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Durability of fingerprints in aquatic environment

Summary

The aim of the study was to determine the influence of environment of stagnant and flowing water on the durability of fingerprints. The fingerprints immersed in two stagnant water reservoirs and 2 flowing water reservoirs were researched. There were two dependent variables: the contrast between fingerprints ridges and valleys and the contrast between the print and space located beyond it.

It was found that fingerprints in stagnant water reservoirs have average longer durability and there is a significant difference in durability within one type of water environment. The contrast between fingerprints ridges and valleys turned out to be the most suitable dependent variable for the research.

Keywords dactyloscopy, aging of fingerprints, durability of fingerprints, acquatic environment

Introduction

The age of fingerprint has been of increasing interest to the courts and authorities responsible for pre-trial proceedings. By commissioning forensic examination, the above authorities attempt to establish whether fingerprints developed at the crime scene could have endured particular conditions for a certain period of time. Especially troublesome are the fingerprints ageing in a specific environment – aquatic environment. Knowledge about the durability of evidence in a given type of aquatic environment would enable its age approximation and in consequence, estimation of an approximate time of committing an illegal act, for example, in the case of the fingerprints developed on arms/weapons used in committing a crime, and subsequently dropped into water. The current state of knowledge does not allow for the formulation of firm conclusions concerning the above matters. The forensic experts who, if at all, decide to issue opinion on the age of fingerprints, usually reach probabilistic, or in rare cases, negative categorical conclusions. The difficulties in fingerprints age determination are due to a high number of factors affecting thereof.

Among those factors, by far better understood are those affecting the fingerprints ageing process in terrestrial environment, as compared with aquatic environment. In the study conducted on dactyloscopic marks immersed in water, Baniuk [1] and Owczarkowski et al. [2] were able to develop fingerprints after 7 days, following the immersion. Moreover, in another study, Nozdryn-Płotnicki et al. [3] successfully developed legible fingerprints in samples immersed for 21 days.

The present study aimed at investigating the influence of a certain type of aquatic environment, i.e., stagnant water vs. flowing water, on the durability of fingerprints. The working hypothesis assumed a shorter lifespan for fingerprints in flowing water, due to continuous and dynamic water movements. A second objective of the study was to determine a maximum lifespan of fingerprints immersed in natural aquatic environment.

Materials and methods

Research plan

An independent variable in the study was aquatic environment considered on two levels: stagnant water and flowing water. Two repetitions were carried out for each type of environment. Two assessed dependent variables were the following: i) contrast between fingerprints' ridges and valleys (Contrast I); ii) contrast between the print and the background (Contrast II). The above dependent variables are not typically used as indicators of fingerprints durability and therefore, their applicability for this purpose was put to the test by the experiments described herein.

Deposition, developing and collection of fingerprints

The research material consisted of fingerprints (composed of sudoral fatty substances) deposited onto microscope glass slides by a 24-year-old male, by pressing the right thumb onto the slide at 5 minute intervals, each time after washing hands and rubbing the thumb against hair and forehead. The glass slides were vertically inserted into grooved planks of 68 x 9 x 4 cm (Fig. 1 The fingerprints deposited on microscopic slides and inserted into the grooved plank; see Polish version) affixed to the holder, which was placed in water. In the case of watercourses, i.e., flowing water reservoirs, the slides were only positioned on the side of a plank that was directly exposed to the water movement.

The specimens were immersed in two reservoirs of stagnant water: i) a pond within the site of the Adam Mickiewicz University Morasko campus in Poznan; ii) Lake Trzesiecko in Szczecinek, and in two reservoirs of flowing water: i) Radacki Canal in the municipality of Szczecinek; ii) Warta River in Poznan.

The Poznan pond experiments were commenced on 23 October, 2011. The research material consisted of 40 immersed glass slides with a total of 80 fingerprints. The planks were affixed to the holder in such a way that they were located 8–15 cm below water surface and 39–46 cm above the bottom of the reservoir. At the time of immersion, the water temperature was 6.9°C.

The Lake Trzesiecko experiments were commenced on 11 March, 2012. The 28 immersed glass slides contained a total of 56 fingerprints. The planks were positioned 19–27 cm below water surface and 41–33 cm above the bottom of the reservoir. The water temperature measured at the time of immersion was 3.1°C.

On 11 October 2011, 18 slides containing 36 fingerprints were placed in Radacki Canal waters. The planks were bundled and positioned in a way that the uppermost plank remained 23 cm below water surface, whereas the bottom-most plank was 27 cm above the bottom and 39 cm below the surface. At the time of immersion, the water temperature was 6.4°C.

The Warta River experiments were carried out in two stages, due to the necessity of supplementing the glass slides – legible fingerprints were developed on all initially prepared slides. The first stage commenced on 20 October, 2011 by immersing 21 slides with 42 fingerprints. Similarly to the Radecki Canal, the slides were inserted into the set of three bundled planks. The slides in the upper most plank were positioned 19 cm below water surface, whereas those in the bottom-most plank were at 33 cm below the surface and 23 cm above the bottom. Due to strong water movement, the holder was additionally ballasted with stones. At the time of immersion, the water temperature was 4.3°C. The second stage, involving the immersion of 12 glass slides with 24 fingerprints, commenced on 24 November 2014 at the measured water temperature of 2.5°C.

Sample fingerprints from the stagnant water and Warta River were developed at 1 day intervals. Each research sample consisted of two fingerprints in the case of Lake Trzesiecko and four fingerprints in the case of Warta River. In the case of Radecki Canal, the research samples consisted of six fingerprints developed after: 1, 3, 23, 27, 46, 50 and 70 hours after the time of immersion. In the above water reservoir, the deposition of vegetation and debris on the holder was observed that might have caused mechanical damage to four of the fingerprints developed after 1 hour and to all fingerprints developed after 3 hours. In the case of Lake Trzesiecko, for the first three days of the study, the bay in which the holder was placed was separated from the rest of the lake by a layer of ice cover.

At the time of immersion of holders into the watercourses, the water velocity values were determined by using the float method [4], in four repetitions. Based on conducted measurements, the surface water velocity in Radecki Canal (estimated over a distance of 5 m) was determined at 0.22 m/s, whereas the velocity in Warta River (measured over a distance of 25 m) equaled 0.80 m/s.

All fingerprints were developed using the SPR (Small Particle Reagent) method, consisting in immersing the samples in a black suspension. The developed fingerprints were transferred onto the transparent gelatin lifter, followed by scanning at a resolution of 1200 dpi.

Measurements and analyses of dependent variables

The measurements of Contrast I, i.e., the difference in pixel intensities between ridges and valleys, were carried out by using the method proposed by Matuszewski et al. [5]. The intensities were assessed by using a histogram function of Adobe Photoshop software. Average intensities, determined within the defined areas of 5 x 5 pixels, were estimated for a set of 15 ridges and 15 valleys. The Contrast I value was obtained by subtraction of the average valley intensity from the average ridge intensity (Fig. 2 The way of measurement of Contrast I; see Polish version).

Similarly, the histogram function of Adobe Photoshop was also used to assess the Contrast II value, i.e., the difference in pixel intensities between the fingerprint and the background material. In this case the intensities were measured within the defined, square shaped areas of 50 pixels side length.

The resultant values of dependent variables were graphed using Statistica software package. For illustration, the datasets were presented on scatter plots and extrapolated with exponential function.

Results and Discussion

With regard to the contrast between ridges and valleys, no significant differences were observed for the function of this independent variable in relation to time, between the reservoirs being the subject of the study or even within a single reservoir (Fig. 3 The changes of Contrast I with ageing for: Morasko pond [M], Lake Trzesiecko [T], Radacki Canal [KR], Warta River [W]. The red line constitutes a fingerprint life limit; see Polish version). Despite a visible decrease in this variable for subsequently developed fingerprints, the differences were not substantial and the decrease progressed mildly. An exception to this pattern occurred in the case of Lake Trzesiecko, where both wider value range for Contrast I and higher mean Contrast I values were observed in all measurements. The characteristic of this reservoir was the lowest decrease of Contrast I for subsequently developed fingerprints.

The fingerprint life limit in aquatic environment was defined as the last experimental day, on which at least one of the developed fingerprints had a Contrast I value greater than 5 units. Beyond that day, the ridges had become adherent, which made it impossible to identify and extract the valleys and thus rendered the fingerprint illegible. The life limit is represented on the graphs by a red horizontal line (Fig. 3; see Polish version). Using the above methodology, the following fingerprint lifespans were determined: 7 days for Morasko pond; 13 days for Lake Trzesiecko; 9 days for Warta River and 50 hours for Radacki Canal. The results are clearly derivable from the graphs for Morasko pond and Warta River, wherein the fingerprints developed beyond experimental day 7 and 9, respectively, have fallen below the line defining the 5 unit threshold. However, in the case of Lake Trzesiecko and Radecki Canal, no Contrast I data points are shown on the graphs in Fig. 3, beyond experimental day 13 and hour 50, respectively. This was due to the slime build-up on the glass slides, which obstructed the fingerprints and hindered the process of developing on day 14 for Lake Trzesiecko and hour 70 for Radacki Canal. The appearance of slime, eventually inevitable in each of the examined water reservoirs, was deemed fingerprints ageing process in aquatic environment, delimiting the boundary of their lifespan. Notwithstanding the slime build-up, the fingerprints developed shortly before its occurrence had a Contrast I value below 5 units. This indicated that the threshold level for the Contrast I would have been reached approximately around the day on which the slime deposition was noticed or shortly thereafter. Therefore, the Contrast I formula could be also used to determine the fingerprint life limit for Lake Trzesiecko and Radacki Canal water reservoirs.

Contrast I proved a valuable tool in determining the lifespan of fingerprints in aquatic environment. Relatively low range of this variable observed throughout the duration of the study and only a moderate decrease with time can be explained by applied method of development - SPR. The suspension particles adhere not only to the substances making up the fingerprint but also to the glass surface, which they contaminate. Such property of the suspension results in the darkening of valley areas, thus diminishing the differences in pixel intensities between valley and ridge components of a fingerprint. Moderate value range of Contrast I would likely prevent this method from being used for fingerprints age determination. However, for the durability assessment, the value range is less substantial, as in this case, the key parameter is the minimum value of Contrast I, not its range. It appears that the latter parameter would better suit the determination of age/durability of fingerprints deposited in other than aquatic environments, developed by other, less “contaminatory” methods.

As distinct from the Contrast I, a wide range of variation, both among water reservoirs and within a single reservoir, has been observed for Contrast II, i.e., the difference in pixel identities between the print and its background (Fig. 4 The changes of Contrast II with ageing for: Morasko pond (M), Lake Trzesiecko (T), Radacki Canal (KR), Warta River (W). The red line constitutes a fingerprint life limit; see Polish version). No evident variation pattern was observed for Contrast II values for stagnant water vs. flowing water. Based on the observations, it has been concluded that in the case of Contrast II formula, the fingerprint life limit oscillated around 10 units. For contrast values below that threshold, the prints blended into the background. The durability threshold is represented on the graphs by a horizontal red line (Fig. 4).

A point of intersection of the threshold line with a line of the exponential function plot determined the maximum lifespan of the print. This method was only applicable to Morasko pond and Warta River, for which the fingerprint lifespans were determined at 7 and 9 days, respectively. In the case of Radacki Canal and Lake Trzesiecko, the exponential function lines have not intersected with the threshold lines. At the time of discontinuation of the experiments (due to the slime build-up) the values of this dependent variable by far exceeded 10 units for all developed prints. Therefore, for the latter water reservoirs it would be impossible to determine the fingerprint lifespans relying solely on the Contrast II formula.

In conclusion, Contrast II provides value for determination of durability of the fingerprints in aquatic environment only when it is used in combination (and subject to interpretation) with Contrast I. A characteristic feature of Contrast II is a relatively wide variation range, which facilitates analyzes of the dynamics of ageing but could nevertheless lead to erroneous conclusions, should Contrast II formula be used as a stand-alone method. For example, if a given

Table 1

Lifetime of fingerprints estimated for specific water reservoirs by means of the analysis of two dependent variables

	Stagnant water		Flowing water	
Dependent variable	**Morasko Pond**	**Trzesiecko Lake**	**Warta River**	**Radacki Canal**
Contrast I	7 days	13 days	9 days	3 days
Contrast II	7 days	–	9 days	–
Maximum lifetime for the type of water reservoir	7 days	13 days	9 days	3 days
Mean maximum lifetime for the type of environment	10 days		6 days	

Based on the results of the present study, only general conclusions can be drawn as to the lifetime of the fingerprints ageing in aquatic environments. In order to gain a better insight into the process of ageing of the fingerprints immersed in water, further research is required, involving greater number of repetitions for each type of aquatic environment.

print has the Contrast I value below 5 units, then despite high values of Contrast II the image appears blurred and the ridges become obscure which renders the print illegible (Fig. 5 Fingerprints developed on 2nd day (A) and on 8th day (B) after immersion in lake Trzeciecko; see Polish version). Therefore, Contrast I value is of key importance for determining the fingerprint durability, since it is indicative of whether the components of the print are sufficiently distinctive to allow for identification. Consequently, Contrast II plays only a subsidiary role. It is notable, however, that the fingerprint life limits determined with the use of this dependent variable were consistent with those obtained for Contrast I.

The conducted study emphasized the significance of water movements as a factor accelerating the ageing process and thus adversely affecting the durability of fingerprints. During the first three days of the experiments at Lake Trzeciecko, its surface has been covered in ice, which resulted in a reduced water movement at the holder installation site. Consequently, a slower ageing rate has been observed. The decrease in values of the dependent variables was only noticeable after experimental day 3 (i.e., following the thaw). An opposite effect, i.e., rapid decrease in analyzed parameters was caused by an unobstructed water movement at the Warta River and Radacki Canal sites. However, in the case of Radacki Canal, other factors must be taken into consideration that might have interfered with the tests, such as mechanical damage to numerous research samples. While interpreting the research results described herein, one should take into consideration a multitude of factors affecting the fingerprints ageing process. A subject of this study was an environmental model testing the water movements. However, the research samples have been impacted by other environmental, individual (e.g. donor characteristics) and circumstantial (e.g. circumstances of deposition) factors. While setting up the experiments, a special attention was paid to curbing the influence of two latter groups of factors on the results, by means of selecting a single donor using the same finger, and by standardizing the deposition procedure (hand washing, observing 5 minute intervals, etc.). Notwithstanding the foregoing, it cannot be excluded that there was a certain degree of variability among research samples, for example different composition of sudoral-fatty substance or different contact pressure between the thumb and the surface, which might have influenced the ageing process and in consequence, fingerprints durability.

Source:

Figs. 1–5: author
Tab. 1: own elaboration

Translation: *Rafał Wierzchosławski*

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