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WALLS OF THE MEDINA OF SALÉ, ARCHITECTURE AND PATHOLOGIES

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ABSTRACT

The walls are fundamental components of the Salé medina. They symbolize authenticity and the history of civilizations that have succeeded in the past on this city. The observation of these walls reveals a defensive construction of medieval type with a beautiful architecture. Unfortunately, the durability of these walls is threatened by several pathologies due to climatic and anthropic factors and the age of the monument. Their enhancement and conservation have become indispensable and require a serious effort from the public authorities.

This article presents a pathological study of these walls based on a field study. It provides a detailed diagnosis of all these walls with a record of all the pathologies observed and the identification of the various possible causes. The survey has allowed to note the effect of successive interventions on these walls. The lack of maintenance had a significant effect on the acceleration of these deteriorations. The influence of these interventions on the monument was noted on its architecture and materials.

Key words: Walls, medina, Salé, monument, pathologies, enhancement, diagnosis, intervention, maintenance, architecture, materials

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1. INTRODUCTION

The World Heritage Convention declares that the identification, protection, conservation and presentation of historic monuments must be ensured [1]. It specifies that the value of cultural heritage lies in its sustainability and persistence so that it continues to contribute to the sustainable development of the country [2]. Heritage bears witness to the architectural richness of a territory and is a collective asset that traces the history transmitted from one generation to the next. Heritage reflects the architectural richness of a territory and is a collective asset that traces history transmitted from one generation to the next. It characterizes traditional knowledge, its techniques and the evolution of ways of life and thinking [3]. Exposed to processes of alteration and degradation over time, this built heritage loses its

integrity and values through the deterioration of its conservation state [4]. They are threatened by destruction as a result of urbanization [5]. New urban development threatens historic urban areas [6]. To the detriment of this urban development, these historic monuments have been devalued, and suffer from several pathologies due to natural, anthropic and age factors [7, 2]. The lack of care or maintenance to accelerate the deterioration of monuments [8]. The Venice Charter of 1964 declared that it is essential for the conservation of monuments that they be permanently maintained [9]

Due to its prestigious past, we can see that in the medina of Salé still subsist its walls as architectural and monumental buildings. They are constructions of medieval and defensive type that mark the history of this medina, and should be safeguarded and preserved as national heritage. This richness and diversity of historic monuments requires that various studies must be made to safeguard and enhance them.

The purpose of this article is the diagnosis of these walls that surround the medina of Salé. This diagnosis allows the characterization of these walls according to their architecture and materials, the identification of the different pathologies that affect them and the proposal of solutions to remedy them.

2. DESCRIPTION OF WALLS

The walls of Salé medina were built in two periods. During the Almohad period in the 12th century (1145-1146), the north and east façades were built, while the south and west façades were built in the 14th century during the Merinid period [10]. They are built on a coastal area in the North-West of Morocco and on the right side of the embouchure of the Bou Regreg river. They are limited on the west side by the Atlantic Ocean, on the south by the Bou Regreg river, and on the east and north by two major roads linking the Salé medina to the other cities of Morocco.

The North façade walls are about 1600 m long, 700 m for the East façade, 1600 m for the South façade and the seafront is 600 m long. The average heights of these walls vary from 6 m to 8 m with a thickness of about 1.50 m. Within the walls, there is a walkway which measures on average 0.80 m. The building materials of these walls are composed of stones from the sandstone limestones of the Plio-Quaternary dunes, clays from the Vindobonian layers that outcrop at the level of the small valleys perpendicular to the Bou Regreg river, pebbles derived from erosion of the Villafranchian layers, and sands to complete the rich range of a generous nature at the service of mankind.

3. FLOW CHART

The methodology adopted for this pathological study of the walls of Salé medina consists of two parts, bibliography and fieldwork. The bibliographical work is important to know the history of the monument and its initial architecture. Then the fieldwork includes the visit of all levels of the monument and the inventory of all its pathologies. A photographic record is important at this level to mark the history of the degradation and its evolution over time. This methodology is represented on the flow chart in Figure 1.

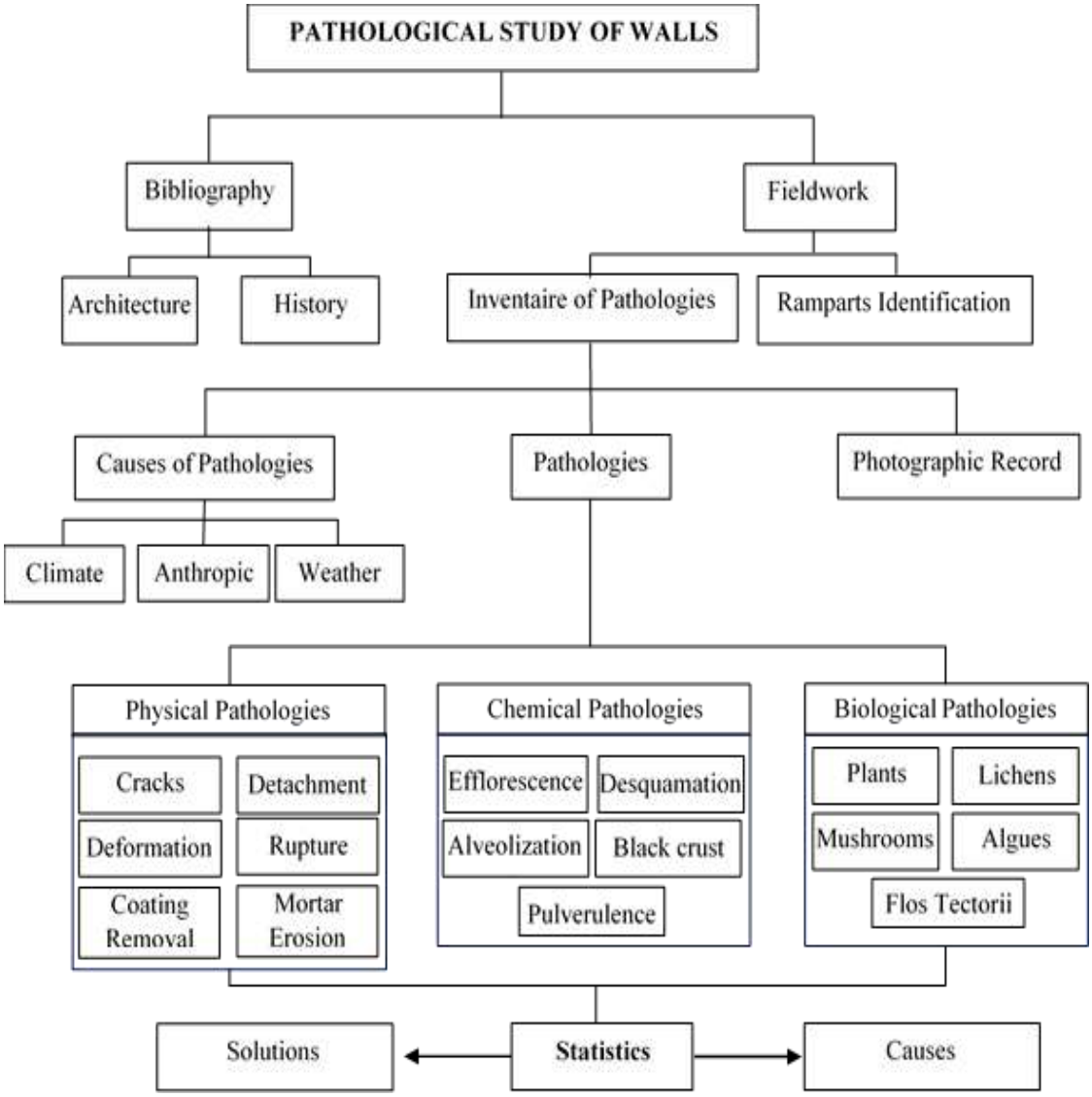

Figure 1 Flowchart of the Pathological Study of Ramparts.

4. RESULTS AND DISCUSSION

4.1. Architecture of Walls

During visits to the walls of the Medina of Salé it was found that they present a heterogeneous architecture composed of three types. Type 1 of these walls is thicker with a larger walkway and a parapet without crenels and rounded on its upper side. Type 2 is between 1.00 m and 1.50 m thick with a parapet of variable height topped by pyramid-shaped crenels and a parapet with a walkway of about 0.70 m in height. The walls of the seafront represent type 3, are thinner and without a parapet walkway or battlements, figure 2. Lime stabilized adobe was also found on the walls of the north-eastern, eastern and southern facades.

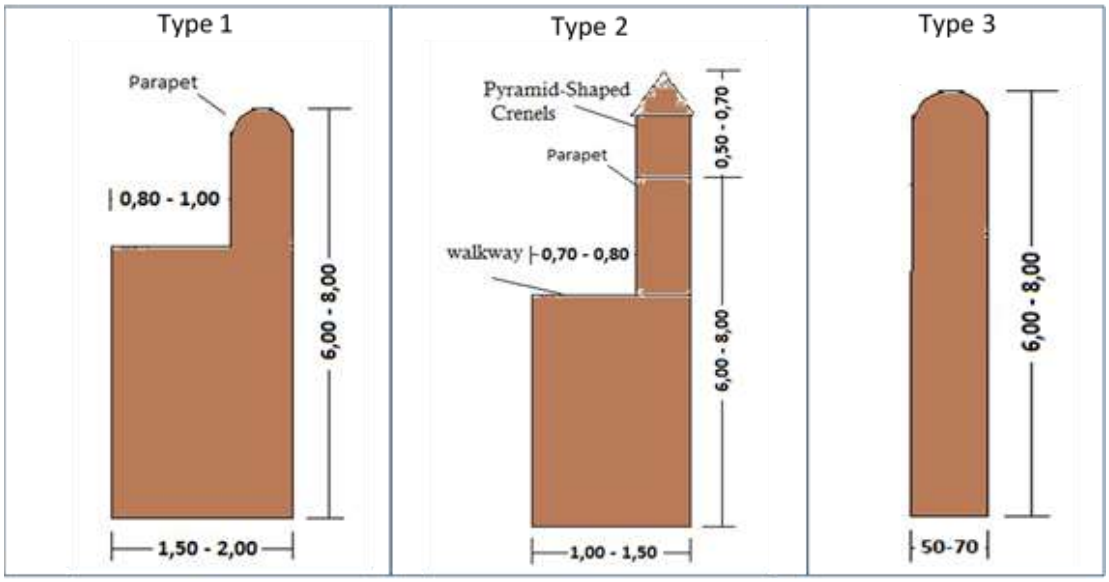

Figure 2 Cup of the walls of the medina of Salé.

4.2. Pathologies

The degradation recorded on the walls of Salé Medina are of different types, chemical, biological and physical. They vary according to the orientation of the walls, intramural and extramural, the nature of the materials, the proximity to the ocean and the traffic routes of cars. Figure 3 shows some types of these pathologies. Table 1 summarizes the different pathologies found on these walls.

Figure 3 Examples of forms of alteration on walls.

Table 1 Wall pathologies

Types of Pathologies					
Physial		**Biological**		**Chimical**	
C	Cracks	P	Plants	EF	Efflorescence
DT	Detachement	L	Lichens	DQ	Desquamation
R	Rupture	AL	Algues	AV	Alveolization
DF	Deformations	M	Mushrooms	PV	Pulverulence
CR	Coating Removal	FT	Flos Tectorii	BC	Black crust
ME	Mortar Erosion				

Figure 4 shows that the most important pathologies threatening the walls are physical. The most preponderant pathologies are Coating Removal (CR 66 %), black crusts (BC 39 %), mortar erosion (ME 35 %), plants (P 30 %), rupture of materials (R 20 %) and mushroom attack (M 20 %).

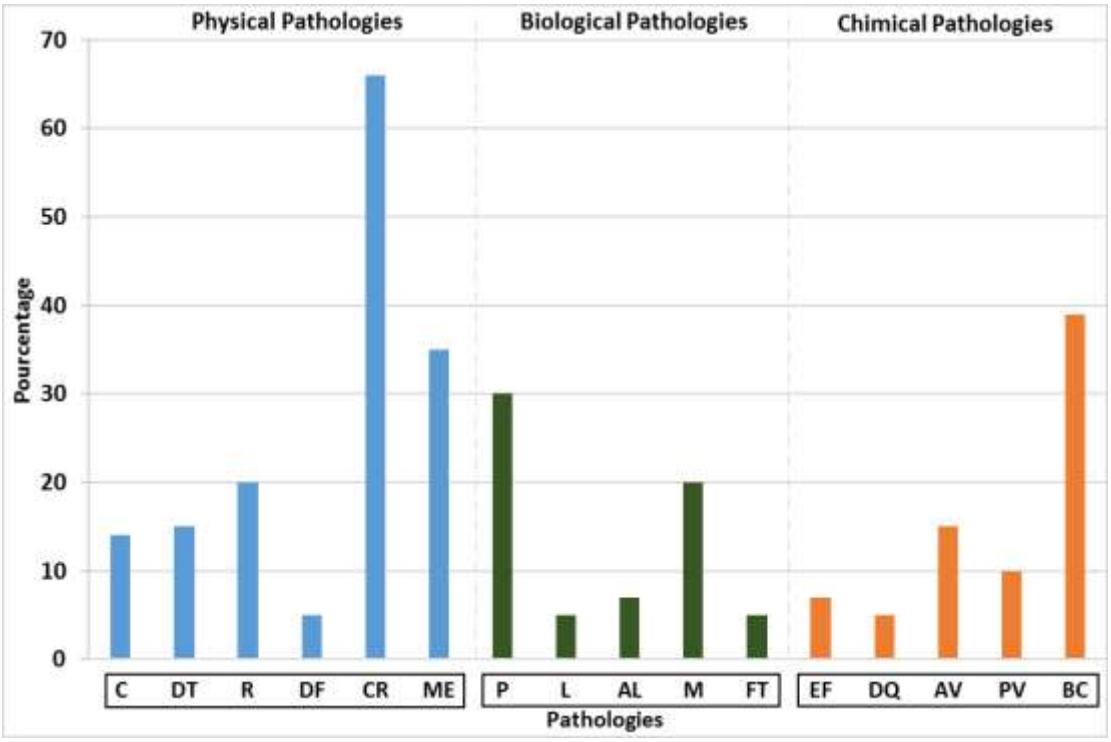

Figure 4 Distribution of pathologies on the walls.

Figure 6 shows the distribution of pathologies on the walls according to their orientation, North, East, South and West. It can be seen from this histogram that the walls are affected by all the pathologies. The latter are more intense on the walls of the western façade.

Physically, the predominant pathologies on the west facade are Coating Removal (CR 78%), mortar erosion (ME 60%), detachment of materials (DT 60%) and material rupture (R 30%). The predominant pathologies on the North façade are plaster degradation (CR 40%) and mortar erosion (ME 28%).This type of pathology does not exceed 20% on the walls of the east and south facades.

With the exception of black crusts, chemical pathologies are more important on the walls of the seafront and include: alveolisation (AV 50%), pulverisation (PV 40%), efflorescence (EF 30%) and desquamation (DQ 20%). Black crusts are significant on the North (BC 30%), South (BC 25%) and East (BC 20%) façades.

Biological pathologies are dominant on the northern facade such as vegetation (P 30 %) and mushrooms (M 23 %).

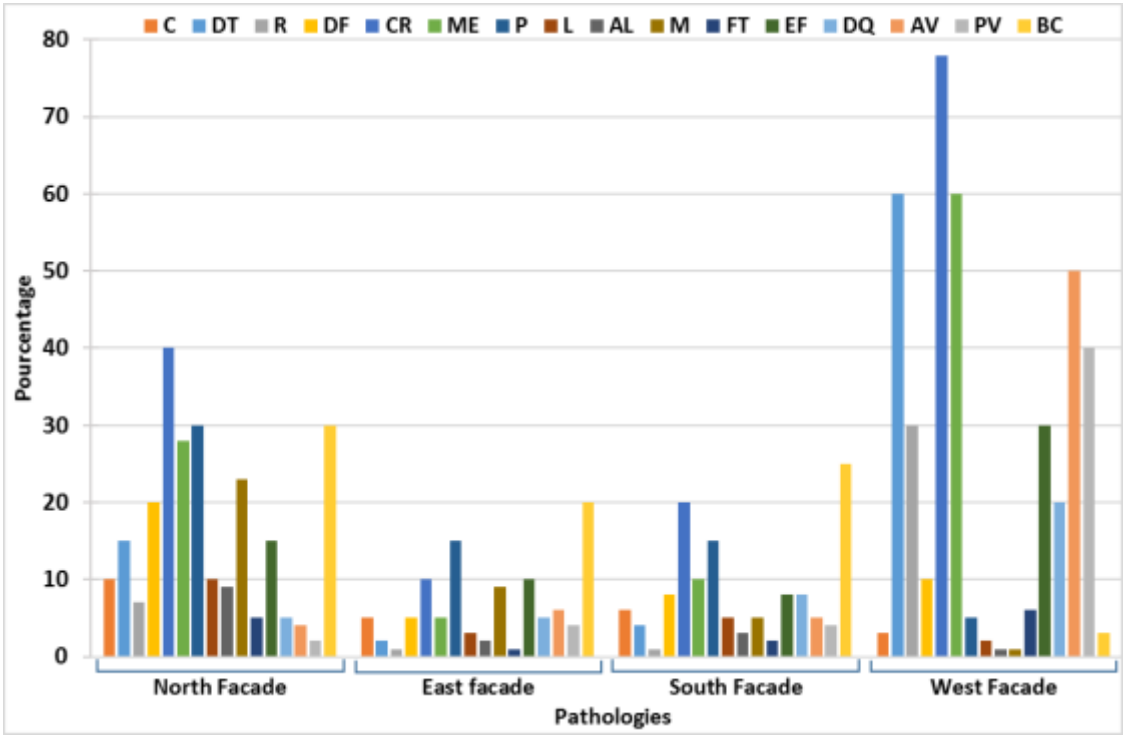

Figure 5 Distribution of pathologies on the walls.

4.3. Discussion

At the architectural level, the shapes of the walls justify the fact that the walls have undergone several interventions throughout their lives. The existence of adobe, can be interpreted as the authentic material of these walls, but in the literature only stone is mentioned as a building material for these walls. In fact, successive interventions have changed the architecture of walls and have led to the total or partial substitution of the authentic materials.

The pathologies observed **on** the walls of Salé Medina are the conjunction of several physical, chemical and biological causes.

For the medina of Salé we note the presence of fresh and humid winds from the West with a speed exceeding 10 km/h. The wind can transport solid microparticles that crush the surface of the exposed walls and cause their erosion [11] [12] [13]. Seeds can be carried by this wind into the pores of building materials and cause growth of plants on the walls [8].

The predominance of biological pathologies on the northern façade is due to the persistence of humidity in the walls. This humidity creates the ideal environment for the development of fungi and microorganisms and causes biological degradation [14]. It is due to rainfall, water drainage defects and the stagnation of water on the walls. The use of waterproof materials such as cement makes it very difficult to evacuate moisture from the inside of the walls [15]. This moisture causes grinding and expulsion of the outer layers of the masonry elements [14].

The chemical pathologies of walls are due to the presence of chlorides, sulphates, nitrates and carbonates. In the proximity of the sea, walls are subject to salt crystallization phenomena that lead to the detachment of materials and affect the performance of the structure [16].

The state of air quality in the city of Salé shows values of Sulphur dioxide SO2 and nitrogen oxide NOx that exceed the standards set by the World Health Organization, see

Table 2, [17]. In a humid environment, Sulphur dioxide SO2 in the presence of limestone leads to the formation of black crusts. On the other hand, nitrogen oxide NO together with limestone leads to the formation of calcium nitrate (CaNO3)2 which crystallizes and causes micro cracks [18].

Table 2 Measured values of air pollutants in the town of Salé [19]

	NOx µg/m3	**SO2 µg/m3**
El Oulja (CI)	246	450
Bab Bouhaja	81	123
Bab Mrisa	166	280
Normes (OMS)	40	80

In addition to these phenomena, walls in Salé have undergone several successive interventions that have caused their degradation [20]. These interventions have been showing their negative impact on these walls and have amplified their degradation [21] [22]. The restorations carried out in the past have not been followed by any permanent maintenance. This lack of maintenance has therefore only accelerated the degradation of the walls.

In order to remedy this situation and enhance the value of these walls, it will be essential to intervene according to the following methodology:

- Establish an archaeological study to confirm the authenticity of the adobe;
- Establish a study of the state of the existing building materials and check the changes in its characteristics during its life;
- Establish studies on substitute materials to verify their compatibility with the authentic materials;
- Establish a restoration study taking into account the above parameters;
- Establish a periodic and permanent maintenance program to ensure the effectiveness of this restoration intervention and to protect this monument.

5. CONCLUSION

The study of walls of Salé medina, has allowed to establish an identification of their architecture and the inventory of their various degradations. The latter are of physical, chemical or biological types. The plaster degradation (PD), black crust (BC), mortar erosion (ME) and vegetation (P) are the most persistent degradations on these walls. The seafront walls are the most degraded and are in a critical state. Successive interventions have accelerated the degradation of these walls and negatively influence their structural durability.

Efforts to restore these walls have had no positive impact if they are not based on the study of the materials and their variations over time. The establishment of a permanent maintenance program is essential to preserve the monument to a higher degree.

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