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Development of submerged and successive latent fingerprints: a comparative study

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Abstract

Background: The use of water to destroy evidences in criminal cases is common. It is uncommon to believe the usefulness of evidences recovered underwater in terms of its forensic significance regarding personal identification especially by the investigating officers, who are responsible to collect and analyse the evidences. In this study, two main factors were considered which may impact the condition of fingerprint evidences: firstly, the time duration for which the evidence remains submerged in water (0.5 h, 24 h, 48 h, 120 h), and secondly, the succession or the number of prints given by the same finger one after the other (5 subsequent prints).

Results: The result of this study revealed the successful development of latent fingerprint using Robin blue and silver magnetic powders on 8 different non-porous surfaces.

Conclusion: The developed prints provide significant individual characteristics; hence, the evidentiary value of the objects found submerged in water should not be undervalued.

Keywords: Forensic science, Submerged evidence, Latent fingerprint development, Powder method, Succession of fingerprints, Non-porous surface

Background

Fingerprints are a distinctive feature of individuals and are one of the oldest and most widely accepted forensic evidence used to establish personal identity (Houck and Siegel 2006; Gaensslen 2009). A report of Federal Bureau of Investigation stated that 'fingerprint identification is the most affirmative form of personal identification which is based on the inimitable and static arrangement of ridge details present on the fingertip' (FBI 1990).

The most familiar prints encountered at the scene of the crime are the latent prints. These are invisible prints retained on a substrate on account of various secretions from the body. Fingerprints can be deposited on a number of substrates, broadly classified as porous, non-porous, and semi-porous surfaces. Non-porous surfaces are characteristically non-absorbent, and hence, the fingerprint residues that are superficially present are more prone to be disturbed.

Fingerprints can be deposited through different mechanisms, on a variety of substrates, and can be exposed to various environmental conditions. This interaction among fingerprint composition, deposition surface, and environment is explained in the fingerprint triangle of interaction which describes that the technique or process to be selected and used to enhance latent prints is governed by the understanding of and the interplay between these three elements (Sears et al. 2012). Because of this concept, there is a vast range of latent fingerprint visualization and enhancement techniques for the differing interactions between the fingerprint composition, substrate, and environment interactions (Dhall and Kapoor 2016; Bradshaw et al. 2008).

This environmental effect can be enhanced when the print is exposed to destructive environments, either through the nature of the crime scene or through an intentional attempt to destroy evidence by the perpetrator of a crime. The fingerprint evidence subjected to such destructive conditions is generally neglected due to the misconception of impossible recovery (Deans 2006).

Criminals consider water and water bodies as perfect disposal sites for weapons of assault and other evidences which may connect them to the crime. These evidences may be retrieved from diverse aquatic environments (Becker 2006). Many researchers were successful at

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recovering latent fingerprints from surfaces exposed to water (Armstrong and Erskine 2011; Becker 1995; Yuille 2009; Beresford et al. 2012; Kabklang et al. 2009; Daéid et al. 2008; Maslanka 2016; Jasuja et al. 2015; Beaudoin 2004; Cuce et al. 2004; Frank and Almog 1993; Polimeni et al. 2004; Olenik 1984; Soltyszewski et al. 2007; Onstwedder 1989; Wood and James 2009; Vandiver 1976).

Considering the earlier research, it is evident that the value of recovering and enhancing fingerprints found at a crime scene can be invaluable in leading to the identification of a person of interest in relation to a crime. Keeping this view into the mind, in this study, we have made an attempt to develop a method to recover and identify the latent fingerprint present on eight different non-porous surfaces that were submerged into the water for different duration of time as well as five successive prints.

Methodology

Substrate

The study was conducted in the month of February 2018. The average max. temp. was 31.2 (±1) °C, and the average humidity was about 45%. In this study, eight non-porous substrates namely glass, laminated paper, plastic mug, floor tile, credit card (golden glitter), debit card (red), aluminium foil, and painted iron saw were used as surfaces for fingerprint deposition. The surfaces were thoroughly cleaned with an alcohol swab. The markings '1', '2', '3', '4', and '5' have been done on the surfaces to note the number and position of the five successive prints, using a permanent marker.

Fingerprint deposits

Fingerprints were taken from a single donor so as to maintain consistency in the sampling. Prints were deposited on the surfaces as described by Sears et al. (2012). Natural prints were deposited onto the substrates with no previous hand-washing or post eccrine (wearing gloves) or sebaceous (rubbing fingers on the nose) grooming of prints. This range of fingerprints allowed to mimic the real-life scenario in which different people shall have secreted varying amount of sweat and even concentration of the sweat composition would also vary in their prints. Furthermore, sweating is also affected by the physiological state of an individual that would lead to variation in the amount of sweat secretions which could affect the nature/form of fingerprint impression found at the crime scene (Kuno 1934).

Submergence

In this study, instant dry prints were developed first. Thereafter, the same surface was thoroughly cleaned with an alcohol swab and air dried, and again, fresh prints were taken on that surface. Then, the surfaces were allowed to submerge in the container with water for the stipulated time periods, i.e. 0.5 h, 24 h, 48 h, and 120 h, respectively. After the completion of the set duration, the surface was taken out from the water and allowed to air dry at room temperature for 45 min.

Fingerprint development powders

The prints were then developed by powder dusting method using separate brushes (Badiye and Kapoor 2015). The process was repeated for two latent print development powders—Robin® blue powder and commercially available silver magnetic dual powder. To avoid contamination and the unintentional prints deposition, gloves were worn throughout.

Analysis

The developed prints and the photograph of the prints (taken using a tripod-mounted Nikon D-3100 DSLR camera with 18–55 mm kit lens w/o flash) were analysed for designating a score based on the fingerprint quality assessment scale as described below (Castelló et al. 2013; Soltyszewski et al. 2007; Devlin 2011; Stow and McGurry 2006):

Score 5	Very good visibility
Score 4	Good visibility
Score 3	Poor visibility
Score 2	Bad visibility
Score 1	Blur/no visibility

Result and discussion

Latent fingerprints were developed after submergence in water from all the eight surfaces used in this study. The quality of prints developed in relation to the two variables studied, i.e. duration of submergence and succession of prints, is depicted in Tables 1, 2, 3, 4, 5, 6, 7, and 8. The developed latent fingerprints, submerged as well as successive, on all the selected substrates are shown in the tables in the Additional file 1.

Overall 400 prints were developed and examined in this study. Half of the total prints (200) were developed using Robin powder blue, of which 174 prints were identifiable with a score of 3–5 and only 26 prints were not properly identifiable with score 2 or 1. However, in case of commercially available silver magnetic dual powder, 25 prints developed on the aluminium foil surface had negligible contrast and hence were discarded. Remaining 175 prints were developed by silver magnetic powder, in which 152 prints were identifiable with a score of 3–5 and only 23 prints were unidentifiable with score 2 and 1 (Fig. 1).

The best quality identifiable prints were obtained on glass (Tables 9 and 10), laminated paper, and floor tile surfaces with 49, 48, and 48 (out of 50) prints

Table 1 Development of submerged and successive prints on glass using Robin powder blue and silver magnetic dual powder

	Glass				
	Print succession				
	1st	2nd	3rd	4th	5th
RPB					
Dry	5	5	5	5	5
0.5 h	5	5	5	5	5
24 h	5	5	5	5	5
48 h	4	4	5	4	4
120 h	4	4	3	3	3
SMDP					
Dry	5	5	5	5	5
0.5 h	5	5	5	5	5
24 h	5	5	5	5	5
48 h	4	4	4	3	3
120 h	5	4	4	3	1

RPB Robin powder blue, *SMDP* Silver magnetic dual powder

Table 3 Development of submerged and successive prints on floor tile using Robin powder blue and silver magnetic dual powder

	Floor tile				
	Print succession				
	1st	2nd	3rd	4th	5th
RPB					
Dry	5	5	5	4	4
0.5 h	4	4	3	3	4
24 h	4	4	4	3	3
48 h	4	4	3	3	2
120 h	2	1	1	1	1
SMDP					
Dry	5	5	5	5	4
0.5 h	4	4	4	3	3
24 h	5	5	4	5	4
48 h	5	4	3	4	3
120 h	3	4	3	3	3

RPB Robin powder blue, *SMDP* Silver magnetic dual powder

respectively with a score of 5, 4, or 3. In addition, floor tile, debit card (red), and painted iron saw surfaces gave 44, 43, and 39 (out of 50) identifiable prints with a score of 5, 4, or 3, respectively, while 21 (out of 50) prints remained unidentified on credit card (golden glitter) surfaces with a score of 2 or 1. In this order, Robin blue powder provided a better quality of prints on credit card (golden glitter) as compared to silver magnetic powder. The reason behind the low quality of print was the conflicting glitter of silver magnetic powder as well as golden glitter of the credit card which rendered poor contrast with the developing powder. On aluminium foil, none of the prints could be developed/visualized with silver magnetic powder due to poor contrast while only one print developed out of the 25 prints, by Robin powder blue, was poor (Table 11).

It is known that the quality of latent fingerprints naturally deteriorates over time (Baniuk 1990; Yuille 2009; Archer et al. 2005; Midkiff 1993), and our results

Table 2 Development of submerged and successive prints on laminated paper using Robin powder blue and silver magnetic dual powder

	Laminated paper				
	Print succession				
	1st	2nd	3rd	4th	5th
RPB					
Dry	5	5	5	5	5
0.5 h	5	5	5	4	4
24 h	4	3	3	3	3
48 h	5	5	5	3	3
120 h	4	3	3	3	1
SMDP					
Dry	5	5	5	5	4
0.5 h	3	5	3	3	3
24 h	3	3	3	3	3
48 h	3	3	3	3	2
120 h	5	4	4	3	3

RPB Robin powder blue, *SMDP* Silver magnetic dual powder

Table 4 Development of submerged and successive prints on plastic mug using Robin powder blue and Silver magnetic dual powder

	Plastic mug				
	Print succession				
	1st	2nd	3rd	4th	5th
RPB					
Dry	5	5	5	5	5
0.5 h	5	5	5	5	4
24 h	5	5	5	4	4
48 h	4	3	4	4	3
120 h	2	3	3	3	2
SMDP					
Dry	5	5	4	4	3
0.5 h	5	4	4	5	4
24 h	5	5	5	5	5
48 h	4	4	4	4	4
120 h	5	4	4	4	3

RPB Robin powder blue, *SMDP* Silver magnetic dual powder

Table 5 Development of submerged and successive prints on Credit card (golden glitter) using Robin powder blue and Silver magnetic dual powder

	Credit card (golden glitter)				
	Print succession				
	1st	2nd	3rd	4th	5th
RPB					
Dry	5	5	3	2	2
0.5 h	4	4	2	2	3
24 h	5	5	3	3	1
48 h	5	5	3	3	1
120 h	3	3	3	2	1
SMDP					
Dry	5	5	5	5	4
0.5 h	3	3	3	3	3
24 h	2	3	3	3	3
48 h	2	2	2	1	1
120 h	2	2	2	2	2

RPB Robin powder blue, *SMDP* Silver magnetic dual powder

are also similar to this. In this order, only 2 prints (out of 75) were not identified, when they were developed after 0.5 h and 24 h. However, when these prints were developed after 48 and 120 h in water using a similar method, the quality of developed prints significantly deteriorated. After 48 and 120 h in water 11 and 32 (out of 75) prints, respectively, were scored 2 or 1. Our results show that prolonged submergence deteriorates the quality of developed prints (Figs. 2 and 3).

Table 6 Development of submerged and successive prints on debit card (red) using Robin powder blue and Silver magnetic dual powder

	Debit card (red)				
	Print succession				
	1st	2nd	3rd	4th	5th
RPB					
Dry	5	5	5	3	3
0.5 h	5	5	5	4	3
24 h	5	5	5	4	3
48 h	5	5	4	3	3
120 h	2	3	3	1	1
SMDP					
Dry	4	4	4	4	4
0.5 h	3	4	4	3	3
24 h	4	4	4	3	3
48 h	4	4	3	4	3
120 h	2	2	3	2	2

RPB Robin powder blue, *SMDP* Silver magnetic dual powder

Table 7 Development of submerged and successive prints on aluminium foil using Robin powder blue and Silver magnetic dual powder

	Aluminium foil				
	Print succession				
	1st	2nd	3rd	4th	5th
RPB					
Dry	5	5	5	5	5
0.5 h	5	5	5	5	4
24 h	4	4	5	5	5
48 h	5	4	4	4	3
120 h	5	3	3	3	2
SMDP					
Dry	NC	NC	NC	NC	NC
0.5 h	NC	NC	NC	NC	NC
24 h	NC	NC	NC	NC	NC
48 h	NC	NC	NC	NC	NC
120 h	NC	NC	NC	NC	NC

RPB Robin powder blue, *SMDP* Silver magnetic dual powder, *NC* No contrast

Our results are in accordance with Castello et al., who found that up to a submersion time of 3 days, the development results were similar for the glass and plastic surfaces with 4 or 5 grades on scale which indicates clear well-identified prints. From the fifth day, significant differences in print development were observed (Castelló et al. 2013). Similarly, some other studies (Soltyszewski et al. 2007; Devlin 2011; Stow and McGurry 2006; Madkour et al. 2017; Trapecar 2012a, b;

Table 8 Development of submerged and successive prints on painted iron saw using Robin powder blue and Silver magnetic dual powder

	Painted iron saw				
	Print succession				
	1st	2nd	3rd	4th	5th
RPB					
Dry	5	5	5	5	5
0.5 h	5	4	4	3	3
24 h	5	5	4	3	3
48 h	4	4	3	2	1
120 h	3	3	2	2	1
SMDP					
Dry	4	3	3	4	4
0.5 h	3	4	4	3	3
24 h	3	3	3	3	3
48 h	3	3	3	3	2
120 h	2	2	2	1	1

RPB Robin powder blue, *SMDP* Silver magnetic dual powder

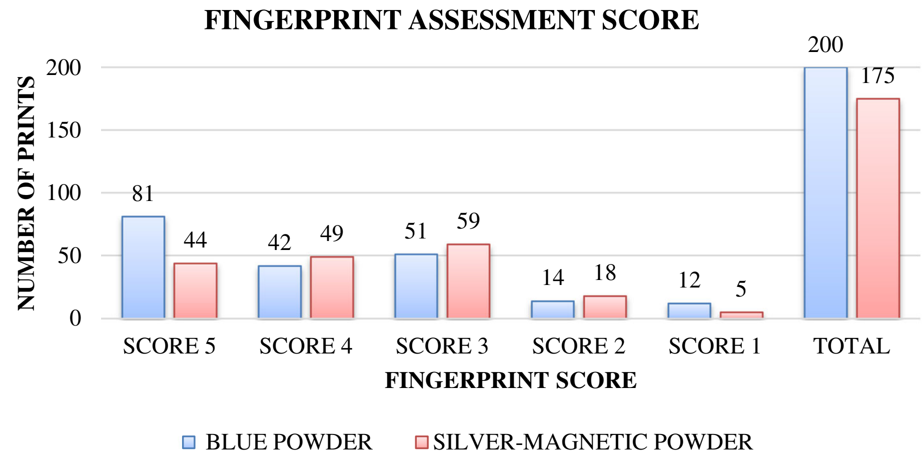


Fig. 1 Fingerprint assessment score in the succession prints developed using both the powders

Rohatgi et al. 2015; Trapecar and Pantic 2017) were also in consensus with the result that the clarity of the prints decreases with an increase in submersion period. By extending the duration of submersion in water, the number of developed useable fingerprints were reduced, and more finger marks remained undeveloped.

It is a well-believed principle that 'everything changes with the passage of time'. There are various changes that occur based on several factors along with the time duration (Cadd et al. 2015). The lengthier the duration, the greater is the degradation (Girod et al. 2012). Additionally, the water-soluble components of the fingerprint residue are more prone to destructive forces such as water, high temperatures, and low humidity (Iten 2012; Barnum and Klasey 1997). If a print is wetted, then the aqueous components of the print are removed, thereby leaving less available components for the powder to adhere to, but the enhancement is still possible and is reported in the current study and in literature (Dhall and Kapoor 2016). On analysing the impact of succession of prints, it was found that the score decreases with subsequent prints. In the first, second, and third prints, a total of 8, 5, and 6 (out of 75) prints

Table 9 Development of successive prints on transparent glass surface using Robin powder blue and silver magnetic dual powder

Surface	TRANSPARENT GLASS				
Duration	INSTANT DRY PRINTS				
	SUCCESSION				
	1st	2nd	3rd	4th	5th
RPB					
Score	5	5	5	5	5
SMDP					
Score	5	5	5	5	5

RPB: Robin Powder Blue; SMDP: Silver Magnetic Dual Powder

Table 10 Development of submerged and successive prints on transparent glass using Robin powder blue and silver magnetic dual powder

Surface	TRANSPARENT GLASS				
Duration	24 hrs				
	SUCCESSION				
	1st	2nd	3rd	4th	5th
RPB					
Score	5	5	5	5	5
SMDP					
Score	5	5	5	5	5

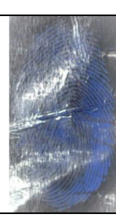
RPB: Robin Powder Blue; SMDP: Silver Magnetic Dual Powder

respectively were unrecognizable with a score of 1 or 2, while in the fourth and fifth subsequent prints, 11 and 19 (out of 75) were unidentifiable with a score less than 3.

The procedure adapted to fingerprint deposition on the surfaces was uniformly maintained to have consistent quality prints before submersion. After all, the results are dependent on the initial prints too. A systematic process can also result in inconsistent fingerprint deposition. There are certain factors that influence latent fingerprint deposition; some may be controlled while some may not be (Fieldhouse 2011). It is unlikely that the chemical and physical composition of two fingerprints will be identical, thus affecting the credibility of conclusions made. Factors associated with the donor (chemical composition) include smoking, illness, medication, age, gender, race, and diet. The factors associated with fingerprint deposition (physical) include force applied during deposition, duration of surface contact, angle of surface contact, substrate, and residue quantity due to washing.

This study is restricted to simulated stagnant water conditions in a laboratory setup, while the natural water bodies that are encountered during investigations of crimes are diverse from laboratory condition. They are subject to a number of internal and external factors

Table 11 Development of successive prints on aluminium foil using Robin powder blue and silver magnetic dual powder

Surface	ALUMINUM FOIL				
Duration	Instant Dry Print				
	SUCCESSION				
	1st	2nd	3rd	4th	5th
RPB					
Score	5	5	5	5	5
SMDP	NC	NC	NC	NC	NC
Score	-	-	-	-	-

RPB: Robin Powder Blue; SMDP: Silver Magnetic Dual Powder; NC: No Contrast

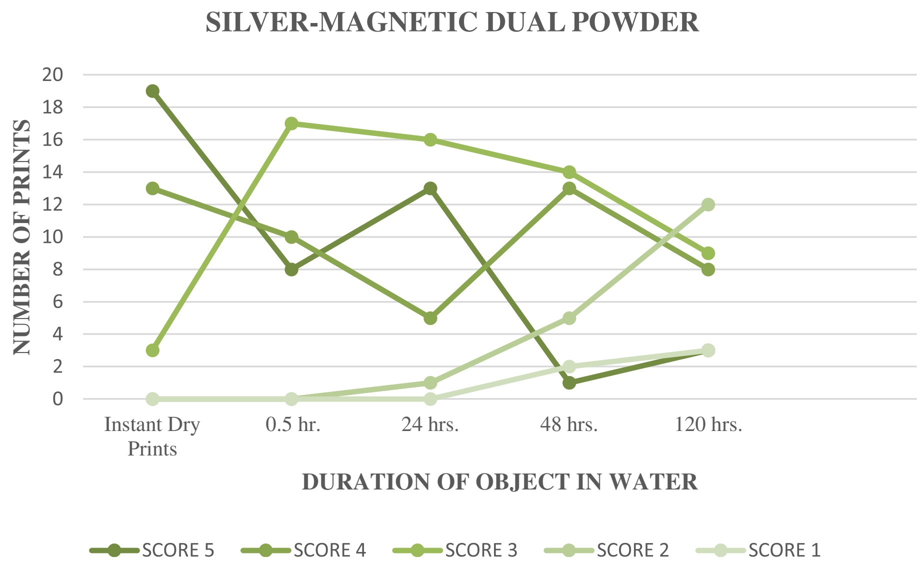


Fig. 2 Development of prints by silver magnetic dual powder

including temperature, wind, aquatic flora and fauna, pH, precipitation, and enclosure.

Conclusion

This study aimed to highlight the notion that evidences recovered under water should be tested for prints as required, irrespective of the amount of time spent beneath water. Considering the use of eight different substrates in the current study, for the effect of succession of prints and submergence in water, on latent fingerprints, was based on our hypothesis that these two factors may played a vital role in a degrading the print quality and texture. Our results were at par with the hypothesis confirming that increasing succession of prints as well as increasing duration of time, the surface containing prints that were exposed to water reduces the quality of visualized prints. Both Robin blue powder and Silver magnetic dual powder have proved to be efficacious in this study. Both the powders are easily available,

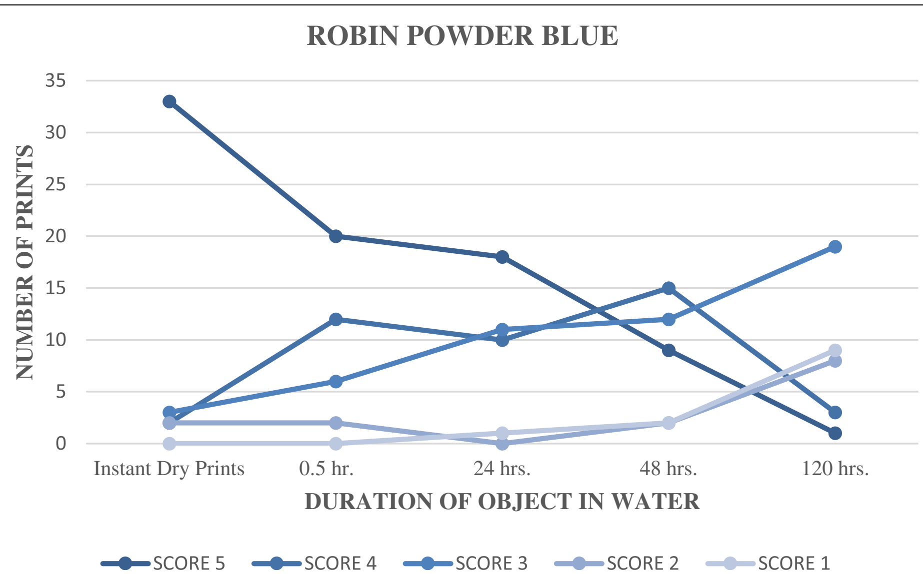


Fig. 3 Development of prints by Robin powder blue

low-cost, and versatile. Powder dusting followed by light brushing method gave notable results. Further research is essential in order to explore the impact of confounding variables on submerged and successive latent print development.

Additional file

Additional file 1: Development of submerged & successive prints on various substrates using Robin powder blue (RPB) and silver magnetic dual powder (SMDP). (DOCX 1440 kb)

Abbreviations

NC: No contrast; RPB: Robin powder blue; SMDP: Silver magnetic dual powder

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Authors' contributions

NK and AB conceptualized and designed the study. SA conducted the experimentation. AB and NK interpreted the results. RS and AB were the major contributors in writing the manuscript. All authors read and approved the final manuscript.

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Ethics approval and consent to participate

Informed consent has been obtained from the participating individual.

Consent for publication

Consent to publish has been obtained from the participating individual who also is a co-author of the manuscript.

Competing interests

The authors declare that they have no competing interests.

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