STUDY OF THE INFLUENCE OF CONSERVATION TREATMENT ON THE CHROMATIC CHARACTERISTICS OF ARABIC MANUSCRIPTS

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ABSTRACT

In the present experiment, a study was conducted to investigate the effect of conservation treatment of an Arabic manuscript on its chromatic characteristics. For this purpose, extremely valuable, unrestored manuscripts (18 - 19th century) were selected from the archives of the National Library "St. St. Cyril and Methodius", on which spectrophotometric chromatic characteristics were measured. The research was conducted at the restoration center of the National Library. The following processes were applied to the manuscript: mechanical cleaning and deacidification. Measurements of color characteristics were taken indifferent parts of the manuscript after each stage of the treatment: before treatment, after mechanical cleaning, after deacidification. The following parameters - CIE Lab, CIE Lch, ΔEab, ΔE_{2000}, ΔL, Δc, Δh was calculated. Based on the results obtained, the changes and effects of each of the chromatic parameters were determined.

Keywords: conservation, conservation treatment of manuscripts, manuscripts, color characteristics, color difference, CIE Lab, CIE Lch.

INTRODUCTION

Conservation and restoration of books, manuscripts and documents is an activity dedicated to prolonging the life of objects of historical and personal value, made mainly of paper, parchment, and leather. The main aim of conservation is to prolong the life of the object as well as to preserve its integrity [1 - 3]. Millions of important books at libraries are deteriorating, and their aging makes them too fragile to handle. Glances at literature suggest that efforts have been made to take preventive and preservative measures for the conservation and restoration of such precious documents. Each paper changes its physical, mechanical, and chemical properties over time - paper ageing - and the process is irreversible. The primary cause of paper deterioration is the presence and development of acidic content during manufacturing and aging [4, 5]. The acidic content attacks the cellulose fibers in the paper and depolymerizes them through an acid-catalyzed hydrolysis process. Other factors, such as oxidation, varying or extreme temperatures and humidity, exposure to light, air pollutants in the storage areas, and the amount of use, also play a significant role in the deterioration of books [6 - 9]. Storage in a cool, dry, clean, and stable location can extend the life of an item [10]. Deacidification is the main chemical stabilization strategy for paper. It is considered as the most important conservation intervention that concerns the preservation of paper in the long term. The purpose of deacidification is not only the neutralization of acids, but also the deposition of an alkaline substance that will neutralize acidity that may develop in the future (alkalinity or alkali reserve) [11, 12]. It should be noted that deacidification cannot restore the lost mechanical strength of aged paper [13].

The color difference is the numerical value defining the distances between colors in the color space and is denoted by ΔE. The basic rule is that the smaller the value of ΔE, the smaller the distance between the points of different colors in the color space. CIE ΔE*ab is the

classical method for determining color change, while CIE ΔE2000 is a method that is tailored to specific features of human perception. The CIE ΔE2000 color difference also gives more accurate results in whites and neutral shades of colors, like the paper of manuscripts. For a more detailed colorimetric analysis of the color changes expressed by ΔE, a further study of the three color coordinates in the CIE* Lch is necessary to determine which coordinate changes in which way [14 - 16].

The aim of the present experiment is to investigate the effect of conservation treatment on the chromatic characteristics of paper manuscripts.

EXPERIMENTAL

Materials and Methods

For the present experiment, four different Arabic manuscripts (18th - 19th century) from the archives of the National Library "St. St. Cyril and Methodius" were used. The documents are very valuable and have not been restored. Three similar fields from each manuscript were selected and chromatic performance measurements were made in CIE* Lab and CIE Lch with a Gretag-Macbeth SpectroEye spectrophotometer. Measurement conditions were CIE Standard Illuminant D50, 2º standard observer, geometry of measurement 45/0, measurements without polarization filter. Different fields were selected Fig. 1, FIELD one being the lightest area of the manuscript, FIELD two an area with a water stain and FIELD three a stain caused by advanced oxidation of the paper. The manuscripts were subjected to mechanical cleaning and deacidification with borate-borax buffer, and measurements were taken before treatment, after mechanical cleaning and after deacidification. Color difference calculations (CIE ΔE*ab and CIE ΔE2000) were performed, and the average values for the four manuscripts were also calculated. The average values for L, C, h was also calculated. The effect of conservation treatment between before treatment and after mechanical cleaning, after mechanical cleaning and after deacidification, before treatment and after deacidification for lightness ΔL, saturation Δc, color tone Δh, color difference ΔE*ab and ΔE2000 was investigated.

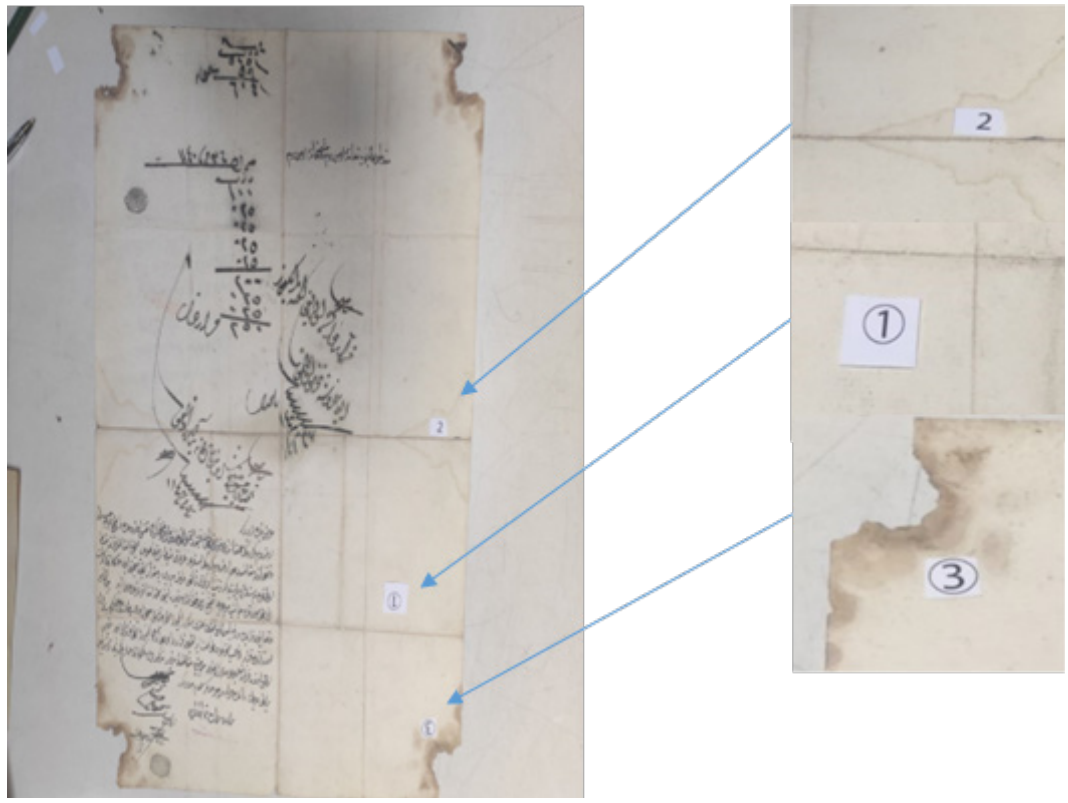

Fig. 1 Manuscript number 4 and the selected fields.

RESULTS AND DISCUSSION

The color characteristics of a document give us important information about the color change of paper manuscripts. From previous studies [4, 5], it has been found that the most suitable colorimetric systems for manuscript aging assessment are CIE Lab and CIE Lch. Each of these color systems determines color using 3 color coordinates. L - chromaticity coordinate which is responsible for light shades (this characteristic is common and the same for Lab and Lch systems), CIE a - red-green contrast, CIE b - yellow-blue contrast, CIE c - chromaticity coordinate, which is responsible for color saturation, CIE h - hue coordinate.

The two colorimetric systems are similar, with the CIE Lch system being a modification of CIE Lab to better interpret the results in terms of the analysis of changes in the Hue and Croma color parameters.

Investigating the effect of conservation treatments on the change of chromatic characteristics from selected fields of Arabic manuscripts expressed by color difference (CIE ΔE*ab and CIE ΔE2000).

The processes of chromatic characteristics change in the conservation process were investigated and their quantification was done by determining the two most commonly used color difference formulas, CIE ΔE*ab and CIE ΔE2000.

Fig. 2 shows the influence of the color difference (CIE ΔE*ab) between the different treatments of the selected similar fields of the four manuscripts in FIELD one, the lightest region of the manuscripts, and in Fig. 3 the change in FIELD two, the region of the manuscripts with water stains.

Fig. 4 shows the influence of the color difference (ΔE*ab) - before treatment and after mechanical cleaning(ΔE*ab1), after mechanical cleaning and after deacidification(ΔE*ab2), before treatment and after deacidification (ΔE*ab3). between the different treatments on the selected similar fields of the four manuscripts in FIELD three, a region of advanced oxidation.

It can be seen from the graphs that there is little noticeable difference before treatment and after mechanical cleaning. The greatest change in color difference between pre-treatment after deacidification in the fields with advanced oxidation. In the lighter areas

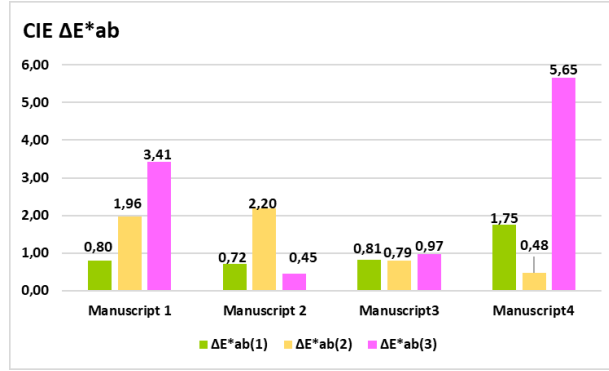

Fig. 2. Influence of color difference (CIE ΔE*ab) between different treatments of the selected similar fields of the four manuscripts (1 lightest area) - (ΔE*ab1) before treatment and after mechanical cleaning, (ΔE*ab2) after mechanical cleaning and after deacidification, (ΔE*ab3) before treatment and after deacidification.

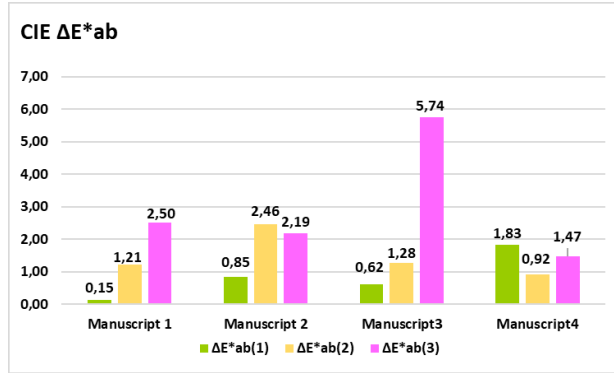

Fig. 3. Influence of color difference (CIE ΔE*ab) between different treatments of the selected similar fields of the four manuscripts (2 - water stain) - (ΔE*ab1) before treatment and after mechanical cleaning, (ΔE*ab2) after mechanical cleaning and after deacidification, (ΔE*ab3) before treatment and after deacidification.

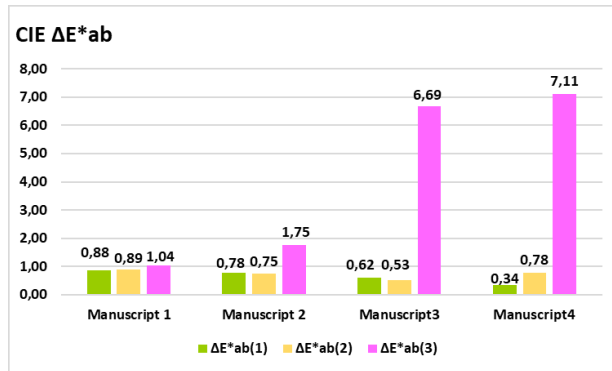

Fig. 4. Influence of color difference (CIE ΔE*ab) between different treatments of the selected similar of the four manuscripts fields (3 - area with advanced oxidation).

of the manuscripts, deacidification has no significant change in color difference, while in the fields with advanced oxidation there is a very large significant difference.

Fig. 5 shows the influence of the color difference (CIE ΔE^*_{2000}) before treatment and after mechanical cleaning(ΔE^*_{2000}-1), after mechanical cleaning and after deacidification(ΔE^*_{2000}-2), before treatment and after deacidification (ΔE^*_{2000}-3). between the different treatments on the selected similar fields of the four manuscripts in FIELD one, and Fig. 6 the change in FIELD two.

Fig. 7 shows the influence of the color difference (CIE ΔE^*_{2000}) - before treatment and after mechanical cleaning(ΔE^*_{2000}-1), after mechanical cleaning and after deacidification (ΔE^*_{2000}-2), before treatment and after deacidification (ΔE^*_{2000}-3). between the different treatments of the selected similar fields of the four manuscripts in FIELD three.

It can be seen from the graphs that there is little noticeable difference before treatment and after mechanical cleaning. The greatest change in color difference between pre-treatment after deacidification in the fields with advanced oxidation. In the lighter areas of the manuscripts, deacidification has no significant change in color difference, while in the fields with advanced oxidation there is a very large significant difference.

Study of the influence of conservation treatment on colorimetric characteristics - lightness (CIE* L), saturation (CIE* C), color tone (CIE* H).

For more detailed colorimetric analysis of the color changes expressed by ΔE, all three coordinates of color in the CIE* Lch, were investigated to determine which coordinate changes in which way during conservation treatments.

Effect of conservation treatment on the lightness (CIE*L) of paper of selected manuscript fields - before treatment, after mechanical cleaning and after deacidification.

Fig. 8 shows the change in lightness (CIE*L) of the manuscripts for different treatments of selected similar fields in the lightest region of the paper, and Fig. 9 for the fields with water stains.

It can be seen from Fig. 8 and Fig. 9 that there is no

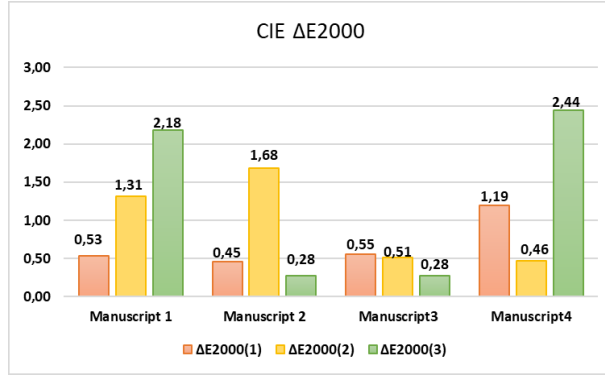

Fig. 5. Influence of color difference (CIE ΔE^*_{2000}) between different treatments of the selected similar fields from the four manuscripts (1 lightest area).

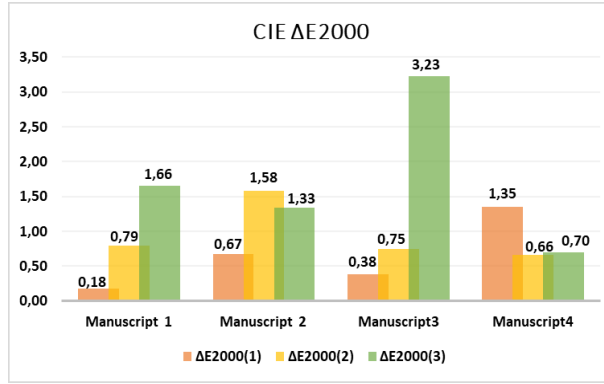

Fig. 6. Influence of color difference (CIE ΔE^*_{2000}) between different treatments of the selected similar fields from the four manuscripts (2 - water stain).

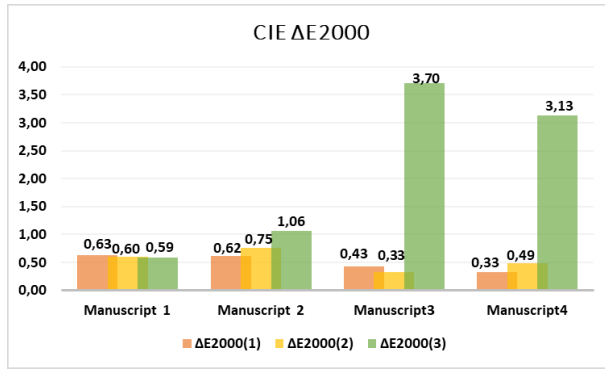

Fig. 7. Influence of color difference (CIE ΔE^*_{2000}) between different treatments of the selected similar fields from the four manuscripts (3 - area with advanced oxidation).

significant change in lightness in the light region of the paper and the water spot areas.

Fig. 10 shows the change in lightness (CIE*L) of the manuscripts for different treatments of selected similar fields in the advanced oxidation region of the paper.

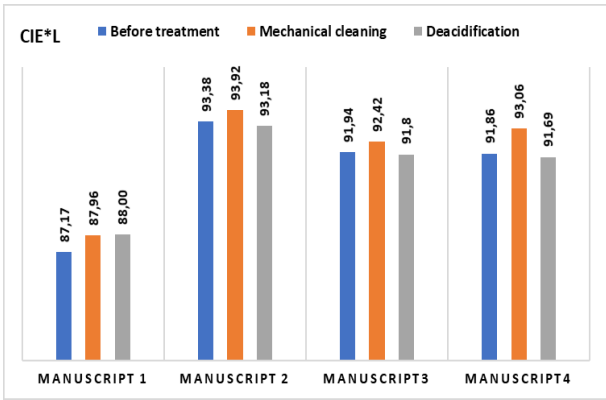

Fig. 8. Investigation of the change in lightness (CIE*L) of the papers under different treatments of selected similar fields (1 - lightest area) of the four manuscripts.

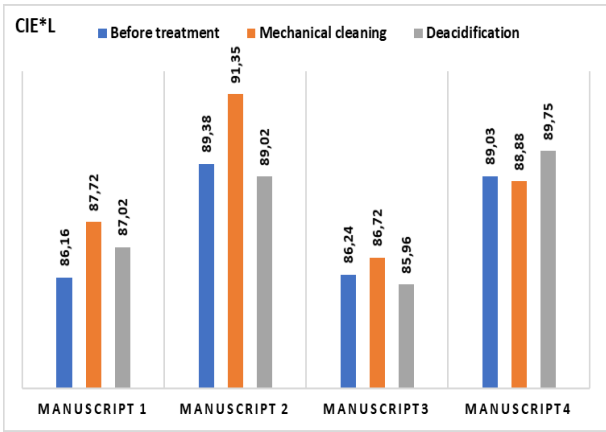

Fig. 9. Investigation of the change in lightness (CIE*L) of the papers under different treatments of selected similar fields (2 - water stain) of the four manuscripts.

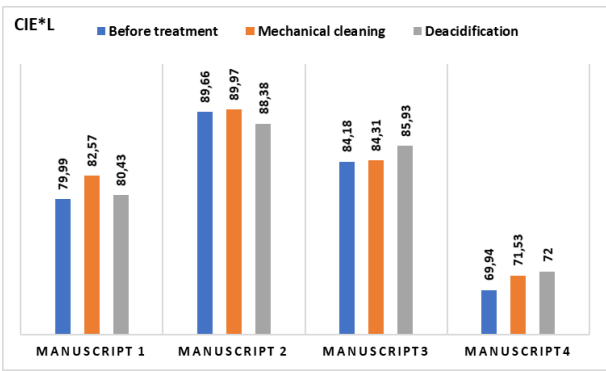

Fig. 10. Investigation of the change in lightness (CIE*L) of the papers under different treatments of selected similar fields (3 - area with advanced oxidation) of the four manuscripts.

From the graphs, there is a significant change in lightness (CIE*L) after mechanical cleaning, which is due to the surface dirt on the paper. The biggest change occurs between before treatment and after deacidification.

Effect of conservation treatment on paper saturation (CIE*C) of selected manuscript fields - before treatment (C1), after mechanical cleaning (C2) and after deacidification (C3).

Fig. 11 shows the change in paper saturation (CIE*C) of the manuscripts for different treatments of selected similar fields in the lightest area of the paper, and Fig. 12 for the fields with water stains.

It can be seen from Fig. 11 and Fig. 12 that there is no significant change is the saturation in the light area of the paper and the water stain areas.

Fig. 13 shows the change in paper saturation (CIE*C) of the manuscripts for different treatments of selected similar fields in the advanced paper oxidation region.

From Fig. 13 there is a significant change in saturation in manuscripts 3 and 4. The smallest change in saturation is before processing and after mechanical cleaning, and the biggest is before processing and after deacidification.

Study of the change in color tone (CIE* h) at different stages of conservation treatment of selected similar fields from Arabic manuscripts.

Fig. 14 shows the change in color tone (CIE* h) in the different stages of conservation treatment of Arabic manuscripts in FIELD one, and Fig. 15 for FIELD two.

It can be seen from Fig. 14 and Fig. 15 that there is no significant change in the color tone in the light area of the paper and the water stain areas.

Fig. 16 shows the change in color tone (CIE* h) at different stages of conservation treatment of Arabic manuscripts in FIELD three. It could be seen that there is a significant change in color tone in manuscripts 3 and 4. The change in saturation is smallest before treatment and after mechanical cleaning, and biggest before treatment and after deacidification.

From examining the color difference (ΔE*ab and ΔE_{2000}) between different treatments of selected fields from the manuscripts, it was found:

- The change in ΔE*ab1 (before treatment and after mechanical cleaning) for FIELD 1 (lightest selected area of the manuscripts) was between 0.72 and 1.75, and ΔE_{2000} -1 (before treatment and after mechanical cleaning) was between 0.45 and 1.19 depending on the manuscript.

- The change in ΔE*ab2 (after mechanical cleaning

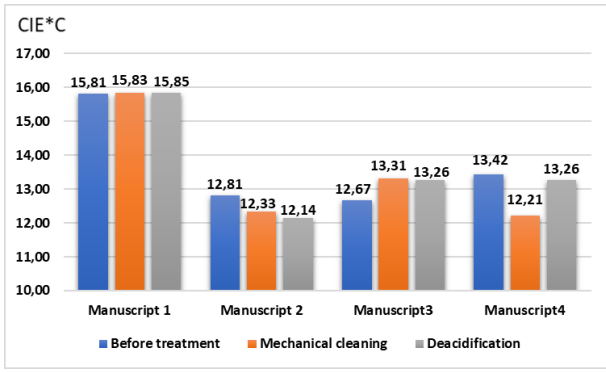

Fig. 11. Investigation of the change in saturation (CIE*C) of the documents under different treatments of selected similar fields (1 - lightest area) of the four manuscripts.

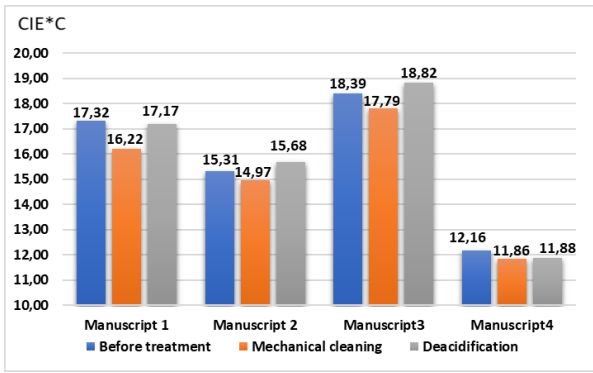

Fig. 12. Investigation of the change in saturation (CIE*C) of the documents under different treatments of selected similar fields (2 - water stain) of the four manuscripts.

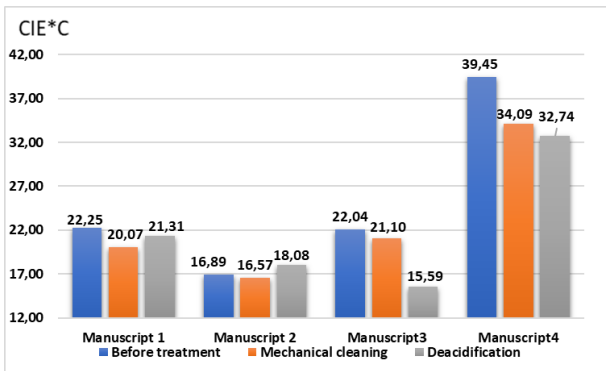

Fig. 13. Study of the change in saturation (CIE*C) of the documents under different treatments of selected similar fields (3 - area with advanced oxidation) of the four manuscripts.

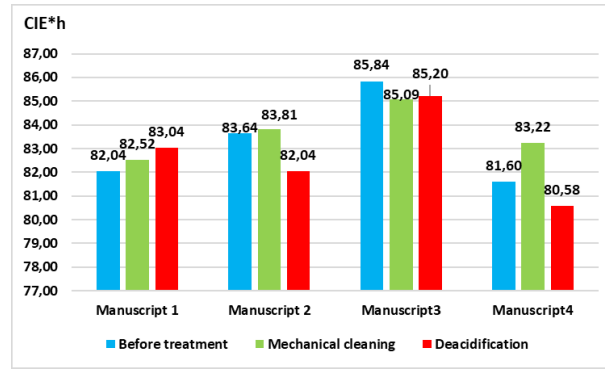

Fig. 14. Change in color tone (CIE* h) before treatment (h1), after mechanical cleaning (h2) and after deacidification (h3) of selected similar fields (1 lightest area) from Arabic manuscripts.

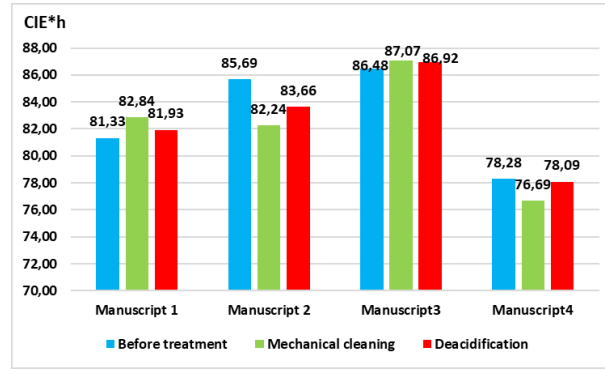

Fig. 15. Change in color tone (CIE* h) before treatment (h1), after mechanical cleaning (h2) and after deacidification (h3) of selected similar fields (2 - water stain) from Arabic manuscripts.

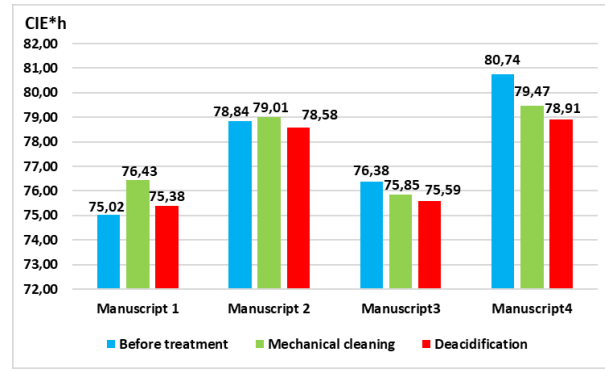

Fig. 16. Change in color tone (CIE* h) before treatment (h1), after mechanical cleaning (h2) and after deacidification (h3) of selected similar fields (3 - area with advanced oxidation) from Arabic manuscripts.

and after deacidification) for FIELD 1 is between 0.48 and 2.2, ΔE_{2000} -2 (after mechanical cleaning and after deacidification) is between 0.46 and 1.63 depending on the manuscript.

- The change in ΔE*ab3 (before treatment and after deacidification) for FIELD 1 is between 0.45 and 5.65, and ΔE_{2000} -3 is between 0.28 and 2.44, and ΔE_{2000} -3 (before treatment and after deacidification) is between 0.45 and 1.19 depending on the manuscript.

- The change in ΔE*ab1 (before treatment and after mechanical cleaning) for FIELD 2 (water stain) is between 0.15 and 1.83, and ΔE_{2000} -1(before treatment and after mechanical cleaning) is between 0.18 and 1.34 depending on the manuscript.

- The change in ΔE*ab2(after mechanical cleaning and after deacidification) for FIELD 2 is between 0.93 and 2.46, and ΔE_{2000} -2 (after mechanical cleaning and after deacidification) is between 0.66 and 1.58 depending on the manuscript.

- The change in ΔE*ab3 for FIELD 2 is between 1.47 and 5.74, and ΔE_{2000}-3 is between 0.28 and 3.23 depending on the manuscript.

- The change in ΔE*ab1 (before treatment and after mechanical cleaning) for FIELD 3 (advanced oxidation) is between 0.34 and 0.88, and ΔE_{2000} -1 (before treatment and after mechanical cleaning) is between 0.33 and 0.63 depending on the manuscript.

- The change in ΔE*ab2 (after mechanical cleaning and after deacidification) for FIELD 3 is between 0.53 and 0.89, and ΔE_{2000} -2 (after mechanical cleaning and after deacidification) is between 0.33 and 0.75 depending on the manuscript.

- The change in ΔE*ab3 (before treatment and after deacidification) for FIELD 3 is between 1.04 and 7.11, and ΔE_{2000} -3 (before treatment and after deacidification) is between 0.57 and 3.70 depending on the manuscript.

CONCLUSIONS

From the study conducted on the chromatic characteristics, it was found that the conservation treatment has a serious impact on the areas with advanced oxidation. The lightest area and the areas with water stains, which are not affected to a high degree by ageing of the paper, are practically unchanged.

As the degree of oxidation and contamination on the manuscripts increases - the value of the color difference, before and after deacidification and treatment increases significantly. In the areas where the manuscript paper is white and not affected by ageing processes, the color difference before and after deacidification and treatment is within the range of the unnoticeable (ΔE< 0.5 - 0.7). The processes of mechanical cleaning and deacidification were found to affect the color difference, mostly by changing the chromatic characteristic of CIE C* - Chroma, and less impact of CIE L*Lightness. The saturation is not affected by the processing.

Changes in colorimetric characteristics - lightness (CIE* L), saturation (CIE* C), color tone (CIE* H) in the conservation treatment have the biggest change between in values before treatment and after deacidification, reaching the highest values in FIELD 3 in all four manuscripts.

The change in the color difference ΔE*ab and ΔE_{2000} before and after mechanical cleaning for FIELD 1 the lightest and FIELD 2 the water stains, is slightly distinguishable.

The mean value of the color difference ΔE*ab before treatment and after mechanical cleaning is 2.62 for FIELD 3 - slightly distinguishable.

The mean value of the color difference ΔE_{2000} before treatment and after mechanical cleaning is 1.30 in FIELD 3.

In three of the four manuscripts, the color difference is not significantly affected by mechanical cleaning, while in manuscript four a large, highly distinguishable color difference is obtained with ΔE*ab at FIELD 3 being 5.65, which is due to surface contamination.

The change in color difference ΔE*ab and ΔE_{2000} before processing and after deacidification for FIELD 1 lightest 0.65 and FIELD 2 -water stains 0.75, is slightly distinguishable.

The average value of the color difference ΔE*ab before treatment and after deacidification is 4.14 for FIELD 3 -strongly noticeable.

The average value of the color difference ΔE_{2000} before treatment and after deacidification is 2.12 at FIELD 3-detectable.

In the light areas of the manuscripts, deacidification does not make a significant change in color difference, while in the fields with advanced oxidation there is a very large significant difference, with ΔE*ab reaching 7.11 in FIELD 3 for manuscript four.

The biggest influence on the resulting ΔE values

after deacidification comes from the change in saturation ΔC, 6.45 - 6.71, and also the lightness ΔL 1.75 makes a significant difference.

The results are extremely important from a scientific and applied point of view. They can serve as valuable information for all restoration centres worldwide. The results can provide important information on which type of treatment has what effect on the chromatic characteristics of the originals in the process of manuscript conservation.

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