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Cartography of Air Pollution in an Industrial City in North-Eastern Algeria by Using Two Indexes: Poleotolerance Index and Atmospheric Purity Index

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Abstract: Of all the methods of studies on bio-estimation of air pollution by lichen flora, the authors cannot justify a choice of one method over another. Consultation of previous work by researchers has allowed us to compare these methods and to better understand their strengths and limitations. Under the terms of estimating the pollution, these methods are classified into three categories. Some are qualitative, quantitative and others are finally some indirect methods. The methods used to assess the overall air pollution relative value for each station studied. As part of our work, the authors have chosen a quantitative approach based on the combination of two methods. They are based on pollution indices obtained from mathematical formulas based on various parameters related to the lichen flora. They are represented by the I.P. (index poleotolerance) and the I.A.P. (index of atmospheric purity) and these two indices allowed us to map of global air pollution in the city of Skikda and petrochemical industry as well as peri-urban areas (Haddaiek, Hamadi Krouma, Hamrouche Hamoudi, Larbi Ben M'Hidi). The authors have identified areas of iso-pollution around different emission centers represented by the largest petrochemical area, traffic and households in urban areas of Skikda, Hamadi Krouma, Hamrouche Hamoudi and Larbi Ben M'Hidi.

Key words: Bio-diversity, bio-indication, lichenic flora, pollution, Algeria.

1. Introduction

The lichen bio-estimation of the air pollution remains substitute and sometimes complementary means to the physical sensors [1, 2]. Of all the methods of studies on the bio-estimation of the air pollution by the lichen flora there is no justification choice of one method over another. The consultation of the previous works realized by Hawksworth [3] and Van Haluwyn [4] allowed to us to compare them and methods to better understand their advantages and their limits. These various approaches contribute to the establishment of a cartography based on iso-pollution areas and classes of lichen species sensitivity on a scale of pollution of a study area. In the case of our works, in the first one the authors used for the first time a quantitative approach called poletolerance index of Strass [5] to assess the degree of air pollution in the city of Skikda and its periphery.

Then, the authors compared the results of this method for the same study area in the I.A.P. (index of atmospheric purity) used by and Fadel & Al Hadjouja [6, 7]. Then, the authors compared the results. A note that these methods allow to assess the air pollution overall relative value for each station studied. They have no direct correspondence with physico-chemical measures of the pollution Steubing [8].

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2. Methods of Study

2.1 Presentation of the Meshing and the Choice of Sampling Stations

The study area is located in a quadriside of 60 km^2. It includes the town of Skikda and peri-urban area, the petrochemical pole, the municipalities of Haddaiek, Hamadi Krouma, Hamrouche Hamadi and Larbi Ben M'Hidi (Fig. 1).

2.2 Establishing Lichen Record

The perimeter of study includes twenty three sampling stations. It is divided into a grid of 40 mesh (1.5 × 1) or 0.003 km and 0.015 gr longitude latitude. The coordinates of each mesh are specified by number in abscissa and by a letter in ordered (Fig. 2). The authors made the statements licheniques in several stations of the zone of study. The authors conducted surveys in several lichen according to the method of Strass [5]. Latter is to consider several trees of different ages and various species. For this four readings on each tree were necessary. Two have been made on the face exposed to the pollution which one at the base and the other at a height of 1 m to 1.50 m above the ground. The other two are on the opposite face. The systematic determinations of lichens were The authors have established a zoning according to exposure to different emanations of various pollution sources and their location in relation to urban areas and industrial zone. In general way, the choice of stations is influenced by the ecological factors (microclimate, abundance of phorophytes and homogeneity of the vegetable formations) but also by the topographic factors [9-11]. During this research work, the authors have considered a coherent ecological system taking into account isolated stations, represented both by roadside trees or isolated trees and secondarily by citrus orchards and the trees of some urban parks.

made using a binocular magnifying glass and in the microscope and for cutting the thallus. Some reagents such as potassium hydroxide in 10% Lugol, iodine and paraphenyl diamine were used for species identification. For species recognition, the authors

Fig. 1 Location of the study area.

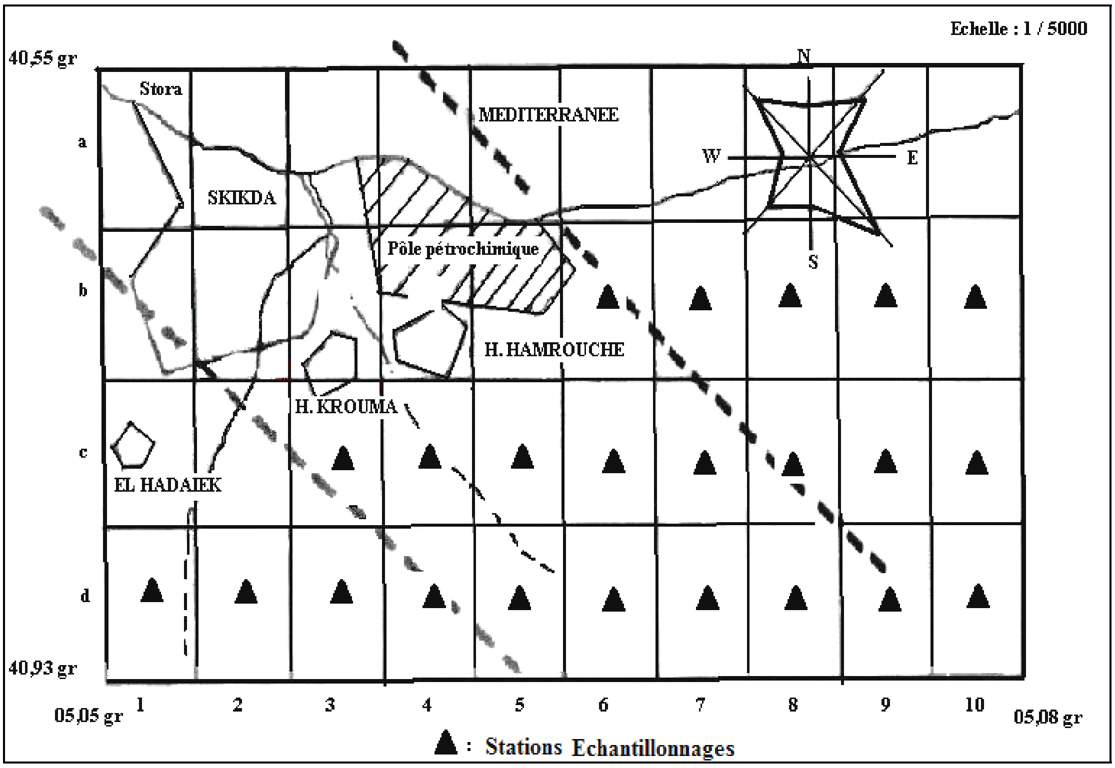

Fig. 2 Sampling stations.

used the lichen flora of Ozenda and Clauzade [12] the guide Jahn [13] and Roux [14]. The authors have identified in our study area 37 species of lichens.

2.3 Calculation of the I.P. (Poleotolerance Index)

The indication I.P. (index of the poleotolerance) is calculated according to the following Eq. (1):

$$I.P. = \sum_{1}^{n} ai \times ci / Ci \quad (1)$$

n: number of species;
ai: poleotolerance degree of a given species;
ci: degree of coverage of a given species;
Ci: total degree of recovery of all species identified.

3. Results and Discussion

The quantitative value *I.P.* (index poleotolerance) calculated for each station is recorded on Table 1.

By the calculations of the poleotolerance index, the results obtained respectively for every station are appearing globally the air quality each of her. Of these values represented on the Table 1, the authors notice that the stations which have a poleotolerance index the

Table 1 Values of the poleotolerance index of study sites.

Stations	*I.P.* (Poleotolerance index)
b_6	1.4
b_7	0.5
b_8	0.4
b_9	0.34
b_{10}	0.34
c_3	1.8
c_4	5.1
c_5	1.1
c_6	1.1
c_7	1.1
c_8	0.60
c_9	0.60
c_{10}	0.60
d_1	0.50
d_2	0.50
d_3	0.50
d_4	1.25
d_5	0.70
d_6	0.65
d_7	0.60
d_8	0.66
d_9	0.65
d_{10}	0.60

most raised are the most exposed to the atmospheric pollution. It is the case of the stations which have a poleotolerance index included between 0.65 and 5.1. These stations are located in the mesh (b_6, c_3, c_4, c_5, c_6, c_7, d_5, d_6, d_8, d_9). On the other hand, stations situated in mesh (b_7, b_8, b_9, b_{10} c_8, c_9, c_{10}, d_1, d_2, d_3, d_7, d_{10}) which have a poleotolerance index included between 0.34 and 0.60 are the least the exposed to the atmospheric pollution. The card of iso-pollution obtained from the values of the I.P. (poleotolerance index) shows that the stations most highly and moderately polluted are located in the corridor of the prevailing wind of the northwest. The latter is responsible for dispersal and for the distribution of polluants emitted by the various industrial homes in the most polluted stations. Stations that are located near the urban fabric of Skikda and main highways are also more exposed to air pollution. The authors also notice in the same figure as the least polluted stations are practically far from the corridor of the winds northwest and are located far from sources of emanation industrial units and urban areas. These stations are located in mesh Northeast, South-East and South-West.

3.1 Comparison of the Methods

Although the I.P. (poleotolerance index) allows a good translation of the zonation of air pollution around a fireplace emission, which allows precise mapping. It is less sensitive than the A.P.I. (atmospheric purity index) because it is not directly related to the richness of the lichen vegetation [15]. It is for that reason two quantitative methods used in the cartography of the same zone of study. It is I.P. (poléotolérance index) applied in the context of our work to that of I.A.P. (atmospheric purity) used by Metalaoui [16] and Hadjoudja [7]. To enable a better reading result, the authors have shown in Table 2 the values of the I.P. (poleotolerance index) and the I.A.P. (atmospheric purity index).

In general, it appears from the table that the index stations poleotolerance have the lowest of the values of the index of the highest purity air. As it is established well that when the values of the poleotolerance index are low. The atmospheric pollution is useless to weakness. As it is established well that when the values of the poleotolerance index are low, air pollution is absent or low. Contrary to the index of atmospheric purity when its values are elevated air pollution is absent or low. This is true all the more if the authors refer on the scale of atmospheric purity established by Rouidi [17] applied to the same zone of study. The latter determined a scale of the indication index of atmospheric purity. They consider when the index of atmospheric purity is understood between 0 and 5, the stations are polluted; 05 in 10 are averagely polluted; upper to 10 are weakly or not polluted. If the authors compare this scale with the values of the poleotolerance index in Table 2, it really emerges that the least polluted

Table 2 Values of the poleotolerance index of study sites.

	I.P. (Poleotolerance index) $I.P. = \sum_{1}^{n} ai \times ci / Ci$	I.A.P. (Atmospheric purity index) $I.A.P. = 1/10. \sum_{1}^{n} Q.f$
b_6	1.4	5.19
b_7	0.5	14.05
b_8	0.4	31.70
b_9	0.34	53.55
b_{10}	0.34	16.90
c_3	1.8	3.20
c_4	5.1	3.90
c_5	1.1	6.24
c_6	1.1	7.52
c_7	1.1	8 .63
c_8	0.60	16.14
c_9	0.60	17.20
c_{10}	0.60	16.45
d_1	0.50	12.58
d_2	0.50	14.85
d_3	0.50	25.78
d_4	1.25	3.50
d_5	0.70	8.25
d_6	0.65	7.10
d_7	0.60	10.06
d_8	0.66	8.51
d_9	0.65	8.46
d_{10}	0.60	10.93

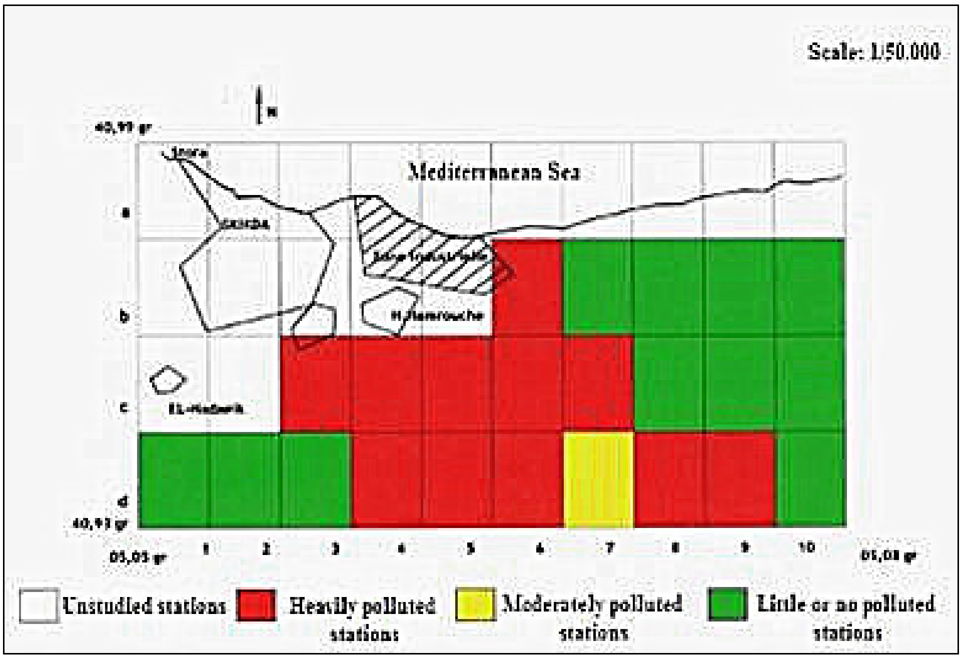

Fig. 3 Map of the air quality of the city of Skikda and its periphery.

stations have low values of the poleotolerance index. This shows well a big similarity of the methods in the cartography of the atmospheric pollution of the studied zone represented in the previous Fig. 3.

4. Conclusions

The results (profits) which the authors obtained allowed us to emit first remark of methodological order. Indeed, the authors note that the use of a biological material of vegetable nature can in any zone devoid of physical analyzers of the atmosphere to measure and to map the region subjected to the pollution by highlighting the zones of iso-pollutions. The results of the index of poléotolérance obtained are respectively for every station created in a global way, the air quality for each of them. The reliability of this method was tested by comparing the zones of iso-pollutions obtained quantitatively with the method of the index of atmospheric purity. The card obtained by the use of the method of the I.P. (index of Poléotolérance) highlighted stations averagely in strongly polluted. They are located in the corridor of pink pollution generated by prevailing winds from the northwest. The latter cross the industrial park and transport pollutants emitted by the various units to deposit them in the stations that are in his direction. The authors also notice that the peripheral stations in the urban fabric are strongly polluted. Stations located near main highways are averagely in strongly polluted. Stations that are weak or non-polluted are located away from sources of emissions of industrial units and urban sources of emissions. They are located outside the corridor, crossed by the prevailing wind of the northwest, and are situated in the meshes of the southeast, the southwest and the northeast. These observations are supported by analytical data of hydrocarbon pollution of the same zone of study [18, 19].

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