

The population of coloured textile fibres on outdoor surfaces

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In case work, fibre examiners are often asked to examine tapings from various outdoor surfaces. The significance of textile fibres is extremely difficult to assess owing to the total lack of background information about the normal fibre population on outdoor surfaces. Tapings were therefore made from a variety of locations (33) and the fibre population was classified according to type, colour and length. The predominance of cellulosic fibres was overwhelming (92%). Colourless cotton was present on all surfaces; blue denim fibres were found on all but three of them, and grey/black and red cotton were also found on the majority of surfaces. Synthetic fibres were relatively rare, the most common form being viscose. Many fibres were under 1 mm long; longer fibres were likely to have been more recently transferred.

Les spécialistes fibres sont souvent requis pour examiner des prélèvements à adhésif sur des surfaces externes diverses. Lors d'investigations criminelles l'importance des fibres textiles est extrêmement difficile à déterminer à cause du manque total d'information sur la population normale des fibres sur les surfaces extérieures. Des prélèvements ont donc été faits dans une variété d'endroits (33) et la population de fibres a été classée selon le type, la couleur et la longueur. La prédominance des fibres cellulose était écrasante (92%). Du coton incolore était présent sur toutes les surfaces; des fibres bleu denim ont été trouvée sur toutes les surfaces sauf trois, et du coton gris/noir et rouge ont également été trouvés sur la majorité des surfaces. Les fibres synthétiques étaient relativement rares, la plus commune étant la viscose. Beaucoup de fibres étaient d'une taille inférieure à un millimètre; et il est vraisemblable que les fibres plus longues étaient transférées plus récemment.

In der Fallarbeit müssen öfters Klebebandabzüge ausgewertet werden, die von Oberflächen im Freien genommen worden sind. Die Bedeutung von Textilfasern auf solchen Oberflächen ist nur schwer zu beurteilen, da über das Faseraufkommen darauf keinerlei Kenntnisse vorliegen. Von 33 verschiedenen Gegenständen im Freien wurden deshalb Klebebandabzüge genommen und die darin enthaltenen Fasern nach Art, Farbe und Länge klassifiziert. Mit 92 % waren zellulose Fasern überdurchschnittlich häufig vertreten. Farblos erscheinende Baumwollfasern wurden auf allen Oberflächen gefunden; bis auf drei Fälle waren stets auch Jeansfasern vorhanden; auch graue bzw. schwarze sowie rote Baumwollfasern wurden auf den meisten Oberflächen angetroffen. Chemiefasern waren vergleichsweise selten, wobei es sich häufig um Viskose handelte. Viele Fasern waren kürzer als 1 mm; längere Fasern scheinen sich erst eine kurze Zeitspanne auf der Oberfläche befunden zu haben.

Con relativa frecuencia se consulta a los expertos en fibras, en casos de rutina sobre materias de diversas superficies externas. Es extremadamente difícil valorar el significado de fibras textiles debido a la total falta de información sobre las fibras normales en superficies externas. Se tomaron muestras de diversos lugares y se clasificaron las fibras de acuerdo con el tipo, color y longitud. El predominio de fibras de celulosa fue abrumador (92 %). Fibras de algodón incoloro estaban presentes en todas las superficies; se encontraron fibras azules de ante en todos los casos menos en tres, y se encontraron también en la mayoría de las superficies fibras de algodón rojas y grises/negras. Las fibras sintéticas fueron relativamente raras, aunque la más común fue la viscosa. Muchas fibras medían menos de 1 mm; las más largas parecían que habían sido transferidas más recientemente.

Key Words: Forensic science; Criminalistics; Fibres; Outdoor surfaces; Fibres – frequency, length, colour.

Introduction

Forensic fibre analysts are often asked to examine tapings from a crime scene and to evaluate the fibre population contained on them. The object is usually to look for fibre "collectives", defined as a number of fibres of the same type and colour with the same morphological characteristics, which draw attention to themselves by repetition. Collectives can provide the investigator with information which may be helpful in finding a suspect and linking him/her to the crime scene. The larger the number of fibres of a particular colour/type combination that are present, the greater is the chance that they have been deposited from a source having had recent contact with that area. The finding of collectives occurs frequently; naturally, although suggestions can be given as to their possible origin, it is not always possible to find/recover the appropriate textile source. Collectives are sought in the initial stage of an investigation, before a suspect has been developed and before clothing has been submitted for comparison purposes. Once this happens, the fibre search can usually be narrowed to looking for specific matching fibres.

Evaluation of the significance of fibres on an outdoor surface, particularly when only relatively few fibres are present, without any apparent collective, is severely hindered by a total lack of background information concerning the "normal" or "expected" fibre population of such surfaces. Information concerning background fibre populations is therefore becoming increasingly important in the evaluation of fibre evidence. The following cases provide examples of the type of outdoor surfaces which may be involved.

A suspected arsonist was alleged to have used his attic window to exit unnoticed from his home by sliding down the roof and climbing down the drain pipe. A request was made to examine the window sill, the roof tiles, the guttering and drain pipe for traces of fibres which might have originated from his blue jeans. Obviously, the question of whether one might expect to find blue jeans fibres on these surfaces under normal circumstances, became one of great importance.

During an incident, shots were fired into a building from the window of adjacent premises. The suspect was alleged to have steadied his automatic weapon on a tree branch outside the window. A taping was made from the branch to see whether it contained "clothing fibres".

Terrorists erected warning signs before blowing up a building. The signs had been pre-prepared and brought to the scene. Any fibres present on them could be used as a possible link to the terrorists or to their environment. It was necessary to discover what types of fibre, if any, one might expect to find on public notices and signs.

A suspect lay on the ground (pavement) while affixing a bomb under a vehicle; the area next to the vehicle was taped for fibre traces which might provide an investigative lead –

a guide to the type of clothing worn by the offender. The significance of fibres found at the scene was unclear.

A manhole cover was thrown through the window of a jewellers shop to effect a smash and grab raid. The suspect was believed to have worn gloves. Any fibres found on the manhole cover might provide a link to the gloves.

Experimental

Tapings were prepared from a variety of appropriate outdoor locations as shown in Table 1. The spring/summer seasonal weather conditions before taping were noted, as it was felt that rain or stormy, windy weather would tend to reduce the number of fibres recovered [1]. It was not practicable for the operators to wear laboratory overalls under the circumstances and a precautionary note was made of the clothing worn during collection. Replicate tapes were made from different examples of the same type of surface.

The tape used was Cellotape 1250 (formerly known as Cellux 760) which is used in this laboratory for case work. The manufacturers quote the adhesive strength as being 60 Newtons/25 mm. In each case, with a few exceptions, a strip of tape measuring 5 x 20 cm was used and was applied five times, representing an area of 500 cm². In a few cases this was not possible due to the adherence of a large amount of background material, e.g., pollen. The areas taped for the park bench, the oak tree and signpost, and the grill hut door were 400 cm², 200 cm², and 100 cm² respectively. For the chain link fence, the tape was applied five times. The total fibre population for each surface was then standardised and expressed as a number per 100 cm². In accordance with normal case work procedure the tapings were affixed to the inner surface of a zip lock polythene bag.

Method

The tapings were scanned using a Wild (Leica) M10 stereoscope (maximum magnification x 80) in combination with a scanning grid or scanning stage. All fibres were removed by cutting through the back of the inverted "closed" tapes and mounted six/slide under individual 12 mm cover slips using Phytohistol [2]. Each fibre was numbered.

Fibres were identified and generic type determinations were made using transmitted and polarised light microscopy at a magnification of x 250 or x 400. All fibres were classified according to colour and their length was measured by comparison with a millimetre scale under the stereoscope. Synthetic fibres were also classified according to cross-sectional shape (estimated from the appearance in a normal slide preparation) and their delustrant status. The classification categories are summarized in Table 2.

Colour classification was made subjectively using a munsell shade card as a guide. Because of limited time available for the project, the decision was taken to restrict the investigation to coloured fibres. Colour is one of the most important parameters in the comparison of textile fibres,

TABLE 1 Details of the surfaces examined and of conditions before and during taping.

<i>Weather conditions</i>	<i>Number</i>	<i>Site</i>	<i>Comments</i>
Two days since rain	1	Park bench (back)	adjacent to a footpath through a wood
	2	Park bench (seat)	as above
	3	Oak tree trunk	in a wood, height of taping 1 m 50 cm
	4	Signpost	by woodland path, height of taping 1 m 50 cm
	5	Grill hut – door	height – shoulder level (party held seven days before)
	6	Grill hut – door	height – hip level
Two days since rain	7	Roof tile	below window, bedding aired regularly on window sill
	8	Roof tile	adjacent to sample 7
	9	Garden gate	in wooden fence, back of property, 60 cm high
	10	Garden gate	as above, front of property
	11	House door	gloss paint, area around handle
	12	Wooden shed	area around handle on door of garden shed
Two days after one week of rainy weather	13	Bus stop seat	plastic, no longer in regular use
	14	Concrete paving slab	within a bus stop shelter
	15	Concrete paving slab	adjacent to sample 14
	16	Car	door, handle area
	17	Metal garage door	handle area
	18	Telephone kiosk	inside of door
	19	Telephone kiosk	from glass side window
No rain for seven days	20	Lamp post	in cul-de-sac, at height 1m 50cm
	21	Stone wall	behind 20, same height
	22	Concrete paving slab	in cul-de-sac, quiet street mainly used by elderly people
	23	Car	front wing
	24	Telephone kiosk	door, around handle
No rain for ten days	25	Car	wing/bonnet
	26	Roof tile	near skylight window
	27	Bus stop seat	plastic (next to 13), not in regular use
	28	Sycamore tree trunk	normal urban street, height 1 m 50 cm
	29	Concrete paving slab	in a second bus stop shelter
	30	Metal garage door	near handle, adjacent to 17
No rain for previous few days	31	Chain-link fence	industrial estate
	32	Chain-link fence	electricity power station
	33	Chain-link fence	large used car dealer

TABLE 2 Summary of categories used for the classification of fibres.

<i>All fibres</i>	<i>Type</i>	Cotton, wool, other vegetable, other animal, acrylic/modacrylic, acetate/triacetate, polyamide, polyester, polyolefin, viscose, other synthetic
	<i>Colour</i>	Red, orange, yellow, yellow-green, green, blue-green, blue, purple, brown, grey, black
	<i>Length (mm)</i>	<0.5, 0.5–1.0, 1.1–3.0, 3.1–5.0, >5.0
<i>Synthetic</i>	<i>Delustrant status</i>	Absent (bright), very low, semi-dull, dull

TABLE 3 Breakdown of the fibre population found on the surfaces examined.

<i>Location</i>	<i>Cotton</i>	<i>Blue denim</i>	<i>Wool</i>	<i>Vegetable</i>	<i>Animal hairs</i>	<i>Polyamide</i>	<i>Polyester</i>	<i>Viscose</i>	<i>Acetate Triacet.</i>	<i>Acrylic</i>	<i>Unident. man-made</i>	<i>Total</i>
Outdoor Seats												
Park Bench	26	1	23	1	1	-	3	3	-	1	3	61
Back												
Park Bench	184	18	23	19	-	3	7	22	2	2	-	262
Seat												
Bus-Stop	37	25	15	2	5	-	1	5	-	3	-	68
Bus-Stop	24	10	1	-	-	-	1	9	-	-	-	35
Trees												
Oak Tree	12	4	-	-	-	-	-	-	-	-	-	12
Sycamore Tree	1	-	-	-	-	-	-	-	-	-	-	3
Posts/Signs												
Signpost	2	1	-	-	-	-	-	1	-	-	-	3
Lamp-post	5	-	-	-	-	-	1	-	-	-	-	6
Wooden Sheds												
Grill hut door	33	14	6	4	-	1	-	2	-	1	3	50
Grill hut door	52	18	5	2	-	1	-	6	1	2	-	69
Garden shed	23	2	2	-	-	-	-	-	1	-	-	26
Roof Tiles												
Roof Tile	44	12	4	1	-	-	-	4	2	3	2	60
Roof Tile	39	2	4	2	2	-	-	3	8	1	-	59
Roof Tile	12	1	1	-	1	1	-	3	-	1	-	19
Fences/Walls												
Wood Fence												
front gate	249	170	1	1	-	-	1	1	-	-	-	253
Wood Fence												
back gate	57	3	1	-	-	-	1	3	-	3	-	65
Stone Wall	4	0	2	-	-	-	-	2	-	1	-	9
Doors												
House Door	39	7	1	2	-	-	1	-	1	2	-	46
Garage Door	25	11	-	-	1	1	-	1	-	-	1	29
Garage Door	11	6	-	-	-	1	-	-	-	-	-	12
Paving stones												
Bus-stop	128	54	9	4	1	2	5	9	-	12	1	171
Bus-stop	87	43	8	2	1	3	1	7	-	6	2	117
Bus-stop	10	2	6	-	1	1	-	4	-	1	-	24
Bus-stop	62	26	5	1	1	-	4	9	-	5	-	87
Cars												
Car	16	12	2	-	-	-	-	-	-	1	-	19
Car	7	1	-	-	-	-	1	1	-	-	-	10
Car	8	3	-	-	-	1	1	1	-	1	-	12
Phone Kiosks												
Door Glass	17	8	-	-	-	-	1	-	1	-	-	19
Window Glass	39	15	-	-	-	-	-	2	-	-	-	41
Door Metal	43	7	-	-	-	-	1	3	-	1	1	49
Chain link fences												
ind.estate	19	9	1	-	-	-	1	1	-	7	12	41
power station	11	5	1	-	-	2	-	-	-	2	-	16
used car dealer	6	1	3	-	-	-	1	1	-	1	-	12
TOTALS	1328	491	124	41	14	17	32	105	16	57	26	1760

and these fibres tend to be given preference in forensic examinations. The presence/absence of colourless cotton was noted, and if colourless synthetic fibres were removed they were identified and noted. A register was kept of all synthetic fibres recovered.

The operators experienced some difficulties with taping, (working single-handed under outdoor conditions) often caused by even the slightest wind and the lack of a flat surface on which to spread out the recipient plastic surface properly. During evaluation of some of the tapes it was noted that the number of blue denim cotton fibres appeared to be relatively high. It was feared that some of these may have been transferred to the plastic by static from the clothing of the operator. It has also been reported [3], that stray fibres can be found on the surfaces of the plastic bags which are cut open and used to receive tapings.

To check against this possible source of contamination, two measures were taken. Firstly, while the operator was wearing blue jeans, "blank" tapes were prepared after going through the motions of taping and then affixed to a cut open plastic bag. Secondly, the surfaces which had raised the question were re-taped with the operator being clad only in white cotton garments.

To investigate the extent to which fibres would be transferred to a smooth, shiny metal surface, two experiments were also conducted in which blue jeans were deliberately brought into contact with a car body, under varying degrees of pressure and movement.

Results and discussion

Fibre type

The outdoor surfaces could be grouped together to make comparison of the results easier and full details of the complete fibre population found on each surface are given in Table 3. Identification was limited to the categories shown in the table.

The distribution of the fibre types found on the outdoor surfaces is shown in Figure 1. Cellulosic fibres made up the greatest portion, with viscose being the commonest synthetic type (6.0%); most of these fibres were normal irregular section rayon fibres, all other synthetics being represented by only 8.4% (Figure 1a). Figure 1b shows the percentage breakdown among the synthetic fibre types. The predominance of cellulosic fibres on the outdoor surfaces was overwhelming, probably because they fragment more rapidly than synthetic fibres and shed readily from textile surfaces [4]. Of a total of 1760 fibres, 1628 were cellulosic (92.5%), and the majority of these were cotton (81.5%).

Apart from viscose (6.0%), the synthetic fibres include acrylic (3.2%), polyester (1.8%), polyamide (1.0%), acetate (0.9%) and various unidentified synthetic fibres (1.4%) which included a collective of 12 fibres on the first sample of chain-link fence.

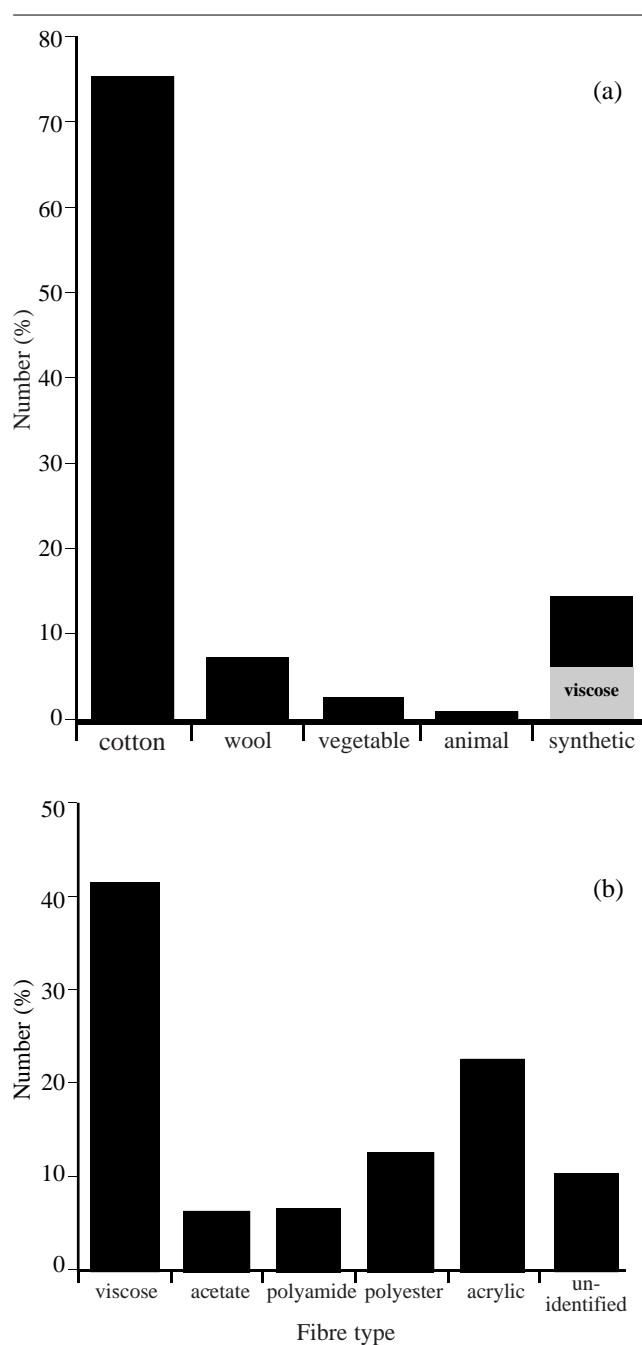


FIGURE 1 Distribution of (a) Total fibre population, and (b) Synthetic fibre population on outdoor surfaces.

This can be compared to a weighted percentage frequency order obtained from the fibre composition of outer clothing researched from a mail order catalogue data collection [5] which at that time contained 40120 fibre types, in records from c. 23,000 items of outer clothing accumulated during 1993 and 1994 (the year concerned). For summer clothing in 1994, the order was: cotton (73.6%), polyester (15.2%), viscose (9.74%), acrylic (0.75%), polyamide (0.41%), wool (0.34%), vegetable (0.14%) and acetate (0.02%). If outer clothing from the whole year is considered the order is only altered in that the positions of polyamide and wool are reversed. The same situation applied in 1993.

The greatest differences between the outdoor and catalogue orders shown above are in the positions occupied by wool and by polyester fibres. The preponderance of certain fibre types on outdoor surfaces is almost certainly not solely dependent on the composition of textiles worn by the public, but also on the fact that cellulosic fibres fragment more readily than synthetics. Figures for the dry breaking force in cN/tex for various fibre types can be found in [4]. The influence of hard, rough outdoor surfaces will tend to increase fragmentation. The rank order determined in this study fits a combination of these features. For example, in Summer, wool is worn less frequently than viscose but this is compensated for by the fact that the wool fibres fragment more readily. Polyester is worn more extensively than viscose in the Summer, but this is offset by the fact that the force required for its fragmentation is much higher (minimum 40 cN/tex) than that of viscose (minimum of 18 cN/tex).

Synthetic fibres were relatively rare; only 253 fibres (14.3%) were found. In all but five samples (85%) viscose was the most common synthetic fibre type. A comparison of the descriptions of colour, shape, delustrant status showed that at least 64% of the population was made up of a minimum of 145 different fibre varieties. If objective colour measurement had been made, this figure would have undoubtedly been much higher. This again [6] shows that the majority of the synthetic fibre population found on a randomly chosen surface is represented by single examples only. Collectives of synthetic fibres are likely to have been the result of a recent contact with a specific textile and can be considered to be evidentially very important.

Colour

The predominating colours for cotton fibres were: blue denim (491 – 36.9%), grey/black (317 – 23.8%), blue (177 – 13.3%) and red (109 – 8.2%). This order is similar to that obtained by Grieve and Dunlop [6] who examined foreign fibre populations on undergarments. The predominant colours of outer clothing worn by men, women and children questioned in an independent research institute survey in 1985 (personal communication: Institut für Demoskopie, Allensbach, Germany) were blue, grey, brown and black. Fibres of these colours are used extensively in coats, jackets, trousers, pullovers, etc. In our study, brown was not so frequent but red occurred more often. The same Institute determined that over a long period of time red has remained the interviewees’ second favourite colour, surpassed only by blue. Colourless cotton fibres were present on all surfaces; blue denim cotton was found on all but three of the 33 surfaces examined, and only 18 fibres in all were found on these three surfaces. Grey/black cotton were absent on only three surfaces (total of only 18 fibres), blue (non-denim) were only absent on five surfaces and red cotton only on six surfaces. This supports the view expressed in [6] that the use of microspectrophotometry to compare cotton fibres of these colours is essential. Unless new and

TABLE 4 An example of the distribution of less common colours among the outdoor population of 1760 fibres.

	<i>orange</i>	<i>green</i>	<i>purple</i>	<i>yellow</i>
cotton	11.0	74.0*	13.0	38.0#
synthetic	16.0	9.0	6.0	34.0#
wool	4.0	5.0	13.0	4.0
%	1.8	5.0	0.76	4.3
% Allensbach survey	0.6	8.8	3.0	3.0

* 36 fibres found in one sample
collectives of 11 and 12 fibres in one sample.

reliable comparative techniques can be applied to comparison of indigo and sulphur black dyed cotton fibres their evidential value, except in exceptional cases, is minimal because of their widespread production and distribution. It must be remembered that colour was only recorded on a subjective basis. However, from Table 4 it can be seen that fibres coloured orange, green, purple and yellow formed very small percentages of the total of the outdoor population seen in this study. Comparative figures from the Allensbach survey referred to earlier are also given. The fibres in these broad categories are certainly not all identical but represent a wide variety of types and colours whose individual frequency will be much lower. Collectives of fibres in these types and colours will not only be immediately recognisable, but will also be highly significant evidentially.

Length

Many of the fibres (65%) were very short fragments, under 1 mm long, as shown in Figure 2. The fibres were often damaged, e.g., with frayed ends or with very poor scale patterns and they often had adherent dirt particles. This appearance did not give the impression of simply being from excessive garment wear. One explanation is that they had probably not been recently deposited. Conversely, longer fibres in good condition were likely to have been the subject of a recent transfer. Only 6.6% of the recovered fibres were over 3 mm long; the highest numbers of these were found on the pavement in bus stop areas, and probably represented fibres that had simply fallen to the ground.

Control experiments

The control experiments conducted to see if fibres from the blue jeans of the operator would be inadvertently transferred to the surface of an open plastic bag by static, showed that it was possible for a very low number of fibres to be transferred in this manner. The three trial tapes contained three, three and five blue denim cotton fibres respectively. A number of this order was insignificant in comparison to the numbers recovered from the bus stop seat and two concrete paving slabs from within the bus stop shelter. Repeat

tapings from comparable surfaces, made when the operator was wearing only white cotton garments, also showed a considerable number of blue denim cotton fibres; when expressed as a percentage of the total cottons the number was similar in both cases. Nevertheless, in a crime scene investigation the need for the use of protective clothing cannot be overstated.

The number of blue jeans fibres remaining on a car body after a deliberate transfer attempt lasting one minute, was surprising. The area was "cleaned" with adhesive tape before the transfer. In the first trial, a static attempt (leaning), 11 fibres were recovered from an area of 500 cm². Increased pressure combined with movement in the second trial caused the number to be more than doubled, to 29 transferred fibres. It is doubtful whether these fibres would persist for long, particularly if the vehicle were driven, due to the effects of wind and possibly rain. The vehicle in question was standing in an open garage. Some information on the influence of weather conditions on fibre persistence outdoors can be found in the work of Krauß [7].

Collectives

The number of acetate fibres in this study is probably artificially high, as it resulted largely from collectives found on roof tiles from the same roof. Bedclothes are often aired and shaken out of the attic window above the tiles. The acetate fibres matched those in a dressing gown belonging to the house owner. This supports the fact that if a collective of synthetic fibres is found on such an outdoor location, it is most probably significant. The chances of finding acetate fibres are small. The data collection [5] shows that acetate fibres represent only 0.6% of all fibre types (>66,000) included in over 39,000 garments of all varieties (outerwear, sports/leisurewear, under/nightwear and accessories) recorded in 1993/4.

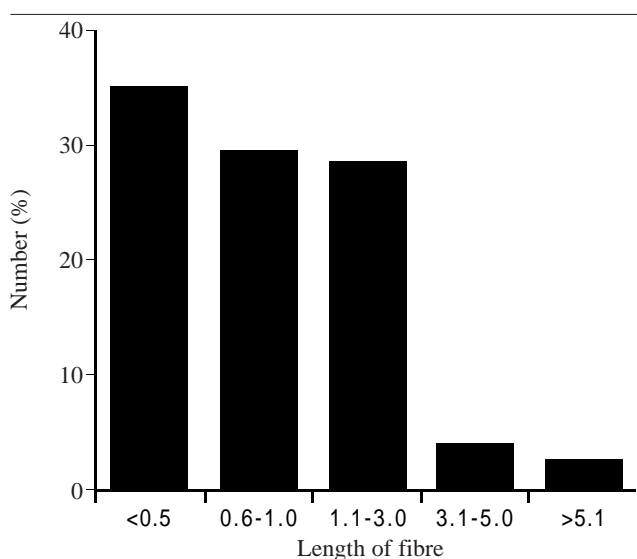


FIGURE 2 Distribution of fibres according to length.

Other collectives found in this study included nine yellow viscose fibres, from a total of 35 fibres on a bus stop seat, 20 grey-blue wool fibres, from a total of 61 fibres on the back of a park bench (more of these fibres were also found on the bench seat), and seven green printed acrylics plus 12 green printed unidentified synthetics, found on the chain link fence on an industrial estate.

Exposure

Table 5 expresses the population for each surface as a number/unit area (100 cm²) and gives the authors' estimation of the likelihood of exposure to fibre sources. The actual population order corresponds very well with that of the expected population and the results support the theory that the potential population on an outdoor surface is dependent on the extent to which the surface is exposed to the public, the nature of the recipient surface and the degree of persistence. Rough hard surfaces allow a higher transfer of fibres, and smooth surfaces provide a lower degree of persistence which may be diminished further by the influence of movement, wind and weather.

Good examples of the extent to which exposure to the public will affect the fibre population on an outdoor surface can be seen by considering the variation seen on tapings made from essentially similar locations. On samples from concrete paving slabs within a bus shelter on a busy road, the large population recovered contained a good variety of types including a relatively high number of synthetic fibres and many blue denim jeans fibres. (Since people do not normally lie on the ground while waiting for a bus, it must be assumed that the great majority of fibres simply fall onto the pavement; the normal rules of transfer do not apply). In contrast, the paving slab from a cul-de-sac in a quiet street, seldom used by children or by young people likely to wear jeans, showed a greatly reduced population with few synthetic fibres and only two blue denim cottons.

One roof tile below an attic window yielded 59 fibres (12 synthetic), while another yielded only 19 fibres (five synthetic) although taken from the same roof. As previously mentioned, bedding was frequently shaken/aired out of the window above the location of the first tile whereas the second tile was situated next to a skylight window which was very rarely opened.

Another excellent example is provided by the samples from two identical gates in a wooden fence. The back gate, which was only occasionally used, had a moderate population of 65 fibres in which a good variety of fibre types were represented. Over four times as many fibres, including 170 blue denim cottons, were present on the sample taken from the front gate, because teenagers wearing blue jeans congregated daily around it and often sat on this gate.

As reported above, the chain-link fence on the industrial estate contained a collective of 19 synthetic fibres which indicated a specific contact.

TABLE 5 Interpretation of fibre transfer to outdoor surfaces, based on the results of this study.

<i>Fibres/100 cm²</i>	<i>Location</i>	<i>Surface</i>	<i>Texture</i>	<i>Expected population</i>
65.0	park bench seat	plastic	rough	very high – direct contact
50.6	gate in fence	wood	rough	very high – direct contact
34.2	paving stone-bus stop	concrete	rough	high – frequent use
23.4	paving stone-bus stop	concrete	rough	high – frequent use
17.4	paving stone-bus stop	concrete	rough	high – frequent use
15.0	park bench back	plastic	rough	high (but <seat)
13.8	grill hut door	wood	rough	medium
13.5	bus stop seat	plastic	smooth	medium – not in constant use
13.0	gate in fence	wood	rough	medium
12.0	roof tile	stone	rough	high (see text)
11.8	roof tile	stone	rough	high (see text)
10.0	grill hut door	wood	rough	medium
9.8	telephone kiosk	metal	smooth	medium (high transfer but low persistence)
9.2	house door	wood, painted	smooth	medium (high transfer but low persistence)
8.2	telephone kiosk	glass	smooth	medium (high transfer but low persistence)
8.2	chain-link fence	wire	smooth	limited surface*
7.0	bus stop seat	plastic	smooth	medium – not in constant use
5.8	garage door	metal	smooth	medium – low
5.2	garden shed	wood	rough	medium – low
4.8	paving stone	concrete	rough	low – little use
4.0	oak tree trunk	wood	rough	low – little contact
3.8	car	metal	smooth	low – rapid loss
3.8	telephone kiosk	glass	smooth	medium – low persistence
3.8	roof tile	stone	rough	low (see text)
3.2	chain-link fence	wire	smooth	limited surface
2.4	garage door	metal	smooth	medium low
2.4	car	metal	smooth	low – rapid loss
2.4	chain-link fence	wire	smooth	limited surface
2.0	car	metal	smooth	limited surface
1.8	stone wall	stone	rough	low – little contact
1.5	sign post	metal	smooth	low – little contact/high loss
1.2	lamp post	metal	smooth	low – little contact/high loss
0.6	sycamore tree trunk	wood	rough	low – little contact

* included a collective of 19 fibres

Surfaces examined two days after one week of continuously rainy weather, showed no lack of fibres (range from 19–171) on the areas tested within the bus stop shelter, the car, garage door and telephone kiosk. It may be that the persistence of very small fibre fragments on rough surfaces can be considerable. This could account for the damaged and weathered appearance of many of the fragments recovered in this study. A long outdoor exposure may affect the microscopical appearance/character of fibres in comparison to unexposed control material [8].

It has been reported by Krauß and Hildebrand [1] that wind velocity up to 6.7 m s^{-1} only affects persistence of fibres on skin under outdoor conditions to a small degree. All sampling in the authors' experiments was done in a geographical area where, during the spring/summer, wind was normally minimal. On many summer days there was hardly sufficient breeze to stir the trees. It is also the authors' opinion that very tiny fibre fragments may become embedded in rough outdoor surfaces, reducing their susceptibility to wind unless it is of considerable strength.

Practical examples of the use of this study

A terrorist case involving an attempt to blow up industrial premises involved looking for fibres on a cut section of chain link fence (point of entry). Four collectives of grey wool fibres (the fibres within the groups matched after the normal comparative examinations) were found in a fibre population of about 480 fibres which could be represented as $33/100 \text{ cm}^2$. This population seemed to be much in excess of what one would expect to find on a randomly chosen chain link fence (cf. results from samples in the study in which only 33 grey wool fibres were found on all surfaces, with no more than four (which were not necessarily of the same dye type) being found on any one surface). These facts lent weight to the argument that the fibres found on the fence were not there just by coincidence.

In a second example, in connection with an arson case, fibres were found on a broken wooden fence surrounding the site. These were cotton fibres in shades of green, brown and black which had come from a printed textile. It was suggested that they could have originated from a military camouflage uniform. A suspect was forthcoming and he was indeed found to own an ex-US Army pair of fatigue trousers. As a result of an industrial enquiry it proved possible to obtain additional evidence to increase the value of this finding. The suspect subsequently confessed.

Conclusions

Textile fibres were present on all of the outdoor surfaces examined. Studies carried out in Germany [9] have shown that every year 1.9 million tons of textiles are manufactured and 1.75 million tons of textile waste must be disposed of. The difference of about 8% is accounted for by loss of

fibres during the normal use and care of clothing (lint in washing and dry cleaning machines). Some clothing fibres will simply be lost into the air and will find their way onto outdoor surfaces.

The predominance of blue denim, grey/black and red cotton fibres emphasizes the need to use microspectrophotometry when comparing these types. Because of their rarity, a collective of synthetic fibres could be considered highly significant, especially when they are of an unusual colour.

The implication of these results is that the application of fibre evidence to high volume crime (breaking and entering) may be of more value than has previously been considered. However, an awareness of the factors which may influence fibre transfer to outdoor surfaces is very important. During an investigation as much background information as possible concerning the normal use of the surface in question should be taken into account, along with any special circumstances. The authors recommend that scenes of crime officers who are making tapings from a crime specific point at an outdoor location, make a further control taping from a separate non-crime related area of the same surface.

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