MUSEOLOGY. ARCHIVISTICS. CONSERVATION

THE CAUSES OF THE DEGRADATION OF ARCHAEOLOGICAL WOOD

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Rezumat: *Lucrarea prezintă principalele aspecte legate de degradarea lemnului arheologic, de la descoperire la valorificare expoziţională.*

Sunt enumerate principalele cauze şi mecanisme, inclusiv factorii de degradare care acţionează asupra lemnului după decopertare, precum şi degradările produse.

Résumé : *L'ouvrage ci-joint présente les principaux aspects liés de la dégradation du bois archéologique, de sa découverte et jusqu'à la valorisation expositionnelle.*

On y a énuméré les principales causes et mécanismes, y inclus les facteurs de dégradation qui agissent sur le bois après la décopertation, ainsi que les dégradations produites.

Keywords: *conservation, archaeological wood, relative humidity, temperature, ventilation, lighting, pollution, deterioration,* degradation

In the event of wooden objects revealed at the time of archaeological excavations, the problem of preventative conservation is very important and extremely complicated. The reason must be sought in the changes sustained by the material, in the coming together of conditions with an adverse environment and a state of equilibrium with the environment, which these objects have reached. At the time of discovery, these objects are exposed suddenly to very different conditions to the previous ones, which can act virulently, destroying irreversibly their worth[1].

Whenever organic goods are discovered, we need to bear in mind the following aspects:

a. *Their particular documentary value*, both for dating and for the evolution of old technology, of the way in which the goods were created (arms, tools, goods of common usage, jewellery or clothes), of the way of life of the respective communities (form of social organisation, art, culture), circulation of the goods over extended areas, and the delimitation of large areas of material culture. Archaeological research represents by far the most important source for the long-ago epochs of mankind.

b. The advanced degree of deterioration to which the findings are subjected at the time of discovery.

The object no longer retains the initial physical chemical properties that it had at the time of burial or sinking. In its new conditions, the object underwent a process of degradation whose evolution depended on both its structure and condition,

surface resistance to the new environmental conditions and factors of nature, which acted upon it.

This process of decomposition is more rapid at the beginning, but with time slows, at other times stabilises and sometimes stops. In the case of organic wooden materials lain in soil with wetter and more aggressive conditions, the process continues until the complete disappearance of their worth.

At the time of discovery, the objects or fragments of these are heavily degraded because of co-habiting with an adverse environment. This leads to important changes in appearance, strength, shape or colour. All archaeological objects, with the exception of ceramics and stone objects and not even these always, present a more or less advanced degree of degradation. In the case of archaeological wood, the scale of these processes of degradation is great.

c. *The state of fragile goods of archaeological wood*, from the moment of discovery, entails many problems, which make necessary the taking of several immediate measures of preventative conservation. About the state of fragile goods, we need to bear in mind the effects of abrupt changes in environmental conditions.

At discovery, the object finds itself abruptly in another environment, with other factors of degradation that act virulently, proportionally to the difference between the two conditions: buried goods and exhumed goods.

In the conditions of buried goods, the process of decomposition of the object permitted a process of slowing down or even of stabilisation. In the new conditions created by the exhumation, the process of decomposition is reactivated with a greater virulence.

This abrupt change in conditions at the time of discovery is a very critical moment for the evolution of the state of conservation of natural organic goods, which can undergo a process of accelerated decomposition.

The abrupt activation of a process of decomposition, after discovery, makes necessary the application of several efficient measures of preventative conservation. There are situations when there is weak concern for the application of these measures of preventative conservation, in the phase at the site.

Many times, this stage is treated superficially. Being used to the discovery, almost exclusively, of pieces made from inorganic materials, which don't present particular problems of preventative conservation, many archaeologists are not prepared to face situations, in which organic materials are discovered, which are more rarely encountered on sites in our country.

The defective approach to the problems of preventative conservation, specifically of pieces made from organic materials, at the time of discovery, explains why very important archaeological tokens were irreversibly lost. An example of this is the degradation suffered by wooden objects taken out of the Lozna bog in Botosani County.

Objects made from organic materials, if they go further into the laboratories of restoration they appear more in a precarious state of conservation than that in which they were found at the time of discovery in many cases. The cause must be

found in the abrupt loss of humidity content, which leads to fragilisation, stiffening, deformation, and loss of mechanical resistance.

Causes and operation mechanism

Generally, it is possible to appreciate that a number of causes determines the moment of discovery, as a critical moment[2]. These causes are:

- Precarious state of the object at the time of discovery;
- The virulence of the factors of the new environment, which are: relative humidity, temperature, incident radiation;
- The way and duration of activities with the object in the period immediately following its discovery: the structure of documentation, photography, drawing, handling and depositing of the object.

In this case, in the absence of corresponding measures taken immediately at the time of discovery, the action of the factors of the new environment accelerates the process of degradation. This explains why, in the case of cultural goods made from organic materials, proceeding from archaeological discoveries, is currently agreed to be a critical moment and why it is very important that intervention from the time of discovery should be executed correctly and in rapid succession.

If we analyse all stages that succeed the discovery, until the time when the object enters into the restoration laboratory, this interval of time can be divided into many more phases:

- The phase of the drawing of the objects;
- The phase of the depositing at the archaeological site;
- The phase of restoration and the phase of exposition/depositing

The critical period does not refer only to a moment as such, but to a certain longer interval of time. This interval of time includes all stages, which follow the discovery, until the moment in which the object arrives at the restoration laboratory.

At every moment of this period, any absent-mindedness, negligence or ignorance can be fatal for the respective object. Unfortunately, too little attention is accorded to these problems. Often this period is very long, from a week to a month until the objects are deposited at the site, not in the best conditions, which for organic archaeological objects represents a very long time.

Fortunately however, several problems can be resolved in the restoration phase, ensuring, that where material conditions and specialists exist, a stability and a better state of conservation. Studying the nature of the degradations, the best means of intervention were found to be, cleaning, neutralisation, consolidation, covering with protective film, thus so that the evolution of the state of conservation of the objects under debate will be a favourable one.

The effects of uncovering on archaeological wood

The uncovering is an extremely risky operation, which must be carried out with established measures of precaution[3]. The uncovering proceeds depending on the following factors:

- The nature and dimensions of the objects;

- The type of soil;
- The state of conservation of the objects;
- The weight.

When the beginning of archaeological digs are planned, it is not known, from the start, which objects will be discovered, for which it is necessary to take measures against all persons involved. The state of health of the objects found depends on all these measures.

The measures from the phase of uncovering have an urgent character. The fact that all organic materials are found, usually, in a state of advanced fragility is well known and therefore the handling of them is extremely difficult. For these, the uncovering is the most critical moment, for the following reasons:

- An object which was seriously affected by the environmental conditions in which it has stood for centuries has a diminished state of conservation and weak resistance;
- The effects of the negative actions of the factors of the new environment are more pronounced when the difference between those environments is bigger;
- The activities, in which the object is involved immediately after discovery, prolong the period of waiting and delay the urgent measures, which sanction the slow, controlled adaptation to the new microclimatic conditions.

The principal factors of a new environment, which act negatively on wooden objects, are temperature, relative humidity and incident radiation. At these factors oxygen, fungus and bacteria spores should be added. Their action determines two successive effects: the growth in temperature of the object and, because of warming, the loss of the humidity content of this. In addition, they have a place of important dimensional changes of all absorbent materials, due to the changes in the water content.

Factors of degradation, which act on the wood after uncovering

Organic materials, which enter into the structure of patrimonial goods, proceeding from the archaeological digs, are absorbent. This property of all organic materials should signify the capacity of a material to yield or to absorb humidity, depending on the relative humidity of the environment, until it reaches a balance with this.

In the preventative conservation of archaeological organic materials, one of the determining factors which can help to retain this, or which can be involved in different processes of degradation, are microclimatic parameters. These are *relative humidity, temperature, ventilation, natural and artificial lighting*. For a good conservation, we should also bear in mind external climatic factors, such as air pollution, daytime, seasonal or annual variations, and the orientation of buildings[4].

Temperature

The main effect of the environmental temperatures is an increase in the temperature of the respective object at the time of uncovering; the temperature of the object is much lower than that of the new one or the environment.

a. *The influence of temperature on the state of conservation of the material, immediately after uncovering*

In this situation, the object heats up quickly, the rate of the heating process will be much greater as the difference between the temperature of the environment and that of the object. In these conditions, the temperature of the object will increase rapidly, and then the process will slow down, according to the declining difference in temperature.

In the case of an object with a larger volume, the length of the stabilisation of the equilibrium will increase. The importance of environmental temperatures needs to be understood correctly, in order to make it possible to take the most efficient measures in conservation, even from the moment of uncovering.

Another effect of the increase in temperature is the increase in the rate of water evaporation. In addition, the increase in temperature leads to an increase in the rate of chemical processes.

Concerning the quality of energy, the temperature has the capacity to produce effects such as the heat or the thermal energy, which can produce degrading effects on the archaeological wood.

b. *The effects of thermal energy*

- enlargement of the intermolecular and interatomic distances, the thermal effect which provokes the weakening of chemical bonds;
- dimensional changes: enlargement/decline in volume;
- change in physical properties, such as: flexibility, rigidity;
- increase in the rate of physical processes, such as: evaporation, condensation, diffusion of gasses and liquids to solids, dissolution, solubilisation, etc.;
- change in the rate of hydrolysis;
- change in the relative humidity values;
- conditioning of the appearance and development of biological pests; temperature influences the proliferation of these, but at the same time it can eradicate certain biological pests, whenever the thermal effect is united with a vacuum;
- increase in the rate of chemical processes, through thermal intensifying.

c. *The relationship between temperature and environmental relative humidity*

The effects produced by temperature on the stability of natural organic materials, lead to severe disturbances in the environmental microclimate, with direct and rapid effects on the state of conservation.

From a number of observations made of the environmental microclimate, it was observed that only the temperature changes the relative humidity values and not the reverse.

d. *Changes caused by the heating of the wood proceeding from archaeological sites*

Dimensional changes in archaeological wood are caused by two factors:

- increase and decrease of the contents of absorbent humidity of the materials, in their whole mass;
- dilation and contraction of the materials.

The heating of wooden objects proceeding from archaeological digs, caused by natural heating and not by lighting systems, can bring about destructive effects. The objects found on an archaeological dig always have a temperature lower than that of the natural environment, of the place in which the archaeological site unfolds.

Archaeological digs taking place in a warm season and not a few times, record differences of up to over 20ºC, between the temperature of the archaeological objects from the layer of culture and that of the environment.

The heating of this object is done immediately, from the moment of uncovering. The heating then continues for a time, because of keeping the object in the archaeological structure, if it is not protected. Its heating will be considerably accelerated if the object is exposed to instant radiation. An abrupt heating will be made, which will be proportional to the difference in temperature between the two systems.

The immediate effect of this rapid heating is the loss of keeping the humidity of the object, the rapid appearance of multiple irreversible degradations, of a chemical, physical and mechanical nature. These degradations are due to the breaking of chemical bonds and result in changes to dimensions and shape, stiffening, cracks, and fissures.

The temperature promotes the intensification and development of factors of biodegradation, whenever their values and those of the relative humidity are favourable to its metabolism. The increase in temperature establishes also the increase in the speed of the chemical reaction, thus t the materials are decomposed into inferior products.

e. *The influence of temperature on the conservation of archaeological wood after its introduction into storehouses*

Heat is a form of energy. Temperature is a conventional way to express the quantity of heating existing in a certain environment. Temperature produces important changes to the structure of the materials proceeding from archaeological digs both after their stabilisation and after their introduction into the storehouses.

Other types of deterioration owing to temperature are those of physical nature. The water and air contained in natural organic materials, move, exiting from the material, which also determines a shift in the fibres. In addition, the raised temperatures promote intensified biological activity of fungi and bacteria, if the values of relative humidity exceed 65%.

Light

Generally, through the photochemical effects which light has, (more choice the incident radiation through their thermal effects), it produces important degradations of the wooden objects dug up on archaeological digs.

Incident radiation is partially absorbed by the surface of the object, and partially reflected. The phenomenon of absorption of incident radiation is a process that depends on the nature of the surface, colour and porosity of it.

Whenever light energy is absorbed into objects, they give birth to a chemical reaction, which transforms the material components. The degradation

produced by light is called photochemical degradation, being in measure breaks certain chemical bonds. It is demonstrated through the weakening of resistance of respective support, friability, colour changes, tearing of the fibres and discolouring.

An uncovered object heats up rapidly when exposed to sunlight for short periods. An abrupt increase in temperature, leads to exfoliation and cleavage in zones of weaker adherence.

Another effect of incident radiation is the acceleration of the evaporation process of water from moist, porous objects and the crystallisation of salts, if these are found in a little bigger concentration. The process of crystallisation is accompanied by very important degradation phenomena.

In the case of wood from archaeological digs, with raised humidity content, the evaporation of this is tantamount to the collapse of the internal structure of the material. Irreversible degradation appears, such as deep cracks, splintering and loss of resistance.

The light sources emit invisible ultraviolet radiation, invisible infrared radiation (heat) and visible radiation (light). These are especially injurious for wooden objects from archaeological digs. Under the influence of lights, certain cellulose materials lose their colour or, after the event, or the colour darkens.

Invisible infrared radiation emits heat. As well as in the event of changes caused by raised temperature, infrared radiation leads to the heating of the materials, a process accompanied by the loss of absorbent humidity and dimensional changes.

Ultraviolet radiation destroys the chemical bonds of materials. For the cellulose fibres an ultraviolet radiation can be so injurious as well as over-chlorination and strong oxidation. The cellulose can be decomposed into an oxycellulose of inferior quality. The wavelengths of ultraviolet radiation rupture the molecular chains of organic combinations. The free roots of the ruptured molecular chains react with the oxygen in the atmosphere and produce other free roots. In this way, a chain reaction of the destruction of the material begins[5].

For the protection of patrimonial objects realised from natural organic materials, ultraviolet and infrared radiation need to be eliminated and visible radiation reduced.

The processes of degradation due to the actions of light depend on the following factors:

- intensity of the radiation, the power of the source;
- spectral quality, how the radiation is emitted, wavelength;
- total quantity of radiation;
- length of the illumination;
- increased temperature (an increase of 10ºC in temperature doubles the speed of the reaction);
- increased humidity in the air;
- oxygen content in the atmosphere;
- grade of the material's resistance to photo-chemical action
- presence of oxygen.

Natural light, the sun, emits a lot of ultraviolet, infrared and visible radiation; a lamp with incandescent light emits little ultraviolet radiation and a lot of infrared, while a fluorescent tube emits ultraviolet radiation and a little infrared[6].

Natural light. From the point of view of preventative conservation, this is the most harmful, because of massive emissions of ultraviolet radiation and the intensity of the radiation with short wavelengths. It also has a very great variability in intensity.

Fluorescent light contains an increased percentage of ultraviolet radiation, the cause of which is very harmful.

Incandescent light is the least harmful, by the much-reduced emission of ultraviolet radiation, but contains a large quantity of infrared radiation, that is heat.

In order to avoid producing photochemical degradation, it is necessary to take adequate measures. The correlation of the light intensity, of the level of illumination, with the grade of sensitivity of the materials, is an absolute necessary action.

Humidity

Atmospheric humidity implicated in the degradation of archaeological wood immediately after discovery

For archaeological materials, the change in the rich water content now of discovery can establish immediate and irreversible degradation. For this, it is important that this water content be retained intact, until the effectuation of laboratory treatments.

Wooden objects, being absorbent, tend to continue to enter into balance with the environment, yielding humidity; in this case, by the loss of water from their own structure, they dry out, contract, and absorb humidity. These structural changes can be the cause of grave deterioration, while the increased grade of absorbent humidity can promote the installation of fungal, bacterial attacks, as well as the spreading of insects.

The buried materials come to a certain level of equilibrium with the respective environment. Immediately after their removal from this environment, if adequate preventative measures are not taken, they will absorb or yield humidity. Depending on the atmospheric humidity, these can determine an abrupt change in the humidity content and the state of equilibrium. Both the yielding and the acceptance of humidity cause serious deterioration of the materials.

Relative humidity implicated in the degradation of archaeological wood after stabilisation and its introduction into the storehouses

Humidity represents the water present in the atmosphere in the form of gas. The warmer the air, the larger quantity of water vapours will contain in it. If at 5ºC, a cubic metre of air can contain a maximum of 7 grams of water vapour, then at a temperature of 20ºC, the maximum quantity of water vapour contained in a cubic meter of air increases to 18 grams, while at 30ºC the quantity is 31 grams.

The maximum level of water vapour that can be reached in a volume of air at a certain temperature is called saturation (S). When this level is not reached, the liquid water present can evaporate. If saturation has been reached, the liquid water cannot evaporate.

The air is rarely saturated. In general, it contains less water vapour than could be contained. The weight measurement of the water vapours actually contained in a certain space is called the absolute humidity (A.H.) and is expressed in grams per cubic metre.

Relative humidity (R.H.) is the ratio between the quantity of water vapours effectively contained (A.H.) in a determined space and the maximum quantity of water vapours which could be contained in this space at the same temperature (S). Thus, R.H. = A.H./S x 100 (t).

In closed spaces, if absolute humidity (A.H.) remains unchanged, that is constant, relative humidity (R.H.) declines when the temperature declines. In other words, temperature and R.H. are inversely proportional factors.

Wooden objects, being absorbent, absorb or yield water, until they reach equilibrium with R.H. of the environment in which they are retained.

Absorbency depends on two factors: by the absorption capacity of the material, which is determined by the structure and composition of the respective material and by the relative humidity of the environment in which the material is found.

The conclusion can be drawn that in order to keep a constant relative humidity in a certain space, whenever the temperature increases, you must enlarge the quantity of water vapour by using humidifiers or atomisers. When the temperature falls, you should eliminate water vapours by using dehumidifiers and condensers. The ideal would be the installation of air-conditioning, which would permit the maintenance of constant values, within the accepted limits of humidity and temperature.

In any closed space, a series of gas products, vapours of diverse origins and solid dust particles, accumulate. The lack of air circulation, together with an increased humidity and temperature, can be the cause of the installation of microbiological attacks, which develop on the material and destroy it.

The conclusion is that there is a need for natural or accelerated ventilation; the ventilation programme should correlate with daily variations in exterior humidity[7]. Natural ventilation is done with the help of windows or of wall air vents or doors. In this case, the change in air is made by difference in temperature between interior and exterior and by the action of the possible currents created.

For large ventilation, it is necessary to widen the openings by which the change in air is made and to reduce the resistance of air circulation, actually the stagnation of the air, which can be produced even against furniture. The stagnation of the saturated air is checked by the height of approximately 40 per cubic metre of earth as well as in the back of the modules laid along the length of the walls.

The ventilation is accelerated (eletroventilation), whenever circulation pipes or air-extractors are used. In this case, two air changes a day are sufficient. The

activation of accelerated ventilation with air that does not have carrying capacity is useless. For this, the programme of ventilation should correlate with the daily variations in exterior humidity.

The optimum values for conservations in storehouses of archaeological wood proceeding from archaeological sites are: maintaining relative humidity between 50-65%, at a temperature up to 18ºC, with a correlation between values of humidity and temperature. The fundamental condition for a correct conservation is, in addition, constancy of thermo-hygrometric values.

The humidity of walls – factor of degradation of natural organic archaeological materials, after their introduction into storehouses

The cleanliness of the rooms in which natural organic goods are kept is of great importance, because the majority of these places are placed in historic edifices. Between these old constructions and the new, there is a fundamental difference.

In old buildings, increased humidity is produced due to infiltrations, having a chronic character, while in newly constructed buildings there is a humidity of construction, which has a passing character. In modern walls, water proceeds from fresh plasters.

During the time of construction, humidity is uniformly widespread with a lower intensity from top to bottom and rapid disappearance over time. The humidity of infiltration is unevenly widespread, being stationary or progressive over time. In old buildings, the humidity of infiltration of walls can proceed either from earth by capillary ascent, or from air by condensation.

The humidity proceeding by capillary ascent is independent of seasons. It has a reduced capacity of rising in walls, impregnates the whole breadth of the wall from one side to the other, and is eliminated relatively rapidly after the repairing of water networks or after suppression of contact with phreatic tissue.

The resultant humidity by the condensation of water vapours becomes manifested every year in the same season, increases to certain levels of wetness on the wall's surface and combines with finishing materials. The absorption of water vapours into the air by the cooling of the contained vapours can be eliminated rapidly by the heating and ventilation of the space. Unfortunately, the humidity continually reappears.

The characteristics of humidity proceeding from the resultant water following the desertions of sewers or of rains can easily be traced. It becomes strongly manifested but localised, in a single area of the building on a certain side. The humidity of phreatic tissue produce effects to the whole building, and the maximum level of growth being in the direction of north, north-east. It is common to buildings everywhere between a certain areas, constructed in a certain period from the same type of materials.

Irrespective of the cause of humidity, these buildings are unsuitable for depositing, displaying, conserving or restoring goods with patrimonial value. The wet walls can contain erosions and efflorescence of salts, and especially harmful white formations, owing to salts that migrate. Such buildings should be avoided or subjected to particular recovery operations.

Pollution – factor in degradation of archaeological wood

All natural organic materials suffer a series of processes of degradation, because of their exposure to polluted air. Much more sensitive to this type of external factor, archaeological wood risks being jeopardised in the absence of adequate measures of preventive conservation[8].

Atmospheric oxygen has the capacity to enter into a chemical reaction and to be combined with many more substances, carbon, hydrogen, organic compounds, iron, magnesium, phosphorous, etc., forming oxides in conditions of light and heat. These rapid oxidations can produce negative effects, which worsen or hinder the good conservation of pieces.

As a rule, the air is a mix of oxygen and nitrogen, with traces of carbon dioxide. It, or rather its composition, presents impurities, determining some of the degradation of the wood. These impurities are sulphur dioxide, hydrogen sulphide, ammonia, nitrogen dioxide, ozone and aerosols.

Aerosols are the polluting elements of the air, which include all tiny solid particles, found suspended in the air, and i.e. dust. In polluted towns, aerosols especially contain soot, resulting from the incomplete burning of fuels. They can further contain ash particles and dust, resulting from construction and from the earth, fibrous fragments, and sodium chloride. Fine salt particles retain water and promote the development of moulds.

Particles in a solid state (dust – a mixture of substances, small natural organic and inorganic particles, skin, soot, salts, silicon, etc.), are very dangerous. The tars and soot have a very small diameter and are not seen. The dust which falls on objects is absorbent, thus forms a crust that becomes a strong factor in degradation, continuing alike also spores of microorganisms. The salts are also very dangerous to this. Industrial aerosols absorb and transport with them sulphur dioxide, hydrogen sulphate, iron particles, which whenever they fall on materials, unleash rapidly destructive chemical reactions.

Polluted atmospheres and those that contain increased SO_2 from large towns and industrial zones produce great damage to natural organic archaeological materials, due to the formation of sulphuric acid, which destroys these materials. The chemical process of the formation of sulphuric acid, in the case of air pollution, is due to the fact that in the presence of traces of metal, SO_2 is oxidised, transforming itself into SO_3 which, in the presence of damp air, is transformed into sulphuric acid, H_2SO_4.

The increase in the concentration of sulphur dioxide, which pollutes the atmosphere, is the result of the burning of fuels and of other industrial activities. Porous natural organic materials absorb Sulphur dioxide. Once absorbed, this reacts like a hydrophilic element, retaining at the same time water and small quantities of iron, finally forming sulphuric acid. Acids and particularly sulphuric acid bring about a reduction in the resistance of the wood. Another polluting agent, which has harmful effects, is hydrogen sulphate.

The ammonia from the atmosphere is harmful for cellulose, establishing alkaline hydrolysis of these. Because of the increased percentage of acid presents as a rule owing to sulphur dioxide from the air, the ammonia absorbed by the material will act, most times, only as a reducer of this acidity. Ammonium sulphate results in a reaction between free ammonia and water vapours, in the presence of other chemical products, forms a colouration on the surface of the materials covered with a film of natural resins.

The ozone is produced at high altitude by the action of ultraviolet radiation on the oxygen. Nitrogen dioxide proceeds, particularly, from the residues of burning automobile fuels. The action of sunlight on the nitrogen dioxide generates a lot of ozone, thus the percentage of these two destructive agents increases ominously.

The ozone destroys natural organic material. Moist cellulose is especially affected by ozone found even in normal concentrations of polluted air.

In polluted air, there is the formation of smog in large towns, which is determined by air currents, but the greatest danger is it forms the phenomenon of air inversion, that is the state of total calm of air currents, which does not allow sufficient refreshing of the air. Atmospheric pollution is accentuated when, along with sulphur dioxide in the air, other are also present such as chlorine, fluorine, ammonia, etc., proceeding from industrial activity.

NOTES:

[1] Sofia Ştirban, *Conservarea preventivă a obiectelor arheologice pe suport organic*, Alba Iulia, 2002, p. 64.
[2] *Ibidem*, p. 88.
[3] *Ibidem* p. 90.
[4] A. Ştirban*, Evaluarea factorilor de degradare care acţionează în colecţiile muzeale asupra materialelor de natură organică* ,Apulum XXXVIII/2, Alba Iulia, 2001, p. 399-400.
[5] A. Moldoveanu, *Conservarea preventivă a bunurilor culturale*, Bucureşti, 1999, p. 124.
[6] C. Neamţu, V. Ioniţă, *Conservarea lemnului arheologic provenit din săpătura Mirăuţi*, în „Restaurare 2000", Iaşi, 2000, p. 248.
[7] D. M. Creanga**,** *Conservarea patrimoniului arheologic mobil,* Suceava, 2007, p. 114.
[8] S. Ştirban, *op. cit*., p. 117