The use of lichensbioindicators in the identification of air pollution.

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Abstract

The Sétifrégion is rich in lichen species, 31 species of lichens are identified, divided into 8 families and 14 genera. The family of Physciaceae is the most important, represented by 9 species of lichens, followed by Lecanoraceae and Teloschistaceae with 8 and 6 species respectively. By the presence of these bio-indicator organisms we quantified the rate of air pollution in the wilaya of Sétif. The nearest stations to the sources of pollution are low in lichen species, by against the more remote stations of pollution sources (North stations) are rich in lichens.The lichens have enabled us to quantify and map the rate of pollution in the wilaya of Sétif.

Keywords: Lichens, Pollution, Air Quality Index, Map Pollution, Sétif, Algeria

Introduction

The study of lichens in Algeria has begun there more than a century, but as explorations of naturalists; who were the collection of lichen species that are harvested on their path. These specimens are identified by Nylander who cited in "prodronuslichenographiaegaliae and Algerians" 189 lichens. Several botanists have then succeeded in this and have marked the history of the Algerian lichenology (Boutabia 2000).

The lichens are actually susceptible to air pollution and are widely used in bio monitoring studies (Nash, 1988; Bargagli, 1998; Dzubaj*et al*., 2008), the bioaccumulation studies, and measurements of the concentrations of substances in organisms, resulting from the pollution (Clement *et al.*, 1995, Van Dobben*et al.*, 2001;. Bargagli*et al*., 2002; Bergamaschi*et al.*, 2007;.Maizi*et al*., 2010). Lichens are very sensitive to gas emission in particular those containing

heavy metal (Douibi*et al*., 2015).

The lichens are considered as appropriate tools to monitor the relative levels of air pollution; in fact they are able to accumulate and store many substances suspended in the environment (Baffi*et al.,* 2002).The contamination of the atmosphere is due to industrial production and vehicular traffic, continuous emission of pollutant in the air is sometimes associated with the combustion process that degrades the environment and human health (Andersen, 2009).

The lack of roots, waxy cuticle and stomata, facilitates the ingress of contaminants within the thallus (Puckett *et al*., 1973; Sloof, 1995; Reis *et al.,* 1999), ahdby their slow growth, the lichens are ideal for long-term studies of air pollution (Stamenkovic et Cvijan, 2003). This study was conducted to evaluate air pollution by the lichens bio-indicators in the region of Setif (Algeria).

Materials and methods

1- Study Area

The Wilaya of Setif is an important junction, which vehicular traffic is very dense. In each Dairas of the Wilaya (region) of Setif (Figure 1) a sampling of lichens was conducted.The lichen surveys are conducted using a transparent grid (20cm × 50cm), with squared mesh 10cm × 10cm in each station six surveys are performed. The results are reported in trees index cards and then grouped in sheets stations. The frequency of each species indicates the air quality index for each station.

Figure 1: Stations sampled in the Sétif region

2- Methods

The method Kirschbaum and Wirth (1997) is applied to the identification and quantification of air pollution in 20 Daïras the Wilaya of Setif. It consists in to transcribe on a map area, a defined surface, a color symbol corresponding to an air quality index, measured based on the identification of lichen species.

2.2.1- Computation the Air Quality Index (IQA)

This index is determined from the sum of the frequencies of lichens species. The estimate of the pollution is facilitated by wide Kischbaum and Wirth (1997) (Table 1).

Table 1: Scale estimation of air pollution

Pollution	Extremely high	Very high	High	Average	Low	Very low
Color						
IndexAQI	0 12.5	25	37.5	50	60	

3- Statistical analysis

Data were first subjected to PrincipalComponents Analysis (PCA) to examine the relationship between the Daïras (stations) and the presence of lichens. Cluster analysis (UPGMA)was carried out on the original variables and on theManhattan distance matrix to seek for hierarchicalassociations among the Stations. The cluster analyseswere carried out using Statistica v10 software.

Results and Discussion

1- Biodiversity of lichens

Out of all the sites explored; 31 lichen species have been identified. The stations of BeniOuartilane and Guinzet have a high number of species with (14 and 11 species) respectively. While the stations with a low number of species are Setif and El-Eulma with 5 species each (Figure 2).

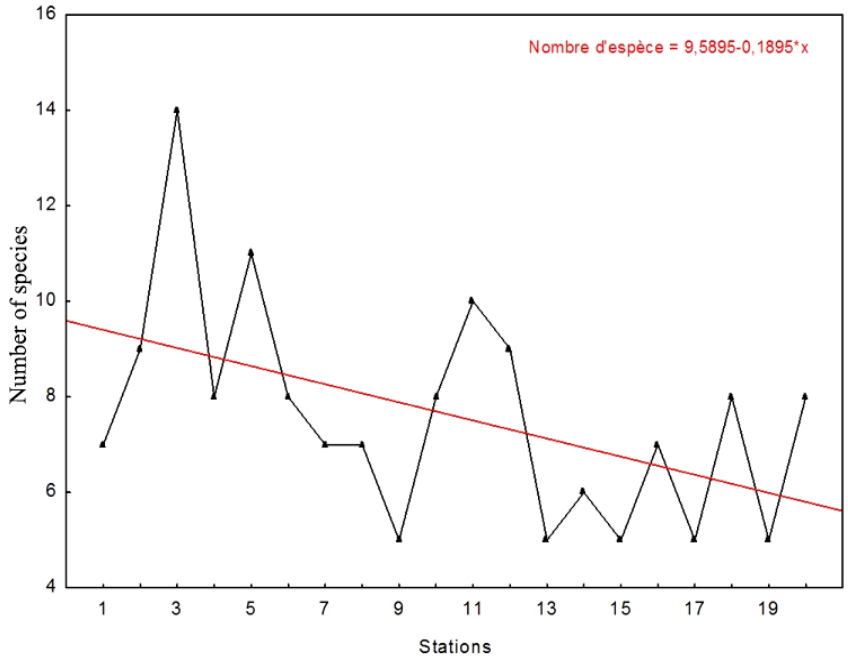

Figure 2: Variation of the number of species in stations studied

The regression curve shows that there is a decrease in the number of northern species south of the Wilaya of Setif; The Daïras of the north are rich in lichen species, probably because of the high humidity and presence of important vegetation, the number of species in the southern Daïras (Ain Azel and Salah Bey) is low.

1.1- Diversity of lichen families

The lichens identified in the study area, belong to 8 families (Figure 3). The family *Physciaceae*is the richest in number of species, with 9 species of lichens; followed by the families *Lecanoraceae* and *Teloschistaceae* with 8 and 6 species, respectively. The families *Thelotremataceae*, *Megasporaceae* and *Acarosporaceae* are represented by 2 species, while*Parmeliaceae* and *Caliciaceae* families are represented by a single species each.

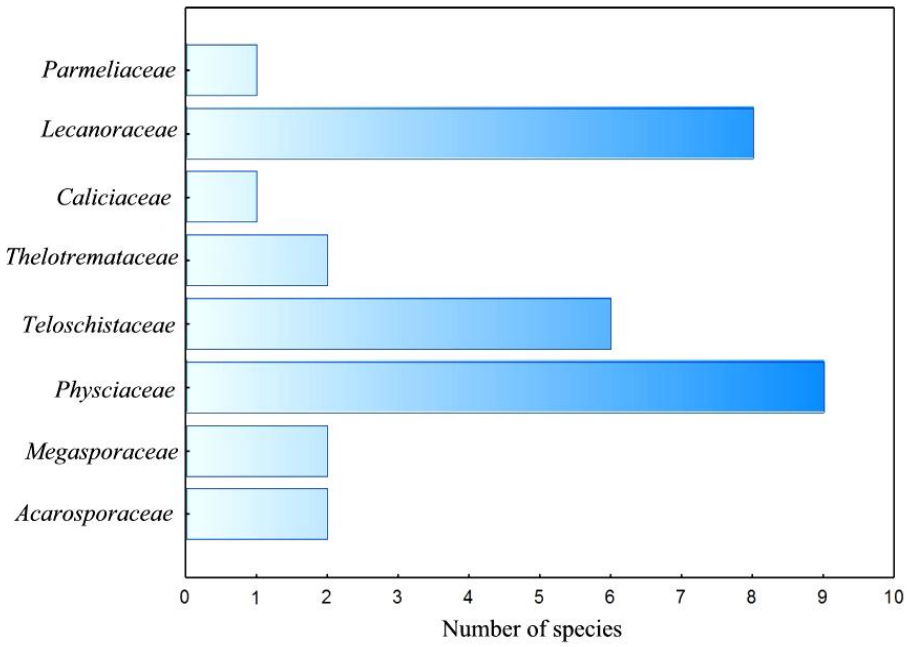

Figure 3: Variation in number of species per family.

1.2- Diversity of types thallus

The lichens of the study area are represented by three types of thalli. The crustacean thallus is the most representative in the field with 23 species; the foliaceous thalli are represented by 7 species (Figure 4). While fruticose thalli are represented by the single species *Heterodermia leucomelos*).

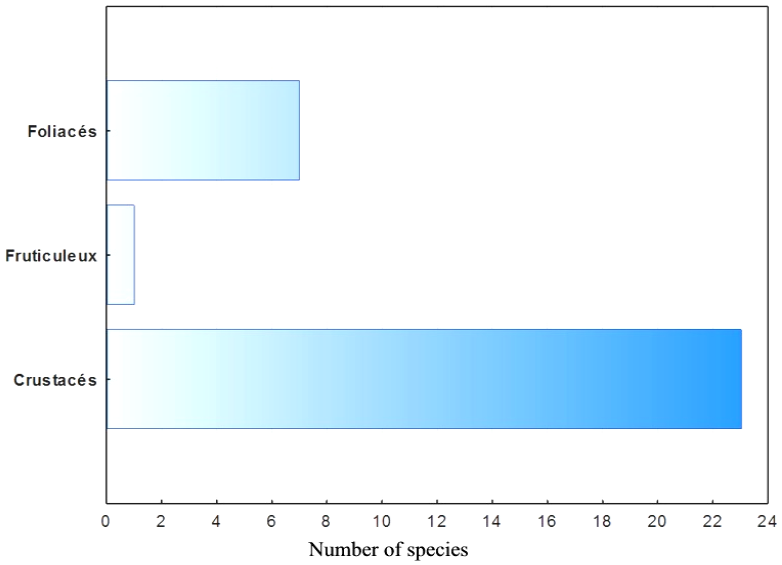

Figure 4: Variation of the types of thallus in the study area.

2- The pollution

The use of lichens associations, located in the Setif region, has allowed us to calculate the index of the air quality (IQA.) (Figure 5). The Daïras of Guenzet, Salah Bey, Djemila, Beni-Aziz and Ain-Arnet are characterized by a high IQA (28.8 to 49.6), but the Daïras of HammamSokhna, Bir El-Arch, Bougaa, El-Eulma and Setif are characterized by a very low IQA.

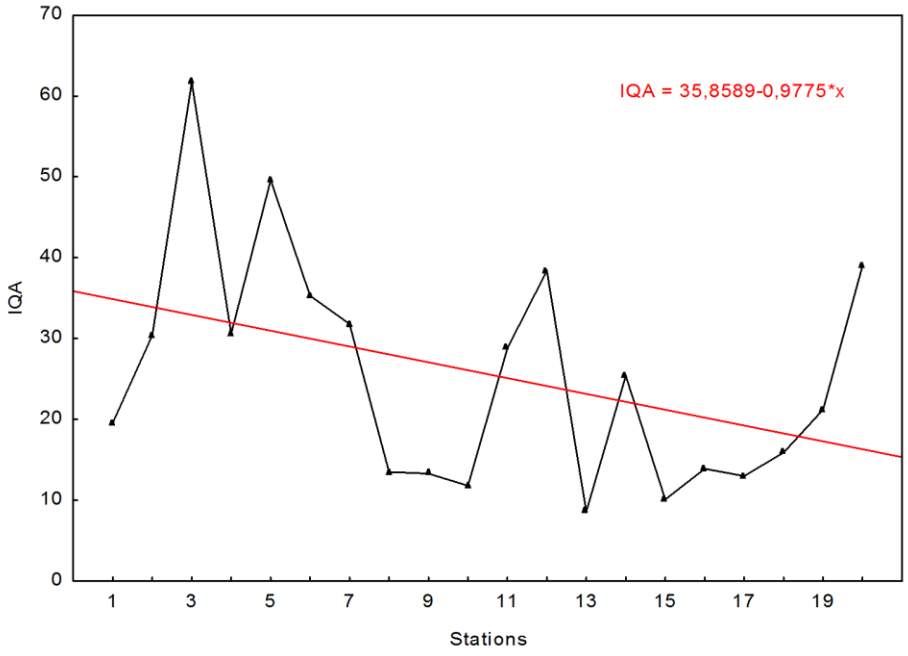

Figure 5: Variation in air quality index in the study sites.

The regression curve shows a significant decrease in air quality index (IQA) from North to South. This shows that the AQI is in direct relation with the presence of the lichen species. This includes that pollution in the northern stations of the study area is lower than the pollution in the southern stations. Calculates of IQA has allowed us to estimate the rate of air pollution in each Daïras (stations). More the index (IQA) is high; more the air pollution is low, so the air quality is good (Table 2).The Daïras of BeniOuartilene, Djemila, Saleh Bey and Guinzet are the least polluted in the study area. However the Daïras of Setif, El Eulma, Bougaa, Ain Oulmene, Ain El-kbira, Amoucha, Bir El-Arch, Ain Azel and Bouandes are the most polluted with a weak indices (IQA) (8.6-21.2)

Table 2: Pollution estimation in the studied stations

Daïras (Stations)	IQA	Pollution
Beni Ouertilen	61.70	**Verylow**
Guenzet	49.60	**Low**
Salah Bey	39.00	
Djemila	38.40	
Guedjel	25.40	**Average**
Ain Arnet	28.80	
Babor	30.41	
Beni Aziz	30.64	
Maoklane	31.80	
Hammam Guergour	35.30	
Ain-Oulmene	13.00	**High**
Ain-El-Kebira	13.30	
Amoucha	13.50	
Bir El-Arch	13.90	
Ain Azel	15.90	
Bouandes	19.60	
HammamSokhna	21.20	
Sétif	8.60	**Very high**
El-Eulma	10.10	
Bougaa	11.80	

3- Statistical Analyses

Comparing the level of presence / absence of lichen species in the study area presents a significant difference, especially regarding species (*Xanthoriaparietina*, *X. polycarpa*, *Physciaaipolia* and *P. stellaris*. The three-dimensional spatial projection of species based on the three main axes from the ACP (Figure 6) shows that our stations (Dairas) are grouped with separation of some stations.

The analysis of the UPGMA divided the regions as two assemblies. The first includes the Dairas of Guenzet and BeniOuartilane, whose pollution is low to very low with quality indices of air (49.6-61.7). The second assembly includes polluted regions and regions with low pollution (Figure 7).

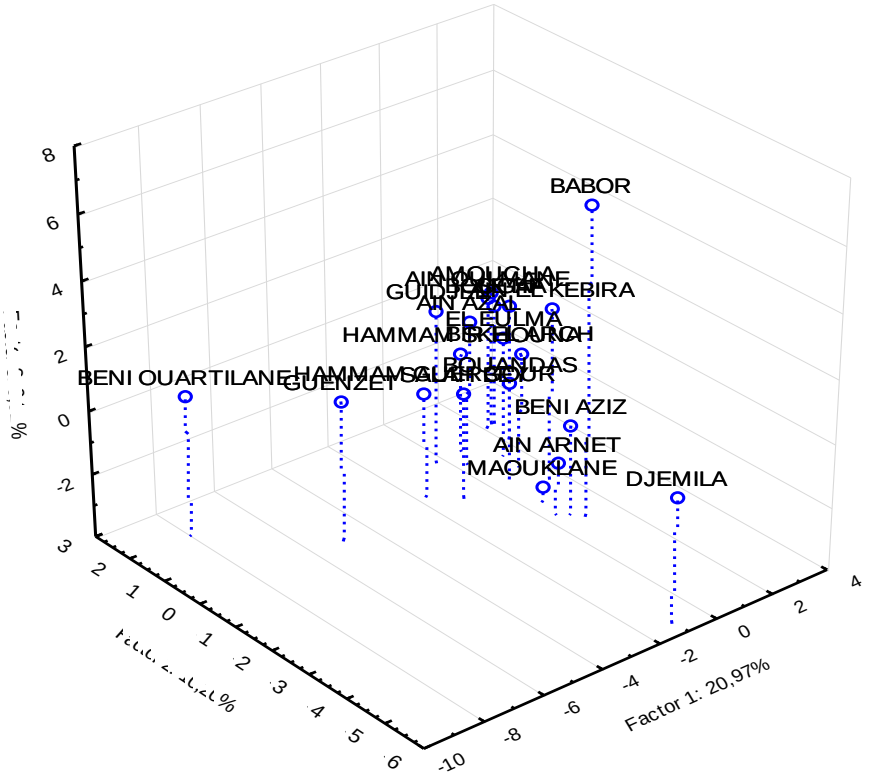

Figure 6: Spatial projection of species on the 3 axes from the ACP

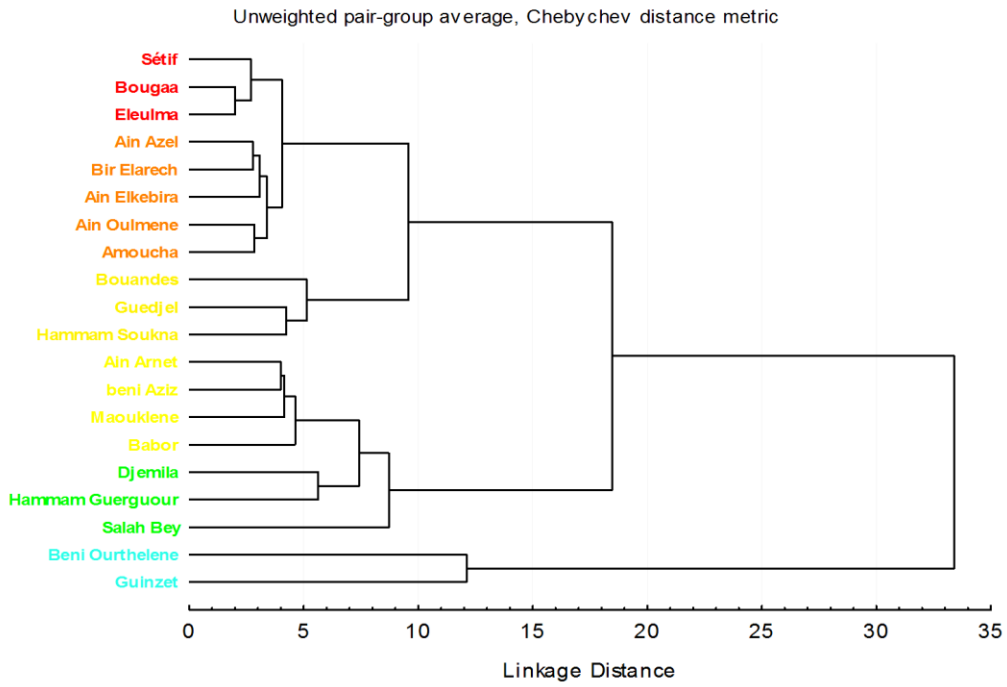

Figure 7: UPGMA des stations

The latter is divided into two groups; the first is represented by the stations with very high pollution (Setif, El-Eulma and Bougaa) and the stations with medium pollution (Ain Azel, BirElarech, ElKebira Ain, Ain Oulemene and Amoucha).The second group is formed by the low-pollution stations (Djemila, HammamGuergour and Salah Bey) and the stations with a average pollution (Bouandes, Guedjel, HammamSoukna, Ain Arnet, Beni Aziz, Maouklene and Babor). Using the indices of pollution and the results from the UPGMA, we could establish the map of air pollution distribution of the Setif region (Figure 8).

Discussion

The inspection and sampling of lichens in the study area, have allowed us to identify 31 lichen species, distributed in 14 genera grouped in 8 families; these numbers are close to those cited by lograda et al., (2015). In the region of OranMosbah(2007),cita 14 lichen species.

In the list witch we identified, two species (*Physciaaipolia* and *P. leptalea*) are protected by the Algerian law (Décret N° 12-304, Janvier 2012). The species *Heterodermialeucomela*, found in the study area is considered extinct in Germany and threatened in Italy and Great Britain. The species *Physciaaipolia*and *P. Stellaris* are registered in the Red List of Threatened Species (Scheidegger*et al*., 2002).

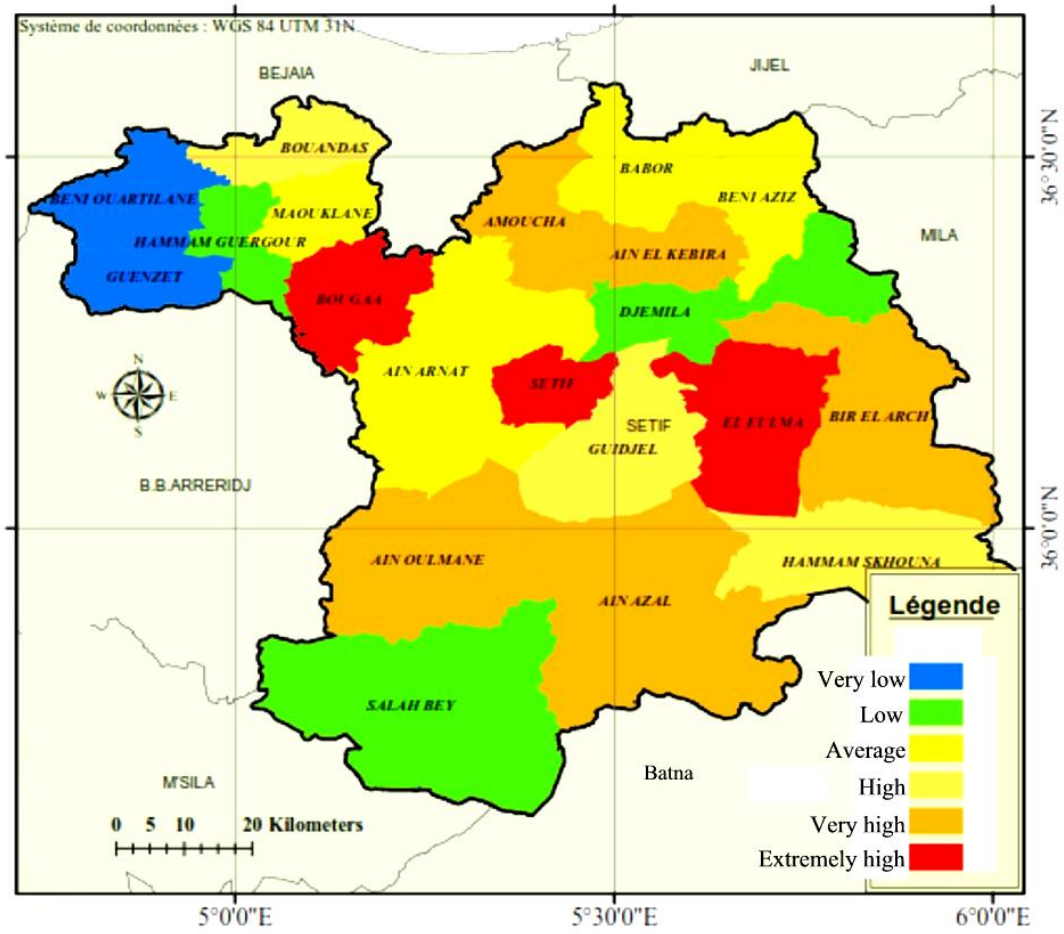

Figure 8: Map of the pollution in the Wilaya of Setif

The morphological groups of lichens found in the Setif region are foliaceous and crustaceans, these groups have predominantly meeting on phorophytes (Nattah*et al*., 2012).

The using of the AQI and the map distribution of pollution, in the Setif region, show that the Daïras of Setif are divided into two group. The first group is represented by the Dairas crossed by the national road N°5, characterized by high pollution. This axis is characterized by very important road traffic. The second group, formed by the daïras of Guedjel, Ain Arnet, babor, Beni Aziz, Maoklane and HammamGuergour are characterized by low to medium pollution. Human activities are also able to issue various substances, mainly in large urban centres (Agnan*et al*., 2013).

Conclusion

Our study of the lichen vegetation of the Setif region, allowed us to identify 31 species of lichens.The calculation of the index of the air quality (AQI) showed that the Setif region has significant air pollution. The southern regions have a higher pollution than northern areas. Generally agglomerations (city centre), show the presence of high pollution, this is probably due not only to traffic but largely by decreased air circulation in this area

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