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Fibre persistence on immersed garment — Influence of water flow and stay in running water

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The persistence of fibre traces is a critical factor in the evaluation of fibre findings in forensic casework. Water can play a major role in affecting fibre persistence as a lot of fibre traces can get lost after washing incriminated garments, after rainfall over the victim's body or after immersion of the victim in water. The influence of immersion in standing water on fibre persistence was previously studied in our laboratory on various knitted recipient fabrics. The present study is focused on the persistence of target fibres on immersed cotton T-shirts through an immersion/stay/emersion process in running water (from 1 h up to 7 h), simulated in laboratory (~0.4 l/s, gentle water flow conditions) and in real conditions (~2000 l/s, medium water flow conditions). A gentle water flow slightly affects fibre persistence, which remains more or less constant over time, regardless of the duration of the stay in water. No rapid loss is observed during immersion in real conditions, including a medium water flow and boat activity. The fibre persistence in running water seems to depend mainly on the immersion step and also, in case of a medium water flow, on the stay in water with a linear loss over hours.

1. Introduction

The persistence of traces left by an offender is a critical factor in forensic fibre examinations. The study of the persistence of traces consists in determining the possible loss of traces due to various external factors. Water can be pointed out as an important factor affecting the fibre persistence through washing suspect's clothes, rainfall over the victim's body that was left in open-air conditions or water immersion of the victim's body.

The effect of water on fibre persistence has already been described in literature with the cleaning of the recipient garment [1–4] and leaving the recipient substrate exposed to rainfall in open-air conditions [5–7]. Few fibres persist (around 10%) after cleaning with a washing machine and an extensive redistribution of fibres takes place [1,2]. Hand washing, machine washing and dry cleaning all decrease the fibre persistence, but rather depending on the garment texture than on the cleaning process [4]. The effect of rainfall is slight unless heavy rainfall (around 10 l/m^2 [5–7]) occurs, causing a higher loss. The washing of hands never shows a total loss of transferred fibres (persistence of ~5%), but no significant difference is noticed between washing hands in standing water and under running tap water [8]. A total loss of fibres on the skin of living subjects is only observed after taking a bath or a shower [9].

In a recent survey [10], this topic was submitted to the opinion of fibre practitioners throughout Europe, the United States and Australia. The answers of the participants largely diverge and are conditioned by different factors: the type of garment, the presence of folds in garments, the nature of the fibre traces, the speed of the running water, the influence of tide/boat activity, the position of the body in relation to the current, the weather conditions and how the body was deposited into the water (from a bridge, from a river bank). Several practitioners have reported interesting examples of casework in which relevant traces were still recovered on a victim found underwater. Cases involving dressed victims especially highlight the importance of recovering fibre traces on dried clothes. Naked victims seem less interesting for fibre investigation, except occasionally for the recovery of fibres in hair or in hairy areas as also reported in literature [11,12]. The effect of water seems to be mostly influenced by the water flow. Immersion in slow-running water (lake or drainage channel) leads to the recovery of a larger amount (hundreds) of transferred fibres, as expected for out of water conditions. Oppositely, a more drastic effect on the amount of transferred traces is observed for higher water flows (river or canal), even for a short stay in water.

This survey highlights a crucial need for a better understanding of the persistence of transferred fibres on immersed bodies. The effect of water immersion was previously studied in our laboratory on various knitted recipient fabrics during an immersion/emersion process in standing water [13]. More structured and textured fabrics are less affected by the immersion/emersion process and fibre findings are closer to their initial amount and distribution before immersion. The amount

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of protruding fibres and the density of the rough fibrous network at the surface of the recipient garment are both found to be key factors that enhance the persistence value. The purpose of this study is to investigate fibre persistence in running water considering:

- a gentle water flow under laboratory conditions,
- a medium water flow (real conditions in the Brussels–Charleroi Canal, including boat and sluice activity).

At the same time, the influence of the stay in water will be studied for time intervals from 1 h up to 7 h, for practical reasons. These immersion time intervals may be considered as a short period, but they reflect the beginning of the immersion process of the victim. A body usually first sinks to the bottom (with or without being weighted), bloats from decomposition gases and resurfaces, and then floats with the river flow [14]. Furthermore, there are debatable issues as to whether a body sinks or floats whenever it is introduced in water and there are various factors (such as fat content, gravity, and clothing) which influence these processes [15]. A mathematical equation can be used to approximate how far a sinking body may travel in water before it comes to rest on the bottom. These calculations involve the water depth and the water current speed, but also a “body drop rate”. In fresh water, a body drops at a speed of 0.6 to 0.8 m/s and a body drop rate of 0.6 m/s is generally used as a standard for all calculations regardless of the water type [14]. Thus, without being weighted, a body could sink within a few seconds before coming to rest on the bottom of the river. Bloating in a temperate environment (20° to 24 °C) on dry land begins about 36 h post-mortem, but this process is delayed by a factor of 2 in water [14].

2. Material and methods

2.1. Recipient garment

Cotton T-shirts (same as those used in [13]) were chosen because those represent the most common structure and texture of garment encountered in casework, and consequently, also in cases involving underwater conditions. In addition, cotton is the predominant fibre type found in population studies [16,17]. Each experiment was repeated three times, using a collection of nine already used T-shirts. Prior to the experiments, the T-shirts were machine washed (60°) without detergent, dried in a drying-machine and finally ironed at the appropriate temperature, in order to mimic the domestic treatment of garments.

The recipient garment was tape-lifted to remove any background of fibres and then pulled on a weighted plastic jug, to build a homemade dummy (Fig. 1). The size of the T-shirt was chosen to fit the plastic jug and the waist of the T-shirt was stapled tight at the bottom of the dummy to prevent undressing during immersion. This was offering a flat surface (without any folds) for transfer.

2.2. Donor textile, target fibres, transfer and counting methods

The donor material and target fibres, as well as the transfer and counting methods, were previously described in details in Ref. [13].

The green acrylic target fibres showed a strong green fluorescence emission under blue light excitation (blue-violet excitation filter BP420-490 D510 LP515, microscope Leica DMRXP, magnification 400×). 50 target fibres (~1 cm long) from a sealed package were deposited on the chest of the dummy and the fibre tuft was spread by means of forceps. A contact was simulated using a weight (~450 g) made of a plastic box filled with 50 glass microscope slides and wrapped in a cotton T-shirt. Before the transfer of target fibres, the T-shirt, the weight and the plastic jug were checked with blue light to prevent contaminations during and between experiments.

For each experiment, the number of target fibres on the recipient garment before and after the immersion/stay/emersion process was directly counted on the pictures taken under a blue light camera (Foster + Freeman, Crime Lite ML2, Blue 420–470 nm + 1.8× magnification lens with GG495 filter + UV–Vis camera 5 Mpixel, 8 mm focal with Autofocus).

2.3. Immersion method

The immersion method involved simulating an immersion/stay/emersion process in running water during various time intervals, ranging from 1 h up to 7 h. The homemade dummy (Fig. 1) was positioned at the water surface and then dropped in running water, in order to obtain a reproducible immersion process. At the end of the desired stay in water, it was recovered out of the water. Overall and zoomed pictures of the target fibres present at the surface of the recipient garment were taken under the blue light camera.

2.3.1. Gentle water flow

As immersion device, a plastic barrel (the same as in [13]) was placed in the sampling room and filled with tap water (~100 l). The water supply at the top of the barrel (water flow ~0.3–0.45 l/s) was then left open, with the tap at the bottom of the barrel (water flow ~0.4 l/s) fully opened. This device provided a gentle water flow of approximately 0.4 l/s. The number of target fibres present in or at the surface of the water (Fig. 1) was observed with a forensic light source (Foster + Freeman, Crime Lite 2, Blue 420–470 nm) and noted during most of the experiments. The barrel was emptied and washed with running water between each experiment and the presence of target fibres was checked with blue light. The homemade dummy was a plastic jug (10 l) filled with sand and water, for a total weight of 12.6 kg. Each

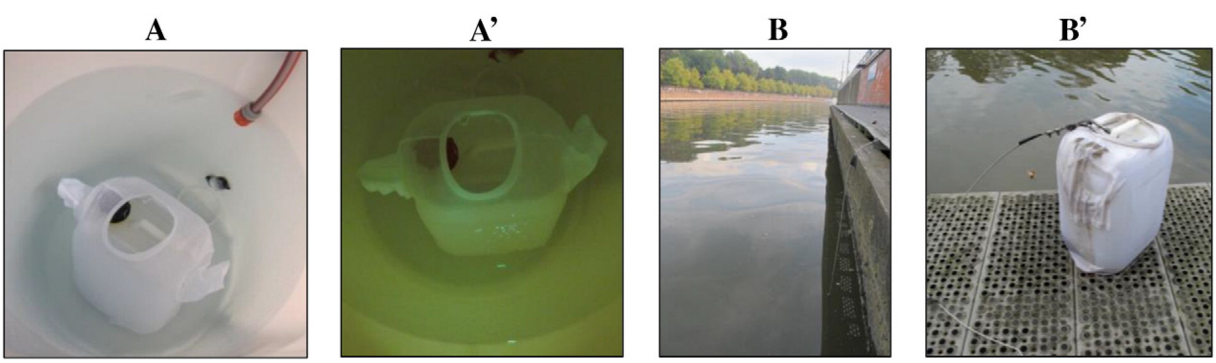

Fig. 1. Left: pictures (under laboratory conditions) of the homemade dummy immersed in the plastic barrel (A) in daylight and (A′) under blue light showing fluorescent target fibres at the surface of the T-shirt and floating in the gentle water flow. Right: pictures (in real conditions) of the immersion site on the Brussels–Charleroi Canal illustrating (B) the metal cable hanging the homemade dummy approximately 2 m under the water surface and (B′) the homemade dummy on the platform after emersion.