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Study of the Influence of External Conditions and Materials on the Preservation of Hidden Prints under Water

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Abstract

Concealment of a crime involves a number of processes that the guilty person performs to destroy their own fingerprints, including immersing or flooding the objects of illegal acts. That is why the expression of the influence of the water environment, its features and external conditions on the preservation of evidence of a crime is an urgent issue. The purpose of the article was to study temperature, time, chemical features of water resources and other factors for the possibility of qualitative detection and research of human fingerprints on various types of materials. In the work, the author independently conducted an experiment that formed its methodological basis. As a result of the conducted research, it was established that the examination of evidence, including fingerprints under water, was an important component of the investigation of the crime.

Keywords: identification; latent fingerprints, water; glass; plastic.

Introduction

When developing forensic science, it is important not only to touch on theoretical matters in the specific field, but also to develop new knowledge considering the practices existing in it. One of the matters, which the authors have chosen to study as a topical one, is the preservation of latent prints on submerged objects. In view of the above, an experiment was conducted in the circumstances most closely approximated to the real situation. Latent prints were left on ten glass bottles and ten plastic bottles imitating the mechanism forming traces of grasping and pressing. Then these objects were submerged in water tanks located in an open place. 10 prints were left on each of the objects. During the experiment, the air temperature, the time of drying out of the water from the object, the start time of visualization of prints, visualization, and lifting agents, and the condition of the prints were recorded. The data collected during the experiment were summarised and analysed. Out of 100 latent prints left on 10 glass bottles during the experiment, 32 prints were recognized as valid for identification of persons, 30 prints reflected papillary lines but did not provide a sufficient number of specific attributes of papillary lines to recognize the print as valid for identification of

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persons. Out of 100 latent prints left on 10 plastic bottles during the experiment, 30 prints were recognized as valid for identification of persons, 32 prints reflected papillary lines but did not provide a sufficient number of specific attributes of papillary lines to recognise the print as valid for identification of persons.

This issue is acute in forensic doctrine, as evidenced by a number of scientific works by various researchers. In particular, X. Wang et al. (2020) analysed the effectiveness of different interpolation methods, namely linear, bilinear, and bicubic interpolation methods to improve the efficiency of fingerprint research. As a result, they managed to come to the conclusion that the bicubic interpolation method was characterized by the highest accuracy and speed, while they have indicated that it requires a large amount of hardware resources. K. Yang et al. (2022) and V. N. Patil and D.R. Ingle (2022) noted that one of the most effective methods of digital processing was precisely the FPD-M-net architecture, which allowed working with complex objects, such as noisy or underwater ones. Unlike previous researchers, S. Singler (2021) paid attention to the work of forensic experts and the main goals of their use of biometric systems. In the conclusion, he singled out such directions as the development of automated criminal registration mechanisms; in biometric documents; for the implementation of forensic examinations; for the improvement of automated criminal detection systems (Abbasov, 2022; Striltsiv, & Fedorenko, 2022).

The examination of the scene is one of criminal procedural activities during which significant volume of evidences is obtained. A scene usually means the place where a criminal offense has happened, but it is not always the only place to be examined to obtain evidence (Cherniavskyi et al., 2019; Sadvakasova & Khanov, 2019). Thus, for instance, a criminal offense may be committed in one place, but the body or some other objects related to the criminal offense may be moved to another place for the purpose of concealing traces of the criminal offense. The significance of examination of the scene is invaluable. The mistakes committed during the examination affect all the further forensic investigation and the admissibility, eligibility, and credibility of further evidence in criminal proceedings (Drozdov & Basysta, 2023; Novikovas et al., 2017). However, these mistakes happen in individual cases (Becker et al., 2013; Shapoval et al., 2018).

One of the situations, which an expert may face in practice, is placed in the water of an object related to a criminal offense for the purposes of concealing the object, as well as destroying the traces left by it (Said et al., 2021; Vapniarchuk et al., 2021). The phenomenon of prints hides in their comparatively widespread occurrence at crime scenes and the possibility of finding them on different types of surfaces. This circumstance makes prints significant in solving criminal offenses, because prints make it possible to identify persons proving that the specific person was in contact with the object, on which these prints were found (Castelló et al., 2013; Yessenbek et al., 2020; Hryshchuk & Paliukh, 2022). Taking into account that prints may be left on surfaces of objects made of different materials, several experiments including objects made of plastic (Costarelli et al., 2020), objects made of glass (Madkour et al., 2017; Kallumpurat & Kudtarkar, 2018), and objects made of metal (Kapoor et al., 2019; Kaur et al., 2020) were held. Furthermore, these latent prints were visualized using different types of Fingerprint Powders and Small particle reagents Cyanoacrylate fuming.

The experiments also demonstrated differences in the time range, when objects with experimentally left latent prints were placed in fresh water from a lake and in salt water from the sea, as well as in the water from the water supply system. When summarising and analysing the input data and results of the experiments conducted by foreign researchers, it can be concluded that the experiments were performed in similar and different circumstances, using similar and different objects, which only extends the range of input data and results of the research. Furthermore, the purpose of this experiment was to maximally approximate the conditions of the experiment to natural ones and to identify the possibility of preserving latent prints on submerged objects in naturally variable temperatures for a period of time from 24 to 240 hours, studying the impact of the time period and temperature fluctuations on the preservation of prints.

Materials and Methods

The experiment was conducted from 8 September 2021 to 18 September 2021. 10 glass bottles and 10 plastic bottles, the surface of which was not cleaned, but was left as is, were chosen as the object receiving prints. 10 latent prints were left on each of the objects imitating the mechanism forming traces of grasping and pressing using variable pressure when leaving the prints. The prints left were natural sweat and fatty substances from palms and fingers without artificially adding sweat and fatty substances from other body parts, for example, the forehead, and the back of the neck. This means that the formation of latent prints left on objects was maximally approximate to the natural conditions of the formation of prints. Overall, 200 latent prints were left on 10 plastic and 10 glass objects.

Prints on all objects were left on 8 September 2021 at an air temperature of 21℃. To prevent the possibility of exhaustion of sweat and fatty substances, a small-time interval was kept before leaving prints on objects. Places where the prints were left were marked on the objects before leaving the prints and then the objects were submerged in water. About 10 minutes passed between leaving prints on the surface of the object and submerging the object in the water. Two plastic containers were prepared for the placement of objects in the water, which was filled with water from the water supply system. The containers were placed outside, thus ensuring that the submerged objects were exposed to air temperature fluctuations and weather changes. During the experiment, the water was standing and was not replaced. The objects (one glass bottle and one plastic bottle) with latent prints left on them experimentally were removed from the water after 24h, 48h, 72h, 96h, 120h, 144h, 168h, 192h, 216h, and 240h. After the objects were removed from the water, they were left to dry. The drying time for plastic objects was from 35 to 83 min, but for glass objects – from 25 to 67 min.

After the objects have dried, the experimentally left latent prints were visualized using the following BVDA (Netherlands) fingerprint powders (adhesion agents): black nonmagnetic powder (Special Blower Black B-35100), black nonmagnetic powder (Swedish Black B-421000), black magnetic powder (Magnetic Jet Black B-45100), black/silver magnetic powder (Magnetic Two Tone Silver/Black B-47750). A BVDA (Netherlands) marabou feather brush with a powder container and a powder supply mechanism (Blower Brush with marabou feather B-52000) and a magnetic brush (Strong Magnetic Brush B-60100) were used for dusting of prints.

The following BVDA (Netherlands) print copying (lifting) agents were used for copying visualized prints: light fingerprint film (Gellifters White B-14000), and silicon paste (Silmark CART White, 75 ml cartridge C-1405). Silicon paste was applied using a silicon paste dispensing gun (Dispensing gun (classic model) for Silmark CART C-8200), mixing tips of the gun (Mixing tips pink for Silmark CART C-8300), a silicon paste spreader (Spreader tips for Silmark CART C-8350), siliconized paper (Siliconized paper (one side only) C-106010). A protocol was created for each object, which specified input data, data, and results obtained during the experiment.

Results

Meteorological elements (air temperature at night and during the day, as well as the air temperature difference) and weather conditions by dates were recorded and summarised during the experiment and are reflected in Table 1.

Table 1: Description of weather during the experiment from 8 September 2021 to 18 September 2021

Meteorological elements				
Date	**Air temperature**	**Air temperature**	**Air temperature**	**Weather conditions**

	at night	during the day	difference	
08.09.2021	12°C	21°C	9°C	Sunny, partly cloudy
09.09.2021	13°C	23°C	10°C	Sunny, partly cloudy
10.09.2021	12°C	25°C	13°C	Sunny, partly cloudy
11.09.2021	10°C	24°C	14°C	Cloudy, occasional rain
12.09.2021	15°C	21°C	6°C	Cloudy
13.09.2021	12°C	17°C	5°C	Cloudy, rainy
14.09.2021	7°C	16°C	9°C	Cloudy
15.09.2021	4°C	15°C	11°C	Cloudy
16.09.2021	3°C	14°C	11°C	Cloudy, rainy
17.09.2021	6°C	13°C	7°C	Cloudy
18.09.2021	5°C	14°C	9°C	Cloudy

Before starting visualization of prints, each object was viewed under combined lighting – in daylight and in artificial oblique light. The latent prints left during the experiment on glass and plastic objects were visualized using four adhesion agents – Special Blower Black, Swedish Black, Magnetic Jet Black, and Magnetic Two Tone (Kaugia et al., 2021; Lall & Zile, 2020). The prints dusted using these four adhesion agents and copied to white silicon paste and white fingerprint film were divided into four groups:

1. Prints valid for identification of persons (the print reflects 12 or more specific attributes of papillary lines).
2. Prints invalid for identification of persons (the print reflects less than 12 specific attributes of papillary lines).
3. An indication of touch/shape.
4. No indication of touch/the print left cannot be seen.

The latent prints left experimentally on glass and plastic objects were dusted using four adhesion agents and after visualization and copying to lifting agents were categorized into four groups and the results obtained were summarised and reflected in Tables 2 and 3.

Table 2: Division of adhesion agents used for visualization of latent prints and visualized prints on glass objects

Adhesion agents	Number of visualised prints according to the category			
	A	B	C	D
Special Blower Black (B-35100)	6	2	0	17
Swedish Black (B-421000)	2	6	0	17
Magnetic Jet Black (B-45100)	10	11	0	4
Magnetic Two Tone Silver/Black (B-47750)	14	11	0	0
Total	32	30	0	38

Table 3: Division of adhesion agents used for visualisation of latent prints and visualised prints on plastic objects

Adhesion agents	Number of visualised prints according to the category			
	A	B	C	D
Special Blower Black (B-35100)	2	8	4	10
Swedish Black (B-421000)	7	7	0	12
Magnetic Jet Black (B-45100)	8	8	1	8
Magnetic Two-Tone Silver/Black (B-47750)	13	9	0	3
Total	30	32	5	33

Magnetic fingerprint powders Magnetic Jet Black and Magnetic Two-Tone Silver/Black demonstrated the best adhesive properties in the visualization of prints on submerged glass and plastic objects. If compare the division of the prints visualized on glass and plastic objects into groups, the conclusion can be made that the results obtained are very similar, because the prints visualized on glass objects, which were categorized into group A, amounted to 32% and those left on plastic objects – to 30%. The prints on glass objects categorized into group B amounted to 30%, while on plastic objects – to 32%. The percentage of the prints left on glass and plastic objects and categorized into group D amounted to 38% and 33% respectively. During the experiment, the evaluation ratio of prints visualized on glass and plastic objects was summarised and analysed after 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, and 240 h and is reflected in Tables 4 and 5.

Table 4: Evaluation ratio of prints visualized on glass objects after 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, and 240 h

Assessment of prints	Time spent by latent prints in water									
	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h	240 h
A	8	6	3	6	3	0	2	1	3	0
B	2	4	2	4	2	4	3	4	2	3
C	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0

Table 5: Evaluation ratio of prints visualised on plastic objects after 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, and 240 h

Assessment of prints	Time spent by latent prints in water									
	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h	240 h
A	5	3	2	8	0	3	0	4	3	2
B	4	6	4	1	1	7	3	3	2	1
C	1	1	2	0	1	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0

Figures 1 and 2 show the graphic ratio of the number of prints left to the division of prints after 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, and 240 h.

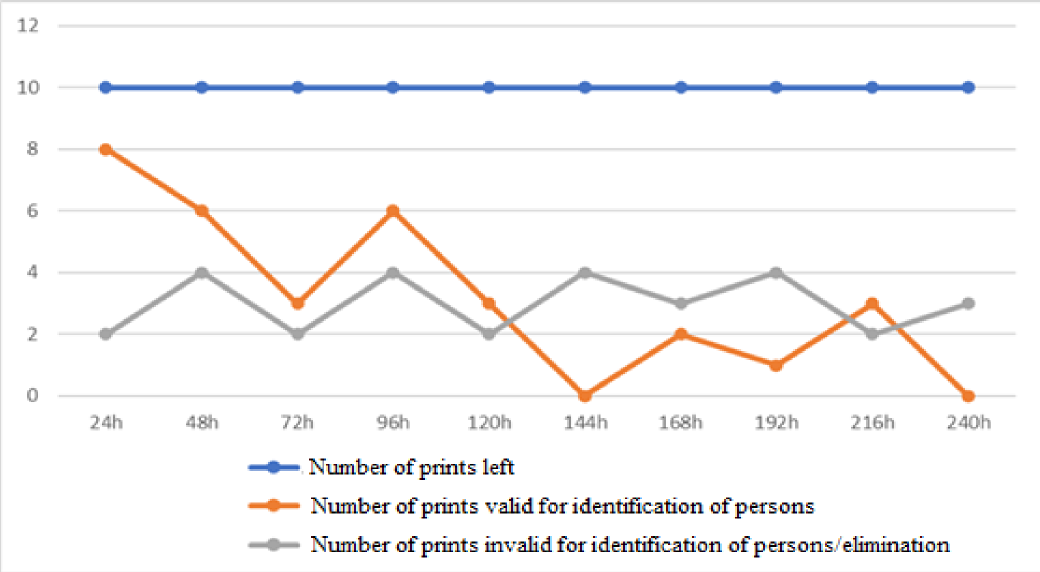


Figure 1 *Graphic evaluation ratio of prints visualised on glass objects after 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, and 240 h*

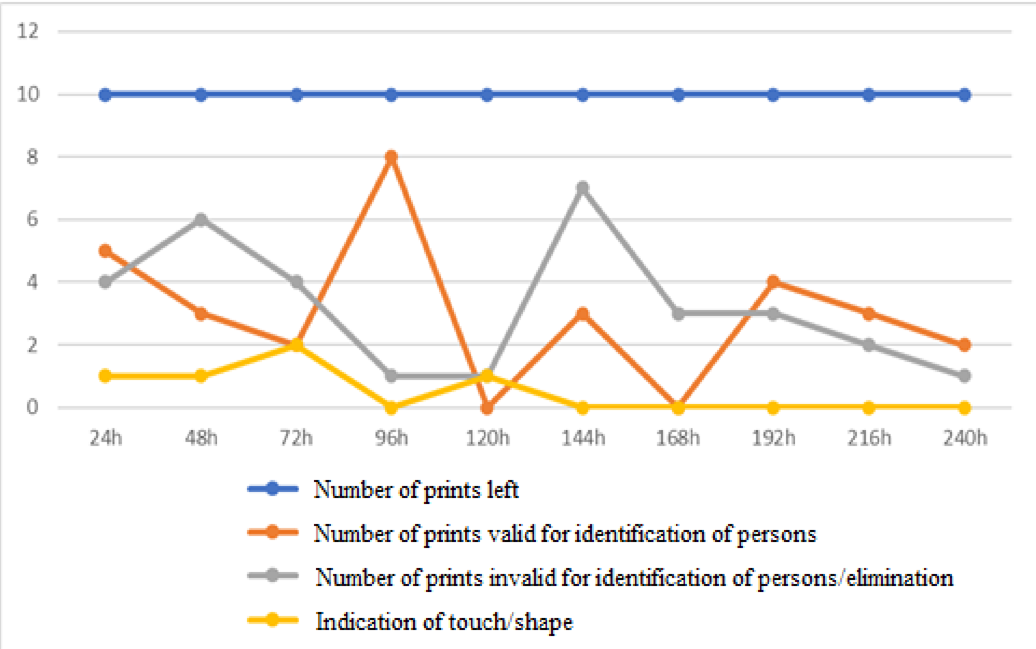
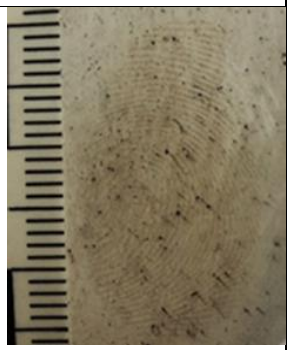


Figure 2 *Graphic evaluation ratio of prints left on plastic objects and visualised after 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, and 240 h*

Based on the summary and analysis of the results obtained, it could be concluded that prints valid for identification of persons can be visualized on glass and plastic objects after they spent in water 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, and 240 h. The data in Table 4 and Table 5 show that the period, when the object was in water is not always the determining factor for prints to be damaged or destroyed. Thus, for instance, after 96 h, 6 prints valid for identification of persons were found on a glass surface and 8 on a plastic surface. After 72 h, 3 prints valid for identification of persons were found on a glass surface and 2 on a plastic surface. Also, there is no proportionate reduction in prints valid for the identification of persons relating to the time spent by the object in the water tank. Although 8 prints valid for identification of persons were stated on the surface of a glass object after 24 h, 6 after 48 h, and 3 after 72 h, no proportionality was observed in the further period. It was also observed that no prints valid for identification of persons were stated on glass objects after 144 h and 240 h and on plastic objects after 120 h and 168 h, but prints including less than 12 specific attributes were found. Images of prints on submerged objects recognized as valid for the identification of persons during the experiment are reflected in Tables 6-9.

Table 6: Prints on submerged objects recognized as valid for identification of persons after 24 h, 48 h, 72 h

Object	**Time spent by latent prints in water**		
	24 h	**48 h**	**72 h**
Glass bottle			

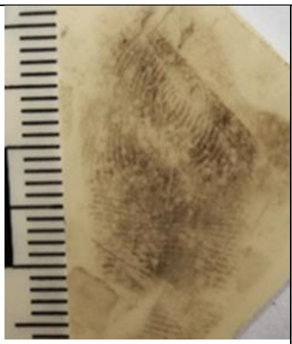
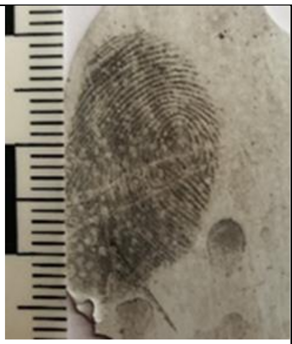
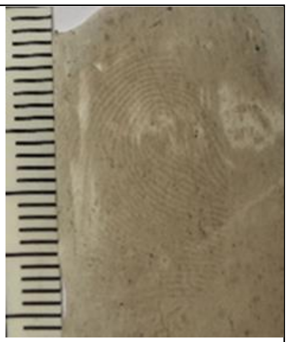
Plastic bottle			

Table 7: Prints on submerged objects recognised as valid for identification of persons after 96h, 120h, 144h

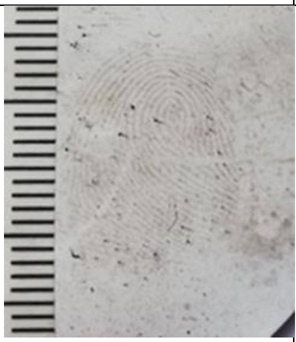
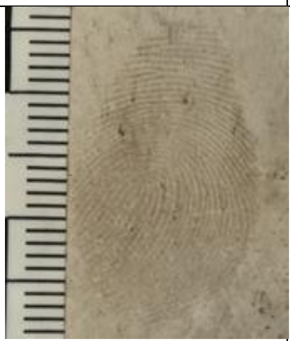
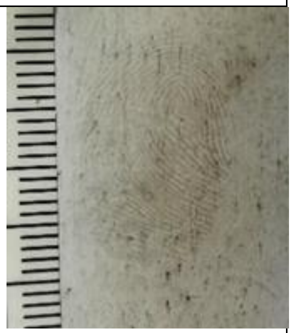
Object	Time spent by latent prints in water		
	96 h	120 h	144 h
Glass bottle			No prints valid for identification of persons were stated
Plastic bottle		No prints valid for identification of persons were stated	

Table 8: Prints on submerged objects recognised as valid for identification of persons after 168h, 192h, 216h

Object	Time spent by latent prints in water		
	168 h	192 h	216 h

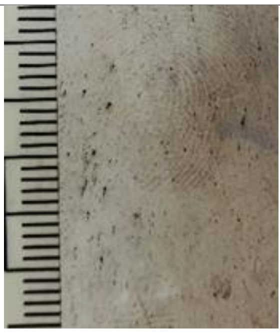
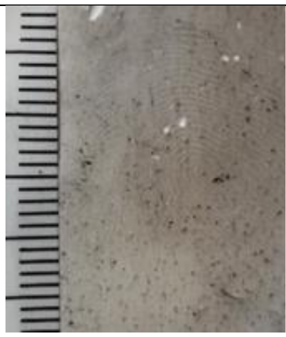
Glass bottle		No prints valid for identification of persons were stated	
Plastic bottle	No prints valid for identification of persons were stated		

Table 9: Prints on submerged objects recognised as valid for identification of persons after 240h

Object	Time spent by latent prints in water
	240 h
Glass bottle	No prints valid for identification of persons were stated
Plastic bottle	

For the purposes of approximating the conditions of the experiment to the real situation containers with water, in which glass and plastic objects with experimentally left prints were submerged, were placed in an open territory and the air temperature was measured during the day and at night. When summarising and analysing the results obtained during the experiment, the potential impact of air temperature and its fluctuations on the preservation of prints was studied. Figure 3 reflects the air temperature during the day and at night, as well as the ratio of prints valid and invalid for identification of persons in accordance with the time period when objects were submerged in the water tank.

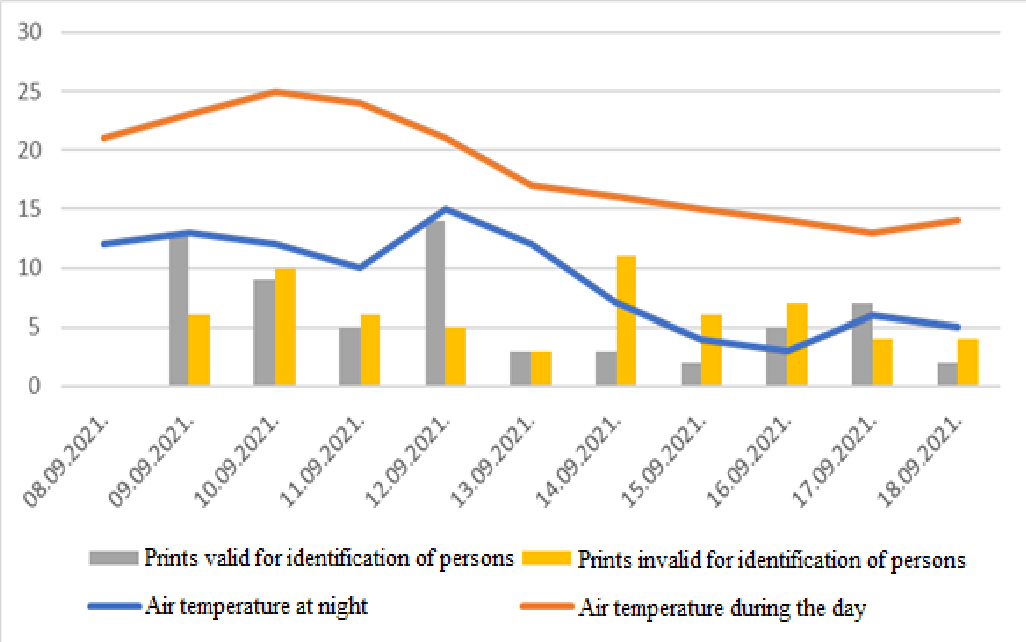


Figure 3 *Graphic ratio of prints on glass and plastic objects valid and invalid for identification of persons to air temperature fluctuations*

During the experiment, the air temperature fluctuated from 13℃ to 25℃ during the day and from 3℃ to 15℃ at night. The temperature fluctuations were from 5℃ to 14℃. The highest temperature fluctuations were observed on September 10, 11, 15, and 16 – from 11℃ to 14℃, while the lowest was observed on September 12, 13, and 17 – from 5℃ to 7℃. A constant temperature fluctuation of 11℃ was observed for two days in a row – on September 15 and 16. When evaluating the impact of temperature and temperature fluctuations on the preservation of prints on submerged objects, it may be concluded that it would be hard to talk about the impact of temperature and temperature fluctuations separately from the effects of water and the time, when the object with prints was in the water, because since submerging of the object into the water the prints on the objects are affected by water, time, temperature and its fluctuations at the same time. However, despite the fact that prints are affected by several factors at the same time, the results of the experiment can be evaluated as positive.

Discussion

In criminal scientific doctrine, in particular in the field of forensics, the study of fingerprints is an important component in the course of studying methods of personal authentication. Different researchers analyse different forms of obtaining and saving fingerprints, which makes it possible to improve the effectiveness of the criminal process and the work of authorized law enforcement agencies. With this in mind, it is important to pay attention to the articles by S. Hemalatha (2020) and P. S. Chanukya and T. K. Thivakaran (2020), in which they explored the general principles and basics of fingerprint pattern authentication. Thus, both works relate to dactyloscopy, namely the method that consists in proving the uniqueness and immutability of a person's fingerprints throughout their life. In particular, S. Hemalatha (2020) points out that although such a technique is quite common among both academics and practitioners, it does not have a proper scientific basis. Despite this, researchers have studied it as a fundamental method in working with patterns on human fingerprints and consider it reliable in the field of forensics. P.S. Chanukya and T. K. Thivakaran (2020) established that the main purpose of such an identification process was to identify and highlight features on prints that are necessarily individual in nature. According to S. Hemalatha (2020), the first type of signs is not characterized by special complexity, since it can be seen without the use of special knowledge. Usually, local features are expressed using the structure of a papillary pattern, which consists of lines, for example, two parallels that diverge and delineate the area of an object. In turn, P.S. Chanukya and T. K. Thivakaran (2020) studied the local features of the papillary pattern, which are often called trifles in scientific doctrine. Their main property is that the lines in such a picture are not repeated, and therefore such signs are individual for each individual fingerprint. The display of this type of signs is possible by a special line ending, bifurcation or its breaking or bending. Comparing the obtained conclusions, it should be noted that the global features of fingerprints in practice can be similar in several people at once. At the same time, local signs are not exactly repeated and are completely individual for individual people (Sezonova & Sezonov, 2022). Taking this into account, it is advisable to agree with the results obtained by the researchers and to indicate that it is on the basis of the first signs that the dactyloscopy database is divided into classes, and with the help of the second – authentication persons within the same class. It should be noted separately that the convergence of the researchers' work and the conclusions of this work is the use of the dactyloscopy method, including the study of submerged objects with fingerprints on them.

In turn, M. Caswell (2021) and P. Gainza et al. (2020) drew attention to the historical development of the process of identification and preservation of human fingerprints. The study of their works is important in the context of this research, as it allows for reflecting the features of the deformation of prints due to the influence of various factors, including water. M. Caswell (2021) in her research emphasizes that back in 1686, it was discovered and proved that the patterns on the fingers were individual and appeared in the form of loops, arcs and curls. In addition, the researcher notes smaller details, such as forks, hooks, islands, intersections. She also explored overseas experience, particularly England's 17-match cap. Based on the content of this act, two fingerprints must have 17 common features, on the basis of which they can be considered identical. The researcher notes that at the moment in forensic doctrine, it has been proven that a sufficient number of common features is 9, which will allow to assert the identity of two fingerprints. P. Gainza et al. (2020) also drew attention to international experience in the study of human fingerprints. In his research, he notes that the generally accepted standard for most countries of the world is exactly 12 characters. As for the preservation of fingerprints, he established that they were almost never deformed and depend only on the object on which they were placed. For example, fingerprints of prehistoric people are found on cave walls, but they can be damaged by natural and physical processes in the stone. At the same time, this method of fixing prints was quite common in the past, because the researchers note that even in Babylon, they were placed on clay discs during the approval of agreements. It is important to note that modern archaeologists have found most of such media precisely in water, and therefore the researcher claims that prints can be preserved in such an environment (Nekliudov, 2022). This fact is confirmed by clay seals on which the fingerprints of the ancient Chinese are still preserved. Based on the obtained results, it should be noted in the analysed articles that flooding the object does not lead to the complete destruction of fingerprints on it. One should agree with the researchers who conducted a historical analysis of the origin and distribution of fingerprints, on the basis of which it is possible to establish their features and the influence of various factors on their preservation (Bibikova, 2022).

Unlike previous researchers, Y. Zheng et al. (2021) and Y. L. Wang et al. (2020) focused on the features of the expert's work in the process of examining an object placed in water. Y. Zheng et al. (2021) argue that this is a common way to hide a crime, which at the same time can help law enforcement officers find the culprit. They explain this by the fact that the prints that the criminal left on the objects before diving into the water remain on them even after entering the water environment. At the same time, the researchers believe that this is an important property of prints, in particular, that they can be found and examined on different types of surfaces. A similar position is taken in his work by Y. L. Wang et al. (2020), who note that the most common materials on which an expert finds prints are plastic, glass, and metal. They pay special attention to the characteristics of the environment in which the prints were stored, such as fresh or sea water, since these factors significantly affect the duration of their preservation and the possibility of identifying the person behind them. Based on the results obtained by the researchers, it should be agreed that the study of reflections on submerged objects is influenced by a number of factors that were also mentioned in this article. Thus, the mentioned positions should be supported, since they not only have common features with this work, but also testify to the peculiarities of the preservation of prints on different types of materials.

Thus, there are many views in forensic science regarding the possibility of examining fingerprints in different forms, mediums and materials. The study of this issue requires the use of historical data, as well as the latest technologies that allow speeding up and increasing the efficiency of the expert's work. Based on the analysed works of researchers, it can be noted that all of them adhere to the opinion regarding the possibility of collecting fingerprints from objects that were under water.

Conclusions

The study and analysis of the data obtained during the experiments allowed to conclude that prints suitable for the identification of persons can be applied to submerged glass and plastic objects after 24 h, 48 h, 72 h, 96 h, 120 h, 144 h, 168 h, 192 h, 216 h, and 240 h. Nor was there a proportional reduction in fingerprints suitable for personal identification with respect to the time the object was in the water tank. The obtained results allowed to conclude that despite the fact that from the moment the object is immersed in water, the prints on it are affected by water, time, temperature, and its fluctuations, as well as the micro flora in the water tank at the same time, it is still possible to obtain prints that can be recognized as valid for the identification of persons.

As a result of the experiment, 32% of prints on glass objects and 30% of prints on plastic objects were recognized as valid for the identification of persons, but group B of prints, which is 30% on glass objects and 32% of plastic objects, is no less important. Although these prints do not contain sufficient fingerprint-specific features, they contain biological material consisting of sweat and fatty substances and can therefore be used for DNA (deoxyribonucleic acid) isolation and personal identification. Based on the above, it should be established that the study of fingerprints on submerged objects is not only possible in the process of investigating crimes, but also a necessary approach. This makes it possible to determine not only the identity of the criminal but also the victim and other subjects who interacted with the subject or object of the crime. In the following scientific works, it is advisable to focus attention on methods of detecting fingerprints on things that have undergone chemical treatment.

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