

Abundance of Plastic Debris in Intertidal Surface Sediments from Arzew Gulf (Western Algeria)

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Abstract The accumulation of large and small plastic debris is a problem throughout the world's seas and coastlines. Arzew gulf is an important southern West Mediterranean coast receiving discharges from many sources. Abundance and sizes of plastic debris in ten stations from intertidal sediments have been reported in this study. The results of the present study shows high plastic fragments accumulation in sediments up to 13.9 % and mostly debris were in size between 0.5 cm and 01 cm. The abundance of plastic debris could be associated with coastal urban centers and their anthropogenic activities (waste rejection). The high presence found can be explained too by the transport of plastic debris via the surface water circulation. This first quantitative and physical study contributes to the enrichment of data on plastic debris pollution and underscores further researches on ecological aspects of this pollution.

Keywords: plastic debris, coastal pollution, intertidal sediments, Arzew gulf, beach pollution, marine environment

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1. Introduction

Anthropogenic debris is accumulating in marine ecosystems throughout the world. It is found at the sea surface, on sandy beaches, and in the deep sea. Between 60 and 80% of marine anthropogenic debris is composed of plastic items. The small size fraction of plastic debris is generated by gradual fragmentation of larger objects, mainly by the action of intense solar radiation. There is also a considerable contribution of small plastic debris from primary sources, such as industrial pellets and tiny plastic pieces used in cosmetics. Small plastic debris can be ingested by invertebrates, such as worms, barnacles and mussels, as well as large vertebrates, such as fishes, birds and mammals. Plastic debris also represents known sources of persistent organic pollutants (POPs) that can be potentially transported and bioaccumulated in marine

organisms. Also, plastic fragments on sandy beaches cause changes in the permeability and heat transfer between sediment grains, which could affect beach organisms. Plastic debris can be transported over long distances from the sites of origin and it accumulates via ocean currents in oceanic gyres [1]. Plastic debris can have deleterious effects on marine organisms. Plastics release phthalates by exposure to sunlight and direct leaching, which may disrupt the endocrine system of mammals. The particles themselves can cause harm or death to seabirds and large marine fauna from ingestion or entanglement, and may affect lower trophic levels as well. They provide substrate for the transport of sessile organisms and are potent carriers of persistent organic pollutants due to their hydrophobic, lipophilic nature. Figure 1 shows interaction between marine organisms and plastic debris until affecting human health possibility via chain food [2].

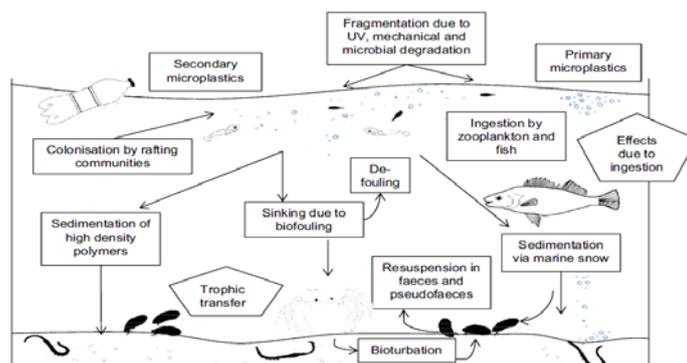


Figure 1. Potential pathways for the transport of plastics and its biological interactions [3]

Table 1. Toxic compounds in or associated with plastics: their uses and effects [4]

Toxic Compound	Use	Effect(s)	Plastic Type(s)	Concentration
Bisphenol A (BPA)	Plasticizer, can liner	Mimics estrogen	PVC, PC	43–483 mg/kg in PVC food wrappers
Phthalates	Plasticizer, artificial fragrances	Interferes with testosterone, sperm motility	PS, PVC	0.5–30.8 mg/kg in food wrappers
Persistent organic pollutants (POPs)	Pesticides, flame retardants, etc.	Possible enological and reproductive damage	All plastics	
Dioxins	Produced in manufacture of PVC, during waste incineration	Carcinogen, interferes with testosterone	All plastics	
Nonylphenol	Antistatic, antifog, surfactant (in detergents)	Mimics estrogen	PVC	10–3300 µg/g
Polyaromatic hydrocarbons (PAHs)	Produced when fossil fuels are burned	Developmental and reproductive toxicity	All plastics	
Polychlorinated biphenyls (PCBs)	Electronics manufacture	Interferes with thyroid function	All plastics	
Styrene monomer	Structure of polystyrene	Forms DNA adducts	PS	<0.001–0.071 mg/kg

Plastic debris can have deleterious effects on marine organisms. The toxic chemicals added to make plastics more flexible, known as plasticizers, can leach into the environment and into organism that ingest plastic. Other dangerous chemicals can concentrate on plastic surfaces increasing the toxicity of plastic (Table 1).

The longevity of plastics is a matter of some debate and estimates range from hundreds to thousands of years. It is considered that (with the exception of materials that have been incinerated) all the conventional plastic that has ever been introduced into the environment still remains to date unmineralized either as whole items or as fragments. However, since we have only been mass-producing conventional plastics for around 60 years, it is too early to say exactly how long these materials will persist. Despite the durability of these polymers, plastic items are fragmenting in the environment as a consequence of prolonged exposure to UV light and physical abrasion. This is particularly evident on shorelines where photo-degradation and abrasion through wave action make plastic items brittle, increasing their fragmentation [5].

Plastic debris is a matter of particular classification according to their size. The term ‘micro-plastics’ and ‘micro-litter’ has been defined differently by various researchers. Micro-litter was defined as the barely visible particles that pass through a 500 µm sieve but retained by a 67 µm sieve (~ 0.06–0.5 mm in diameter) while particles larger than this were called meso-litter. Others including a recent workshop on the topic defined the micro-particles as being in the size range <5 mm (recognizing 333 µm as a practical lower limit when neuston nets are used for sampling.) Particles of plastics that have dimensions ranging from a few µm to 500µm (5 mm) are commonly present in sea water. For clarity, this size range alone is referred to as ‘micro-plastics’ here; the larger particles such as virgin resin pellets are referred to as ‘meso-plastics’ [6].

The accumulation of both macro- and micro-plastics has consistently increased on shores and in sediments for the last four decades [5]. The widespread occurrence of

micro-plastics in various marine and freshwater habitats worldwide is at present well documented, and has mainly been investigated in sandy beaches and coastal/transitional sediments. Despite isolated regional surveys regarding mainly sandy beaches, estuarine and sub-tidal habitats, and marine sediments all over the world, data on the distribution and dispersion of micro-plastics in the Mediterranean are almost completely lacking. The only available study, reporting abundance values for micro-plastic particles floating in the water column, was recently carried out in the Tyrrhenian [7]. The need for more knowledge becomes necessary.

Arzew gulf is the most important North African industrial area [8], characterized by points of waste released from bigger Western Algerian towns as *Oran* and *Mostaganem*. The gulf is housing a long sandy beaches coveted by mass tourisms in summer period. In this study, intertidal surface sediment pollution by plastic debris has been inspected in order to illustrate contamination kind and drive further investigations.

2. Description of the Study Area

The Arzew gulf (Figure 2) is one of the major units of the continental Algerian West shelf. It is between the Arzew massif (Carbon cape, 0° 20'W) at the West and the Cheliff Delta at the East (Ivi cape, 0° 20'W), which gives a longitudinal development on about 50 km. Two rivers of very unequal importance feed the gulf, the middle Cheliff at East and the minor Macta at the West. Figure 3 shows, also, the sedimentary map of the concerned area, which is characterized by the following aspects:

- The calcareous sediments clearly presented by calcareous-clay vases, cover a large area of the gulf.
- Sludge siliceous-clay at continental sides, lining the gulf with a large mudflat.
- An alternance with terrigenous sand and sediment mixed or purely organogenic on the coastal fringe from Carbon cape to *Mostaganem*.

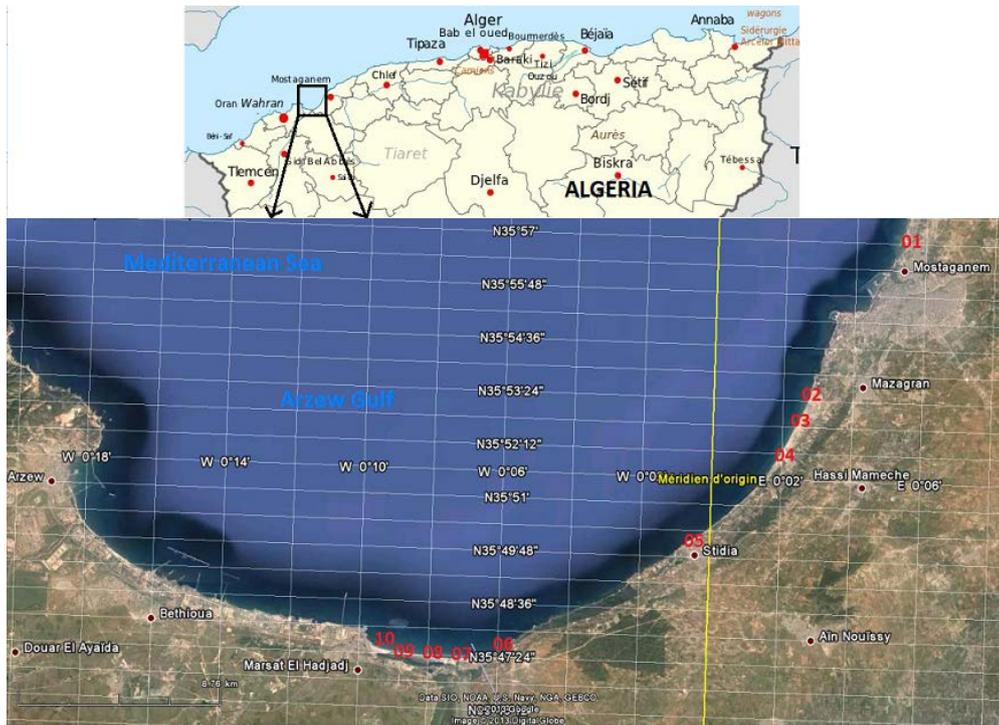


Figure 2. Geographic emplacement of Arzew gulf and sampling stations

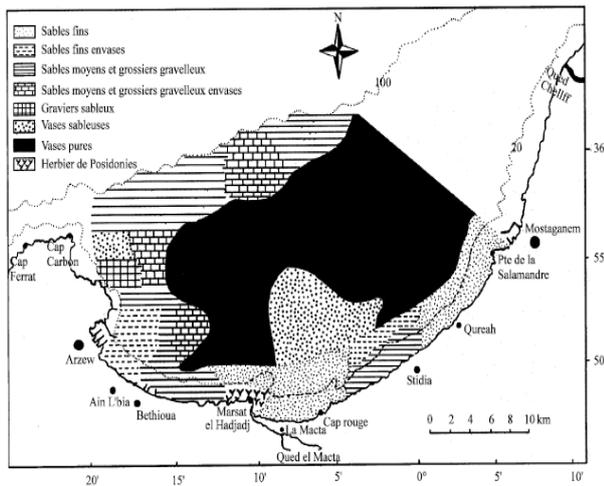


Figure 3. Sediments distribution in the Arzew gulf [8]

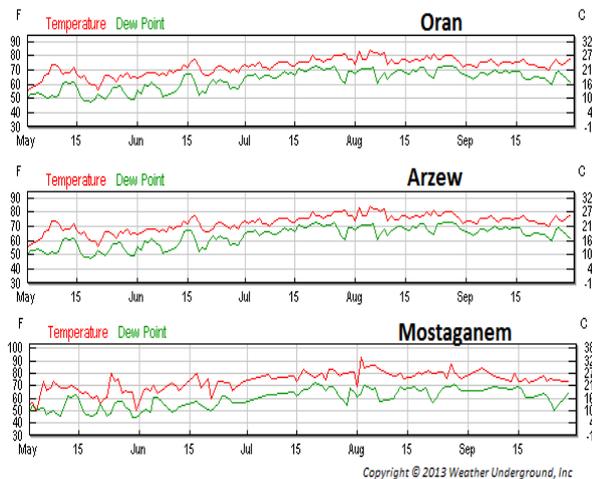


Figure 4. Temperature variations between 01 May and 30 September 2013

The intertidal studied zone extends between *Mostaganem* and *Marsat El Hadjadj* towns on about 30 km (Figure 2). Many points of discharge of urban and industrial effluents are found along the studied coast. *Arzew* gulf is the spot rejection of the *Cheliff* wadi. The river is 795 km long and carries wastewater from many towns. This part of Mediterranean Sea is characterized by a consequent marine traffic and important fishing activities. Several works demonstrate a high richness of the fisheries resources and benthic communities [9].

2.1. Climate

The area has a Mediterranean climate with semi-arid characteristics. The rainfall regime is mainly governed by mid-latitude disturbances and Mediterranean cyclones. Oran receives 370 mm of rainfall per year. Characteristic of the Algerian climate is the extreme irregularity of rainfall.

The general circulation along the North African coast is created by offsetting entry of Atlantic water through the Strait of Gibraltar. This results in an eastward current plated on the coast by the Coriolis drift. In detail, the presence of the *Arzew* gulf induces the formation of a cons-westward coastal current and an upwelling phenomenon in the western part of the gulf [9].

In the Mediterranean Sea, evaporation exceeds precipitation and river runoff so that Atlantic water flows in at the surface through the Strait of Gibraltar. The circulation of this water is generally anticyclonic in the western Alboran Sea, but in the eastern part of the sea, it either follows the African coast or, in most cases, flows south-eastward as a jet from Cape Gata in the south-east of Spain (near Almeria) to the western part of Algeria (near Oran). Other situations, with a more diffuse Almeria-Oran jet, directed southward or eastward, are less frequent. The reasons why the Atlantic water follows one circuit rather than another is now better understood but the possible relationships between these circuits and the

characteristics of the Atlantic flow east of ~ 0°, the Algerian current per se, are still not elucidated. In any case, it is confirmed from a statistical analysis of the infrared imagery that the Algerian current generally flows eastward as a coastal vein from ~ 0° [10].

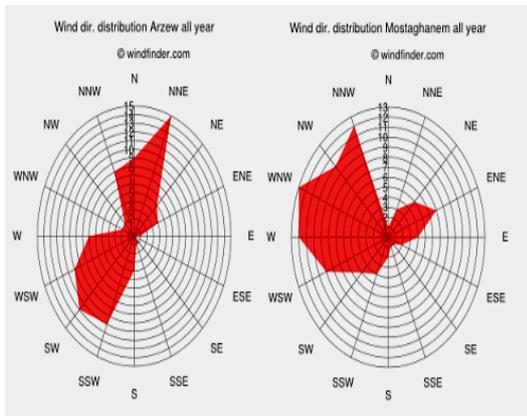


Figure 5. Arzew and Mostaganem wind distribution during 2013 year (Prevision for October, November and December are included)

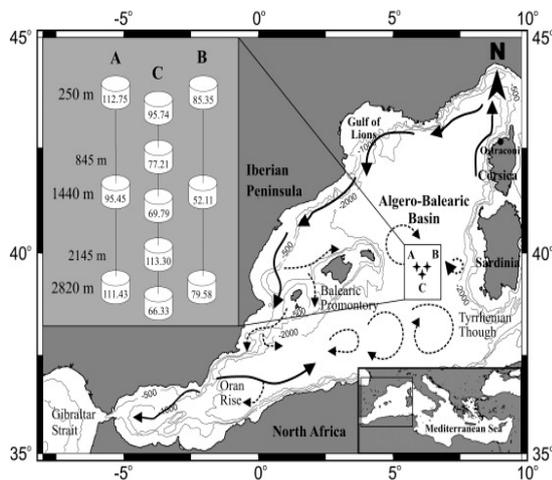


Figure 6. Circulation of surface water in the West Mediterranean Sea [11]

3. Sampling Method

During summer season, between first of May and thirty September 2013, surface sediments samples at ten stations were collected monthly in the intertidal areas of the Arzew gulf. Summer sampling period was chosen according to important temperature elevation (Figure 4) and increasing beaches frequentation by holidaymakers. Sampling sites were selected based on their accessibility, human traffic and waste discharge. Using non-standardized metallic cube of 250 cm³, the cube was Shari'a along the sampling station with a depth of (0-10 cm) until it is filled with sediment surface.

Sediment samples were packed in polythene bags and transported to the laboratory.

For every station and sampling campaign, sediments were dried under sunlight. The whole volume of sediments contained in the cube (250 cm³) was sieved through a 0.5 mm mesh. Plastic items separation was based only on visual aspect and microscope use. Particles recognized as plastics debris were weighed, a ration mass was calculated according to initial dried sediments. At the end of the sampling campaigns, percentage average plastic debris has been calculated for each station.

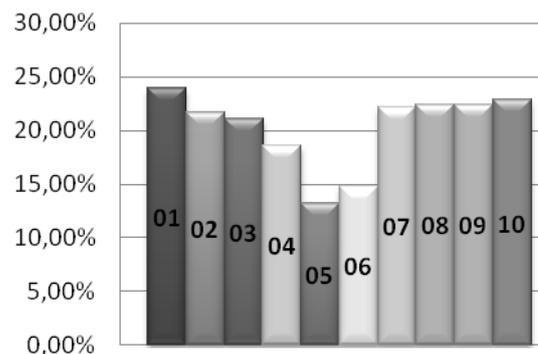


Figure 7. Plastic debris distribution in Arzew gulf surface sediments.

4. Results and Discussion

Table 2. Percentage and range size of plastic debris in sediments

Station	01	02	03	04	05	06	07	08	09	10
Average plastic debris (%)	13.9	11.7	11.1	08.6	03.2	04.8	12.1	12.4	12.4	12.8
Range size particles (θ)	0.5 cm < θ < 01 cm			01 cm < θ < 03 cm			03 cm < θ			
	47.2 %			29.5 %			23.3 %			

Results show that particles larger than 0.5 cm identified as plastics are defined as macro-plastics debris; some were clearly recognized as bottles fragments. Table 2 shows average plastic debris percentage from intertidal surface sediments. The proportions vary from 08.6 % to 13.9 %. Highest percentages are found in station 01, 08, 09 and 10 near Mostaganem and Marsat El Hadjadj towns; this latter is the outfall of minor Macta river. Plastics presence in sediments may have as origin; - waste towns rejections, - rivers contributions and rubbish left by holidaymakers. Industrials effluents and waste releases are not suspected as sources of plastic debris, because most of companies in the industrial Arzew platform are refining petroleum and producing natural gas, with typical waste. Plastics represent 10.5 % of municipal solid waste of Mostaganem city [12].

Majority of plastic debris are in size between 0.5 cm and 01 cm, this means that plastic particles are severely exposed to degradation under climatic conditions and waves hydrodynamic forces. Table 3 presents plastics among benthic marine litter per number of items in some Mediterranean regions. In our study, plastics average presence in intertidal surface sediments is about 10.3% (masse rate).

Table 3. Plastics among benthic marine litter (per number of items)

Region	Plastic (%)	reference
Greece, 59 sites	55.5	[5]
Greece, Patras gulf	79-83	[5]
W & S Greece	55.9	[5]
Gulf of Lion	70.5	[5]
East Corsica	45.8	[5]
Adriatic Sea	69.5	[5]
Sicily/Tunisia channel	75	[5]
Oriental basin	37	[5]

Sea water circulation in the Mediterranean basin (Figure 6) can allow regional and even global dispersion of plastic debris pollution. The gulf of Arzew is less than 300 nautical miles far from the Strait of Gibraltar and the Atlantic Ocean. Wind distribution as shown in Figure 7 which is closely with the movement of surface water may have influence on dispersion of plastic debris in Arzew gulf. Contamination of the area increase with distances from sources pollution, because most plastics move more easily than do more dense materials such as glass or metal, and because they last longer than other low-density materials such as paper.

Even if the comparison doesn't concern the same aspect and method, it's clearly observable that if 10.3 % of sediments composition is plastic this means that sediments are contaminated seriously.

5. Conclusion

The result given in this paper reports the first quantitative and physical study of plastic debris pollution in intertidal surface sediments from Arzew gulfs. High sediments contaminations, which have mainly origin humane activities, can constitute serious danger for marine ecosystem, human health and even tourism economy development in this part of Algeria. Further studies expecting the final aspects of this pollution kind are in perspectives.

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