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## Original paper

# ***Investigations regarding the biodegradation of the cultural heritage. Case study of traditional embroidered peasant shirt (Maramures, Romania)***

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## Abstract

The studied textile object is a traditional female embroidered peasant shirt, old of about 100 years, from a private collection. Bacteria and fungi were assessed through specific methods. Determination of most common fungi and yeasts, consists in: *Penicillium* spp., *Cladosporium* spp., *Fusarium* spp., *Alternaria* spp. and *Candida* spp. These can contribute to the fabric fiber bio-deterioration and, in order to emphasize such aspects, the SEM images obtained from the electronic microscope were analyzed; the contamination with fungi, yeasts and bacteria can also negatively influence the health condition of those who handle such pieces (storage rooms, museums, etc.) and of those who wear such objects (even occasionally). Evidence decontamination was made by treating them with Chitosan.

## Keywords

Fungi, yeasts, heritage, preservation, human health, SEM images, decontamination, Chitosan.

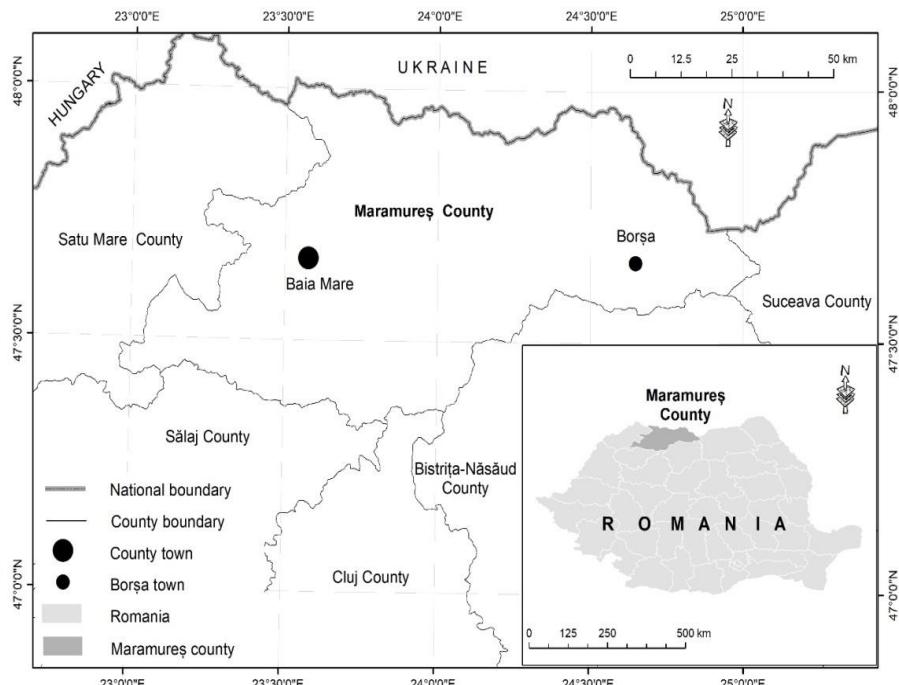
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## Introduction

This study is part of the digitization and online accessibility process of an element belonging to the valuable Romanian cultural heritage. The studied textile object is a women traditional Romanian shirt, from ethnographic area Maramureş, Borşa locality (Fig. 1). The origin of the analyzed object is reflected in the material and symbolic characteristics that this element of specific

Romanian cultural heritage “shirt” incorporates. These include the age, the material and the stylistic features. Therefore, the traditional shirt studied represents a valuable source of information about the past, regarding the activities practiced, the materials used, the beliefs, superstitions and knowledge of the local communities, transmitted and rendered in the form of this product. In this context, the present study aims to create a model of good practice in the direction of conservation and capitalization of the material heritage [1].



**Figure 1.** Geographical outline of area of belonging of investigated traditional object.

The shirt, made of home woven cloth, is about 100 years old (Fig. 2) and is part of a private collection. In order to determine the biodegradation degree and the possible influence upon the human health, it was accomplished the monitoring of microbial and mycological loading with bacteria and fungus of this embroidered shirt. This monitoring is necessary because the textile objects contaminated with fungi can negatively affect the health of people who come in contact with them. Regarding the textile materials, digitization [2] can successfully contribute to the creation and facilitation of ways to access and use the information about the respective object and implicitly to the preservation and conservation of old textiles, valuable for the national culture and not only.

**Literature review.** General studies were accomplished referring to the importance of the digitization process for the cultural heritage [3]; methods for 3D digitization of cultural heritage were presented [4], while specifically for textile materials, should be mentioned also many important studies done in the last years [3, 5, 6, 7, 8, 9]. Amongst the studies about fungi upon textiles and bioremediation, we mention the papers of Popescu et al,

2014; Faryal and Hameed, 2005 etc. [10, 11]. Through the various authors, Helmi et al, 2008, analyzes valuable textiles from Egypt [12]. Many studies regard the microbial deterioration analysis and disinfection methods, through these we mention those of Gutarowska et al, 2016 [13].

In Romania we mention the papers published about this topic ever since 1974, dedicated to biodeterioration of objects from museum [14], museum airborne fungal biodeteriogens [15, 16, 17, 18, 19, 20, 21] investigations and transdisciplinary studies (nuclear techniques) for valorisation of cultural heritage [22, 23].

## Material and Methods

**SEM investigations.** Using a Scanning Electron Microscope (SEM) was assessed the surface morphology and the potential physical, chemical and thermal damage to the internal fibers composition [24, 25, 26].

**Isolation of microorganisms.** Samples of 1 cm<sup>2</sup> were taken from the textile material surface, using sterile cotton swabs [27, 28]. Cotton swabs were submerged in 1 mL of sterile distilled water and decimal dilutions were

performed. Suitable dilutions of each sample were inoculated into nutrient agar on petri dishes to identify bacteria and on Sabouraud agar with cloramphenicol for isolation of fungi. They were incubated at 37°C for 72 h (isolation of bacteria) and at 25°C for 5-7 days (isolation of fungi).

The bacterial cultures were identified by using staining techniques and macroscopic characteristics. The fungal cultures were identified, cultural and morphological characteristics, on the basis of microscopic (using Lactophenol cotton blue staining) and macroscopic characteristics [29].

Using the colony counting, the colonies were counted. It was used the horizontal method with colony counting

technique at 30°C, with the pouring in plates technique (SR EN ISO 4833 1/2014). In order to count the culture microorganisms through sowing in agar nutritional culture environment (after aerobic incubation at 22°C and respectively at 37°C) (SR EN ISO 6222: 2004), it was used the horizontal method for counting yeasts and musts (SR ISO 21527-2/2009).

In order to emphasize the micro-flora which develops at the temperature of the environment, 22°C, the total number of germs was identified (over 76 hours), as well as at human body temperature, 37°C (for 48 hours). It was emphasized the total number of yeasts and fungi on two culture environments and two thermostat points (DG18 la 25°C and Sabouraud at 37°C), for 5-7 days.

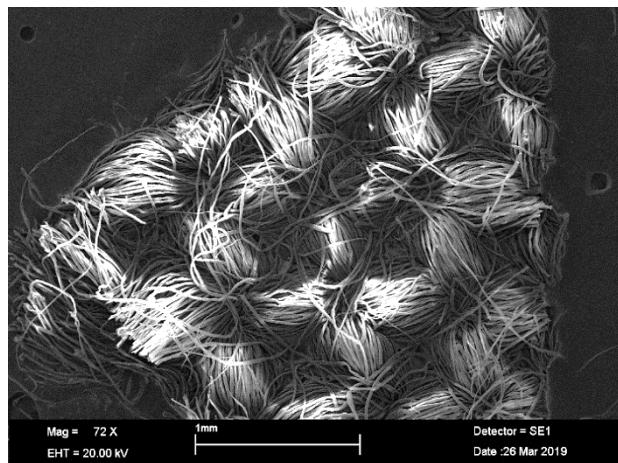


**Figure 2.** Traditional embroidered shirt, Maramures County, Romania  
(age: cca 100 years, private collection)

## Results and Discussion

Microbiological quality assessment of the material is one of the most important investigations to determine the biodegradation possibilities and influence on human health. The information about the both airborne bacteria and fungi is necessary to estimate the health hazard and for heritage objects preservation.

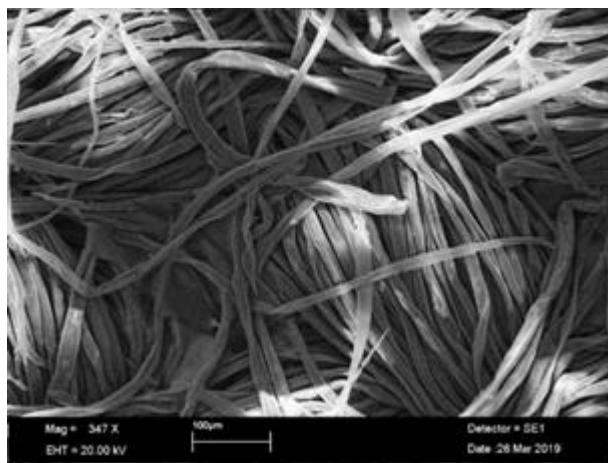
Samples of fibers from the investigated traditional shirt were examined using a scanning electron microscope (SEM) to assess surface morphology and the potential physical, chemical and thermal damage to the fibers that make it. A sample of the material was also subjected to tests that distinguish between simple impurities such as atmospheric dust and potential fungi and other microorganisms [25].



**Figure 3.** Sample, SEM image shows the weave of the fibers and the weft pattern of the examined fabric with x 74 magnification.

Almost all the samples SEM image (Fig. 3) show good condition and shows the weave of the fibers and the weft pattern of the examined fabric with x 74

magnification. Only in the lower left part (Fig. 3) of the pictures can be seen the mechanical destruction of one of the fiber bundles visible.

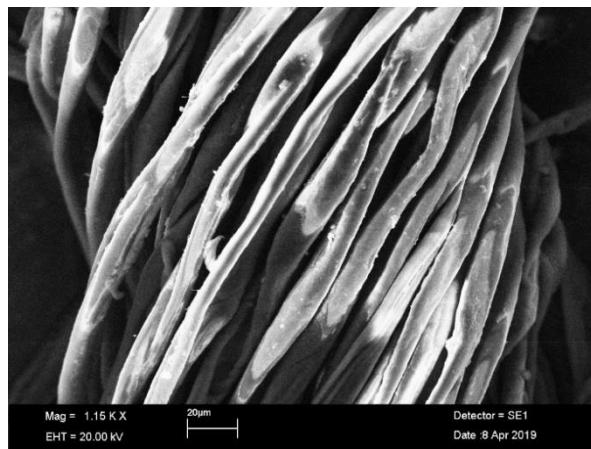


**Figure 4.** Sample, SEM image, x 347 magnification

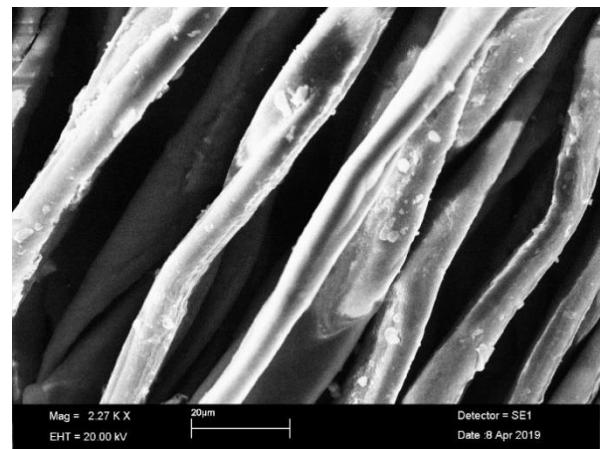
Successive magnifications of the image (Fig. 4), till x 347, confirm previous observation. The condition of most fibers is good, both in terms of the original arrangement of the weave and strength to external factors (humidity, temperature). The material, apart from individual threads, does not show any damage, which proves its good quality, also good storage conditions or low degree of use (everyday use). However, even at this magnification, in

the upper left of the image and in the center of the picture are visible probably indicative of chemical changes. In addition, traces of dust are visible in the upper left corner.

Magnification of the image x 1150 and x 2270, respectively, of the same fragment of the sample (Fig. 5 and Fig. 6), shows extra-details of the tested fibers, which allowed to clearly detect the presence of dust particles and microorganisms (Fig. 6).



**Figure 5.** Sample, SEM image x 1150 magnification



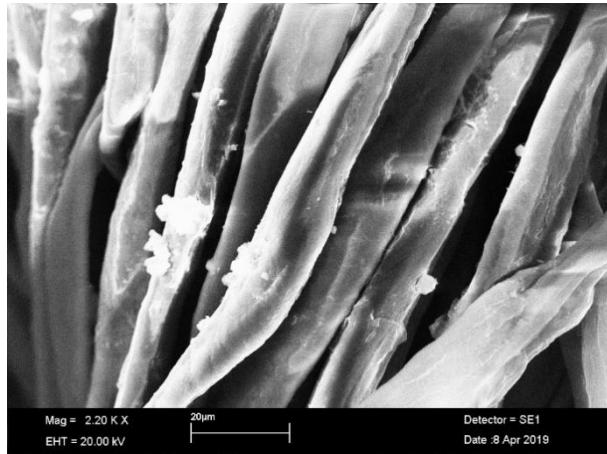
**Figure 6.** Sample, SEM image x 2270 magnification

Confirmations of this observation are the SEM images of the next sample with clearly visible single fibers at x 2200 magnification (Fig. 7) and at x 2270 magnification (Fig. 8), in which, apart from impurities, probably spores and/or fungi could be seen.

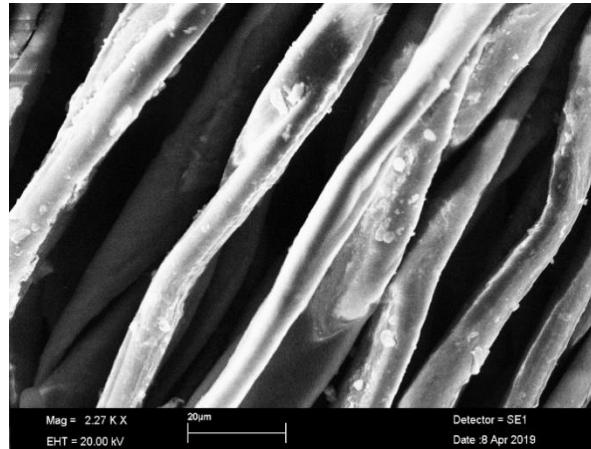
The identified fungi by the macroscopic and microscopic examination methods belong to the genus: *Penicillium* spp., *Cladosporium* spp., *Fusarium* spp.,

*Alternaria* spp. The yeasts belonging to *Candida* species; were also isolated and filamentous bacteria from genera *Actinomyces* sp and *Streptomyces*.

Regarding the total number of colonies: NTF/ml or /g= 6.14 x 104, larger than 300 both at 22°C and at 37°C (Fig. 9 and Fig. 10) (the dilution used for extract was of 1/10 = 1 gram of fabric at 9 ml of dissolving solution), according to standards, they show an average microbial load.



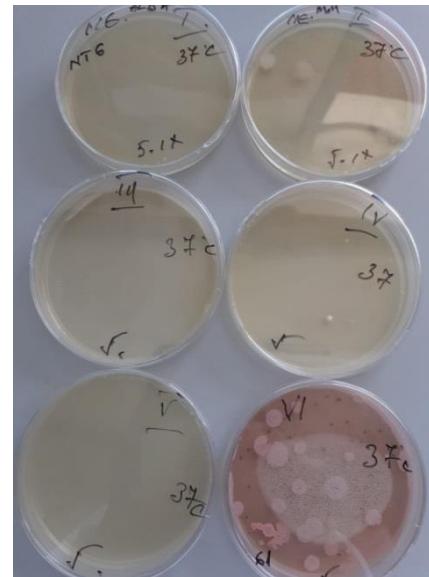
**Figure 7.** Sample SEM image x 2200 magnification with dust and impurities.



**Figure 8.** Sample, SEM image x 2270 magnification with dust and impurities.



**Figure 9.** Total number of colonies 22°C



**Figure 10.** Total number of colonies 37°C

Some fungal genera and bacteria were identified, presenting risks for their preservation and for the human health. The special epidemiological studies pointed out the association of exposure to fungi, especially from the *Alternaria alternata* and *Cladosporium herbarum* genus with the development, persistence and severity of asthma. Prolonged exposure to fungi from the species *Candida*, *Penicillium*, enhance the development of ABPM (*Allergic Bronchopulmonary Mycosis*). The main characteristic forms of ABPM include severe asthma, bronchiectasis, as well as significantly increased levels of total IgE (E immunoglobulins have an important role in mediating the allergic reactions which occur as a result of exposure to allergens) [30]. According to the studies of Rick et al, 2016, sensitivity to fungi is different according to their type [31]; thus, fungi from the *Alternaria* family are associated with severe asthma episodes, depending on the exposure level.

On the other hand, fungi from the *Candida* and *Penicillium* families can be a persistent allergen stimulus, independent of their aerial concentrations; their capacity to germinate within the breathing system can lead to non-invasive infections which could complicate the inflammatory process. Fungi from the families: *Candida* spp., *Fusarium* spp., *Cladosporium* spp., *Penicillium* spp., *Alternaria* spp. can determine, in case of prolonged exposure, complex respiratory disorders which are included in the term of allergic bronchopulmonary mycosis (ABPM), which implies the presence of asthma (characterized by exhaling dyspnea or the chocking sensation and wheezing) or the deterioration of the pulmonary function consecutive to repeated infections (characterized by coughing with expectorations, nocturnal sweats and sensations of fast fatigue) [32].

In order to decontaminate the pieces of evidence, after treating them with Chitosan, the decontamination

efficiency was checked by counting the colonies at 30°C [33]. The total number of germs was diminished in most pieces and it was totally reduced in the case of those which had lower loads (up to 10<sup>2</sup>).

## Conclusions

Microbiological monitoring of textiles is necessary both to estimate the health hazard and the control of preservation. The presence of a high number of germs which develop both at the environment temperature and at body temperature, and the presence of a large number of microorganisms, represents high hazard both for preserving the fabrics and for the people around them. The treatment applied with Chitosan is efficient and diminishes the degradation hazard for the fabrics and the hazard for those who take care of/use them. The techniques used are non-invasive and can be applied for museum pieces and for private collections, too.

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