneous. These materials can therefore accommodate different types of inorganic waste whether they are treated or untreated. Several studies have been conducted in recent years in this area, adding sludge from sewage treatment plants and their ashes, waste of natural stone, slag, waste metal, sandy cuttings, etc. [11, 12].

2 Materials and method used

The studied sediments were collected in the harbor of what is now known as the town of Bathioua dedicated exclusively to oil activities (see Figure 1). The raw materials used for the manufacture of bricks are of two basic types: the clay and sand.

Figure 1: Sediment sampling site (Port of Bathioua).

The studied sediments were collected using a mechanical dredge which is basically an excavator mounted on a pontoon. Samples were collected from the Bathioua locality. This area is classified as oil zone, which explains the high levels of hydrocarbons in these sediments. The dredged material was homogenized and stored in clean waterproof bags and transferred the same day to different laboratories. The study includes a set of physical properties determination such as state parameters, nature, water content and grain distribution, the study includes also chemical properties determination like pH, conductivity, organic matter and hydrocarbons, it determining mineralogical and microscopic properties is also part of the study.

2.1 Physical properties

The water content was determined according to NF P94-050 standard and the true density was determined according to NF P94-054 standard. The results are shown in Table 1. The particle size analysis was carried out by wet process on a series of sieves of the XP P94-041 standard (see Figure 2). The granulometric curve shows the presence of a clay fraction of the order of 2%, siliceous fraction of the order of 20% and a sand fraction in the order of 78%, particle diameters of d10 = 3 microns and d90 = 270 microns.

Table 1: Physical and chemical parameters of the materials studied.

Settings	Marine sediment	Clay brick
Density (g/cm^3)	2.2	2.6
Fraction< 63 µm (%)	58	88
Fraction> 63 µm (%)	42	12
Wp (%)	30.0	49.8
WL (%)	18.9	25.7
VBS (%)	1.56	5.3
O.M (%)	1.88	3.66
pH	8.7	8.1
Conductivity	361 ms	169 µs

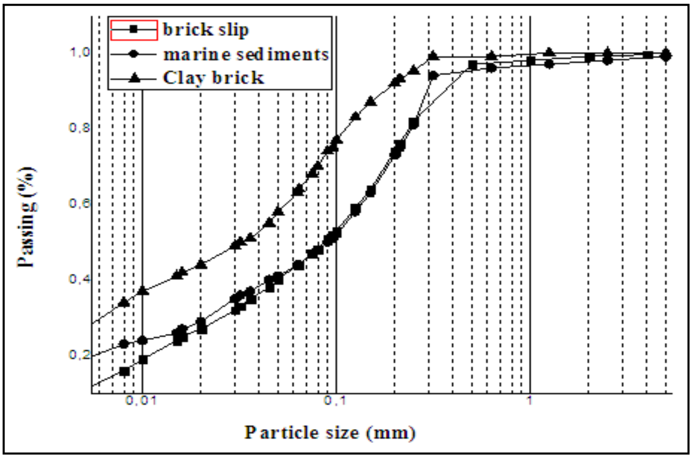

Figure 2: Curves of marine sediment grain size, clay brick and brick slip.

The Atterberg limits were carried out according to the NF P94-051 standard with liquid limit WL = 30.2% and a plastic limit Wp = 19.6% for marine sediments. However, for the clay used in the manufacture of bricks, these values are respectively in the range of 50.1% and 25.2%.

2.2 Chemical properties

Table 1 shows the chemical properties such as pH, conductivity, organic matter and hydrocarbon. The pH was determined according to the NF X31-103 standards, electrical conductivity was measured with a conductivity cell calibrated according to the DIN ISO 11265 standard, the measurement of the organic material was carried out using the XP P94-047 standard and finally the elements traces were determined by atomic absorption spectrometry. The results are summarized in Table 2 and show that there's a presence of hydrocarbons in marine sediments. Between N1 and N2 levels, further investigation may be necessary depending on the specific project and the degree of exceeding the level N1. Tests are then performed to assess the overall toxicity of sediments.

Table 2: Relative levels to trace elements (in mg/kg dry sediment analyzed on the fraction smaller than 2 mm), GEODE (2000).

Metals	Units	Marine Sediment	Clay brick	Level 1	Level 2
Lead (Pb)	mg/kg	< 0.01	<0.01	100	200
Mercury (Hg)	mg/kg	< 0.01	<0.01	0.4	0.8
Chromium (Cr)	mg/kg	<0.005	<0.005	90	180
Cadmium (Cd)	mg/kg	< 0.01	< 0.01	1.2	2.4
Arsenic (As)	mg/kg	< 0.05	< 0.05	25	50
Tin	mg/kg	< 0.01	< 0.01	/	/
nitrite	mg/kg	0.00	0.00	37	74
phenol	mg/kg	0.017	0.017	/	/
total hydrocarbon	mg/kg	1.010	0.441	/	/

To get a better idea about the chemical composition of the materials studied, we conducted an X-ray fluorescence test. The results are summarized in Table 3 and expressed in weight percentage. This detailed analysis of the results is based on the comparison of the various oxides levels , which show that alumina (Al_2O_3) is related to the plasticity and the contents of this oxide reported in our clay used for the manufacture of brick is greater than the content of marine sediments. To increase the plasticity it is necessary to mix up these marine sediments with bricks clay.

Table 3: Chemical composition of major elements in materials.

Oxide content (mass%)	S_iO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	Cl	P_2O_5	T_iO_2	LOI
Marine sediments	27.9	6.1	4.01	29.4	2.71	0.85	0.70	0.34	0.02	0.11	0.18	28.9
Clay brick	48.4	12.2	7.72	10.7	2.50	0.70	2.03	0.55	0.05	0.21	0.56	16.1
Brick slip	61.0	12.1	5.48	9.05	1.76	0.04	1.13	0.46	0.13	0.11	0.72	7.80

The levels of silica (SiO_2) in marine sediments are roughly classified within standards. This oxide (SiO_2) is due to the presence of quartz which shows a sufficient amount to act as a degreasing agent without addition of an inert element such as sand.

The iron oxide (Fe_2O_3) is the main colorant in clays and is responsible for the red color after cooking. Lime (CaO) content is high for marine sediments.

2.3 Mineralogical properties

Figures 3, 4 and 5 show mineralogical identification made from qualitative XRD analysis performed on a crushed fraction of about 80 µm of marine sediments, for slip bricks a Bruker D8 diffractometer was used. The results show the presence of quartz, calcite and dolomite as major minerals.

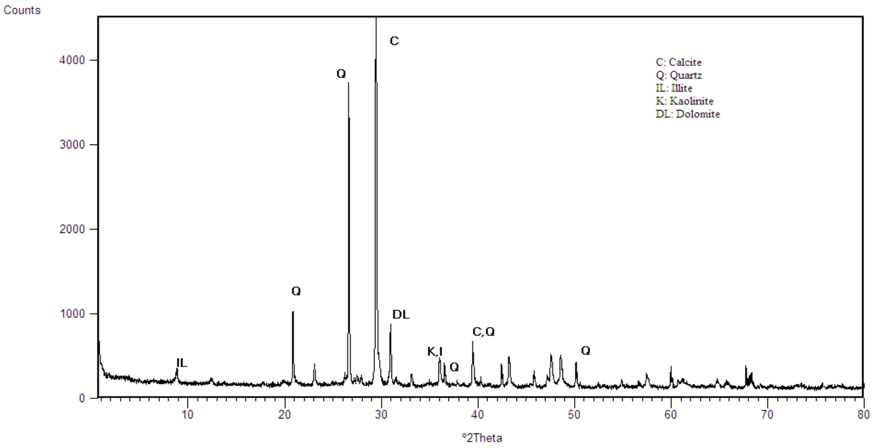

Figure 3: XRD diffractogram of marine sediments.

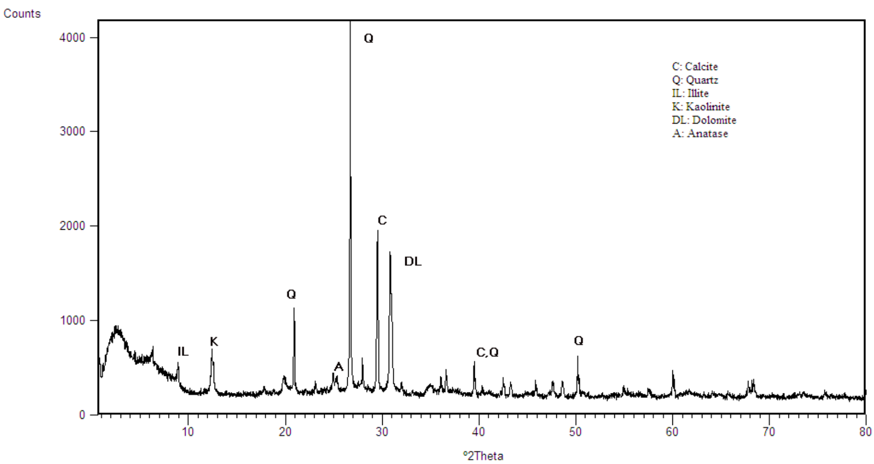

Figure 4: XRD diffractogram of clay brick.

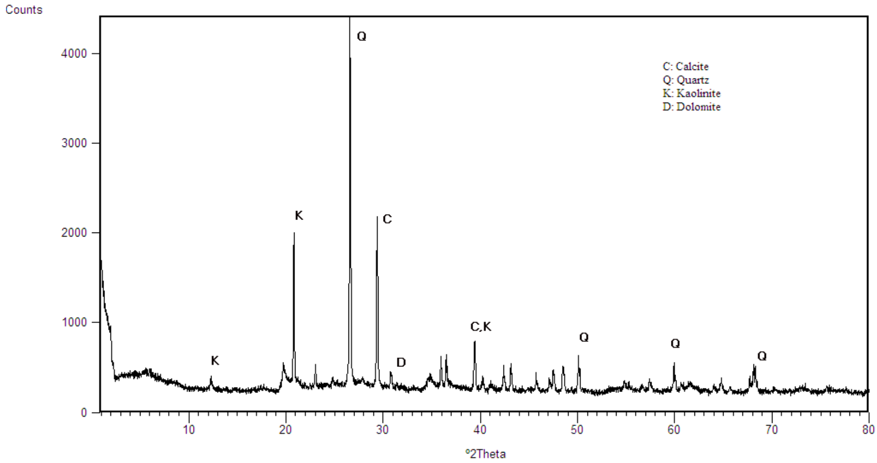

Figure 5: XRD diffractogram of the brick.

2.4 Properties microscopic

Microscopic study revealed the presence of a white product in marine sediments. This product may be due to the high salinity which was detected by the high value of the conductivity which is relatively higher than that of the slurry brick. It is also noted from Figures 6, 7 and 8 that the grains are highly variable in shape and size, they are formed by the agglomeration of grains of smaller sizes (≈ 1 micron).

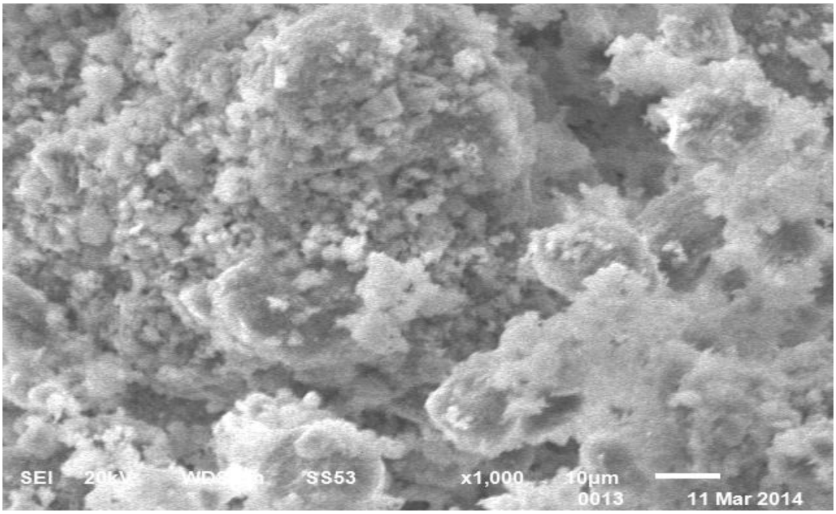

Figure 6: Microscopic analysis of the clay brick.

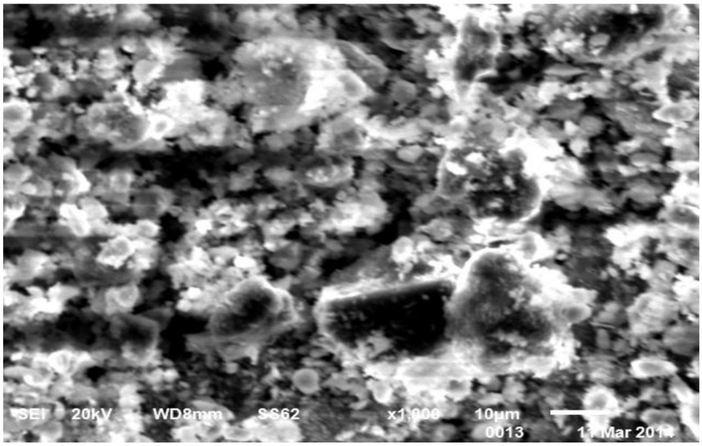

Figure 7: Microscopic analysis of marine sediment.

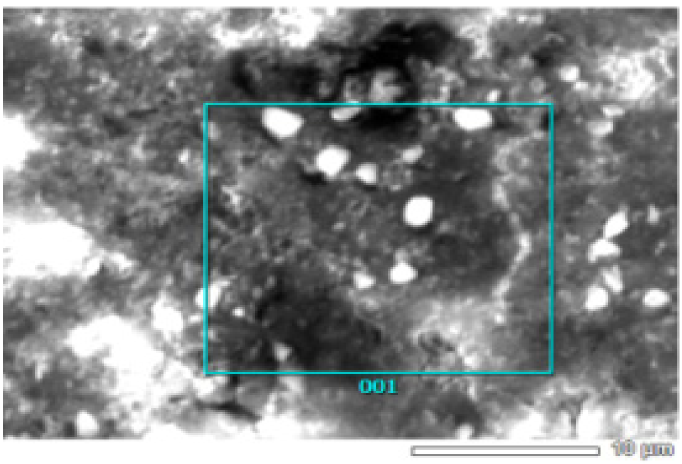

Figure 8: Microscopic analysis of the brick slip.

3 Conclusion

The physical characterization of port dredging sediment from the locality of Bathioua shows that these sediments are valuable materials and may constitute a source of the production of bricks. Chemical characterization of the sediments was used to evaluate their potential for use with the necessary need to mix these marine sediments with clay bricks to increase their plasticity. Bathioua port dredging sediment, however, has a high rate of hydrocarbons due to the nature of the port activity. We particularly noticed the absence of metal pollution.

It appears that these sediments with grain size comparable to that of the brick slip can be attractive economic raw materials for local construction companies, especially brick factories. The mineralogical characterization of marine sediments appears similar to that of the clay used to make bricks. This shows that the recovery of sediment in the brick production industry is a very promising step to be taken to promote local economy.

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