Detection of Heavy Metals Pollution in Mascara (Algeria) by Using (*Platanus acerifolia*.Wild) Leaves

L. Aissa [1*], B. Kéloufi [2]

[1] Djilalli Liabès University, Faculty of Sciences, B.P.89, Sidi Bel Abbès, 22000. Algeria.
[2] Mustapha Stambouli University, Faculty of Sciences, Mascara, Algeria.

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*Corresponding author: L. Aissa [1]
E-mail: a_kakhdari@yahoo.fr

ABSTRACT

This work illustrates the interest of the use of flora species to detect the air pollution by heavy metals from road and vehicle in the town of Mascara (north-west of Algeria). The (*Platanus acerifolia*.Wild) leaves were tested as a possible biomonitor of heavy metals pollution; they are taken from different locations with different degrees of metal pollution (urban roadside and control site). Then, the concentrations of lead, zinc, copper, nickel and chromium were measured using a flame atomic absorption spectrophotometer. The results showed that the highest and the lowest metal concentration were found in the heavy traffic sites and the control site, respectively. However, the Zn, Pb, Cu, and Ni are generally higher than Cr in all samples taken from roadside sites. The mean values of Zn, Ni, Pb, Cu, and Cr are 292.20, 3.45, 2.55, 1.90, 1.05 ppm respectively. In regard to the results of this study, the trees' leaves can be applied to monitor the pollution by heavy metals in urban atmosphere.

KEYWORDS

pollution, heavy metals, Algeria, leaves, biomonitor, plane-tree.

Introduction

Air pollution with heavy metals is the most important problem in urban areas; they cause serious risks to human health. (Pagotto, 1999) reported that two sources of heavy metals in urban areas; Firstly, heavy metals caused by corrosion of the materials constitute vehicle (body, tire, brake), and the use of the various fluids (oil brake, gasoline). The brake has been an important source of copper, nickel and chromium are used in catalysts. Secondly, they on one hand result to the corrosion of road, and on the second hand, with abrasion of the safety fence of the roads.

The metals emitted by traffic either deposited directly on road, or to be diffused in the atmosphere, then they deposit later on road, soil and vegetation on the sides of road, by wet or dry deposits. Generally traffic pollutants include potentially toxic metals for health such as lead, zinc and cadmium (Viard, *et al*. 2004).

In return, heavy metals are natural components of earth's crust and they can enter the water and food cycles through a variety of chemical and geochemical processes (Tinsley, 1979). They are considered hazardous contaminants that can accumulate in the human body, with a relatively long half-life. For instance, it has been stated that, Cd has a half-life of 10 years in the human body (salt, *et al*. 1995). Heavy metals cause serious environmental risks and therefore, their effect has been examined extensively (Abdel-Ghani, *et al*. 2007).

Some trace metals are essential in plant nutrition, but plants growing in a polluted environment can accumulate trace elements at high concentrations. However, the use of plant tissues in sampling has long been shown to be an effective indicator of atmospheric pollution (Goodman and Robert, 1971).

Different bio-indicators are used in monitoring air pollution. Botanical materials such as fungi, lichens, tree, bark, tree rings and leaves of higher plants have been used to detect pollution (Huseyinova, *et al*. 2009). Lichens in particular have been widely used as trace element atmospheric biomonitors, they are widespread and capable of absorbing elements directly from the atmosphere and accumulate them in their tissues. The accumulation of metals in the plants is variable according to the species and within the same species according to the variety considered. The use of plants as a complementary tool to traditional methods of studding atmospheric pollution from anthropogenic and natural sources became an established technique in the recent years, because of the development of powerful analytical techniques.

Uptake of element into plants can happen via different ways. Plants can absorb trace elements through their roots from soil and are then transported to the leaves; also they may be taken up from the air, or by precipitation directly via the leaves. Once deposited on the leaf surface some elements may also be taken up into the leaf via the stomata (Reimann, *et al*. 2001).

The main objective of this work is to determine the pollution levels of Pb, Cu, Zn, Ni, and Cr in the atmosphere of Mascara city stat of Algeria by using the plane-tree (*Platanus acerifolia*.Wild) leaves as a bio-indicator.

Materials and Methods
Study area

Mascara is located in the north-west of Algeria (Figure.1). It has an elevation of around 900m above sea level. The population of the town of Mascara is estimated at 11000 inhabitants, this city counts more than 350 km of urban network road. The city suffers from high traffic density caused by vehicles. However, the number of vehicles is 5200 (old and recent) with the predominance of the old vehicles; more than 62 % of the latter are probably the most polluting.

Nowadays, plane-tree covers the majority of urban trees in Mascara.

Figure (1) Map of study area.

Sampling collection and analysis

Samples of leaves were collected from seven sites indicated by; S1, S2, S3, S4, S5, S6, S7 located in the urban environment near the roadside, and a control site named St (Figure. 2). The control site is located far from traffic and other anthropogenic source of metal contamination and is to be used for controlling results. In each site plane-tree leaves were colleted from old trees according to the main wind direction. They were selected ≥ 2.5m, from the stems of neighboring canopy tree to avoid potential microsite variation (Boerner and Kslowsky, 1989). The samples were separately colleted into clean cellulose bags and brought to the laboratory on the same day.

In laboratory, the samples were carefully washed three times with distilled water to remove adhering particles (Babaoglu, *et al.* 2004). All leaves samples were weighed separately and then dried in an oven at 70°C for 48 h. Samples of (1g) of finely ground leaves were digested with concentrations HNO_3. This digest was filtered by a Whatman filter paper and used to determine heavy metals concentrations.

Heavy metals concentrations were measured by the flame atomic absorption spectrophotometer (Perkin-Elmer, 280 model).

Pearson correlation coefficient was used to measure the degree of correlation between the metal concentrations. The hierarchical clustering technique was used to compare the significant difference in the mean concentration of heavy metals between the sampling sites. Pearson correlation coefficient and hierarchical clustering was performed bay using the STATISTICA program (6.0).

	Pb	Cu	Ni	Zn	Cr
Pb	1	0.527*	0.474*	0.703**	0.105 NS
Cu		1	0.304*	0.752**	0.137 NS
Ni			1	0.596*	0.902**
Zn				1	0.326*
Cr					1

NS- not signifiant. **P< 0.01.

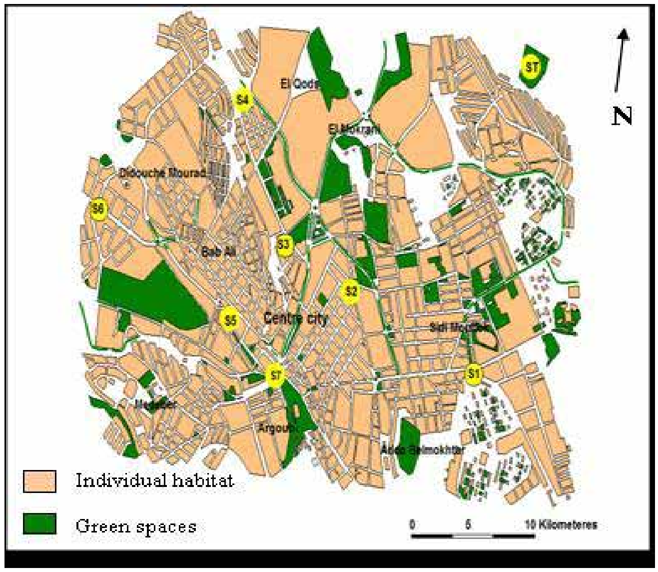

Figure (2) Locations of sampling sites.

The trace element concentrations measured in the plane-tree leaves are reported in Table 2. The results indicated significant difference in Pb, Zn, Cu, Ni and Cr concentrations in plane-tree leaves colleted from different sites. The mean metal concentrations values for the seven sites are arranged in the following order: Zn >Ni > Pb >Cr> Cu. The lead, zinc, copper, nickel and chromium content were found at high concentrations in roadside comparatively the control site.

Table 2. Trace element concentrations (ppm) in leaves of Plane-tree collected from different sites.

Sampling site	Zn	Pb	Cu	Ni	Cr
S1	346.83	1.63	2.26	4.03	1.48
S2	314.71	2.55	3.46	1.89	0.55
S3	329.12	3.75	2.70	4.67	1.24
S4	187.01	2.01	0.93	4.18	1.01
S5	314	2.38	1.70	3.71	1
S6	245.06	2.37	1.14	3.48	1.73
S7	307.69	3.19	1.17	2.20	0.39
St	10.33	0.54	0.21	0.60	0.30

The Pb levels were the lowest at the control site (0.54ppm) and the highest at site three (3.75ppm), which has probably higher traffic density. Lead pollution local scale is caused by emission from motor vehicle using lead gasoline (Koeppe, 1981, Yilmaz and Zengin, 2003, Viard, *et al*. 2004). In Algeria, the addition of lead in gasoline is 0.45g/L (Semadi and Deruelle, 1993). (Kinalioglu, *et al*. 2010) noted that the deposition of Pb is mainly incorporated into street dust and in sites with an active dust, Pb can also be associated with coarse particles. The close relationship between lead concentrations and traffic intensity has been demonstrated in details by many authors (Gromov and Emelina, 1994, Li, *et al*. 2001, Viard, *et al*. 2004). In this research, there was a significant correlation between high Pb level and heavy traffic at Mascara city. The contamination from lead is closely related to vehicle emissions due to fuel combustion and abrasion of tire.

The zinc concentrations were also higher than those of the other elements. The highest Zn concentrations were observed in site one (346.83 ppm). Environmental pollution of Zn greatly influences the concentrations of this metal in plants (Srinivas, *et al*. 2009). Zinc is an essential element for plants and considered an important factor in the biosynthesis of enzymes, auxins and some protein. But when their concentrations reach a certain level, they become toxic to plants and reports produce various physiological and biochemical changes in plants. The high contents of zinc in leaves and plant roots may cause the loss of food production and the low levels in plants may cause deformation of leaves (Bucher and Schenk, 2000, Celik, *et al*. 2005, Kashem, *et al*. 2007). Zn arises mainly from atmospheric deposition and it is essential to plants and it could also be derived from vehicular traffic (Conti, *et al*. 2008). Elevated concentrations of heavy metals in plant tissue generally indicate contamination associated with these elements (Guderian, 1977).

Copper is minor trace metal for plants. (Wilkinson, 1994) reported that the normal content of Cu in plants ranges to be 2-20 ppm, but in most plant, the normal Cu contents are in a narrower range of 4-12 ppm. It is an important constituent of many enzyme of oxidation-reduction reaction (Raven and Johnson, 1986, Celik, *et al*. 2005). An excessive supply of copper can cause symptom of chlorosis (Bergman, 1983). On the other hand, excessive Cu may destroy sub-cellular structure of plants (Sresty and Madhava, 1999). The results indicated that the lowest mean value of copper (0.93ppm) was found in samples colleted from site four (S4), the highest mean value of Cu (3.46ppm) was found in samples colleted from site two (S2); this site is characterized by the slope and a high traffic density, therefore braking in the slope increased the emissions of copper, from fine particles deposited on the surface leaves and road (Maatoug, *et al*. 2007).

Ni is essential for plants in low concentrations. This metal is absorbed easily and rapidly by plants (Gune, *et al*. 2004). The highest mean value of nickel (4.18ppm) was found in samples collected from site four, whereas the lowest mean value was determined in a control site (0.60ppm). The highest concentrations of Ni are attributed to emissions from motor-vehicle that use nickel gasoline and by abrasion and corrosion of nickel from vehicle part (AI-Shayeb and Seaward, 2001).

The chromium concentrations in this study were also lower than those of the other elements. Similar results were found for chromium by (Kord, *et al*. 2010) in needles samples of the Pine (*Pinus Eldarica* .Medw) collected near the highway in Tehran city. Cr is a toxic metal, non essential element for plant (Shanker, *et al*. 2005). Effects of Cr on plants are symptoms of chlorosis on leave and decrease of root growth (Yagdi, *et al*. 2000). In this study, chromium pollution is caused by the body erosion of automobile parts.

Data processing with a hierarchical clustering technique was performed using the Euclidian distance, from the resulting dendogram three clusters can be identified as shown in figure 3.where sites with similar metals concentrations patterns are grouped.

According to the dendogram, cluster 1 includes the control site, this cluster has a good air quality, characterized by low concentrations of trace metals; 10.33, 0.60, 0.54, 0.30, 0.21ppm respectively for Zn, Ni, Pb, Cr and Cu (table 3), which is explained by the absence of any sources of contamination by heavy metals in the control site. Cluster 2 includes sites four and six (S4, S6). The mean values of Zn, Pb, Cu, Ni, and Cr in this cluster are 216.03, 2.19, 1.03, 3.83, 1.37ppm, respectively. This cluster has a good air quality if compared to cluster 3. However these sites are characterized by low slope and low density traffic, for this reason, low concentrations of heavy metals were found. Cluster 3 includes sites; S1, S2, S3, S5, S7. The mean values of Zn, Ni, Pb, Cu, and Cr in this cluster are 322.47, 3.3, 2.7, 2.25, 0.93 ppm, respectively. This cluster has a bad air quality, where the highest levels of heavy metals are found (346.83, 4.67, 3.75, 3.46, 1.48 ppm) respectively for Zn, Ni, Pb, Cu, and Cr. All these sites located in the centre of the city where the high traffic density, frequency of cars stoppage, more abrasion of asphalt and the safety fence, abrasion of tire and brake. These sites are characterized by important slopes. The slope requires the vehicle to develop more power, therefore emit more heavy metals (Madany, *et al*. 1990). Lead caused by emissions from motor vehicle using lead gasoline, braking on the slope, caused the abrasion of materials constituting the brakes and they result in increased emissions of zinc and copper, nickel and chromium pollution caused by body erosion of automobiles and extensive road by yellow chromate paint. Meanwhile, these sites are closed sites, where the air flow does not allow the dispersion of metallic pollutants over long distances. High metal concentrations in plants are contained in roadsides due to the traffic density comparatively the control site.

Table3. Heavy metals concentrations (ppm) in the three clusters.

	Pb	Zn	Cu	Ni	Cr
Cluster 1	0.54	10.33	0.21	0.60	0.30
Cluster 2	2.19	216.03	1.03	3.83	1.37
Cluster 3	2.7	222.47	2.25	3.3	0.93

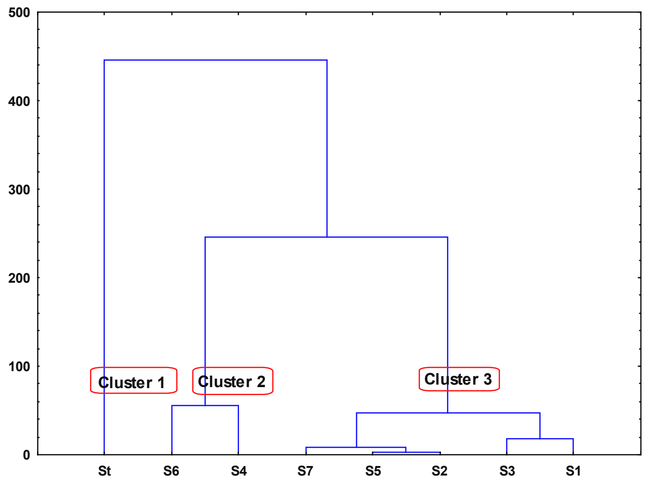

Figure (3) Dendrogram of studied sites.

Conclusion

The results of this study show that the highest and the lowest metal concentrations were found in the heavy traffic and the control site, respectively. The mean values of metal concentrations are lower at the control site compared to all other sites. This indicates that the traffic and the road have been important sources of heavy metals in urban atmospheres. Heavy metals produce undesirable effects, on human and animal life if their emissions are not controlled effectively. From the results, it is clear that plane-tree (*Platanus acerifolia* Wild.) leaves can be used as indicator for heavy metals in urban atmospheres.

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