International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 12, No. 4, p. 117-126, 2018

INNSPUB

RESEARCH PAPER OPEN ACCESS

Assessment of the state of pollution of the Mediterranean Sea by persistent synthetic materials: case of the coastline of Annaba East Algerian

Asma Boussaha*, Borhane Djebar

Laboratory of Ecobiology of Marine and Coastal Areas, Department of Marine Science, Faculty of Science, University of Badji Mokhtar, Annaba, Algeria

Key words: Macro-wastes, coastline, Annaba, Algeria.

http://dx.doi.org/10.12692/ijb/12.4.117-126 Article published on April 08, 2018

Abstract

This article is based on a thesis that is currently underway at Badji Mokhtar University in Annaba addressing the management of coastal macro waste. The objects of this study, solid and visible to the naked eye, are a pollution of the coast and contribute in reducing its attractive value. The accumulation of glass, plastics and metals in the marine environment is worrying, especially since we do not know the scale or the impacts of this pile.We have developed a flexible methodology that takes into account both the quantitative and qualitative aspects of pollution through two fundamental criterias: nature and weight. Our results show a predominance of glass with a rate of 78% whereas it accounted for only 22% in 2007. Plastics come in 2nd position with 18%, in 2007 they reached 29% finally, the rate of metals fell significantly from 23 to 4% between 2007 and 2015. This is the direct consequence of its valuation through its marketing since 2000.This work is part of a perspective of awareness concerning clean beaches and the protection of public health and the environment. We suggest the implementation of a monitoring program that will regularly assess the potential sources of contamination and the establishment of a coastal management plan in joint venture with the municipality of Annaba.

* **Corresponding Author:** Asma Boussaha ✉ asmabsh23@gmail.com

Introduction

The management of macro-waste is one of the most serious environmental issues for all cities in the world. Nevertheless, it is more complex for cities in developing countries whose GDP is <US 825 / inhabitant (Charnay, 2005).

In Algeria, for 20 years, with demographic change, forced urbanization and the development of petrochemicals and plastic-based food packaging techniques, the quantities of waste are constantly growing and the problems of evacuation, treatment and general management is further complicated. Despite significant investments in this sector, local officials do not find satisfactory solutions; they face a public opinion who is increasingly aware of the risks generated by waste to public health in general.

This observation leads us to think that the problem of macro wastes is much more a question of organization, functioning of structures and user practices, than a financial issue (Chaouch *et al.*, 2006).

The Algerian coastline, with its 1622 km of coastline, alternates rocky shores, sandy beaches and wetlands. However, it is characterized by a concentration of 70% of the population and industrial activities. Coastal municipalities spend huge sums of money cleaning their beaches, especially before and during the summer season.

Located in the east of the country, Annaba is the third largest city in Algeria stretching over 1412 km², open on the Mediterranean coast for 80 km, it had in 2015 about 610 000 inhabitants. In 2014, the average household waste was in the range of 0,7 to 0,8 kg / inhabitant / day in urban areas and 0,5 kg / inhabitant / day in rural areas (personal communication, APC Annaba 2014).

This city is exposed to different types of anthropogenic pollution, in particular persistent synthetic macro-debris such as plastics, glass or metals that accumulate on beaches. These constitute an aesthetic nuisance and a danger for terrestrial and marine fauna. To this harmfulness are added odors, the proliferation of insects, animals and soiling.

The characterization of these macro wastes, their level of pollution and their spatio-temporal variations along the coast of Annaba are considered a priority.

The latter was partially supported in 2015 through the identification and quantification of plastics, glass and bulky metals monthly on 11 bathing beaches.

Materiel and methods

The golf of Annaba is located in the extreme north-east of Algeria between Cap Rosa (8° 15E and 36° 58N) and Cap de Garde (7° 16E and 36° 58N). It collects direct discharges from several industries and sewages from urban complexes installed along the coast through 3 wadis: Seybouse, Mafrague and Meboudja in addition to the industrial and urban waste of the surrounding departments.

Description of the waste collection sites

We have identified and quantified the waste found on the sand in 3 stations containing 11 beaches or substations along the coast of Annaba (Table 1 and Fig. 1). From East to West: Sidi Salem, Joinoville, Levée de l'aurore, Plage des juifs,Rezgui Rachid (ex. Saint Cloud), RiziAmor (ex. Chapuis), Caroube, Refészahouan (ex. Toche), Belvedère, Ain Achir and Cap de garde.

Methodology

The methodology developed must take into account both the quantitative and qualitative aspects of pollution. For this last aspect, two criteria were retained: nature and origin of the waste.

Quantitative aspects

We selected as measurable and significant variables: the weight, easily accessible on ground and the number. These parameters are complementary. The general idea is to obtain weights and numbers of characteristic waste related to a fundamental unit, in order to be able to compare the stations with each other.

Sampling strategy

We chose a stratified random sampling in a substation.The following case illustrates our remarks: on a coastline of 80 km half of the pollution is concentrated on 50m and 50% on 200 m. the estimate of the overall quantity will be biased if random samples ignore areas of high concentration.

Fig. 1. Satellite images showing the geo location of 3 selected stations (St. 1, St. 2 and St. 3) and substations (St. 1.1 to St. 3.4.)(Google earth 2018 modified).

Stratified sampling, on the other hand, recognizes beforehand the different concentration zones called strata and randomly performs sampling effort ± proportional to the pollutant load in each stratum. This has the advantage of defining the average and minimizing the variance of it's estimation.

The method consists of

1. To recognize the terrain and divide it into known length strata, each corresponding to a type of concentration.
2. To randomly select, in each stratum, a sample composed of a certain number of transects (at least 2 to have a variance).
3. Obtain, by weighting averages and variances, an estimate of the overall mean and associated variance from the reference unit.

The substations (sampling unit) are materialized in the field by transects (Fig. 2), perpendicular to the axis of the strata of defined width and of sufficient length to integrate the different zones of accumulation from bottom to top of the beach.

Note

Width of the transect we selected 30 m, however, when the stratum is heavily polluted to reduce the sampling time, this width has been reduced to 20 or

10 m, the general principle remaining to bring everything back to the meter. In the case of slightly polluted strata, this width may be increased to 40 m.

Length of the transect

The lower part of the transect is naturally limited by the sea. Towards the top of the beach however, the limit is not always implicit. We stopped the transect to the top of the beach when we meet the break of slope or when we meet the vegetation. It is obvious that wind or tramping leads to waste inwards.

Sample size

The sample size or number of substations depends on the wanted precision and the time spent sampling. As an indication, the total number of stations performed is provided per site.

Harvesting waste

It is the visible waste and they alone, which were harvested. Partially buried waste, a portion of which is visible, is removed. It was not envisaged to harvest buried waste. However, the sand adhered to the waste or contained by the waste is removed before weighing.

Qualitative aspects

Given the extreme variety of the macro-wastes encountered, we approached the problem according to the chemical nature of the debris according to 3 major classes: plastic, glass and metal.It will be noted that we have retained in our classification only the macro-wastes that have been used as objects by man. The "natural" biodegradable macro-wastes that are in particular, algae, plants (*Posidonia*), woods, wrecks, corpses, cartons and tissues were excluded.For glass, we counted pieces (shards) of size greater than or equal to cm^2.

Results

Dimensioning stations 1, 2 and 3

Station 1 is composed of 2 substations: the St. 1.1. Sidi Salem and St. 1.2.or Joinoville, it spreads over 744726 m^2. We quantified macro wastes on 6 transects of 2352 m^2 (Table 2).

Table 1. Geographic location and designation of study 3 stations and 11 substations.

Station	Substation	Designation	Municipality	GPS Position
1	St.1.1	Sidisalem	El Bouni	36° 51' 24.11" N 07° 47' 26.58" E
1	St.1.2	Joinoville	El Bouni	36° 52' 20.12" N 07° 46' 02.80" E
2	St.2.1	Levée de l'aurore	Annaba	36° 54' 33.44" N 07° 46' 20.89" E
2	St.2.2	Plage des juifs	Annaba	36° 54' 58.91" N 07° 46' 06.65" E
2	St.2.3	Fellah Rachid (St cloud)	Annaba	36° 55' 07.77" N 07° 45' 57.15" E
2	St.2.4	RiziAmor (Chapuis)	Annaba	36° 55' 38.24" N 07° 45' 40.41" E
2	St.2.5	La caroube	Annaba	36° 56' 01.70" N 07° 45' 48.29" E
3	St.3.1	Toche	Annaba	36° 56' 37.18" N 07° 46' 03.14" E
3	St.3.2	Belvédère	Annaba	36° 56' 48.32" N 07° 46' 14.39" E
3	St.3.3	AinAchir	Annaba	36° 57' 25.55" N 07° 46' 48.64" E
3	St.3.4	Cap de garde	Annaba	36° 57' 57.36" N 07° 46' 58.61" E

Table 2. Dimensions of station 1, its 2 substations and 6 transects (L: length (m), l: width (m) and S: area (m^2).

Station 1						
Substation 1.1.			Transects			
l	L	S	N°	l	L	S
143	4118	588874	1	21	19	399
			2	20	21	420
			3	19	18	342
Substation 1.2.			Transects			
l	L	S	N°	l	L	S
94	1658	155852	1	28	17	476
	Total	744726	2	25	16	400
			3	21	15	315
					Total	2352

Station 2 is composed of 5 sub stations covering a total of 51102 m² and the total area used for the quantification of macro-debris on 15 transects is 4748 m² (Table 3). Station 3 has 4 substations: St. 3.1. or Toche, the St. 3.2. or Belvedère, the St. 3.3. or Ain Achir and the St. 3.4. or The carob. The 12 selected transects cover a total of 3860 m² (Table 4).

Table 3. Dimensions of station 2, its 5 substations and 15 transects (L: length (m), l: width (m) and S: area (m²).

Station 2						
substation2.1			Transects			
l	L	S	N°	l	L	S
38	221	8398	1	15	16	240
			2	14	18	252
			3	20	15	300
substation2.2.			Transects			
l	L	S	N°	l	L	S
12	71	852	1	8	12	96
			2	8	10	80
			3	8	9	72
substation2.3.			Transects			
l	L	S	N°	l	L	S
24	568	13632	1	20	24	480
			2	16	25	400
			3	14	20	280
substation2.4.			Transects			
l	L	S	N°	l	L	S
41	181	19721	1	22	25	550
			2	25	21	525
			3	24	26	624
substation2.5.			Transects			
l	L	S	N°	l	L	S
27	315	8505	1	16	15	240
	Total	51102	2	18	18	324
			3	15	19	285
					Total	4748

Thus, on a total area of 833521 m² covering 11 beaches or substations we identified and quantified 3 groups of macro waste: glass, plastics and metals on a set of 33 transects corresponding to 10960 m².

Thus, on a total area of 833521 m² covering 11 beaches or substations we identified and quantified 3 groups of macro wastes: glass, plastics and metals on a set of 33 transects corresponding to 10960 m².

Quantification of macro-debris in stations 1, 2 and 3.

The monthly weightings of the 3 types of macro-debris on the coast of Annaba (Table 5) show that in 2015, in Station 1, glass totals more than 380,66 kg while plastic does not exceed 60,58 kg and the metal 17,47 Kg. The same is true in St.2 where glass remains the dominant macro waste with 383.65 Kg before plastic 131,3 Kg and metal with 22,95 Kg. This finding is also noted in the St. 3 in fact, glass totals more than 640,73 kg while plastic does not exceed 126,12 kg and the metal 31,03 kg (Table 5).

Plastics account for 13% of the macro debris encountered in the St. 1, they reach 25% in the St. 2 and 16% in the St. 3 (Fig. 3). The weight of its macro waste peaks in May with an average of 56,45 kg while in July it represents only 17,09 kg (Table 6).

Glass totals more than 83% in St. 1,71% in St. 2 and 80% in St. 3 (Figs. 3 and 4). This macro waste reached in 2015 a maximum of 169,75 kg in December and January (Table 6) and just after the cleaning of the beaches in spring the total of its weighings does not exceed 72,8 kg in July (Table 6).

Metals represent an average of around 4% in the 3 study stations (Fig. 3). They reached a maximum weight of 9,19 kg in May and 4,19 in June 2015 (Table 6), it should be noted that the metals are mainly represented by cans and tin cans (Fig. 4) have been collected for the recycling and processing industry for 10 years.

Table 4. Dimensions of station 3, its 4 substations and its 12 transects (L: length (m), l: width (m) and S: Area (m^2).

Station 3						
substation 3.1.			Transects			
l	L	S	N°	l	L	S
31	432	13392	1	21	19	399
			2	20	18	360
			3	15	14	210
substation3.2.			Transects			
l	L	S	N°	l	L	S
26	138	3588	1	17	18	306
			2	17	16	272
			3	18	18	324
substation3.3.			Transects			
l	L	S	N°	l	L	S
39	273	10647	1	19	19	361
			2	20	18	360
			3	19	18	342
substation3.4.			Transects			
l	L	S	N°	l	L	S
23	438	10074	1	20	19	380
	Total	37701	2	16	15	240
			3	18	17	306
					Total	3860

Discussion

The macro debris of anthropic origin such as plastics, metals, glass, paper, textiles are synthetic and persistent. Their progressive accumulation is considered a problem of environmental pollution because of their heterogeneity, strength, composition, size, visibility and durability (Gabrielides, 1995).

In Algeria more than 2/3 of the population resides on 4% of the territory, the coastal departments which counted on average 100 000 inhabitants in 1997 doubled their populations in 2006. While they occupy only 2% of the territory these cities concentrate 40% of the population (Djebar *et al.,* 2006).

In the city of Annaba the population is growing annually by 1,52%, with nearly 612 000 inhabitants (433 inhabitants / km^2). This rate is mainly related to industrial and urban development (Environmental Inspection of Annaba, 2015).

Table 5. Monthly quantification (Kg) of the 3 types of macro wastes in the 3 stations in 2015.

	Station 1			Station 2			Station 3		
	Plastic	Glass	Metal	Plastic	Glass	Metal	Plastic	Glass	Metal
January	6,64	46,20	1,59	12,72	47,95	2,22	12,43	75,60	3,01
February	3,57	35,00	1,09	9,74	20,65	1,97	7,60	39,90	2,71
March	3,58	6,51	1,76	7,43	22,05	1,41	11,84	42,63	2,89
April	4,66	31,85	1,77	11,76	31,50	2,79	12,39	53,90	2,67
May	7,22	27,30	1,91	32,01	40,65	3,29	17,22	42,35	3,99
June	4,62	39,90	1,82	7,48	13,65	0,86	6,72	39,90	1,51
July	4,58	29,05	0,93	6,30	17,15	1,51	6,21	26,60	1,99
August	3,53	31,50	1,26	7,30	23,45	1,49	7,61	51,80	2,27
September	4,58	23,10	1,28	6,59	52,15	1,53	9,74	48,60	2,12
October	5,16	30,45	1,26	8,98	30,80	1,55	11,38	65,80	2,52
November	5,30	36,75	1,41	9,95	39,20	1,88	10,64	71,40	2,61
December	7,14	43,05	1,39	11,04	44,45	2,45	12,34	82,25	2,74
Total	60,58	380,66	17,47	131,30	383,65	22,95	126,12	640,73	31,03

The agglomeration of Annaba is the second industrial pole of the country after that of the capital Algiers. It houses the El Hadjar steel complex, which is the largest in Africa, and the phosphate and metal industries through Seybouse phosphate complex and the Allelik metallurgical complex. Private industry is concentrated in the agri-food, metal processing, wood and its derivatives and building and public works.

Table 6. Monthly cumulative quantifications (Kg) of 3 types of macro wastes along the Annaba coastline in 2015.

	Stations 1, 2 et 3		
	Plastic	Glass	Metal
January	31,79	169,75	6,82
February	20,91	95,55	5,77
March	22,85	71,19	6,06
April	28,81	117,25	7,23
May	56,45	110,3	9,19
June	18,81	93,45	4,19
July	17,09	72,80	4,43
August	18,44	106,75	5,02
September	20,91	123,85	4,93
October	25,52	127,05	5,33
November	25,89	147,35	5,90
December	30,52	169,75	6,58
Total	317,996	1405,04	71,45

The city of Annaba has more than twenty uncontrolled dumpsites where more than 700 tons of solid waste are dumped daily, 350 of which are from the municipality of Annaba alone (Cheniti, 2014).

Household waste consists mainly of putrescible waste with a proportion of 46%, textile, plastic, paper and cardboard fractions represent respectively 15,10%, 10,01% and 5% and fine particles reach 12% (Cheniti, 2014). Nearshore solid waste is mainly generated from domestic and industrial activities, coastal dumps, agglomerations, storm water and sanitation networks, and watercraft. Beach users, nearby inhabitants, heavy rains and winds, accentuate this pollution.

The assessment of the health status of the Annaba coast by the identification and quantification of bulky wastewater at the main bathing beaches allowed us to make a preliminary diagnosis of the state of health of this coastal ecosystem.

Glass is the predominant macro-waste all along the year 2015 especially in the beaches Toche with 208,25 Kg and Cap de Garde with 219,8 Kg. Along the coast of Annaba the glass, generally composed of bottles of beer and wines, represent 78,29% of macro-waste or a total of 1405,04 Kg. Our results are not in conformity with those obtained by Chaouch in 2007 which shows that glass is the third pollutant after plastics and metals; it reached only 22% of the macro-debris present along the coast of Annaba.

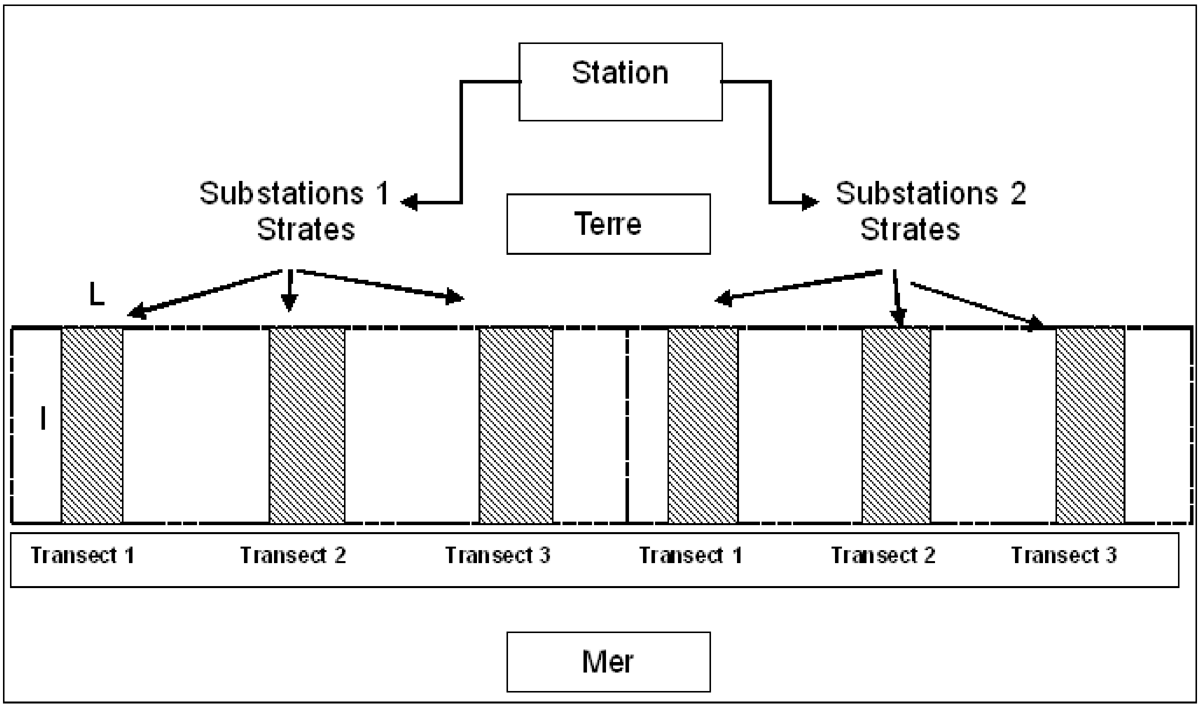

Fig. 2. Schematization of the sampling strategy, the station (St) is composed of substations or ranges (sampling unit) composed by strates materialized in the field by transects 1, 2 and 3.L: length, l: larger.

Plastics, mainly bottles of mineral water, dominate in the Cap de Garde with 38,32 kg. Along the coast of Annaba, they represent 371,996 kg or 17,72% of litter collected. The beaches Levée de l'auroreand Jews are the least polluted. Plastics that come in 2nd position with 18% were ranked 1st in 2007 making up 29% of total macro-wastes.

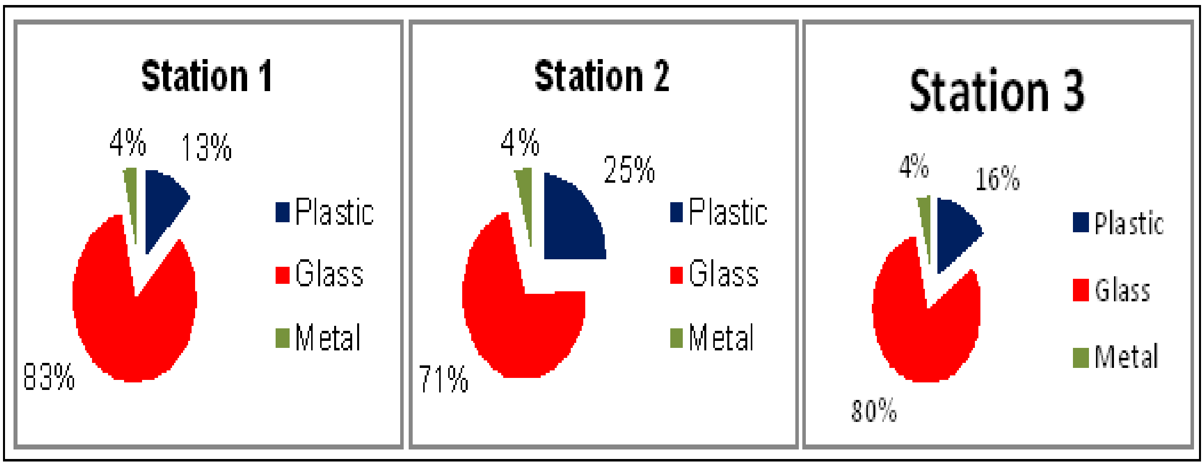

Fig. 3. Distribution of the 3 types of macro waste: Plastic, Glass and Metalin the 3 stations.

Unassimilable by nature without the intervention of humans, plastics present a specific problem. Only the sun can cut chains of macromolecules and reduce the plastic particles in small particles invisible to the naked eye, after about twenty years. These particles are still not biodegradable because they have no energy interest for microorganisms. By way of example, 1/3 of the sediments of the beaches around Southampton are composed of micro-particles of plastics resulting from the degradation of larger objects (bottles, ropes, packaging), the effects of these plastic particles on the marine fauna are still unknown (Thompson *et al.,* 2004).

Fig. 4. Photographs showing the pollution of the coastline of Annaba by plastics mainly PVC bottles, metals mainly drink cans and glass usually bottles of beer.

Metals are the dominant macro debris in the Cap de Garde beach where we weighed 9,27 kg. They represent only 3,98% of all the waste assembled on the coast of Annaba. This rate has, following its valuation, dropped significantly from 23 to 4% between 2007 and 2015.

The same case for glass as metals or plastics, the beaches Levée de l'aurore and Jews are the least polluted. Between 2007 and 2015, we note a qualitative and quantitative inversion of the distribution of macro-wastes encumbering the coast of Annaba. In fact, 10 years ago we put plastics in front of metals and glass while in 2015 it is the glass that occupies largely the first place with 78% far ahead of plastics and metals.

Of the 11 swimming beaches in Annaba, the waste is very heterogeneous in nature. In the summer season, there is a plethora of newspapers and fatty papers, relative meals and bottles of sunscreen. To these are added solid and liquid wastes brought by the marine currents, they might be effluents, garbage rejected by the vacationers, or waste related to the economic activity of the littoral.

If in the past, waste was composed of natural matter easily biodegradable, it is not the case today with partially toxic waste that nature is no longer able to eliminate. That is why this ancient practice of the sea, considered as a landfill, has become one of the main cause of pollution of the soil, water and air of Annaba. The wood, the leaves of *Posidonia* and the algae which we did not retain in our study constitute important quantities of vegetable waste which the town of Annaba has to treat, systematically entailing important additional costs during the cleaning of the beaches.

Conclusion and perspectives

It can be said that in Annaba, coastal macro-wastes are partly taken into account in the waste management policy. It is necessary to define an annual preventive program (sensitization, monitoring of the deposit) and curative (maintenance of the shorelines) and to envisage channels of treatment.

This public policy must integrate the fact that garbage, a priori not dangerous for the environment such as glass, plastics or metals, can pollute or simply degrade the environmental quality of natural environments and in particular the coastline.

Our study has allowed us to develop a flexible methodology that will enable field campaigns to establish on a pre-selected site a quantitative and qualitative baseline on the load and structure of pollution.

It can be said that pollution on some beaches of Annaba is a real problem and that the foreign components, generally related to household waste, are very important and reach areas where their presence was not very suspected.

The establishment of a monitoring network is a possible emergency, on certain critical sites, and spatio-temporal monitoring of the quantitative evolution of waste and its structure (nature and origin) would, through an information policy, be deterrence, repression, cleaning and recycling of considerable help to the mayor of Annaba to fight against this pollution. The first step to reduce this pollution is to minimze the sources and therefore reduce the production of waste.

References

APC (Communal People's Assembly) Annaba. 2014. Documentation.

Chaouch R. 2007. Identification et quantification des déchetssolidesencombrant les plages de la villed'Annaba: aspects physico-chimiques et bactériologiques des eaux, mémoire de Magister Université Badji Mokhtar-Annaba.

Chaouch R,Djebar AB.2006.Identification et quantification des déchetssolidesencombrant les plages du littoral d' Annaba. Communication du 1er Congrès Méditerranéend' Océanologie, Alger, 20 - 22 novembre.

Chaouch R, Abbes A, Djebar AB. 2006. Identification et quantification des déchetssolidesencombrant les plages du littoral d' Annaba, Communication du 1erCongrés Méditerranéed' Océanologie Alger.

Chaouch R, Abbes A, Djebar AB.2007. Déchetssolidesencombrant les plagesd' Annaba. Revue Synthèse n° **17**,46 – 56 p.

CharnayF.2005. Compostage des déchets urbains dans les Pays en Développement: élaboration d'une démarche méthodologique pour une production pérenne de compost (thèse de doctorat). Université de Limoges.

Cheniti H. 2014. La gestion des déchets urbains solides: cas de la villed' Annaba, thèse de doctorat Université Badji Mokhtar - Annaba.

Djebar AB, Abbes A, Guedah D.2006.Evaluation de la pollution le long du littoral Algerian, 1ercolloque Francophone en environnement et santé. 21-28 mai Dakar-Sénégal.

Gabrielides GP. 1995. Pollution of the Mediterranean sea, Wat. Sci. Tech, vol. 32, n°9-10, 1995, 1-10.

Inspection de l'environnement Wilayad' Annaba.2015. Etude d'impactsurl' environnement du projet du centred' enfouissement technique de berkazergagroupementurbaind' Annaba.

Thompson RC, Olsen Y, Mheli RP, Davis A, Rowland SJ, John AWG, Mcgonigle D, Russell AE. 2004.Lost at sea: where does all the plastic go. Science **304**,838.