A PRELIMINARY STUDY ON MACRO-LITTER POLLUTION ON BEACHES ALONG AÏN EL TURK BAY (WESTERN MEDITERRANEAN)

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Abstract. Marine anthropogenic litter is one of the most important environmental problems that affect directly and indirectly all marine ecosystems. A lot of efforts are made to reduce the litter pollution in oceans, and, in this way, to reduce their negative effects on the marine biota. This study provides information about the quantities of marine litter found on 10 beaches situated along the occidental coast of Algeria. A total of 14537 items were collected throughout Aïn El Turk beaches. From this litter, 93% were plastics and the remaining 7% were represented by rubber, glass and metal. The results highlight a heterogeneous distribution along the coastal beaches, with higher concentrations at some beaches rather than others, as well as the west coast, which seems more affected compared to the east coast. We notify that the litter has the tendency to accumulate in the upper levels of the beach, which confirms that these beaches are exposed to litter from land-based sources rather than from maritime activities.

Key words: Pollution, Macro-litter, Coastline, Beaches, Oran Bay

1. INTRODUCTION

Marine litter is a human-created waste, transported by wind and rivers into the sea and on beaches. It is defined as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment" (UNEP/PAM/MEDPOL, 2009). The problem of plastic waste first appeared in the 1950s, when massive production of plastic began, and then it became one of the most significant global environmental problems. Plastics are a major component of this waste dumped in the environment; it becomes the dominant category of litter present especially in the marine environment. Plastic debris has been detected in all major marine environments worldwide, from shorelines and surface water to the deepest parts of the ocean, even at the bottom of the Mariana Trench (WWF, 2018). The UNEP/WHO/IAEA (1988) report estimates that only 15% of the waste is floating on the surface of the sea, 15% is hovering in the water column, and 70% is on the sea bottom. Since 2000, the world has produced as much plastic as all the preceding years combined (WWF, 2019). Beaches are subject to several threats both from land and from the sea, the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP, 2019) estimating that land sources account for up to 80% of world sea pollution, of which 60% to 95% is plastic waste (Kurtela & Antolović, 2019). Fishing activities (Tschernij & Larsson, 2003), marine traffic (Mato *et al*., 2001; Moore, 2008) and recreational coastal activities (Gregory, 1996; Bravo *et al*., 2009) are also important sources of coastal and marine litter.

The versatility of plastic materials has resulted in a substantial increase in their use. The global production of plastics has increased from 5 million tons/year (1950s) to nearly 300 million tons/year in 2013 (Andrady & Neal, 2009; Lechner *et al*., 2014). Geyer *et al*. (2017) estimated that, until 2015, 8300 million metric tons (Mt) of virgin plastics have been produced and 6300 Mt of plastic waste have been generated, 9% of which had been recycled, 12% was incinerated, and 79% was accumulated in landfills or natural environments. In 2016, the global average production was 335 million tons, from them between 33% and 50% was designed to be non-reusable (Crawford & Quinn, 2017; Alimba & Faggio, 2019). These plastic materials can be found into a vast range of products that bring numerous societal benefits, especially in healthcare, agriculture, transport, construction and packaging (Plastics Europe, 2016). About 50% of these materials is in the form of such products as plastic bags, drinking bottles, cutlery, straws, ear sticks etc., which are discarded after a single use (Nerland *et al*., 2014). In 2002, 58% of the debris collected in the International Coastal Cleanup was attributed to shoreline and recreational activities (Allsopp *et al*., 2006). Work in the Northern area of the South China Sea also found that most floating and beached plastic debris originated from coastal recreational activities and land-based sources (Lee *et al*., 2013).

Macroplastics typically refer to items larger than 20 mm (Arthur *et al.*, 2009). Depending on the size, plastic litter is classified generally as nanoplastic (<1 µm), microplastic (1 µm - 5 mm), and macroplastic (>5 mm) (SAPEA, 2019), while other studies describe debris > 5 cm as macroplastics (Van Emmerik *et al*., 2018). Due to the high visibility of plastic material and its contamination in the environment, the macroplastics may be perceived as one of the most disturbing forms of plastic pollution, as well as micro and nanoplastics (Thompson & Napper, 2019)

Most studies on marine plastic debris have focused on its occurrence in coastal waters and open ocean areas. Researching macro-debris on beaches uses different approaches (Hidalgo-Ruz & Thiel, 2015), and relevant studies typically range from a local (Lee *et al*., 2013) to a regional scale (Bravo *et al*., 2009) covering a broad temporal range. Research by Barnes *et al*. (2010) found that macroplastics have spread to uninhabited areas, such as Antarctica, where they found a plastic cup and two fishing buoys in the Dumont d'Urville and Davis seas, as well as two pieces of plastic packaging and a fishing buoy in the Amundsen Sea.

Pollution produced by macroplastics has become a problem of global concern, so due to the importance that the government program gives to touristic development, the control of this problem becomes essential to manage and conserve these spaces. If tourism is one of the sectors that suffer from this pollution, it is, on the other hand, one of the main incriminated factors.

To increase awareness of this pollution and obtain new scientific information at a national level, the paper presents a characterization of the pollution by macroplastics on the beaches of western Algeria. The aim of the present study was to determine the composition and spatial distribution of plastics on the beach; there were investigated regional distribution, composition, and abundance of plastic items in order to improve marine governance, awareness and ecosystem health.

2. MATERIAL AND METHODS

The current study was performed on the shores of Aïn El Turk Bay, which is located about fifteen kilometers west of the wilaya of Oran (Fig. 1). It is a highly coveted area by summer visitors who come to enjoy its extraordinary natural landscapes. The Bay of Aïn El Turk opens to a length of about 8 km, between Cap Falcon in the north-west and the tip of Saint Roch in the south-east. The contact between sea and land is ensured by a discontinuous line of shallow sandy beaches covering a rocky substratum, at the foot of a modest slope, which does not rise above 15 m. These slopes form the edge of a large sand-limestone shell-shaped frame, to some extent encrusted, covering a plateau that extends south to the schist formations on the northern slope of Murdjadjo Mountain. The submarine topography slopes quite steadily down to the isobath of -50 m. The continental shelf then plunges into the abyss, which carves out an important underwater valley (Ghodbani, 2009; Ghodbani & Semmoud, 2010).

The data analyzed in this study were collected on ten (10) beaches of Aïn El Turk Bay in the western region of the Algerian coastline (Fig.1). To identify the characteristic distributions of litter accumulated on the selected beaches, the identification, the description and the counting were carried out *in situ*, manually, following European methodology (Cheshire *et al*., 2009; Hanke *et al*., 2013) for the assessment of marine litter. All ten beaches were sampled on a single occasion, between March and April 2019. For each beach, a fixed section was delimited, covering the whole area between the water line to the beach backshore over a length of 100 m. Sampling was always performed at low tide, recording all macro-litter items (>5 cm). This procedure was repeated until the sea line was reached, and the entire sampling area was covered.

3. RESULTS AND DISCUSSION

In this study, ten (10) beaches were selected according to substratum similarity and exposition to the same marine currents: a total of 14537 items were collected and the number of recorded items varied between 245 in Claire Fontaine to a maximum of 3472 in La Madrague beaches (Fig. 3). It seems that beach litter mainly originates from

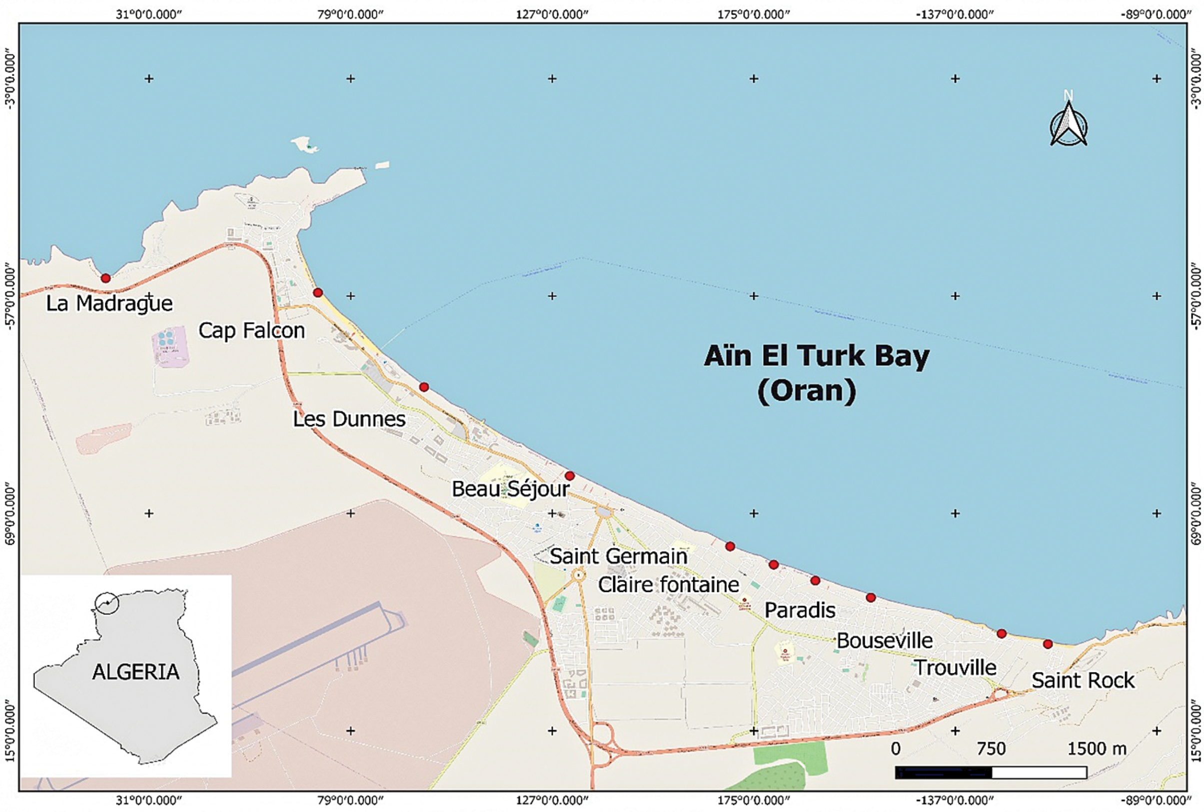

Fig. 1. Location of study sites.

Fig. 2. Litter pollution.

anthropic sources, tourism and river inflow. The results are presented in a global way by comparing all the sampled sites with each other, regarding the concentrations of macro-litter as number, then according to the categories of plastics found.

Four beaches presented very low densities (≤0.05 items/m^2): Trouville, Bouisseville, Paradis and Claire Fontaine. The beaches presenting highest density of litter (> 1 item/m^2) were Saint Roch, Saint Germain, Beau Séjour, Les Dunes, Cap Falcon and La Madrague.

Plastic is the dominant component found on the beaches (Table 1). In the studied area, it was observed that plastics represent 93% of all beached litter items found, this being confirmed by a project carried out by the European Regional Development Fund in 2016-2018 and published in January 2021. Within these plastics, the most prevalent litter type found was food wrappers, followed by plastic bags. Three types of polymers have been identified as those commonly used in the plastic items: polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET).

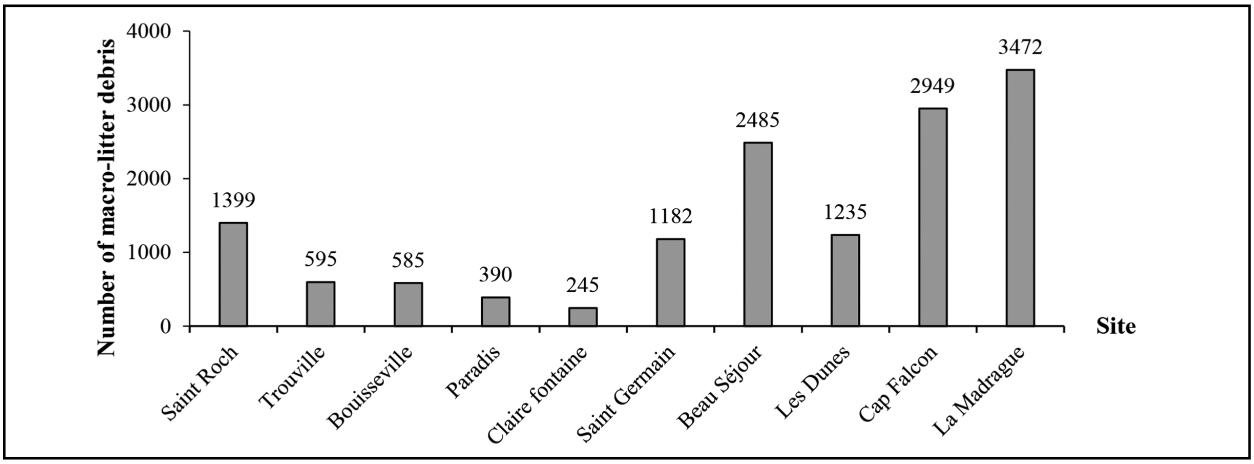

Fig. 3. Concentration of macro debris in number per beach.

Table 1. Most common macro-litter collected from the beaches.

Items	Count	Frequency (%)	Plastic type usually used in the items
Plastic beverage bottles	880	6.08	Polyethylene terephthalate (PET)
Food wrappers	8893	61.48	Polyethylene (PE), Polypropylene (PP)
Plastic bags	3809	26.33	Polyethylene (PE)
Other	884	6.11	-

Litter densities are related to the closeness of urban centers, and the beach characteristics, such as the slope, vegetation and the type of shore (Table 2). On the studied beaches, the abundance of plastic litter was found positively correlated with the type of shore. Some sedimentary types are considered being more prone to marine litter then others, as observed on Cape Falcon and La Madrague beaches, which have a rocky nature in their composition.

Three beaches presented the highest densities (> 1 item/m^2): La Madrague, Cap Falcon and Saint Germain (Fig. 4). The first two sites are rocky in nature, which has allowed the installation of many illegal constructions that discharge debris in the form of domestic waste. The surfaces of the beach of Beau Séjour and that of the Dunes are very close, however, the Dunes beach is far from being as polluted as it is Beau Séjour beach; the reason is the urbanization of Beau Séjour which is more important than that of the Dunes. The beaches presenting low densities (< 0.5 items/m^2) are: Trouville, Bouisseville, Paradis and Claire Fontaine.

Table 2. Variation of plastics beach densities depending on the type of shore.

Site	Plastics (%)	Size (cm)	Type of shore
Saint Roch	60	> 5	sandy
Trouville	60	> 5	sandy
Bouisseville	53	> 5	sandy
Paradis	55	> 5	sandy
Claire Fontaine	41	> 5	sandy
Saint Germain	56	> 5	sandy, boulders
Beau Séjour	57	> 5	sandy
Les Dunes	57	> 15	sandy, boulders
Cape Falcon	64	> 10	boulders, cliffs
La Madrague	63	> 10	pebbles, boulders, cliffs

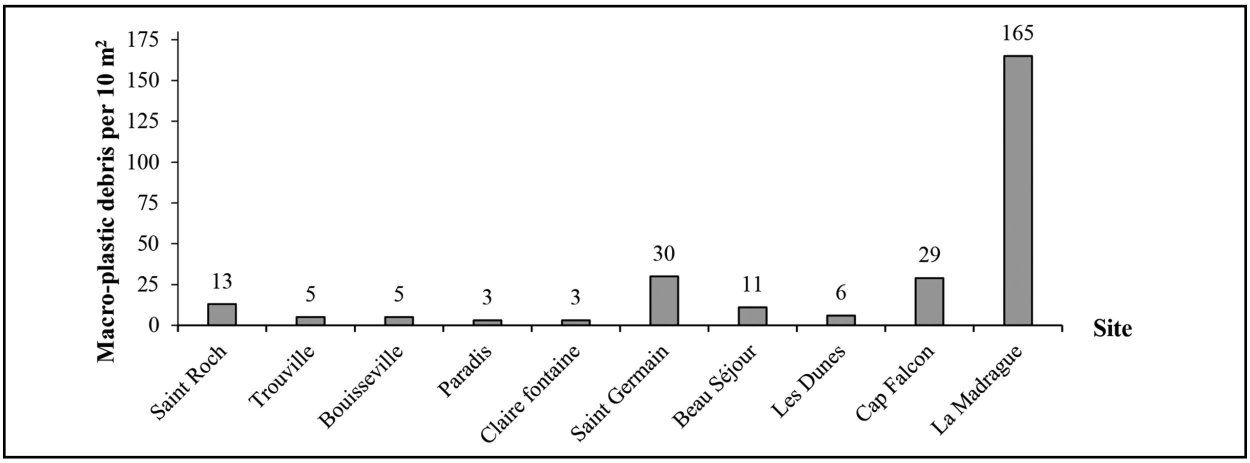

Fig. 4. Concentration of macro-litter in number per 10 m^2 of beach.

For a better representativeness, the results were brought back to the same scale of comparison and presented in Figure 4, which highlights the concentrations of macro-litter per 10 m^2 of surface. The concentrations vary from 3 items in Paradis and Claire Fontaine to 165 at La Madrague. The plastic waste collected on La Madrague beach showed a significantly higher average over an area equivalent to the remaining beaches. Saint Germain and Cap Falcon beaches follow with, respectively, 30 and 29 macro debris per 10 m^2. Saint Roch and Beau Séjour showed similar concentrations with, respectively, 12 and 11 macro debris on the same surface. The significant pollution recorded at La Madrague can be attributed to the presence on the site of an open landfill where the inhabitants of the area dump their domestic waste.

At the various sites, among all the debris collected (macro debris), it should be noted that plastic debris made up nearly 90% of the total number, the other types of macro debris consisted mainly of rubber, glass and metal. The general composition of macro-litter showed the preponderance of food packaging, which was always the most represented category (61%) (Fig. 5).

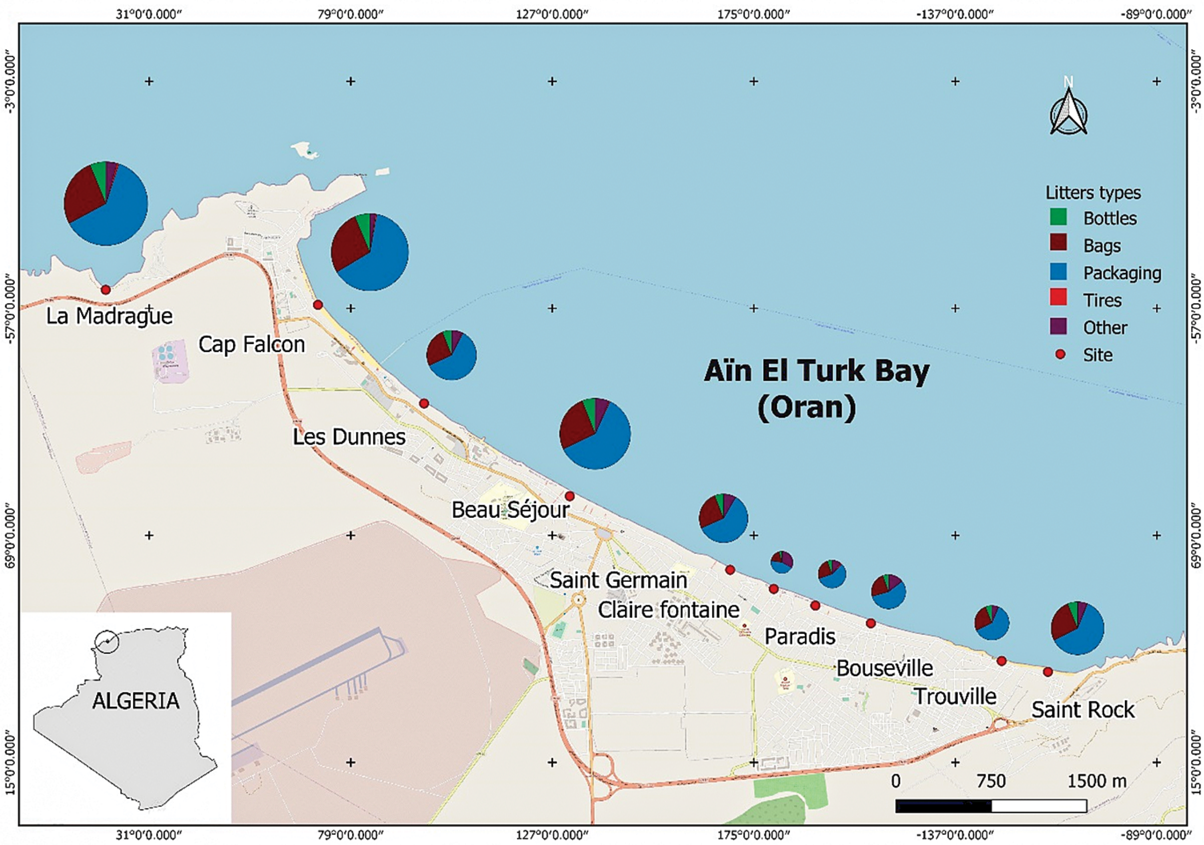

Fig. 5. Types of litters collected.

This food packaging litter comes from the waste rejected mainly by the inhabitants of the area, where plastic bags and bottles reached 33%. Considering the other categories, such as containers, care products, baits, lollipop sticks and straws, they reached the proportion of 6%. What was noted during this study is that these beaches are exposed to litter coming from land rather than from maritime activities, and this is due to the rapid urbanization that this area is experiencing, which causes a great damage.

4. CONCLUSIONS

According to the Bouroumi 2014 Report, Aïn el Turk is a city that is already 90% urbanized. Uncontrolled and unsuitable urbanization of the Oran corniche has negatively transformed the formerly popular, natural space. In Algeria, even though coastal areas are regulated by coastal law (02-02) of February 5th, 2002, urban planning and regional planning law (90-29) of December 1st, 1990 and state law (91-454) of November 23rd, 1991, unfortunately, they did not prevent from suffering a lot of damage. The concentration of population in coastal areas is one of the direct consequences of the establishment of industrial zones in this sector, and the direct cause of the pollution by macroplastics.

During the investigations, intra-site spatial variations were observed, and a tendency for litter accumulation in the upper levels of the beach was noted, in accordance with the results of other studies carried out notably in Australia (Plastics Europe, 2015), and in the Gulf of Oman (Cleareboudt, 2004). This would therefore imply pollution mainly of land origin, caused by beach users whose activities are concentrated in the upper parts of the beaches. There were also noticed a heterogeneous distribution along the coastal beaches with a high concentration at La Madrague; these differences are due to tourist activities and to the density of the population.

The west shore of the coast has a proven dominance in the concentration of plastic debris compared to the east coast, and this is due to the high density of its population and to the path of marine currents caused by winds, without forgetting the shape of the bay of Aïn El Turk, which influences the dispersion of plastic debris. The current caused by the westerly wind is blocked by l'Aiguille off Oran Cape, which turns it into an easterly current and the water carries a considerable quantity of debris towards the beaches of Aïn El Turk.

This study constitutes a preliminary work that can serve as a premise for a more in-depth study concerning a larger number of beaches in Algeria. However, this study has the merit of demonstrating the urgency of the situation regarding the pollution of western beaches. This pollution could, in the short term, destroy biodiversity, but also affect the tourist activity of the region, with tourists who could turn away from those beaches in favor of other destinations. Therefore, awareness-raising campaigns should be carried out, to reach the citizens.

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