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Evaluation of levels of plumbic pollution near Highway using phanerogamic and cryptogamic species in the city of Annaba (Algeria)

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ABSTRACT

Nowadays, a serious problem emerged in the natural environments of many countries: they are increasingly subjected to a large number of air pollution: industrial pollution, pollution related to agriculture, but also pollution related to transport. The pollution of lead has constantly evolved over time, due to the considerable increase in the number of vehicles on the market. Our work is based primarily on the use of plants as bio indicator of air pollution in the region of Annaba. The evaluation of the pollution levels near the main roads is a complex exercise, given the many factors to consider at this scale. To do this, we chose three locations on three main roads Greater Annaba: ((RN 44): Annaba - El Kala; (RN 16): Annaba - El Hadjar; (RN 44): Annaba - Skikda), plants used are: phanerogamic namely species (*Fraxinus angustifolia*, *Eucalyptus camaldulensis*, and *Eriobotrya japonica*) and a cryptogamic species (a lichen (*Ramalina farinacea*)). An appropriate sampling strategy, a spatio-temporal monitoring, a counting vehicle at our study sites and measurements of physiological parameters combined with the determination of lead allowed us to assess not only the state of the air quality but also the impact of this pollution on the environment caused by a heavy traffic in the area.

Keyword: Pollution, lead, bio indication, bioaccumulation, road traffic, Annaba, Algeria.

I. INTRODUCTION

During the last century, the industrialization and the development of transport played a major role in the evolution of society. These activities were synonymic of progress, modernity and enrichment. But since, an increasing awareness is felt as for the engendered environmental consequences. Indeed, big quantities of chemical substances are loosened in the environment, of which most of them being considered as dangerous. The introduction of these compounds implies serious risks for the environment and the alive bodies, in particular the human health **[1]**. Among different pollutants poured regularly in the atmosphere, the lead of motor origin occupies a dominating place; its toxicity for the biocenosis is evident and deteriorates more and more through the food chain to become dramatic by affecting the man **[2]**.

In Algeria, our capital was classified number one in the report of the World Bank, due to the 180 tons of lead which glide permanently in the atmosphere **[3].** For that purpose, at the level of the region is from Algeria, and more particularly in the region of Annaba; there is for several years a progressive problem of atmospheric pollution bound to an important road network **[4,5,6];** On one hand because of the existence of a very important motor vehicle population with regard to the traveled distances, and on the other hand of certain topographic characteristics (the closeness of the sea, the existence of plans of water, the presence of the heights and their orientations, these topographic devices in basin and in corridor favors the phenomenon of temperature inversion and its obstinacy) and climatic (the relative humidity always very high all year long and the direction of winds pulling alternative movements of air land breeze, sea breeze, contributing to maintain pollutants above the zone of broadcast, as well as a naturally frequent fog to Annaba) which create a climate convenient to the development of the pollution **[5,6].**

Since the seventies of numerous researches were led on the use of vegetables as bio indicators and bio accumulators of the pollution, particularly the lichens which reveal excellent results concerning the bio accumulation in particular that some heavy metals. **[7-15 ; 5,6].** The various components of the environment react to the pollution differently, the lower vegetables especially lichens often present physiological, morphological and structural changes before even the appearance the slightest symptoms of poisoning at the man **[16].**

Our research on the study of the pollution plumbic of automobile origin in the region of Annaba by using in a relevant way the bio indicators, in particular lichens and some vascular plants to the objective to characterize the environmental state of the middle studied by highlighting a plumbic pollution bound to the road traffic, to study the impact of the latter on the morphology and the physiology of the used vegetables and to propose relevant bio indicators of this pollution.

II. METHODS AND MATERIAL

Annaba, coastal city, renowned for its wet ecosystems, bathed in a Mediterranean climate with character sub wet, leaned in the mountain range of Edough. It is considered as being one of the cities the most polluted on the national territory and in the North of Africa; the main broad casting source of the lead is the road traffic which evolves in a disturbing rhythm.

The analysis of the built-up area of Annaba allows to distinguish in the global scale three expanding main trunk roads of growth and development and which converge on the city center of Annaba:

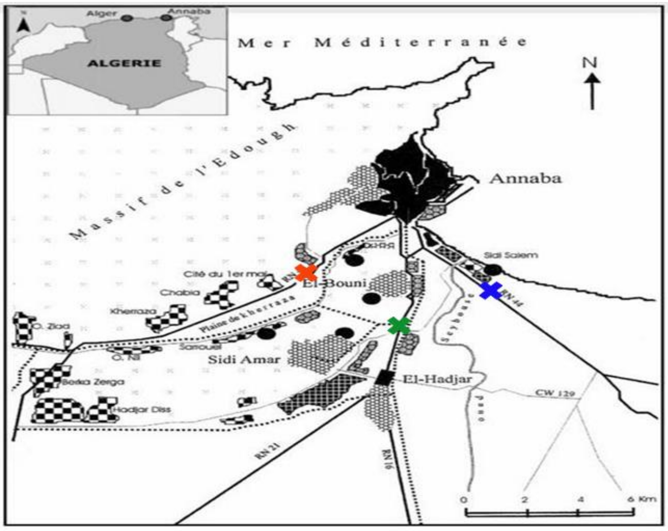
- The axis RN 16 which connects the big and old two poles Annaba - El Hadjar,
- The axis RN 44 East- is connecting Annaba - El Tarf,
- The axis RN 44 West – connecting Annaba to Constantine.

The population of the wilaya of Annaba did not stop increasing during these last years to reach609 499 inhabitants where we register more over an annual average of growth closely 1,01 % and an irregular distribution of the population with a variation of the density from a municipality to another one. The axis Annaba - Sidi Amar and El Bouni represents the sites where the majority of the population are concentrated (44,65% to Annaba, 20,04% to El Bouni and 12,80% to Sidi Amar). The socioeconomic characteristics (commercial, industrial, university pole and the quality of the services) are factors limiting some distribution of the population **[17].**

Nowadays we find an important motor vehicle population by which the annual growth rate of car registration documents is only increasing year by year. From 2002 till 2003, the rate considerably increased from 0,92 % to 3,57 % **[18]**. In 2005, the realized analysis reveals that the vehicle of tourism represents a 68 % rate with regard to the other ways of transportation. Compared with the other Algerian wilayas, Annaba is ranked second after the capital with a park automobile reaching100 000 vehicles, with 94 passenger cars for 1000 inhabitants and overtake widely Constantine and Oran which are respectively 79 and 81 cars for 1000 inhabitants **[19].**

Since 2003, we registered an acceleration of motorization of more than 9 %, the latter rose during these last year’s respectively with a rate of increase of more of 14 % in 2004 and more than 42 % between 2004 and 2008.

A. Presentation of the Sites of Surveillance and Measure of the Automobile Pollution:



Site 1 ✖ Site 2 ✖ Site 3 ✖

Figure 1 : Geographical location of the sites of study 1, 2 and 3 on three main highways harming the city of Annaba (Source : P.D.A.U, 2004).

The evaluation of the levels of pollution near the axes of circulation is a complex exercise, considering the numerous factors to be considered in this scale. The concentrations in pollutants registered in border of way indeed depend on local broad casts generated by the car traffic (depending themselves on conditions of traffic and on the composition of the motor vehicle population), parameters influencing the dispersal of pollutants (local meteorology and configuration of public road network) and levels of thorough concentration of the surrounding zones.
To do it, we chose three sites located on three main highways serving the urban area of Annaba (Fig. 23):

Site 1: (R.N. 44): Annaba-El Kala, it is approximately 4 km in the Southeast of Annaba. **Site 2:** (R.N. 16): Annaba-EL Hadjar. It was chosen in 5 km in the South of Annaba. **Site 3:** (R.N. 44): Annaba-Skikda: it was realized in 3 km in the Southwest of Annaba.

B . **The Climatic Parameters**

Certain climatic parameters are considered in our study because they have a role particularly mattering in the distribution and the dilution of the impurities:
· The city of Annaba presents in general lines of Mediterranean type with floors bio - climatic sub-wet and wet;
· The climate is characterized by sweet temperatures in winter, warm in summer and plentiful precipitation;
· The rose of winds allows to put in evidence a dominant direction of the wind of Northeast the western South **(Fig. 2).**

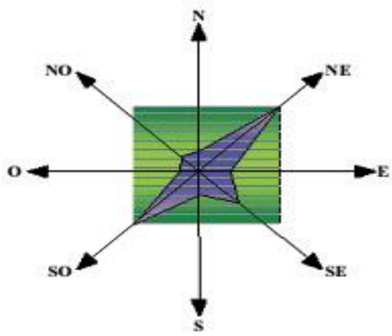


Figure 2 : Wind rose in Annaba built upon 10 year history (1999-2008).

B. Choice of the Vegetal Species

In the current studies of bioaccumulation of elements atmospheric metal tracks, three big types of bodies are used: lichens, mosses and superior vegetables. We distinguish two approaches: the first one consists in harvesting the naturally present individuals on the zone of study, the second to be exposedon sites chosen by the individuals beforehand cultivated in standardized conditions or harvested or in not contaminated circles.In this article, our choice concerned as well cryptogams as phanerogams:

1) Phanerogamic species "in situ":

We chose the most representative vegetables of the region: species leaves of which were taken are: *Fraxinus angustifolia*, *Eucalyptus camaldulensis* and *Eriobotrya japonica.*

- ***Fraxinus Angustifolia***

Figure 3 : *Fraxinus angustifolia*

Classic classification

Reign: *Plantae*
Division : *Magnoliophyta*
Class: *Magnoliopsida*
Order: *Scrophulariales*
Family: *Oleaceae*
Genre: *Fraxinus*

- ***Eucalyptus Camaldulensis***

Figure 4: *Eucalyptus camaldulensis*

Classic classification

Reign : *Plantae*
Division : *Magnoliophyta*
Class : *Magnoliopsida*
Under class : *Rosidae*
Order : *Myrtales*
Family : *Myrtaceae*
Genre : *Eucalyptus*

- ***Eriobotrya Japonica***

Figure 5 : Fruits of *Eriobotrya japonica*

Classic classification

Reign: *Plantae*
Under reign: *Tracheobionta*
Division: *Magnoliophyta*
Class: *Magnoliopsida*
Order: *Rosales*
Family: *Rosaceae*
Genre: *Eriobotrya*

2) Cryptogamic Species

The lichen is a complex vegetable trained by the association of a mushroom the mycosymbiote, Lichens are included in Thallophytes, vast group vegetables devoid of stalks, leaves and roots and which are not thus vascularized. Their thallus or vegetative device which appears in more or less regular heap of cells, in more or less cut blades and offers an original morphology with regard to that of the seaweeds and the mushrooms which make up it. The capacity of bioaccumulation of lichens **[20],** appears to us a sensible approach to estimate the impact of the road traffic on the environment. These vegetables are capable of accumulating pollutants whatever are their conditions of broadcast, distribution and dispersal, when the physic-chemical measures can turn out to be difficult to realize.
Our choice concerned a fruticose species, *Ramalina farinacea*, on one hand because of its sensibility and on the other hand because of its abundance at the level of the site of origin. In Algeria, the works of Semadi **[16]** in the zone of Annaba and those of Alioua **[15]** in the region of Skikda demonstrated the sensibility of this species to rates mattering of pollutants.

We took branches covered with Thallus of *Ramalina farinacea* in their original environment, El Kala, situated east of Annaba (national park). This site of taking is situated except the polluted zones; the qualitative methods used on numerous occasions in Europe allow to determine the degree of pollution directly from the observation of the lichen populating **[8, 21, 22].** We transferred these samples to the levels of the various chosen sites of transplantation. The transplantation took place on January 15th, at the level of three chosen sites. Vegetables chosen at the level of sites located on main highways are as follows:

- Site 1: (R.N.44): Annaba-El Kala, the twigs of branches of *Olea europaea* covered with *Ramalina farinacea* were fixed to *Fraxinus angustifolia* perpendicularly in the main highway in 2 m of the road.
- Site 2: (R.N.16): Annaba-EL Hadjar. The transplants of *Ramalina farinacea* was fixed to *Eucalyptus camaldulensis* between both senses of the highway in 2 m; besides, the leaves of *japonica Eriobotrya* situated in 5m were also used.
- Site 3: (R.N.44): Annaba-Skikda: the transplantations of the fragments of branches of *Olea europaea* covered with *Ramalina farinacea* were fixed to *Eucalyptus camaldulensis* between both senses of the highway in 2 m; we also used the leaves of *Fraxinus angustifolia* in 2m.

A taking is made at the beginning of every month, by removing a part of the thallus of lichens on the phorophyte. The study lasted seven months and the treatment of samples was made that very day by the taking or the next day with three repetitions for every site and every measure.

D. Technique of Takings of Samples

To realize our sampling, we operated on a height varying 1, 50 m and 2 m of the ground. The takings took place according to the specific nature of the vegetable. For the treelike species, we took every time 10 in 20 sepals around of the tree at the level of man to have a homogeneous average sample.

For lichens, we removed a part of thallus on the phorophyte by means of a knife for every sampling. The taken samples are placed in plastic labelled bags carrying all the indications (in particular date and place of taking), closed by means of an elastic to limit the losses of water by evapotranspiration until the arrival to the laboratory.

E. Analytical Techniques

After drying of samples in the steam room in 105°C, they are carefully crushed, put in pill box where they are handled by the peroxide of hydrogen until complete mineralization. The recent dosages of the lead were made by using the technique of spectrophotometer of atomic absorption (S.A.A.). The measures were made from the solutions of 20ml of nitric acid for 2 %. For the same solution, three measures (repetitions) are made, the average being considered.

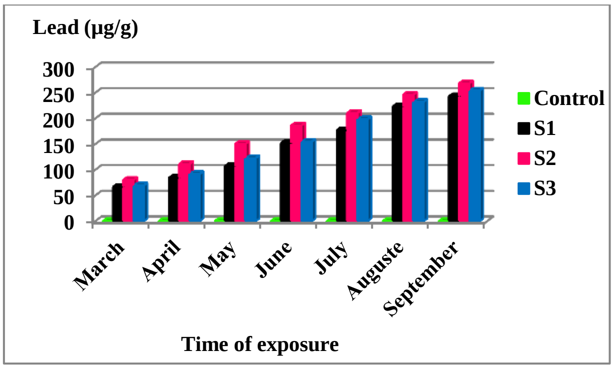
Before proceeding to the dosage of the lead in samples, it is necessary to establish at first a curve of calibration from the solutions of lead known concentrations. The results are directly read on the device if it is

III. RESULT AND DISCUSSION

A. Variation of the average monthly traffic in the three axes serving the urban area of Annaba during rush hours

On average, we see that road traffic increases during the summer especially at the axis 2. This is related to the environment of this axis and its features (surrounded by several important facilities: commercial, industrial, settlements etc...), so it seems to be the busiest.
Analysis of variance with two criteria for classification on the patio-temporal variations of traffic in the three axes serving the metropolitan area of Annaba during peak hours shows that it is highly significant in space (**p = 0,000*****) and time **(p = 0,000***).**

B. Bioaccumulation of the lead by vegetables



The **Fig. 7** reveals a fluctuation in the spatiotemporal accumulation of the lead by *Ramalina farinacea* transplanted at the level of all the sites with an ascendancy at the level of the site 2, this can be explained by the intense road traffic registered at the level of the latter. The comparison of the spatiotemporal variation of the lead accumulated by *Ramalina farinacea* show that this variation is very highly significant in the space **(p = 0,000 ***)** and in the time **(p = 0,000 ***)**, that is the more transplants is exposed and the more the accumulation of the lead is important.

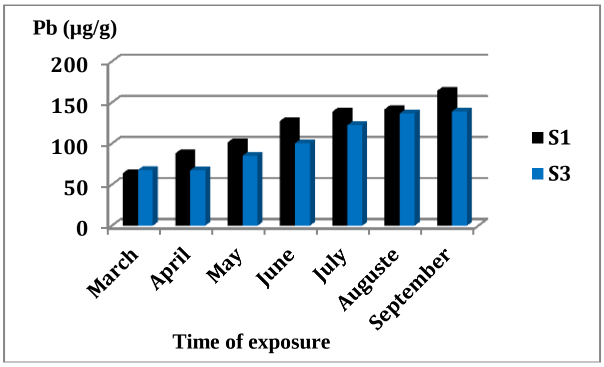


Fig. 8: Variations spatiotemporal of lead accumulated by *Fraxinus angustifolia*

According to **(Fig. 8)** relative to the spatiotemporal variation of the accumulation of the lead by Fraxinus angustifolia, we notice that this accumulation is more and more important in summer, what is perfectly understandable by the impact of the climatic factors, in particular the absence of the precipitation which tend to wash the various particles fixed to the foliage in winter. At *Fraxinus angustifolia*, the analysis of the variance in two criteria of classifications relative to the spatiotemporal variation of the lead shows that the latter is very highly significant in time**(p = 0,000***),** and highly significant in the space **(p = 0,007**).**

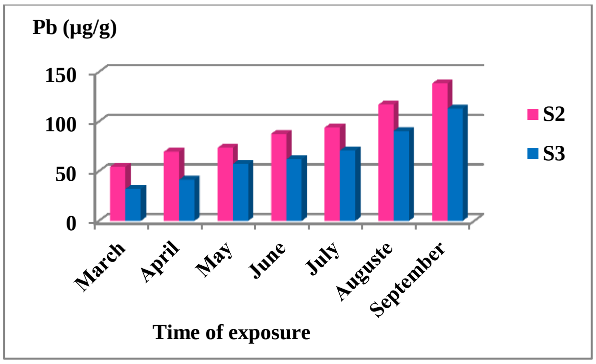


Fig. 9: Variations spatiotemporal of lead accumulated by *Eucalyptus camaldulensis*

Eucalyptus camaldulensis answers in the same way as the previous species, always with an ascendancy at the level of the site 2 which presents a strong volume of road traffic what explains the lead contents accumulated by the vegetable.

As well as for the comparison of the variation of the lead average accumulation to Eucalyptus camaldulensis who shows that it is very highly significant in the space **(p = 0,002**)** and in the time **(p = 0,000***)**, this is demonstrated by the accumulation of the lead to the Eucalyptus according to the time of exposure as well as the site of transplantation.

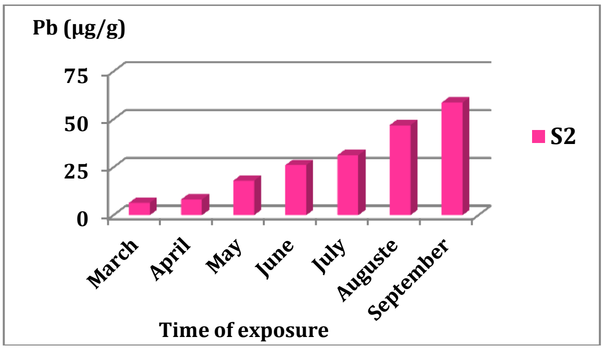


Fig. 10: Variations spatiotemporal of lead accumulated by *Eriobotrya japonica*

In the same way the spatiotemporal variation of the accumulation of the lead follows the same trend as that of the previous species with a clear progress from the first taking to affect a maximal value in September of **58,8 µg / g**, however this value remains lower than that registered to the previous species.

C. Variation of the Content in Chlorophyll

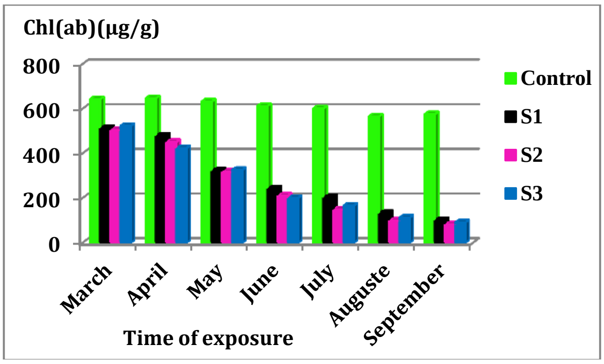


Fig. 11: Variations spatiotemporal of chlorophyll by *Ramalina farinacea*

We recover that the rate of the chlorophyll tends to decrease in time in exposure, in other words as the lichen weakens considering its exhibition in the pollution; this is going to influence the photosynthetic process. The rate of the chlorophyll varies well according to the site of exposure.

The comparison of the content average some chlorophyll (ab) at *Ramalina farinacea* shows that it is very highly significant in the time **(p = 0,000***)** while it is only significant in the space **(p = 0,010*)**.

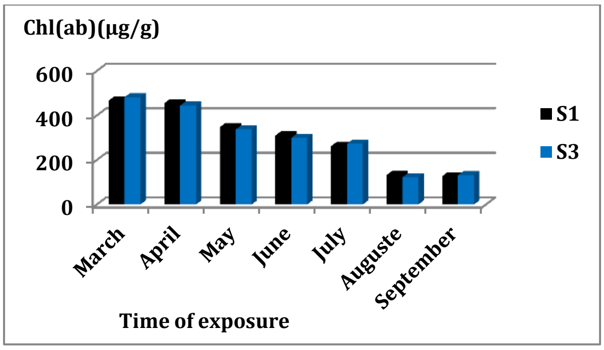


Fig. 12: Variations spatiotemporal of chlorophyll by *Fraxinus angustifolia*

The fluctuations in the time in the chlorophyll (ab) at Fraxinus angustifolia vary between 482.15 and 1.34 µg/g at the level of the site 3 and between 466.81 and 17.23 µg/g for the site 1.

The comparison of the content average in chlorophyll (ab) at *Fraxinus angustifolia* shows that the variation of the chlorophyll (ab) is very highly significant in the time **(p = 0,000***)** but it is not it in the space **(p= 0,722).**

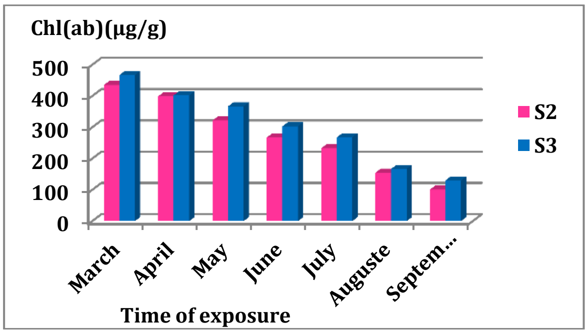


Fig. 13: Variations spatiotemporal of chlorophyll by *Eucalyptus camaldulensis*

According to **fig. 13**, we notice that the chlorophyll is more important for spring. The tree in question is subjected to a single pollution the spring vegetative push allows a good photosynthesis which generally will eventually perturbed after a period which will stay function of the environmental factors. In other words, for the rest of the time we register a decrease of the chlorophyll. The comparison of the content average in chlorophyll (ab) at *Eucalyptus camaldulensis* shows that the variation of the chlorophyll (ab) is very highly significant in the time **(p = 0,000***)** and in the space **(p= 0,003***).**

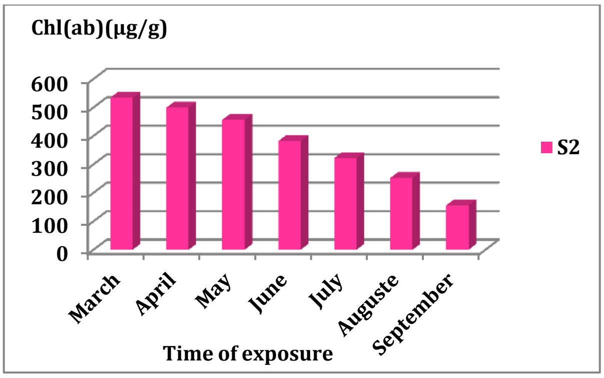


Fig. 14: Variations spatiotemporal of chlorophyll by *Eriobotrya japonica*

According **fig. 14**, the chlorophyll seems to fluctuate also as well in the time as in the space.

D. Variation of the Content in Proline

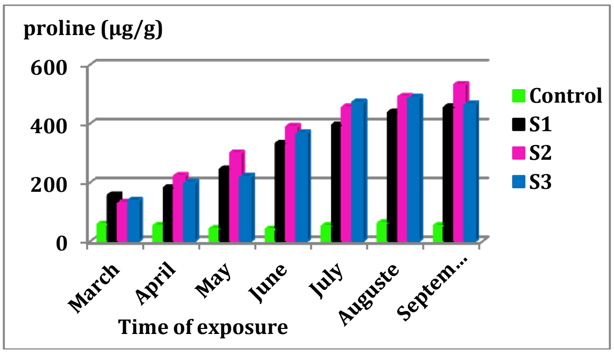


Fig. 15: Variations spatiotemporal of proline at *Ramalina farinacea*

Fig. 15 show that the contents it proline at *Ramalina farinacea* are important at the level of three main highways during the months of exposure.
Concerning the comparison of the spatiotemporal variation of the proline at *Ramalina farinacea*, it shows that the latter is very highly significant in the time **(p = 0,000***)** while it is only significant in the space **(p = 0,017*)**.

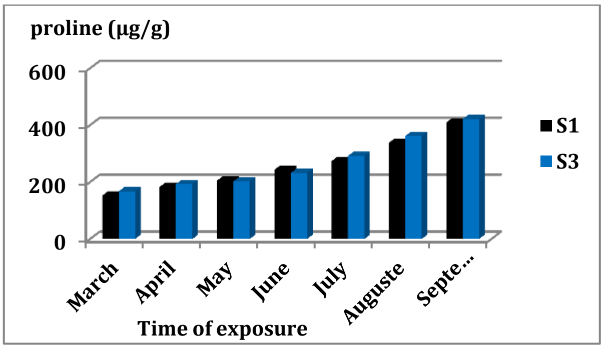


Fig. 16: Variations spatiotemporal of proline at *Fraxinus angustifolia*

Analysis of the variance in two criteria of model classification crossed fix relative in the spatiotemporal variation of the proline at *Fraxinus angustifolia* show that it is very highly significant in the time **(p = 0,000***)** but it is not her in the space **(p = 0,093)**.

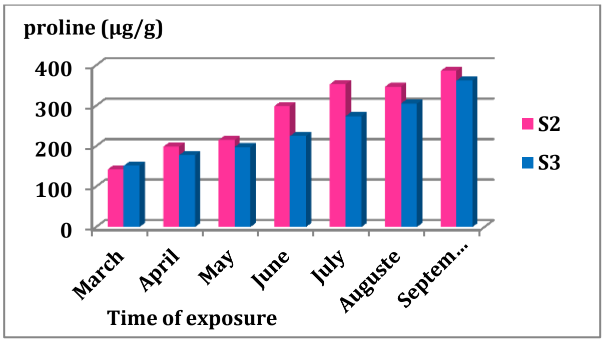


Fig. 17: Variations spatiotemporal of proline at *Eucalyptus camaldulensis.*

The **(Fig. 17)** reveals that the rate of the proline to *Eucalyptus camaldulensis* follows the same trend as that of the Fraxinus, because we notice an increase of this content according to the time of exhibition.

The comparison of the content average of her of the proline to *Eucalyptus camaldulensis* shows that it is very highly significant in the time **(p = 0,000***)** but it is only significant in the space **(p = 0,025*)**.

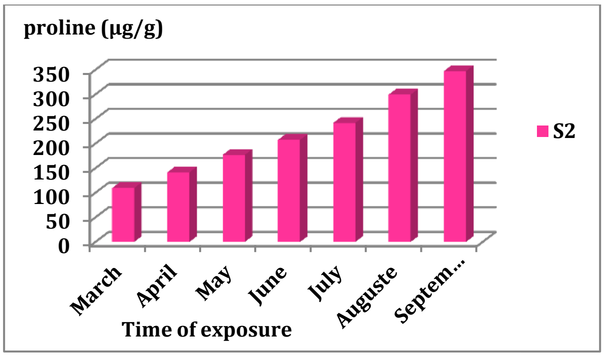


Fig. 18: Variations spatiotemporal of proline at *Eriobotrya japonica.*

According to the results appropriate to **Fig. 18**, we notice that the rate of the proline at *Eriobotrya japonica* increases from the first taking and persists until the last taking to affect **347.32 µg / g** a value which always remains lower than the content proline noticed to the other superior vegetables.

E. Variation of the Report Fresh Material/Dry Material

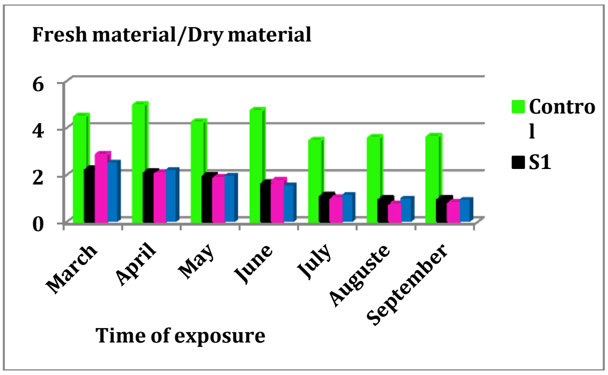


Fig. 19: Variations spatiotemporal of report Fresh material/Dry material at *Ramalina farinacea*

Dry material decreases also considerably with fluctuations in a site in the other one especially for the site 2 or the maximal value is affected the first taking with **2.87** and the minimal value is affected the sixth taking with **0.76**.

The comparison of the variation of the report FM / DM by means of the analysis of the variance to two criteria of classification, show that this spatial variation is not significant **(p = 0,917)** and that the temporal variation is very highly significant **(p = 0,000***)**.

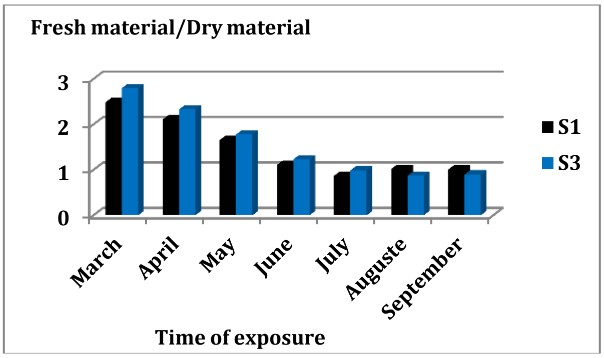


Fig. 20: Variations spatiotemporal of report Fresh material/Dry material at *Fraxinus angustifolia*

Also at *Fraxinus angustifolia*, we note fluctuations in the report fresh material/dry material from March till June followed by stability the rest of the months.

The comparison of the spatiotemporal variation of the report FM / DM at *Fraxinus angustifolia* shows that the latter is very highly significant in the time **(p = 0,000***)** but it is not it in the space **(p = 0,202***)**.

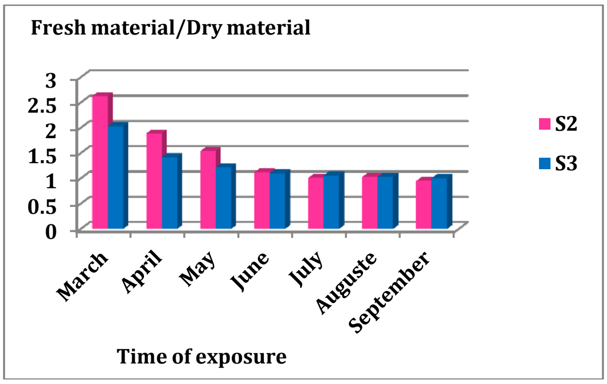


Fig. 21: Variations spatiotemporal of report Fresh material/Dry material at *Eucalyptus camaldulensis*

sis

presents fluctuations during the first three months followed by stability at the level of both main highways the rest of the time.

The comparison of the spatiotemporal variation of the report FM / DM at Eucalyptus camaldulensis shows that this variation is very highly significant in the time **(p = 0,003***)** but it is not it in the space **(p = 0,120).**

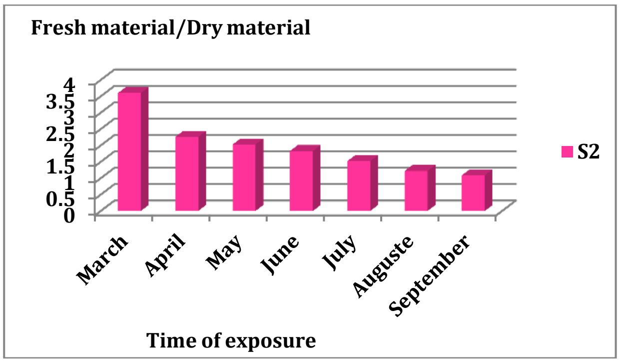


Fig. 22: Variations spatiotemporal of report Fresh material/Dry material at *Eriobotrya japonica*

Further to the data analysis appropriate to the **fig. 22**, we notice that the report FM / DM tends to decrease considerably after the second taking, this decrease stays function of several parameters to know the degree of pollution, the climatic parameters as well as other factors which interfering.

In comparison with the volume of road traffic at the level of three axes for the same schedules of counting, we notice that there is no difference between the axis 1 and 3 during the schedules of counting, on the other hand the latter is smelt at the level of the axis 2 where the road traffic seems more intense during rush hours. This gives some explanation by the importance of the urban areas and the infrastructures served by this strongly frequented axis. Indeed, the latter serves the city El Bouni, the urban areas of El Hadjar, Sidi Ammar, Chaïba, the University and the steel-making Complex as well as the other destinations towards Guelma and Souk Ahras.

Concerning the accumulation of the lead, the results which we obtained demonstrate well the presence of a strong pollution of lead by automobile origin, not only revealed by the use of transplants of lichen (the most sensitive bio indicators) which accumulate approximately 268,33 µg / g, but also by certain phanerogamic species in situ which, in our sense present degrees different from sensibility face to face of this shape of pollution with an ascendancy at *Fraxinus angustifolia* and in this particular case at the level of the axis 1.

While at the level of the site 2 where the road traffic is the most intense, *Eucalyptus camaldulensis* situated along the main highway register **138.37 µg/g**, while *japonica Eriobotrya* accumulated only **58.8 µg/g** in 5 m. These results denote a specific difference as for the reaction towards the pollution of lead and consequently a strong accumulation is indicated at the species to the persistent foliage. This is confirmed by **Madany and al. (1990)** who demonstrates that the emitted polluting particles are better got by the rough surfaces with embossed; but the presence of a pilosity also favors their retention by the smooth skins where covered with cuticles and it for the same site and the same exposure in the automobile pollution **[28]**. While **little (1978),** notice that the rough leaves can collect ten times more lead than the smooth leaves **[29]**.

Besides, we register a net temporal lead accumulation between May and September during the period of drought. Generally, we consider that the precipitation during March and April tend to wash particulars pollutants at the level of the foliage, what influences the lead concentration accumulated. Thus dusts containing heavy metals accumulate on the air parties, particularly the leaves. This deposit of surface of leaves can be qualified as latent pollution, because the cuticle is considered as aim pervious barrier which opposes the penetration of pollutants in leaves. **Arvik and Zimdahl (1974)** showed that very fine lead particles could penetrate into stomata, but it is improbable that big lead quantities penetrate in this way thus this process can be responsible only for a low part of the contamination of leaves by the lead **[30]**.

However, when leaves age, the efficiency of this barrier is altered; then it appears microphone cracks and pollutants which remain normally on-surface can penetrate easily **[31]**. But also, lead particles put deposited on the surface of leaves do not practically penetrate inside and can be easily washed. The most important of the ways of the harmful share of pollutants consist in their penetration in the organs of breath of vegetables represented by the stomata of leaves **[32].**
These vascular plants testify well of the air quality to be able to them accumulator. However the latter rest always function of the nature of the species (its morphology, its vegetative cycle), of the exposure time, the intensity of the pollution, and to the environmental factors such as the direction of winds, the precipitation, the humidity ....etc

The spatiotemporal follow-up of the moderate physiological parameters (content in chlorophyll,) testifies well of the air quality of every site.
The follow-up of the counting of vehicles on three road main trunk roads serving the urban area of Annaba demonstrated well the intensity marked with the road traffic at the level of the R.N.16 Annaba-El-Hadjar with regard to two other axes or it remains nevertheless not insignificant.

Besides, the variation of the physiological parameters of the used vegetables for which the accumulated lead content, is largely responsible in a parallel to other pollutants which can interfere seen the presence of several polluting infrastructures. However, we deduct that all the species of a perimeter, affected by a pollution do not react in the same way to pollutants. However there are intrinsic factors in plants, morphological where physiological, which determine the resistance, the tolerance where the sensibility of plants. Other factors biotic aged-related, at the physiological stage can intervene also in the sensibility of vegetables in this pollution of lead **[31].**

IV. CONCLUSION

Considering the lead important contents accumulated by the used bio indicators we can extract two main conclusions:

- ✓ The species used in our study have proved of very good bio accumulative of lead, nevertheless the species of lichen: *Ramalina farinacea* present a power much higher accumulator that of the vascular plants.
- ✓ There is a strong urban pollution especially of lead in the region of Annaba particularly at the level of three main highways serving the urban area with ascendancy at the level of the axis 2.

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