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Characterization of the Biodegradation of Kasbahs of the Gharb Region (Mehdia and Kenitra Kasbahs, Morocco)

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Abstract

With the aim of contributing to the solutions linked to the problems of the preventive preservation and the restoration of the Kasbah of Mehdia or the Kasbah of Moulay El Hassan, a study of the flora populating the facades of these historical monuments was realized and showed the presence of a varied and diverse vegetation populating these buildings left to the ravages of time. The inventory of this flora showed the existence of 70 species among which 48 were exclusively detected at the Kasbah of Mehdia, 11 other species were only discovered at the Kasbah of Kenitra and 11 vegetal species were inventoried at both Kasbahs. These plant species are divided into 28 families. Four families clearly dominate the flora inventoried at both Kasbahs of the Gharb region. These are the *Asteraceae* (15.7%), *Poaceae* (10%), *Apiaceae* (8.6%) and *Scrophulariaceae* (5.7%). These families alone account for 41.4% of the specific size of the flora of the studied sites. The most dominant vegetal type is the therophytes with 61.4% of the total specific size, followed by hemicryptophytes with 17.1%. Located at the top or the base of walls, these plants, fitting into joints or cracks, have a chemical action on the stones by acids which they release and also have a mechanical action on the stones by the growth of roots inside cracks. This vegetation remains one of the most important biological factors of the degradation of historical monuments.

Keywords

Weed Flora, Historical Monuments, Kasbahs, Kenitra, Mehdia, Morocco

1. Introduction

The stone of the buildings is constantly exposed to several deteriorating factors (wind,

rain, sun, humidity, etc.). In addition, the effect of biodegradation allows organisms and different microorganisms to grow on any surface in the form of bio-films.

A careful examination at the Kasbah of Moulay El Hassan and the Kasbah of Mehdia shows that all the forms of the vegetal life can colonize the stones. We find indeed not only seaweeds, mushrooms, lichens, but also froths (mosses), ferns and vascular plants there. Because these buildings are poorly maintained, it is not rare to find trees of which roots are obviously devastating.

The Kasbah of Kenitra was built by Sultan Moulay El Hassan and was completed by his successor Moulay Abdelaziz in 1895 [1]. It is about a citadel at the heart of the city of Kenitra, which is, at present, considered as one of the most modern Moroccan big cities and one of the most important cities of the northwest of the Kingdom (**Figure 1**). It is a recent city, contrary to the imperial cities of the Kingdom, because its creation goes back to only 120 years.

Mehdia's Kasbah was built in the sixth century before J.C. by the Suffete Hannon, the first magistrate of Carthage, and was restored for the first time in 1185 by Sultan Yacoub El Mansour [2]. It is located at the level of the Mehdia's picturesque coastal town situated on the west of the city of Kenitra at a distance of approximately 10 km.

The city of Kenitra is located in the north-west of Morocco, near the Atlantic Ocean between Rabat and Tangier. It is built on the bank of the Oued Sebou and located 40 km in the north of the capital Rabat with latitude: 34˚08'00" North and longitude: 6˚34'00" West.

The city of Mehdia is located in the west of the city of Kenitra at a distance of about

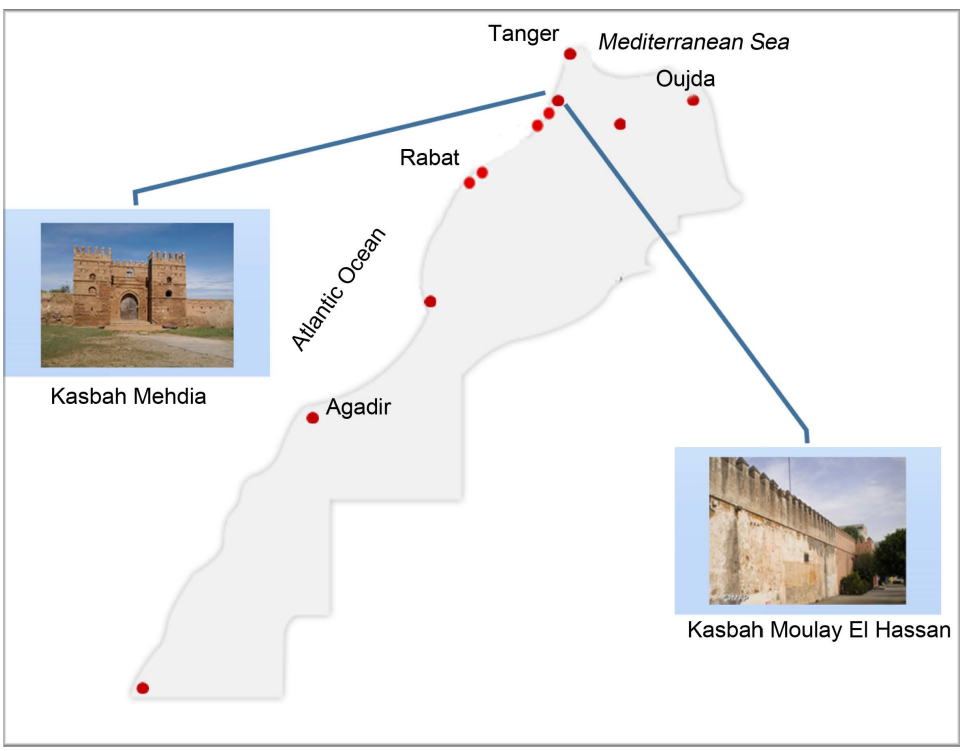

Figure 1. Location of Moulay El Hassan and Mehdia Kasbah's.

10 km. It is bounded by the Atlantic Ocean to the west, Sebou River and Lake Sidi Boughaba to the north and the rural commune of Sidi Taibi to the south.

The cities of Kenitra and Mehdia are situated in the center of a rich agricultural region, Gharb. Besides the sea of Mehdia beach, we find near these cities, the biological reserve of the lake Sidi Boughaba, classified site RAMSAR, and its numerous species of migratory birds, as well as the forest of the cork oak of Maamoura.

The climate at the level of the cities of Kenitra and Mehdia is hot and moderate. The winter characterized by precipitation is more important than in summer. The annual average temperature is of 18.4˚C there. The average of the annual precipitation reaches 570 mm.

The objective of this study is to inventory and characterize the flora inhabiting the construction of two Kasbah of the Gharb region. This inventory will doubtless help other specialists to make concrete proposals of conservation and the restoration and the rehabilitation of these monuments.

2. Material and Methods

2.1. Sampling

The floristic surveys were realized according to a systematic sampling in the facades of the most important walls of the Kasbah of Kenitra and the Kasbah of Mehdia. Facades chosen in this study are the most affected by macro and microorganisms (Figure 2 and

Figure 2. Facades of some walls considered in the floristic inventory at the Kasbahof Moulay El Hassan in Kenitra ((a), (b), (c) and (d)).

Figure 3). The method adopted during these surveys consists in inventorying the various types of existing flora on each facade of the wall studied according to three separate places: basal Part, middle part and the top of the wall. So, a herbarium was established at each Kasbah.

The study of the flora populating building materials in the Kasbah of Kenitra and that of Mehdia revealed diversified vegetation. Left with the ravage of time without any restoration and rehabilitation, both studied Kasbahs contain several facades invaded by various types of vegetation.

The floristic surveys at both Kasbahs were realized during the period between the months of March and April 2014.

2.2. Species Identification

The determination of the plant species, taken at the Kasbah of Moulay El Hassan and Mehdia one, was made in the Department of Natural Resources and Environment, of Vegetable Ecology, at the Agronomic and Veterinary Institute Hassan II in Rabat thanks to the following florae: the flora illustrated with adventitious of the cultures of Gharb [3], the flora has a practice of Morocco [4] [5] [6]. The check of the identifications was made by referring to the Catalog of the Plants of Morocco [7] and the synonymic Index of let us tax presents in the cultivated circles and artificializes of Morocco. The nomenclature used is the flora of Morocco [4] [5] [6].

Figure 3. Internal and external facades of some walls considered in the floristic inventory at the Kasbah of Mehdia ((a), (b), (c) and (d)).

3. Results

3.1. The Kasbah of Mehdia

- **Systematic appearance**

Table 1 presents an exhaustive list of the vegetal species found at facades of the walls studied at the Kasbah of Mehdia. These inventoried species are in number of fifty nine (59), distributed on fifty four (54) genus and twenty six (26) vegetal families.

According to their relative contributions, four families dominate clearly the flora populating the historical buildings of the Kasbah of Mehdia, namely:

✓ *Astereaceae* (15.2%) with 09 species;
✓ *Poaceae* (10.1%) with 06 species;
✓ *Apiaceae* (8.5%) with 05 species;
✓ *Scrophulariaceae* (6.7%) with 04 species.

These families totaled 24 species alone, or 40.6% of the specific size of the flora of the site.

The importance of these families can be explained by their preponderances nationally, their Mediterranean biogeographical distribution and their ability to adapt to unstable and highly diverse habitats [8] and more of high productivity seeds, the to revise longevity of seeds, seed dispersal by wind and birds and phenology perfectly suited to the nature of building materials of historical monuments [9].

- **Biological aspect**

To decide the form ethology, the classification adopted as ethology notation reference observed and dominant in the field is that of Raunkiaer [10], which is based on the position of permanent buds during the period of vegetative rest with respect to the surface soil.

The spectrum established for the entire weed flora, detected in the walls of the Kasbah of Mehdia, reveals five biological types (Table 2). This flora is dominated by therophytes (annual) comprise 38 species or 64.4% of the specific effective, followed by hemicryptophytes with 8 species or 13.5% of the specific effective and phanerophytes with 10.2% the actual inventory to the site (Table 2).

3.2. The Kasbah of Kenitra

- **Systematic Appearance**

Table 3 shows the plant species encountered in the various fronts of walls studied at the Kasbah of Moulay El Hassan. These species are inventoried number of twenty-two (22) spread over thirteen (13) botanical families.

According to their relative contributions, two (02) families dominate sharply flora inhabiting the historic walls of the Kasbah of Moulay El Hassan in genera and species, namely:

✓ *Astereaceae* (18.18%) with 04 species;
✓ *Poaceae* (18.18%) with 04 species.

These two families totaling 08 species alone, or 36.36% of the specific size of the flora of the site.

Table 1. Vegetal species found in the historical buildings of the Kasbah of Mehdia divided into vegetal families.

Families	Species	Number of species	Biological type
Apiaceae	*Ammimajus*	**5**	Therophyte
	Ammivisnaga		Therophyte
	Smyrniumolusatrum		Hemicryptophyte
	Torilisarvensis		Therophyte
	Torilisnodosa		Therophyte
Araceae	*Arisarum vulgare*	**1**	Geophyte
Asteraceae	*Carduusmyriacanthus*	**9**	Therophyte
	Chrysanthemum coronarium		Therophyte
	Hypochoerisradicata		Hemicryptophyte
	Phagnalon saxatile		Phanerophyte
	Scolymus maculatus		Therophyte
	Sonchus oleraceus		Therophyte
	Taraxacumofficinale		Therophyte
	Urospermumpicroides		Therophyte
	Reichardia tingitana		Therophyte
Brassicaceae	*Diplotaxis catholica*	**2**	Therophyte
	Lobularia lybica		Therophyte
Caryophyllaceae	*Cerastium glomeratum*	**1**	Therophyte
Chenopodiaceae	*Beta maritima*	**2**	Hemicryptophyte
	Chenopodium murale		Therophyte
Convolvulaceae	*Convolvulus althaeoides*	**1**	Geophyte
Crassulaceae	*Cotyledon umbilicus-veneris*	**1**	Therophyte
Euphorbiaceae	*Euphorbia helioscopia*	**3**	Therophyte
	Mercurialis annua		Therophyte
	Ricinus communis		Phanerophyte
Fabaceae	*Lotus arenarius*	**2**	Therophyte
	Retama monosperma		Phanerophyte
Geraniaceae	*Geranium molle*	**2**	Therophyte
	Geranium sp.		Therophyte
Lamiaceae	*Ajuga iva*	**3**	Hemicryptophyte
	Marrubium vulgare		Chamaeophyte
	Stachys ocymastrum		Therophyte
Malvaceae	*Malva hispanica*	**2**	Therophyte
	Malva parviflora		Therophyte
Moraceae	*Ficus carica*	**1**	Phanerophyte
Myoporaceae	*Myoporum sp.*	**1**	Phanerophyte
Papaveraceae	*Papaver rhoeas*	**1**	Therophyte
Plantaginaceae	*Plantago lanceolata*	**1**	Hemicryptophyte
Plumbaginaceae	*Plumbago europaea*	**1**	Hemicryptophyte
Poaceae	*Brachypodium distachyum*	**6**	Therophyte
	Bromus rigidus		Therophyte
	Cynodon dactylon		Geophyte
	Hordeummurinum		Therophyte
	Lagurusovatus		Therophyte
	Loliumrigidum		Therophyte
Polygonaceae	*Emex spinosa*	**1**	Therophyte

Continued

Primulaceae	*Anagallis arvensis*	1	Therophyte
Rubiaceae	*Rubia perigrina* *Sherardia arvensis*	2	Geophyte Therophyte
Scrophulariaceae	*Misopates orontium* *Veronica polita* *Veronica hederifolia* *Verbascum sinuatum*	4	Chamaeophyte Therophyte Therophyte Hemicryptophyte
Solanaceae	*Hyoscyamusalbus* *Nicocianaglauca* *Solanumsodomaeum*	3	Hemicryptophyte Phanerophyte Chamaeophyte
Valerianaceae	*Fedia cornucopiae*	1	Therophyte
Urticaceae	*Parietaria lusitanica* *Urtica membranacea*	2	Therophyte Therophyte

Table 2. Biological spectrum at the Kasbah of Mehdia.

Biological type	Number of species	Contributions (%)
Therophyte	**38**	**66.1**
Hemicryptophytes	**8**	**11.9**
Phanerophytes	**6**	**10.2**
Geophytes	**4**	**6.8**
Chamaeophytes	**3**	**5**
Total	**59**	**100**

- **Biological Appearance**

According to the classification of Raunkiaer [10], the 22 weed species belong to four biological types. This flora is clearly dominated by therophytes (annual) comprise 13 species or 59.1% of the specific effective, followed by hemicryptophytes with 5 species or 22.7%, geophytes with 3% cash soit 13.6 and phanerophytes with one species or 4.6% of the specific strength (Table 4).

3.3. Comparison between the Two Kasbahs

From Table 1 and Table 3, we can deduct that the total number of the botanical species inventoried at the two studied Kasbahs in the Gharb region sum-up to 70 species among which 48 are exclusively detected in the Kasbah of Mehdia, 11 other species are only discovered in the Kasbah of Kenitra and 11 vegetal species are simultaneously inventoried at both Kasbahs (Table 5).

The abundance of plant flora at the Kasbah of Mehdia, compared to that of Kenitra, is due to the large area of the monument (40 hectares) on the one hand, and the lack of recovery operations and systematic rehabilitation at the second Kasbah. Thus, the walls of several monumental buildings of this building are colonized by a variety of vegetation that certainly have a detrimental effect on the stones used in the construction of this historic site (Figure 3). At the level of the Kasbah of Kenitra, the invasion of the facades of the walls by the flora is less important compared to the Kasbah of Mehdia.

Table 3. Plant species encountered in the studied walls of the Kasbah of Moulay El Hassan in Kenitra divided into botanical families.

Families	Species	Number of species	Biological type
Amaranthaceae	*Amaranthusviridis*	1	Therophyte
Apiaceae	*Conium maculatum*	1	Hemicryptophyte
Asteraceae	*Scolymusmaculatus*	4	Therophyte
	Sonchusoleraceus		Therophyte
	Andryalaintegrifolia		Therophyte
	Erigeron canadensis		Geophyte
Boraginaceae	*Heliotropiumeuropaeum*	1	Therophyte
Caryophyllaceae	*Silene vulgaris*	2	Geophyte
	Polycarpontetraphyllum		Therophyte
Chenopodiaceae	*Chenopodiumambrosoides*	1	Hemicryptophyte
Euphorbiaceae	*Mercurialisannua*	2	Therophyte
	Ricinus communis		Phanerophyte
Plantaginaceae	*Plantagolanceolata*	2	Hemicryptophyte
	Plantagomajor		Hemicryptophyte
Poaceae	*Oryzopsismiliacea*	4	Hemicryptophyte
	Cynodondactylon		Geophyte
	Lagurusovatus		Therophyte
	Bromusrigidus		Therophyte
Primulaceae	*Anagallisarvensis*	1	Therophyte
Rubiaceae	*Galiumaparine*	1	Therophyte
Scrophulariaceae	*Verbascumsinuatum*	1	Hemicryptophyte
Urticaceae	*Parietarialusitanica*	1	Therophyte

Table 4. Spectrum ethology at the kasbah of Kenitra.

Ethological type	Number of species	Contributions (%)
Therophytes	**12**	**54.6**
Hemicryptophytes	**6**	**27.3**
Geophytes	**3**	**13.6**
Phanerophytes	**1**	**4.5**
Total	**22**	**100**

This is due to maintenance has suffered this monument over time, although they are inadequate and are, themselves, a factor of degrading this Kasbah. However, the review of internal facades of the walls, left without maintenance, surrounding the Kasbah, also showed a marked diversification of vegetation inhabiting this building (Figure 2).

The total number of these plant species is divided into 28 botanical families. According to their relative contributions, four (4) families clearly dominate the flora inventoried at both Kasbahs of the region of Gharb. There are:

Table 5. Plant species encountered at both Kasbah of Kenitra and Mehdia divided into botanical families.

Families	Species	Location	Number of species	Biological type
Amaranthaceae	*Amaranthusviridis*	K.Kenitra	**1**	Therophyte
Apiaceae	*Ammimajus*	K. Mehdia	**6**	Therophyte
	Ammivisnaga	K. Mehdia		Therophyte
	Smyrniumolusatrum	K. Mehdia		Hemicryptophyte
	Torilisarvensis	K. Mehdia		Therophyte
	Torilisnodosa	K. Mehdia		Therophyte
	Conium maculatum	K. Kenitra		Hemicryptophyte
Araceae	*Arisarum vulgare*	K. Mehdia	**1**	Geophyte
Asteraceae	*Carduusmyriacanthus*	K. Mehdia	**11**	Therophyte
	Chrysanthemum coronarium	K. Mehdia		Therophyte
	Hypochoerisradicata	K. Mehdia		Hemicryptophyte
	Phagnalon saxatile	K. Mehdia		Phanerophyte
	Scolymus maculatus	K. Mehdia + K. Kenitra		Therophyte
	Sonchus oleraceus	K. Mehdia + K. Kenitra		Therophyte
	Taraxacumofficinale	K. Mehdia		Therophyte
	Urospermumpicroides	K. Mehdia		Therophyte
	Reichardia tingitana	K. Mehdia		Therophyte
	Andryalaintegrifolia	K. Kenitra		Therophyte
	Erigeron canadensis	K. Kenitra		Geophyte
Boraginaceae	*Heliotropiumeuropaeum*	K. Kenitra	**1**	Therophyte
Brassicaceae	*Diplotaxis catholica*	K. Mehdia	**2**	Therophyte
	Lobularia lybica	K. Mehdia		Therophyte
Caryophyllaceae	*Cerastium glomeratum*	K. Mehdia	**3**	Therophyte
	Silene vulgaris	K. Kenitra		Geophyte
	Polycarpontetraphyllum	K. Kenitra		Therophyte
Chenopodiaceae	*Beta maritima*	K. Mehdia	**3**	Hemicryptophyte
	Chenopodium murale	K. Mehdia		Therophyte
	Chenopodiumambrosoides	K. Kenitra		Hemicryptophyte
Convolvulaceae	*Convolvulus althaeoides*	K. Mehdia	**1**	Geophyte
Crassulaceae	*Cotyledon umbilicus-veneris*	K.Mehdia	**1**	Therophyte
Euphorbiaceae	*Euphorbia heliscopia*	K.Mehdia	**3**	Therophyte
	Mercurialis annua	K. Mehdia + K. Kenitra		Therophyte
	Ricinus communis	K. Mehdia + K. Kenitra		Phanerophyte
Fabaceae	*Lotus arenarius*	K. Mehdia	**2**	Therophyte
	Retama monosperma	K. Mehdia		Phanerophyte
Geraniaceae	*Geranium molle*	K. Mehdia	**2**	Therophyte
	Geranium sp.	K. Mehdia		Therophyte
Lamiaceae	*Ajuga iva*	K. Mehdia	**3**	Hemicryptophyte
	Marrubium vulgare	K. Mehdia		Chamaeophyte
	Stachys ocymastrum	K. Mehdia		Therophyte
Malvaceae	*Malva hispanica*	K. Mehdia	**2**	Therophyte
	Malva parviflora	K. Mehdia		Therophyte
Moraceae	*Ficus carica*	K. Mehdia	**1**	Phanerophyte
Myoporaceae	*Myoporum* sp.	K. Mehdia	**1**	Phanerophyte
Papaveraceae	*Papaver rhoeas*	K. Mehdia	**1**	Therophyte
Plantaginaceae	*Plantago lanceolata*	K. Mehdia + K. Kenitra	**2**	Hemicryptophyte
	Plantago major	K. Kenitra		Hemicryptophyte

Continued

Plumbaginaceae	*Plumbago europaea*	K. Mehdia	**1**	Hemicryptophyte
Poaceae	*Brachypodium distachyum*	K. Mehdia	**7**	Therophyte
	Bromus rigidus	K. Mehdia + K. Kenitra		Therophyte
	Cynodon dactylon	K. Mehdia + K. Kenitra		Geophyte
	Hordeummurinum	K. Mehdia		Therophyte
	Lagurusovatus	K. Mehdia + K. Kenitra		Therophyte
	Loliumrigidum	K. Mehdia		Therophyte
	Oryzopsismiliacea	K. Kenitra		Hemicryptophyte
Polygonaceae	*Emex spinosa*	K. Mehdia	**1**	Therophyte
Primulaceae	*Anagallis arvensis*	K. Mehdia + K. Kenitra	**1**	Therophyte
Rubiaceae	*Rubiaperigrina*	K. Mehdia	**3**	Geophyte
	Sherardiaarvensis	K. Mehdia		Therophyte
	Galiumaparine	K. Kenitra		Therophyte
Scrophulariaceae	*Misopates orontium*	K. Mehdia	**4**	Chamaeophyte
	Veronica polita	K. Mehdia		Therophyte
	Veronica hederifolia	K. Mehdia		Therophyte
	Verbascum sinuatum	K. Mehdia + K. Kenitra		Hemicryptophyte
Solanaceae	*Hyoscyamusalbus*	K. Mehdia	**3**	Hemicryptophyte
	Nicocianaglauca	K. Mehdia		Phanerophyte
	Solanumsodomaeum	K. Mehdia		Chamaeophyte
Valerianaceae	*Fedia cornucopiae*	K. Mehdia	**1**	Therophyte
Urticaceae	*Parietaria lusitanica*	K. Mehdia + K. Kenitra	**2**	Therophyte
	Urtica membranacea	K. Mehdia		Therophyte

- ✓ *Astereaceae* (15.7%) with 11 species;
- ✓ *Poaceae* (10%) with 07 species;
- ✓ *Apiaceae* (8.6%) with 06 species;
- ✓ *Scrophulariaceae* (5.7%) with 04 species.

These families alone totaled 41.4% of the specific size of the flora of the sites.

The spectrum established for the entire weed flora, detected in the walls of the Kasbah and the Kenitra Mehdia, reveals five biological types. This flora is dominated by therophytes, which consist of 43 species or 61.4% of the specific effective, followed by hemicryptophytes with 12 species or 17.1% of the specific strength (**Table 6**).

4. Action of Plants, Algae and Lichen on Monuments

Many living organisms can easily colonize stonework and be responsible, in addition to their unattractive character, more or less significant damage [11]. Biological weathering agents are mainly mosses, fungi and lichens, algae but also some bacteria and some plants.

Plants growing on buildings generally indicate the presence of moisture in the attached materials. After sowing (presence of seeds), the environmental parameters which promote the growth of these plants are light, oxygen and carbon dioxide. Inorganic salts derived from stone materials [12]. In general, the roots accentuate the deterioration of masonry. The presence of plants on buildings mainly reflects a lack of maintenance of the building [12] (**Figure 4**).

These herbs, vines and shrubs that thrive are destructive buildings because their root systems seep into cracks and joints between stone exerting enough pressure to significant fragmentation of the stone (Figure 5). They also generate moist micro-soils, which are a source of salt and place of intense biological activity [13].

Table 6. Ethology spectrum at the Kasbah of Kenitra and Mehdia.

Ethological type	Number of species	Contributions in %
Therophytes	43	61.4
Hmicryptophytes	12	17.1
Phanerophytes	6	8.6
Geophytes	6	8.6
Chamaeophytes	3	4.3
Total	70	100

Figure 4. Colonization facades of walls by higher plants at the Kasbah of Kenitra.

Figure 5. Development of herbs and shrubs joints between the stones at the walls at the Kasbah of Mehdia.

On the other hand, the presence of mosses and plants at the historical monuments, including the facades of the walls of the Kasbah of Kenitra (**Figure 6(a)**) and the Kasbah of Mehdia (**Figure 6(b)**), already indicates a certain degree alteration which must be fixed.

The development of fungi and lichens can be destructive [14] because it weakens the stone locally mechanically by the growth of their fronds embedded in the stone and their roots, rhizines. These roots can penetrate deep into the stone in chemical form; because the stone is attacked by the release of their metabolisms such as oxalic acid that attacks the carbonates to form oxalates often responsible for ocher color of the stone surface [15]. Foams are less harmful than lichens but they maintain moisture on the walls, which promotes the growth of bacteria. They are often found at the base of the walls, where occur rising damp from the ground [16] (**Figure 7**).

5. Conclusions

The study of the flora of the Kasbah of Kenitra and Mehdia was especially centered on the superior vegetables populating the facades of the studied walls. The inventory of this flora showed the existence of much-diversified vegetation. By its chemical action and its mechanical effect on stones of the buildings, this flora deeply contributes to the degradation of the studied historical monuments.

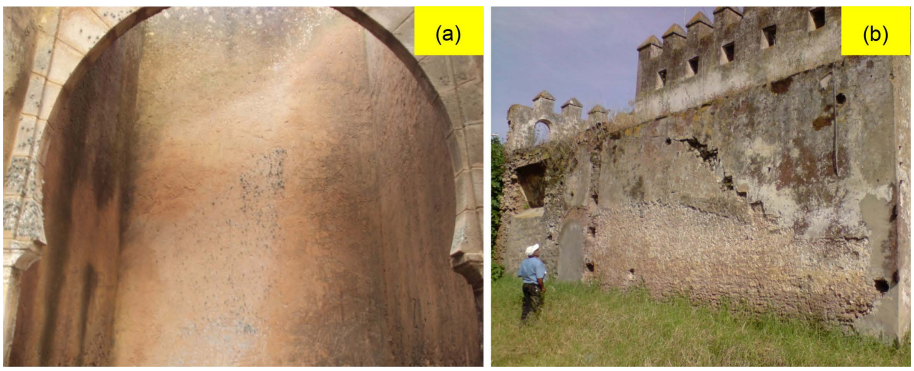

Figure 6. Development moss and lichen on a facade of a wall at the Kasbah of Mehdia (a) and the Kasbah of Kenitra (b).

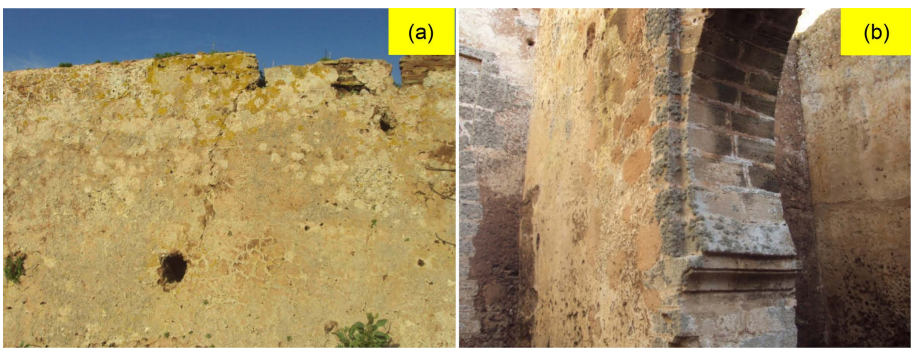

Figure 7. Development of lichen and algae (red and green) at the top of the wall (a) and lichens and algae at the base of another wall at the Kasbah of Mehdia (b).

At both Kasbah of the Gharb region, the studied buildings also suffer the action of algae and lichens. Algae sometimes cover the facings locally and organisms related thereto; this finding is still linked to the presence of moisture. The existence of this vegetation is mainly visible in the basements of the facades or in the zones in contact with the ground, because of the upwelling of water by capillarity. The presence of algae on a facing is important to quickly locate moisture on an element.

This work coupled with an another study about the other important degradations of the construction materials used in the edification of the kasbahs studied in Kenitra and Mehdia, will serve, certainly, as an important document, for the specialists, to propose tangible solutions for a better preservation and a rehabilitation of these monuments.

References

[1] Benbdallah, A. (1975) Villes et Tribus du Maroc, Imprimerie Fédala.

[2] Dalimi, M. (2013) Contribution à l'étude de la dégradation des monuments historiques situés sur la façade atlantique du Maroc. Thèse de Doctorat, Univ. Hassan II Mohammedia —Casablanca, Faculté des Sciences et Techniques de Mohammedia.

[3] Taleb, A. (1995) Flore illustrée des adventices des cultures du Gharb. Thèse Doctorat ès-Sciences Agronomiques, Institut Agronomique et Vétérinaire Hassan II, Maroc, 2 volumes, 369 p.

[4] Fennane, M., Ibn Tattou, M., Mathez, J., Ouyahya, A. and El Oulaidi, J. (EDS) (1999) Flore pratique du Maroc. Vol. 1, Travaux Institut Scientifique, Rabat, Service. Botanique 36, Rabat.

[5] Fennane, M., Ibn Tattou, M., Ouyahya, A. and El Oulaidi, J. (EDS) (2007) Flore pratique du Maroc. Vol. 2, Travaux Institut Scientifique, Rabat, Service. Botanique 38, Rabat.

[6] Fennane, M., Ibn Tattou, M. and El Oulaidi, J. (EDS) (2014) Flore pratique du Maroc. Vol. 3, Travaux Institut Scientifique, Rabat, Service. Botanique 40, Rabat.

[7] Jahandiez, E. and Maire, R. Catalogue des plantes du Maroc 1931, 1932, 1934. Éditions Lechevalier, Paris, 3 Volumes, 913.

[8] Taleb, A. and Maillet, J. (1994) Mauvaises herbes des céréales de la Chaouia (Maroc). I. Aspect floristique. *Weed Research*, **34**, 345-352. https://doi.org/10.1111/j.1365-3180.1994.tb02003.x

[9] Bourhim, B. (2009) Inventaire des altérations et de la biodégradation de la kasbah de Mehdia, mémoire de 3ème cycle, Diplôme d'ingénieur d'état en agronomie, (IAV. Hassan II, Rabat).

[10] Raunkiaer, C. (1905) Types biologiques pour la géographie botanique. *Bulletin Académique*, *Revue Scientifique Danemark*, 347-437.

[11] Warscheid, T. and Braams, J. (2000) Biodeterioration of Stone: A Review. *International Biodeterioration & Biodegradation*, **46**, 343-368. https://doi.org/10.1016/S0964-8305(00)00109-8

[12] Baghdad, B., Taleb, A., Bouhache, M., El Mouhadi, M., Ballesteros, E.M. and Iñigo, A.C. (2005) Flore nuisible aux monuments historiques du Maroc: Cas des villes de Rabat et Sale.

[13] Phillipon, J., Jeannette, D. and Lefevre, R. (1990) Altération des pierres monumentales en France. CNRS édition/Ministère de la Culture, Paris.

[14] Seaward, M.R.D. (1997) Major Impacts Made by Lichens in Biodeterioration Processes. *International Biodeterioration & Biodegradation*, **40**, 269-273.

https://doi.org/10.1016/S0964-8305(97)00056-5

[15] Bromblet, P. and Martinet, G. (2002) Joints, mortiers de pose et produits de ragréage (2ème partie) Les différentes pathologies. Réflexions et préconisations. Pierre Actual 785, janvier 2002, 66-77.

[16] Zaouia, N. (2007) Contribution à l'étude de l'altération de la Calcarénite en œuvre dans les monuments de Rabat. Influence de la pollution atmosphérique et des aérosols marins. Thèse de Doctorat, Univ. Mohammed V-Agdal, Faculté des Sciences, Rabat.