MICROCLIMATIC MONITORING IN THE ARCHAEOLOGICAL AREAS:

FROM DESIGN TO USE. THE CULTURAL SYSTEM OF AN ARCHAEOLOGICAL AREA IN CAGLIARI

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Abstract

The valorisation of archaeological areas requires that the design display respects the issues of cultural contextuality, mitigation of environment effects and use. The conservation of ruins and findings at open air depends on external factors – environment and microclimatic conditions – as well as intrinsic factors – the durability of the materials, the techniques of building and decoration. The balance between use and conservation requires to achieve the compatibility among accessibility, reduction of the interference of the intervention on the site and the ability to understand the site.

In the case of archaeological sites, obviously, the only possible re-use is that aimed at valorisation and fruition. The control of the conditions of use is a fundamental aspect in the process of conservation of the site. At present, the optimal threshold between conservation and valorisation is yet a challenge for the protection and use of the archaeological sites. The aim is to obtain the design of architecture and plants harmonically integrated, functional and fitting the preservation of sites.

The paper aims to understand the role of diagnostics and microclimate monitoring in designing the use of the archaeological areas. In fact, monitoring is a fundamental and mandatory activity both in the preliminary analysis and during the use of the sites for mitigating the risk factors, the fulfilment of the preservation activities, managing the stake holders of conservation.

The paper presents the study case of a roman tomb in Cagliari. The tomb has wall painting and relief decoration that went under monitoring and restoration since more than one year.The information process deals with the knowledge of the site (the documentation of the archaeological excavation), the environment and microclimate conditions (continuous recording of data, thermography, psychrometric), materials (sampling and analysis of the surfaces), of damages (biological analysis), that are required to design the conservation project of the important decorations still present.

Processing the acquired information and data fundamental bases the project of the conservation and valorisation of the site, with the aim to stabilize and optimize the microclimatic condition (including the lighting kind and time). Moreover, the data system is planned to be continuously updated with the new information coming up during the restoration.

The virtuous collaboration among University and Protection Offices for the Archaeological areas allowed the stake holders to realize the ambitious project to test and systemize the best practices, those generally are more common for the large, diffused Cultural heritage.

Keywords: *archaeological site, risk assessment, microclimatic monitoring, preventive planned conservation, valorization*

Introduction

The balance between the use and conservation requires to achieve the compatibility among accessibility, reduction of the interference of the intervention and display of the site. In fact, the use of Cultural Heritage (CH) mainly deals with the balance between all the requirements mentioned especially in the case of the built landscape and the archaeological sites.

Considering the wide span of typologies of the CH, many uses can be considered. A compatible new use, having an accurate and proper planning and management, allows to achieve a constant control prevent neglect and loss of cultural and material features; it fits the requirements of sustainability (also economic) of the new social needs and supports the knowledge and popularization of the object itself, the site, the area and its resources [1, 2].
In the case of the archaeological areas, instead, the use can not have the same wide span of solution as in the case of a historic buildings [3]. The mean use of archaeological heritage at open air especially in the case of grave archaeology, is visiting the sites with the priority of conservation, valorization and continuous control of the site.

Again, art. 29 defines the process of conservation and the plan of conservation is the tool for its achievement: the plan includes the modalities of the use, the required checks and controls for reaching the expected results[1]. The application of the conservation process on the archaeological areas, stresses the valorization as well as the continuous care and maintenance. The valorization requires that design of site respects the issues of cultural contextuality, mitigation of environment effects and use [4,5].

The conservation of ruins and findings depends on many factors – external and internal – [5] therefore in a project of conservation and valorization is important to determine all these factors, characterize them and understand their contribution to the state of conservation of the site. For that the diagnostics and microclimate monitoring have a key role in designing the use for archaeological areas. Hence, monitoring is a fundamental and mandatory activity since the preliminary analysis up to the use of the sites [6, 7].

Methods and tools

In the following, the paper refers of the monitoring of a necropolis in Cagliari area [16,17]. Monitoring lasted 21 months, by the acquisition of hourly values of air T and RH, the seasonal double measurements by psychrometer, seasonal IRT scanning of all the surface inside the tomb, sampling and measuring the water and salts content.
The results of data crossing allowed the authors to identify the factors inducing the microclimatic variations inside the tomb and the site, how much and how they affect the condition of the conservation. The procedures of measurements and data processing followed the present standards [10,11,12, 13].

In the case of the tomb the first acceptable release of monitoring data has been considered after 12 months and additional 6 months have been necessary to understand if the registered phenomena are due to the seasonal variation, or if some damage happened.
As well known – especially for organic material and also porous building materials – it is important that the parameters of T and RH that make the so-called “historical climate” are maintained [8]. It is necessary to study the microclimate for at least one

[1] The “Linee guida per la conservazione delle architetture di interesse archeologico. Conoscenza, prevenzione, manutenzione” promoted in 2009 by the Ministry defines two phases of the process of conservation: first the inspection and monitoring the activities of degradation and the risks, then the development of plans and programs of maintenance.

year or its multiple to determine the historical climate of a given object. The analysis has consequences when a tomb has been closed for a long time, monitoring is mandatory before making it accessible to visitors. Studies [9] show the existence of "time windows" during which, especially for the hypogeal environments, the recorded variations outside and inside are similar, hence opening of the sites does no cause sudden changes microclimate. By comparing the values, these "windows" can be identified. The study of the microclimate has the purpose of defining the range of typical values of the microclimate under study, monitoring any changes that may be harmful and identifying "time windows".

Results

Monitoring

The integration of the results allowed the authors to ascertain that the major variations of T and RH of the air affect a limited space at the entrance and it is due to the poor insulation of the wall. In fact, a previous non-congruous use of the hypogeum caused the demolition of the entrance wall and its reconstruction with brick-lined having different thermal transmittance from the other sides of the tomb excavated directly in the rocky bank. In addition, the entrance side has orientation South-West and receives sun irradiation since midday to the evening.
The distribution of both T and RH has been studied in time and in space by mapping vertical surfaces by IR and along horizontal section by psychometry. It resulted homogeneous throughout the year, with a minimum seasonal variation of 2°C and Relative Humidity ranging between 90 and 100%.
The main thermal anomalies recorded by thermography are close to the entrance wall of the tomb and sometimes near the vaults of some niches. This anomaly is due to a different thickness of the rock. A specific study on the thickness of the rock can be useful to define, in case of heavy rains, the possibility of water infiltration from the ceiling. The water content of the samples taken from the interior surfaces resulted very high as one of the consequence of the high values of RH and SH detected in the tomb and probably localized, capillary infiltrations of water from the upper rock bank. Furthermore, it is observed that the samples taken closer to the entrance are drier than the samples taken in the niches at the bottom of the Tomb. This could confirm the poor insulation of the entrance wall, which in this case allows to partially dry the surfaces. The introduction of an air conditioning system should slowly dry the surfaces and the repetition of gravimetric investigations will verify the absence of infiltrations from the rock above if the water content will decrease.
The microclimatic monitoring has allowed to establish that the daily mean values of RH and T are almost independent from the external variations. The temperature values recorded inside are subject to a variation of about 0.5° C every 10 days, and

show a delay between the peaks (both minimum and maximum) of two months compared to the outside ones. Recently, archaeological excavations in the tomb and in front of the main entrance have led to wider variations in temperature and slight variations of Relative Humidity, if compared the ones recorded in the previous year. In particular, the total amount of the variation is similar to the previous period, but with larger and more frequent fluctuations.

On the base of the achieved results, opening the tomb will have to take into account three main risk factors: the presence of the tourists, the water permeability of the rock and the further stabilization of the microclimate. The first affects the variation of temperature and can increase the quantity of spores causing biological degradation. The second considers the presence of water infiltration from the top of the tomb. The third will include the design of an entrance closed space for ensuring the good insulation inside.

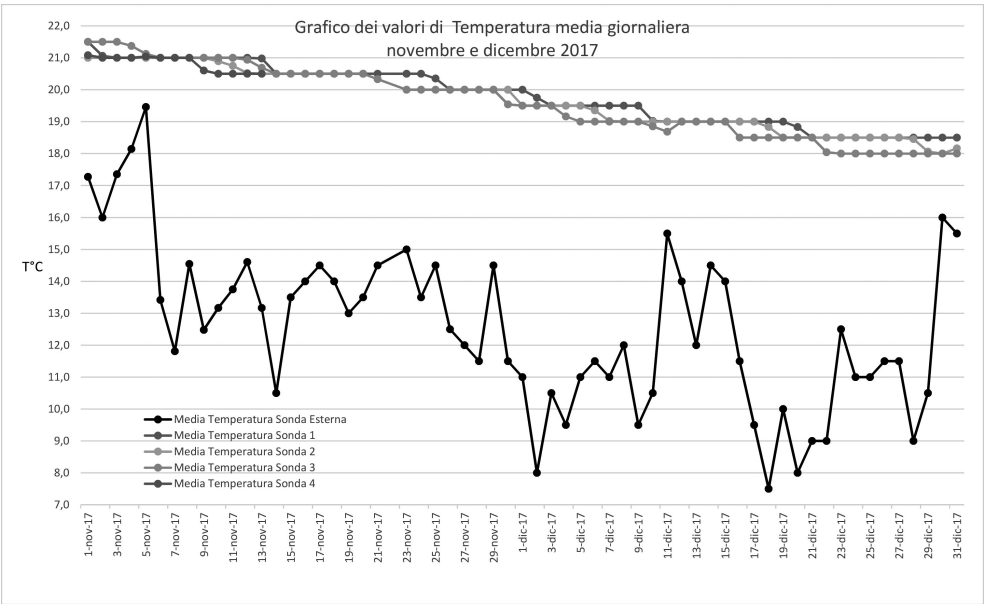

Figure 1 - Graph of the daily average Temperature values recorded between November and December 2017

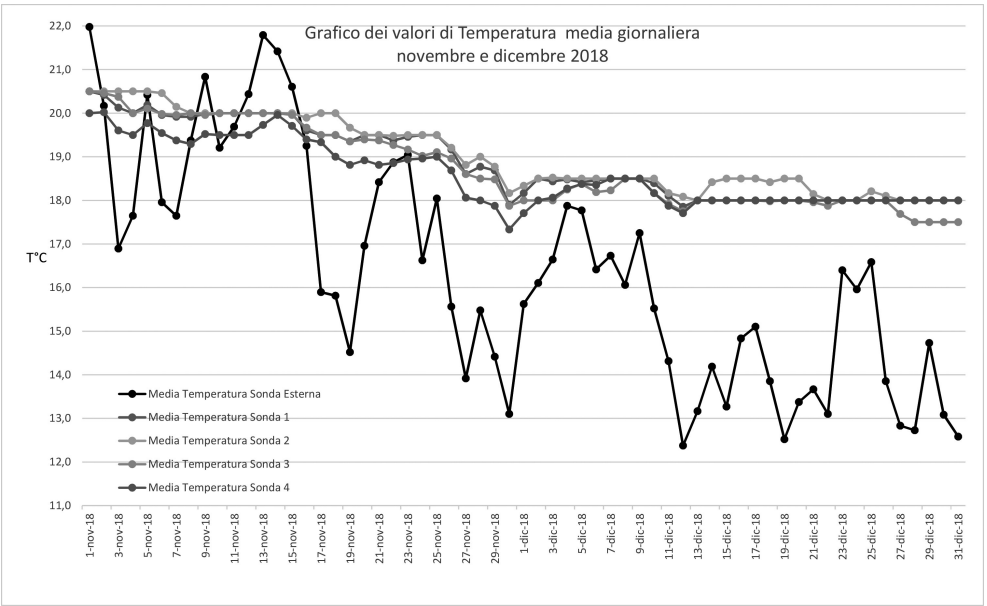

Figure 2 – Graph of the daily average Temperature values recorded between November and December 2018

Systemization of information: Conservation plan and GIS

In compliance with the Italian law, according to the art. 29 of the Code of Cultural Heritage, the Conservation Plan was prepared to plan the activities and costs. The information included in it is related to the activities carried out, controls and preventive actions.

At present, the activities carried out concern the archaeological excavation activities; the preventive activities concern the maintenance of the surrounding areas, to avoid interference with the site such as infiltrations of water or infestations, vegetation growth, that could develop roots intruding the rock; finally, the control activities are instrumental and concern the microclimatic monitoring as previously described. In particular, for this last point, the microclimatic monitoring allows the evaluation of the thermo-hygrometric variations during the excavation phases with respect to the previous condition of closure of the tomb. The comparison between the two conditions makes it possible to check the variations with or without people[2] inside and the opening or total closure of the tomb. Experiments on the site planned to study the interactions between the presence of visitors, the new facilities and the internal

[2] Figures xx show the comparison between data collected at November-Dicember 2017 (absence of persons) and at November-Dicember 2018 (presence of a maximum of 5 workers during the excavation phases)

microclimatic conditions, so as to determine the maximum number of visitors that may be present in the tomb without alterations or harmful changes in microclimatic values. The purpose of these investigations is the definition of the thresholds for the use of the site.
The plan is not prepared on an Information System, therefore the output is presented in the form of cards where all the activities concerning the tombs are recorded.
The use of GIS will be the tool for registering the surface mappings and the carried out activities.
With respect to the dissemination of knowledge, a website has been created where citizens can see the evolution of activities. The goal is to disseminate the methodology used and to stimulate interest in a site that for many years has remained unknown to the community.

The new use

The necropolis is one of the largest in the South of Sardinia and it is located in the city of Cagliari [15,16,17]. It includes many different types of tombs dating back from the Punic to the Roman periods. This entails a greater difficulty in the accessibility of some tombs with so-called "a well" entrance, and minor difficulties for other "chamber" tombs which have small differences in height within them. The advantages of operating in an archaeological park are many and are given by the systemic relationship created among the different tombs. The enhancement project will include the design of the reception and services that can be unique for the entire park.

The present capability to conduct more appropriate restorations and to investigate the chemical-physical properties have allowed the feasibility study for opening of some tombs, through the study of air control and the management of the number of accesses. The hypogeal environments resulted with good thermal inertia due to the thickness and the quality of the rocks. On the contrary this determines that the environments are particularly humid and, with scarce possibility to reduce the humidity. The major thermal unbalances are located near the entrances and during their opening.
The use of the online platforms also allows to present the results achieved so far and to show the images of some tombs in the archaeological park closed to the public for reasons of accessibility.

The fruition project provides access only to some tombs which, due to their shape and more durable materials: walkways will be have only few points of contact with the ground and will be large enough for the passage of only on along a circular path in the site. In this way the visitor will be able to observe from a distance the decorated

surfaces of the room, having a good visibility of the site and protecting it from any mechanical and anthropic damage. The material chosen for the finish of the walkway will be aesthetically compatible and waterproof to stand the high humidity. Special care has been devoted, design the entrance room, with the aim to create a double space isolate the microclimate from the external variation and guarantee an intermediate space for disables.
Solar panels will provide the required energy for the illumination of the Tomb and the monitoring of microclimate to promptly intervene if the maximum threshold is exceeded.

Conclusions

The information process deals with the knowledge of the site, the documentation of the archaeological excavation, the environment, microclimate conditions, materials, damages, that are required to design the conservation project of the important decorations remaining.
Processing the acquired information and data is the base of the project of conservation and valorization of the site, with the aim to stabilize and optimize the microclimatic condition (including the lighting kind and time). Moreover, the data system is planned to be continuously updated with the new information coming up during the restoration.

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