JPMTR 108 | 1807
DOI 10.14622/JPMTR-1807
UDC 004.91-028.25:676.22

Research paper
Received: 2018-03-05
Accepted: 2018-04-10

Use of Ecofont software in digital printing on permanent papers

Veronika Štampfl and Diana Gregor-Svetec

Faculty of Natural Sciences and Engineering,
Snežniška 5, 1000 Ljubljana, Slovenia

veronika.stampfl@ntf.uni-lj.si
diana.gregor@ntf.uni-lj.si

Abstract

The durability of paper and permanence of printed text is important for publications and documents in libraries and archives, among them for long-lasting correspondence, that is mostly produced by using digital printing techniques. Nowadays, a very important issue is sustainability, that requires a sustainable graphic design of printed documents. The use of Ecofont software enables printing text documents with up to 50 % less use of printing ink. The purpose of the presented research was to establish the permanence of text, which was printed on permanent paper in two different font types (Times New Roman and Arial) and four sizes, from 8 pt to 14 pt. Two printing techniques were used for each font type, inkjet, and electrophotography, along with the Ecofont software. The research has shown that the use of the Ecofont software is appropriate for printing documents with the requirement for longer stability period, but the choice of printing technique, material and type combination is important and must be taken into consideration. In our research, the best combination was font Arial in size 12 pt printed with Ecofont software using inkjet technique. Generally, the combination of Ecofont software and electrophotography resulted in lower durability than Ecofont software-processed text printed with inkjet technique.

Keywords: legibility, text permanence, sustainability, accelerated ageing

1. Introduction

The permanence of printed documents and publications is mostly needed in archiving important documents. It is of great significance for publications and documents in libraries and archives. For this purpose, standards ISO 9706, ISO 11108, and ANSI/NISO Z39.48 have been published, which state the required properties of a printed substrate, i.e. paper (International Organization for Standardization, 1994; 1996; National Information Standards Organization, 1992). These properties enable longer permanence of printed documents in a controlled environment (Adcock, 1998).

Besides durability of substrates, the stability and permanence of printed text and images are important for long-lasting publications and documents. The overall durability of prints is a function of the ink, substrate and any printing, pre- or post-printing processing steps, which need to be optimized for the conditions that the print is expected to endure (Bugner and Gordon, 2012). With the growth of the quantity of digital prints in libraries, museums and archives, complete assessment of image and text permanence, including heat and light stability, fastness to humidity and atmospheric pollutants is very important (LaBarca, 2014). The influence of temperature, humidity, and light on typographic and colorimetric properties of inkjet prints in order to establish an appropriate typeface style for business correspondence was studied by Rat, et al. (2011) and Možina, et al. (2010). In the study of Venosa, Burge and Nishimura (2011), lightfastness of various digital prints (inkjet, electrophotography, dye sublimation, digital presses with liquid and dry toner) was examined. It was shown that prints undergo colorant fade, but in general digital prints were less sensitive to light than traditional prints, with some exceptions.

Digital prints are known to yellow as a consequence of different deterioration processes (Nishimura, et al., 2013). They are sensitive to oxidation of the colorants and image fading as well, though in general, digital prints tend to be less reactive with various enclosure types than traditional prints (Burge and Rima, 2010). Determination of the print permanence of digital prints to a variety of environmental conditions showed

that the electrophotographic prints were generally more resistant than offset prints (Burge, Farnand and Frey, 2012). Color stability of prints depends on the type of accelerated ageing, printing technique, a composition of ink and paper characteristics (Grilj, Muck and Gregor-Svetec, 2012).

Digital printing is considered as more environmentally friendly printing technique compared to the traditional printing techniques, such as offset printing (Viluksela, Kariniemi and Nors, 2010). Nowadays, the concept of sustainable printing will have an important influence on the future of print design. One of the key factors of environmentally responsible graphic design is designing a product that uses less material and energy. Aside of carefully selecting the inks depending on their levels of harmful substances, minimizing the ink coverage and with it, the quantity of ink needed for printing is an important part of the sustainable graphic design (Romano, 2014). Some studies have shown that changing the typeface can reduce ink consumption considerably. Bigelow, et al. (2011) claimed that changing the default font for office applications and printing from e-mail could reduce ink consumption by 30 %. Use of Century Gothic font instead of Arial can save about 1.5 % ink consumption. On the other hand, thicker and larger fonts, such as Book Antiqua, increase also the consumption of paper, because they require more leading to increase legibility (Carver and Guidry, 2011).

By using Ecofont, ink consumption is reduced by placing holes or striations in a given font (Bigelow, et al., 2011). Ecofont software enables up to 50 % lower level of used printing ink, while it reforms the text letters so they contain some voids (Ecofont, 2013). With this way of printing, the printed surface is smaller, which enhances the level of recyclability but keeps the legibility of the text good enough for a reader not to see the difference.

The goal of the present research was to evaluate the permanence of printed text processed with Ecofont software and printed on paper marked as permanent paper. We wanted to determine if the use of Ecofont software is appropriate for correspondence, such as business correspondence, where information permanence needs to be ensured for a longer time. This is achieved with dry heat ageing method since this type of documents is mostly stored in stacks and in closets, which eliminates the effect of light. Since this is our first research on this topic, it is not designed to be broad, but merely give insight in the behavior of printed text in some circumstances. Effect of humidity is planned to be observed in another research.

2. Materials and methods

2.1 Paper properties

In the research, uncoated paper Fedrigoni Arcoset declared as permanent paper, was used. Before printing, some physical properties of the material were determined. Among basic physical properties, basis weight, thickness, density and moisture content of paper were measured. The method of cold water extract was used for evaluating pH value of paper. The mechanical properties of paper were evaluated by determining folding resistance, bursting strength, tensile strength, strain at break, elastic modulus and bending stiffness. Bending stiffness was determined with cantilever bending, where bending of the sample originates from the weight of the sample itself. Elastic modulus was calculated from the measured propagation of sonic waves in material and paper density. The ISO brightness was determined with the spectrophotometer, surface roughness by a surface roughness tester TR-200. Results of measured characteristics presented in Table 1 have con-

Table 1: Paper properties

Paper characteristic	Method	Average value	Standard deviation
Grammage	ISO 536	129.26 g/m^2	0.10 g/m^2
Thickness	ISO 534	0.17 mm	0.002 mm
Density	ISO 534	762.23 kg/m^3	11.47 kg/m^3
Moisture content	ISO 287	3.60 %	0.90 %
pH	ISO 65881	8.3	0
ISO brightness	ISO 2470	95.50 %	0.29 %
Roughness – R_a	ISO 4287	3.44 µm	0.34 µm
Folding endurance	ISO 5626	258 in MD; 136 in CD	60.7 in MD; 63.1 in CD
Bursting strength	ISO 2758	297 kPa	11.6 kPa
Tensile strength	ISO 1924-2	114 N in MD; 60 N in CD	1.4 N in MD; 0.8 N in CD
Strain at break	ISO 1924-2	1.90 % in MD; 4.00 % in CD	0.10 % in MD; 0.13 % in CD
Elastic modulus	Sonic velocity	4.14 GPa in MD; 2.26 GPa in CD	0.108 GPa in MD; 0 GPa in CD
Bending stiffness	Clark method	1.71 Nmm in MD; 0.92 Nmm in CD	0.05 Nmm in MD; 0.02 Nmm in CD

(MD – machine direction; CD – cross direction)

firmed good mechanical properties of paper which are in accordance with the requirements for durability of paper and its long-lasting performance.

2.2 Test form

The first test form was created using programs Microsoft Office Word 2010 and Adobe Illustrator CC. It contains test patterns and text written using fonts Times New Roman and Arial in size of 8 points (pt), 10 pt, 12 pt and 14 pt. Different font sizes were chosen regarding the frequency of their use in various printed text documents, while two fonts were chosen due to their differences in design. With font Times New Roman the permanence of serifs and unevenly thick strokes are tested after the exposure to accelerated ageing, while with font Arial the permanence of sans serif fonts is observed. Differences between the digital form of letter 'a', that is computer generated in its printed versions, are also taken into consideration.

The second test form was designed in the same way as the first one, but with applying the Ecofont software. With this step the text is modified as shown in Figure 1. Both test forms were placed in one document and positioned so they fit on one A4 page. The test form used for printing is shown in Figure 2.

2.3 Printers

Three digital printing techniques were used. First, inkjet technology, since it is widely spread in office environment where printed documents should also have permanence over a longer time (Le, 1998). Second,

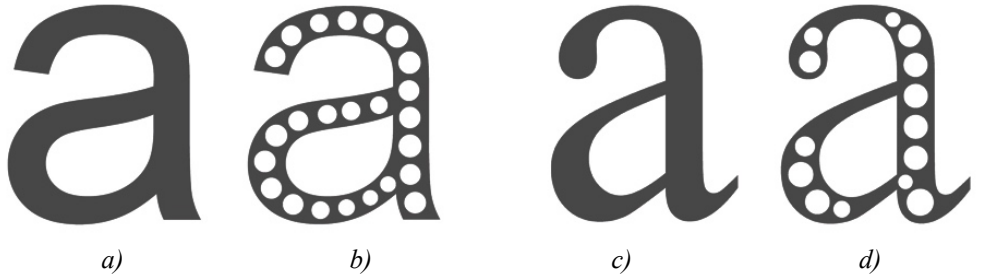


Figure 1: Digital form of letter 'a': (a) Arial, (b) Ecofont software-processed Arial, (c) Times New Roman, (d) Ecofont software-processed Times New Roman

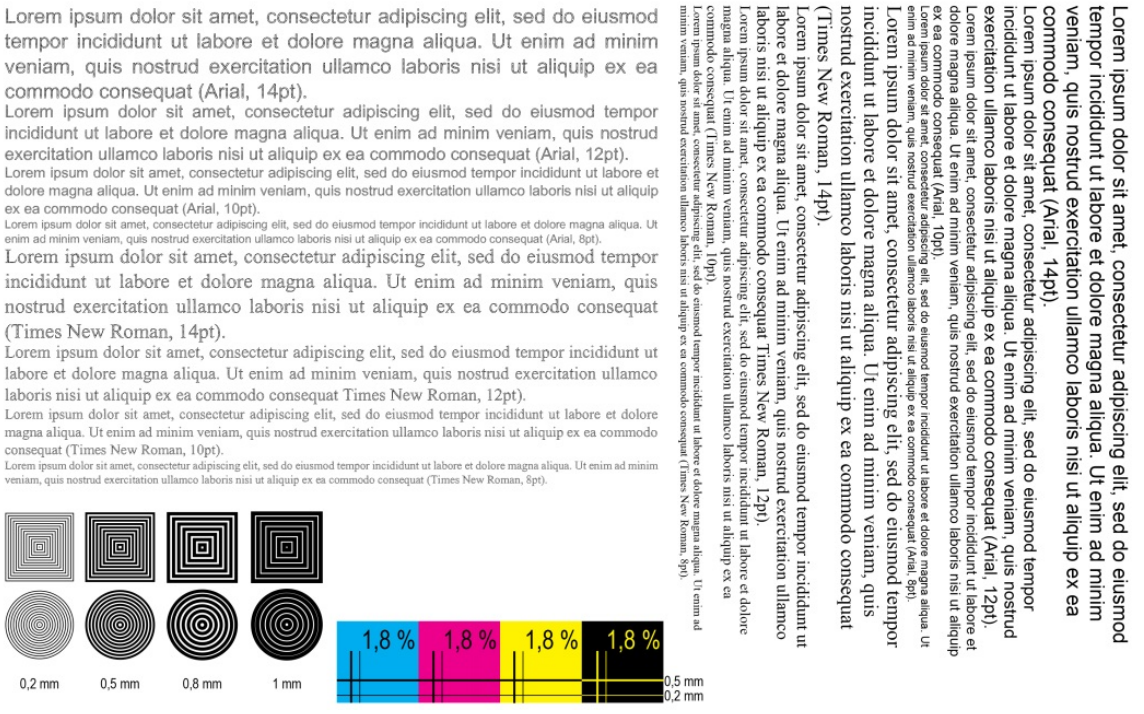


Figure 2: Test form, with test patterns and Ecofont software-processed Arial and Times New Roman on the left side, and text with respective conventional fonts on the right side

LED-UV inkjet printing technique, while it gives longer permanence to printed images and text (Majnarić, Bolanča Mirković and Golubović, 2012). It is used in order to make a comparison among printing techniques regarding stability of prints. Third, electrophotography is used, which is commonly used in offices and is known for its' precision, which is much higher than with inkjet technologies (Majnarić, 2015).

For inkjet printing, a multifunction device Brother MFC J5320SW0020 (abbreviated as IJ) was used as a representative of inkjet print-on-demand technology. Second used printer (LED-UV curing system) was Roland LEC300 (abbreviated as IJECO). The third, electrophotographic printer was Canon C1+ (abbreviated as EF). All selected printers used resolution of 300 dpi for printing test forms.

2.4 Evaluation of prints – ink surface coverage

Three prints made with each of the three printers were evaluated. To digitalize printed text at high enlargements, a microscope Nikon SMZ800 equipped with a camera Nikon D700 was used. The same camera settings were applied for taking pictures of the letter 'a' in all possible combinations; printing technology, font type, type size, with and without the use of the Ecofont software. Photographs were cropped to the size of 1800 px × 3000 px and transformed to binary pictures using ImageJ software. With the same software, the coverage of the paper surface with printing ink was determined (ImageJ, 2015).

Prints were aged using dry heat treatment at 105 °C and exposed to this temperature for 72 hours according to the standard ISO 56301 (International Organization for Standardization, 1991). After the ageing process, measurements of ink coverage were performed again.

2.5 Evaluation of prints – legibility

Printed test forms after dry heat ageing were optically scanned using a multifunction device Brother MFC J5320SW0020 with the resolution of 600 dpi and saved in PDF files. This provided images with a number of details to clearly recognize various transformations of text. By using Adobe Photoshop CC the scans were cropped and individually saved as images in TIFF format in original resolution. Paragraphs were separated by the font type and font size, e.g. Arial 14 pt. Then they were matched with the corresponding Ecofont software-processed version from the same test form. Both paragraphs combined formed new image used for legibility analysis. This lead to 48 different images used to test legibility: four for Arial (8, 10, 12, and 14 pt) and four for Times New Roman (8, 10, 12, and 14 pt), each combination repeated two times due to two printing technologies and another three times due to three prints of test forms.

Images for assessing legibility were shown to 42 observers on screen. The observers were asked not to read the text in the images, but merely observe the shape of the text whether they find it pleasing. According to that and the capability to see the difference among version of the text which was or was not processed with Ecofont software, the observers marked the image with one of the following three marks:

- 2: second paragraph (Ecofont software-processed) is visually more pleasing,
- 1: there is no difference between the paragraphs,
- 0: first paragraph (original font) is more visually pleasing.

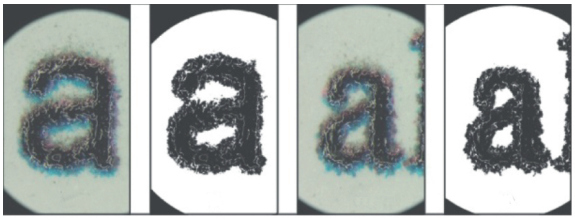
The numbers 0, 1 and 2 were then used for calculating *PC*-index according to Equation [1], where n is the number of observers, m is the number of samples and v_i is the value with which the observer marked the test form (0, 1 or 2). The *PC*-index values vary from 0 to 200, where 200 represents perceiving the Ecofont software-processed text as a good quality text, while 0 corresponds to poor text quality.

$$PC\text{-index} = \frac{\sum_{i=1}^{n} v_i}{2 \cdot n \cdot (m-1)} \cdot 200 \qquad [1]$$

Since the images were formed using text paragraphs in Latin (Lorem ipsum) and the analysis was performed on observers who have no knowledge of this language, it can be stated that the meaning of the text does not influence the readers' perception of the shapes to the extent which would affect legibility itself. This kind of legibility testing method has been proven effective in the research made by Milošević, et al. (2016), therefore it was found applicable in this case.

3. Results and discussion

When printing with the printer IJECO, difficulties occurred. As shown in Figure 3, where photographs of letter 'a' and their binary versions of prints made with IJECO are presented, there was a problem with the presence and registration of a cyan layer (Figures 3a and 3c), which resulted in a higher coverage of surface after binarization compared to other samples. Another problem was a high gloss of the print, which resulted in some reflections of the surface, seen as white marks in the letter (Figures 3b and 3d). This could be corrected with retouching but again this would lead to mistakes, especially when evaluating the ink coverage at Ecofont software-processed text. For these reasons, prints made with the printer IJECO were eliminated from further evaluation.



a) b) c) d)

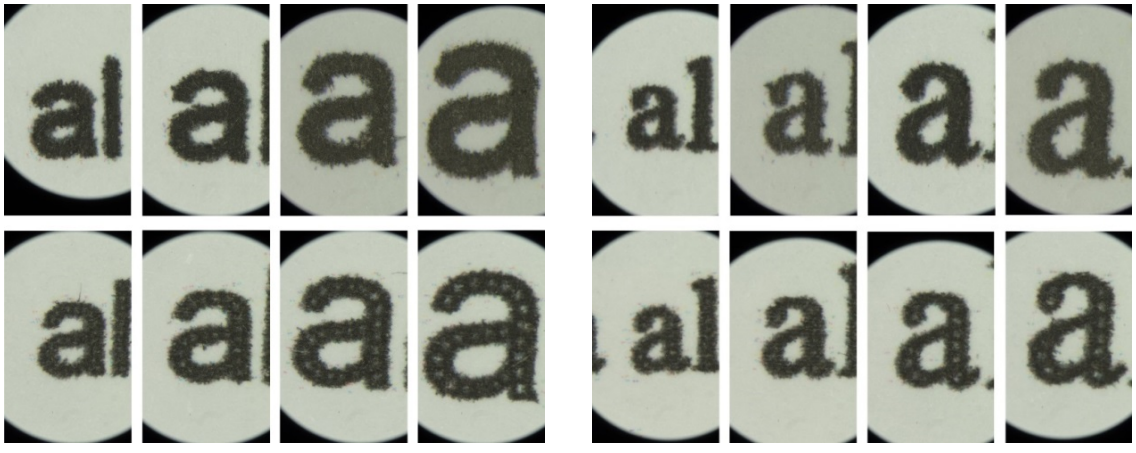
Figure 3: Photographs and binary pictures of letter 'a' printed with the printer IJECO: (a) and (b) Arial, (c) and (d) Times New Roman; all in 12 pt size

In Figures 4 and 5, photographs of the letter 'a' printed with the printers IJ and EF in all four sizes of fonts Arial and Times New Roman printed with and without using Ecofont software are presented. The difference between used printing techniques is obvious.

3.1 Surface coverage with ink

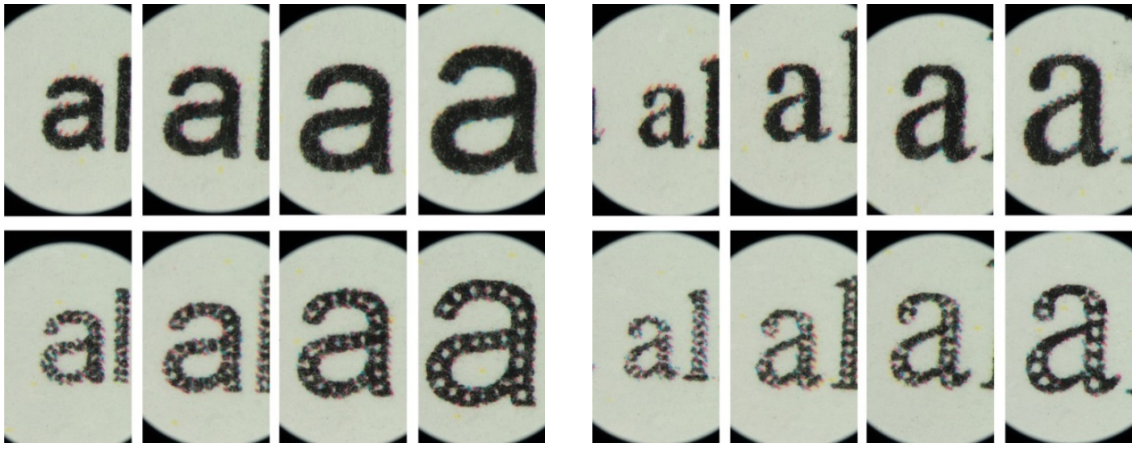
In Table 2, ink saving values when using Ecofont software are presented. Computer modulated letters 'a' in various sizes and their Ecofont software-processed versions were used for these calculations. Obtained results correspond to the previously stated (Ecofont, 2013) ink saving value, up to 50 %. Savings vary depending on the font and font size. Arial has higher ink saving value than Times New Roman in general.

Differences within one font indicate that not only one form of a letter is generated by the Ecofont software, but they are generated according to font size, since one ink saving value does not repeat in any other font and font size combination. In Figure 6, the differences between the surface coverage of digital shape of letter 'a' and of the printed letter 'a' using printers IJ and EF



a) b)

Figure 4: Photographs of letter 'a' in all four sizes printed with IJ: (a) Arial, (b) Times New Roman; first row: unprocessed text, second row: Ecofont software-processed text



a) b)

Figure 5: Photographs of letter 'a' in all four sizes printed with EF: (a) Arial, (b) Times New Roman; first row: unprocessed text, second row: Ecofont software-processed text

Table 2: Ink saving when printing with Ecofont software for two fonts and four font sizes

Font	Font size	Ink saving [%]
Arial	8 pt	51.97
	10 pt	49.86
	12 pt	51.07
	14 pt	51.22
Times New Roman	8 pt	42.78
	10 pt	42.37
	12 pt	40.85
	14 pt	40.41

of different fonts and font sizes are presented. All values are positive, which indicates spreading of ink at printing for both printing techniques. The gain at prints made with the printer EF and font Arial was higher than the gain with font Times New Roman for all font sizes. This is a consequence of typographic features of used fonts, while Arial has thicker and more even strokes, which results in bigger amounts of applied ink and furthermore in higher wicking. With bigger font size, the difference in coverage is also increasing. The gain in comparison to the digital form of the letter is much higher when using Ecofont software. The differences are more obvious in Arial font, where the difference is

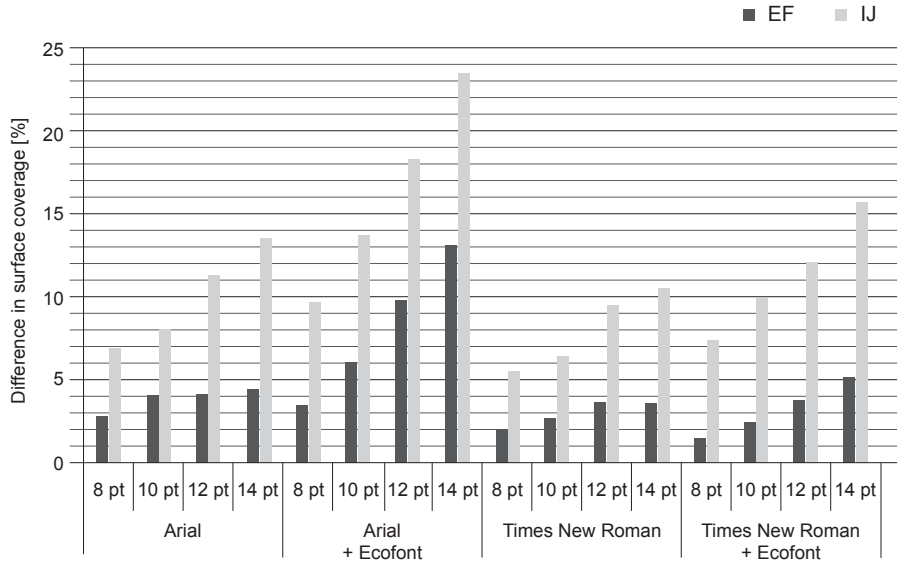


Figure 6: Differences in surface coverage between digital form of letter 'a' and printed letter 'a' in prints made with the printer IJ and EF

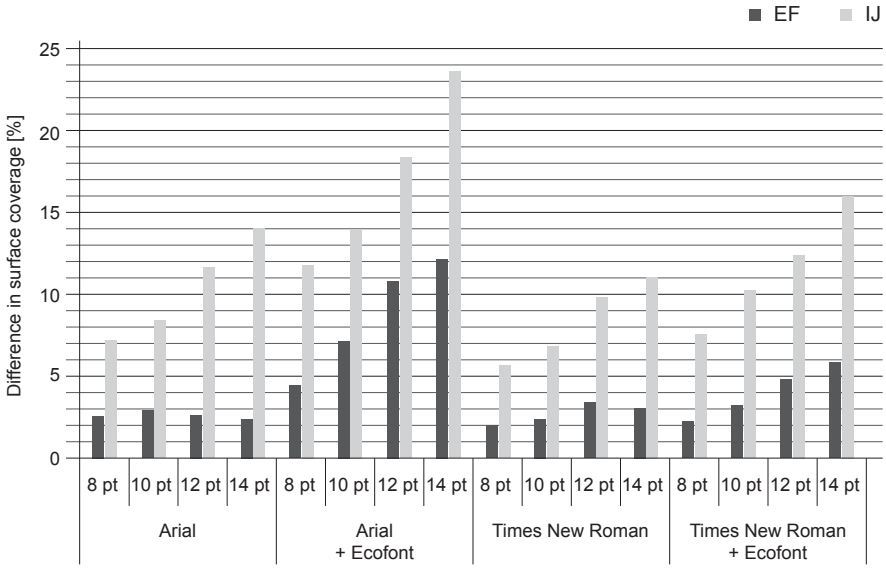


Figure 7: Differences in surface coverage between digital form of letter 'a' and printed letter 'a' in prints made with the printer IJ and EF after ageing

14 % at size of 14 pt. When comparing font Times New Roman, the differences between Ecofont software-processed and conventional fonts, are minimal, which suggests the higher quality of EF print. The measurements have confirmed the expected result, that the gain at surface coverage with ink is much higher when using inkjet technology in comparison to electrophotography. Consequently, the differences between prints with and without the use of Ecofont software are much higher.

3.2 Surface coverage with ink after accelerated ageing of prints

The surface coverage of the digital shape of letter 'a' and surface coverage of printed letter 'a' using IJ and EF printers after accelerated ageing with dry heat was determined. The differences between the digital and aged printed letter 'a' obtained for different fonts and font sizes are presented in Figure 7. All obtained values are positive, which means that dry heat treatment did not damage the prints to the level where the ink would cover less surface than it has been originally printed. The difference between surface coverage of the computer generated letter and the printed letter is in general increased with bigger letter size. Derogation of this trend is only seen at prints made with the electrophotography for font Arial.

3.3 Comparison of surface coverage before and after accelerated ageing of prints

When comparing the differences of surface coverages with ink on the prints and the original surface coverage of computer-generated letter 'a' for prints before and after exposing them to the accelerated ageing with a dry heat (Figure 8), some values were negative. Font size affects the permanence of letter 'a' differently. The measurements show that with the use of the printer IJ and font Arial there is no significant change in the surface coverage before and after ageing of the prints, regardless of the font size. The same trend was obtained at prints printed with the printer IJ and font Times New Roman for both, conventional and Ecofont software-processed text. When using Ecofont software with font Arial, big differences are seen. With smaller letter size the applied ink is spreading much more, which results in closing the empty spaces generated with Ecofont software. In addition to that, strokes of letters start to merge, which leads to illegibility.

When using Ecofont software on EF prints, the font size does not have different effects on the permanence of prints. The deviation from the trend can only be seen with combination Arial + Ecofont software + 14 pt, which can be marked as a feature of prints, since it is observed with all three printed test forms for this type combination and we cannot find an explanation that would be consistent with the effects of accelerated ageing method. Otherwise, the results are consistent in their category. With ageing, prints with normal type are damaged more than the ones where Ecofont software is used. Negative values mean that the surface, which is covered with printing ink, has shrunk after accelerated ageing. However, these negative values do not indicate damage to the surface coverage to the extent, which would result in disappearing text. This is already stated in sections 3.1 and 3.2 since the difference in surface coverage on all prints is positive.

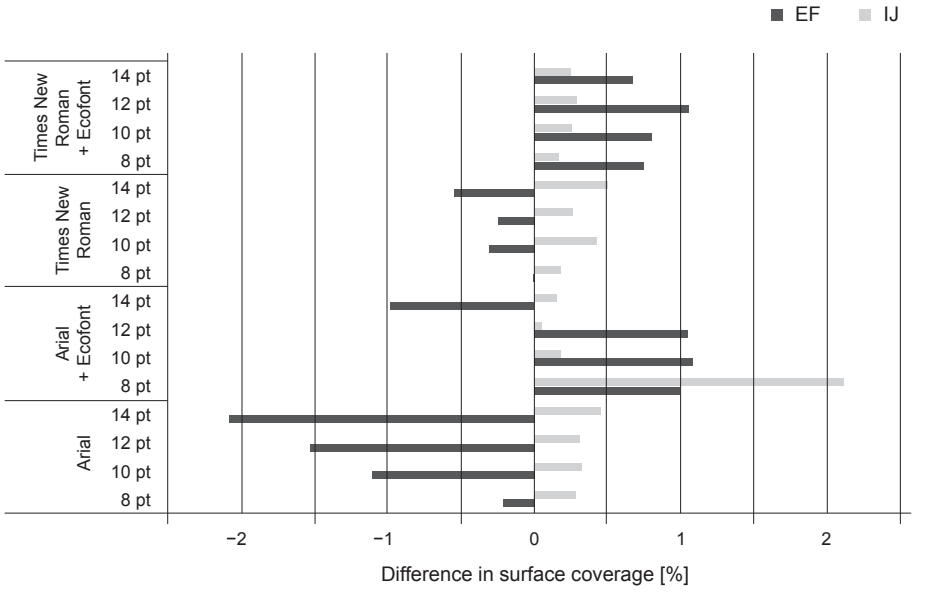


Figure 8: Differences in surface coverage of digital form of letter 'a' and printed letter 'a' between prints made with the printers IJ and EF before and after ageing

The reason for negative values (Figure 8) is the lower stability of ink (dry toner) used at EF printing, which is affected differently by temperature than IJ printing ink. At IJ printed samples the covered surface is expanding with ageing, or in other words, the ink continues to spread via fibres and forms even higher degree of 'wicking'. With EF, the toner is 'peeled' off the surface, resulting in smaller surface coverage.

Although all of these values vary from –2 % to 2 % in surface coverage difference, which is not obvious on the first sight, it is interesting to observe, that the most damaged prints are the ones without the use of Ecofont software in case of EF. This means that normal type is less stable than the Ecofont software-processed type. It can be assumed that the cohesive forces of the applied toner are stronger than the adhesion forces between the toner and substrate. With ageing this can lead to 'peeling' of larger clusters from the surface of the paper. Since the amount of toner applied with normal type is bigger than with Ecofont software-processed type it can be concluded that the clusters are in this case bigger. This would result in quicker degrading of printed text.

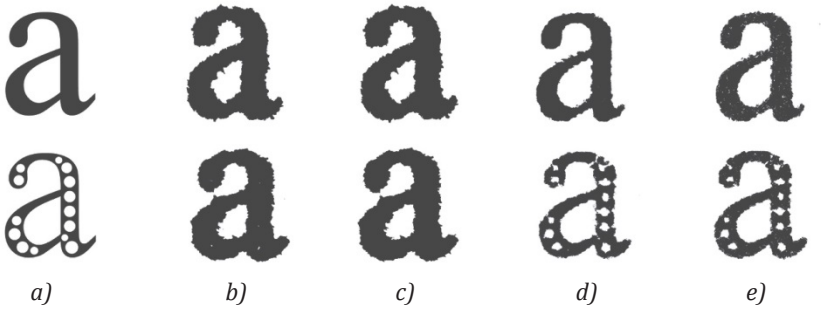
In Figures 9 and 10, binary versions of the letter 'a' are presented in fonts Arial and Times New Roman printed with IJ and EF. Computer modulated version of the letter is also shown. With visual control of letter 'a' shown in Figures 9 and 10, we can see how ageing method affects the prints. Comparing samples of the same fonts and the same font size before and after ageing give us a general impression of the changes occurred while ageing the prints.

The comparison clearly shows that with ageing of IJ prints (Figures 9 and 10, samples (b) and (c)) the surface coverage is bigger than before ageing. This is especially visible when comparing the Ecofont software-processed versions of the letters (Arial and Times New Roman), where all generated gaps inside the letters have been completely closed. Wicking of the border is changed to a higher value. The difference is not in the size of the wicks but in their frequency.

Quite the contrary can be observed with the EF prints. Comparing letters before and after ageing (Figures 9 and 10, samples (d) and (e)) shows how the surface coverage is decreasing. With the conventional use of fonts the coverage decrease can be seen spread evenly in random patches throughout the letter surface and with higher enlargements, it is obviously seen that the wicking is significantly enlarged. With the printed letters using Ecofont software, there are multiple changes. The surface coverage is generally decreased in the same way as with the conventional use of the fonts, as well as the wicking of the outer border is higher after ageing.

a) *b)* *c)* *d)* *e)*

Figure 9: First row: Arial, second row: Ecofont software-processed Arial; (a) computer modulated, (b) IJ printed, (c) IJ printed after ageing, (d) EF printed and (e) EF printed after ageing



a) *b)* *c)* *d)* *e)*

Figure 10: First row: Times New Roman, second row: Ecofont software-processed Times New Roman; (a) computer modulated, (b) IJ printed, (c) IJ printed after ageing, (d) EF printed and (e) EF printed after ageing

An interesting occurrence is seen with the generated gaps inside letters. Since it would have been expected for the gaps to widen and their wicking to enlarge, due to the ink coverage decrease in these cases, the opposite is observed. Generated gaps are more closed after ageing, while the wicking is hard to observe and determine the difference. This shows an interesting migration of EF toner while ageing with the selected method and its influence on the letter shapes.

In the previous observations, it has been described how the surface coverage of EF prints is also reduced in some cases. With this visual analysis, it can be seen that former negative quantitative results do not necessarily mean shrinking of the covered area in width and height, but it can be interpreted as decreasing the thickness level of the applied toner. When comparing (d) and (e) examples of Figures 9 and 10 it can be clearly seen that new blank surfaces are generated where the surface used to be covered before ageing. This can be observed with IJ and EF made prints. Still, these changes are not that significant and do not result in poor legibility.

3.4 Evaluation of legibility

Legibility tests were only performed using prints after accelerated ageing as test forms (presented as images on the screen), as has been stated in section 2.5. The legibility tests on aged prints give good results and correspond to previous quantitative findings. In Table 3, average values of answers from 42 observers are shown. The primary aim of collecting answers from observers with this kind of grading was to determine *PC*-index. If we followed the Equation [1] as it is, the result would be one value, which would describe how 42 observers perceive 48 different test forms, i.e. 96 texts. This description is too broad, therefore the original equation had to be altered. For each test form, the obtained answer values were summarized into one value, which became the numerator of the equation. In denominator *n* and *m* values had to be replaced with each other, since the 42 answers (from 42 observers) are in this case samples. If this would not be done, the denominator would result in zero-value and the equation could not be resolved with non-imaginary numbers. This modification is presented, for 42 observers, with Equation [2], where non-variables are inserted and v_i stands for the obtained answer (value 0, 1 or 2). In Table 3 average values of *PC*-indexes calculated for each legibility test form are presented.

$$PC\text{-index} = \frac{\sum_{i=1}^{42} v_i}{2 \cdot 1 \cdot (42 - 1)} \cdot 200 \qquad [2]$$

It has to be stressed that none of the average answer values is 0 or 2, which means that all observers never found one specific text better than the other. From results obtained it is obvious how the average answer values correspond with calculated *PC*-indexes. This was expected since there is no other variable taken into the account when calculating *PC*-index for a specific test form. It also confirms the accuracy of used Equation [2]. Since both comparisons give the same results, the first comparison is commented, due to an easier interpretation of results.

If v_i value 1.0 is treated as the orientation point, since answer value 1 means equally good legibility of texts, it can be seen that text with used Ecofont software has

Table 3: Average values of answers obtained in legibility test and average PC-index values for different fonts, font sizes and printing technologies for each legibility test form

Font	Printing technology	Font size	Average answer value	Average *PC*-index value
Arial	Inkjet	8 pt	1.3	132
		10 pt	1.1	109
		12 pt	1.4	143
		14 pt	1.3	133
	Electrophotography	8 pt	0.8	86
		10 pt	0.7	76
		12 pt	0.8	85
		14 pt	0.9	94
Times New Roman	Inkjet	8 pt	1.1	115
		10 pt	0.9	94
		12 pt	1.1	117
		14 pt	1.1	110
	Electrophotography	8 pt	0.4	40
		10 pt	0.5	48
		12 pt	0.3	31
		14 pt	0.6	57

better legibility than normal text when printed with IJ printer regardless of used font, although Arial has higher average answer values. Printer EF gave results with a lower value, which means that text without the use of Ecofont software has better legibility than with since answer values are below 1.0. Here the difference between used font is more obvious. It is visible that Times New Roman has much lower legibility in comparison with used Ecofont software when printed with EF.

Times New Roman printed with EF has very low legibility answer values. These low values lead us to the statement that the use of Ecofont software is not suitable for prints using this font and EF printer. Considering the results for Arial, we can furthermore conclude that Ecofont software is not suitable for EF printing technology either.

In combinations Arial IJ, Arial EF and Times New Roman IJ a trend can be seen when comparing answer values for 8 and 10 pt sizes. Legibility rating decreases when the font size is changed from 8 pt to 10 pt. This happens due to more applied ink, which results in more wicking, which does not only close the gaps in the printed letter, which would normally result in better legibility, but also the whitespace in the kerning of the words, which leads to worse legibility. Interesting to see, when enlarging the font size to 12 pt, the opposite happens. Answer values for texts in this size are higher, which means the legibility of Ecofont software-processed texts is better. Prints made with IJ have again better legibility when increasing the type size for another 2 pt, i.e. to 14 pt.

The same trend of increasing or decreasing legibility is seen in these three cases, except in combination of Arial EF size 14 pt. This type combination has already proven to be isolated from other measurements in the previous section 3.3 where the surface coverage has been questioned. In Figure 10 it can be seen how accelerated ageing drastically changed the surface coverage of prints for combination Arial, Ecofont software processing, and EF. Therefore, this can again be treated as a print feature, since this finding is completely isolated from the others and does not correspond to any of them. This leads us to a general assumption that the legibility when using Ecofont software is better using certain type sizes, in this case, 8 pt and 12 pt has been proven to be more legible than sizes 10 pt and 14 pt.

In general, it can be seen from Table 2 that the best legibility score and consequently the best case to use Ecofont software is in Arial font and IJ printing technology. In this case, sizes 8 pt, 10 pt, 12 pt and 14 pt are suitable, with size 12 pt being the most visually pleasing.

4. Conclusion

The results of the research have shown that digitally printed text on permanent paper could be used for long-lasting correspondence, where information permanence needs to be ensured for a longer time. The highest ink coverage was obtained for IJ prints and font Arial. Results gained in legibility tests also state that combination of IJ, font Arial, Ecofont software processing, and font size 12 pt is the most visually pleasing when comparing it to other tested combinations. Because of higher precision of EF, the use of Ecofont software resulted in higher ink reduction at EF prints compared to IJ prints. The dry toner used in EF printing was seen to be less stable after accelerated ageing at dry heat, while prints made with IJ ink either maintained surface coverage or it has been even enlarged. The combination of Ecofont software and EF printing results in lower durability than Ecofont software-processed text printed with IJ.

Ecofont software is suitable for printing documents with demanded longer stability and permanence, but with its use, it is important to take into the account other factors, such as printing technique, font type, and font size.

Acknowledgments

This work was supported by the Slovenian Research Agency (Programme P2-0213).

References

Adcock, E.P. ed., 1998. *Principles for the care and handling of library materials.* [pdf] Paris: IFLA PAC. Available at: <https://www.ifla.org/files/assets/pac/ipi/ipi1-en.pdf> [Accessed February 2018].

Bigelow, C., Dowd-Hinkle, D.J., Horowitz, D. and Voorhees, G., 2011. *Sustainable by design: an investigation into ecologically friendly typography.* Rochester: Printing Industry Center at RIT. Available through: RIT Scholar Works website <http://scholarworks.rit.edu/books> [Accessed February 2018].

Bugner, D.E. and Gordon, S.T., 2012. Factors to consider in the design and evaluation of commercial printing inks and substrates for permanence and durability. In: *NIP & Digital Fabrication Conference, International Conference on Digital Printing Technologies*. Quebec, CA, 9–13 September 2012. Springfield: IS&T, pp. 381–386.

Burge, D., Farnand, S. and Frey, F., 2012. Review of research at RIT comparing the print value and permanence of digital prints vs. offset lithography and silver-halide prints. In: *3rd International Symposium on Technologies for Digital Photo Fulfillment 2102.* Las Vegas, Nevada, 8–9 January 2012. Springfield: IS&T, pp. 39–43.

Burge, D. and Rima, L., 2010. Selecting suitable enclosures for digitally printed materials. *Journal of Physics*: *Conference Series*, 231(1).

Carver, J. and Guidry, N., 2011. *Rethinking Paper & Ink: The Sustainable Publishing Revolution.* Portland: Ooligan Press.

Ecofont, 2013. *Ecofont: tot 50 % besparingen in verbruik van printerinkt en -toner op miljoenen prints.* [pdf] Utrecht: Ecofont. Available at: <https://www.nokavision.com/wp-content/uploads/2014/10/ecofont_whitepaper_20-10-2013.pdf> [Accessed 2 February 2018].

Grilj, S., Muck, T. and Gregor-Svetec, D., 2012. The ageing resistance of offset and electrographic prints. *Nordic Pulp & Paper Research Journal*, 27(4), pp. 739–749.

ImageJ, 2015. *ImageJ.* [online] Available at: <http://rsb.info.nih.gov/ij/> [Accessed 2 February 2018].

International Organization for Standardization, 1991. *ISO 5630-1:1991 Paper and board – Accelerated ageing – Part 1: Dry heat treatment at 105 degrees C.* Geneva: ISO.

International Organization for Standardization, 1994. *ISO 9706:1994 Information and documentation – Paper for documents – Requirements for permanence.* Geneva: ISO.

International Organization for Standardization, 1996. *ISO 11108:1996 Information and documentation – Archival paper – Requirements for permanence and durability.* Geneva: ISO.

Le, H.P., 1998. Progress and trends in ink-jet printing technology. *Journal of Imaging Science and Technology*, 42(1), pp. 49–62.

LaBarca, J.E., 2014. New and coming ISO image permanence and durability standards and how they promote the photo fulfillment industry. In: *5th International Symposium on Technologies for Digital Photo Fulfillment*. Las Vegas, Nevada, 5–6 January 2014. Springfield: IS&T, pp. 31–34.

Majnarić, I., 2015. *Osnove digitalnog tiska.* Zagreb: Sveučilište u Zagrebu, Grafički fakultet.

Majnarić, I., Bolanča Mirković, I. and Golubović, K., 2012. Influence of UV curing varnish coating on surface properties of paper. *Tehnički vjesnik*, 19(1), pp. 51–56.

Milošević, R., Nedeljković, U., Banjanin, B., Novaković, D. and Kašiković, N., 2016. The analysis of ink jet printed eco-font efficiency. *Journal of Graphic Engineering and Design*, 7(1), pp. 13–17.

Možina, K., Medved, T., Rat, B. and Bračko, S., 2010. Influence of light on typographic and colorimetric properties of ink jet prints. *Journal of Imaging Science and Technology*, 54(6), pp. 60403-1–60403-8.

National Information Standards Organization, 1992. *ANSI/NISO Z39.48-1992 Permanence of paper for publications and documents in libraries and archives.* Baltimore: NISO.

Nishimura, D., Burge, D., Bigourdan, J.-L. and Gordeladze, N., 2013. Reanalysis of yellowing of digitally printed materials in cultural heritage collections. *The Book and Paper Group Annual*, 32, pp. 123–128.

Rat, B., Možina, K., Bračko, S. and Podlesek, A., 2011. Influence of temperature and humidity on typographic and colorimetric properties of ink jet prints. *Journal of Imaging Science and Technology*, 55(5), pp. 50607-1–50607-8.

Romano, C., 2014. *Rethinking Print Design: The Impact of Sustainability on the Future of Print.* Bachelor's thesis. Tampere University of Applied Sciences.

Venosa, A., Burge, D. and Nishimura, D., 2011. Effect of light on modern digital prints – photographs and documents. *Studies in Conservation*, 56(4), pp. 267–280.

Viluksela, P., Kariniemi, M. and Nors, M., 2010. *VTT Research Notes 2538: Environmental performance of digital printing: Literature study.* Helsinki, Finland: VTT Technical Research Centre of Finland, p. 60.