Biodiversity study in the quarry area of the Safi cement plant: Spatio-temporal overview of the fauna and flora species

Prof. Mostafa KABINE

Faculty of Sciences Ain Chock –Biology Department
University Hassan II of Casablanca - Morocco

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A- Introduction

Due to multiple human activities, global warming and natural disasters, the living world is at great risk of erosion and loss of fragile species around the globe. Knowledge of biodiversity and its long-term conservation is a challenge today. Thus, it is time to identify the plant and animal species associated with each type of ecosystem to take the necessary measures for rational, sustainable and effective protection.

The objective of this contribution is to assess the biodiversity in the perimeter of the quarry area near Safi cement plant, located in the coastal zone Abda-Doukkala (Figure 1). This interdisciplinary framework is to identify the interactions between the living world, environmental parameters and socio-cultural context that are the basis of the current organization of biodiversity in this site. A thorough knowledge of the vegetation, the impact of human activities and especially the dynamics of plant formations, is of paramount importance for the reconstruction of natural ecosystems and for development projects.

This scientific approach aims to highlight the list of plant and animal species in space and time in the quarry area (~ 63 ha). The vegetation cover was monitored monthly to understand the functioning of the ecosystem and to detect the relationships of the main taxa with the parameters of the physical habitat, the man activities and the climate effect.

For vegetation, the methods used were those of the phyto-sociological surveys of Braun-Blanquet. The families, biological types, and phyto-geographic affinity of the species were analyzed using the raw spectra. Phytosociological inventories showed a floristic richness of 152 species distributed in 37 families. The species richest families are Asteraceae (32) Poaceae (17), Fabaceae (15), Apiaceae (10), Brassicaseae (10) Caprifoliaceae (5) and Plantaginaceae (5). There is also an abundance of therophytes which, combined with the Poaceae richness, reflects a drier and arid climate. The relative abundance of Mediterranean species on the other phyto-geographic types confirms the xericity of the study area, thus with South Mediterranean affinity. The fauna assemblages are more complex with Arthropoda, Mollusca, Amphibians, Reptilians, Mammalians and birds. The wildlife identified in the area also confirms the aridity in Quarry 2 of the Safi Cement Plant.

1. Importance of Biodiversity in Morocco

Knowing the crucial importance of biodiversity and knowing that multiple human activities are damaging it, one conclusion is necessary: strategies must be implemented to preserve it. While it is relatively simple to agree that it must be protected, the determination of what action to take to do so is more complex and more controversial. In terms of conservation, humans often tend to restrict reflection to species only. Because the disappearance of endangered species is easier to observe but the degradation or erosion of genetic diversity or the decline of an ecosystem are difficult to see. From a scientific point of view, it is easier to study species than genes or ecosystems, which is of enormous interest even among biologists specializing in conservation issues.

Morocco's biodiversity is of particular ecological importance, with more than 24,000 animal species and 7,000 plant species, with an overall endemism rate of 19% for vascular plants (Benabid 2000, Aafi *et al.,* 2005, 2007, Fennane *et al.* 1999, 2007 and 2014). Ecosystem diversity is equally remarkable; in fact, in addition to coastal and marine, Mediterranean or Atlantic ecosystems, ~ 40 mainland habitats have been identified as particularly rich in biodiversity, of which nearly 25% are represented by strict forest ecosystems and pre-forest and pre-steppe ecosystems.

However, the general trend is to degradation and significant threats, stemming essentially from the multiple human activities, which weigh on the biodiversity in Morocco and this, in spite of the enormous effort of conservation granted by various concerned actors. Ecosystems are more or less affected by direct or indirect activities related to economic development and population growth in the country (intensive agriculture, overgrazing, overexploitation of natural resources, mining industry, quarries of aggregates and cement, pollution, urbanization ...). In extreme cases, the repercussions of these activities lead to an irreversible loss of species of plants and animals and to sometimes irreversible degradation of certain ecosystems (Central Rif, where cork oak has been destroyed, or around cities where areas of agricultural land are urbanized, Meseta Doukkala-Abda with the disappearance of the oak tree (*Quercus suber*) and argan tree).

2. Geological, geographical and botanical aspects in the Abda-Doukkala area

Quarry 2 of the Safi Cement Plant is part of the southern coastal Meseta area of Morocco. It is located between Oualidia and Safi (Figure 1). The morphology is more or less regular because of a very advanced agro-sylvo-pastoral development in the region during the 20th century in the region (cereal farming often lean and not mechanized and an intense pastoral route during year). The complete absence of any regeneration of natural species has hindered the renewal of these ecosystems.

Anthropogenic activities have multiplied during historical periods and have deeply disturbed the balance of the environment leading to a recovery of severely degraded woody groups, which has encouraged the effects of soil erosion in the coastal Meseta. In some places around Safi, there is an ultimate stage of desertification marked by a significant reduction in natural vegetation.

The plains of the Abda-Doukkala are separated from the Atlantic Ocean by long ridges parallel to the coast, with inter-dune depressions flat bottom, elongating in basins more or less swampy. The region is characterized by the total absence of a hydrographic network due to the karstification of the carbonate rocks, which are responsible for the closure of the interior plains and plateaus, by the coastal barrier of Moghrebian formation (Quaternary) age. The aridity of the region can be explained by the lack of hydrographic networks during the Quaternary period where calcium carbonate deposition and the generalization of calcareous crusts are noted (Mouhiddine, 1990). Soils are little evolved, chestnut, isohumic, calcimagnese (Figure 2) with vertisols in places (Mouhiddine, 1990). The surface formations of the region are constantly changing under the action of the winds, which correspond in the region of Abda to the main cause of erosion (Varnier, 1952).

Figure 1. Location of the Safi cement plant in the region of Abda-Doukkala

Figure 2: Soil profile in quarry 2 showing a shallow surface layer (5-20 cm deep)

Geological and geomorphological data collected from a literature review show that vegetation cover in the coastal Meseta between Abda and Doukkala has undergone a gradual degradation process resulting in desertification (Barbero *et al.,* 1990). Indeed, palynological analyses (Ballouche and Carruesco, 1986) demonstrated the presence of a cork oak forest (*Quercus suber*) in this region during the prehistoric period. Its disappearance is explained by global warming, which has led to the depletion of the non-calcareous soil that is essential for the development of cork oak, while the oyster and pistachio have taken over (Mouhiddine et al., 2005).

Moroccan botanists (Benabid, 2000; Aafi *et al.,* 2005) agree that cork oak has disappeared in this region because of a long period of drought which led to the severe aridity and carbonation of the cork

siliceous substrate. This global warming has also disrupted the formation at Oléastre (Olea eauropaea) and Pistachio (Pistachia atlantica). According to the old map of vegetation distribution in Morocco (Emberger, 1939 and Benabid, 2000), the region Abda-Doukkala is located in the field of semi-arid bush Olivier-Pistachier- Palm dwarf (Doum). This formation is observed particularly on heavy and compact clay soils.

The strong wind erosion of the soil made it possible to expose the limestone slab in many sites covered by the oyster (Slimani, 1994). Ballouche and Caruesco (1986) demonstrated, according to palynological observations, that the Abda-Doukkala region was under a humid climatic environment responsible for the formation of heavy and compact clay soils during the period 8000-6500 years BP.

Following intense aridity, the argan tree becomes the main tree in this region rich in limestone, where climatic parameters are favorable. Anthropozoogenic action has also led to the regression of the natural argan tree since the beginning of the historical period. Thus, forest ecosystems have been degraded to lead to a steppe formation first and then to a vegetation dominated by herbaceous strata (therophytes) following various land developments for agro-pastoral purposes. Soils provide rapid growth and seed production following a perfect adaptation to water stress.

The Argan tree (Argania spinosa) has suffered intense degradation in the Abda region. The specimens observed in the Jorf Lasfar region at the beginning of the 20th century are the last representatives of the argan tree in the Doukkala-Abda region. Two native accompaniment species of the Argan tree: *Retama monosperma*, *Olea europaea* and *Chamaerops humilis*. Throughout the plain of Abda, collective lands are often bare while private properties show a plant formation dominated by *Retama monosperma, Chamaerops humilis* and *Chamaecytisus albidus* brings even in summer, a note of greenery at the same time effective protection against wind, rain and anthropogenic erosion. This protection was therefore possible and the work was worth undertaking to avoid the total degradation of a region whose livestock, agriculture and tourism constituted the main wealth. This degradation of the vegetation cover in this semi-arid and steppe environment can have harmful consequences on the hydrological behavior of the soil, especially on its water balance and its sediment production. As reported by Sabir et al. (2000), the reduction of vegetation cover by human intervention is often noted in areas subject to intensive grazing.

3. Climatic data in the studied area

Meteorological data were collected from Safi weather station which is located less than 30 km as the crow flies south of the study site. These are monthly rainfall, maximum, average and minimum temperatures, wind force and direction, and monthly relative humidity. The results are grouped in Figures 3 and 4.

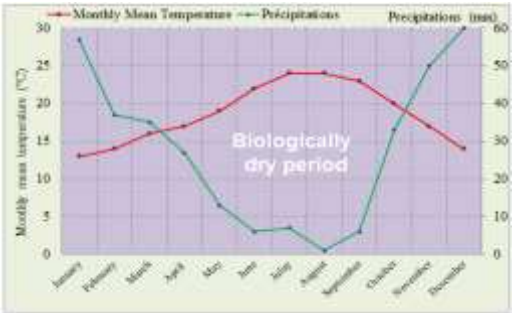


Figure 3 : Ombrothermic diagram showing the period biologically dry between April and September

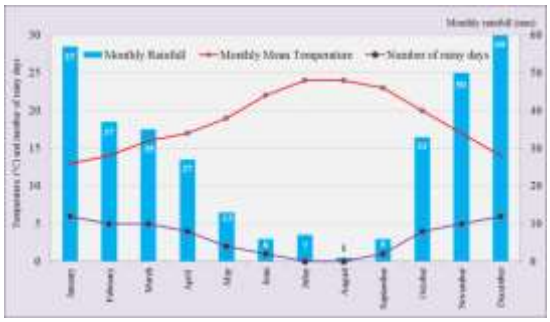
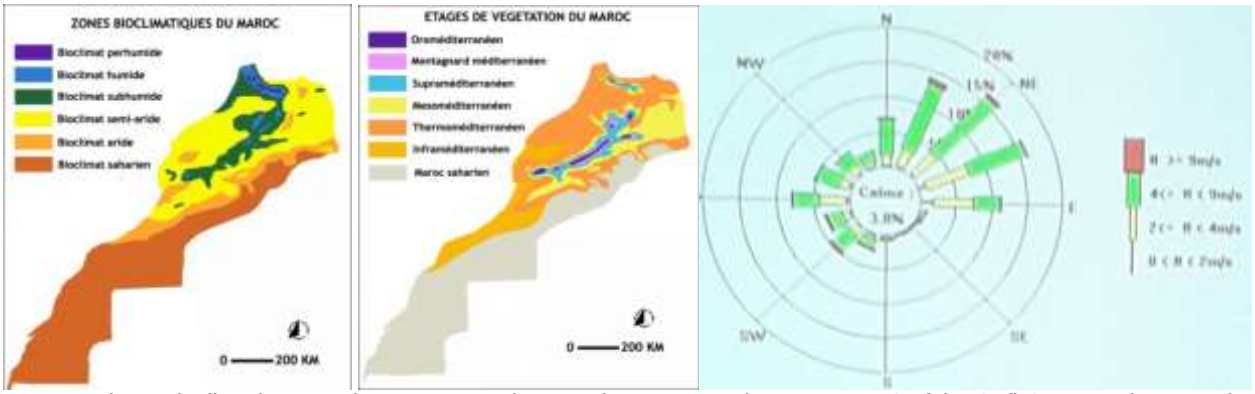


Figure 4: Monthly rainfall, number of rainy days per month and monthly average temperature

The Emberger climate diagram includes the Abda-Doukkala zone in the semi-arid bioclimatic climate with temperate winter. The dry period extends over 6 months, from mid-April to mid-October. The least amount of rainfall occurs in August, with an average of 2 mm. In December, the precipitation reaches its peak, with an average of 59.6 mm. In August, the average daily temperature is ~ 24 ° C. January is the coldest month of the year. The heat record is 47 ° C recorded on Wednesday, July 19, 1967 and the cold record of -2 ° C recorded on January 29, 2005. The prevailing wind blows from the Northeast with a frequency of 65% and an average force of 6 m / s. the strongest winds rarely exceed 9 m / s (Figure 5c).

The average annual rainfall is 350 mm with a maximum of 510 mm recorded in 2005, but the oceanic influence maintains atmospheric humidity which partly compensates for the scarcity of rainfall. The most important character of the climate is the frequency and the violence of the winds that blow from the west and north-west or from the east during the summer, with an overwhelming regularity. The Emberger climagram includes the Abda-Doukkala zone in semi-arid bioclimatic atmosphere with temperate winter. The dry period extends over 6 months, from mid-April to mid-October.



Figures 5a, b, c. Bioclimatic zones in Morocco and vegetation stages to locate quarry 2 of the Safi Cement plant: semi-arid region where the natural tree vegetation is almost absent. b. The vegetation stage corresponds to the thermo-Mediterranean (Benabid, 2000). c. Wind Rose showing the dominance of the North East direction

METHODOLOGY AND FLORISTIC AND FAUNISTISTIC MONITORING

SAMPLING STATIONS DESCRIPTION

The seasonal surveys covered 6 zones (or stations) of 20 m length, ie a minimum area of 400 m^2 per station (minimum area), from February to July 2018, i.e 6 visits in total to identify the flora and fauna and abundant wildlife in all stations. These areas are S1, S2, S3, S4, S5 and S6 (Figure 6).

Figure 6: Sampling Stations in Quarry 2 of the Safi Cement Plant

Station 1 (S1): site located in the bottom with a deep soil rich in organic matter. Chestnut, loamy-sandy soil;
Station 2 (S2): located on the southern slope with a shallower soil (10-15 cm), sandy loam with limestone grains;
Station 3 (S3): Located on the top of the hill south of the quarry. Less deep soil (8-10 cm) revealing limestone bedrock;
Station 4 (S4): located in the bottom of the eastern part of the quarry, rich in gravel and silt with limestone aggregates; shallower soil (15 cm);
Station 5 (S5): site located in the top of the hill, very exposed to the wind, with calcaine gravel and a shallow soil revealing the limestone bedrock;
Station 6 (S6): Station difficult to reach because of the blocks of stones. Excellent place for the natural conservation of flora and fauna, wild and nocturnal because of the shelters and burrows between the blocks.

The phyto-sociological surveys were carried out according to the Braun-Blanquet method in 20 x 20 m sampling stations (sampling sites) for the 2 woody and herbaceous strata. These areas were selected taking into account the minimum area generally adopted for the plant survey station area (Benabid 2000). These sites were marked by pickets to find them at each visit. For each survey, the list of all species affected by the abundance-dominance coefficient of Braun-Blanquet according to an abundance-recovery ratio was drawn up:

- 5: species covering 75 to 100% of the survey area;

- 4: species covering 50 to 75% of the survey area;
- 3: species covering 25 to 50% of the survey area;
- 2: species covering 5 to 25% of the survey area;
- 1: species covering 1 to 5% of the survey area;
- (+): species covering less than 1% of the land area.

The observations were made monthly from February to July. The short study period greatly limited the representative situation of herbaceous species that generally completed their development cycle during this period. The species limited to the autumnal period are not represented in this work.

Nomenclature and systematic classification adopted for flora

The first reform of the classification of plants proposed by Carl Von Linné (1707-1778) was based on binomial nomenclature. This nomenclature adopted in all countries, then completed and applied to the whole of the living, was later perfected by various authors. The most recent phylogenetic classification of flowering plants, adopted in 2009 by the entire scientific community, is APG III, Angiosperm Phylogenic Group (Phylogenetic Group of Angiosperms). In this work, we adopted the phylogenetic classification and consult e-flora Tela botanica 2018 (http://www.tela-botanica.org/). The nomenclature followed is that of the Practical Flora of Morocco (Fennane et al., 1999, 2007 and 2014) and the Catalog of Vascular Plants of Northern Morocco (Valdés et al., 2002). The order of presentation of the species follows the classification published in the Botanical Journal of the Linnean Society (APG III, 2009). The works used to identify the species observed are the New flora of Algeria and southern desert regions Quézel & Santa (1963), Benabid (2000) and the Practical Flora of Morocco in three volumes (Fennane *et al.,* 1999, 2007 and 2014).

The floristic species richness and frequencies were determined from the list of records. The frequencies made it possible to express the occurrence of the species: the frequent species are recorded in at least 50% of the surveys; infrequent species are present in 25-49% of records and rare species are present in less than 25% of records. The families, biological types and phytogeographic affinity of each species are illustrated using the raw spectra.

The plant species are classified according to their biological type determined by the general morphology of the plant, which expresses its adaptation to the type of the ecosystem. Five main types of plants are defined: phanerophytes, chaméphytes, hemycryptophytes, cryptophytes (or geophytes) and therophytes.
1- Phanerophytes are plants whose persistent buds are in principle more than 50 cm above the ground. In the study area, there are nanophanoréphytes and mesophanerophytes;
2- The Chaméphytes are sublime plants whose perennial buds are located 50 cm from the ground;
3- Hemicryptophytes are perennial plants whose perennial buds are located on the ground.
4- Geophytes are plants that have their permanent organs buried in the soil (bulbs, rhizomes or tubers).
5- Therophytes are annual plants whose durability during the adverse season is ensured by seeds.

Vegetation recovery is defined as the proportion (in%) of recovery of all plant species present in the site for a specific time. The recovery of a species corresponds to the proportion of the surface of the ground covered by the vertical projection of the aerial organs of this species.

FAUNA (WILDLIFE):
Visual observations of molluscs (gastropods and slugs), arthropods, insects, reptiles, mammals and birds were carried out at each visit to the 6 sampling stations. Tapping takes place during the day according to a defined sampling plan, which consists of covering the entire perimeter of the quarry, including the operating zone. The method consists of recognizing bird songs, identifying species and recording the number of individuals observed by binoculars. The quantitative study (counting the number of visible individuals) was only for mammals, birds and reptiles (lizards). For insects, arthropods and molluscs (slugs and gastropods), the observations mainly concerned the fauna under the stones, under the leaves of plants, in clumps of vegetation and especially on flowers (bees, butterflies, beetles). It involves browsing the study area and noting all the animal species observed with binoculars.

The wildlife inventory is based on direct observations or by listening (bird songs and screaming squirrels). Given the restricted area of the study site, the animal species were photographed or collected for identification (insects and molluscs). The dung was also considered to recognize the nocturnal species (amphibians and hedgehogs). The zoological nomenclature used in this study is that defined by the International Commission on Zoological Nomenclature. For the verification of scientific names, we used the "Zoological Record" which is an electronic index of the zoological literature which also serves as a register of scientific names in zoology.

RESULTS AND DISCUSSIONS

FLORISTIC BIODIVERSITY:

Floristic inventory

The plant species identified during the study period are grouped in Table 1 in the appendix (Table 1: Detailed floristic inventory of the vascular plant species of quarry 2 of the Safi cement plant). The floristic inventory was made from monthly surveys in the 6 zones of the quarry. A total of 152 vascular plant species and subspecies, belonging to 37 families, are recorded in the study area. This number of taxa corresponds to ~ 5% of the Moroccan flora, which has 4339 species and sub-species (Benabid 2000, Fennane et al., 2014) and ~ 78% of the botanical entities present in the low and medium altitude regions (less than 1000 m) from Morocco, where the climate is influenced by the Atlantic Ocean (Collin, 2012). In terms of number of species, the best represented families are mainly Asteraceae, with annual and perennial species, followed by Poaceae, Apiaceae, Brassicaceae and Fabaceae (Figure 7). The number of taxa listed only in the perimeter of the quarry (~ 63 ha) shows the quantitative importance of the floristic richness which persists to develop progressively during the year according to the appropriate biological cycle for each species. No endemic and endangered species are included in this list.

However, we must point out the remarkable degree of naturalness and synantropic flora linked to the activities of man: *Nicotiana glauca, Dittrichia viscosa, Inula hirta, Scolymus hispanicus* and *Verbascum sinuatum*. These species are particularly abundant along the trails marked by trucks carrying blocks of limestone for the Cement plant. The first 3 species are the most representative and the most abundant in the edges of the quarry during the study period.

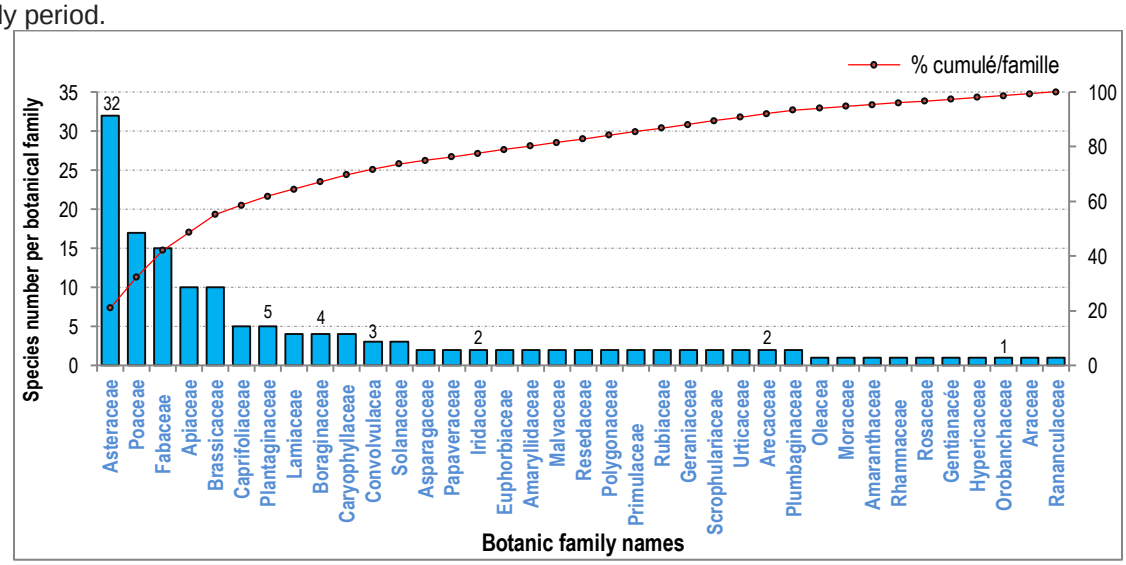


Figure 7 : Species number for the 37 botanic families identified in the quarry 2 area

Distribution of the plant species in the space - time

The table 1 in the appendix shows 152 species belonging to 37 families, which explains the importance of plant biodiversity in this agricultural region. The diverse flora consists mainly of spermaphytes (angiosperms), monocotyledons with 6 families, dominated by Poaceae. Broadleaf weeds (Dicotelydons) are represented by 31 families. The ranking of these families by the number of species is given in Figure 7. The first 5 families (Asteraceae, Poaceae, Apiaceae, Fabaceae and Brassicaceae) share more than 50% of all the species recorded, while the 32 families share less than 50%, of which 10 are represented by one species each.

These plant communities are linked to the nature of lean limestone soil in organic matter and climatic parameters (relatively high summer temperatures and fairly low rainfall and often in the form of showers in just a few hours). The bulb and rhizome plants appear just after the first rains: *Allium neapolitanum*, *Arisarum simorrhinum* and *Drimia maritima*. The recovery rate attributed to these 3 species together exceeds 80% during February March and early April in lowland resorts (relatively deep soil and retains more moisture).

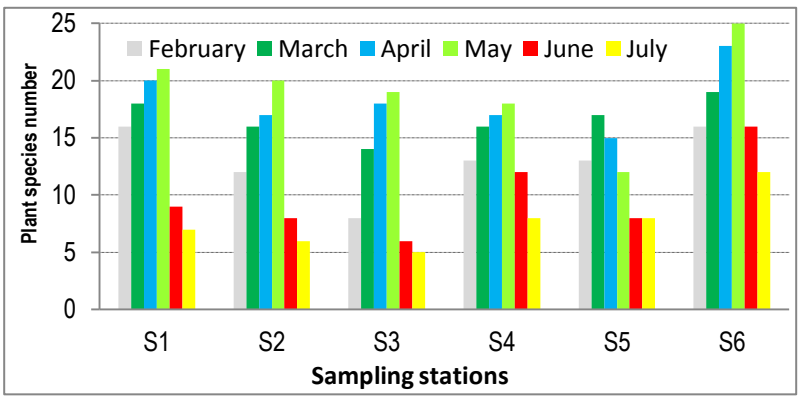


Figure 8: Number of plant species by station and month

The evaluation of the floristic diversity of the different sectors analyzed in the quarry (Figure 8) shows that the maximum number of species of the restoration plays an important role. In fact, the oldest parts are richer in species while the more recent ones (Part B corresponding to the northward flank) are less diversified in species and show significant clumps of *Dittrichia viscosa, Nicotiana glauca and Scolymus hispanicus*. These values may, however, be affected by the different surface and in particular the sedimentary composition less structured and less rich in nutrients. Many deep and extensive fissures occur on the southern and northern flanks of deep whitish soil. These fissures are transformed into huge furrows very eroded under the rains and only *Dittrichia viscosa* and *Nicotiana glauca* persist in these slopes.

Figure 5: Biological types graphics calculated in quarry 2 of the Safi Cement Plant

Space floristic diversity and diversity index of Shannon Weber

The floristic diversity was evaluated by applying specific indices (Shannon Wieber index) calculated from the formula:

H': Shannon Biodiversity Index
i : a species of the study station
p_i : relative proportion of a species i to the total number of species (S) in the study station (or site-specific richness), calculated as follows: $p(i) = n_i/N$: n =number of individuals for species i and N is the total number (individuals of all species in the same station).
where n_i is the number of individuals for species i and N is the total number (individuals of all species in the station).

The figure 6 shows the maximum, average and minimum values calculated for each station in the perimeter of quarry 2. The values are small compared to the maximum diversity which varies between 3.2 and 3.8 for the entire quarry. The lowest values are observed mainly in stations S5 and S4, and the high values correspond to station S6. The low values and observed fluctuations are attributed to the instability of the ecosystem which undergoes very extensive grazing in the region (there is a daily passage of 200 to 300 sheep, in addition to 2-3 mules attached along the day at a picket by a 25 m rope in places with abundant vegetation. The dust released by the trucks contribute to the clogging of plant leaves and reduce photosynthesis which contributes to a slowdown in the growth of species. These factors contribute to the disruption of vegetation cover, which is reduced by the lack of water in this arid region and by pasture and dust.

1. **Structure et répartition des espèces végétales dans le temps et dans l'espace**

Le tableau 1 en annexe montre 152 espèces appartenant à 37 familles ce qui explique l'importance de la biodiversité végétale dans cette région à vocation agricole. La flore diversifiée se compose principalement de spermaphytes (angiospermes), des monocotylédones avec 6 familles, dominées par les Poaceae. Les dicotylédones représentées par 31 familles. Le classement de ces familles par le nombre d'espèces est donné dans la figure 7. Les 5 premières familles (Asteraceae, Poaceae, Apiaceae, Fabaceae et Brassicaceae) se partagent plus de 50% de l'ensemble des espèces recensées, alors que les 32 familles se partagent moins de 50%, dont 10 sont représentées par une seule espèce chacune.
Ces communautés végétales sont liées à la nature du sol calcaire maigre en matière organique et aux paramètres climatiques (températures estivales assez élevées et des précipitations assez faibles et souvent sous forme d'averses en quelques heures seulement). Les plantes à bulbes et à rhizomes apparaissent juste après les premières pluies : *Allium neapolitanum, Arisarum simorrhinum* et *Drimia maritima,*. Le taux recouvrement attribué à ces 3 espèces réunies dépassent 80% durant février mars et début avril dans les stations des bas-fonds (sol relativement profond et rettenant plus d'humidité).

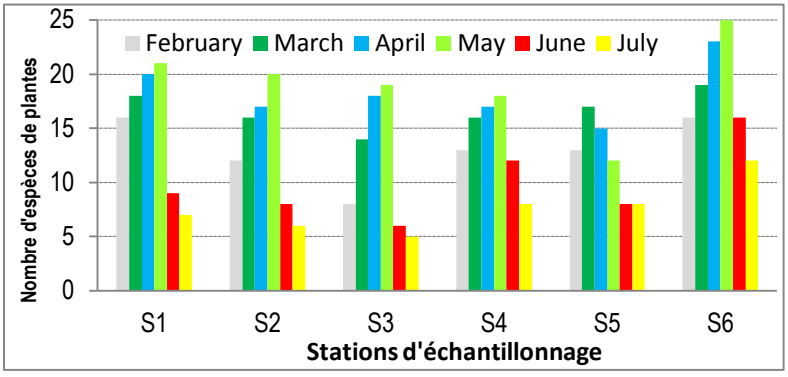


Figure 8 : Nombre d'espèces de plantes par station et par mois

L'évaluation de la diversité floristique des différents secteurs analysés dans la carrière (Figure 8) montre que le nombre maximum ne peux excéder 20 espèces dans l'ensemble du périmètre étudié, exception faite pour la station 6 qui demeure la moins perturbée par le passage quotidien fréquent des nombreux troupeaux de moutons qui broutent l'herbe et piétinent le sol. En effet, de nombreuses espèces sont bien conservées dans la station 6 entre les blocs de roches et atteignent des tailles normales : *Allium neapolitanum*, *Scabiosa atropurpurea maritima*, *Reichardia tingitana* et *Phagnalon rupestre* subsp. *illyricum* (Photos 1-4). Ces espèces montrent des tailles plus petites dans les autres stations et sont broutées la plupart de temps par les moutons, les ânes et les mulets (cas du *Phagnalon rupestre* et *Salvia verbenaca* L. subsp *eu-verbenaca* Maire.

1: Allium neapolitanum Cirillo 2: *Scabiosa atropurpurea maritima* (L.) 3: *Reichardia tingitana* (L.) Roth. 4 : *Phagnalon rupestre illyricum*

Photos 1 - 4 : Espèces de plantes bien conservées dans la station 6 entre les blocs de pierres (photos M. Kabine)

Photo 5 montrant le développement idéal d'*Arisarum simorrhinum* entre les blocs de roches

Le couvert végétal connait un changement progressif dans le temps, avec une apparition d'un tapis nettement dominé par *Marcus-kochia triloba* (L.) Al-Shehbaz =*Malcolmia triloba* (Photo 6). L'espèce est présente dans toutes les stations avec un taux de recouvrement allant de 30 à 60% et se trouve souvent associée à *Drimia maritima allium neapolitanum* et *Arisarum simorrhinum*. Cette association est également observée dans de nombreux endroits de la Meseta côtière et dans la forêt de la Mamora (Aafi et al, 2005).

Photo 6 : Tapis végétal dominé par *Marcus-kochia triloba* (L.) Al-Shehbaz = *Malcolmia triloba en* Février-Mars

Cette phase printanière se substitue progressivement dans le temps pour céder la dominance à *Allium neopolitanum* et *Moraea sisyrinchium* (L.) Ker Gawl. Durant la période mars-Avril. Le taux de recouvrement de

ces deux espèces va de 40 à 70% (photo 7)

Photo 7 : Tapis végétal montrant la dominance d'*Allium neapolitanum* et *Moraea sisyrinchium* en Mars-Avril

La phase estivale se termine par l'apparition des espèces épineuses non broutées par le bétail, comme le montre la photo 7. Onopordum macracanthum est l'espèce dominante durant la période Juin juillet. Les autres espèces sont asséchées et broutées par les chèvres et les moutons. Les fleurs de ces chardons offrent un gite préféré pour les coléoptères cétoines.

Photo 7 : Dominance du chardon Onopordum macracanthum durant la période juin- juillet

2. Types biologiques dominants dans les secteurs prospectés

Selon les résultats issus des trois années de prospections sur le terrain, nous avons dressé le diagramme (Figure 5) pour déterminer les différents rapports entre les 5 types biologiques caractéristiques da la flore recensée dans la région. On note 61% de thérophytes et 13% géophytes seulement ce qui démontre que la diversité floristique est dans stade dégradé par l'influence du pastoralisme et de l'influence humaine (agriculture et piétinement fréquent des troupeaux de bétail). Ces plantes annuelles ou bisannuelles complètent le cycle de vie soit par les graines (thérophytes), soit par les rhizomes et les tubercules (géophytes). La thérophytisation est largement dominante aussi bien dans les bordures de la carrière que dans l'ensemble du périmètre étudié. Les thérophytes poussent en abondance dans cette région où l'aridité est accentuée.

L'aridité de moindre importance favorise le développement des géophytes et des chaméphytes (Bammi et Douira, 2004). L'aridité du climat est exacerbée par les effets de l'érosion des sols dont le vent est le principal responsable dans la plaine d'Abda. Ainsi, il est recommandé à implanter des arbustes d'origine locale bien adaptés à ce climat aride : Arganier, pistachier, caroubier et olivier sauvage.

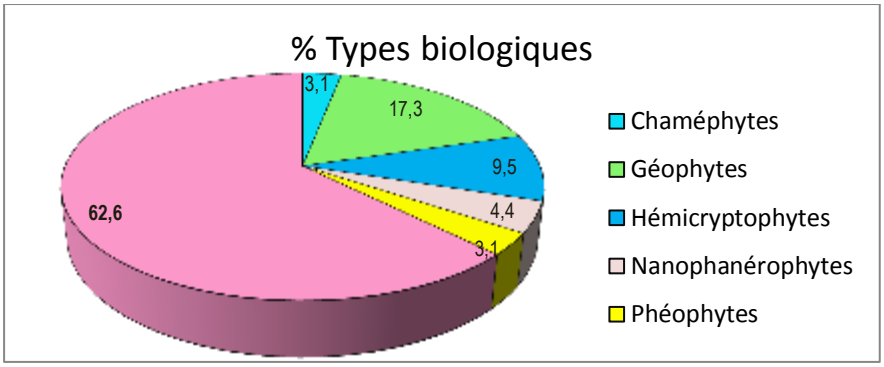


Figure 5 : Représentation des types biologiques calculés dans la carrière 2 de la Cimenterie de Safi

3. Diversité floristique spatiale et indice de diversité de Shannon Wieber

La diversité floristique a été évaluée en appliquant des indices spécifiques (indice de Shannon Wieber) calculé à partir de la formule :

H' : indice de biodiversité de Shannon

i : une espèce de la station d'étude

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

p_i : Proportion d'une espèce *i* par rapport au nombre total d'espèces (S) dans la station d'étude (ou richesse spécifique du site), qui se calcule de la façon suivante :

$$p(i) = n_i/N$$

où n_i est le nombre d'individus pour l'espèce *i* et N est l'effectif total (les individus de toutes les espèces).

La figure 6 illustre les valeurs maximales, moyennes et minimales calculées pour chaque station dans le périmètre de la carrière 2. Les valeurs sont faibles par rapport à la diversité maximale qui oscille entre 3,2 et 3,8 pour l'ensemble de la carrière. Les plus faibles valeurs sont observées principalement dans les stations S5 et S4 et les fortes valeurs correspondent à la station S6. Les faibles valeurs et les fluctuations observées sont attribuées à l'instabilité de l'écosystème qui subit un pâturage très poussé dans la région (on compte un passage quotidien de de 200 à 300 moutons, en plus de 2-3 mulets attachés le long de la journée à un piquet par un une corde de 25 m dans les endroits riche en végétation. La poussière dégagée par les camions contribuent au colmatage des feuilles des plantes et réduise la photosynthèse ce qui contribue à un ralentissement de la croissance des espèces. Tous ces facteurs contribuent à la perturbation du couvert végétal qui se réduit à la fois par le manque d'eau dans cette région aride et par le pâturage et la poussière.

La présence d'arbres de figuier et de palmier dans la station 6, ainsi que le taux d'humidité élevé entre et sous les blocs de roches calcaires expliquent les valeurs élevées des indices ainsi que le nombre important d'espèces végétales. Cette humidité s'accompagne également par un développement important de lichens sur l'ensemble des blocs de pierres (photo 2).

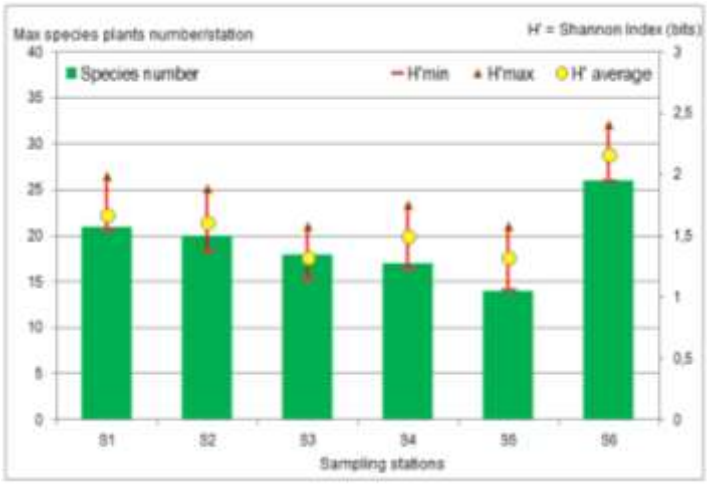


Figure 7 : Fluctuations des indices de Shannon Wieber dans les 6 stations de la carrière 2 durant la période d'étude

Photo 8*: Xanthoria parietina* (L.), Beltr. Lichens développé sur blocs de roche dans la station 6 avec le papillon de nuit Bombyx Shargacucullia verbasci – Avril 2018)

4. La faune associée à l'écosystème de la carrière 2

La faune associée à l'écosystème aride de la carrière 2 de la cimenterie de Safi compte un nombre dépassant 50 espèces appartenant à 16 ordres et à 6 classes (voir liste détaillée en annexe. Les vertébrés sont dominés par les oiseaux qui sont attirés par les insectes et les arthropodes. 4 espèces d'oiseaux sont nicheuses, l'alouette des champs dont on a repéré un nid camouflé entre les rochers dans la station 6 (voir photo). Un couple de la chouette chevêche est observé en permanence dans les falaises de la carrière et deux jeunes sont observés en juin avec leurs parents. Trois couples de faucon crécerelle sont observés en permanence sur les falaises de la carrière.

4 couples du guêpier d'Europe construisent leurs nids près de la station 4 à la suite du creusement d'un tranché laissant apparaitre une paroi verticale très propice pour creuser les terriers pour mettre les nids (Photo). De nombreuses crottes du hérisson d'Algérie et de l'amphibien *Sclerophrys mauritanica* (Schlegel) (= *Bufo mauritanicus).* Ces deux espèces sont insectivores à activité nocturne. Les crottes sont dominées par les restes des coléoptères en particulier.

L'écureuil de berbérie *atlantoxerus getulus* est représenté par une population de 8-10 individus, actifs durant la journée parmi les blocs de roches (station 6) et dans les falaises de la carrière en activité d'exploitation.

Les reptiles sont représentés par une seule espèce de lézard *Psammodromus algirus* (Linnaeus, 1758) qui se camoufle dans les buissons du palmier nain ou sous les pierres et les caillous. C'est un insectivore qui se nourrit également de mollusques gastéropodes. L'espèce est assez fréquente durant la période estivale et très rare durant les périodes du froid.

La station 5 proche du sommet de la colline est composée de nombreux cailloux sous lesquelles se cache le scorpion Buthus atlantis. L'espèce est relativement abondante en juin juillet et se trouve associé avec des araignées.

La période humide (février mars) est très marquée par une abondance remarquable de la limace grise *Deroceras reticulanum*. Son abondance atteint 4 individus/m2 et on a compté parfois sous les pierres 10 individus par m2. L'espèce se nourrit des feuilles des plantes. Dès le mois de mai, les conditions climatiques deviennent défavorables pour l'espèce.

Deux espèces de papillons de nuit sont sédentaires et les larves sont très attachées aux plantes. La larve de l'espèce *Shargacucullia verbasci* est observée uniquement sur les feuilles de *Verbascum sinuatum* (voir photo) alors que la larve de Bombyx *Lasiocampa (Pachygastria) trifolii* a été repéré sur plusieurs espèces de plantes. Les adultes de ces deux espèces sont très abondants dans la station 6 où ils se camouflent entre les blocs des rochers.
L'ensemble des espèces de la faune est caractéristiques des zones arides du Maroc.

Scorpion Buthus atlantis *Alauda arvensis* Tropinota hirta *Atlantoxerus getulus* *Psammodromus Algirus algirus*

Mylabris hieracii

Terriers de nidification pour guêpier d'Europe

Shargacucullia verbasci

Bombyx : Lasiocampa trifolii

Troupeau de moutons dans le périmètre de la carrière 2

Medicinal and Aromatic Plant species identified in the Quarry 2

The MAP species identified in the quarry 2 of the Safi Cement Plant are:
1. *Ajuga iva var. eu-pseudoiva* (Robill & Castagne ex DC.) Steud.
2. *Allium neapolitanum* Cirillo;
3. *Lavandula stoechas* L. subsp. *atlantica* (Braun-Bl.) Romo. ;
4. *Charybdis maritima* (L.) Speta (= *Urginea maritima*) = *Drimia maritima*);
5. *Arisarum simorrhinum* Durieu;
6. *Marrubium vulgare* Linnaeus;
7. *Salvia verbenaca* L. subsp *eu-verbenaca* Mayor.

These plants have ecological peculiarities and are mainly used in the traditional medicine by the north African populations for therapeutic, nutritional and/or cosmetic purposes. They are sold dry in herbalists in all the Maghreb countries.

The data collected bellow are from authors' observations and from: APG III (2009), Aeschimann *et al.* (2004), Benabid (2000), Bellakhder (2006, 2007), De Fior (1981), Goldstein *et al.* (1983), Fischer (2008), Pignatti (1982), Poldini (1989, 1991, 2002), Poldini *et al.* (2001), Rothmaler *et al.* (1995), Simonetti & Watschinger (1986). We give detailed description of the species Ajuga iva var. *eu-pseudoiva* and its medicinal virtues:

Common names: French name. Bugle fausse Ivette; English vernacular name: Southern Bugle. Arabic: Chendgoura

Classification APGIII	Eudicotyledones	Order: Lamiales	Family : Lamiaceae

Ajuga iva subsp. eu-*pseudoiva* or false bugle musk Ivette, is a herbaceous perennial plant of 8-20 cm, woody at the base, hairy-whitish, with musk odor. The flowers are completely yellow and the whole plant is hairy, including the base of the flower and stamens (see photo). Leaves are of linear shape slightly lanceolate, all sessile, rolled edges, whole or a little toothed at the top. The flowers are yellow, 2-4 per whorl in the axils of the leaves and shorter than they are. The corolla has an upper lip and a lower lip with three lobes. Corolla shows a funnel tube, often aborted. The plant is very small but the corolla are large, however shorter than the leaves.

Ajuga iva eu-pseudoiva frequents dry and stony soils, along tracks, wastelands and dry grassy sites. Its

abundance is noted in the arid, semi-arid and sub-humid bioclimatic environments with a hot variant of North Africa. Typically Mediterranean between 0-600 m altitudes in the warm Mediterranean countries, it does not venture far beyond the coast and the low hills that surround it. The flowering period is from July to November, the fruit is an achene.

Ajuga Iva eu-pseudoiva in the quarry 2 of the Safi Cement Plant (Photo M. Kabine, july 2018)

The bugle *A. iva eu-pseudoiva* is widely used in traditional medicine to treat diabetes, hypertension, gastralgia, female infertility, hemorrhoids, and to relieve pain. Pharmacological studies have shown antiulcer, hypoglycemic and anti-inflammatory activities. The large number of flavonoids contained in this plant has given it a broad spectrum of pharmacological activities: diuretic, hypoglycemic, hypolipidemic, antihypertensive and vasodilator, it is considered a panacea in the Maghreb.

This plant is well known among North Africans because of its medicinal properties (hypotensive, hypoglycemic). Used in a broad spectrum of pharmacological activities: diuretic, hypoglycemic (antidiabetic), hypolipidemic, antihypertensive and vasodilator.

The musk ivy has a bitter and resinous flavor and a strong smell that is close to musk. The dry leafy stems are used in infusion as antispasmodic, tonic, febrifuge, diuretic, antiarthritic and appetizer. A decoction of 20g in one liter of water in case of headache, kidney and bladder.

The active ingredients of the plant are the phenolic acids, caffeine and ajugarin.

Conclusion

This study shows that plant and animal biodiversity is of ecological importance to maintain equilibrium in the semi-arid ecosystem in the region. The floristic composition of 152 species, recorded between February and July 2018, demonstrates the importance of biodiversity in the region. In fact, this flora, the development of which only requires soil rich in organic matter and water, is the basis of the life of a large number of animal species to complete the trophic chain up to tertiary consumers (hawks and owls) through herds of cattle. Thus the pyramid of the trophic chain is completed with a complexity of animal species ranging from invertebrates to vertebrates, whose representatives are few in view of the scarcity of shelter and the security required by wildlife.
It is clear that therophytes predominate in terms of land use. This therophytization marks an advanced stage of degradation.

At the end of this work, we can conclude that the arid climate that is increasingly felt by the prolongation of drought is the result of a degradation of vegetation due to the increase of aridity and the intense anthropogenic action (frequent passage of herds of cattle). The means of combating this imbalance must be put in place to remedy this alarming situation. It is important to think about planting the Argan tree, which was probably the rightful occupant of the soil. His eventual reintroduction into the quarry, will help to partially recover some features of the ecological balance that was the rule before the destructive intervention of man and his flock.

The ultimate stage of degradation in the study area is desertification which will be marked by biological imbalances produced in the water supply of plants and their supply of nutrients mineral nutrients. This situation is aggravated by the destruction of the soil and the outcropping of the limestone slab due to intense wind erosion. If the situation remains reversible in subhumid and humid bioclimates on less eroded soils, after

desertification, in arid and locally semi-arid zones, on the other hand, it is a real desertification that is taking hold.

Useful recommendations for biodiversity conservation in the region include: 1- Extend investigations throughout the year to identify all species of plant and animal biodiversity; 2- Establish posters for the remarkable flora and fauna species in quarry 2 to make this biodiversity known to the various audiences and decision-makers in the region (raising awareness and valorising the region); 3- Put biodiversity in the concern of the Safi cement plant and demonstrate that the berberie squirrel, the owl owl and the European bee-eater are installed in the vicinity of the quarry, creating ideal conditions for these species. 4- Proceed to plant the perimeter of the quarry by shrubs or trees adapted to the climate and soil (argan, carob, pistachio tree 5- Limit the passage of cattle herds in the region to preserve the species of plants and animals already in place 6- Dig other trenches as is the case in Station 4 to attract more European Bee-eater pairs 7- to reflect on the modalities of intervention for the fight against desertification which begins to be felt.

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