



# ENVIRONMENTAL EFFECT ON DIFFERENT TYPES OF BLOOD STAINED FABRICS

<sup>1</sup>Shruti Gad, <sup>2</sup> Rajee Johnson

<sup>1</sup>Student, <sup>2</sup>Professor,

<sup>1</sup>Department of Forensic Science,

<sup>1</sup>Garden City University, Bengaluru, India

**Abstract :** Bloodstain pattern analysis plays a crucial role in forensic science, providing valuable information about the sequence of events at crime scenes. However, various environmental elements—such as temperature, humidity, sunlight, water, and the presence of contaminants— can significantly alter the appearance, distribution, and chemical properties of bloodstains. These changes may challenge accurate forensic interpretation. Additionally, the type of fabric on which the blood is deposited—like cotton, polyester, denim, or satin—affects how the blood is absorbed, how it spreads, and the final shape of the stain, adding another layer of complexity to the analysis. This research investigates the effects of different environmental conditions on bloodstains across several commonly used fabrics through carefully controlled experiments. Blood samples were subjected to particular environmental influences for defined durations, and observations were made regarding changes in blood stains. The stain colour was assessed through visual inspection, pH levels were determined using Universal pH paper, clotting was tested with hydrogen peroxide, and the ABO blood group was identified using the Absorption Elution method. A comparative assessment was conducted to evaluate how various fabric types and environmental exposures influenced these changes. This study can be applied to improve the interpretation of bloodstain evidence in crime scenes exposed to various environmental conditions. By understanding how these factors alter blood characteristics over time, forensic experts can more accurately estimate the age of bloodstains, determine the sequence of events, and assess the credibility of witness statements ultimately enhancing the reliability of crime scene reconstructions.

**Key Words:** Bloodstain analysis, Environmental factors, Fabric types, Stain morphology, ABO grouping, Forensic interpretation, Crime scene reconstruction

## I. INTRODUCTION

Blood is the one of the most important forms of evidence found at the scene of crime [1]. It is the key component for forensic investigation. It is mostly found on victim's clothing or any other physical evidence but it is often affected by environmental factors. These environmental factors degrade the bloodstains and other biological evidence, in some cases it is seen that the blood stains are almost washed off due to environmental factors. [1]. As the blood stains on any fabric age, they tend to become darker and brittle due to breakdown of hemoglobin and it becomes difficult for investigator to analyse the blood stains. [2]. Blood stains are mostly used to reconstruct the crime scene by following the patterns of the blood staining.[1]

Blood plays a crucial role in identifying the individual through ABO blood grouping and DNA analysis. [5]. The ABO blood grouping system has been discovered by Karl Landsteiner, he identified A, B, O and AB blood types in 1900.[7]. Various environmental factors affect the blood morphology and its antigenicity found on fabrics [8]. Human blood tends to dry faster and coagulate slower as it contains high concentration of platelets.[2]. Environmental factors significantly influence the stability and appearance of bloodstains. Temperature, for example, affects how quickly blood dries. In warmer climates, blood tends to dry faster,

leading to coagulation and a colour change [2], which can make forensic interpretation more difficult. In contrast, colder temperatures can help preserve blood for longer durations by slowing down decomposition, though this may hinder certain forensic procedures. Humidity also plays a critical role—high humidity delays drying and increases the risk of bacterial degradation, while low humidity encourages quicker drying and crust formation. Sunlight, especially ultraviolet (UV) rays, can degrade hemoglobin, resulting in colour changes that reduce the visibility of the stain over time.

Moisture or rainfall may dilute or eliminate bloodstains, posing challenges for investigators. Wind and airflow can speed up drying but may also spread blood droplets, interfering with the analysis of blood patterns. Furthermore, exposure to chemicals like cleaning products or pollutants can alter the chemical makeup of blood, potentially compromising forensic findings. Environmental conditions can further impact the state of fabrics, adding complexity to forensic investigations. Prolonged exposure to ultraviolet rays from sunlight can weaken fabric fibers, causing discoloration and deterioration. Moisture can lead to fabric rotting, Mold growth, or weakening of fibers, potentially altering the quality of bloodstains. Extreme temperature changes may cause certain fabrics to become brittle or cause fibers to expand, influencing how blood interacts with the material.

It is crucial that all the evidences must be collected from the crime scene to identify the potential biological samples from victim or suspect [1]. As the degradation of blood may lead to loss of colour, making it harder for identification and differentiation.

The primary objective of this study is to investigate how different environmental conditions such as exposure to sunlight, low temperatures, ambient room temperature, and damp underground soil affect various characteristics of blood. These include blood group identification, clotting patterns, colour changes, and the overall degradation process. Gaining insight into how these environmental factors influence bloodstains is crucial in forensic science, particularly in determining the timing and circumstances surrounding blood deposition on surfaces or fabrics.

Environmental influences can significantly affect the detectability of blood groups, alter pH, influence clotting behaviour, change the color of stains, and speed up degradation, all of which are vital for accurate forensic analysis. This research aims to overcome a major challenge faced by forensic investigators differentiating between fresh and aged bloodstains and evaluating whether environmental conditions have compromised the evidential quality of the blood. However, prolonged exposure to sunlight can lead to the photodegradation of hemoglobin making blood group identification more difficult. Likewise, microbial activity in wet soil can accelerate the breakdown of biological components, reducing the stain's viability for forensic testing.

### **NEED OF THE STUDY.**

Bloodstains found at crime scenes are essential pieces of biological evidence. However, their integrity can be compromised due to various environmental exposures like sunlight, cold, moisture, and soil burial. These factors can lead to discoloration, degradation, clotting, and antigen deterioration, thereby affecting blood group identification and forensic interpretations. Additionally, different types of fabrics (cotton, polyester, denim, satin) absorb and retain blood differently, which further complicates forensic analysis. Therefore, it is vital to understand how environmental influences and fabric types impact the characteristics of bloodstains to improve the accuracy and reliability of crime scene reconstructions and evidence analysis.

### **3.1 Population and Sample**

The study involved a single known human blood sample (B positive). Four types of fabrics—cotton, satin, denim, and polyester—were chosen. Each fabric was stained with blood and subjected to four distinct environmental settings: direct sunlight, room temperature, cold storage, and moist underground soil. A total of 480 samples were prepared (4 fabrics × 4 environments × 30 days). Each day, a new set of samples was analyzed for 30 days to monitor changes in stain color, clotting, and blood group retention.

### **3.2 Data and Sources of Data**

Data for this research were collected from freshly stained fabrics exposed to controlled environmental conditions. Observations were made daily on stain color transitions, presence or absence of clotting, and the persistence of identifiable ABO blood group antigens. Analytical techniques included visual examination, clot detection using hydrogen peroxide, and the Absorption-Elution method for blood grouping.

### **3.3 Theoretical framework**

This study is grounded in forensic serology and environmental degradation theory. It explores how external factors

## **RESEARCH METHODOLOGY**

### **Sample collection and preparation:**

Fresh blood from an individual with known blood group 'B positive' was collected. Four different types of fabric (cotton, Satin, Denim, Polyester) were selected. A drop of blood was placed on the center of each fabric sample. Each type had 30 samples allocated to each environmental condition, making a total of 480 samples (4 fabrics × 4 environments × 30 days samples). The stained fabrics were placed in four different mediums: Direct sunlight exposure, Room temperature, Cold environment (refrigerated), Underground moist soil. Each day 4 stained samples (one from each fabric type under the same environmental condition) was examined.

**Analysis:****Procedure:****1. Visual Examination of Stain Colour**

A direct visual inspection of each stain was carried out. Observations were made for any noticeable changes such as discoloration, fading, or hue variations, with attention to differences based on fabric type.

**2. Clotting detection using hydrogen peroxide**

A few drops of hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) were applied to the stained area. The reaction was observed for bubbling or effervescence. A strong reaction indicated that the blood was fresh and unclotted, while a weaker reaction suggested clotting had taken place.

**3. ABO blood grouping**

- Take clean and dry slides which are having wells.
- Cut the blood stain and remove threads and stick thread to the wells.
- Add anti-A serum, anti-B serum and anti-H lectin respectively and keep at 4°C for overnight
- Then remove the antiserum and give 3-4 washings with ice chilled 4. normal saline.
- After the last wash remove whole of the normal saline and add one drop of fresh normal saline.
- Incubate the slides for 50-60 °C for 15-20 minutes.
- Add drop of 0.2 -0.5% A, B and O indicator cells in the respective wells and keep at 4°C for half an hour.
- Shake and examine the contents for agglutination both macroscopically and microscopically.

**3.1 Population and Sample**

The study involved a single known human blood sample (B positive). Four types of fabrics—cotton, satin, denim, and polyester—were chosen. Each fabric was stained with blood and subjected to four distinct environmental settings: direct sunlight, room temperature, cold storage, and moist underground soil. A total of 480 samples were prepared (4 fabrics × 4 environments × 30 days). Each day, a new set of samples was analyzed for 30 days to monitor changes in stain color, clotting, and blood group retention.

**3.2 Data and Sources of Data**

Data for this research were collected from freshly stained fabrics exposed to controlled environmental conditions. Observations were made daily on stain color transitions, presence or absence of clotting, and the persistence of identifiable ABO blood group antigens. Analytical techniques included visual examination, clot detection using hydrogen peroxide, and the Absorption-Elution method for blood grouping.

**3.3 Theoretical framework**

This study is grounded in forensic serology and environmental degradation theory. It explores how external factors (temperature, humidity, light, and microbial activity) and fabric composition influence the chemical and physical characteristics of bloodstains. The research builds on principles of hemoglobin degradation, clotting behavior, and antigen stability to assess how time and environment affect forensic evidence. The study also considers the absorption and retention properties of various fabrics, providing a theoretical basis for evaluating how material and environmental conditions interact to impact blood evidence analysis.

## IV. RESULTS AND DISCUSSION

### 4.1 Results

#### a) Visual Colour examination

##### 1. Cotton

Table 1.1 shows the colour change of blood stain on cotton fabric under various conditions

Time period	Underground	Sunlight	Cold temperature	Room temperature
1 <sup>st</sup> - 5 <sup>th</sup> day	Red to dark red	Red to dark red	Red to dark red	Red to dark red
5 <sup>th</sup> - 10 <sup>th</sup> day	Green to black	Maroon to dark brown	Dark red to red brown	Red to brown
11 <sup>th</sup> - 20 <sup>th</sup> day	Green to brown	Dark brown to brown /black	Red to brown	Dark brown
21 <sup>st</sup> - 25 <sup>th</sup> day	Brown	Brown to black	Red to brown	Dark brown
26 <sup>th</sup> - 30 <sup>th</sup> day	Dark brown	Brown to black	Red to brown	Dark brown

The table illustrates the progression of bloodstain color over a 30-day period. Initially, all samples appeared red, and by the second day, the color shifted to dark red, remaining stable for the next 2–3 days. Significant color variation was observed in the sample on cotton fabric buried in moist underground soil. By the 5th and 6th days, the stain color changed from green to reddish, indicating fungal growth. From the 7th to the 21st day, the stain color ranged from green to brown, eventually turning fully brown by the 22nd day. By the 26th day, the stain had become dark brown. In direct sunlight, the stain changed to dark brown by the 5th and 6th days and maintained that shade until the 19th day. From the 20th to the 30th day, the stain darkened further, turning brown to black. Under cold conditions, the stain shifted to a red-brown hue by the 6th day and remained consistent through to the 30th day. At room temperature, the stain transitioned to a red-brown shade between the 5th and 11th days, and then turned dark brown from the 12th day onward, staying that way until the 30th day.

##### 2. Polyester

Table 1.2 Shows the colour change of blood stain on polyester fabric under various conditions

Time period	Underground	Sunlight	Cold temperature	Room temperature
1 <sup>st</sup> day	Red	Red	Red	Red
2 <sup>nd</sup> - 4 <sup>th</sup> day	Dark red to brown	Dark red	Dark red	Dark red
5 <sup>th</sup> -6 <sup>th</sup> day	Red to green/ greenish	Dark brown	Red to brown	Dark red to maroon
7 <sup>th</sup> - 14 <sup>th</sup> day	Green to brown	Brown to light brown	Red to brown	Maroon to brown
15 <sup>th</sup> -30 <sup>th</sup> day	Light brown	Light brown	Brown to orange	Maroon to brown

The above table shows the change in colour of blood stains on polyester in different mediums. Initially on all the samples the colour of the blood was red to dark red in colour for 2-3 days. On polyester fabric buried in moist underground soil, the bloodstain color appeared dark red to brown by the 2nd day. By the 5th day, it transitioned to red with green tones, becoming completely green by the 6th day. Between the 7th and 16th days, the stain gradually shifted from green to brown. On the 17th and 18th days, it remained brown, and from the 19th day through to the 30th day, the stain took on a light brown shade, which remained stable. When exposed to direct sunlight, the stain began to darken to a deep brown color from the 4th day, turning brown by the 7th day. Starting from the 12th day, the stain lightened to a pale brown, which stayed unchanged until the 30th day. Under cold temperature conditions, the bloodstain color changed to red-brown by the 6th day and remained the same up to the 20th day. From the 21st to the 30th day, it gradually transitioned to a brown-orange hue. At room temperature, the stain developed a dark red to maroon color starting on the 6th day. From the 13th day onward, it shifted to a maroon-brown shade, which persisted until the 30th day.

### 3.Denim

Table 1.3. Shows the colour change of blood stain on denim fabric under various conditions

Time period	Underground	Sunlight	Cold temperature	Room temperature
1 <sup>st</sup> -3 <sup>rd</sup> day	Red to dark red	Red to marron	Red to dark red	Red to dark red
4 <sup>th</sup> – 7 <sup>th</sup> day	Greenish red to brown	Dark brown	Reddish brown	Reddish brown
8 <sup>th</sup> – 16 <sup>th</sup>	Greenish brown to yellow	Brown to grey	Brown	Brown
17 <sup>th</sup> – 21 <sup>st</sup> day	Pale yellow	Brown grey	Brown to orange	Brown to orange
22 <sup>nd</sup> – 26 <sup>th</sup> day	Pale yellow	Brown to grey	Brown to orange	Brown to orange
27 <sup>th</sup> – 30 <sup>th</sup> day	Pale yellow spots	Black	Dark brown to orange	Brown to orange

The above table shows the changes in colour of the blood stains on the denim fabric under different mediums. Initially, the bloodstains on all samples exhibited a red to dark red coloration, which remained consistent for the first 2–3 days. In underground moist soil, the stains developed a greenish-red hue by the 5th and 6th days, shifting to greenish-brown on the 7th day. From the 8th to the 16th day, the stains gradually turned yellow and remained that way. Between the 17th and 26th days, they appeared pale yellow, and from the 27th to the 30th day, only faint pale-yellow spots were visible. When exposed to sunlight, the stains turned maroon, followed by a dark brown shade observed on the 5th, 6th, and 7th days. From the 9th to the 26th day, the stains changed to a brownish-grey tone. By the 27th day, the stains appeared black. Under cold conditions, the stains showed a reddish-brown color from the 5th to the 7th day. Starting from the 8th day, the color shifted to brown, and between the 22nd and 26th days, it changed to a brown-orange shade. From the 27th day onward, the stains took on a dark brown to orange tone. At room temperature, the stains became reddish-brown between the 5th and 7th days. From the 8th to the 15th day, the color turned brown. Then, from the 16th to the 30th day, the stain gradually shifted to a brown-orange hue.

#### 4. Satin

Table 1.4. Shows the colour change of blood stain on satin fabric under various conditions

Time period	Underground	Sunlight	Cold temperature	Room temperature
1 <sup>st</sup> day	Red	Red	Red	Red
2 <sup>nd</sup> – 4 <sup>th</sup> day	Red to dark red	Dark red / maroon	Dark red	Dark red/ maroon
5 <sup>th</sup> – 7 <sup>th</sup> day	Red to brown	Dark brown	Red to brown	Brown
8 <sup>th</sup> – 14 <sup>th</sup> day	Light brown to yellow	Brown	Red to brown	Brown
15 <sup>th</sup> -22 <sup>nd</sup> day	Light brown to yellow	Brown/ light brown	Brown	Brown
23 <sup>rd</sup> – 27 <sup>th</sup> day	Pale yellow/ yellow spots	Light brown to yellow	Brown	Brown
28 <sup>th</sup> -29 <sup>th</sup> day	Pale yellow spots	Light brown to yellow	Brown	Brown
30 <sup>th</sup> day	No colour visible	Light brown to yellow	Brown	Brown

The above table shows the progression of bloodstain color on satin fabric under various conditions. Initially, all stains appeared red and darkened to a deep reddish tone by the second day, which remained consistent for the next 2–3 days. In moist underground soil, the stain on satin fabric developed a whitish to brown appearance by the 6th day, likely due to fungal growth. On the 7th and 8th days, the stain transitioned from whitish to a light brown shade. Between the 9th and 18th days, the color gradually changed from light brown to yellow. From the 19th day onward, the stain appeared pale yellow, and by the 27th day, only faint pale-yellow spots remained visible, persisting until the 30th day. When exposed to sunlight, the bloodstain on satin fabric began changing color by the 3rd day, turning maroon. From the 4th to the 8th day, the stain deepened to a dark brown shade. Between the 9th and 18th days, it remained brown. Starting from the 19th day, the color gradually shifted to light brown, and from the 23rd to the 30th day, the stain appeared light brown to yellow. Under cold temperature conditions, the bloodstain appeared reddish-brown by the 6th day and maintained this color until the 11th day. From the 12th day through to the 30th day, the stain's color remained unchanged. At room temperature, the bloodstain on satin fabric turned maroon by the 4th day. Starting from the 5th day until the 17th day, the stain changed to a brown shade. From the 18th day onward through to the 30th day, the color gradually shifted from brown to light brown.

**b) ABO blood grouping**

Table 1.5 shows the ABO blood grouping for 30 days

Condition and Fabric	Time period														
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Underground															
Cotton	B	B	B	B	B	B	B	B,O	B	B,O	NIL	B,O	B,O	B,O	NIL
Polyester	B	B	B	B	B	B	B	B,O	B,O	B,O	NIL	NIL	NIL	NIL	NIL
Denim	B	B	B	B	B	B	B	B,O	B,O	B,O	B	B	B	NIL	NIL
Satin	B	B	B	B	B	B	B	B	B,O	B,O	NIL	NIL	NIL	NIL	NIL
Sunlight															
Cotton	B	B	B	B	B	B	B	B	B	B	B	B,O	B,O	B,O	B,O
Polyester	B	B	B	B	B,O	B,O	B,O	B,O	B,O	B,O	NIL	NIL	NIL	NIL	NIL
Denim	B	B	B	B	B,O	B,O	B,O	B,O	B,O	B,O	B	B	B	B,O	B,O
Satin	B	B	B	B	B,O	B,O	B,O	B,O	B,O	B,O	NIL	NIL	NIL	NIL	NIL
Cold temperature															
Cotton	B	B	B	B	B	B	B	B	B	B	B	B,O	B,O	B,O	B,O
Polyester	B	B	B	B	B	B,O	B,O	B,O	B,O	B,O	B	B,O	B,O	B,O	B,O
Denim	B	B	B	B	B	B,O	B,O	B,O	B,O	B,O	B,O	B,O	B,O	B,O	B,O
Satin	B	B	B	B	B	B,O	B,O	B,O	B,O	B,O	B,O	B,O	B,O	B,O	B,O
Room temperature															
Cotton	B	B	B	B	B,O	B,O	B	B,O	B	B	B	B,O	B,O	B,O	B,O
Polyester	B	B	B	B	B,O	B,O	B,O	B,O	B	B,O	B	B,O	B,O	NIL	NIL
Denim	B	B	B	B	B,O	B,O	B,O	B,O	B	B,O	B	B,O	B,O	B,O	B,O
Satin	B	B	B	B	B,O	B,O	B,O	B,O	B	B,O	B	B,O	B,O	NIL	NIL

The above table shows the blood grouping of all the samples kept in different mediums. The blood grouping of all the samples were done after every alternate day. The technique which was used to do the blood grouping is Absorption-Elution technique. Initially for all the samples it showed B positive results. Later from day 10<sup>th</sup> onwards the it started to show B+ and O+ blood group, almost in all mediums.

a) Underground moist soil medium : Initially it was observed that till day 14<sup>th</sup> the blood group was B positive for all the samples and from day 16<sup>th</sup> onwards there was a significant change in blood group, the samples started showing B and O blood group results. Later from day 22 onwards it was seen that in some of the samples especially polyester and satin showed NIL results and by day 30 all the samples showed NIL indicating no detectable blood group.

- b) Sunlight Medium :Initially it was observed that till day 8<sup>th</sup> the blood group was B positive for all the samples. From day 10<sup>th</sup> onwards a noticeable change was seen where cotton showed only B positive result where as the other samples i.e. polyester, denim and satin showed B and O blood group till day 20<sup>th</sup> later from day 22 onwards polyester and satin showed NIL results and, denim and cotton showed B and O blood group.
- c) Cold Temperature :It was initially observed that in cold temperature till day 10<sup>th</sup> all the samples exhibited B blood group. Then from day 12<sup>th</sup> onwards cotton sample showed only B blood group result till day 22 and from day 24<sup>th</sup> it showed B and O results, Whereas the other samples showed B and O result till day 30.
- d) Room temperature: Initially, it was observed that till day 10<sup>th</sup> the blood group was B positive for all the samples. From day 12<sup>th</sup> onwards a change was seen where all samples started showing B and O blood group result which continued. Later from day 24<sup>th</sup> onwards, cotton and satin samples showed NIL results which polyester and denim continued to show B and O results upto day 30.

## DISCUSSION

The study emphasises the role of the environmental conditions and fabric type in the forensic analysis of bloodstains. Fabrics buried in moist soil exhibited rapid discolouration, due to microbial and fungal activity, indicating decomposition. Whereas exposure to sunlight caused the stain to darken, due to effect of ultraviolet rays which causes breakdown of haemoglobin. Cold environment helped to maintain the stain colour for a longer period of time by slowing down the biological and chemical degradation, whereas room temperature conditions resulted in moderate changes in blood stains over time.

Fabric composition also plays an important role in appearance and preservation of bloodstains. Cotton being more absorbent material it absorbs blood more deeply and showed more significant changes in colour. Whereas polyester and satin, which does not absorb blood, shows discolouration. Denim fabric showed moderate effect, depending on their material.

The study also emphasizes the ability to identify the blood groups from stains which are exposed to different environmental conditions. The stains from underground moist soil quickly lost the blood group identity. Exposure to sunlight decreases the ability to identify the bloodstains due to break down of blood group antigens. In contrast, cold temperatures helped maintain the detectability of blood groups for more than three weeks and room temperature allowed blood grouping for up to 24 days, although with minor degradation.

The results from this study provide a valuable insight into how long and how well the blood evidence can be preserved and analyzed from different types of fabrics exposed to different environmental conditions. Proper collection and preservation techniques are critical to maintain the evidentiary value of bloodstains.

## II. ACKNOWLEDGMENT

At the very onset of my acknowledge note, I **Shruti Pravin Gad**, want to express my deep sense of gratitude to Chancellor **Dr. Joseph V.G**, Vice Chancellor **Dr. GR Naik**, Registrar **Dr. M S Sheeja** and Head of the Department **Prof. Joemon K.**, for permitting us to utilize all the necessary facilities of the institution and support us throughout the completion of this project report. I deeply acknowledge my guide **Ms. Rajee Johnson**, Professor, Department of Forensic science, Garden City University for extending facility and permission to carry out our lab work under his guidance. I am grateful for his timely supervision of our work and going through the manuscript. Hereby, I feel lucky to have such a cooperative guide. I also want to acknowledge all the teachers of the Department of Forensic Science, Garden City University for their help, for their suggestion and innovative ideas in different stages of our Lab work. I would also like to express my heartfelt thanks to my guide **Ms. Shruti G Savardekar**, Laboratory Technician, Goa State Forensic Science Laboratory, Verna, for her valuable support and guidance during my internship phase, which significantly contributed to the successful completion of this project.. I am also deeply indebted to those who generously gave of their time and willingly took on the roles, apparently with great relish, in order to provide me with the numerous samples that I required for my research work

## REFERENCES

1. Hanslip C, (2021), The factors affecting the recovery of bloodstain evidence from buried clothing. Bournemouth University.
2. Dalia H Samak, Wafaa Bader, Yasser S El-Sayed, Kadry M Sadek, Hamida M Saleh, (2024), Exploring the Impact of Environmental Variables on Bloodstains: Insights into Forensic Analysis of Human and Animal Origin. Damanhour Journal of Veterinary Sciences 12 (1), pg.no.1-9
3. Aqsa Khalid, Rana Muhammad Mateen, Muhammad Irfan Fareed, Ahmed Ghulam Nabi, Asma Tariq, (2024), Persistence of bloodstains on natural and synthetic clothes at different temperatures using hand-wash and machine-wash with or without detergent, Chronicles of Biomedical Sciences, Vol.1 (1)

4. Adarsh Dixit, Jyoti Yadav, Rekha Lagarkha, Aishwarya Yadav, Pragya Singhal, (2023), Tracing the Clues: Exploring Dried Bloodstain Analysis on Multiple Objects in Varied Environment Conditions, International Journal for Multidisciplinary Research (IJFMR), Volume 5, (4)
5. MC Janaki, S Anil Kumar, (2023), A forensic study on lifespan of blood stains on different soil in different Temperature, Research Journal of Forensic Sciences, Vol. 11(2), pg.no.1-6.
6. Houssine Benabdelhalim, David Brutin, (2023), Influence of the relative humidity on the blood drip stain formation on jeans fabrics, Forensic Science International, Volume 350. <https://doi.org/10.1016/j.forsciint.2023.111808>
7. Bagban MohammedAzim, NK Jain, (2015), Effects of Fabric Materials on Abo Blood Grouping of Blood Group A and B From Blood, International Journal of Innovative Research and Advanced Studies (IJIRAS), Volume 2 (10).
8. Puri A.C.\* And Gang A., (2019), An effect of dry and moist condition on blood stained forensic samples, Research Journal of Forensic Sciences, Vol. 7(1), 1-3.
9. You-Rim Lee, Seungyeon Lee, Sohyen Kwon, Jiyeong Lee, Hee-Gyoo Kang, (2023), Effect of environmental conditions on bloodstain metabolite analysis, Environmental Research, Volume 216, Part 3, <https://doi.org/10.1016/j.envres.2022.114743>
10. Prakash M Mohite, Atul Keche, Anil J Anjankar, Sudhir Ninave, (2011), Effect of ageing & environmental condition for detection of blood group from blood stain, Journal of Indian Academy of Forensic Medicine 33 (4), pg.no. 306-308.
11. Frank Ramsthaller, Peter Schmidt, Roman Bux, Stefan Potente, Cristina Kaiser, Mattias Kettner, (2012), Drying properties of bloodstains on common indoor surfaces, International journal of legal medicine 126, pg.no. 739-746.
12. HF Miles, RM Morgan, JE Millington, (2014), The influence of fabric surface characteristics on satellite bloodstain morphology, Science & Justice 54 (4), pg.no.262-266.
13. Khushbu Katiyar, Shalika Nigam, Rashmi Kulkarni, (2017), Identification of blood stains under different environmental conditions, international journal of biomedical research, VOL. 8 NO.12.
14. M. Jermy; C. Knock; S. Michielsen; F. Smith; R. Rough; T. De Castro; L. Dicken; D. Brutin, (2022), Drying Processes in the Formation of Bloodstains at Crime Scenes. The Royal Society of Chemistry, ch.10, pg.no 171-190.
15. Stacey Anderson, Brandi Howard, Gerald R. Hobbs b, Clifton P. Bishop, (2005), A method for determining the age of a bloodstain, Forensic Science International, Volume 148, (1).
16. Terry Laber, Paul Kish, Michael Taylor, Glynn Owens, Nikola Osborne, James Curran (2010), Reliability Assessment of Current Methods in Bloodstain Pattern Analysis.
17. Dicken, Lisa, Knock, Clare, Carr, Debra J. Beckett, Sophie (2022), The effect of reactive dyeing of fabric on the morphology of passive bloodstains, Forensic Science International, Volume 336.
18. Yoshihiko Fujita, Koichiro Tsuchiya, Shinji Abe, Yoshiharu Takiguchi, Shin-ichi Kubo, Hiromu Sakurai, (2005), Estimation of the age of human bloodstains by electron paramagnetic resonance spectroscopy: Long-term controlled experiment on the effects of environmental factors, Forensic science international 152 (1), pg.no.39-43.
19. Ken-Ichiro Nakao, Ryo Shimada, Kenji Hara, Kazuhiko Kibayashi, (2013), Experimental Study on Age Estimation of Bloodstains Based on Biological and Toxicological Analysis, The Open Forensic Science Journal,6 pg.no.6-11.
20. Cenya Russell, Aaron Opoku Amankwaa, (2025), The persistence of bloodstains on buried fabrics and robustness of the leucomalachite green test in detecting aged bloodstains on buried fabrics, Volume 370, <https://doi.org/10.1016/j.forsciint.2025.112463>.
21. Teaghan McDonald, (2017), Investigating the effect of high temperatures and substrates on the detection of human blood using the ABACard® Hematrace® kit.
22. UK Kulkarni, NR Gosavi, KV Kulkarni, (2016), Effect of ageing and environment of north Maharashtra on ABO grouping substances of blood stain, Journal of Pharmaceutical, Chemical and Biological Sciences 3, pg.no. 608-611.

23. Sandip Ghosh\*, (2022), ABO Typing in Forensic Analysis: to be or not to be in the epoch of genotyping, International Journal of Forensic Science & Pathology (IJFP), 9(3), pg.no.487494.
24. JR Storry, Martin L Olsson, (2009), The ABO blood group system revisited: a review and update, Immunohematology 25 (2), pg.no. 48.
25. Kuldeep Kumar, Luv Sharma, Meenu Gill, Ruchi Tanwar, Vinod Kumar, (2021), Reliability of Postmortem ABO Blood Grouping: A Study of 100 Cases, Medical Research Archives 9 (12).
26. Rolf H Bremmer, Karla G De Bruin, Martin JC Van Gemert, Ton G Van Leeuwen, Maurice CG Aalders, (2012). Forensic quest for age determination of bloodstains, Forensic science international 216 (1-3), pg.no.1-11.
27. Kannika Sutthapodjanarux, Nathinee Panvisavas' and Nopadol Chaikum,(2009), Effect of Temperature and pH on Bloodstain Evidence.
28. Muhammed İkbal Yildirim, Muhammet Uzun, (2022), Forensic analysis applications in textile and chemistry, Tekstilna industrija 70 (2).
29. Rakshita Singh, (2020), Blood stain identification and its DNA stability on different fabrics, International Journal of Forensic Medicine,2(1): Pg.no. 21-24.
30. Livia Sliskovic, Ivana Milos, Antonia Zecic, Sendi Kuret 3 and Davorka Sutlovic, (2024), Does Sunlight Affect the Quality for Purposes of DNA Analysis of Blood Stain Evidence Collected from Different Surfaces? Genes.

