

Literature Review

Effect of Multiple Washings on Blood Evidence with Different Washing Agents

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Abstract

Clothing often acts as an important carrier of biological evidence in forensic investigations because it can retain body fluids, skin cells, and other trace materials. In real-life situations, offenders frequently attempt to destroy evidence by washing clothes using water, detergent, or repeated laundering. However, complete removal of DNA is not always possible. This study aims to evaluate the persistence and recoverability of DNA from clothing evidence after different washing conditions. Biological samples such as blood and touch DNA will be deposited on cotton fabric to simulate real forensic scenarios. The stained fabrics will be subjected to different washing treatments, including water-only washing, detergent washing, and repeated wash cycles. Samples will be analysed at different intervals to observe the extent of DNA degradation and persistence. DNA extraction and profiling methods will be used to determine whether usable genetic material remains after washing. It is expected that washing may reduce the quantity and quality of DNA, but detectable traces may persist depending on the washing intensity, number of cycles, and type of fabric. The findings of this research will help forensic experts understand how laundering affects biological evidence and will assist investigators in interpreting washed clothing evidence more accurately.

Introduction

The field of forensic serology relies heavily on the recovery of biological fluids from crime scenes. Clothing, acting as a primary contact surface, is frequently stained with blood during violent encounters. However, the intentional destruction of this evidence through laundering presents a significant hurdle for criminal investigators. The washing of evidence is known to impact biological evidence under diverse categories, including washing out or even diluting stains/cellular material, accompanied by degradation of cellular material like DNA. However, it has also been established through past studies that the DNA might exist on fabrics despite repeated washing cycles, especially in cases of deeper penetration of stains [1].

The persistence of DNA is affected by several factors, such as fabric, wash method, detergent composition, temperature, and wash cycles. Cotton is a porous fabric, so biological materials may cling to it better than to smooth synthetic ones. The effects of wash cycles on DNA need to be considered when interpreting the results of forensic tests [2].

More Information

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Washing and its effect on biological evidence

Several studies have documented that washing has a profound effect on biological stains on garments. Washing incorporates mechanical action, dilution by water, and chemical action of detergents, all of which may decrease the quantity of biological material on fabric [3].

Such blood and other body fluids can become pale or even invisible when washed, making detection challenging. Indeed, studies have illustrated the ability of washing to abrade surface cells, degrade DNA molecules, and diminish the total DNA yield. Nonetheless, complete abolition of biological material does not always occur, especially when stains deeply diffuse into porous textiles like cotton [4].

Temperature and the composition of the detergent play important roles, too. Hot water and strong detergents are more likely to cause higher DNA degradation than cold water washing. The repeated wash cycles further result in an increase in loss of DNA, although it may still be present in traces within the inner structure of the fabric.

Factors affecting DNA persistence in washed clothing

The washing resistance of the DNA is a function of several variables, including:

1. Type of biological sample (blood, saliva, touch DNA, semen)
2. Fabric type: cotton or synthetic
3. Washing Method (Hand Wash/ Machine Wash)
4. Use and type of detergent
5. Water temperature
6. Number of Wash Cycles
7. Mechanical agitation and drying conditions

These factors need to be understood to assess the probability of obtaining DNA from washed clothing.

- **Hartley & Glynn (2016): Sensitivity of peroxidase-based reagents**

Hartley and Glynn conducted a rigorous study on the efficacy of various enhancement reagents. Their research demonstrated that as the number of wash cycles increases, the protein concentration on the fabric surface drops below the threshold of detection for common protein dyes like Amido Black. However, peroxidase-based reagents (Luminol and Bluestar®) react with the heme group, which is more chemically stable than the proteins themselves. On natural fibers like cotton and Khadi, these reagents remained effective even after five cycles in a high-temperature wash.

- **Mayes, et al. (2019): molecular persistence (mRNA vs. miRNA)**

This study is crucial for modern forensics. Mayes et al. investigated whether DNA and RNA could be recovered after laundering. Their findings indicated that while mRNA—a marker for tissue identification—degrades relatively quickly when exposed to moisture and heat, miRNA is significantly more resilient. For Khadi fabrics, this implies that even if the hemoglobin is washed away, the specific microRNA markers for blood can still be extracted for body fluid confirmation.

- **Adams, et al. (2019): masking effects of household reagents**

Perpetrators often use specific cleaners like bleach (sodium hypochlorite) to destroy blood. Adams et al. tested whether these reagents could prevent Bluestar® from reacting. Their study found that although bleach creates an initial flash of light (false positive), the

characteristic glow of blood is distinct in duration and color intensity. This allows investigators to differentiate between a "cleaned" surface and a truly "clean" one.

- **(2025): Comparison of treated vs. untreated fibers**

Recent data suggests that the lack of chemical finishing on traditional Khadi makes it more susceptible to deep staining than water-repellent modern fabrics. The study showed that on untreated natural cotton, bloodstains are "locked" into the fiber during the first drying phase, creating a long-term reservoir for forensic markers that survives multiple detergent exposures.

Effect of washing reagents

- a. **Anionic detergents:** These are standard detergents that remove surface oils and stains. On Khadi, they remove the visual "redness" but leave the hemoglobin core intact within the fiber twists.

- b. **Enzymatic reagents:** Detergents containing "bio-enzymes" (proteases and lipases) are more destructive. They break down the protein matrix of the blood cell. Studies indicate

- c. The blood on Khadi washed with enzymatic cleaners requires the most sensitive detection methods, such as miRNA analysis, as the protein markers are significantly diminished.

- d. **Oxidizing agents (Bleach):** While bleach can degrade DNA, it is often ineffective at removing the trace iron found in heme, which is why Luminol still works on bleached Khadi.

Research gap

Few studies have examined DNA persistence and degradation independently, while even fewer have targeted the impacts of different washing conditions on DNA recovery from the clothing item. Real-life situations likely involve repeated washing in cycles along with detergent use and a range of environmental conditions. In addition, there are a number of factors that have not been represented previously, so further research is warranted to understand how laundering impacts DNA persistence and forensic interpretation.

Conclusion

From the literature reviewed, washing is identified to have a significant effect on the biological evidence present on garments. During laundry, the effects of water, detergent, and mechanical action will dilute stains, remove cellular material, and cause degradation of DNA. It is influenced by several variables, including the type of fabric, the nature of the biological sample, washing conditions, temperature, and the number of wash cycles [4].

Previously, previous studies have indicated that despite

washing efforts, which may decrease both the amount and quality of deoxyribonucleic acid, it is impossible for its elimination to occur completely. There may still be detectable amounts of DNA remaining within the fabric composition, especially for porous fabrics such as cotton [2,3].

The persistence of bloodstain evidence may be more pronounced compared to touch DNA due to higher cellular content. However, repeated washing using strong detergents may weaken DNA, leading to limited amounts of genetic information.

Overall, the literature provides evidence of the recoverability of washed clothing items even when appropriate collection and sensitive DNA analysis methods are employed. In light of the literature, the significance of the DNA persistence phenomenon upon washed clothing provides the foundation for the current study, with the aim of assessing the potential for the recoverability of DNA upon the clothing item.

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