

1 **Evaluation of levels of lead pollution from automobiles near Highway**  
2 **using phanerogamic and cryptogamic species in the city of Annaba**  
3 **(Algeria).**

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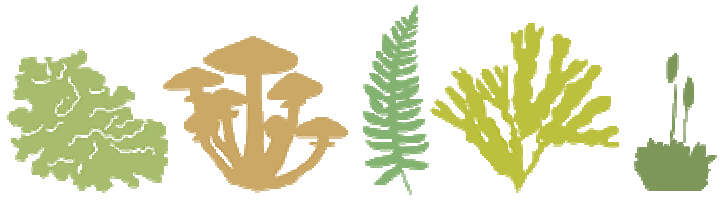
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15 Nowadays, a serious problem emerged in the natural environments of many countries:  
16 they are increasingly subjected to a large number of air pollution: industrial pollution,  
17 pollution related to agriculture, but also pollution related to transport. The pollution of lead  
18 has constantly evolved over time, due to the considerable increase in the number of vehicles  
19 on the market. Our work is based primarily on the use of plants as bio indicator of air  
20 pollution in the region of Annaba.

21 The evaluation of the pollution levels near the main roads is a complex exercise, given the  
22 many factors to consider at this scale. To do this, we chose three locations on three main  
23 roads Greater Annaba: ((RN 44): Annaba - El Kala; (RN 16): Annaba - El Hadjar; (RN 44):  
24 Annaba - Skikda), plants used are: phanerogamic namely species (*Fraxinus angustifolia*,  
25 *Eucalyptus camaldulensis*, and *Eriobotrya japonica*) and a fungal species (a lichen (*Ramalina*  
26 *farinacea*)).

27 An appropriate sampling strategy, a spatio-temporal monitoring, a counting vehicle at our  
28 study sites and measurements of physiological parameters combined with the determination  
29 of lead allowed us to assess not only the state of the air quality but also the impact of this  
30 pollution on the environment caused by a heavy traffic in the area.

31 **Keyword:** Pollution, lead, bio indication, bioaccumulation, road traffic, Annaba, Algeria.  
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41 **1. INTRODUCTION**



42 During the last century, the industrialization and the development of transport played a  
43 major role in the evolution of society. These activities were synonymic of progress, modernity  
44 and enrichment. But since, an increasing awareness is felt as for the engendered  
45 environmental consequences. Indeed, big quantities of chemical substances are loosened in  
46 the environment, of which most of them being considered as dangerous. The introduction of  
47 these compounds implies serious risks for the environment and the alive bodies, in particular  
48 the human health [1]. Among different pollutants poured regularly in the atmosphere, the  
49 lead of motor origin occupies a dominating place; its toxicity for the biocenosis is evident and  
50 deteriorates more and more through the food chain to become dramatic by affecting the man  
51 [2].

52 In Algeria, our capital was classified number one in the report of the World Bank, due to the  
53 180 tons of lead which glide permanently in the atmosphere [3]. For that purpose, at the level  
54 of the region is from Algeria, and more particularly in the region of Annaba; there is for  
55 several years a progressive problem of atmospheric pollution bound to an important road  
56 network [4,5,6]; On one hand because of the existence of a very important motor vehicle  
57 population with regard to the traveled distances, and on the other hand of certain topographic  
58 characteristics (the closeness of the sea, the existence of plans of water, the presence of the  
59 heights and their orientations, these topographic devices in basin and in corridor favors the  
60 phenomenon of temperature inversion and its obstinacy) and climatic (the relative humidity  
61 always very high all year long and the direction of winds pulling alternative movements of air  
62 land breeze, sea breeze, contributing to maintain pollutants above the zone of broadcast, as  
63 well as a naturally frequent fog to Annaba) which create a climate convenient to the  
64 development of the pollution [5,6].

65 Since the seventies of numerous researches were led on the use of vegetables as bio  
66 indicators and bio accumulators of the pollution, particularly the lichens which reveal  
67 excellent results concerning the bio accumulation in particular that some heavy metals. [7-15 ;  
68 5,6]. The various components of the environment react to the pollution differently, the lower  
69 vegetables especially lichens often present physiological, morphological and structural  
70 changes before even the appearance the slightest symptoms of poisoning at the man [16].

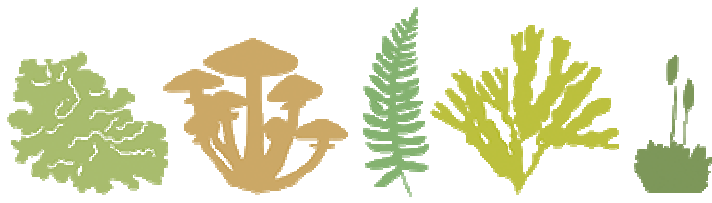
71 Our research on the study of the pollution plumbique of automobile origin in the region of  
72 Annaba by using in a relevant way the bioindicators, in particular lichens and some vegetables  
73 superior to the objective to characterize the environmental state of the middle studied by  
74 highlighting a plumbique pollution bound to the road traffic, to study the impact of the latter  
75 on the morphology and the physiology of the used vegetables and to propose relevant bio  
76 indicators of this pollution.

## 77 2. MATERIAL AND METHODS

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

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

85 - The axis RN 16 which connects the big and old two poles Annaba - El Hadjar,



- 86 - The axis RN 44 East- is connecting Annaba - El Tarf,  
87 - The axis RN 44 West – connecting Annaba to Constantine.  
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89 The population of the wilaya of Annaba did not stop increasing during these last years to  
90 reach 609 499 inhabitants where we register moreover an annual average of growth closely  
91 1,01 % and an irregular distribution of the population with a variation of the density from a  
92 municipality to another one. The axis Annaba - Sidi Amar and El Bouni represents the sites  
93 where the majority of the population are concentrated (44,65% to Annaba, 20,04% to El  
94 Bouni and 12,80% to Sidi Amar). The socioeconomic characteristics (commercial, industrial,  
95 university pole and the quality of the services) are factors limiting some distribution of the  
96 population [17].

97 Nowadays we find an important motor vehicle population by which the annual growth rate  
98 of car registration documents is only increasing year by year. From 2002 till 2003, the rate  
99 considerably increased from 0,92 % to 3,57 % [18]. In 2005, the realized analysis reveals that  
100 the vehicle of tourism represents a 68 % rate with regard to the other ways of transportation.  
101 Compared with the other Algerian wilayas, Annaba is ranked second after the capital with a  
102 park automobile reaching 100 000 vehicles, with 94 passenger cars for 1000 inhabitants and  
103 overtake widely Constantine and Oran which are respectively 79 and 81 cars for 1000  
104 inhabitants [19].

105 Since 2003, we registered an acceleration of motorization of more than 9 %, the latter rose  
106 during these last years respectively with a rate of increase of more of 14 % in 2004 and more  
107 than 42 % between 2004 and 2008.  
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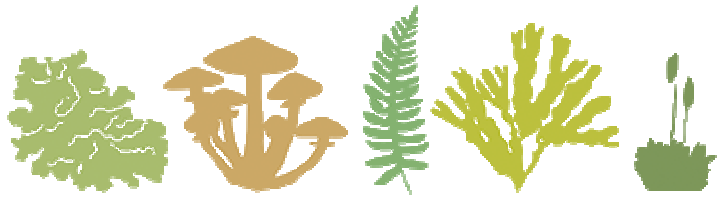
### 109 **1.1. Presentation of the zone of study**

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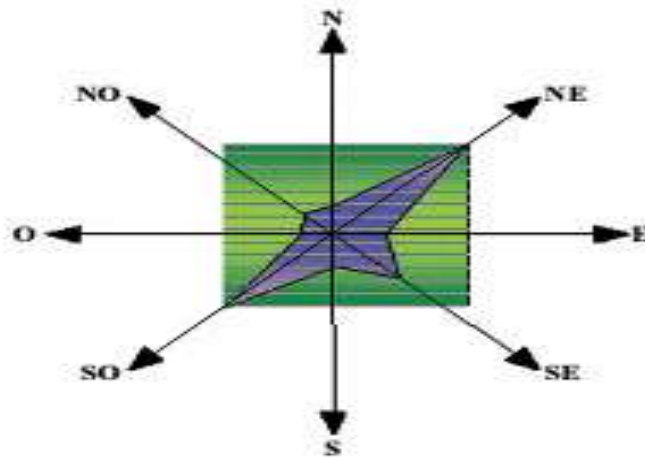
### 126 **2.2. The climatic parameters**

127 Certain climatic parameters are considered in our study because they have a role  
128 particularly mattering in the distribution and the dilution of the impurities:

- 129 · The city of Annaba presents in general lines of Mediterranean type with floors bio - climatic  
130 sub-wet and wet;



- 131 · The climate is characterized by sweet temperatures in winter, warm in summer and plentiful  
132 precipitation;  
133 · The rose of winds allows to put in evidence a dominant direction of the wind of Northeast the  
134 western South (Fig. 2).  
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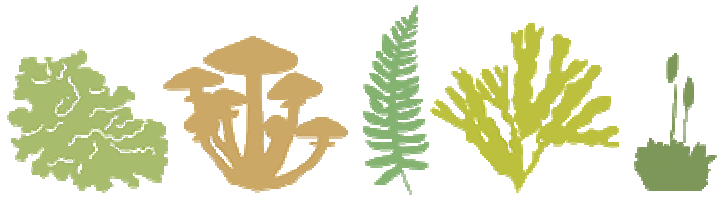


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140 **2.3. Choices of the sites of surveillance and measure of the automobile pollution:**

141 The evaluation of the levels of pollution near the axes of circulation is a complex exercise,  
142 considering the numerous factors to be considered in this scale. The concentrations in  
143 pollutants registered in border of way indeed depend on local broadcasts generated by the car  
144 traffic (depending themselves on conditions of traffic and on the composition of the motor  
145 vehicle population), parameters influencing the dispersal of pollutants (local meteorology and  
146 configuration of public road network) and levels of thorough concentration of the  
147 surrounding zones.

148 To do it, we chose three sites located on three main highways serving the urban area of  
149 Annaba (Fig. 23):

- 150  
151 · Site 1: (R.N. 44): Annaba-El Kala, it is approximately 4 km in the Southeast of Annaba.  
152 · Site 2: (R.N. 16): Annaba-EL Hadjar. It was chosen in 5 km in the South of Annaba.  
153 · Site 3: (R.N. 44): Annaba-Skikda: it was realized in 3 km in the Southwest of Annaba.  
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## 2.4. 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 exposed on 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:

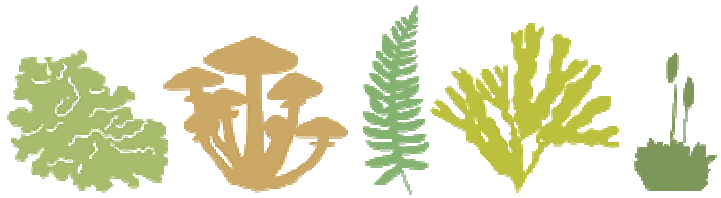
### 2.4.1. Phanerogamic species "in situ":

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

#### 2.4.1.1. *Fraxinus angustifolia*

The Ash tree with narrow leaves or ash tree of Noon (*Fraxinus angustifolia*) from Greek phraxis, "hedge", Or of the Latin fraxinus, "lightning", because isolated, it attracts the lightning. It is a tree belonging to the family of Oleaceae (family of the olive tree) and in the genre Fraxinus.

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194 **2.4.1.2. *Eucalyptus camaldulensis***

195 The red gum tree (*Eucalyptus camaldulensis*) is a tree of the genre eucalyptus which we  
196 find in numerous continents but which is native of Australia where it is widely spread at the  
197 edge of the rivers of the inside of the country. Curiously, it pulls fires, hisLatin name of the  
198 convent of Camaldoli near Naples, place where it was described for the first time;it was  
199 introduced in Europe, where it very well acclimatized on the Mediterranean banks, as well as  
200 in Portugal, where immense forests were planted for the production of paper mass. It was also  
201 planted in North Africa, notably in Algeria, in Morocco, in Libya and in Tunisia.

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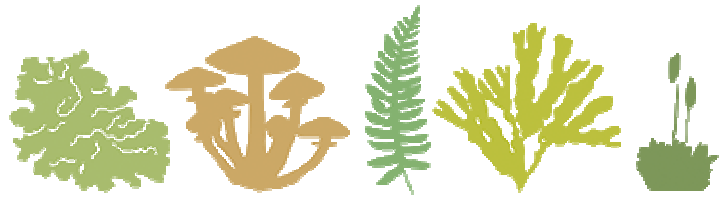


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205 **2.4.1.3. *Eriobotrya japonica***

206 The medlar of Japan either bibacier (*japonica Eriobotrya*) is a tree of the family of Rosaceae  
207 (tribe of Maleae), cultivated as fruit tree in the hot regions for its edible fruit, the medlar of  
208 Japan or bibasse, or more widely as decorative plant.

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#### 2.4.2. Cryptogamic species

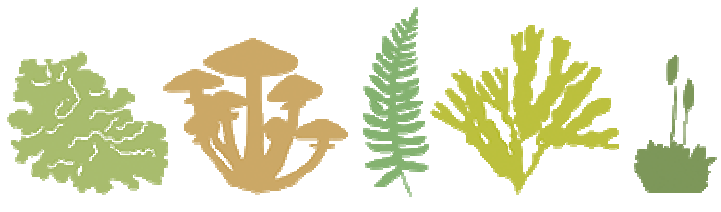
The lichen is a complex vegetable trained by the association of a mushroom the mycosymbiote, heterotrophic (dependent on another human being for its carbon food) and a seaweed, the phycosymbiote, autotrophic (capable of photosynthesis), both living in symbiosis.

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 physico-chemical measures can turn out to be difficult to realize.

Our choice concerned a fruticuleuse 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 populating lichéniques [8, 21, 22]. We transferred these samples to the levels of the various chosen sites of transplantation. The transplantation took place on January 15th, 2009 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.



243 · Site 3: (R.N.44): Annaba-Skikda: the transplantations of the fragments of branches of  
244 *Oleaurospora* covered with *Ramalina farinacea* were fixed to *Eucalyptus camaldulensis*  
245 between both senses of the highway in 2 m; we also used the leaves of *Fraxinus angustifolia* in  
246 2m.

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

## 252 **2.5. Technique of takings of samples:**

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

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

## 261 **2.6. Analytical Techniques:**

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

267 Before proceeding to the dosage of the lead in samples, it is necessary to establish at first a  
268 curve of calibration from the solutions of lead known concentrations.  
269 The results are directly read on the device if it is preset according to the indications of the  
270 builder or on the curve of calibration in microgram of lead. The used device is a  
271 spectrophotometer (Perkin-Elmer model 400)

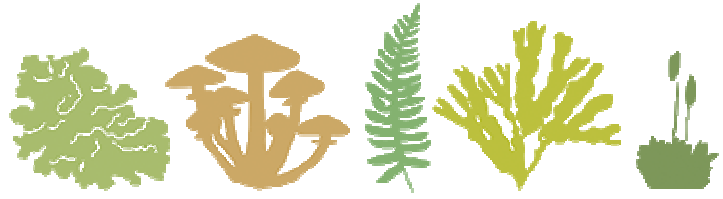
272 - For the dosage of the chlorophyll, we used the method proposed by Rao and The White [23],  
273 the used device is the spectrophotometer in two wavelengths 645nm and 663nm (Genesys™  
274 8).

275 - The method used for the dosage of the proline is the one of Troll and Lindsley [24] simplified,  
276 finalized by Dreier and Göring [25]. The used device is the spectrophotometer in the  
277 wavelength 528nm (Genesys™ 8).

278 - Having taken the fresh samples leaves and lichens from ground, we took a number of leaves  
279 which we weighed ( M.F.) and 1.5g lichens (M.F.), then put in the steam room in 105 °C during  
280 72 a hour to determine M.S.. So the report M.F./M.S. An idea onto the purity of the air of the  
281 site in question [26] is defined to give us. More the air is pure is more the development of the  
282 vegetable is normal that is the fresh material is in its optimum on the other hand if the air is  
283 polluted it entrains the appearances of chloroses, necrosis to the detriment of the  
284 fresh material.

## 285 **2.7. Appreciation of the road traffic:**





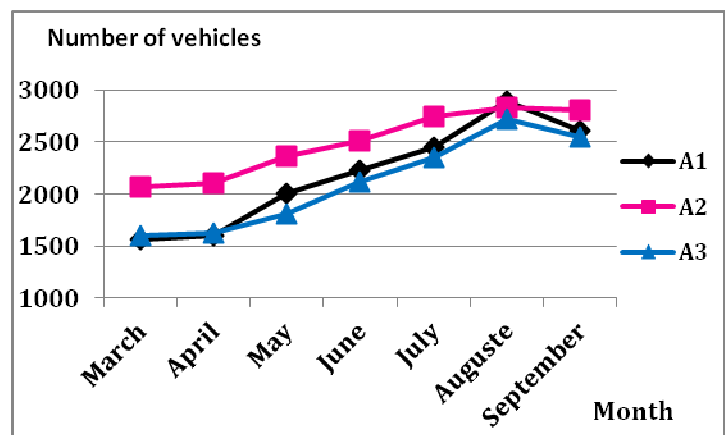
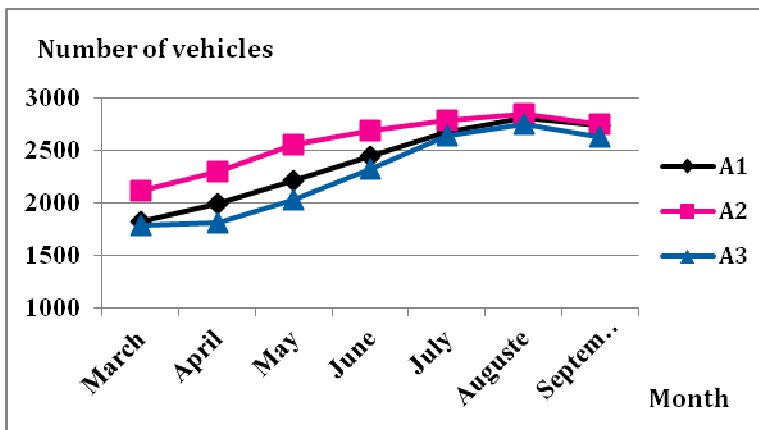
The counting of vehicles was made at the level of three main highways in the region of Annaba. We chose a site of just counting of vehicles instead of lichénique transplantation during the rush hours: 8 am at 9 am, 12 am at 1 pm and 4 pm at 5 pm.]. This counting was thus made at the rate of three times a day and once every week; the monthly average being taken into account and it during 07 months as from the month of Mars until September.

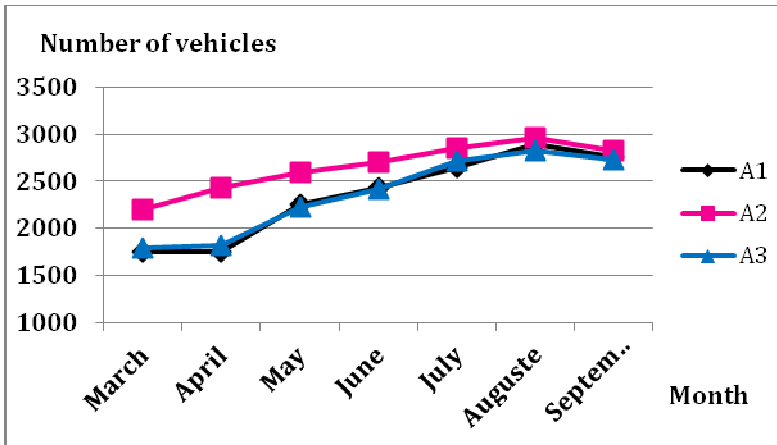
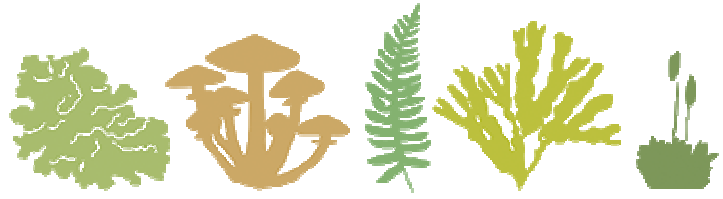
### 2.8. Statistical analysis of the data:

The tests of analysis of the variance in two criteria of classification were used to make a comparison for every characteristic between sites on one hand and between months of experiment on the other hand [27]. All the calculations were realized by the commandof stepwise of the software MINITAB.

## 3. RESULTS and DISCUSSION

### 3.1. Variation of the volume of traffic long-distance truck driver at the level of three axes serving the urban area of Annaba during rush hours





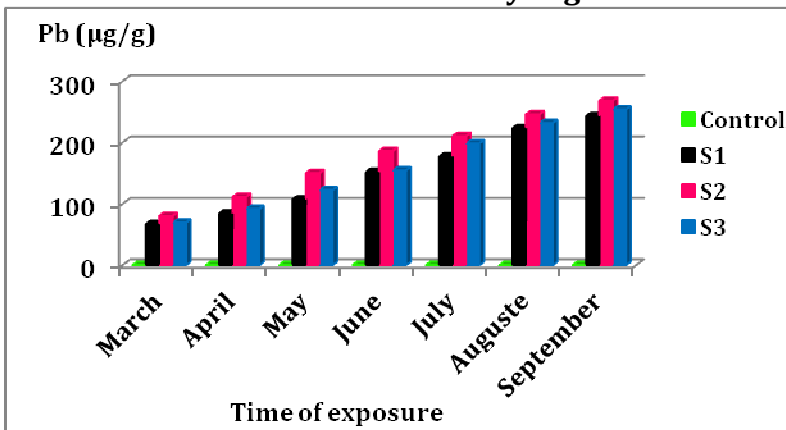
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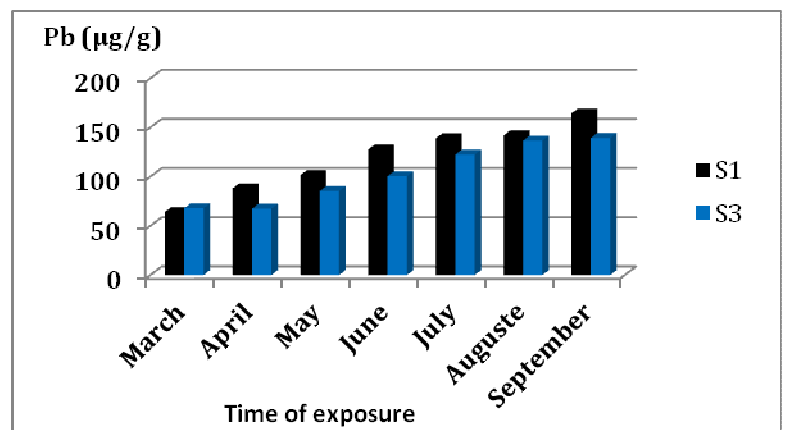
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### 3.2. Bioaccumulation of the lead by vegetables



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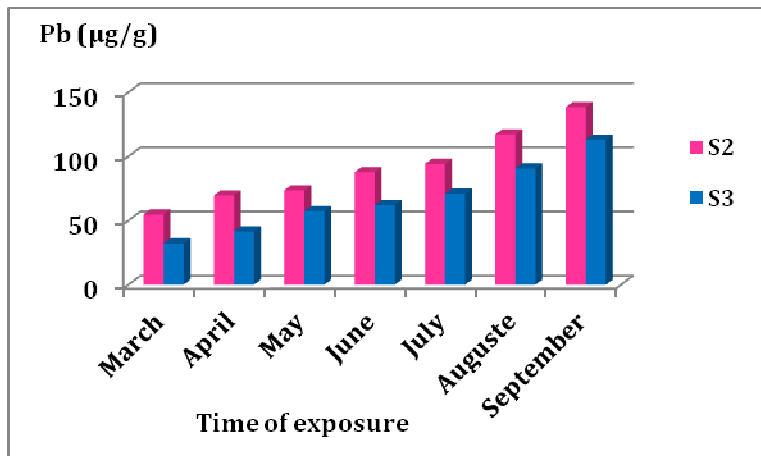
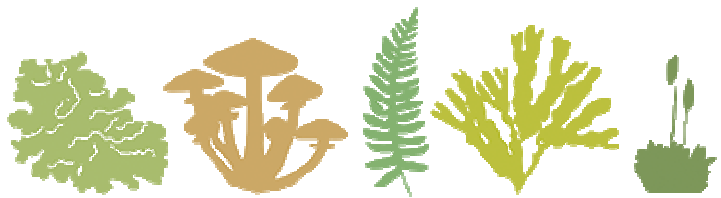
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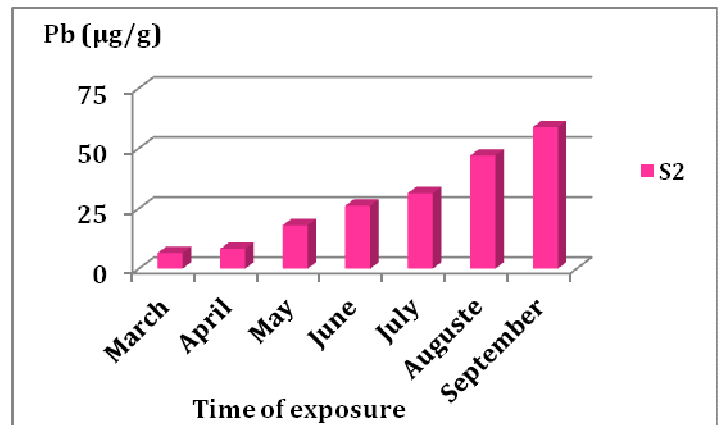
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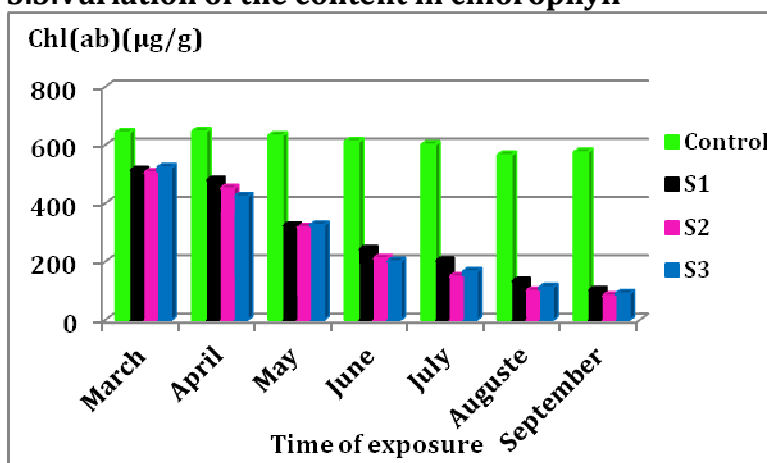


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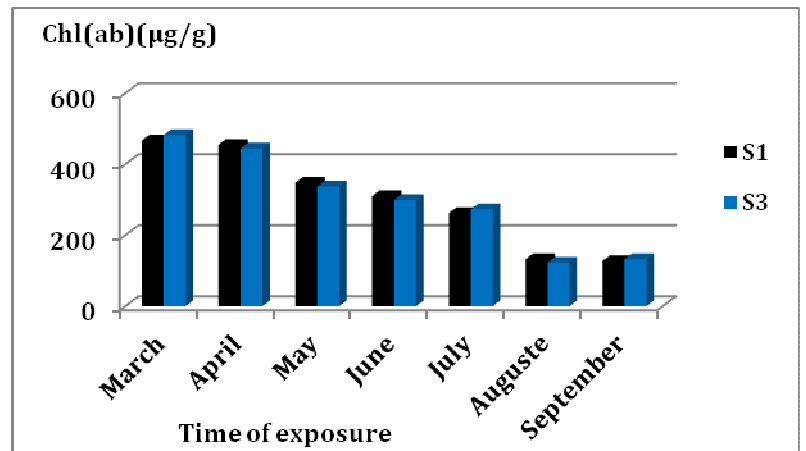
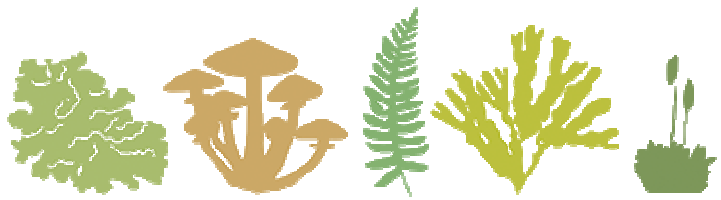


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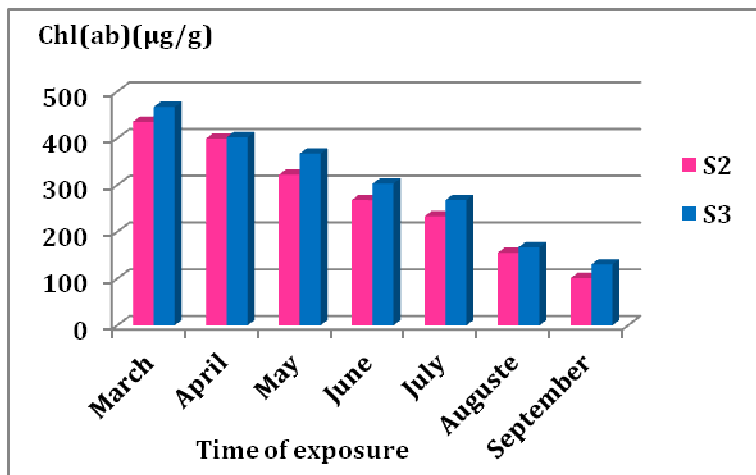
### 3.3.Variation of the content in chlorophyll



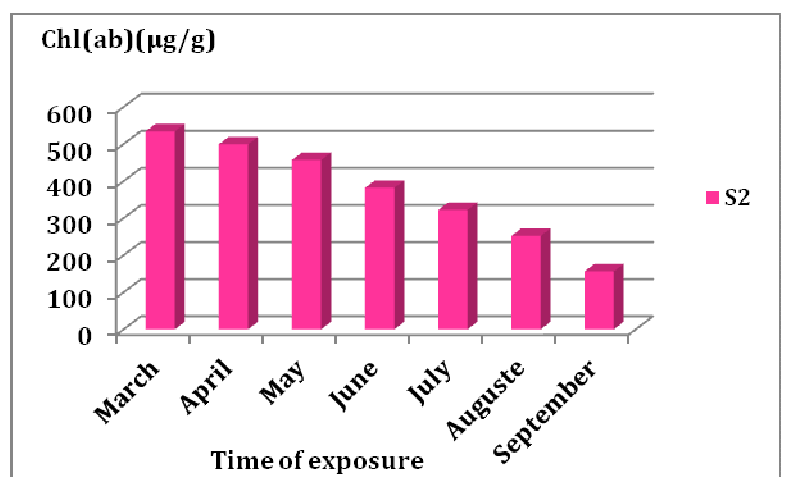
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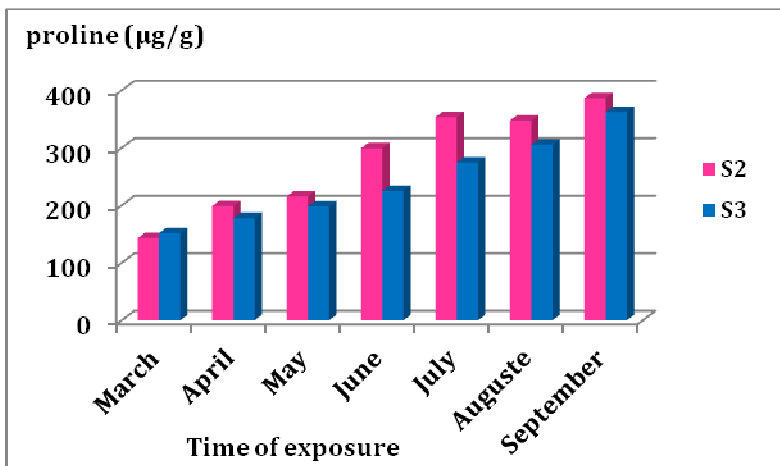
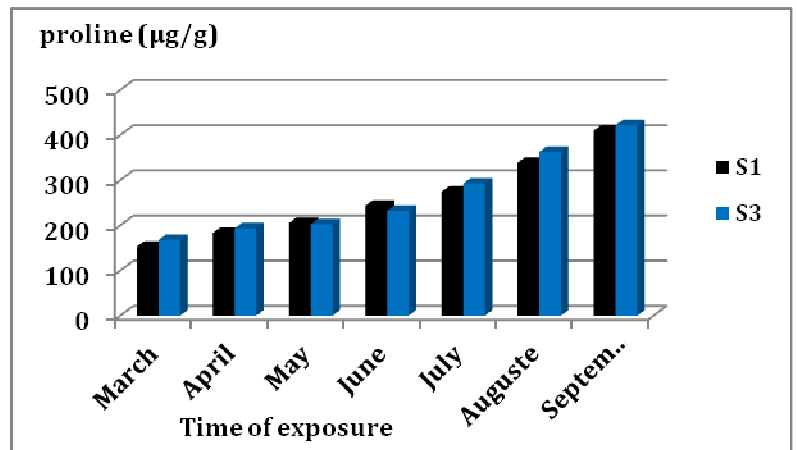
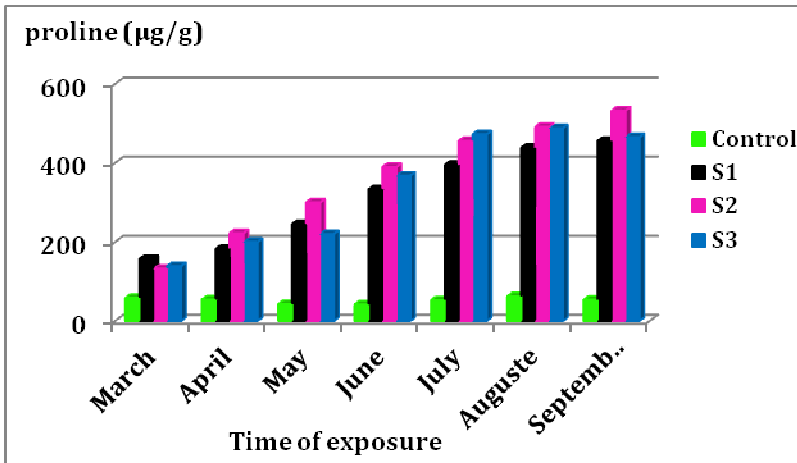
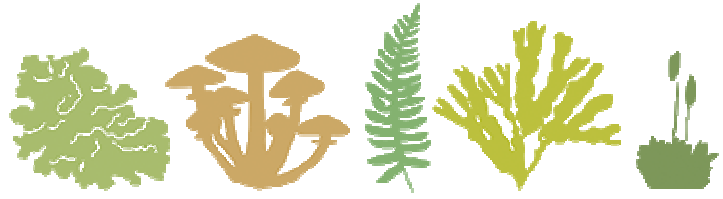
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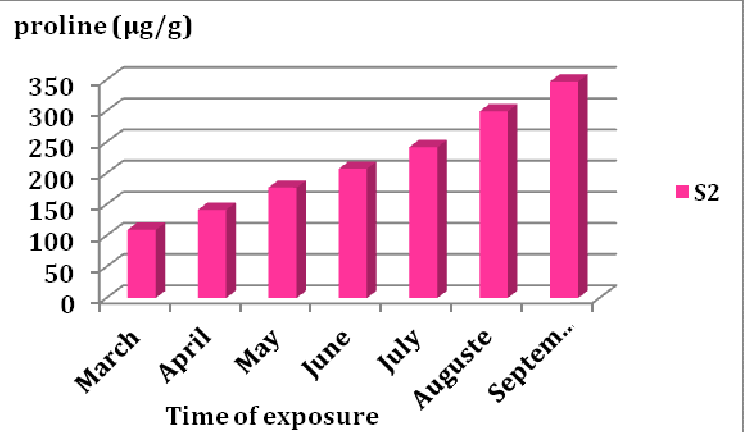
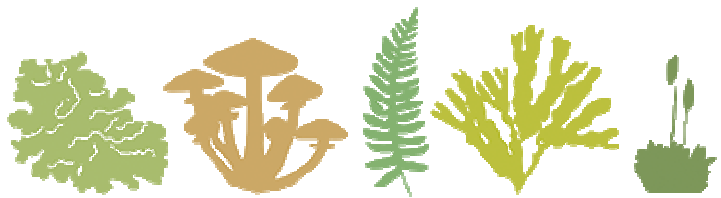
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### 3.4.Variation of the content in proline

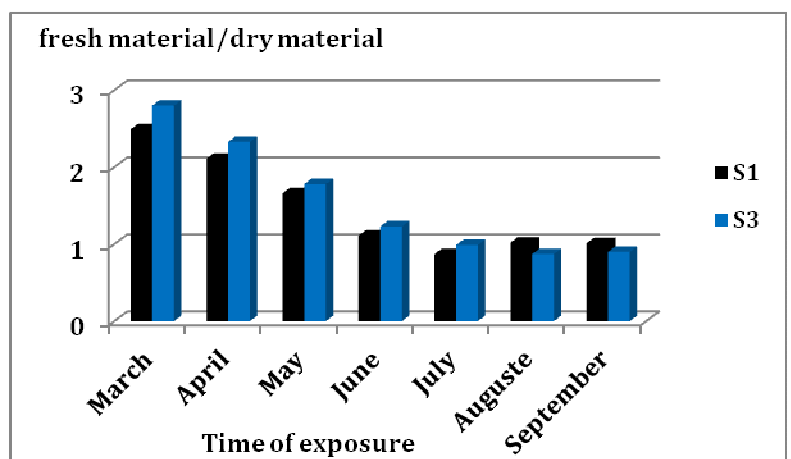
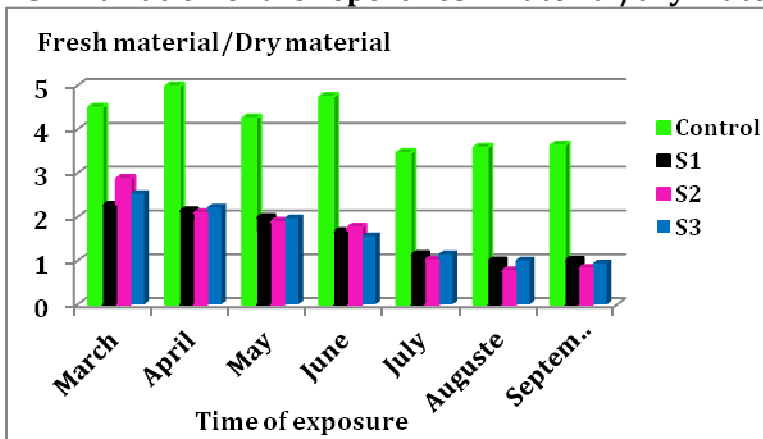
# XX SIMPÓSIO DE BOTÂNICA CRIPTOGÂMICA

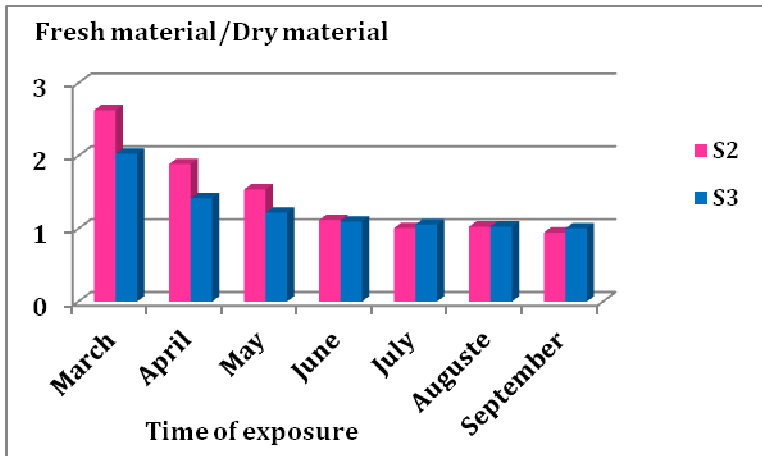
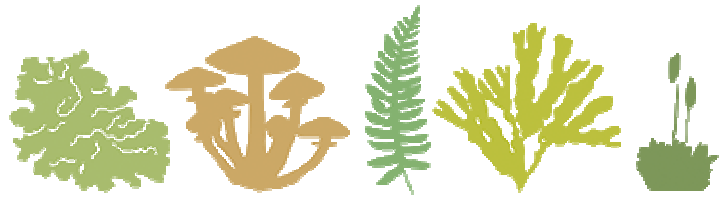
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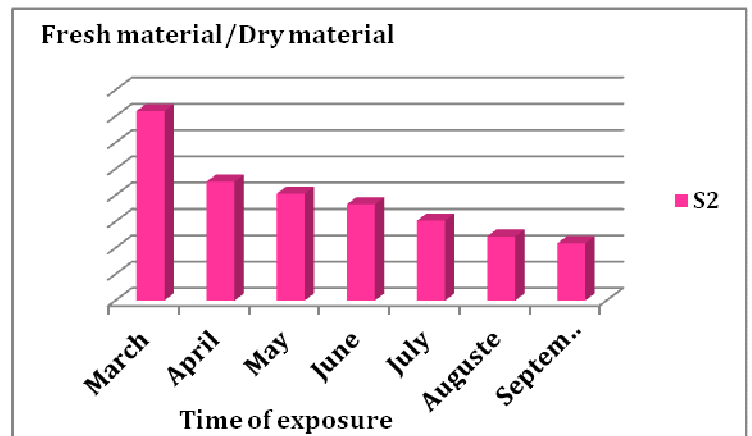


### 3.4.Variation of the reportfresh material/dry material





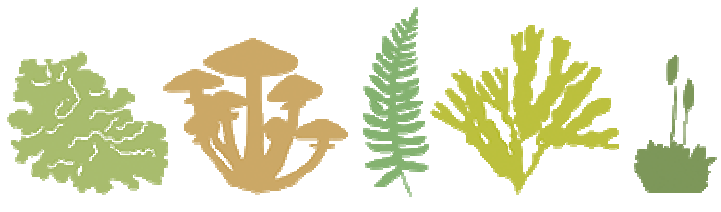
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353 In comparison with the volume of road traffic at the level of three axes for the same  
354 schedules of counting, we notice that there is no difference between the axis 1 and 3 during  
355 the schedules of counting, on the other hand the latter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

361 Concerning the accumulation of the lead, the results which we obtained demonstrate well  
362 the presence of a strong pollution of lead by automobile origin, not only revealed by the use of  
363 transplants lichéniques (the most sensitive bioindicators) which accumulate approximately  
364 268,33  $\mu\text{g/g}$ , but also by certain phanerogamic species in situ which, in our sense present  
365 degrees different from sensibility face to face of this shape of pollution with an ascendancy at  
366 *Fraxinus angustifolia* and in this particular case at the level of the axis 1.  
367 While at the level of the site 2 where the road traffic is the most intense, *Eucalyptus*  
368 *camaldulensis* situated along the main highway register **138.37  $\mu\text{g/g}$** , while *japonica*  
369 *Eriobotrya* accumulated only **58.8  $\mu\text{g/g}$**  in 5 m. These results denote a specific difference as for



370 the reaction towards the pollution of lead and consequently a strong accumulation is  
371 indicated at the species to the persistent foliage. This is confirmed by **Madany and al.**  
372 **(1990)** who demonstrates that the emitted polluting particles are better got by the rough  
373 surfaces with embossed; but the presence of a pilosity also favors their retention by the  
374 smooth skins where covered with cuticles and it for the same site and the same exposure in  
375 the automobile pollution [28]. While **little (1978)**, notice that the rough leaves can collect ten  
376 times more lead than the smooth leaves [29].

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

387 However, when leaves age, the efficiency of this barrier is altered; then it appears  
388 microphonic cracks and pollutants which remain normally on-surface can penetrate easily  
389 [31]. But also, lead particles put deposited on the surface of leaves do not practically penetrate  
390 inside and can be easily washed. The most important of the ways of the harmful share of  
391 pollutants consist in their penetration in the organs of breath of vegetables represented by  
392 the stomata of leaves [32].

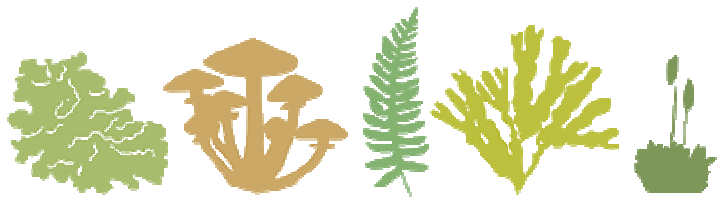
393 These superior vegetables testify well of the air quality to be able to them accumulator.  
394 However the latter rest always function of the nature of the species (its morphology, its  
395 vegetative cycle), of the exposure time, the intensity of the pollution, and to the environmental  
396 factors such as the direction of winds, the precipitation, the humidity ....etc

397 The spatiotemporal follow-up of the moderate physiological parameters (content in  
398 chlorophyll, in proline and the report Fresh material/Dry material) testifies well of the air  
399 quality of every site.

400 The follow-up of the counting of vehicles on three road main trunk roads serving the urban  
401 area of Annaba demonstrated well the intensity marked with the road traffic at the level of the  
402 R.N.16 Annaba-El-Hadjar with regard to two other axes or it remains nevertheless not  
403 insignificant.

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





#### 4. CONCLUSION

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

➤ The species used in our study have proved of very good bio accumulative of lead, nevertheless the species lichénique: *Ramalina farinacea* present a power much higher accumulator that of the superior vegetables.

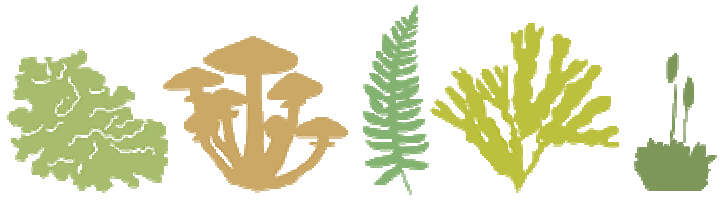
➤ There is a strong urban pollution especially of lead in the region of Annaba particularly at the level of three main highways serving the urban area with an ascendancy at the level of the axis 2.

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