



## RESEARCH PAPER

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## Impact of urban and industrial pollution on water quality, people and the environment in the Annaba agglomeration and its surroundings

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### Abstract

Annaba, a coastal town in north-eastern Algeria with a mainly industrial vocation and its status as steel capital, makes it one of the most polluted regions in the country. Water quality is deteriorating due to the existence of high concentrations mainly of heavy metals as well as major elements indicating a multiple origin of pollution. Air quality is affected by the presence of harmful chemical species that can be pollutants in the form of gases, smoke, solid or liquid particles. The interest of this work is to appreciate the contribution of water pollution (Drilling, wells and wadis) and that of the atmosphere in Annaba city and its surroundings (El Bouni, Sidi Amar and El Hadjar) and its impact on human health and the environment

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## Introduction

The growing perception of pollution and nuisances is linked above all to the intensification of industrial activities and urbanization which induce the development of transport and, in certain cases, to a strong demographic growth (Caro, 1979).

The various investigations and studies that have been carried out in the Annaba region and its industrial and agricultural areas for decades are very affirmative in relation to the degree of pollution reached in the region and have called for an awareness of the gravity of the situation. We can also cite some studies that have been carried out in chronological order and concerned several types of pollution: Djabri, 1996; Debieche, 2002; Hani, 2003; Chaffai *et al*, 2003; Chaffai *et al*, 2005; Chaffai *et al*, 2006; Chaffai and Mourdi, 2011; Hamzaoui *et al*, 2017; Sayad *et al*, 2017; Boubelli *et al*, 2018 and Toumi *et al*, 2018.

The data concerning air pollution show that it is generated by a large industrial fabric, fairly dense road traffic and particularly fine particles "dust" from the combustion of certain materials, cement plants and particles from diesel vehicles. This shows the impact that this combination of pollutants can have on the health of citizens in particular and the environment as a whole (Chaffai and Mourdi, 2011).

In Algeria, the unhealthy environment, all causes combined, is mainly that of the urban world. The Health/Environment report is mediated by an interrogation on pollution, a hyperonymous formula to signify the nuisance of the living environment. To understand the complexity of this situation, we propose through this study the directory of pollution in the Annaba agglomeration and its surroundings as well as the impact of this scourge on health in particular and the environment as a whole. The surveys conducted and the results obtained are based on:

- Water pollution induced by different industries (Arcelor Mittal, Fertial...) and the consequences due to agriculture (chemical fertilizers, pesticides... etc.).
- Air pollution generated by a large industrial fabric, fairly dense road traffic and particularly dusts due to

the combustion of certain materials, cement plants and particles from diesel vehicles. This gives an idea of the impact that this combination of pollutants can have on man, the environment and the ecosystems of the Annaba region.

A look at the figs. for waterborne and respiratory diseases and adverse effects in all receiving environments from initial investigations in the region (Mourdi, 2011; Mourdi *et al*, 2012; Mourdi *et al*, 2014) is dizzying and suggests a new approach to protecting the environment in general and humans in particular.

## Material and methods

### *Study area*

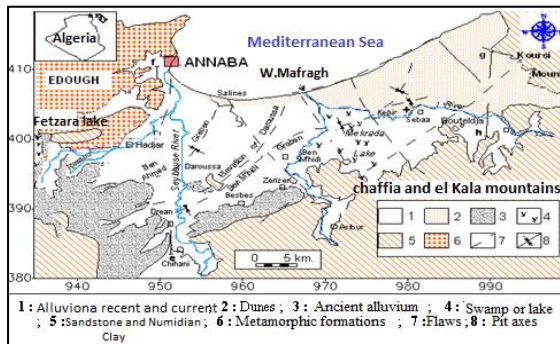
The study area is part of the Annaba plain and comprises: Annaba City, El Bouni, Sidi Amar and El Hadjar, it is limited: in the North, by the Mediterranean Sea; in the West, from North to South by the massifs of Edough (1008m), Boukhadra (152m) and Belelleita (287m); in the South, by the numidic chain and in the East by the eastern extension of the Annaba-Bouteldja aquifer system. It benefits from a Mediterranean climate characterized by an average annual temperature of 18.05°C and an average annual rainfall that varies from 659 mm (saltworks), 649.6mm (Pont Bouchet), 653mm (Berrahal) and 1210mm (Seraidi).

The Annaba region is part of the Tell Algerian North East geological complex. It is characterized by formations ranging from Primary to Quaternary and represents the metamorphic complex that lies only west of the plain in the massifs of Edough, Bellielita and Bouhamra. Sedimentary formations occupy most of the region (Fig. 1).

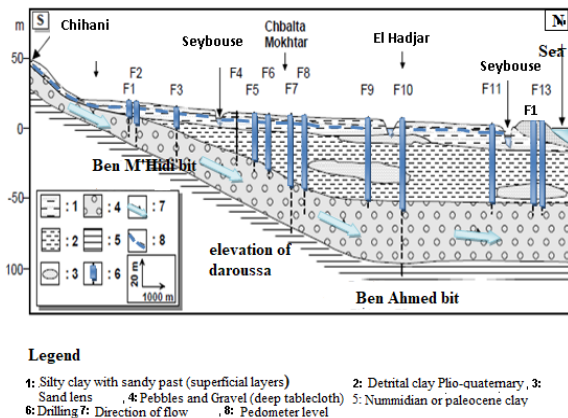
*The study area is characterized by the existence of two types of aquifers:*

- A superficial aquifer that encompasses the slick of altered gneisses, pebbles and terraces, the dune barrier and that of recent and present alluvial deposits.
- A deep aquifer that includes the cipolin and gravel aquifers.

These horizons are fed by the effective infiltration of rainfall, adjacent slicks by drainage, wadis and leakage flows (Fig. 2).



**Fig. 1.** Geological situation of the plains of the Annaba-Bouteldja region after Strojexport, 1975 (in Hani, 2003).



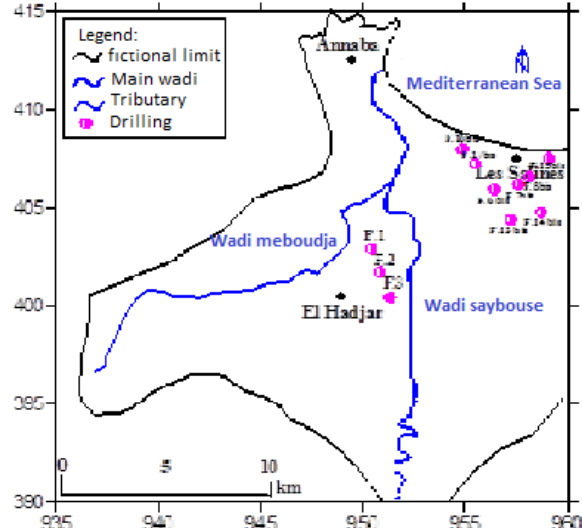
**Fig. 2.** Schematic hydrogeological profile of the Annaba plain (in Hani, 2003, slightly modified).

*Water and air pollution*

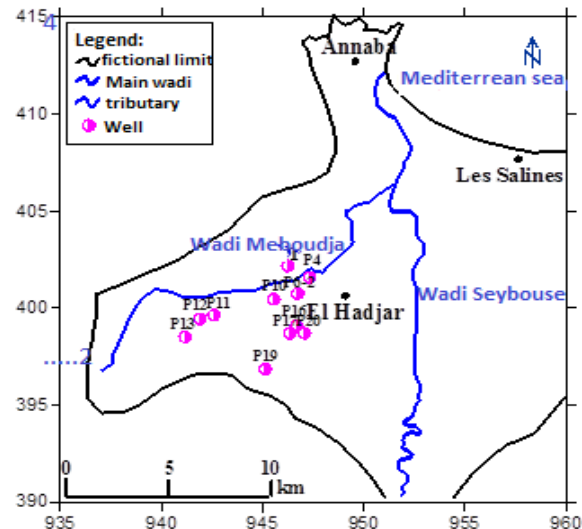
To identify groundwater and surface water pollution (boreholes, wells and wadis), its origin and the genesis of certain pollutants, analytical data and spatial distribution maps have been developed to monitor the physico-chemical evolution of the water: Drilling water analyses carried out by the Seata: a sampling campaign was carried out in September 2017 on 11 boreholes distributed in the study area as follows: 03 boreholes at Pont Bouchet and 08 at Les Salines (Fig. 3).

*Well analyses*

A sampling campaign was carried out in May 2006 on 11 wells (Fig. 4), distributed around the Méboudja wadi and on the El Hadjar plain (Bougherira, 2008).



**Fig. 3.** Drilling inventory map analyzed (September 2017).

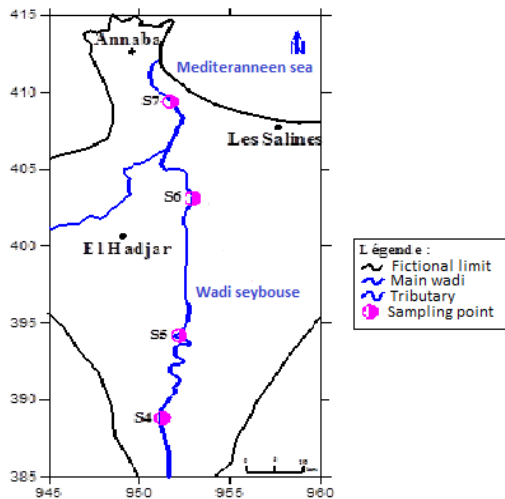


**Fig. 4.** Inventory map of analyzed wells (May 2006).

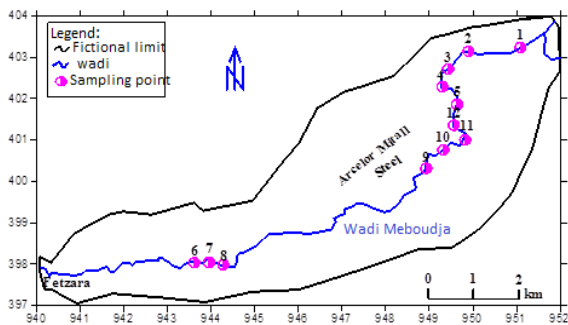
*Wadi analyses*

- Seybouse (Fig. 5): a sampling campaign was carried out in January 2007 at wadi Seybouse with a sampling of 04 samples (Khadri, 2009).
- Mebouджа (Fig. 6): a sampling campaign was carried out in April 2008 with a sampling of 12 samples distributed along this wadi (Lekoui and Kahal, 2008).
- Bouhdid and Boudjemâa (Fig. 7): a sampling campaign was carried out in February 2009 with 16 samples distributed as follows: 08 samples at the Bouhdid wadi and 08 at the Boudjemâa wadi (Saboua, 2010).

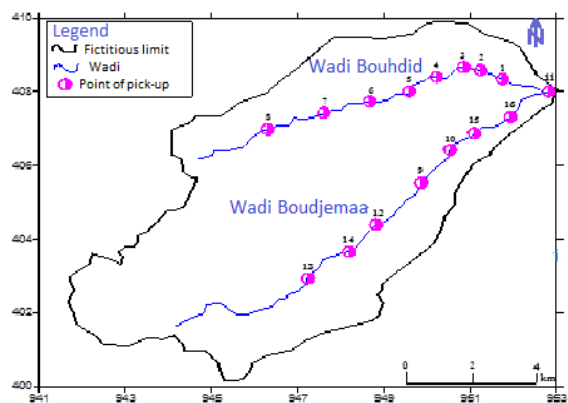
The assessment of air pollution in the Annaba region is continuously monitored through the establishment of an air quality monitoring scheme called 'Sama Safia'. This network (Fig. 8) consists of four stations (Annaba ville, El Bouni, Sidi Amar and Les Salines), it gives the results of air analyses during the period (2002-2007).



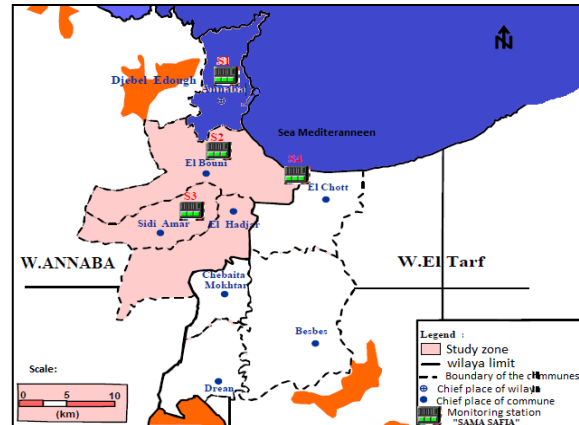
**Fig. 5.** Inventory map of the points taken in Wadi Seybouse (January 2007).



**Fig. 6.** Inventory map of the points taken in Wadi Meboudja (Avril 2008).



**Fig. 7.** Inventory map of the points taken in Wadis Bouhdid and Boudjemaa (February 2009).



**Fig. 8.** Location Map of Air Quality Monitoring Stations (Sama Safia).

**Result and discussion**

Mineral compounds in natural waters originate mainly from exchanges between water, soil and the atmosphere. Natural water in contact with air can dissolve atmospheric gases (Legrand and Poirier, 1976). The proportion of each of them in the air, their respective solubility, temperature as well as water turbulence or wind speed, influence this transfer through the water-air interface (Cabridenc, 1977; 1979). But it is often biological activity that conditions the concentrations of dissolved gases.

*Water pollution*

To know the state of pollution and its evolution in space, concentration maps were drawn up and gave the following results:

- The deep water table (drilling) is subject to several effects of natural contamination by the existence of gypsum, clay, saline lenses and the dissolution of carbonate formations, hence the presence of these elements : Ca, Mg, Na, K, Cl, SO<sub>4</sub>, HCO<sub>3</sub> and Fe.T.
- The surface water table (wells) affected by several pollution processes is either natural due to leaching of geological formations, or industrial, marked by the presence of Pb, Zn, Iron. T, Cu and Ni, or urban marked by the presence of PO<sub>4</sub><sup>3-</sup>.
- Surface waters (wadis), particularly in the Boudjemâa, Bouhdid, Méboudja and Seybouse wadis, are also affected by the different types of pollution: industrial, urban and agricultural since they constitute the first receptacle of the different discharges.

This contamination is marked by high levels of Ca, Mg, Cl, SO<sub>4</sub>, PO<sub>4</sub>, Pb, Zn, Fe, T, Cu and Ni.

*Air pollution*

The study of air pollution is based on the results of air analyses during the period (2002-2007). These results show that air temperatures are very low accompanied by very high humidity due mainly to the presence of the sea and many bodies of water (Lake Fetzara, swamps...). This can allow the accumulation of some pollutants such as carbon monoxide and dust, while some pollutants are present in small to negligible quantities such as NO, NOX, NO<sub>2</sub>, SO<sub>2</sub> and O<sub>3</sub>.

Air quality in Annaba and its surroundings (El Bouni, Sidi Amar and the Salines) was generally good during 2006. Nevertheless the existence of a strong pollution due to dust is noted near the industrial complexes, in particular El Hadjar.

*Impact of pollution on man and the environment*

The surveys carried out and the results obtained at the level of the Annaba agglomeration and its surroundings give an idea of the impact that this pollution can have on the health of citizens in particular and the environment as a whole.

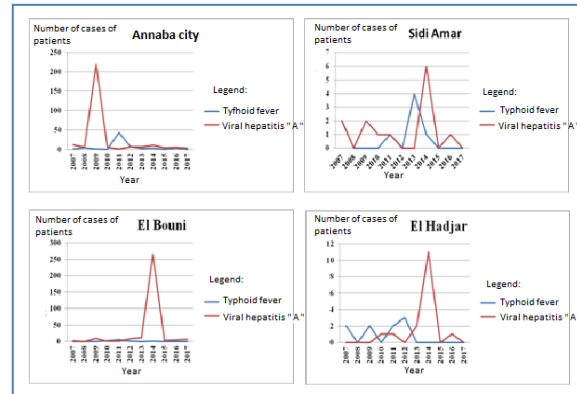
*Impact on Man*

Studies have shown that there is a direct relationship between the number of cases of health problems in patients and the concentrations of pollutants in water or emitted by industries and vehicles (Masplet, 2005).

*Water-borne diseases (Fig. 9)*

According to the Department of Epidemiology and Preventive Medicine (SEMEP) of Annaba, it was not possible to collect the number of patients affected by Typhoid Fever and Viral Hepatitis "A" during the period (2007-2017). Fig. 9 shows that the study area generally does not have a large number of patients affected by typhoid fever and viral hepatitis "A" during the period (2007-2017), with the exception of Annaba city which has a considerable number of cases of patients affected by viral hepatitis "A" disease reaching 219 cases during 2009 and typhoid fever

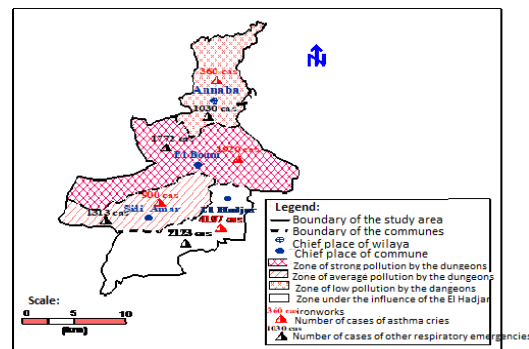
reaching 43 cases during 2011. The municipality of El Bouni presents 264 cases of patients affected by viral hepatitis "A" during the year 2014 which indicates a contamination of drinking water by wastewater during this year.



**Fig. 9.** Evolution of number of cases of patients affected by typhoid fever and viral hepatitis "A" during the period (2007-2017) at 04 communes.

*Respiratory diseases*

According to the Annaba Health Centre (Pneumology Department), data on the number of medical consultations for asthmatics and other respiratory emergencies were collected across the four municipalities (Annaba, El Bouni, Sidi Amar and El Hadjar) and during 2006 and 2009. In the Annaba region (Fig. 10), the good correlations between the high dust levels and the number of medical consultations during 2006, hence the number of cases of asthma attacks and other respiratory emergencies increases with the dust level and varies from one municipality to another.



**Fig. 10.** Correlation map between dust pollution and the number of cases of asthma attacks and other respiratory emergencies for the year 2006.



*Impact on the environment*

The consequences of water and atmospheric pollution on the environment are reflected in:

*The greenhouse effect*

Results from a considerable increase in gases: water vapour (H<sub>2</sub>O), CO<sub>2</sub>, CH<sub>4</sub>, O<sub>3</sub>, NO<sub>2</sub> and Chlorofluorocarbons (CFCs).

*Acid rain*

This includes not only wet precipitation that has captured various naturally occurring or human-induced air pollutants, but also dry deposition of these same pollutants.

**Conclusion**

The impact of urban pollution on water and the atmosphere is now a reality proven by all the results of the various studies conducted by many researchers working on a multitude of vulnerable ecosystems in the north-eastern regions of Algeria. This pollution generates consequences that can be serious on the health of the populations of Annaba and its surroundings by the presence of certain diseases induced by water transmissions during the periods from 2007 to 2017 such as typhoid fever and viral hepatitis "A", confirmed by contamination of drinking water by wastewater. Breathing difficulties (caused by the atmosphere) result in a considerable number of cases of asthma attacks and other respiratory emergencies. Their number indicates a strong pollution by dust generated by a dense road network, a sustained industrial activity whose impact on the environment is reflected in an increase in the greenhouse effect and acid rain. These phenomena affect plants, animals, water, soil and materials.

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