Airborn soils pollution evaluation with heavy metals in Annaba region (Algeria)

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Abstract
Urbanization and increasing of industrialization have played a key role in the evolution of Annaba region. These activities were synonymous with economic and social progress. Annaba has known recently many problems in ecological terms, due to various urban pollutants (waste disposal, mining, smelting, and chemical industries etc.). In fact, large concentrations of chemical substances introduced into the environment may represent a potential risk for all living organisms, including humans. In our study, soil samples were collected from different sites of the Annaba city. The content of eight soil heavy metals (Pb, Cu, Zn, Cd, Fe, Mn, Ni and Co) was measured in the collected samples. According to analysis results, the highest degree of soil contamination with lead, copper, iron, manganese and zinc, was found in Annaba center and the area of sidi Amar located in the southeast, near the steel plant of El Hadjar. Meanwhile, the content of cadmium, cobalt and nickel in soils of all four studied sites, was at the level of geochemical background.
Keywords: SOIL CONTAMINATION, HEAVY METALS, TECHNOGENIC POLLUTION, ANNABA

1. Introduction

In urban and industrial areas, chemical pollution sources are numerous (Madrid et al., 2002; Imperato et al., 2003). Diffuse metal contamination of soils is caused mainly by atmospheric fallout from various sources, the most important being industrial and traffic emissions (Alloway, 1995; Martley et al., 2004; Möller et al., 2005; Rodriguez Martin et al., 2006). Metal contamination has been shown to reach significantly higher concentrations in urbanized landscapes than in agricultural areas (Imperato et al., 2003; Ordonez et al., 2003), especially in industrial sites (Sterckeman et al., 2000). Direct inputs are other important sources of soil contamination. They mostly come from agricultural activities like sewage sludge or fertilizer spreading (Alloway, 1995; Romic and Romic, 2003). Metals present a risk for human health because they are non-degradable pollutants, having a large spectrum of effects (e.g., nervous or digestive system disturbances and carcinogenic effects), especially for young children who are more sensitive than adults (Li et al., 2004). Humans, particularly children, may ingest the metals directly from top soil or indirectly through food processing (Ljung et al., 2006). The region of Annaba in recent years has known a huge economic development, due to many potential

that it holds. Such as landscape diversity, basics infrastructures and its industrial potential .The districts of Annaba, Sidi Amar and El Bouni represent the sites where the majority of the population is concentrated (44.65% in Annaba, 20.04% in El Bouni and 12.80% at Sidi Amar). Socioeconomic characteristics (pole commercial, industrial, academic and service quality) are factors limiting the distribution of the population. (Plan Directive d'Aménagement Urbain, 2008).

Therefore, due to this development the rise of various types of waste (industrial or household) released into the environment causing health and environmental problems.

The greatest environmental contamination of soils with heavy metals detected at a distance of 2-4 km from the metallurgical plant of El Hadjar. (Benselhoub et al., 2015)

In industrial cities, carry out identification of different sources of pollution is difficult. The reason is that the sources of anthropogenic emissions of pollution are numerous and are located at different distances.

2. Material and methods

2.1. Study Area

Annaba is a port and industrial city in north-eastern Algeria (Fig.1) it is located between latitudes 36 ° 30 N and 37 ° 30 N and longitude 7 ° 20 E and 8 ° 40 E. Its area is 1411.98km2; it is bounded to the south by the wilaya of Guelma, to the west by the wilaya of Skikda, in the east by the wilaya of El Tarf (Tunisian border) and to the north by the Mediterranean Sea (Semadi, 2010). The city and its suburbs are undergoing constant demographic increase (from around 100 000 inhabitants in 1970 to an estimated population of 621 000 in 2007, (http://www.interieur.gov.dz) combined with economic growth, in particular in fertilizer production and the metalworking industry. One of the most productive metallurgical plants in Africa with an annual capacity of around 2 000 000 tons of steel (Broutin, 2009), is located within 12 km to the south-west of the city. Moreover, the city has a high vehicular traffic density, constituted by a fleet of old cars, almost 90% of which still use premium (leaded) gasoline (http://www.memalgeria.org). The climate is typically Mediterranean, with an average annual temperature of 18 °C and an annual rainfall ranging from 650 to 1000 mm with a winter peak and a deficit during summer (Debieche, 2002). The city is bounded to the north and the west by the Edough massif (highest altitude: 850 m), the Mediterranean Sea to the east and the Seybouse alluvial plain to the south. The Edough massif is characterized by a Primary metamorphic rock platform of gneiss, schist, and micaschist. The alluvial plain is characterized by Tertiary gravelly and sandy-clayed layers at depth and arable Quaternary clay cover (Debieche, 2002). The dominant wind comes from the north, north-east and, to a lesser extent, from the north and the west.

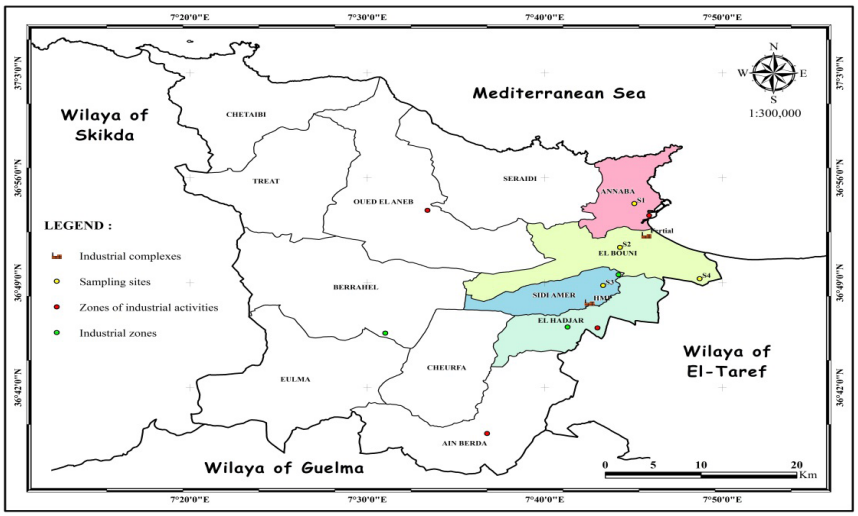

Figure1. Map of study area location

2.2. Sampling sites

Soil sampling was carried out at 4 different sites in Annaba;

- Site (01): center of Annaba city.
- Site (02): El Bouni, distant of 6 km from Annaba close to the Fertial complex.
- Site (03): Sidi Amar distant of 12 km from Annaba close to El Hadjar steel plant.
- Site (04): international Airport of Annaba situated at 10 km of the city.

2.3. Chemical analysis

Soil samples were prepared for chemical analyses

using conventional methods. The content of eight soil heavy metals (Pb, Cu, Zn, Cd, Fe, Mn, Ni and Co) in the collected samples was determined by flame atomic absorption spectrophotometer (Model S-115, Ukraine). The instrument setting and operational conditions were done in accordance with the manufacturers' specifications.

3. Results and discussion

The Table.1 shows the distribution of lead, cadmium, copper and zinc in the soil extracts with 1N HNO_3 using nitric acid and ammonium acetate buffer (AAB).

Table 1. The content of lead, cadmium, copper and zinc in soils of Annaba (mg / kg)

Sampling site	Layer cm	Pb		Cu		Zn		Cd	
		1NHNO$_3$	AAB	1NHNO$_3$	AAB	1NHNO$_3$	AAB	1NHNO$_3$	AAB
Annaba centre	0-5	103,03	21,48	24,54	0,74	180,5	62,16	0,71	0,43
	5-10	351,37	20,04	30,09	0,58	176,46	59,32	0,66	0,35
	10-20	136,44	18,42	22,31	0,6	197,41	66,81	0,64	0,34
El Bouni	0-5	23,45	9,28	5,37	0,63	49,05	6,47	0,50	0,35
	5-10	22,59	7,58	4,97	0,62	36,88	4,54	0,53	0,32
	10-20	22,31	8,11	5,09	0,53	16,46	3,57	0,50	0,32
Sidi Amar	0-5	79,82	10,89	7,43	0,41	34,38	6,49	0,43	0,27
	5-10	37,13	8,43	6,96	0,46	21,4	4,18	0,34	0,24
	10-20	23,32	4,4	7,46	0,42	13,8	1,89	0,27	0,16
Airport	0-5	15,14	10,76	1,74	0,61	18,98	5,16	0,78	0,63
	5-10	16,59	9,69	2,61	0,63	16,76	4,14	0,83	0,62
	10-20	12,6	10,03	1,8	0,71	10,34	2,89	0,76	0,61

Analysis of obtained data suggests that the greatest degree of soil contamination with lead, copper and zinc in the center and in the site (03), located in the southeast, near the steel plant of El Hadjar. For example, according to the excess of nitric acid extracts adopted in France and Algeria, maximum permissible concentration of lead (100 mg / kg) in the center of Annaba was 1,4-3,5 times. Explanation of the phenomenon on the surface: the pre-emptive use of leaded petrol vehicles in the cities of the country. It was established that 90% of the gasoline in Algeria is still represented by gasoline with inclusion of lead as an additive. (http://www.mem-algeria.org/francais/index.php=pagejle-marche-algerien).

It is known that copper and zinc enter in soil with pesticides (Bordeaux mixture, zinc phosphide, etc.), mineral and organic (sewage sludge), by fertilizers (Baker and Senft, 1995). Historically, the steel plant in El Hadjar was built in the south-west of Annaba on alluvial deposits plains Seybous. In recent decades, the area used for the needs of the agricultural sector. Clearly that the high content of copper in the site (01) and site (03), zinc - in the site(01) and the site(02) due both to aerotechnogenic exposure from industrial enterprises (El Hadjar metallurgical plant and phosphate fertilizer plant «Fertial» in El Bouni) and with the need to conduct agricultural activities in the south.

The low value of the concentration of cadmium in soil extracts (less than 1 mg / kg) indicates no exceeding of the geochemical background.

The distribution of iron, manganese, nickel and cobalt in soil extracts with 1N HNO_3 using nitric acid and ammonium acetate buffer (AAB) is shown in Table 2.

Table 2. The content of iron, manganese, nickel and cobalt in soil of Annaba (mg / kg)

Sampling site	Layer, cm	Fe		Mn		Ni		Co	
		1N HNO_3	AAB	1N HNO_3	AAB	1N HNO_3	AAB	1N HNO_3	AAB
Annaba center	0-5	1175,3	3,89	426,33	103,81	4,73	1,18	3,9	1,36
	5-10	1141,5	3,68	385,4	107,63	4,66	0,97	5,2	1,08
	10-20	1278,2	3,89	424,25	127,43	4,53	1,03	3,89	1,09
El Bouni	0-5	701,0	10,21	399,58	83,39	6,41	1,77	6,41	1,46
	5-10	971,47	8,32	410,76	87,63	6,59	1,68	6,60	1,45
	10-20	936,61	8,82	255,55	61,51	6,41	1,62	6,10	1,51
Sidi Amar	0-5	1152,43	3,99	646,79	82,86	5,8	1,12	5,42	1,01
	5-10	787,47	4,51	431,56	72,1	6,22	1,14	5,28	0,95
	10-20	1105,0	5,4	391,14	55,69	6,84	0,88	5,5	0,52
Airport	0-5	49,61	4,74	173,4	83,36	5,82	2,24	5,41	2,38
	5-10	110,05	5,39	171,19	78,32	6,09	2,36	5,69	2,24
	10-20	42,69	5,6	152,57	75,54	6,11	2,43	5,69	2,39

In this study, iron and manganese were measured mainly as an indirect «marker» oxides ratio Fe / Mn, which affect the mobility of heavy metals in soils (Alloway, 1995). Iron is the main component of pig iron and steel, and manganese is introduced as a supplement. Comparison of the obtained data shows that the greatest degree of soil contamination with iron and manganese found in the site (03) and in the Site (01). Specific differences between the content of nickel and cobalt in soil samples from the four designated zones not revealed.

4. Conclusions

The following points on airborn technogenic contamination of soils with heavy metals in the study area should be highlighted:

1. According to the analysis of obtained data which indicating that the highest degree of soil contamination with lead, copper, iron, manganese and zinc, has been found in the Annaba center and the area of Sidi Amar located in the southeast, near the steel plant of El Hadjar.

2. High content of copper was found in the center of Annaba and in the Sidi Amar area, zinc - in the center of Annaba and in El Bouni area due both aerotechnogenic exposure from industrial enterprises (El Hadjar steel plant and the phosphate fertilizer plant «Fertial"), and with the need for fertilization and the use of pesticides for agricultural work in the south.

3. The preferential refueling of vehicles in Algeria with the use gasoline as an antiknock additive of tetraethyl lead is the leading cause of soil contamination by lead along the highways. Further, the high lead content in soils of Annaba center is associated with the high traffic in this area.

4. The content of cadmium, cobalt and nickel in soils at all four study areas of the city, was at the level of geochemical background.

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