Utilization of lipase enzyme loaded with Wacker OH polymer and " Nano-silica in reducing the negative impact of climatic changes on the damage of limestone reliefs"

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1. Abstract

In fact, the process of climate change do not define countries, nor does it respect the social status of human beings, rich or poor, small or large, and this is what we call (global challenges), which require the solidarity of the whole world.
Climate change is a source of concern as a result of the unprecedented magnitude of changes occurring in the world, and reports indicate that humanity is responsible for climate change, as it leads to destabilizing environmental and social conditions around the world, and as a result climate change has negatively affected the natural and cultural heritage owned by the world The issue of the effects of climate change on the World Heritage has received great attention at the present time to reduce the negative impact of climate change.
The research deals with an experimental and applied study of the use of the lipase enzyme loaded on pure Wacker OH and Nano-silica in cleaning the dirt resulting from climatic changes and strengthening the wall reliefs made of limestone.

2. Key words

Wall paintings and reliefs, Climatic changes , lipase enzyme , Nano silica.

3. Introduction:

Climate change has emerged as one of the most pressing global challenges of our time, significantly affecting various aspects of life on Earth. Among the many consequences of this phenomenon, the impact on cultural heritage and monuments is particularly concerning. Monuments, as physical embodiments of our history, culture, and identity, are increasingly vulnerable to the effects of climate change.

Rising temperatures, shifting precipitation patterns, and extreme weather events pose serious threats to monuments around the world. These changes can accelerate deterioration processes, leading to structural damage, erosion, and loss of aesthetic and historical value. For instance, increased rainfall can cause flooding and water damage, while heatwaves can lead to thermal expansion and cracking in building materials.

Moreover, the effects of climate change are not uniform; they vary by region and depend on local environmental conditions and the materials used in the construction of monuments. This variability necessitates a comprehensive understanding of how different monuments are affected and what strategies can be employed for their preservation.

Hundreds of thousands of significant archaeological, cultural, and natural heritage sites along the coasts of every continent are threatened by sea level rise, and many will be lost or damaged **(Reimann et al., 2018).**

4. Materials and Methods:

The environment: It is the surrounding medium of humans that affects them and is affected by them, and it includes all natural and human aspects.

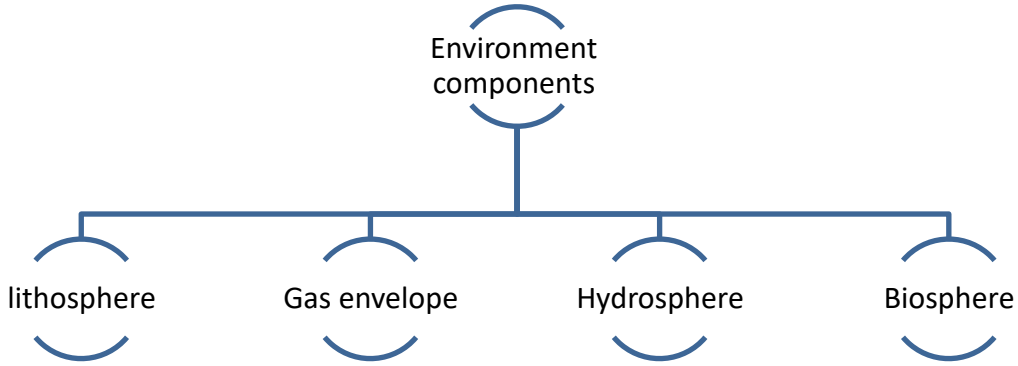

Figure No. (1) Shows the components of the environment

4.1: Steps of human interaction with the environment:

Humans have been linked to the environment since the beginning of creation, seeking to exploit its resources to satisfy their needs. The interaction of humans with their environment has gone through several stages that show the relationship of influence and being influenced between them. These stages can be summarized as follows:

4.1.1: The first stage: At the beginning of this stage, humans lived a life of continuous movement, searching for their food and drink, practicing fruit gathering and hunting animals. Humans had no impact on the environment due to the limited nature of their activities and basic needs. However, by the end of this stage, hunting tools and methods developed, and fire was discovered, leading to increased basic human needs and human activity, and their impact on the environment became limited.

4.1.2: The second stage: Humans learned agriculture due to the availability of water and fertile soil, settling near their farms in residential clusters known as villages, representing the first forms of human settlement. Their impact on the environment increased; they began to use and control river waters, and dig canals. These human activities produced

waste, but it did not have a negative impact on the environment. This stage is considered the beginning of human interaction with the environment.

4.1.3: The third stage: This stage extends from the beginning of the industrial revolution in the mid-eighteenth century until the mid-twentieth century, during which humans used machines for various purposes. They began burning fossil fuels (coal and oil) to power different means of transportation. During this stage, the manufacturing process led to the emergence of multiple environmental problems, such as pollution in its various forms, and the negative impact of humans on the environment became evident.

4.1.4: Fourth stage: This is the stage we are currently living in, starting from the second half of the twentieth century until now. In this stage, electronic computers appeared, and communication means developed. This stage is characterized by the increasing impact of humans on the environment, leading to more serious environmental problems, such as soil degradation, pollution, and the extinction of plant and animal species ، The previous phase was characterized by the depletion of natural resources, global warming, and nuclear pollution. The world has begun to take initiatives to address these problems and work towards preserving the environment and sustaining its wealth for future generations.**(Hassan&etl ،2024)**

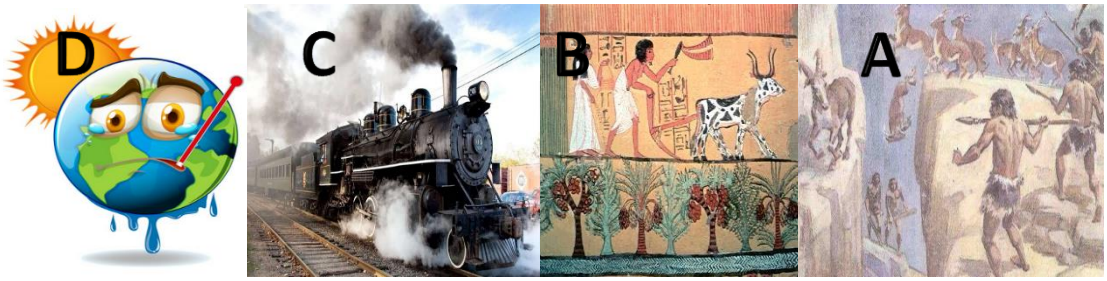

Figure **No. (1) and building the stages of human interaction with the environment, where (A) the first stage, (B) the second stage, (C) the third stage, and (D) the first stage (From internet)**

4.2: Wall paintings and reliefs

Wall paintings and reliefs are among the important artifacts in Egyptian civilization since the dawn of history, as they allow us to read and understand the events and developments of Egyptian history and to grasp the life of the ancient Egyptian. Wall paintings usually contain low concentrations of organic materials and are largely dominated by inorganic materials. They are characterized by their high porosity and long exposure to severe environmental conditions. **(Charlotte،2008)**

One of the results of the fourth phase of human interaction with the environment is the emergence of the phenomenon of global warming, which is one of the most important factors of deterioration that negatively affects antiquities in general and wall inscriptions in particular. The variation in temperatures that occurs within a single day (daily thermal range) also significantly affects the weakening and

disintegration of limestone grains, color grains, and color media, leading to what is known as "THERMAL SHOCK," especially when compared to seasonal changes. This is due to the processes of expansion and contraction, where the surface of the rock is in a state of expansion while its depth is in a state of contraction during the day, and vice versa at night. This results in a state of instability that the artifact experiences.

Rocks expand with heat and contract with cold, but they do not return to their original size after cooling, with a range between 0.02% to 0.045 %.**(Shehat،1986)**

With the repetition of this process, it weakens the structural composition of the rock, as the surface layer or crust tends to separate (FLAKING OR SCALING) from the surface that is naturally cooler, resulting in flakes. This process is called flaking.

The wall paintings are not homogeneous as they contain several minerals and different layers, as well as the crystalline system. Each of them has its own coefficient of expansion and conductivity, which leads, when temperature changes occur, to the emergence of varying stresses and pressures in the rock in different directions, resulting in cracks and granular disintegration of the rock components, contributing to the fragmentation and separation of the layers. **(Gamal ،2020)**

4.3: The experimental study of using lipase enzyme loaded on Wacker OH polymer materials and nano silica for cleaning and strengthening the limestone wall inscriptions:

Tests and experiments are considered one of the most important stages in the restoration and maintenance process of archaeological artifacts. They are necessary to avoid mistakes or unexpected results during restoration and maintenance work. They are essential to obtain the best results; therefore, the materials intended for use on the archaeological pieces must be tested starting with modern samples to undergo experimentation before application. They must pass through various tests and aging processes, and the evaluation must ultimately indicate their ability to preserve the archaeological materials without any change to the original characteristics. Thus, a set of experimental samples was prepared, and thermal aging cases were conducted using a thermal oven to study the effect of global warming on the limestone wall inscriptions and to apply signs of damage to these samples for study.

In fact, the deposits on the surfaces of the wall inscriptions are represented in the particles suspended in the air (Aerosols), which include many particles of materials, whether of natural or artificial origin, with a diameter of less than 10 microns. Examples of natural particulates include dust particles or silica and calcium carbonate or carbonates and sulfates. The sample was examined under a light microscope to determine the extent of the weakness suffered by the samples due to thermal aging, and it became clear that the structure of the limestone particles was weak and severely affected by heat, as heat works to break down the binding materials present in the colors of the wall inscriptions. Heat also aids in drying processes, leading to the appearance of some cracks.

Figure **No. (2) shows the preparation of limestone inscription samples for experimental study**

The sample was examined under an optical microscope to determine the degree of weakness that the samples suffered from as a result of thermal aging. It became clear that the composition of the limestone grains was weak and that it was severely affected by heat, as heat breaks down the binding materials present in the colors of the wall inscriptions. Heat also helps in the drying process, thus causing some cracks to appear.

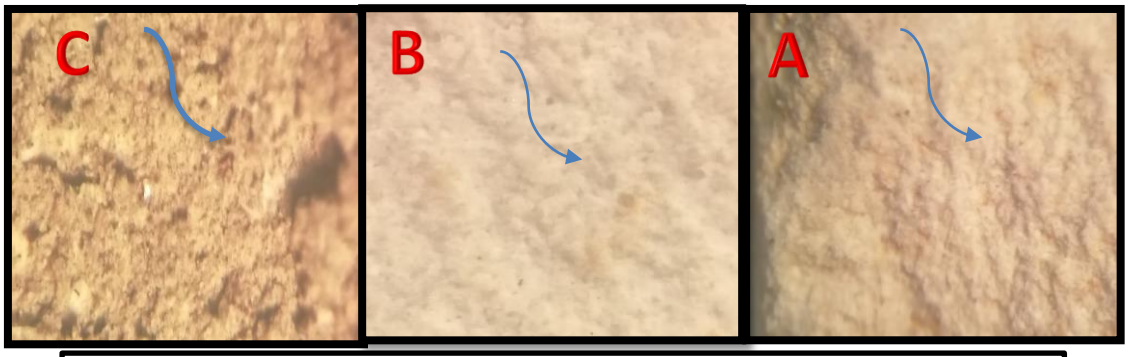

Figure **No. (3) is a group of microscopic images of limestone samples and shows the effect of heat on the stone grains. (B, A) show the severe weakening and disintegration of the limestone grains, and (C) shows the dirt.**

5. Application:

The lipase enzyme was loaded onto pure OH polymer with nano silica at the National Research Center in Dokki at a ratio of 2:96:2. After preparing the experimental samples and using wooden sticks (the wooden sticks wrapped with cotton) and immersing them in the compound solution and cleaning the samples with the solution, the experiment was conducted on three samples to determine the effectiveness of the solution, and the results were as follows:

5.1: The solution gave excellent results in cleaning the calcified dirt in the first, second, and third samples, as shown in (Figures 4, 5, 6).

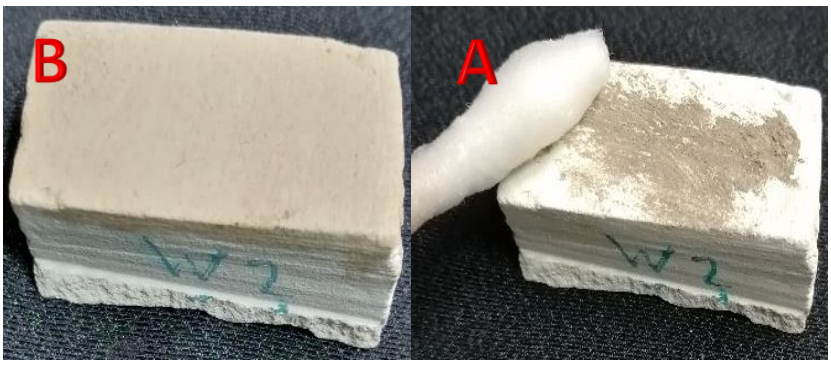

Figure **No. (4) shows the result of using the lipase enzyme loaded on the pure Faker polymer and nano-silica in cleaning the surfaces of the limestone wall inscriptions of the first sample, where (A) shows the dirt and (B) the result of cleaning.**

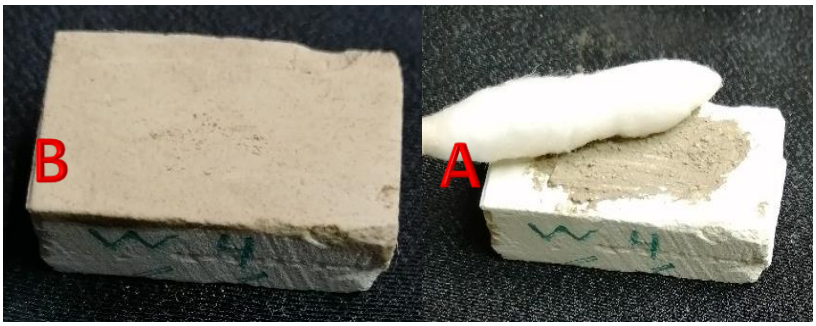

Figure **No. (5) shows the result of using the lipase enzyme loaded on the pure Faker polymer and nano-silica in cleaning the surfaces of the limestone wall inscriptions of the second sample, where (A) shows the dirt and (B) the result of cleaning.**

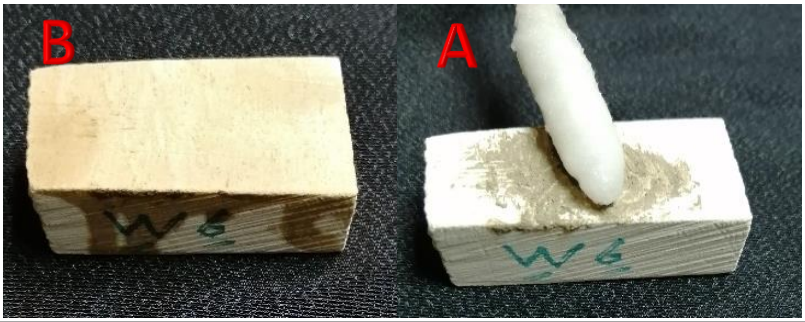

Figure **No. (6) shows the result of using the lipase enzyme loaded on pure Alfakar polymer and nano-silica in cleaning the surfaces of the limestone wall inscriptions of the third sample, where (A) shows the dirt and (B) the result of cleaning.**

5.2: The samples were examined under a light microscope to evaluate the cleaning process. It was found that the lipase enzyme is highly effective in cleaning surface dirt resulting from the environment and climate change. This was observed through visual

inspection and also through examination under the light microscope, as shown in (Figure: 7).

Figure **No. (7) is a group of microscopic images of limestone samples after cleaning using the lipase enzyme loaded on the Faker and nano-silica. (A) Shows the cleaning of the first sample, (B) the second sample, and (C) shows the third sample.**

6. Consolidation:

Consolidation By examining the limestone sample with a scanning electron microscope after thermal aging, it became clear the extent of the weakness of the stone grains and their susceptibility to heat and the disintegration of the binding material, as illustrated in (Figure: 8).

After using the solution composed of lipase enzyme loaded on a polymer and Nano silica, it was evident that the strengthening material penetrated deeply into the pores of the stone and bonded the grains, as shown in (Figure No: 9).

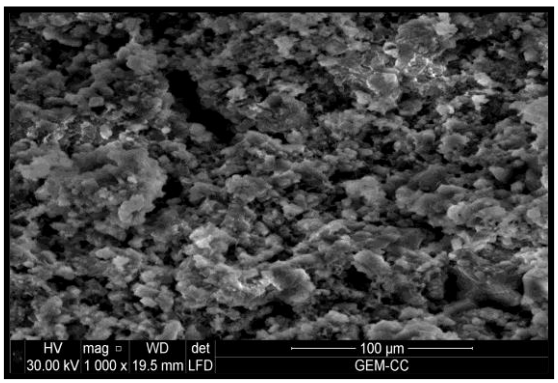

Figure No (8) shows the thermal aging representation of the limestone sample at 1000 X and illustrates the weakness of the binding material for the grains

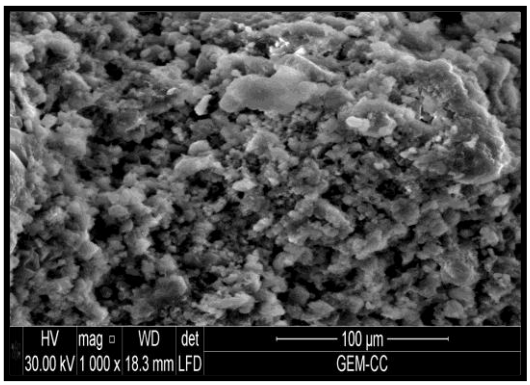

Figure No (9) shows the strengthening representation of the limestone sample at 1000 X and illustrates the penetration of the strengthening material.

7. Results:

Through the experimental study, it was found that the lipase enzyme loaded on the OH facker polymer and nano silica has an effective ability to clean the dirt resulting from climate change, such as dust and clay deposits, as well as to bond the particles of wall

inscriptions made of limestone well, through examination using light microscopy and using scanning electron microscopy.

Recommendations: • Weather changes do not recognize borders, countries, or individuals; therefore, the world must unite to overcome this crisis. • Global warming weakens the structure of the particles of wall inscriptions made of limestone and leads to the presence of some residues, dirt, and dust on their surface. • Loading the lipase enzyme on the OH facker polymer and nano silica helps speed up the treatment stages, as this compound has the ability to clean and strengthen in one step. • Loading the lipase enzyme on the OH facker polymer and nano silica helps clean the dirt resulting from weather changes effectively. • Loading the lipase enzyme on the OH facker polymer and nano silica helps bond and strengthen the limestone particles of the wall inscriptions.

8. References:

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استخدام انزيم الليبيز المحمل على بوليمر الفاكر OH والنانو سليكا في الحد من التأثير السلبي للتغيرات المناخية علي تلف النقوش الجدارية الجيرية

في الواقع إن عملية التغير المناخي لا تعرف دول ، ولا تحترم الحالة الاجتماعية للبشر، الأغنياء أو الفقراء، الصغير أو الكبير، وهذا ما نطلق عليه (التحديات العالمية)، والتي تتطلب تضامن العالم أجمع"، إلا أن التغير الدائم لمناخ كوكب الأرض جعل قضايا تغير المناخ مصدر قلق نتيجة ضخامة التغيرات غير المسبوقة التي تحدث في العالم، وتشير التقارير إلى أن البشرية هي المسؤولة عن تغير المناخ، فهو يؤدي إلى زعزعة استقرار الظروف البيئية والاجتماعية حول العالم، ونتيجة لذلك أصبح تغير المناخ يؤثر سلباً فيما يملكه العالم من التراث الطبيعي والثقافي، وقد حظي موضوع تأثيرات تغير المناخ في التراث العالمي باهتمام بالغ في الوقت الحالي للحد من الأثر السلبي للتغيرات المناخية.

ويتناول البحث دراسة عملية تجريبية وتطبيقية لاستخدام انزيم الليبيز المحمل على مادة الفاكر OH النقي ومادة النانو سليكا في تنظيف الأتساخات الناتجة عن التغيرات المناخية وتقوية النقوش الجدارية المصنوعة من الحجر الجيري.

الكلمات الدالة:
النقش الجدارية – التغيرات المناخية –أنزيم الليبيز – النانو سليكا.