Journal of African Earth Sciences 116 (2016) 213–224

Contents lists available at ScienceDirect

Journal of African Earth Sciences

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

# Assessing surface sediment dynamics along the north-west coast of Marsa Dhouiba (Tunisia, southern Mediterranean)

Nouha Khiari [a], Abdelfattah Atoui [b], Mouldi Brahim [b], Chérif Sammari [b], Abdelkrim Charef [a], Lotfi Aleya [c, *]

[a] Laboratory of Georesources, Technopole of Borj Cedria, 273 Soliman, 8020, Tunisia
[b] Institut National des Sciences et Technologies de la Mer, 2025, Salammbô, Tunisia
[c] Université de Bourgogne Franche-Comté, Laboratoire de Chrono-Environnement, UMR 14, CNRS 6249, Place Leclerc, F-25030, Besançon, Cedex, France

ARTICLE INFO

*Article history:*
Received 11 November 2015
Received in revised form
7 January 2016
Accepted 8 January 2016
Available online 11 January 2016

*Keywords:*
Sediment dynamics
Currents
Swell
Minerals
Northern Tunisia

ABSTRACT

An investigation was conducted from summer 2012 to winter 2013 at 25 stations along the Tunisian coast near Kef Abbed at Marsa Dhouiba (north-east Mediterranean Sea) to analyse grain size, sediment mineralogy and currents. Particle-size analysis shows that sand deposits at shallow depths are characterised by S-shaped curves, indicating a degree of agitation and possible transport by rip currents near the bottom. At greater depths (between 10 and 30 m), the bottom is covered by coarse sand and gravel. A current was observed transporting sediment eastward along the coast; another seaward current was also noted. Generated by wind, swell and especially waves from west to north-west, the two currents transport clay and silt-sized sediment seaward. An Acoustic Doppler Current Profiler showed Marsa Dhouiba's coastal current to follow a direction 175° East, with its main axis running north/north-west parallel to the coast and its minor axis also running north/north-west. Analysis of current components indicates that the velocities *u* and *v* are oriented north to south. Sediment evolution in shallow waters is dependent on detrital inputs from streams and winds. The coarse fraction of surface sediments in Marsa Dhouiba presents 87% of total sediments and is located at depths of 10–30 m. Sediment dynamics in the Marsa Dhouiba region are closely related to the west/north-west swell.



## 1. Introduction

It is well known that both anthropogenic and erosive pressures on coastal areas increase over time. Sandy shoreline areas, which constitute about 34% of global coastlines are complex and dynamic, subjected to numerous physical and sedimentary factors (Nourisson and Scapini, 2015). They suffer from human activities, resulting in an alteration of wave processes and longshore exchanges of sediments (Bourgou, 1993; Paskoff, 1998; Roberge and Long, 2003; Paskoff, 2004; Brahim et al., 2014, 2015). This, in turn, can affect intertidal species development leading to beach ecosystem dysfunctions (Spalding and Jackson, 2001; Nordstrom, 2014), and even leading to regrowth of disease-causing microbes, including harmful bacteria, viruses, nematode larva and eggs, and harmful yeast and fungi (Solo-Gabriele et al., 2015).

The coast of northern Tunisia, which is of ecological interest due to its untouched natural environment, is influenced by a regional western Mediterranean current, the Atlantic Water (AT), which enters the Straits of Sicily to split into two branches: one flowing to the south-eastern Mediterranean and the second, called the Atlantic Tunisian Current (ATC), flowing southwards along the Tunisian coast (Ben Ismail et al., 2012, 2014). Geo-morphologically varied, the area includes rocky shorelines, capes, dunes and beaches located along bays encased by steep cliffs of a diverse nature: carbonated sandstones dating from the Tyrrhenian and upper Pleistocene (Oueslati, 2004). The coast, however, has been altered due to expanding urbanization, ports, seaside resorts, and engineering structures such as dams and dikes which pose a threat by reducing the sediment supply (Helali et al., 2015; Ennouri et al., 2015; Zaaboub et al., 2015). Located within this northern coastal zone (Fig. 1), the pristine Marsa Dhouiba area is characterized by successive rocky outcrops that define sandy bays, naturally fed by sediments transported by the flow of its many streams. The area consists specifically of a bay approximately 3 km across and a beach lying between two capes. Furthermore, some of the beaches along

* Corresponding author.
*E-mail address:* lotfi.aleya@univ-fcomte.fr (L. Aleya).

http://dx.doi.org/10.1016/j.jafrearsci.2016.01.015
1464-343X/

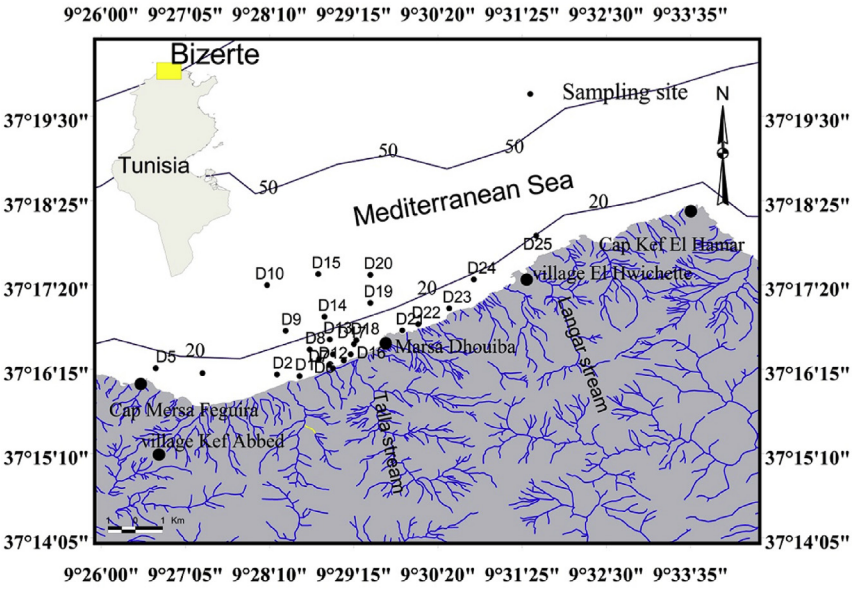


**Fig. 1.** Study area with location of sampling sites of surface sediments.

the Marsa Dhouiba coast consist solely of sand and exhibit a transverse profile, fringed by dunes composed mainly of quartz. Dating from the Eutyrrhenian age, the area is covered by sandstone deposits inherited from pre-historic rivers, and also by consolidated dunes of a yellowish to beige colour, dating from the upper Quaternary (Paskoff and Sanlaville, 1983). It is strategically located and has never before been studied for spatial distribution, composition or size of mineral particles, nor have any investigations been undertaken of the area's currents, winds and wave influence on particle erosion, transport or deposition. Such studies would undoubtedly be of paramount importance, not only regarding the management, sustained development and quality control of the area's beaches, but also in the prospect of the future construction of a nuclear power plant.

The objective of this paper is to clarify, using high spatial resolution, the principal mechanisms driving sediment dynamics through a detailed analysis of hydrodynamics, grain size and mineral composition of surface sediments along the unspoilt beach of Marsa Dhouiba.

## 2. Materials and methods

### 2.1. Study site

The coast of northern Tunisia is generally characterized by rocky areas and sandy bays that collect sediments transported by streams (Fig. 1). As part of the western Mediterranean Alpine chain, the area developed within the geodynamic evolution of the Tethys Ocean. The principal soil types found are: (i) red soils which are derived from are consolidated dunes from the Quaternary, (ii) brown soils leached from bedrock flysch of Oligocene origin (Belkodja et al., 1966) (iii) hydromorphic soils as shown by concretions and (iv) vertisoils which are characterized by clay content and appearing on marl, clays and colluvium (Belkhodja, 1966). The main outcrops in this coastal area date from (i) the Triassic (Crampon, 1971; Ouakad, 2007) (ii) the upper Cretaceous (Jauzien and Rouvier, 1965; Glaçon and Rouvier, 1971) (iii) the Oligo-Miocene (Glaçon and Rouvier, 1967; Rouvier, 1977) (iv) the Jurassic (Alouani et al., 1990) and (v) the Quaternary (Jauzien and Rouvier, 1965; Paskoff and Sanlaville, 1982, 1983). Coastal geology is dominated by alternating sandstones and clays of Numidian flysch (Paskoff and Sanlaville, 1983). Many factors have played a role in coastline's formation: tectonics, hydrology (well-developed river system), hydrodynamics (strong swell action) and bathymetry—highly variable along the coast (Ayari and Afli, 2003; Ayari, 2010)—with a sea bottom landscape of algae and animals, both sessile and motile (Afli et al., 2008 a,b).

The Marsa Dhouiba coast is located between latitude 37°13′30″N and 37°19′00″N and longitude 9°26′00″E and 9°34′00″E (Fig. 1). The ancient marine deposits identified at Cape Negro, Sidi Mechreg and Marsa Dhouiba have been hypothetically attributed to the Tyrrhenian (Morel, 1974).

Fetch lengths in northern Tunisia are as follows: 1) for the north/north-east sector 570 km (5°), 510 km (45°), 600 km (70°), and 2) for the east/north-east sector: 825 km (270°), 570 km (290°), 510 km (310°) and 710 km (335°). According to annual statistics for 2008–2012 (INM, 2008–2012) the dominant wind and waves both come from the north-west sector, generating shoreline currents towards the north-west which provide longshore sediment transport to near-shore environments, an important factor in explaining

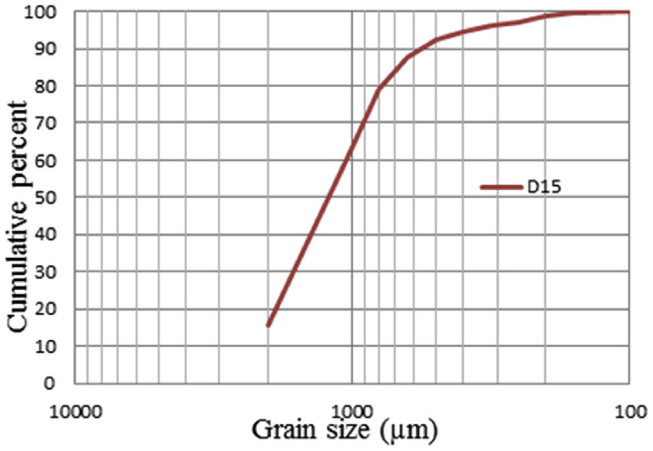


**Fig. 2.** Hyperbolic curve of surface sediments of Marsa Dhouiba (summer 2012).