

Research Article.

Abundance and distribution of microplastics in sand beaches of Bou Ismail Bay (Western Mediterranean)

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ABSTRACT

In order to assess the abundance and distribution of microplastics particles in the sediments of the Chenoua, Palm Beach and Colonel Abbas beaches, a 100 m long transect composed of five (05) stations was sampled at each beach. The samples were divided into two fractions (F1 of 1-5 mm and F2 of 250 μ m - 1 mm). The Microplastics (MPs) particles were identified and quantified by visual reading under an optical microscope, scanning the entire filter and taking into consideration the following criteria: shape, size, color and texture of the particles. However, the level of organic matter (OM) and granulometric analysis were carried out in all the sampling sediments. The results revealed highly abundances of microplastics particles in the sediments of the three beaches. While, the maximum abundance was revealed in the Chenoua beach. Thus, this abundance in MPs is higher in the fraction F2 for the three beaches. It varied between 253 MP/m² and 544 MP/m² in the fraction F1 and between 442 MP/m² and 986 MP/m² in fraction F2.

KEYWORDS

Abundance;
Distribution;
Microplastics;
Sand beaches;
Bou Ismail Bay.

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1 INTRODUCTION

Plastic is one of the world's most widely used synthetic materials in all fields, due to its strength and durability as well as its low cost. Due to the increase in plastic production, the low recycling rate and poor management, large quantities of plastic debris are being released into the environment (Le Juge, 2022), reaching rivers and oceans through a number of direct and indirect factors (Boucher and Friot, 2020).

These plastics also come in a smaller form known as 'microplastics', which are plastic particles smaller than 5 mm. These particles may originally have been manufactured in this size for use in industry, which are primary microplastics (Schäfer, 2015), or they may have resulted from the fragmentation of macroplastics by the action of several environmental factors: physical, chemical and biological (Rafa *et al.*, 2024), which are secondary microplastics, and these PMs, whether primary or secondary, are dispersed in the environment and reach the marine environment via several transport routes: runoff, sewage systems, marine currents and wind, especially for light PMs such as packaging (Kedzierski, 2017).

MPs represent a threat to the marine environment in its various compartments, especially for the biota, because aquatic organisms ingest these MPs by considering them as food particles (Carbery *et al.*, 2018), which will cause physical damage to these organisms such as suffocation and injury (Allsopp *et al.*, 2006), and chemical damage such as changes in behavior, slow metabolism, and disruption of growth and reproduction (Pandey *et al.*, 2022).

In Algeria, the problem of MPs is little studied, which means that the level of pollution by MPs in

the Algerian basin has not yet been determined. Among the studies that have dealt with this problem on the Algerian coast, there are two studies that have been carried out to the west of the Algerian coast, Taïbi *et al.* (2021) studied the distribution of micro and macroplastics in beach sediments on the west coast of Algeria, and Bouchentouf and Ainad Tabet (2013) studied plastic debris in the Gulf of Arzew. There are also four studies that have been carried out to the east of the Algerian coast, two of which are similar to our study, Tata *et al.* (2020) studied microplastics in the sediments of the beaches of Annaba, Grini *et al.* (2022) who studied microplastics in the sediments of the beaches of Skikda, Bencheikh and Chiheb (2021) who studied the pollution by micro-waste in the East coast and Oudina and Agrane (2018) who evaluated the microplastics pollution in the coast of Jijel. In the central region, one study assessed PM in the sediments and surface waters of Zemmouri Bay (Elbachir and Hamza, 2021), and two studies assessed PM in the surface waters of Bou Ismail Bay (Khettab and Lachtar, 2017; Setiti *et al.*, 2021).

The aim of this study is to assess the abundance and distribution of microplastics particles in beach sands of Bou Ismail Bay, which will help to improve existing knowledge of this form of pollution in this coastal area.

2 MATERIALS AND METHODS

2.1 Study area

Our study area corresponds to Bou Ismail Bay, which is located in the central part of the Algerian coastline, extending from the Ras-Acrata promontory in the East to Mount Chenoua in the West over a stretch of coastline of more than 60 km, with a surface area of 509km².

To carry out our study, three sites were chosen: Chenoua beach in the extreme western part of Bou Ismail Bay, Colonel Abbas beach in the middle part, and Palm beach in the eastern part of the bay (Fig. 1).

The beaches were selected according to the conditions of the protocol adopted, which requires a large sandy beach.

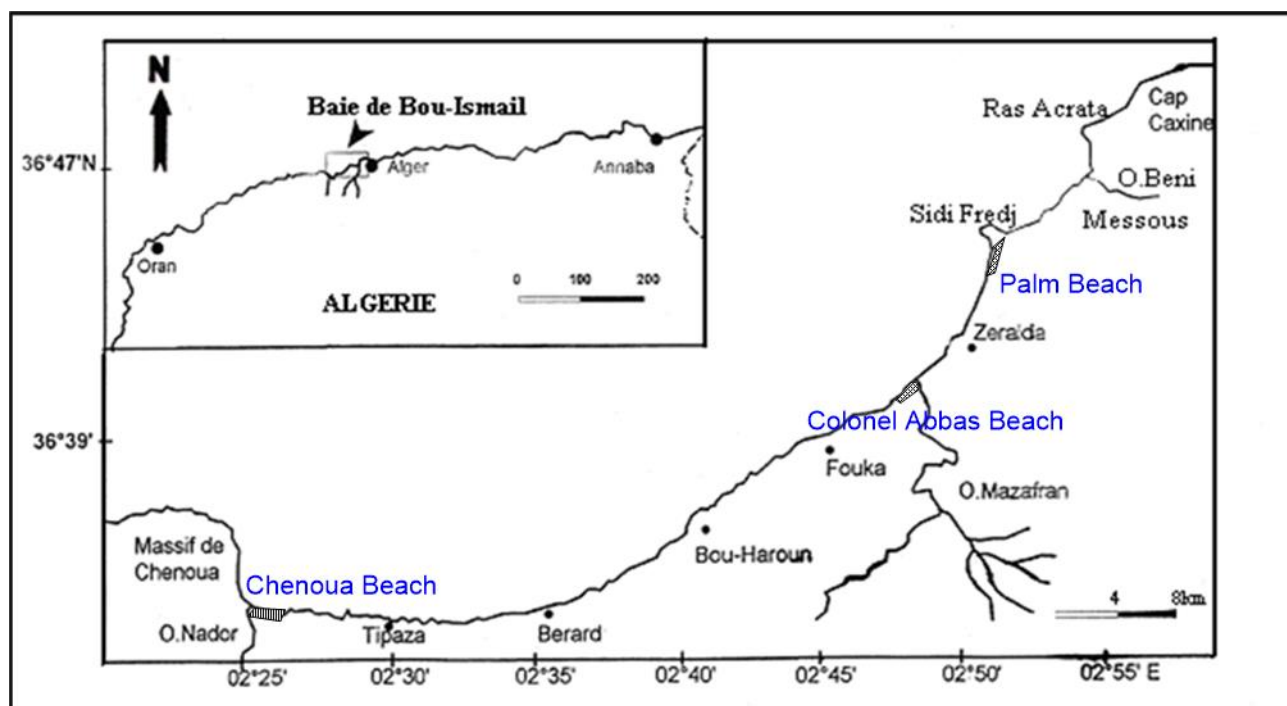


Figure 1. Location of study area and sampling beaches

2.2 Sampling

Sediment samples were taken from the three selected beaches on 18 February 2024, following the steps set out in the protocol (Fig. 2). First mark the area where the sample is to be taken by defining a transect 100 m long parallel to the shore and above the last high tide line, then determine five stations along the length of the transect defined so as to have a distance of 20m between the stations, then place the 50 x 50cm quadra (divided into four 25 x 25cm sections) at

the predetermined station, the section of the quadra from which the sample will be taken must be mentioned.

In the section, we collected the first centimeter of sand measured with a tape measure, using a metal spoon or metal shovel, and stored the sample in a pre-cleaned metal or glass container fitted with a lid and labelled with the code for each sample. Finally, the samples were frozen until analysis.

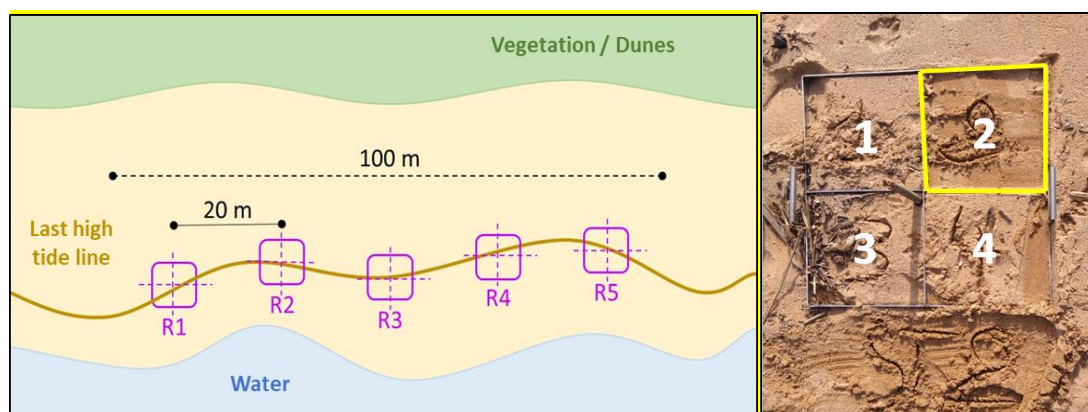


Figure 2. Delimitation of the sampling area (transect) and the sampling points (R1 to R5) at each beach (adapted from OSPAR and Burgess *et al.*, 2014)

2.3 Extraction of microplastics particles

2.3.1 Drying

After thawing the samples completely and weighing them, we dried them in the oven at a temperature $\leq 50\text{ }^{\circ}\text{C}$ until they reached a constant weight. Then, the dry weight of each sample has been recorded.

2.3.2 Sieving

In order to obtain two fractions of each sample, we sieved all the samples separately, through the 250 μm , 1 mm and 5 mm sieves, then we recovered the fractions retained in the 250 μm fraction of (250 μm – 1 mm) and the 1mm fraction of (1 mm – 5 mm) and weighed each fraction, we discarded any material retained on the 5mm sieve and which passed through the 250 μm sieve.

2.3.3 Separation by density

To separate the MPs particles from the sand grains, we carried out a separation by density using the saturated NaCl solution 1.2 g/cm^3 , which we poured into a glass beaker making sure that the solution contained about five times the

volume of the sample, and we added a drop of liquid detergent as a surfactant to prevent the particles to be adhering to the walls of the beaker.

Then, we poured the sand fraction into the beaker, and to complete the separation we covered the beaker with aluminum foil and placed it for 20 to 30 minutes on a magnetic stirring plate, and after stirring we left it to stand overnight to allow settling, after settling we filtered the supernatant through a metal sieve, once the sample had been filtered we rinsed the walls of the flask and metal sieve with distilled water to collect the remaining particles.

2.3.4 Organic matter digestion

To remove the organic matter from our microplastic samples, we used hydrogen peroxide (H_2O_2).

2.3.5 Filtration

The samples have been filtered to recover the MPs particles, with a vacuum filtration ramp and using 1.2 μm glass filters. Then, the filters have been placed in aluminum containers and dried in the oven at 40 $^{\circ}\text{C}$, after, they have been kept at

room temperature until microscope visualization.

2.4 Identification of MPs particles

MPs particles were identified and quantified by visual reading under an optical microscope, scanning the entire filter and taking into consideration the following criteria: shape, size, color and texture of the particles.

2.5 Microplastics particles abundance

Following the protocol, we expressed the results of the visual reading under the microscope as the abundance of PMs per m² and per kg of dry sediment, by applying the following equations

$$\text{MP abundance (MP/m}^2\text{)} = \frac{\text{Total microplastics in the filter}}{\text{Surface area of sample analyzed}} \quad (\text{Eq 1})$$

With Surface area of sample analyzed = 0.0625m²

$$\text{MP abundance (MP/kg)} = \frac{\text{total microplastics in the filter}}{\text{Dry weight of sample (kg)}} \quad (\text{Eq 2})$$

2.6 Organic matter analysis

We analyzed this parameter in our sand samples to check if there was a link between the level of organic matter and the abundance of MPs. Therefore, the loss on ignition method (Rodier, 1996) was applied. The principle of this method is based on the incineration of dried sediment sample in a muffle furnace at 500 °C for 2 hours in order to burn off all the organic matter. The samples are weighed before and after incineration and the difference in weight between P1 and P2 represents the organic matter content of the sample.

2.7 Granulometric analysis

The granulometric analysis were performed for the sands from the three beaches to determine the type of sand from each beach and to check if

the MPs have a preference for a specific particle size.

To prepare our samples for analysis, we dried a homogeneous weight of sediments from the five stations for the three beaches in an oven, then we mechanically sieved them on a vibrating table using a series of five sieves (maximum limit of the sieve shaker) with diameters of 4 mm, 2 mm, 1 mm, 315 µm and 125 µm.

3 RESULTS AND DISCUSSION

3.1 Distribution of MPs by station

The number of MPs in the three beaches (Fig. 3) shows that the most contaminated beach in terms of MPs is Chenoua beach, which has a high number of particles in all its stations, with the highest value being 168 particles at station CH4 and the lowest value being 18 particles at station CH2, After the Chenoua beach comes the Colonel Abbas beach where the highest value is 156 particles which were marked in the station CAB4 and the lowest value is 14 particles which were marked in the station CAB1, and the last beach which is the least contaminated in MPs is the Palm Beach, because the highest value of the MPs in this beach is 68 particles which were marked in the station PB3 while the lowest value is 33 particles which were marked in the station PB1. Concerning the distribution of the MPs in the stations of the three beaches, we noticed that the beach of Chenoua and the beach of Colonel Abbas have a heterogeneous and not equal distribution on the whole of their stations, whereas the beach of Palm Beach to go up a distribution which is more or less homogeneous of the MPs in the whole of its stations.

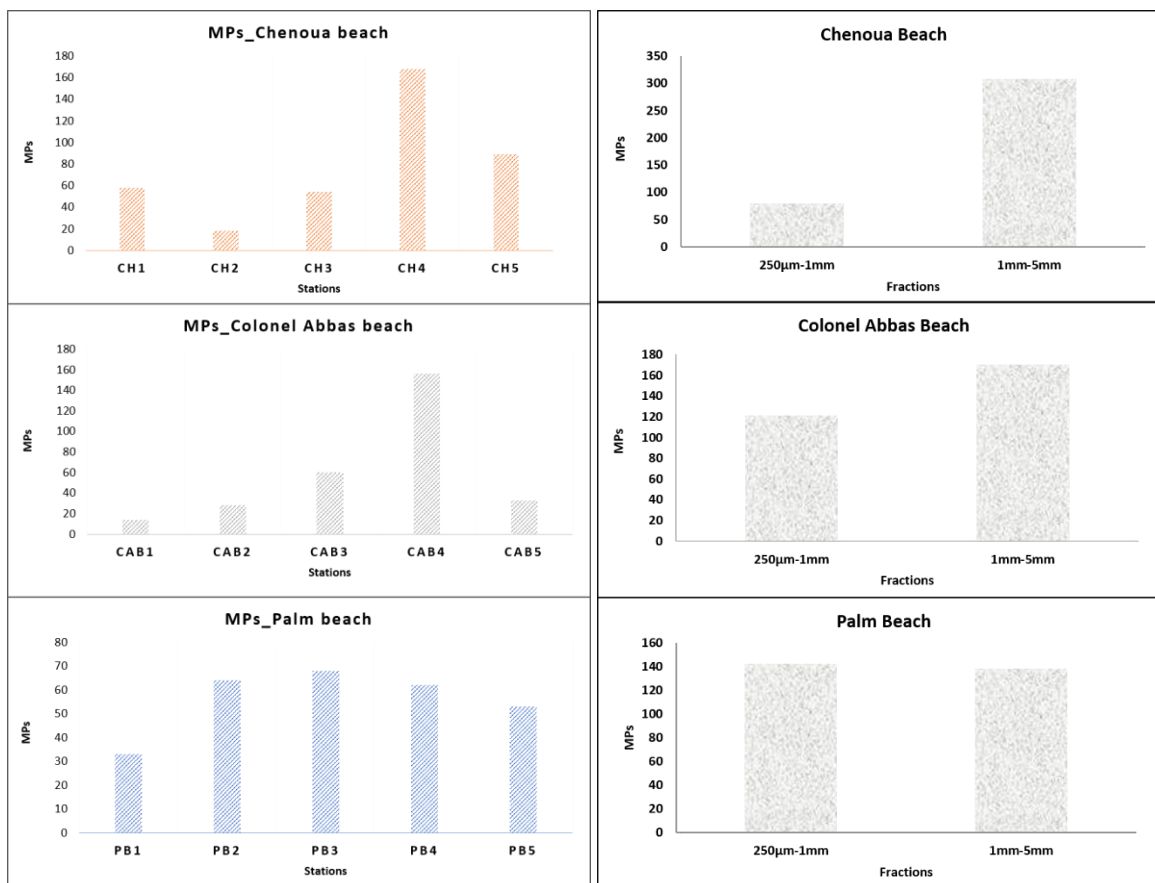


Figure 3. Spatial variation of MPs particles in Chenoua beach, Colonel Abbas beach, and Palm Beach stations

Figure 4. Distribution of MPs identified in the two fractions in Chenoua beach, Colonel Abbas beach, and Palm Beach stations

3.2 Distribution of MPs by fraction

The distribution by fraction (Fig. 4) of the MPs in the three beaches allowed us to notice that there is a very large difference in the contribution of the two fractions (250 µm - 1 mm) and (1 mm - 5 mm) in the total number of MPs in the three beaches, in the Chenoua beach we noticed that the number of MPs in the fraction (1 mm - 5 mm) is four (4) times more than that in the fraction (250 µm - 1 mm) which means that the great majority of MPs in the sediments of the Chenoua beach are concentrated in the fraction (1 mm - 5 mm), for the Colonel Abbas beach we noticed that the number of MPs in the fraction (1 mm - 5 mm) exceeds that in the fraction (250 µm - 1 mm)

which means that the MPs in the Colonel Abbas beach are more concentrated in the fraction (1 mm - 5 mm), as for the Palm Beach we noticed that the numbers of MPs of the two fractions (250 µm - 1 mm) and (1 mm - 5 mm) are almost similar which means that the contribution of the two fractions in the number of MPs of the Palm Beach is the same.

3.3 Distribution of MPs by type

The visual reading under the microscope made it possible to identify different types of MPs in the three beaches where we noted that the Chenoua Beach is the most diversified in terms of types of MPs where we identified nine (9) types of MPs with different proportions where polystyrene

constitutes more than half with a proportion of 54%, followed by 15% of fibers, 12% of fragments, 5% of pellets, 4% of sponges and rubber, 2% of films, straws, and unidentified particles, Then Palm Beach, where we identified eight (8) types of MPs, with fibers making up the largest proportion (64%), followed by 17% fragments, 11% films, 6% pellets, 1% polystyrene and unidentified particles, and almost no straw

and sponge, and finally the Colonel Abbas Beach, which is the least diversified in terms of types of MPs, where we have identified five (5) types of MPs, the proportions of which are different: fibers make up almost half with a proportion of 49%, followed by 26% of pellets, 15% of fragments, 8% of films and 2% of polystyrene (Fig. 5).

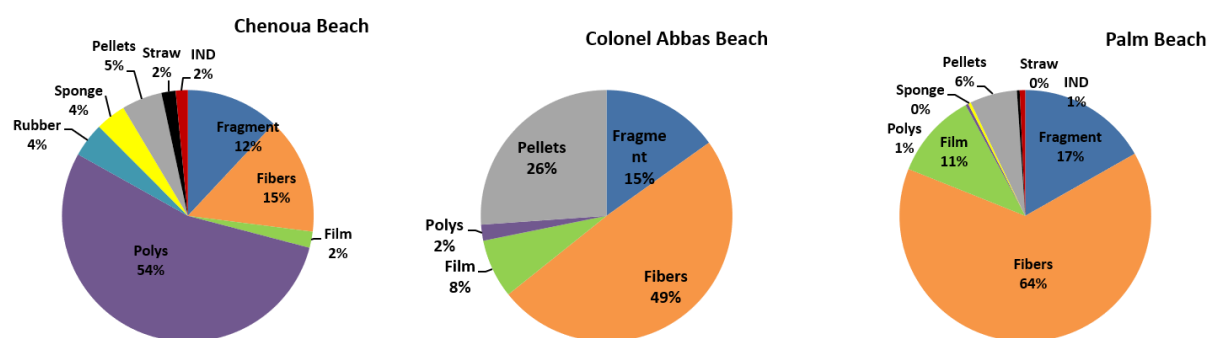


Figure 5. Distribution of MPs by type in Chenoua Beach, Colonel Abbas Beach, and Palm Beach stations

Table 1. MPs abundances (MPs/kg and MPs/m²) in the two sand fractions and in the whole samples of each Beach

Beach	250 µm – 1 mm		1 mm – 5 mm		Total	
	MPs/m ²	MPs/kg	MPs/m ²	MPs/kg	MPs/m ²	MPs/kg
Chenoua	253	316	986	1232	1239	1548
Colonel Abbas	388	484	544	680	932	1164
Palm Beach	455	568	442	552	897	1120

Table 2. Comparison between the abundances of MPs (MPs/kg and MPs/m²) obtained in this study and other studies in the Mediterranean Sea

Location	Site	MPs/m ²	MPs/kg	Reference
Algeria (Tipaza)	Chenoua	1239	1548	Present study
	Colonel Abbas	932	1164	
	Palm Beach	897	1120	
Italia	Lido di Danté	-	1512	Lots <i>et al.</i> (2017)
Turkey	Dikili	-	248	Lots <i>et al.</i> (2017)
Malta	-	1462	-	Karthik <i>et al.</i> (2018)
Algeria (Skikda)	Guerbes	1889	188	Grini <i>et al.</i> (2022)
	Kef Fatma	14337	1433	

3.4 Abundance

Calculation of the abundance of MPs per unit mass and per unit area in the two fractions and in

the sediment as a whole revealed the following results (Table 1).

3.5 Comparison

The abundances of MPs particles identified in the sediments of the three beaches (present study) show a relative similarity with other abundances reported for other areas of the Mediterranean Sea (Table 2).

3.6 Organic matter rate

The results of the analysis of organic matter in the sediments of the stations on the three beaches show that the levels of organic matter determined in the surface sediments of Chenoua Beach and Colonel Abbas Beach are similar, with the same mean and standard deviation values. However, the levels of OM are higher at stations PB4 and PB5 on Palm Beach.

3.7 Granulometric parameters distribution

The results of the granulometric analysis of the sediments from the three beaches show that the Chenoua, Colonel Abbas and Palm Beach are all characterized by the same type of sediment, which is fine sand.

4 CONCLUSIONS

In the present study, different concentrations of MPs were found on the three beaches, with Chenoua Beach reaching a concentration of 1239 MPs/m² or 1548 MPs/kg, Colonel Abbas Beach reaching a concentration of 932 MPs/m² or 1164 MPs/kg, and Palm Beach reaching a concentration of 897 MPs/m² or 1120 MPs/kg. Chenoua Beach has a much higher level of microplastic pollution than Colonel Abbas and Palm Beach, which is the least polluted Beach in terms of abundance of MPs.

This study has produced some very interesting results, as it is the first to assess microplastic pollution in beach sediments in Bou Ismail Bay. It would be a good idea to complete this study by

identifying all the plastic polymers identified in all the stations. A database of the spectra of the various plastic polymers is therefore recommended to make it easier to identify the polymers and determine the chemical composition of the microplastics.

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