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Mapping of lichen biomarkers of atmospheric pollution in the Agadir urban area

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Abstract – Air pollution refers to a combination of gases and suspended particles present in the atmosphere, whose concentration levels vary depending on emissions and weather conditions. These substances are harmful to human health and the environment. Analyzing air pollution is a key to assess the level of the pollution in an area. Commonly, the spatial distribution of some plants serves as bio-indictor for air pollution monitoring. Citing for example, lichens, are autotrophic and symbiotic living organisms composed of a beneficial association between an alga and a fungus, as well as "Nicotianaglauca" tobacco plants.

The city of Agadir is characterized by an increasing industrial activity and heavy traffic, causing significant air pollution. In this context, our study focuses on monitoring air pollution through mapping lichens and "Nicotianaglauca" tobacco plants over three different zones. The first one located in the East-West axis, is near to the Faculty of Sciences of Agadir, while the other two zones are the Valley of Birds and Agadir Oufella. Using these pollution-sensitive organisms as a mapping method proves to be a simple, flexible, cost-effective, and efficient approach to establish pollution maps. The collection and analysis of lichens and "Nicotianaglauca" tobacco plants in these different zones will allow us to assess the levels of air pollution and create pollution maps for these specific regions.

Keywords – Air pollution, lichens, bio-indicator, Agadir, environment.

I. INTRODUCTION

The city of Agadir is located in south-west Morocco on the Atlantic coast, 500km south of Casablanca, 235km west of Marrakech and 173km from Essaouira. It belongs to the Ida-Ou-Tanane massif, a low-lying area forming the western terminus of the High Atlas. The city of Agadir characterized by a booming industrial activity and heavy traffic, leading to significant air pollution. In this context, our study focuses on the analysis of air pollution.

Generally speaking, air pollution is the cause of many problems, both for the environment and for health. The air quality index, which is distributed daily, enables us to assess the quality of the air we breathe, but the method of using pollution-sensitive organisms is particularly simple, flexible, economical and effective for mapping pollution in space and time.

II. MATERIALS AND METHOD

Our field study of lichens is carried out at three different stations, because we've divided the work area into three zones. The first is located next to our faculty on the East-West bar, which is characterized by heavy traffic, the second station is in the Bird Valley, and the last is Agadir Oufella, next to the beach, where humidity is high and traffic lower.

The tobacco plant is also included in our study, as it is a bio-indicator of ozone levels in the atmosphere.

1. *Characteristics of a bio-indicator*

A bio-indicator is a living creature selected according to precise criteria. It must live permanently in the environment under study and be easily observable [1].

Observation of the effects of atmospheric pollution on the environment has led to the development of monitoring tools that complement physico-chemical approaches. Many of these are based on the use of plants, and lichens are veritable sentinels of air quality [2].

2. *Lichens as a bio-indicator of air pollution*

A lichen is an autotrophic, symbiotic living organism composed of a mutually beneficial association between an alga and a fungus. Lichens are particularly well-suited to the study of gaseous or particulate air pollution, as they display a number of particularly favorable anatomical and physiological characteristics [3]. Lichens are found everywhere, with 20,000 species worldwide.

The reason for using lichens is that, in the event of air pollution, however slight, they absorb the pollutants, which can even make them disappear. This is why lichens can be used as bio-indicators of air quality [4].

3. *Lichen characteristics*

Because of their ability to react to atmospheric pollutants at different levels, their low growth rate [5], and their ability to indicate the presence of these pollutants, lichens are veritable "sponges", recovering compounds present in the atmosphere all year round, among their characteristics:

- Absence of cuticle, stomata and conductive vessels
- Presence of a mucilage-rich cortex
- Reviviscence
- Year-round photosynthetic activity
- Slow growth
- Lichenic acids bind pollutants

4. *Thallus*

Among the characteristics that allow us to identify lichens is the type of thallus, of which there are three main types :

- *Crustacean thallus*

Very well attached to the trunk over the entire surface of the lichen, shaped like a short [6]. Lichens with this type of crustaceous thallus are not affected by atmospheric pollution.

Figure 2: Crustacean lichen thallus (inventairefac.com)

- *Foliaceous thallus*

Lobes shaped like leaves are not attached to the trunk, but fall off when scratched [7]. Lichens with a foliaceous thallus are generally not very sensitive to atmospheric pollution.

Figure 2: Foliaceous lichen thallus (inventairefac.com)

- *Fruticular thallus*

The thallus is only attached to the trunk by a very small part at the base, so falls off easily [8]. Lichens with this type of thallus are very fragile in the face of atmospheric pollution.

Figure 2: Fruticose lichen thallus (inventairefac.com)

Most lichens grow very slowly (1 to 10 m), their thallus resembling a gel that absorbs water very quickly from its surface, but can also lose it very quickly in dry conditions [13].

5. *Tobacco (Nicotiana glauca), a bio-indicator of urban pollution*

Tobacco plant leaf Nicotiana glauca used for bio-indication of urban, industrial or road pollution [11]. The action of ozone on tobacco was first observed in 1944 in tobacco growing in the Los Angeles area of California, and tobacco was used to demonstrate the presence of ozone.

- *L'ozone origine et formation*

It is a colorless, irritating gas with a pungent odor, and is a molecule composed of 3 oxygen atoms (O3), which gives it strong oxidizing power. It is a secondary atmospheric pollutant resulting from chemical reactions between primary pollutants requiring UV radiation [12].

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Figure 4: Tobacco plant (bio-surveillance- air.info)

- *Les nécroses*

Ozone causes lesions in leaf tissues, manifested by the appearance of leaf necrosis (small round spots that can later coalesce to form large areas) [9]. Leaf necrosis reflects the death of leaf epidermal cells [12].

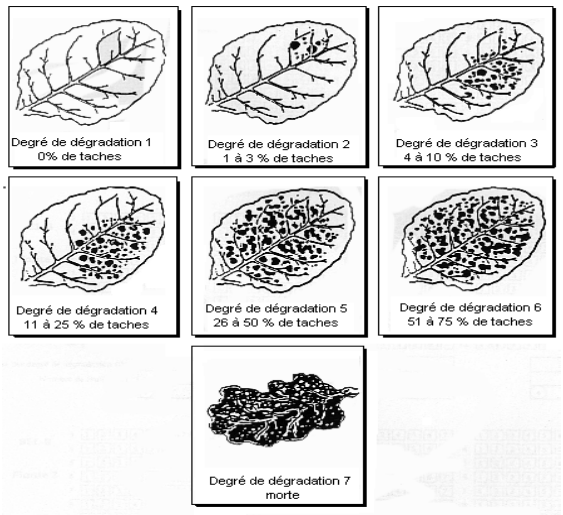

Figure 5: Degree of leaf degradation under the effect of ozone (SVT LYON)

6. *Study areas*

- The first station : The East-West bar

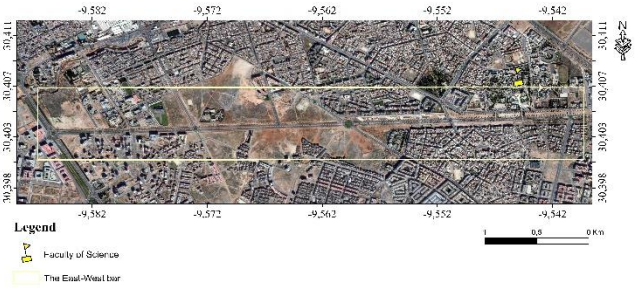

Figure 6: The Est -West bar

- The second station : Valley of the birds

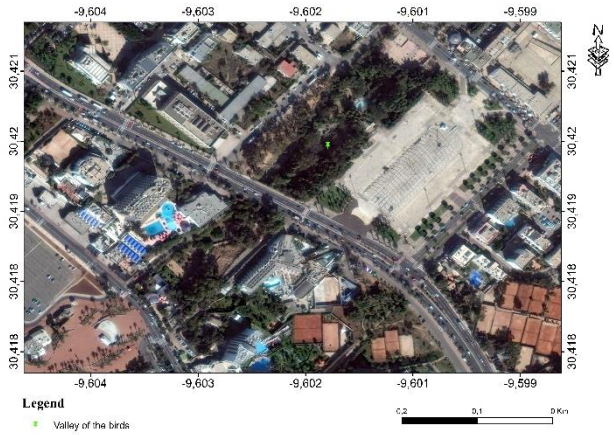

Figure 7: Valley of the birds

- The third station : Agadir Oufella

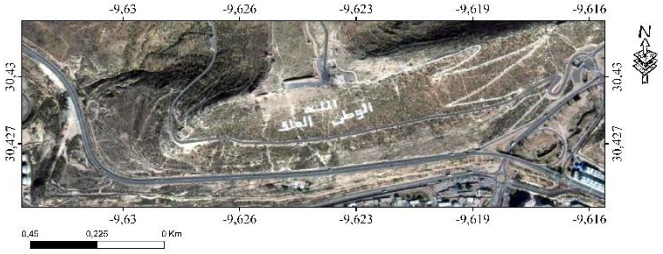

Figure 8: Agadir Oufella

III. RESULTS

The aim of this study is to assess air quality in the Agadir conurbation, following our field missions to the East-West bar, which is characterized by heavy traffic, and two other stations close to the beach (Vallée d'oiseaux and Agadir Oufella) with less traffic and a humid climate.

The preservation of the bird valley is due to the presence of lichen species, as this area is primarily located in an environment characterized by low sunlight levels due to the existence of a valley. After studying these stations, we found no species in the first station (the East-West bar), but in the other stations we found lichen and tobacco species in different areas.

IV. DISCUSSION

The presence of lichens and tobacco in stations with low vehicular traffic and their absence in the East-West bar shows that the latter is more polluted than stations close to the sea.

Almost the same experiment was carried out in Kinshasa, but with the same result using biological indicators. Four roads were chosen according to whether they were heavily, moderately or lightly trafficked. Lichens were used as bio-indicators to establish the relationship between their presence or absence, on the one hand, and motorized traffic, on the other, on air quality. The results revealed a total of 19 lichen species, with the route de l'ouest at the University of Kinshasa (Unikin) showing a high specific diversity of epiphytic lichens, with 12 species (63.2%), while the By-pass and Mondjiba roads were poorly represented, with 4 lichen species (21.1%), followed by the Lumumba boulevards with 3 species (15.8%).

The results show that trees along the low-traffic route de l'Ouest are entirely covered with lichens belonging to all three lichen groups: foliaceous, fruiting and crustaceous, unlike those on other high-traffic roads.

V. CONCLUSION

All the observations made at the three pollution stations were used to map road pollutants. These various studies have demonstrated the perfect role of lichens in mapping different locations and locating sources of pollutants. Lichens and tobacco can form networks of bio-indicator plants for air pollution, and their use is proving to be a particularly simple, flexible, economical and effective method for mapping pollution in space and time. Such a map can therefore provide answers to questions concerning the problem of air pollution in the city of Agadir.

Identifying pollution in sensitive organisms also makes it possible to detect deterioration in air quality before it severely affects the biotope or human beings.

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