Inventory of the Flora of Kabylia According to an Altitudinal Gradient of Pollution

LEMBROUK L. and SADOUDI-ALI AHMED D.

***Abstract*—**We have opted for a floristic inventory according to an altitudinal gradient of pollution (from 100 m to 765 m altitude) following a transect from a forest (the yakouren forest) to an industrial zone (Oued Aissi) through transit stations including the great industrial potential of the wilaya of Tizi-Ouzou (Algeria), namely the Electro-Industry of Azazga and ENIEM. of Oued-Aissi. The transect includes five stations (Yakouren, Taddart, Tirsatine, Tizi Rached, Oued Aissi) located equidistant from the forest of Yakouren to the Sebaou Valley in Greater Kabylia.

We adopted random sampling during the spring season of 2015 by harvesting all the plant species encountered in a comprehensive manner, while focusing on their distribution taking into account environmental factors including climate, rainfall, temperature, altitude and the nature of the substrate as well as the rate of metal pollution of each station.

The collected species are sorted, identified and counted. The recorded flora is divided into 5 classes (Magnoliopsida, Liliopsida, Pteridophyta, Monocotyledons and Equisetopsida), 25 orders divided into 27 families and 65 species. It shows the apparent impact of heavy metals, altitude and climate emerges.

***Keywords*—** altitude, biodiversity, flora, Kabylia, pollution.

I. Introduction

The flora of a geographical area is the most important biotic component [1], which expresses the ecological conditions (climatic, geological, historical, geomorphological and edaphic) that prevail there [2]. Thus, [3] and [4] point out that the Mediterranean region is one of the world's major centers of plant diversity whose current flora corresponds to various heterogeneous assemblages linked to the paleo-history of the region in [5]-[6].

Algeria, one of the few biogeographic countries, has an exceptional ecological entity in the biosphere, by its extensive surface constituted by various ecosystems. Its vegetation cover is a very important ecological factor, especially in Kabylia, because of its topographical heterogeneity and the anthropic action that has created a very fragmented vegetation landscape that is presented in the form of rather complex mosaics.

The reference [7] points out that the analysis of the floristic richness of the different groups, their biological and chronological characteristics, would make it possible to highlight their floristic originality, their state of conservation and, consequently, their heritage value. Knowledge of the biological and ecological peculiarities of the species as well as the identification of historical and current factors causing flora fluctuations are essential for any action to conserve biodiversity.

Preserving and conserving Kabylia's remarkable plant biodiversity is first and foremost achieved by conducting ecological inventories of the environment; this, in order to locate them and make an objective assessment of their heritage value and related issues, prior to any implementation of conservation actions.

It is in this perspective that we carried out an inventory of the Kabyle flora. This inventory is followed by an ecological study which made it possible to identify an important set of species whose distribution is related to the factors of the environment, in particular the climate (the precipitation and temperatures), altitude and nature of the substrate.

The taxonomic and nomenclatural reference chosen for the citation of the species is the African Plant Database (version 3.3.3), Conservatory and Botanical Garden of the City of Geneva and the South African National Biodiversity Institute, Pretoria, access March 2011, whose lead author for North Africa is A. DOBIGNARD, as well as Angiosperms Phylogeny Group (APG) III (2009) & APG IV (2016).

II. Material And Methods

Our study area is located in the north of Algeria, in the wilaya of Tizi-Ouzou (located 100 km east of Algiers), in the great Kabylia and in the heart of the Djurdjura massif, in 36 ° 42 'North latitude and 4 ° 13' East longitude. It extends, in its current boundaries over an area of 2958 Km2 where the Mediterranean climate prevails with a mild and rainy winter and a hot and humid summer considering the proximity of the dam Taksebt. The vegetation is classified in the thermomediterranean floor dominated by the olive tree (Olea europea).

We were interested in the effect of environmental factors (rainfall, temperature, altitude and substrate quality) on the distribution of the flora identified during the inventory carried out on an equidistant altitudinal transect between the different sampling stations (Yakouren, Taddart, Tirsatine, Tizi Rached, Oued Aissi) from a forest (Yakouren forest), high altitude, to the Oued Aissi area, in the valley of Sebaou. In addition to the inventory, a soil and heavy metals analysis of the stations are carried out.

III. Results And Discussion

A. Substrate Analysis

The results of the physico-chemical analyses obtained are

LEMBROUK L. and SADOUDI-ALI AHMED D., M. MAMMERI University of Tizi-Ouzou, Algeria.

illustrated in Table I which is interpreted according to international standards.

TABLE I: RESULTS OF PHYSICO-CHEMICAL ANALYZES OF THE SOIL OF THE STUDIED STATIONS.

Soil of Stations	Physical analyzes					Chemical analyzes					Texture
	A%	LF%	LG%	SF%	SG%	pH	$CACO_3$ Total	C.E ds/cm	C Total	M.O	
Y.	8.7	9.25	28.86	34.63	18.55	7.5	2.02	0.2	3.43	5.89	SL
Tad.	38.55	15.6	19.42	11.8	14.62	7.4	2.3	0.2	3.92	6.74	CL
Tir.	14	15.85	17.39	13.65	39.11	7.4	2.3	0.2	2.82	4.84	SL
TR.	7.1	19.15	12.67	28.89	32.18	7.1	2.02	0.2	0.37	0.67	SL
OA.	8	10.3	14.22	12.37	55.11	7.2	2.02	0.2	2.02	3.47	SL

The physicochemical characterization of the soil of the study stations allowed us to distinguish a sandy-silty texture with the exception of the Taddart station, which is of clay-silty texture. They are neutral pH soils, slightly salty which have an EC of the order of 0.2 ds / cm and a very low level of limestone. However, the rate of organic matter varies from Yakouren station at high altitude to Oued Aissi at low altitude.

2. DETERMINATION OF HEAVY METALS

The results of the chemical analyses of heavy metals carried out on the soils studied are given in Table II. The results obtained are interpreted according to Algerian and Dutch standards.

TABLE II: RESULTS OF CHEMICAL ANALYSES OF HEAVY METALS FROM THE SOILS OF THE STUDY STATIONS.

Station soils	Pb	Cr	Ni	Zn	Cu	Fe	Al
	mg/kg					g/kg	
Y.	29.6 ± 5.2	45.5 ± 6.7	5.7 ± 1.0	34.4 ± 3.4	18.8 ± 1.3	18.5 ± 0.45	51 ± 2.7
Tad.	25.0 ± 4.9	63.7 ± 7.9	4.7 ± 0.8	53.5 ± 5.2	20.4 ± 1.4	38.85 ± 0.97	68 ± 3.1
EI.	30.1 ± 5.2	58.7 ± 7.7	7.5 ± 1.3	129 ± 8	19.9 ± 1.4	30.92 ± 0.77	48.4 ± 2.6
TR.	10.4 ± 3.1	22.0 ± 4.7	7.6 ± 1.3	20.6 ± 2.0	6.4 ±0.5	32.27 ± 0.81	67.7 ± 3.1
ENIEM.	30.1 ± 5.2	98.3 ± 9.9	5.4 ± 0.9	310 ±16	31.6 ± 2.2	27.4 ± 0.68	48.2 ± 2.6

According to the results of Table II we see a difference between the soils of the study stations or the EI stations. and ENIEM. are the richest in metals. ENIEM. which is an industrial zone under goes an accumulation effect of most of the heavy metals dosed (Pb, Cr, Zn, Cu) following erosion and infiltration due to its location at low altitude in the middle of the Sébaou valley.

At the EI station. the waste is stored in the open air and on the ground directly. In addition, we report the presence of a pool of discharges of various toxic products (example: cyanides) as well as the discharge from the neutralization and treatment plants that are defective.

3. ANALYSIS OF THE FLORA

Table III shows all the floristic groups inventoried in the different sampling stations (Yakouren, Taddart, Tirsatine, Tizi-Rached and Oued Aissi) following an altitudinal gradient of the highest mountains of Yakouren towards the Sebaou Valley during the spring season of the year 2015.

TABLE III: SET OF IDENTIFIED GROUPS IN THE STUDIED STATIONS

Classes	*Magnoliopsida*	*Liliopsida*	*Pteridophyta*	*Monocotylédones*	*Equisetopsida*
Orders	18	3	1	1	2
Families	20	3	1	1	2
Species	53	7	1	2	2

A total of 65 species belonging to 5 classes (Magnoliopsida, Liliopsida, Pteridophyta, Monocotyledonous and Equisetopsida) were distributed over 25 orders and 27 families were.

4. Effect of altitude

The diversity of the vegetation comes from the variety of climatic conditions because of the differences in the altitude between our study stations; this is observed in fig. 1.

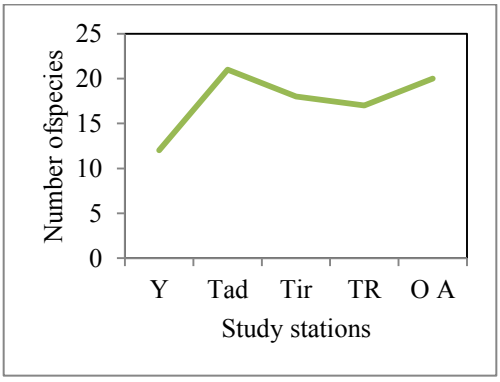


Fig. 1: Evolution of the number of plant species inventoried according to altitude.

According to Fig. 1, the plant species are unequally

distributed according to the difference in altitude. They are more abundant in medium altitudes following the favorable climatic conditions notably a rainfall of 336.4mm / year and an average annual temperature of the order of 15.4 ° C. In the same way, the loam-clay texture of the soil retains a certain humidity of the substrate and a good richness in organic matter.

IV. Distribution of Floristic Groups in the Different Stations.

Fig. 2 illustrates the distribution of flora in the different study stations.

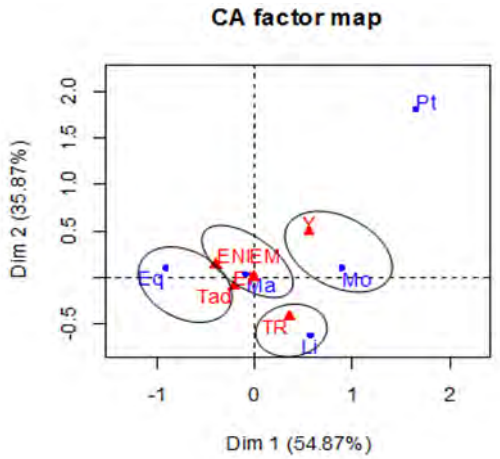
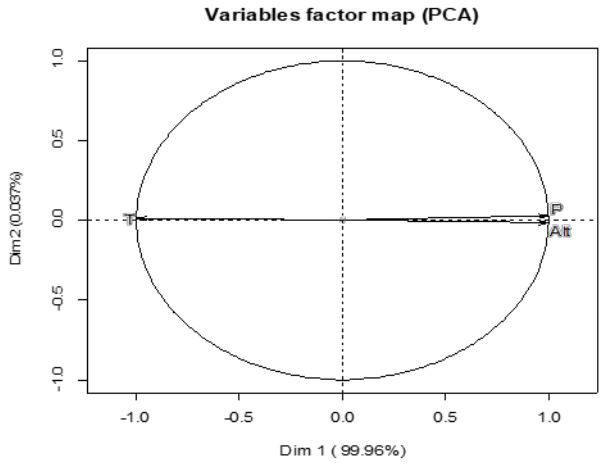


Fig. 2: Distribution and nuclei affinity of the floristic groups and studied stations in the F1 × F2 factorial plane.

In the AFC of Fig. 2, 4 homogeneous groups are required:

- Group1, connects the Monocotyledon class to the Yakouren station,
- Group 2, shows the relation of the Equisetopsida class and the Taddart station,
- Group 3, connects the Tizi-Rached station and the Liliopsida class,
- Group 4, connects the EI (Tirsatine) stations and ENIEM (Oued Aissi) with Magnoliopsida class.

This analysis of the previous figure is well explained by the results of Fig. 3 which express the relation of the heavv metals, edaphic factors and climatic characters with the spatial distribution of the inventoried plant species.



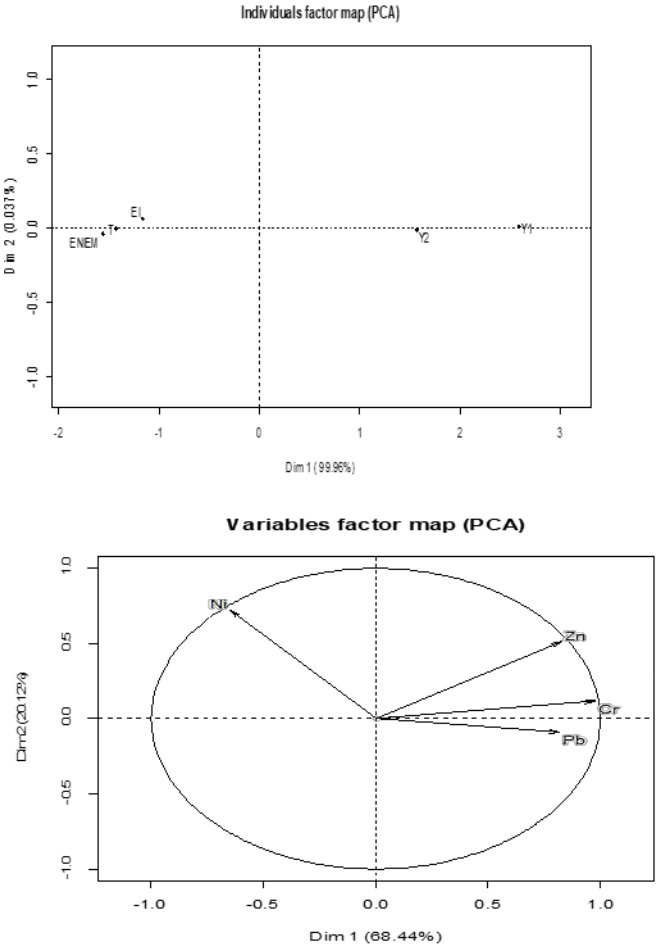


Fig. 3: Representative ACP of the distribution of climatic characters, altitude and heavy metals in the studied

According to Fig. 3, the Yakouren and Taddart (the richest in CaCO3) stations, at high and medium altitude, are correlated with precipitation and the stations Tirsatine (EI), TR. and Oued Aissi (ENIEM), at low altitude wich are contain the lowest amounts of MO. and neutral pH, are correlated with temperatures which creates the floristic mosaic of this region.

The Zn, Cr and Pb are positively correlated and oppose the Ni. It interprets the important influence of quantified heavy metals (Pb, Cr, Zn, Ni) especially in the ENIEM station. The Tizi-Rached station is positively correlated with the Ni and the EI station. seems to contain metals including Zn and the Ni. The Y1 and Y2 stations are not influenced by any metal, which makes them reference stations far from any source of industrial pollution.

V. Discussion

The protection of the biodiversity and the environment is one of the major concerns of humanity; it has even become a leitmotif in recent years taking into account the global warming. This can only be done with the assessment of the biodiversity, generally based on the structure and composition of communities, as the biodiversity, is a multidimensional

concept [8] which reflects the biological complexity of communities [9].

The inventory and the floristic analysis of the natural vascular vegetation of an environment are essential to know the overall composition of the existing taxa, the biogeography of the species listed and the ecology of the study environment [10].

Measuring biodiversity, as it was originally defined by [11], means "counting the whole species present in a given place". Vegetation is therefore used as a reliable reflection of stationary conditions; it is the synthetic expression according to [12]-[13].

The Algerian floristic diversity is represented from the biogeographical sub-division of [14], and from the international map of the vegetation cover of [15]. At the biocenotic level, the arranged, following a decreasing altitudinal gradient, illustrate the biological and structural aspects of the mosaic of plant communities present in the stations and their dynamic links. These surveys show 65 species belonging to 5 classes (Magnoliopsida, Liliopsida, Pteridophyta, Monocotyledons and Equisetopsida) which are distributed over 25 orders and 27 families. The class of Magnoliopsida is the best represented with the order of the Asterales which ranks first with 15 species. These results confirm those obtained by [5] who worked on the flora of the Mediterranean region, [16]-[17] who treated the therophytic status of Mediterranean lawns in Languedoc, as well as [18] who studied the evolutionary trends of Mediterranean flora and vegetation.

Magnoliopsida are most often referred to as dicotyledons. They are very important green plants in botany of which all these species are flowering plants, some are herbaceous but some woody plants exist, such as magnolias [19].

The identified plants species are more abundant at medium altitudes following favorable climatic conditions with a rainfall of 336.4mm / year and an average annual temperature of around 15.4 ° C as well as the soil texture, silty-clay, which keeps some humidity of the substrate and a good richness in organic matter. This confirms that climate plays an essential role in determining the distribution of plants, which are distributed uneuanlly according to the difference in altitude. This role is particularly emphasized by [20] concerning the Mediterranean vegetation.

The reference [21] have bioclimatically characterized the forest vegetation on the Mediterranean rim. • They approach the concept of vegetation stage by taking into account the major climatic factors and in particular the average annual temperature which allows it a posslble translation these variations the overall altitudinal and latitudinal successions of the vegetation. As a result, rain and temperature are the hinge of the climate [22] which defines the Mediterranean bioclimate of which Kabylia is part [4].

According to [2], vegetation is the result of the integration of floristic, climatic, geological, historical, geomorphological and edaphic factors. From a purely biogeographical point of view, the current Mediterranean flora corresponds to various heterogeneous sets linked to the paleo-history of the region, declare [5]-[6].

Biodiversity at the level of a landscape is therefore the result of the processes of disturbance, succession and the spatial organization of environmental gradients that results from it [23].

VI. Conclusion

The analysis of the flora of Kabylia has enabled a better knowledge of its floristic, altitudinal and chorological values. This important flora which extends between 100 and 765 m takes turns following an altitudinal gradient falls under Five classes namely Magnoliopsida, Liliopsida, Pteridophyta, Monocotyledons and Equisetopsida, living in very specific conditions. Faced with these harsh climatic conditions, nature is obliged to adapt so as to vary its environments in order to resist. Adding to this; it is includes the effect of forest fires (almost every summer) that must be managed well in order to safeguard this flora richness by integrating the population and participating rural people in the work undertaken by the administration (plantations, opening of roads, brush clearing and opening of firewalls for fire prevention, firefighting teams, etc.) This can only be ensured with a good execution of the environmental legislation which protects the natural heritage and the intensification of surveys and sociological studies applied with adequate technologies and means, especially the adoption of soils emergency protection measures.

Finally, it should be remembered that the project to manage at least part of the Akfadou forest, of which Yakouren is a part, in the National Park dates back to 1921 and that, today more than ever, it is necessary to relaunch and to materialize thus restart the forest school project in Yakouren, which is already subsidized by the European Union in 2008 as part of the Euromed program.

The current landscapes are the result of a common natural and human history that spans several thousands of years. The state of the ecosystem will ultimately depend on human action. One of the greatest threats to biodiversity is the degradation of ecosystems.

References

[1] OZENDA P,1982: Les végétaux dans la Biosphère, Index, Paris, Doin.

[2] LOISEL R., 1978: Phytosociology and phytogeography; phytogeographic significance of the French continental South – East Mediterranean. Docum. phytosociological, N.S. Vol II. Lille. pp 302-314.

[3] MYERS N., MITTERMEIER, R. A., MITTERMEIER, C. G., DA FONSECA, G.et KENT, J., 2000: "Biodiversity hotspots for conservation priorities, Nature 403: 853-858. https://doi.org/10.1038/35002501

[4] QUEZEL P. & MEDAIL F., 2003: Ecology and biogeography of the forests of the Mediterranean basin. Elsevier. Environment Collection. Paris. 573 p.

[5] QUEZEL P., 1978: Analysis of the flora of Mediterranean and Saharan Africa.Missouri Bot. Gard. 65, 2. pp: 411-416. https://doi.org/10.2307/2398860

[6] QUEZEL P., 1985: Definition of the Mediterranean region and the origin of its flora. In Gomez-Campo Edit.: Plant conservation in the Mediterranean area. Junk. Dordrecht. 9 p.

[7] QUEZEL P., GANISANS J. & GRUBER M., 1980: Biogeography and establishment of Mediterranean flora. Naturalia Monspeliensia, special issue number. pp 41-51.

[8] DAHMANI M., 1996: Biological and phytogeographic diversity of Algerian green oak groves. Ecologia Mediterannea XXII. (3/4). pp 19-38.

[9] PURVIS, A. & HECTOR A., 2000: Getting the measure of biodiversity. Nature 405: 212 – 219. https://doi.org/10.1038/35012221
[10] HEDDE M., VAN Oort F., Renouf E., Thénard J., Lamy I., 2013: Dynamics of soil fauna after plantation of perennial energy crops on polluted soils, Applied Soil Ecology, Volume 66: 29-39. https://doi.org/10.1016/j.apsoil.2013.01.012
[11] HAMMADA S., DAKKI M., IBN TATTOU M., OUYEHYA A. & FENNANE M., 2004: analysis of the floristic biodiversity of wetlands in Morocco, rare, threatened and halophilic flora. Acta BotanicaMalacitana 29, Malaga pp. 43-66. https://doi.org/10.24310/abm.v29i0.7226
[12] WILSON E.O., 1988: Biodiversity. National Academy Press. Washington. D.C. USA.
[13] BEGUIN C., GEHU J-M. & HEGG O., 1979: Symphytosociology: a new approach to plant landscapes. Doc. Phytos. N.S. 4 pp 49-68. Lille.
[14] RAMEAU J-C., 1987: Phytoecological and dynamic contribution to the study of forest ecosystems. Applications to the forests of the North-East of France. University of Besançon. State thesis.
[15] QUEZEL P. & SANTA S., (1962 -1963): New flora from Algeria and the southern desert regions. C.N.R.S. Paris. 2 vols. 1170 p.
[16] BARREY J-P., CELLES J-C. & FAUREL L., 1974: International map of plant cover. Scale: 1/1000000. Alger. 1 card.
[17] DAGET PH., POISSONET J. et POISSONET P., 1977: The therophytic status of Mediterranean lawns in Languedoc. Phytosociological conferences, pp 80-99.
[18] DAGET PH., 1980: On botanical biological types as an adaptive strategy, the case of therophytes. In "Research in theoretical ecology". Adaptive strategies. pp 89-114.
[19] PIGNATI S., 1978: Evolutionary trends in the Mediterranean flora and vegetation. Vegetatio. 37. pp 175-185. https://doi.org/10.1007/BF00717651
[20] MOORE M., BELL C., SOLTIS P. & SOL I ing pla t id geno e - ca le data to re o lve enig at ic relation h ip a o ng ba al angio per P A vol 4 December 2007, p. 19363–8. https://doi.org/10.1073/pnas.0708072104
[21] EMBERGER L., 1930: On a climatic formula applicable in botanical geography. C.R. Acad. Sc. 191. pp 389-390.
[22] EMBERGER L., 1971: Botany and ecology work. Ed. Masson. Paris. 520p.
[23] BARBERO M., LOISEL R. & QUEZEL P., 1982: Bioclimatic characterization of the levels of forest vegetation on the Mediterranean rim. Methodological aspect posed by zonation. Coll. Int. School. High altitude. 24. pp 191-202.
[24] BARY-LENGER A., EVRARD R. & BATHY P., 1979: The forest. Vaillant Carmine S. Printer. Cork.611 p.
[25] FROISE B., 1999: Landscape ecology: concept, methods and applications. Tec Ed Doc pp111.