Handling of Submerged Evidence – literature review
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If you have any related papers, or body-found-in-water or drowning cases you can share for our research please contact me. Thank you.

When a body is found in the water special care needs to be taken to decrease the loss of any existing trace evidence. Too often personnel who recover a body-found-in-water assume that the incident is an accident or suicide, and assume that there will not be any useful trace evidence left on the body itself or on articles associated with the body. Valuable trace evidence has been successfully collected from bodies found in open water environments and bodies that have been washed, that have helped gain successful convictions (Sweet & Shutler, 1999, Ernos & Beyer, 1981)

Condoms

Offenders may discard condoms used during sexual assaults in toilets or other areas of water in an attempt to hide or destroy evidence. Lee et al. (2001) used nuclear magnetic resonance spectroscopy (NRMS) to analyze and identify 38 different brands of condoms that had their lubricant wiped off and then were soaked in tap water for up to 24 hours. The samples were then air dried at room temperature and extracted with hexane. The lubricant was wiped off because PEG, a common lubricant, is water soluble.

Soaked condoms developed brown patches that were not observed on fresh condoms. The soaked condoms darker yellow-brown hexane extracts than did the fresh condoms. There was minimal difference between the NMRS spectra between soaked and fresh condoms, with the main difference was that the soaked condom "PEG[1] peak was much lower in intensity appearing only as a small, broad lump", and the spermicide peaks disappeared. Condoms that had the spermicide dissolved in highly insoluble PDMS[2] lubricants did not show these differences between soaked and fresh condoms.

With the few differences found between soaked and fresh condom samples, twenty-nine out of thirty-three soaked condoms were able to be identified with NRMS.

Fibers

The majority of fiber forensic analysis involves comparisons between fibers found associated with the victim and fibers found associated with the offender(s). The first step is to characterize the fibers, which can be done by examining their morphologies with an optical microscope, by documenting their polymer composition with Fourier Transform Infrared (FTIR) spectroscopy, and by examining their color.

The evidentiary value of fiber evidence in court is based on the closeness of the match. A question that should arise is how will this match be affected if the fibers associated with the victim have been exposed to an outdoor environment for a period of time, while the fibers associated with the offender have remained protected from the elements?

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[1] polyethylene glycol
[2] polydimethylsiloxane

Causin et al. (2005) studied poly (ethylene terephthalate) (PET) fibers, which are common class of polyester fibers. Polyester fibers can be more difficult to differentiate than acrylic fibers, because polyester fibers are less variable in their monomer composition. They studied colorless, single PET fibers that were exposed to sun or room temperature water for three months, and compared these fibers to fiber matches that remained protected from the elements to observe the effects of the water and sun on such fibers. The fibers that were fully submerged in water for three months were dried with paper towels prior to analysis.

Optical microscopy showed that submersion did not cause any notable swelling or morphological changes. There was no change in the *gauche/trans* ratio between the soaked and protected fibers. Unpolarized infrared spectroscopy was employed and no significant differences were found between the soaked and protected fibers. When evidence is collected, scene investigators should document as many of the environmental variables as possible so that differences between crime scene fibers and offender-associated fibers can be analyzed within the context of these variables. Thorough and accurate scene documentation can help produce more valid laboratory analyses that will stand up better in court.

Offenders may deposit a body or other evidence in water with the hopes that evidence will be destroyed or washed away. Research has been conducted on the effects of hand and machine washing on the ability to recover trace fiber evidence. Although hand and machine washing are not the same as clothing being left in bathtubs, pools, or openwater environments, the results of these studies are worth examining in the context of evidence being simply immersed or submerged in water that is still, enclosed as in a bathtub, or moving as in a river.

Robertson & Olaniyan (1986) used hand pressure to place fibers from a red 100% acrylic jumper with a medium texture and placed them on ten receiver items of clothing that included acrylics, cotton-polyester mixes, nylon, wool, polyester-mixed fibers, and polyester garments with fine, smooth, fluffy, or medium rough textures. Fibers were put into four different groups based on length (under .25 cm, .25 to .50 cm, .50 to .75 cm, over .75 cm) and placed on the recipient garments with documentation of fiber location. The recipient garments were then hand washed, machine washed in normal loads with other garments, and dry cleaned for three separate tests. Fibers were recovered with high adhesive tape and were counted using stereo microscopy.

1. Results of fiber recovery ranged from 75% from the acrylic garments down to less than 3% recovery from the nylon garments. Polyester had the second best fiber retention with cotton being third.
2. There were no significant differences found between machine and hand washed garments in either percentage of fibers recovered.
3. Machine washed garments had a greater distribution of fibers from original contact location when compared to hand washed garments.
4. Shorter fibers were more likely to be recovered from hand washed garments than were fibers longer than .50 cm.
5. Fibers under .25 cm had the greatest recovery rates regardless of type of washing.
6. Dry cleaned garments showed an approximate 40% recovery regardless of type of material of the garment.
7. Fibers may be broken or fragmented during washing.

Palmer (1998) conducted two similar studies. In the first study laboratory coats were put in contact with a yellow polyester/cotton polo shirt, and were then set to a commercial laundry facility. Few of the transferred fibers were found remaining after the laundering. The second study involved a mock assailant wearing a blue acrylic sweater who attacked mock victims with significant upper body contact. The victims then went home and machine washed their upper garments. Results included a wide variation in number of recovered fibers that could not be linked to type of garment, time of wearing garment prior to washing, or other variables.

Larger fibers were more likely to be lost as was found in the Robertson & Olaniyan (1986) study. A Foster & Freeman FX5 Automated Fibre Finder was used and compared to the findings by a human searcher with no significant difference found between the two.

Forensic analysis of garments also includes looking for body fluids such as blood. A variety of blood stained cloths were immersed in water for as long as 20 days and positive benzidine and phenolphthalein findings.[3] Cellulose acetate and cotton fabrics with blood stains were tested after washing with the result that cotton held the blood stains while acetate had decreased blood retention.[4]

Cox (1990) tested 12 different fabrics with fresh human blood stains with various drying times followed by normal domestic laundering with a chlorine-containing detergent and a cold-water cycle conducted every 3 hours for a period of 48 hours. Control and bloodstained cloths were tested after each washing with phenolphthalein and orthotolidine screening tests. Results were as follows:

1. The 100% synthetic fibers, acetate, nylon, and polyester, did not present a positive presumptive test for blood
2. The 100% cotton and the 50-50 cotton polyester blend cloths presented with positive tests for blood every time for both the phenolphthalein and orthotolidine screening tests.
3. The 50-50 polyester and rayon cloth presented positive results for all the orthotolidine tests, but failed in every phenolphthalein test.
4. The 35% cotton-65% polyester cloth only gave positive results for both screening tests for washings that occurred after a 9 hour drying time, and gave negative results for shorter drying times.
5. The 20% cotton-80% polyester cloth gave positive orthotolidine results after the 6 hour drying period, but never gave positive results for the phenolphthalein tests.
6. Four of the fabrics (synthetic and mixed fibers) presented with a light green to blue green color that could have been interpreted as false-positives if the presence of blood had not been known.

In summary, the 100% acrylic cloths gave negative tests while the high cotton content cloths yielded positive results regardless of drying time or number of washings. Longer pre-washing blood drying times increased the likelihood of positive tests for cotton blends. The orthotolidine test was more sensitive than the phenolphthalein test.

Marine Oils

Oil spills need to be identified so correct action can be taken against the offending company causing the spill. Oil spills contaminate shoreline soils as well as immersed items exposed to the

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[3] Jain, P. and Singh, H.P. "Detection and Origin of Blood Stains on Various Types of Cloth Immersed in Water for a Prolonged Period." *Canadian Society of Forensic Science Journal,* Vol. 17, No. 2, 1984, pp, 58-61 cited in Cox (1990).

[4] Spector, J. and Von Gemmingen, D., "The Effect of Washing on the Detection of Blood and Seminal Stains," *Canadian Society of Forensic Science Journal,* Vol. 4, 1971, pp. 3-9. cited in Cox (1990).

oil. It could therefore be useful to be capable of identifying oil mixtures to determine where the oil came from and were a moved item may have come from. For example, consider a corpse or other evidence that was deposited in an area contaminated with oil that is then moved miles away by currents and is later found in an area with no contamination.

Rouen & Reeve (1974) used several different types of analytical methods to identify samples of petroleum products found floating on seawater. All outfall pipes or fuel lines that discharged into the area, and all ships in the vicinity of the samples had representative samples taken to see if they could be matched to the recovered floating samples. Infrared analysis was found to not be useful in "characterizing oil samples." They were successful in localizing sources of oil spills by using a combination of the following techniques: "gas chromatography analysis, refractive index measurements, ash residues, percentage ash composition, and emission spectrographic analysis of the ashed residues."

Paper documents

Unlawful wagering activities frequently use water-soluble paper, which was studied by Lyter (1980). Walter-soluble paper is a misnomer because what it actually does it disperse quickly and finely, creating a residue or suspension. Lyter

Vehicles Found in Water

Baudoin, Lavabre, & Vayne (2002) studied turned-on car headlights that contact water. This was done to help answer questions about a car with two decedents that was found in a gravel pit after the water level dropped. Investigators wanted to know if this was a night time accident and therefore wanted to determine if the headlights had been on at the time of the incident. The high and low beams were taken out and the mud covering them was removed. One bulb was broken and the other intact, and investigators thought that the intact bulb may have been evidence that the lights were not on during immersion. The broken bulb filament had two fractures and a weak deformation of coil structure. The mud layer demonstrated that both bulbs had been in contact with the water. The mud covered filament coils were invisible until they were cleaned with ultrasounds in an acetone solvent.

The researchers supplied 12V voltage to 15 different well-known brands of head light bulbs that were collected from old but not damaged cars in junkyards. The bulbs were tested first with low beams on and then high beams on for 15 minutes and were then removed and immersed in a 5 L bucket with 20^{o}C water to see if immersion caused a bulb to break. A second series of tests involved bulbs left turned on with water trickled over them. Only 20% of the bulbs broke, which means that 80% of bulbs will keep working when submerged.

The three bulbs that did break had a "deep blue color oxidation and small rounded cavities", discovered with S.E.M.[5] on the filaments, which was also true of the damaged bulb from the car in the gravel pit. Unlike the latter bulb, the three test bulbs showed tungsten excrescences between the spires of the filament coils by S.E.M. The ultrasound used to clean the gravel pit car bulb may have destroyed any excrescences. This study showed that both headlights could have been turned on during the vehicle's immersion in the gravel pit.

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[5] Scanning electron microscope