

## Recovery Of Fingerprints From Submerged Items

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### ABSTRACT

The use of fingerprints as a biometric tool has been used for over 2000 years and it is the most common and oldest physical evidence used in identifying suspects who are involved in crime scenes, incidents, accidents and so forth. Fingerprints are found to be largely in use in law enforcements applications. Underwater recovery operations in acquiring submerged fingerprints have been practiced for several years and studies show that obtaining prints from water that are left for several days appear to still be of good quality. The focus of this project is to investigate the stability of fingerprints from individuals who are of different ethnic and cultural backgrounds and the effects of secretions such as an individual's diet, drinking habits and the climate in which the individual lives, on the fingerprint when immersed in different types of water for a sustained period of time. The prints were immersed in different types of water to assess the extent to which the prints remained clear and identifiable, and the length of time taken before they deteriorate was also used as a variable, to consider if and how the type of water affected the results. This study considers whether fingerprints from people of a particular ethnic background remain more stable than others, and discusses the reasons why this might be, such as the effect of diet, drinking habits and climate on the chemical make-up of the different excretions.

Keywords: Fingerprint, biometric, submerge, water, diet, drinking habits.

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## **Abstract**

The use of fingerprints as a biometric tool has been used for over 2000 years and it is the most common and oldest physical evidence used in identifying suspects who are involved in crime scenes, incidents, accidents and so forth. Fingerprints are found to be largely in use in law enforcements applications. Numerous studies and research state that each individual is known to have unique, immutable fingerprints and the uniqueness of a fingerprint can be determined by the pattern of ridges, furrows and minutiae points that are found in a fingerprint.

Increases in incidents where criminals feel that weapons and other criminal evidence are thrown into water have increased, and so has recreational waterway usage such as accidents, drowning, violent crimes and homicides.

Submerged items are recovered as a means of evidence in matching the prints with a criminal/defendant at a setting such as water drowning, violent crimes and homicides.

Due to an increase in all these incidents, the law enforcement agencies and other professionals in the field have become more involved in underwater recovery operations.

Underwater recovery operations in acquiring submerged fingerprints have been practiced for several years and studies show that obtaining prints from water that are left for several days appear to still be of good quality.

The focus of this project is to investigate the stability of fingerprints from individuals who are of different ethnic and cultural backgrounds and the effects of secretions such as an individual's diet, drinking habits and the climate in which the individual lives, on the fingerprint when immersed in different types of water for a sustained period of time.

The prints were immersed in different types of water to assess the extent to which the prints remained clear and identifiable, and the length of time taken before they deteriorate was also used as a variable, to consider if and how the type of water affected the results.

The study considers whether fingerprints from people of a particular ethnic background remain more stable than others, and discusses the reasons why this might be, such as the effect of diet, drinking habits and climate on the chemical make-up of the different excretions.

### **Project aims:**

This study had two aims.

- 1- To assess the effect of ethnic and environmental factors on the stability of fingerprints when immersed in water for a sustained period of time.
- 2- To evaluate the effect of different types of water on the stability of submerged fingerprints from individuals who are of different ethnic and cultural backgrounds, and to assess the length of time before these prints deteriorate.

## **1. INTRODUCTION**

### **1.1 What are fingerprints?**

A fingerprint is an impression of the friction ridges (pattern) found on the inner surface of fingers, palms, toes, and soles of feet, which are composed of ridges and furrows as stated by Ashbaugh (2004).

One of the greatest problems facing society is impersonation, where one individual claims to be someone else in order to commit a crime, to go against the law, or to help/support someone else, (Campana, 2009). In order to counter this threat, the security services use methods of authentication and identification are sought. Polemi (1997) describes identification as methods to prove that a specific individual is who they say they are, this would be proved by such evidence as the use of I.D. cards, driving licence, bank cards, student I.D. cards and so forth. Verification is the service in which a specific individual verifies his/her identity with the means of a known password or by human characteristics such as fingerprints (biometrics).

The use of fingerprints as a biometric system has been used for over 20 years by the use of computers for personal identification as stated by O’Gorman (1998). O’Gorman (1998) also states that fingerprints were and are mostly in use for law enforcements applications and Katz (2005) supports this statement stating that fingerprints is the most cost effective tool for suspect identification and that fingerprints are a valuable type of physical evidence that can be found in an incident/accident/crime scene and

therefore, fingerprinting is the most common method used. Gupta (2001) states that fingerprint analysis is based on “minutiae” which are individual unique patterns that are found in a fingerprint pattern, for example on a fingerprint image there may be at least 30-40 minutiae seen on a live scan device. There is also increasing evidence, which is supported by the Federal Bureau of Investigation (FBI) that two individuals cannot have more than 8 common minutiae. Gupta (2001) claims that fingerprint technology such as an Automated Fingerprint Identification system (AFIS) has greatly enhanced the accuracy rate for identification purpose giving a 98% positive identification rate and with a false positive rate of less than 1%. The good advantage of AFIS compared to manually analyzing fingerprints is that the system can hold a large database size of images, and therefore the matching discrimination process is geometrically increased.

## 1.2 The History of fingerprints

The history of fingerprints started in the 14<sup>th</sup> century where some of the ancient cultures in countries like Babylon, China, and Persia used fingerprints as a means of sealing documents or signing official documents as stated by Frenette (2004). In 1686, a Professor of anatomy at the University of Bologna named Marcello Malpighi noticed the hallmark of fingerprint patterns known as: ridges, spirals and loops (Frenette, 2004). Later, in 1823, another Professor of anatomy at the University of Breslau named John Evangelist Purkinji published his thesis on the existence of nine fingerprint patterns. However he did not mention the importance of these patterns with regards to an individual identification (U.S. Marshals Service, 2012)

According to Frenette (2004), in 1858 the English began using fingerprints when Sir William Herschel used his own handprint to sign official documents instead of using his own signature in case it would be reproduced for some other reason. He later on required palm prints (right index and middle fingers) for the binding of official documents he then realised that none of the inked impressions were the same, on the contrary each one was unique and that they stayed the same throughout the individual’s life. During the 1870 s, Dr Henry Faulds, a British Surgeon-Superintendent of Tsukiji Hospital in Tokyo, Japan, was the first person who not only recognised the importance of fingerprints as a means of identification whilst studying “skin-furrows” but who also devised a method of classification. He then published an article in the Scientific Journal, "Nautre”, discussing the importance of fingerprints with the use of printer ink

as a tool of acquiring such prints (U.S. Marshals Service, 2012). He then forwarded an explanation of his classification system to Sir Charles Darwin asking for some assistance, which he then passed on to his cousin, Francis Galton. Galton then, later in the 1880's, started observing the use of fingerprints (Frenette 2004). However the first known use of fingerprints as a means of preventing forgery was in the United States by Gilbert Thomson of the U.S. geological Survey in New Mexico in 1882.

In 1892, Dr Faulds published a book about all his findings regarding the individuality and permanence of fingerprints and also devised a classification system, for example, the original five details that are found in a fingerprint such as a dot, ending ridge, enclosure, bifurcation and an island, all known as the "Galton's details" as described by Frenette (2004). He also concluded that the odds of an individual acquiring the same fingerprints of another individual are about 1 in 64 billion; hence fingerprints do not change over time. The first criminal fingerprint identification was made in 1892 by Juan Vucetich, who used 'Galton's fingerprint patterns' and later in 1901 England and Wales used fingerprints as a means of criminal identification. Sir Edward Richard Henry later revised Francis Galton's classification system and introduced the system which is now what all English-speaking countries use. It was only in 1905 when the U.S. army began using fingerprints for personal identification, and then later, in 1918, a 'quota' was introduced by Edmond Locard, which states that if there are 12 points of details that match between two fingerprints then a positive identification is made. According to Frenette (2004), this 'quota' is used in many countries; however there may be other standards that must be met as well for a positive identification to be made. The art of positive identification using fingerprints has improved greatly, from manually maintained to the use of computer systems (database) which allows unknown prints to be scanned and matched with prints already scanned on file through an automatic search.

### **1.3 How are fingerprints formed?**

Fingerprints are developed in early embryonic development, for example, at twelve weeks of gestation whilst in the mother's womb during foetal movements. Depending on the exact position of the foetus and the exact composition and density of surrounding amniotic fluid that is swirling around the fingers, as the foetus touches surrounding structures/stretches the skin or bends his/her fingers, a fingerprint

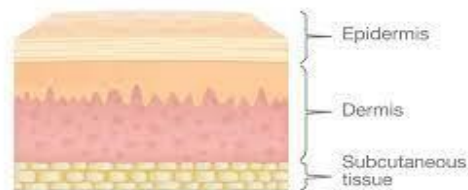
begins to form as described by Roizen (2012). The ridges that are formed have a pattern that is unique and that cannot be made twice due to the entire development process being by chance.

### 1.3.1 Skin Anatomy

The skin is one of the largest organs of the body, which consists of tissues that function together, millions of sensory receptors, and a vascular network (Ashbaugh 2004). The skin has many functions which include the regulation of body temperature, water retention, protection, sensation, and excretion, immunity from various organisms such as bacteria, viruses and so forth. The total area of skin around the body is about 2 m<sup>2</sup> and its thickness does not exceed 2mm. The skin is divided into two distinct layers namely the epidermis and dermis. (Romotowski, 2001).

The epidermis consists of 5 layers (stratified) and that is of squamous (flat) epithelial tissue, as described by Ashbaugh (2004). The innermost layer that sits just above the dermis is the stratum germinativum (basal cell layer). This layer consists of columnar epithelial cells which, when divided, push into the stratum spinosum which is basically a prickle cell layer that is held together by fibrils, as described by Romotowski (2001). When these two layers are combined, they are known as the Malpighian layer. These cells then travel upwards to the skin surface; they begin to grow and enlarge to then begin forming the next layer where Keratohyalin granules are formed known as the stratum granulosum (granular layer). The nuclei then begin to break off or dissolve which then results in epidermal cell death and a turnover in cytoplasmic granules. Another layer, known as the stratum lucidum, consists eleidin, which is basically a transformation product of the keratohyalin present in the stratum granulosum. Eleiden converts to keratin, which is continuously being sloughed off the surface of the epidermis, resulting in the need to replenish keratin that has been lost from the cells beneath it. A cell that is beginning its life in the stratum germinativum has a life of 28 days when it reaches the stratum corneum. The stratum corneum is the top layer and consists of 25-30 layers of stratified, squamous dead keratinocytes that are being constantly shed (Romotowski 2001).

### The Layers of Skin



The dermis is much thicker than the epidermis, and its main function is to support the epidermis. The dermis consists of two layers, the papillary and the deeper reticular area (Ashbaugh 2004). The papillary layer is an area that contains loose connective tissue with fine elastic fibers, which then extend up into the epidermal as dermal pegs/finger-like projections and the deeper reticular layer as stated by (Ashbaugh 2004). There is a boundary between the epidermis and dermis where the two tissues are separated and it is known that these finger-like projections are there to support/strengthen the epidermis/dermis junction. According to Ashbaugh (2004) these finger-like projections increase the “surface area for the exchange of nutrients, oxygen, and waste products between the dermis and the epidermis” pg 3. As the dermal papillae get older, they tend to flatten and increase in numbers; however, they form groups and maintain the same size so that they tend to look smaller as stated by Ashbaugh (2004).

#### 1.3.2 Sweat glands

There are three major glands that are responsible for the secretion of sweat and they are called: eccrine, apocrine, and sebaceous glands respectively. Eccrine glands are usually found throughout the body, but its highest densities are found in the palms and soles of the feet. Sweat glands are increased in the soles of the feet and less on the back of an individual. Gland formation begins in the first trimester of foetal maturation on the palms and soles of the feet, and at five months on the rest of the body, the glands are then fully mature in the eighth month of maturation. Its structure resembles a tubule that contains a duct portion that moves down into the dermis in a helical movement as described by Romotowski (2001). This sweat gland tubule functions in reabsorbing substances such as sodium, bicarbonate, chloride and glucose. It also secretes amino acids such as serine, which is one of the abundant

amino acids that are of primary importance in the development of latent prints, as stated by Yamashita and French (2011). Overall Eccrine sweat contains approximately 99% water and 1% solids (sodium chloride and amino acids, urea and peptides), as stated by Ashbaugh (2004).

### 1.3.3 Subaceous glands

Subaceous glands resemble sack-like organs that can be found in the dermis layer of the skin. They are found throughout the body and mainly associated with hair such as the scalp, anus, and nose. They are also found in the mouth and face and are not found in the palms and soles of the feet. The secretions of these glands, empty out into the hair follicle before ever touching the skin's surface. Its function is to help in preventing sweat evaporation as described by Yamashita and French (2011).

The skin around the body is relatively smooth, and friction ridges are found on the digits, palms and soles of the feet as they are said to have a protective mechanism in assisting a person's ability to grasp and hold onto objects.

Friction ridges are formed in the stratum basale of the epidermis during foetal development and, these blue prints do not change except in incidences such as injury, disease, decomposition after death or injury to the basale layer which then leaves a scar.

The stages of friction ridge skin growth during foetal development is important for the identification specialist, as the persistency and uniqueness of fingerprints is then better understood (Ashbaugh 2004).

## 1.4 Fingerprint patterns

There are three main fingerprint patterns and they are known as: arches, whorls and loops respectively.

### 1.4.1 Arches:-

Arches are ridges that run from one side to the other and account for 5% of fingerprints that have been encountered. One common feature is that there is no delta point in an arch pattern (not usually seen). If seen, however, the delta point and

the core do not meet the recurving ridge. There are two subgroups in the classification of the arch pattern and they are called the plain arch and the tented arch. The plain arch has an even flow to it, where it starts on one side of the finger and then goes to the other side. It also appears to have a centred up thrust wave to it in the centre. The plain arch is one of the simple finger print patterns to study as stated by Frenette (2004).

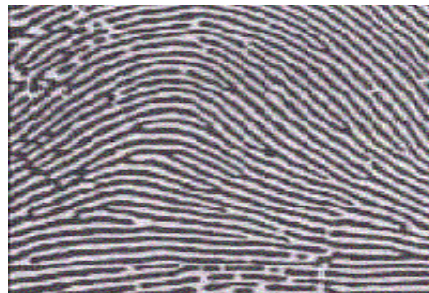


Figure 1: Plain arch pattern that gives an even flow impression, starting from one side to the other. In the centre, there is a wave-like up-thrust. There is no delta point noted.

#### 1.4.2 Tented arch:-

The tented arch is similar to the plain arch in the sense that it starts from one end and flows outward to the other end in the same way. The difference between the plain arch and the tented arch is that the tented arch has more of an upper angle where the ridges flow from one side and then converge and thrust upward in the centre giving a ‘tent’ appearance, as described by Frenette (2004).



Figure 2: The flow of ridges flowing from one side to the other. Notice the ridges in the centre of the print, it gives an upward thrust, hence the name given, tented arch. Frenette (2004).

#### 1.4.3 Loop:-

Loops are found to be in 60-70% of fingerprint patterns. The ridges of a loop pattern look like a reverse image when we look at ourselves in the mirror. The ridges give a

backward turn, but do not twist. The ridges of a loop pattern tend to start from one end and recurve and pass through an imaginary line between delta and core, and then pass out from where it started, as described by Frenette (2004). There is only one delta found in a radial loop pattern. There are two subgroups and they are called: radial loops and ulnar loops. There is only one delta found in a radial loop pattern. “The flow of ridges in a radial loop pattern is more of the direction of a radius for example towards the direction of the thumb and is commonly found in the index finger”.

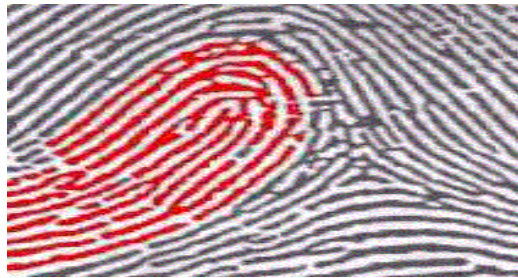


Figure 3: The flow of ridges starting from two sides of the print flowing in the direction of the radius gives a radial loop pattern. (Fenette, 2004).

#### 1.4.3.1 Ulnar loops:-

Ulnar loop patterns are named after the bone in the forearm, and the ridges run towards the direction of the little finger. Its appearance is basically the opposite of a radial loop pattern.

Below is an image of an ulnar loop pattern as described by Frenette (2004).



Figure 4: An ulnar loop pattern that looks the opposite of a radial loop pattern. Notice the delta point in the bottom left hand side. The directions of the prints are flowing from the direction of the thumb to the little finger.

#### 1.4.4 Whorls:-

Whorls have been found to be in 23- 35% of fingerprint patterns. Whorls are unique in that in the majority of times they appear to have a running circuit in the middle of the print. They also have more than one delta point and it is stated that if they have more than two delta points, then a whorl pattern is then defined. There are four subgroups of

whorls and they are: plain whorls, central pocket whorls, double loop whorl, and accidental whorls.

#### 1.4.4.1 Plain whorls:-

Plain whorls are the most common type of whorl patterns to be seen and they consist of ridges making a turn of one complete circuit and with two deltas. Below is an image of a plain whorl, taken by Frenette (2004).

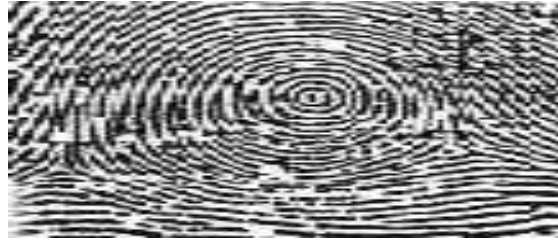


Figure 5: A plain whorl consisting of two delta points at each end of the circuit (bottom right and bottom left hand side) as described by Frenette (2004).

#### 1.4.4.2 Central Pocket loop whorl:-

The central pocket loop whorl consists of at least one recurving ridge or some might say an obstruction at right angles to the direction of flow, also has two or more delta points. There is usually a complete circuit seen as well. Below is an image of a central pocket loop whorl, taken by Frenette (2004).

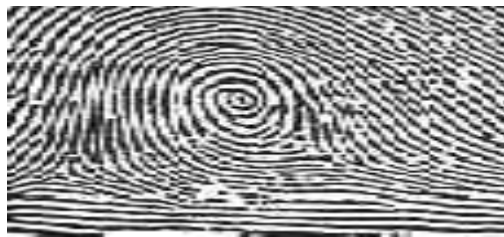


Figure 6: Central pocket loop whorl consisting of two delta points at the bottom left and right hand sides and a complete circular/ovalish circuit in the middle of the print and a recurve of ridges at right angles to the direction of flow.

#### 1.4.4.3 Double loop whorls:-

These prints are usually with two separate loop formation with two separate opposite sets of shoulder and delta points. Below is an image of a double loop whorl pattern, taken by Frenette (2004).



Figure 7: Double loop whorl pattern consisting of two separate loop formations with two separate opposite sets of shoulder and delta points.

#### 1.4.4.4 Accidental Whorls:-

Accidental whorl patterns appear to have two distinct types of patterns and with two delta points. Accidental whorls are also classified if ridges form a pattern that meets the requirements for two or more different types of patterns within the subgroups of whorls. They also consist of two or more than two deltas. Below is an image of an accidental whorl pattern, taken by Frenette (2004).

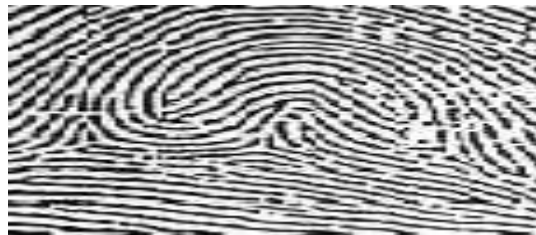


Figure 8: Accidental Whorl pattern appearing to have two distinct types of patterns and with two delta points.

### 1.5 The different types of fingerprints:-

There are three main types of fingerprint impressions that can be found in crime scenes by a forensic scientist/investigator in search of evidence as to a missing individual or for other identification purposes. The three main types of fingerprints are as follows:

#### 1.5.1 Patent Prints:-

Patent prints are visible prints where the majority of these prints are wholly visible to the unaided eye, not many methods are needed for the preservation of these. An example of a patent print can be seen when left on blood, paint, ink, grease, mud or dirt, which then leaves a clear friction ridge impression that is visible without

development. Light sources are a good measure for acquiring good patent impressions (Yamashita and French 2011).

### **1.5.2 Latent prints:-**

Latent prints are not easily seen to the naked eye and hence the meaning of latent, hidden or unseen. These prints are detectable once they have been treated with a physical or chemical process designed to enhance the visibility of prints (Yamashita and French, 2011). Frenette (2004) states that latent prints are formed from the sweat from sebaceous glands on the body or water, salt, amino acids and oils contained in sweat, which all create prints, and it is with chemicals reagents or fuming that these prints can become visible.

### **1.5.3 Plastic prints:-**

A plastic print is created when a print is found to be in a soft pliable surface (pushed into the substance), that then leaves behind at the time of contact the three dimensional aspects of the skin-friction ridge structure (Yamashita and French 2011). Soft pliable surfaces that can all retain plastic impressions include clay, wax, paint, melted and plastic, heavy grease. These impressions are enhanced when using oblique lighting because it can differentiate between ridges and furrows more easily. (Yamashita and French, 2011).

## **1.6 Forensic significance of fingerprints**

The scenes of crimes such as theft, drug trafficking, murders and so forth are important because these are crimes that need to be resolved so that criminals can be convicted of their crimes as stated by Sidebottom (2008). Without sufficient evidence, criminals would be allowed to run freely, people would continue to steal, murderers would continue to kill, drug traffickers would continue to deal and so forth, unless there was an eye witness at the time of incident which would therefore account for appropriate evidence (Sidebottom 2008). At present, police officers, detectives and forensic scientists use scientific analysis to convict criminals of their crimes, as compared to many years ago when science was not used and sufficient evidence was based on 'eye witnesses'. Fortunately, today science is used as a gold standard in solving crimes for example; any traces that are found at a crime scene can be traced to specific criminals via scientific evidence and therefore scientific evidence plays a crucial role when convicting criminals. The field of study dealing with criminal investigation is known as forensic science, which basically means the application of science to the law. Throughout history, appropriate evidence such as eyewitnesses

was classed as evidence to be used to convict criminals of the crimes that they have committed. In today's world, the methods of choice have dramatically changed to bring about more precise and accurate techniques such as with the use of forensic science- including fingerprints, which can be used to solve any investigation, as, stated by Sidebottom (2008).

## 1.7 Recovery of fingerprints

### 1.7.1 Latent prints recovered:-

As mentioned before, latent prints are prints that are hidden/unseen to the naked eye and are detectable once they have been treated with a physical or chemical process designed to enhance the visibility of prints, as stated by Yamashita and French (2011). The process in which latent prints are recovered depends entirely on the surface of the object in which the prints were left behind and the condition in which it was deposited (Van Hollen 2009). Van Hollen (2009) states that these surfaces can be divided into four categories:

1. Non-porous: glass, metals, plastics
2. Porous: paper, cardboard, cloth, unfinished wood
3. Semi-Porous: glossy papers, printed boxes
4. Sticky Surfaces: tapes labels adhesives

At a crime scene, an investigator/detective will look for latent prints on surfaces that the perpetrator could have left, for example, signs of forced entry from a front door and therefore the front door knob and the door surface would be the first steps in acquiring latent prints, claimed by (Layton, 2005). It is important not to touch non-porous surfaces when trying to acquire latent prints as it could destroy the evidence, and therefore the paragraph below explains the methods used in acquiring latent prints from non-porous surfaces.

### 1.7.2 Powders

Powders are one of the most useful methods for non-porous surface. Such powders include metallic silver and velvet black powder. Powders are commercially available in a variety of colours, and the type/colour of powder that is chosen depends on the colour of the material that holds the print (Layton, 2005). Grey (aluminium dust) and

black (carbon or charcoal) powders are often used for acquiring latent prints. Grey powders are used for dark coloured surfaces, whilst black powders are used on white or light coloured surfaces. Other powders such as fluorescent powders are used for ultraviolet light purposes (Ahmad and Musa 2002).

These powders will readily adhere to perspiration residues and / or deposits that have been left on the surface of objects once applied carefully with a fibreglass brush. Once the colour of powder has been chosen, for example the best colour contrast with the surface, the investigator will then gently brush the powder onto the chosen surface in a circular motion until a print is visible, and once the print is visible the investigator will then start brushing in the same direction in which the print ridges are facing. Before lifting takes place, a photograph is taken and then clear tape is then stuck onto the powdered print and moved back in a smooth motion into a fingerprint card that resembles the same colour as the powder (Layton 2005).

The disadvantage of the powder technique is that it will only work in the presence of moisture and therefore prints that have been left for days on surfaces will not adhere to the powders sufficiently, usually fingerprints require more than a general dusting for prints, as dusting which is usually used for non-porous surfaces is only useful if the prints are fresh and therefore other techniques need to be implemented in order to acquire or visualise the prints. The chosen techniques need to be carefully selected, as using an incorrect method can destroy the latent print evidence (Ahmad and Musa 2002).

### 1.7.3 Cyanoacrylate (Super Glue) fuming

Gaseous superglue is another method used to chemically enhance fingerprints on non-porous surfaces, mentioned by Karlinsky and Harkai (1990) and cited in Ahmad and Musa (2002). Dusting for fingerprints is pointless when latent prints need to be acquired after a short period of time, as sweat from the latent print will dry out. However, amino acids that have been left from the print can remain for several months depending on the right conditions, and it is with superglue that prints can be acquired. Superglue is said to have an affinity for these amino acids where superglue can bring these amino acids together and solidify around them, leaving a sticky image of the print. It is also stated that superglue reacts with proteins and fatty acids in the

latent print and it is the moisture of the air that enables the production of a visible sticky white material that forms along the ridges of the fingerprint as stated by (Ahmad and Musa, 2002).

Most common liquid superglues are either methyl cyanoacrylate or ethyl cyanoacrylate. In order to make latent prints visible, the constituents of sweat could be selectively fixed by using different chemical reagents such as ninhydrin reagent, iodine fuming and superglue fuming. Chemical reagents such as ninhydrin and eosin are used as a means of enhancing latent fingerprints on non-porous surfaces, (Ahmad and Musa, 2002).

In a situation where the investigator suspects that latent prints are on metals, glass, or plastics, Cyanoacrylate is poured into a metal plate to heat for about 120 F (Layton 2005). After the metal plate has been heated, it is then placed into a container such as an airtight chamber with a heat source and the object containing the latent print (Van Hollen 2009). An airtight container such as an aquarium is a good piece of equipment, as it avoids the operators from inhaling superglue fumes. It is the fumes from the Cyanoacrylate that make the latent prints visible (Layton 2005). The good advantage to this technique is that whilst the fumes are enhancing the visibility of the latent prints, it does not do anything to damage the prints, as claimed by Layton 2005). However, Van Hollen (2009) states that these prints may be difficult to see. Van Hollen (2009) also claims that some prints produce white deposits, which makes them more durable and it is the preferred method of choice when prints need to be stored for a long period of time prior to processing and also before powders are to be used. There are also a few factors that can affect the superglue process and they include room temperature, humidity, length of time the prints are fumed, and whether the superglue chamber is airtight as stated by Van Hollen (2009). Below is a photo of an airtight chamber, in this case an aquarium used for superglue fuming.



Figure 1: A photo describing the set up procedure for superglue fuming. The 'aquarium' has an airtight lid, a non-melting container to hold the glue (foil is recommended), a mug warmer that us used to heat superglue, a beaker of hot water to increase humidity and a can that is used to suspend items (wire is attached at the top of the chamber), as described by Van Hollen (2009).

#### 1.7.4 Ninhydrin

Ninhydrin for porous surfaces, ninhydrin can be used is sprayed onto the porous surface of an object and works by forming a purple-bluish colour with the presence of amino acids that have been left from perspiration. (Ahmad and Musa, 2002).

One of the good advantages of using the ninhydrin reagent is that it can be used in acquiring prints that have been left on surfaces as old as 15 years; however it has to be dissolved in an organic medium (drawback) as stated by Ahmad and Musa (2002).



#### 1.7.5 Iodine

Iodine is basically used in the form of solid crystals that change directly into vapour when heated, and the suspect material is placed into a cabinet with the iodine crystals and a heat source. Once the heat source has started, the resultant vapour will

combine with the elements of the latent prints in order to make the fingerprints of the suspect visible. Although iodine fuming is said to be the oldest method used for visualising latent prints, it also has some drawbacks for example, it reacts with residual water that has been left from perspiration in the suspects print .Another disadvantage is that the toxicity of iodine is a health and safety issue when using the method; also, the prints are not permanent and therefore need to be fixed (Ahmad and Musa 2002).



#### **1.7.6 Advantages and disadvantages of these methods**

The disadvantages of using cyanoacrylate have been found to be due to: getting hold of the required and uniform concentration and vapours in greater volumes; is difficult. Another issue is polymerization on the ridges of fingerprints and the surrounding surface of the object, leaving the resultant coating being difficult to remove, as the surface is linked by chemical bonds such as with calcium ions which are converted once deposited into oxide or carbonate and this results in further reactions being too slow for any practical use, claimed by (Ahmad and Musa, 2002)

Ahmad and Musa (2002) conducted a study based on the conditions that were necessary for effective use of superglue fuming, ninhydrin reagent and eosin reagent for the visualisation of fingerprints. Superglue fuming was used on non-porous surface types such as an aluminium sheet, a transparent plastic bag and a glass Petri dish, and the method was all found to be effective in all cases for the enhancement of fingerprints. The visualisation of these latent fingerprints was highly dependent on the size of the tank and humidity of the air, which was the same as of ambient conditions and the heating temperature of superglue fuming was in the range the 40-50 C, compared to the normal boiling points for most superglues at 49-65 C. Prints were developed within two hours and up to 3 months for plastic bags and 1 week for

aluminum sheets; however it took up to 2 days for latent prints to be developed from glossy flash cards.

The ninhydrin technique was used on porous surface types such as white writing paper and manilla cards, which all developed as purple prints due to the reaction of ninhydrin with the amino acids from sweat. Good quality prints started to appear within an hour and lasted up to 24 hours and then became weaker. One of the problems that were found with the ninhydrin technique was the coloured background interference which then made it harder to visualize the prints on some surfaces.

The Eosin technique was used on non-porous surface types such as glossy flash cards and white plastic wrappers. This technique involves the use of a phase transfer catalyst to fix the calcium ions in sweat such as *t*-butyl ammonium iodide and to speed up the reaction between the insoluble calcium and eosin. The latent prints were quickly developed within 5-10 minutes giving pink coloured impressions. Good quality impressions were seen on white papers, but not on other coloured paper such as red or pink. Good quality prints were also detected from glossy flash cards that had been left for up to 1 week and also detected that the prints could be left for up to 3 months with visualization being satisfactory, due to the interaction of calcium ions and the cellulose paper. These findings can show us that fingerprints can be lifted from other non-porous surfaces, such as laminated and smooth surfaces for example on documents such as driver licence cards, identity cards and credit cards.

### **1.8 Submerged items:-**

The reason, for which submerged items are recovered, as a means of evidence in matching the prints with a criminal/defendant at a setting such as water, is due to the increase of recreational waterway usage such as accidents, drowning, violent crimes and murders. An increase in incidents where criminals feel that weapons and other wrongful evidences are thrown into water have also increased as stated by Becker (2000). Becker (2000) explains that due to the influx of criminals seeking such methods for example, to use recreational waterways as a means of hiding such evidence, it has now caused the law enforcement agencies and other professionals in the field to become more involved in underwater recovery operations. Historically, it was fire departments that provided personnel trained in search and rescue diving,

when incidents occurred that needed the retrieval of evidence that had been submerged in water. Law enforcement agencies believed that the need to retrieve evidence from submerged water was nothing more than ‘the salvage operation’ and that divers did not need to have special skills in the handling and processing of what may have been important evidence. (Becker, 2000) over time, their belief was then questioned with regards to what could have been missed in the salvage process. They asked whether conclusions from pictures, measurements and photographs were satisfactory What remained untold due to the failure of properly handling, processing and packaging of evidence, which then caused a missing study/analysis when it came to forensic scientists in doing their job? Is salvaged material of value if it cannot be matched up with the defendant?

Processes in the analysis and conclusions of submerged items, from investigators to forensic scientists in the crime laboratory can become useless if evidence cannot be properly discovered, or is ignored or contaminated (Becker 2000).

According to Becker (2000) there are some myths or misconceptions that certain agencies cling to regarding for instance, the ultimate objective and composition of the dive recovery team; the forensic value of submerged evidence; the assumptions concerning accidents and the ability to locate submerged items geographically, mentioned by Ogloff and Pfeifer (1992), cited by Becker (2000).

**1.8.1 The ultimate objective of the dive recovery team -Myth 1:-**It is stated that the Becker (2000) “The dive recovery team’s ultimate objective is to recover a submerged item”. If agencies still believe in this conception then it is thought that the diver’s ultimate goal is to retrieve the item and return it safely. Becker (2000) believes that these are admirable objectives but still remain shortsighted in terms of law enforcement policies, perspectives and so forth. Becker (2000) argues that the need to convict criminals for their crimes with the help of underwater recovery emphasises the true objective of the dive recovery team.

**1.8.2 Composition of the dive recovery team- Myth 2:-**

It is stated that the Becker (2000) “The dive team is made of a primary diver, safety diver, line tender, on scene commander, and others involved in the process

respectively”. By reading the former myth, this one even becomes interesting, as when a criminal becomes convicted of a crime he/she has committed, agencies recognize that the primary objective of winning convictions lies with the dive recovery teams; they also begin to realize that other personnel such as investigators and crime laboratory personnel are dive recovery team players as well. It is also worth mentioning that the “first responding officers set the tenor of underwater investigations” stated by Becker (2000) pg 2. These officers have the responsibility for ensuring crime scene integrity, acquiring witness identifications, authorizing and setting unauthorized entrances for wanted and unwanted individuals; recognizing potential locations/sites of potential evidence (entry and exit); protecting the sites and so forth. As these members of staff (officers) play a major role in the underwater investigation process, agencies should train them in the theory/basics of processing an underwater crime scene, including what they must protect, and also mentioning the roles of other team members. Is also stated that often members of the dive recovery team, such as investigators, crime laboratory personnel and prosecutors, lack an understanding of the scientific field in approaching true evidence. For example, divers need to realise that submerged evidence has the same value as evidence found on land, and therefore investigators may then fail to understand that their job role includes the need to collect samples of water from the bottom and surrounding areas so that a ‘control’ can be used in the laboratory. A control is useful in the laboratory as it can exclude background contamination, and any traces of evidence that may have been left (Becker 2000).

### **1.8.3 Forensic value of submerged evidence Myth-3:-**

It is stated that the Becker (2000) “All submerged evidence is bereft of forensic value”. This could be due to examinational findings on submerged evidence; for example, in an investigation, investigators may find fibre evidence on the body of a murder victim when the body was disposed of in a river by the perpetrator, as stated by Deadman (1984) cited in Becker (2000). Often submerged items are potentially valuable sources of evidence; however, this myth explains the assumption that investigators may unknowingly overlook contaminated items/destroy the items during the recovery process Becker (2000).

### **1.8.4 Firearm recovery**

Firearm recovery: firearms are practically difficult to recover from water, as there have been many failed attempts. There are a few places in the firearm that can still retain fingerprints and these include: protected surfaces such as lubricated areas, for example, the magazine of a semiautomatic pistol or the shell or the shell casing of the rounds of the magazine where the perpetrator's thumb was pushed into the magazine. Weapons used in contact wounds can also carry valuable sources of evidence such as blood, tissue, bone, hair and so forth which is stored on the barrel of the firearm ( Spitz ,1993), cited by Becker (2000). When firearms are deposited into water, the barrel is the first place in which water will reside, and will therefore create a block for any material to reside in the barrel. The valued evidence resides there until a pressure such as an improper recovering technique is used and all or most of the valuable evidence has been removed/lost. An improper technique includes the handling of the barrel and lifting the weapon above the head after surfacing the water. This drains all the contents and loses potential evidence. It is now noted that if firearms are found underwater, the diver needs to package and handle the weapon underwater carefully to retain all valuable evidence.

#### **1.8.5 Accident assumptions-drowning-myth 4:-**

“All drownings are presumed accidents”. According to Becker (2000), experienced homicide investigators presume that all unattended deaths are to be pronounced murders, unless proven otherwise, except when deaths are in water. Many investigators have been found to recover presumed accidental drowning victims and have found other meaningful evidences to suggest that the cause of death was not accidental. Becker (2000) states that it is important for investigators to treat ‘accidental drowning’ with the same investigation protocol as that which is met on land.

#### **1.8.6 Air disasters:-**

Air disasters are presumed disasters which are another myth that lies under the heading of accidental assumptions. Aircraft crashes can happen in every part of the world and the majority of aircraft crashes are found in water such as the ocean, rivers and lakes, due to the fact that most of the world is covered in water. If investigators assume that aircraft crashes are accidents, they could destroy crucial evidence, and may overlook contaminated evidence that could have been the result of a criminal intervention. According to Becker (2000), the two most important goals for investigators in aircraft underwater operations are to try and identify the passengers and to figure out the cause of the incident.

#### **1.8.7 Geographical retrieval – myth 5:-**

“It is not necessary or possible to locate submerged items geographically”. This myth is said to evolve due to the fact that most underwater recovery operations are on sites with limited visibility. However, when it has been found that a vehicle accident has occurred, the investigator can tell the direction in which the vehicle was travelling and approximately the speed of impact. Another example mentioned by Becker (2000) could be the position of a weapon, if a witness recalls the perpetrator disposing of the weapon in a certain place and the investigators finding it in another direction, questions could then be focused onto the witness. It is very important for investigators to mark their site when underwater operations are taking place as lack of marking sites can result in more time being taken to search for the desired location, and loss of potential evidence, more diving becoming necessary, inability to orient parts of a vehicle, firearm, aircraft and so forth.

Due to an increase of incidents occurring underwater, agencies are now overlooking all these myths and taking a closer look, and are now understanding the complexities that occur in underwater operations such as the recovering process and, most importantly, to not look at it as just an underwater salvage operation. Agencies now appreciate the forensic value of submerged evidence and the processes and investigational steps that need to be in place for underwater operations such as aircraft crashes, as well as the need for highly skilled diving personnel in solving crimes (Becker, 2002).

### **1.9 Studies of latent print detection on items recovered underwater**

Nelson conducted a series of experiments in order to detect fingerprints on items submerged in water on sequential days, and at the same time testing two different methods used for the enhancement of prints. The first part of the experiment involved the usage of several large tubs of water that were used to hold pieces of angled aluminium cut into two-inch sections. Before putting the pieces of angled aluminium into the water tubs, they were first cleaned with alcohol swabs, left to dry and then printed on the outside faces. Three pieces of aluminium were taken out each day to then be subjected to powdering and then each piece to be subjected to cyanoacrylate fuming. Negative controls consisted of the inside faces of the tubs of water, whilst the positive controls consisted of the prints which were tested by each method daily. For this experiment, it was concluded that when the prints were drawn from the water, prints were detected and enhanced on all pieces using both methods; however the results were inconsistent, for example, on one day prints were detected whilst on other days no prints were detected and some prints had less detail than others.

In another experiment, Nelson used glass slides as another type of surface to test for prints. The glass slides were also cleaned with alcohol swabs, left to dry and then printed twice on one side and then dropped into the tubs of water. Just like the aluminium method, three glass slides were tested daily and were also subjected to powdering and then each glass to cyanoacrylate fuming. The results showed that on each day, all the glass slides had prints on them and that both the methods used for enhancement worked well however the disadvantage was that the quality of the prints degraded as days went on. It was also stated that transport could not be a factor that could have an effect on this experiment, as the slides were taken out of the tubs of water after being transported to the laboratory.

In the last experiment, Nelson used spent pistol cartridges as another type of surface to test for prints by using the same principle of methods used in the two former methods. Three cartridges were tested with prints facing on either side of the shell. The results showed that prints were detected on the firing pistols cartridges and could also be enhanced using both the methods, for example, powdering and cyanoacrylate fuming.

Decent pictures of the enhanced cartridge prints could not be established; however the shells were available for examination. The powdering method produced a more clearly visualized print than the "super glue" fuming followed by powdering.

From all the experiments conducted, it was concluded that the basic principle of detection of prints after several days of immersion was very good. It was also stated that the experiment was carefully designed but that it could not reproduce the true effects of items that had been thrown into a river, lake or ocean for several days. True items, such as when a perpetrator has tried to hide weapons in water and they have been left there for several days, probably would not be handled carefully enough to keep the prints intact. Factors such as currents, bottom mud and among others could cause degradation of the appearance of prints. However, Nelson suspects that it could be due to a "real world" effect that aluminium is inconsistent with the results or glass slides and brass pistol cartridges. It was also suggests that a thorough investigation using natural and realistic conditions with greater times spent under water, more types of surfaces and other methods of detection and enhancement need to be studied.

## 2. Experimental method

To begin with, fingerprints were taken from different people from different countries on non-porous surfaces like glass. These prints were immersed in different types of water; before immersion in water the initial clarity of the fingerprints was confirmed, and then the fingerprints were left in the water to study their stability.

The equipment used in the study included different types of water. The types of water used were: tap water; canal water; sea water and deionised water. These types of water were each placed in a plastic basin; then the fingerprints were individually immersed in the different types of water on a glass slide.

Chemical substances were also used to examine the fingerprints. The chemicals used for non-porous surfaces were super glow and aluminium powder.

To retain the fingerprints, glass slides were chosen because they are clean and pure, without risk of contamination.

The fingerprints were chosen carefully. Fingerprints from people of different nationalities were taken in order to study and note the existence and extent of the impact of different native weather conditions and different eating habits on the strength of the fingerprint and the fingerprint's resistance to different types of water.

The types of water were also carefully selected. Different types of water were chosen like canal, sea, tap and deionised water, to see if they had the same effect or not. This is because the fingerprint is made up of fat, amino acid and water, so the study hoped to find out how each type of water affects the fingerprint and how long the fingerprint can be resistant to the different types of water.

5L plastic bowls were used to contain the water, and 4.5L of each type of water was added to the bowl. This allowed easy access to examine the slides, as well as allowing normal air flow at the surface of the bowl. After the slides were immersed in the bowls, the water was not changed, and the slides remained in the water as long as the fingerprints remained clear, which in some cases was more than a week. The slides were suspended in the water on lengths of string, to which they were attached by small clips.

The fingerprints were checked daily. To check them, the slides were removed from the water and allowed to dry naturally. When they were dry, they were first examined visually, and then with a microscope. The results were recorded photographically, and measurements taken to compare the condition of the prints at each inspection with their original condition before immersion.

The prints were also evaluated for clarity, in other words, the ability to see the ridges and the characteristics of the fingerprints clearly, in order to be able to compare the fingerprints and identify them. Clarity was recorded in terms of 1st, 2nd and 3rd level detail.

### Level 1

Includes a general flow of the character and composition style. Level 1 is not enough detail for the identification of an individual, but can be used for exclusion. Level 1 may include details of guidance and information to enable the core and delta location, and discrimination of a finger against the palm, (Ashbaugh, 2005).



Figure that show the loop, arch, and whorl patterns described by Witzke, (2011).

### Level 2

Includes details of the configurations, as specified from the end of the character, bifurcation point, or combinations thereof. The relationships at level 2 are able to give individual details, (Ashbaugh, 2005).

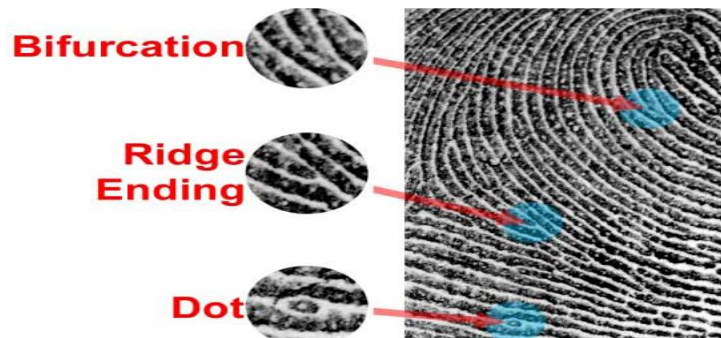


Figure that show the level 2 described by Witzke, (2011).

### Level 3

Includes all the features of details of dimensions of a series of ridges, such as the deviation of the path of the character, width, shape, and pores, edge contour, and the ridges and, breaks, wrinkles, scars and other details of permanent features, (Ashbaugh, 2005).



Figure shows the level 3 features (deviation of the path of the character, width, shape, and pores, edge contour, and the ridges and, breaks, wrinkles, scars). Described by Witzke, (2011).

The clarity of the prints was expressed on a scale from 5 to 0. The different points on the scale were defined as described below:

5: Very clear, very easy to identify. (Level 3)

4: Ridges very clear even to the naked eye. (Level 3)

3: Can see some ridges and characteristics. (Level 2)

2: Can see a few ridges and characteristics but not enough for comparison. (Level 1)

1: Cannot see ridge and characteristics at all. (Level 1)

0: Not any ridge and characteristics (not prints) can be developed. (Not any level)

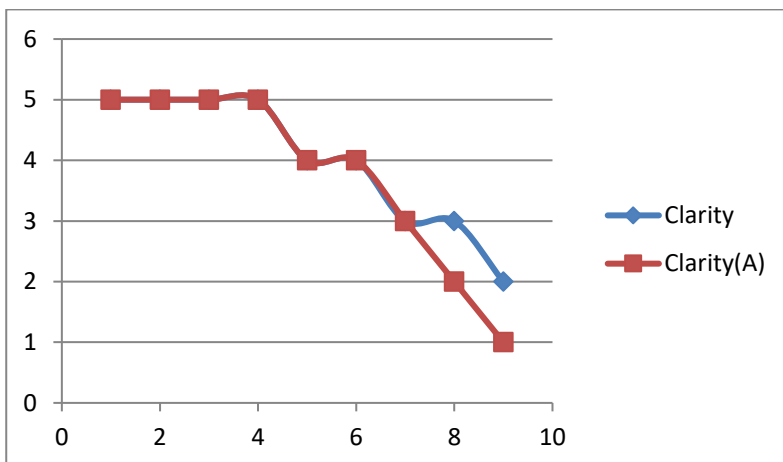
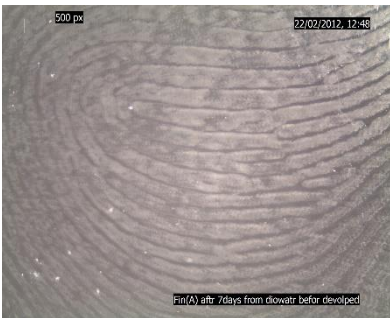
### 3 Results and Discussions

This test was conducted for two people, one from Africa and the other from the UK. The results were as follows:

The effect on the fingerprints and the vulnerability of the prints differed depending on the person and not the type of water.

#### 3.1 Deionised water:-

Deionised water had a strong impact on the print from the person from the UK, while for the fingerprint from the person from Africa, the effect was not so strong and the print remained clear for a longer time than the one from person from the UK.

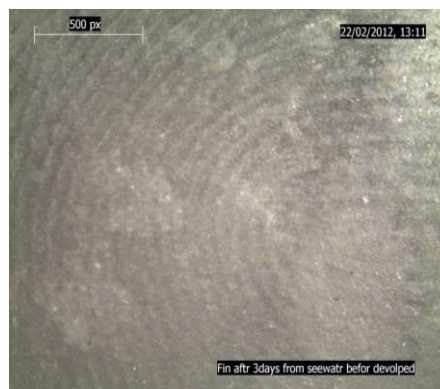


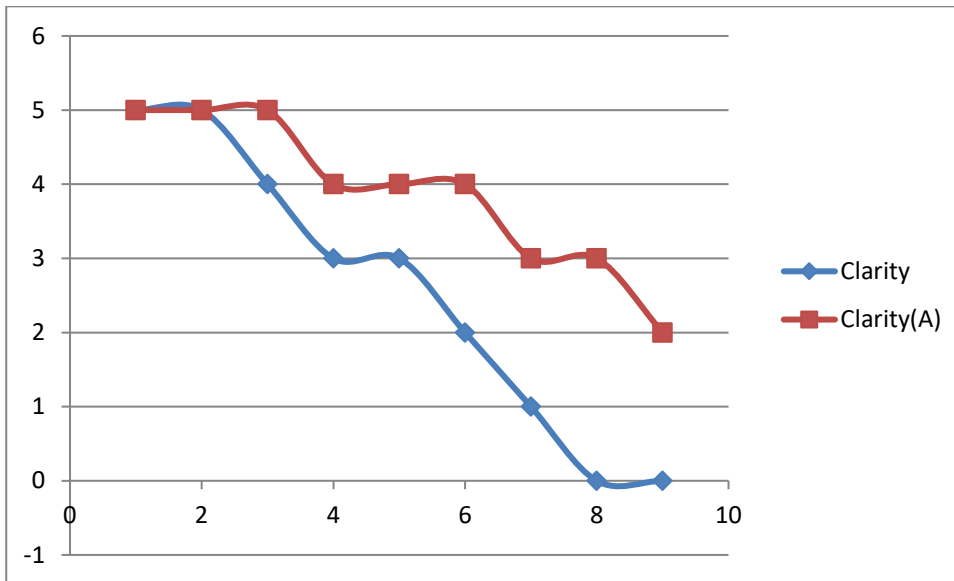
Days are on the x-axis and Clarity is on the y-axis.

Figure1 Clarity of fingerprint in **Deionised water** over a period of days, comparing different countries.

### 3.2 Sea water:-

Sea water had a strong impact on the fingerprints of the person from the UK, while for the prints from the person from Africa, the effect was not so strong and the print remained clear for a longer time than that from the person from the UK.





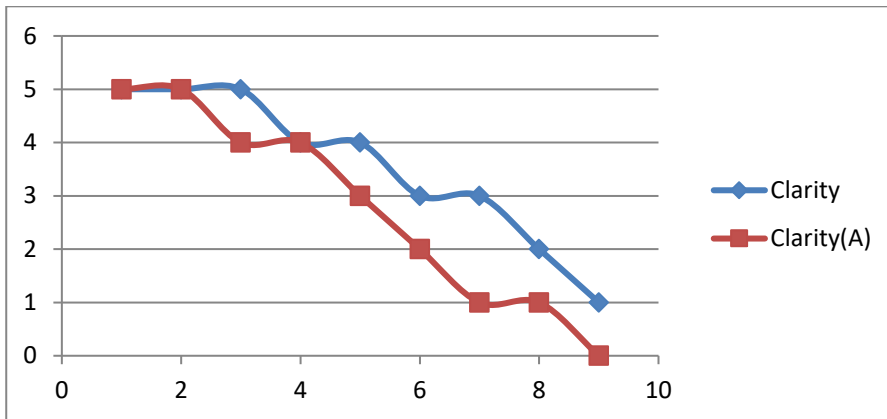
Days are on the x-axis and Clarity is on the y-axis.

Figure2 Clarity of fingerprint in **Sea water** over a period of days, comparing different countries.

### 3.3 Canal water:-

In canal water the fingerprint from the person from the UK remained clear for a long time compared to the print from the person from Africa.





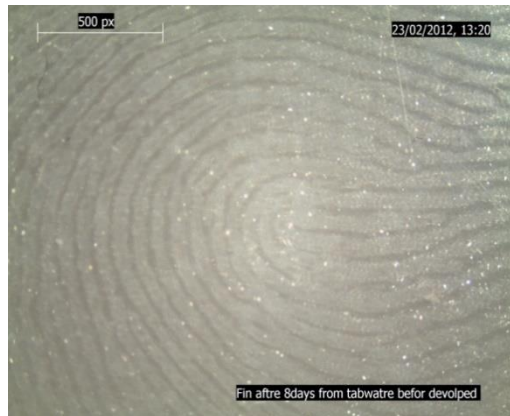
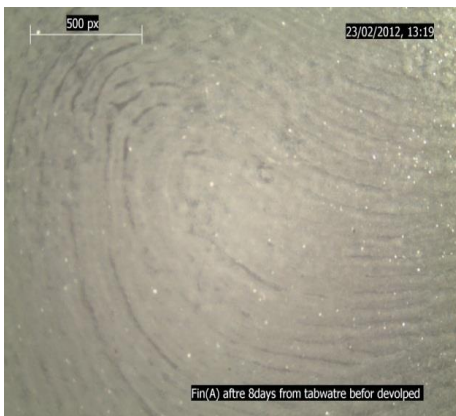
Days are on the x-axis and Clarity is on the y-axis.

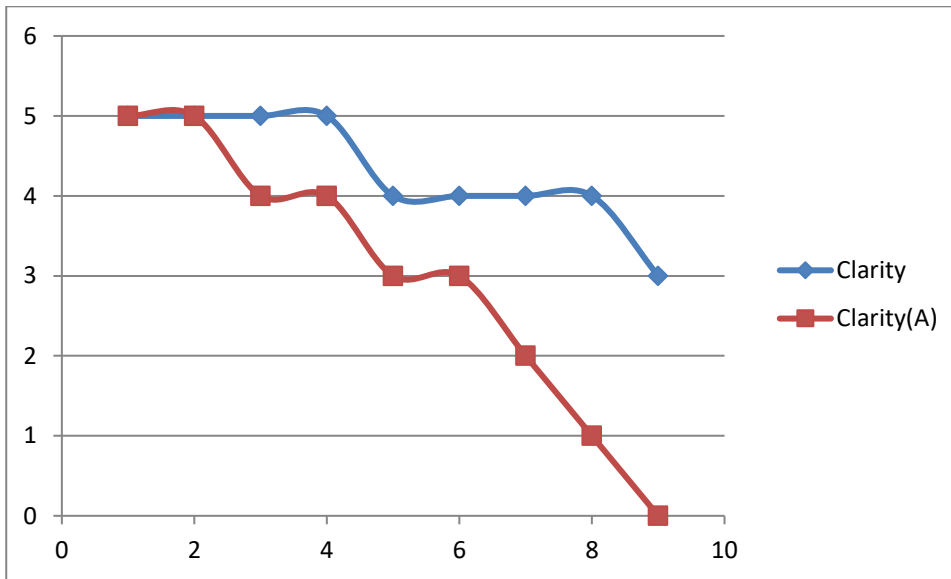
Figure3 Clarity of fingerprint in **Canal water** over a period of days, comparing different countries.

### 3.4 Tap water:-

Tap water showed no visible difference in effect.

The same experiment was repeated on fingerprints from two people from Africa and two from the UK.





**Days are on the x-axis and Clarity is on the y-axis.**

Figure4 Clarity of fingerprint in **Tap water** over a period of days, comparing different countries.

**The results were as follows:**

The differences in the strength and clarity of the fingerprints varied according to the person, where one of them was strong and the other was not clear. There were some limited differences in the effects depending on the type of water, which will be discussed in the next section.

#### 4 Conclusions

This study had two aims, which were to assess the effect of ethnic and environmental factors on the stability of fingerprints when immersed in water for a sustained period of time. The second aim was to evaluate the effect of different types of water on the stability of submerged fingerprints from individuals who are of different ethnic and cultural backgrounds, and to assess the length of time before these prints deteriorated. Although the results were not conclusive, the prints from the person from Africa appeared to remain stronger and to deteriorate less quickly over a period of time than those of the person from the UK, in both deionised water and sea water. The result from sea water may be because the person from Africa lived close to the sea, which may have caused physiological changes which affected the composition of his

fingerprint, making it more resistant to the effects of sea water. On the other hand, the print from the person from the UK was less affected when immersed in the canal water, which again may be the result of physiological factors caused by the effects of his native environment. However, this was a limited study and further research would be needed to test this theory further. It should also be noted that the prints immersed in tap water showed no significant difference in the rate of deterioration.

In general, however, the effect of different types of water was relatively small, and in most cases one fingerprint (the one from the person from Africa) was stronger and deteriorated less after submersion regardless of the type of water. This suggests that the strength of a fingerprint and how clear it is depends on the nature of the person, and may be affected by the type and quality of food and drink consumed, and the climate. There is therefore a need for further, more detailed research into the effects of a person's environment and habits on fingerprints. For example, how do factors such as climate, what a person eats and drinks, drugs they have taken and so on, affect the strength, clarity and durability of their fingerprints? It is likely that the climate and other geographical aspects of where a person lives may affect their physiological system, which will in turn have an effect on the sweat and fatty acids left behind in a fingerprint. For example, a person living near the sea will have physiological differences from a person living inland. Similarly, warmer temperatures may have an effect, due to the need to drink more, and the production of more perspiration, which again can affect a person's print.

Drugs also can have an effect on a person's fingerprint, since drugs contain amino acids, which will be evident in the print.

### **Future work**

This raises a further area for possible research, in terms of investigating other possible reagent materials for fingerprint analysis to assess a person's consumption of drugs. For example, ninhydrin can be used to determine amino acids in a print, but there are other materials, such as those used in drugs analysis, which could be investigated for use in fingerprint science.

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