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Turner, Andrew

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1 **Trace elements in laundry dryer lint: a proxy for household**
2 **contamination and discharges to waste water**

3
4 **Andrew Turner***

5 *School of Geography, Earth and Environmental Sciences,

6 University of Plymouth

7 Drake Circus

8 Plymouth PL4 8AA, UK

9 aturner@plymouth.ac.uk

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23

24 **Abstract**

25 Seventy samples of laundry dryer lint from 19 households have been analysed for trace elements
26 (As, Br, Cu, Fe, Ni, Pb, Sb, Zn) by energy-dispersive portable x-ray fluorescence (XRF) spectrometry.
27 Bromine, Fe and Zn were detected in more than sixty samples encompassing all households, with dry
28 weight concentrations ranging from 5.5 to 213 $\mu\text{g g}^{-1}$, 76 to 3580 $\mu\text{g g}^{-1}$ and 24 to 3540 $\mu\text{g g}^{-1}$,
29 respectively. Lead and Sb were detected in twenty and eight samples from ten and seven
30 households, respectively, with respective concentrations ranging from about 8 to 110 $\mu\text{g g}^{-1}$ for Pb
31 and 40 to 90 $\mu\text{g g}^{-1}$ for Sb. In contrast, As was only detected in six samples from the same household
32 with concentrations ranging from about 10 to 250 $\mu\text{g g}^{-1}$. Analysis of 72 items of new or clean
33 clothing and linen revealed the ubiquity of Sb in synthetic (largely polyester-based) articles and the
34 presence of Br in a variety of natural and synthetic articles, suggesting that the dominant source of
35 these elements in dryer lint is derived from clothing fibres themselves; specifically, Sb_2O_3 is
36 employed as a catalyst in the manufacture of polyester and various brominated compounds appear
37 to be used as disperse dyes. No detectable As or Pb in the clothing-linen samples indicates that their
38 presence in dryer lint arises from contamination of laundry from extraneous sources (e.g. household
39 dust and material accumulated from outdoor activities) and suggests that concentrations can be
40 used as proxies for exposure or household contamination. Since dryer lint is representative of
41 material shed during the washing of clothes and linen, its composition also serves as a proxy for
42 contaminants entering the environment from this process. Of particular significance in this respect is
43 the discharge of chemicals specific to textiles and associated with microfibers.

44

45 **1. Introduction**

46 Laundry lint is generated during the drying of clothes and linen in a clothes dryer and accumulates
47 on a screen or filter. Lint is composed of fibres of clothing-linen as well as extraneous material that is
48 associated with laundry, like dust, pollen, skin, hair, food, microorganisms and soil, and, potentially,
49 residues of laundry detergent.

50 Mahaffy et al. (1998) proposed using dryer lint as a novel and non-invasive proxy of household
51 contamination and non-dietary exposure since samples are readily collected and material on
52 clothing may reflect a composite of individual chemical sources within and external to the
53 household. To this end, the authors determined the concentration of Pb in dryer lint samples
54 collected by participants from three different groups: a control, comprising university members of

55 staff with no known occupational or recreational exposure to the metal; an urban composite,
56 consisting of samples taken from communal dryers in a city centre; and an occupational, made up of
57 radiator shop employees whose managers were aware of potentially high Pb exposure. Arithmetic
58 mean values of Pb in lint were about 20 $\mu\text{g g}^{-1}$ for the former groups and about 60 $\mu\text{g g}^{-1}$ for
59 secondary radiator shop employees (i.e. clerical or managerial staff) and 350 $\mu\text{g g}^{-1}$ for primary shop
60 employees (i.e. those directly involved with soldering). Some participants or family members of the
61 latter category exhibited Pb blood levels above recommended action thresholds.

62

63 Stapleton et al. (2005) analysed samples of domestic dryer lint and detected various brominated
64 flame retardants. Their presence was attributed to household dust (and associated flame retardants)
65 being picked up by clothing, although contributions from the dryers themselves could not be ruled
66 out. More recently, Ouyang et al. (2017) tentatively identified a spectrum of chemicals in domestic
67 laundry dryer lint that included pesticides, therapeutic and illicit drugs, fragrances, plasticizers and
68 compound metabolites. Significantly, the concentrations of some compounds, including one
69 commonly employed as an insect repellent, were considerably higher in lint than in household dust.

70 Given that the composition of dryer lint reflects the signature of chemicals shed in solid form (and
71 mainly as fibrous microplastics) from the washing of clothes and linen, analysis of lint can also be
72 used to gain semi-quantitative information on chemicals discharged to the environment from this
73 process. Thus, while there has been considerable recent interest in laundry as a source of
74 microplastics to water treatment plants and aquatic systems (Hernandez et al., 2017; Almroth et al.,
75 2018), analysis of lint may afford a simple means of chemically characterising these plastics.

76 In the present study, domestic dryer lint samples have been analysed for a broad suite of
77 environmentally relevant and potentially toxic trace elements by portable x-ray fluorescence (XRF)
78 spectrometry, a non-destructive, multi-element technique that entails minimal sample preparation
79 and is capable of a high throughput of samples. Specifically, the instrument is configured in a low
80 density mode that has previously been applied to plastics, foams and biological material (Turner and
81 Solman, 2016; Bull et al., 2017; Massos and Turner, 2017) and that is validated through independent
82 sample measurements by inductively coupled plasma (ICP) spectrometry following acid digestion. In
83 addition, and in order to evaluate the relative significance of different sources of trace elements to
84 the lint, articles of clothing and linen, constructed of both synthetic and natural fibres, have been
85 analysed by the same approach. The results are discussed in terms of the use of dryer lint as a
86 potential indicator of household contamination and human exposure and as a measure of chemicals
87 that are lost to the environment through washing.

88

89 **2. Methods**

90 *2.1. Sampling and sample preparation*

91 A total of nineteen households within 80 km of Plymouth (south west England), and encompassing
92 urban, suburban, rural and agricultural settings, provided between one and eight samples of lint
93 from individual operations of domestic vented or condenser tumble dryers. Samples were collected
94 manually from lint filters immediately after dryer use in clear polyethylene bags or brown envelopes
95 and information was supplied on any particular articles laundered or any specific recent activities of
96 household occupants. The load of clothing dried was measured by some participants and ranged
97 from about 2.5 to 4.5 kg on a dry weight basis.

98 In the laboratory, individual lint samples were weighed on a Sartorius Genius five-figure balance and
99 coded according to colour. Samples were then packed in to polyethylene XRF sample cups
100 (Chemplex series 1400; 21-mm internal diameter) to a depth of 20 mm (the critical depth for plastics
101 is ~ 5 to 10 mm; Niton, 2011) and collar-sealed with 3.6 μm SpectraCertified Mylar polyester film
102 (Figure 1). For samples too small to completely fill the XRF cups, quartz wool was added beneath the
103 lint such that the sample was in full contact with the polyester film and at a depth of at least 10 mm.

104 *2.2. XRF analysis*

105 Samples were analysed for a suite of elements, of which the trace elements: As, Br, Cu, Fe, Ni, Pb,
106 Sb, Zn; are the focus of the present study, using a battery-operated, energy-dispersive Niton XL3t
107 950 He GOLDD+ portable XRF spectrometer. The instrument was configured nose upwards in a
108 shielded laboratory test-stand and activated remotely by a laptop via USB connection. Samples were
109 placed centrally, and with the polyester film facing downwards, over the 8 mm (50 mm^2) x-ray beam
110 before being counted for 60 seconds in a low density, standardless plastics mode (40 seconds at 40
111 μA and 50 kVp and 20 seconds at 100 μA and 20 kVp). Measurements were then repeated at four
112 different locations towards the perimeter of each sample surface. Spectra arising from sample
113 counting were quantified by fundamental parameter coefficients to yield elemental concentrations
114 in $\mu\text{g g}^{-1}$ and a measurement error of 2σ (95% confidence) that were downloaded to the laptop via
115 Niton data transfer software. For quality assurance and instrument performance purposes, two 13
116 mm-thick Niton reference plastics that had been impregnated with various elements (PN 180-554
117 batch SN PE-071-N: Br = $495 \pm 20 \mu\text{g g}^{-1}$, Pb = $1002 \pm 40 \mu\text{g g}^{-1}$; PN 180-619 LOT#T-18: As = $50 \pm 7 \mu\text{g g}^{-1}$,
118 Pb = $150 \pm 12 \mu\text{g g}^{-1}$, Sb = $96 \pm 10 \mu\text{g g}^{-1}$) were analysed at regular intervals throughout each

119 measurement session, with concentrations returned by the XRF always within 10% of corresponding
120 certified values.

121 Measurement limits of detection, based on three counting errors, varied among the elements and
122 samples because of variations in sample composition but mean values ranged from $< 10 \mu\text{g g}^{-1}$ for
123 As, Br and Pb to $> 70 \mu\text{g g}^{-1}$ for Fe. Measurement precision, based on quintuplicate readings of the
124 same sample and at the same location with respect to the detector, was better than 10% for all
125 elements with the exception of Br, Cu and Pb ($< 15\%$).

126 In addition, 72 items of clothing and linen were analysed by XRF. Here, new or freshly washed items
127 constructed of (mainly) cotton, wool or polyester or mixtures thereof, and including shirts, blouses,
128 trousers, skirts, underwear, jackets, fleeces, scarves, gloves, hats, sportswear, towels, tablecloths
129 and bedsheets, were gathered to a depth of at least 10 mm onto a plate of clear glass on a solid
130 floor. The nose of the XRF spectrometer, shielded with a PVC-tungsten collar, was pressed firmly
131 against the measurement surface and activated by hand and using the trigger mechanism under the
132 conditions and times specified above.

133 *2.3. Validation of XRF measurements using ICP*

134 In order to evaluate the performance of the XRF on lint samples, including any interferences arising
135 from the presence of air in the matrix, five samples were subsequently acid-digested and analysed
136 by inductively coupled plasma-optical emission spectrometry (ICP-OES). Briefly, triplicate 250 mg
137 subsamples were weighed into 50 ml Pyrex beakers to which 3 ml concentrated HNO_3 and 3 ml
138 concentrated HCl were added. Beakers were covered with watch glasses and left for 2 h before
139 being simmered for a further 2 h on a hot plate, with additions of acid undertaken as necessary to
140 maintain a near-constant digest volume. After cooling, the contents were filtered into volumetric
141 flasks and diluted to 50 ml with distilled deionised water. Digests were analysed for As, Br, Cu, Fe, Ni,
142 Pb, Sb and Zn using a Thermo Scientific iCAP 7000 Series ICP Spectrometer calibrated with matrix-
143 matched mixed standards and blanks.

144 A comparison of results arising from ICP and XRF, shown in Figure 2, reveals overall agreement
145 within 12% and a Pearson' moment correlation coefficient defining the data of close to unit value.

146

147 **3. Results**

148 A total of 70 dryer lint samples were analysed as part of the study, with dry weights ranging from
149 about 0.2 to 3 g. Given the clothing loads reported, it is estimated that lint arising from tumble

150 drying represents between about 0.02 and 0.1% of the mass of material processed; that is, up to a
151 few parts per thousand of each load is lost via lint. Sample colour was usually grey or off-white, but
152 shades of blue, pink and purple were evident in many cases and occasional samples were brown
153 (Figure 1). Colours varied between samples from the same participant suggesting that the types of
154 and colours clothing or linen dictate the precise colour of the final material.

155 Regarding elemental concentrations returned by the XRF, the relative standard deviation arising
156 from five measurements taken at different locations on the same sample surface was less than 25%
157 but always greater than the respective measurement precision. This may be partly the result of
158 inconsistencies in sample thickness or the presence of fold-lines arising from manual packing but is
159 largely attributed to an inherent heterogeneity within the material. Such heterogeneity was most
160 evident where samples exhibited small but visible colour or textural transitions beneath the
161 polyester film, an effect that may have resulted from uneven distribution of material across the lint
162 filter or some cross contamination of lint between drying loads.

163 Table 1 summarises the number of positives and concentrations for each element both per
164 household and on an individual sample basis. The latter are based on the mean of five
165 measurements performed at different locations on the same sample while the former is based on an
166 average of mean measurements on multiple samples (or, in some cases, a single sample) from the
167 same participant. The two measures are different, therefore, because different numbers of samples
168 were taken among the households and some elements may have been detected in differing
169 numbers of cases within the same household. For example, Cu was detected in 46 samples among
170 17 households, with a maximum average concentration per household of $264 \mu\text{g g}^{-1}$ but a maximum
171 individual sample concentration of $456 \mu\text{g g}^{-1}$.

172 Overall, Br, Fe and Zn were detected in all households, and Zn was detected in all samples. In
173 contrast, Sb was detected in seven samples from six different households, Ni in six samples from six
174 different households and As in six samples from the same household. With the exception of the
175 latter three elements, concentrations were highly variable among households and samples, with a
176 range spanning at least one order of magnitude in most cases. Significant associations were limited
177 to Cu-Ni ($r = 0.88$; $n = 6$) and Cu-Fe ($r = 0.77$; $n = 38$) and there was no clear relationship between
178 trace element concentrations and sample colour or mass.

179 Shown in Table 2 are summary statistics for trace elements in the new or cleaned clothing and linen
180 samples. Antimony and Br were detected in almost one half of all samples tested and Fe was
181 detectable in 25 cases; among these elements, concentrations were variable and spanned at least an
182 order of magnitude, and mean, median and maximum concentrations of Sb and Br were higher than

183 respective values for the lint samples on either a household or sample basis. In contrast,
184 concentrations of Cu, Ni and Zn were returned in less than ten clothing-linen samples each while
185 neither As nor Pb were detected throughout. There were no significant associations between the
186 elements in clothing-linen articles, and while Sb and Br coexisted in 22 samples, combinations of any
187 of the remaining elements were only observed in four items of clothing.

188 A comparison of clothing-linen and lint was made for each trace element by dividing the sum of
189 concentrations in the former by the sum of concentrations in the latter, with resulting ratios shown
190 in Table 2. Comparisons are semi-quantitative because of the different numbers of samples in each
191 category and different XRF detection limits among the elements studied. Nevertheless, high ratios
192 for Br and, in particular, Sb, signify that clothing-linen itself is the dominant source of these elements
193 to dryer lint while values close or equal to 0 (As and Pb) signify the presence of these elements in lint
194 solely from extraneous sources.

195 Concentrations of trace elements in dryer lint are comparable with the limited number of published
196 concentrations in the literature. Thus, Mahaffy et al. (1998) report acid-digestible dry weight
197 concentrations of Pb ranging from 6 to 110 $\mu\text{g g}^{-1}$ and a mean of about 20 $\mu\text{g g}^{-1}$ in samples collected
198 from homes of 20 university staff with no known occupational or recreational origins of the metal;
199 additional samples from communal dryers for low income inner city communities ranged from 6 to
200 55 $\mu\text{g g}^{-1}$. Ene-Parent and Zikovsky (2001) determined various elements in ten samples of lint from
201 “white-collar” households by neutron activation analysis, with Br, Cu, Fe, Sb and Zn concentrations
202 ranging from 6 to 41 $\mu\text{g g}^{-1}$, 19 to 109 $\mu\text{g g}^{-1}$, 293 to 701 $\mu\text{g g}^{-1}$, 6 to 43 $\mu\text{g g}^{-1}$ and 21 to 490 $\mu\text{g g}^{-1}$,
203 respectively.

204

205 **4. Discussion**

206 Dryer lint is an heterogeneous assortment of natural and synthetic fibres, human and animal hairs,
207 household dust and various other extraneous solids that have accumulated on clothing and linen
208 and remain after washing and drying. Despite this heterogeneity, the results of the present study
209 have shown that various trace elements are rather homogeneously distributed within individual
210 samples, at least over the resolution of the XRF detector (50 mm²). More important are variations
211 both within and between households where samples were taken.

212 Of the elements considered in the present study, Br and Sb were frequently encountered in new and
213 washed articles of clothing and Sb was detected in a few samples of linen. Antimony was restricted
214 to articles composed entirely or partly of synthetic, polyester fibres and its presence at, on average,

215 about $150 \mu\text{g g}^{-1}$, may be attributed to the use of Sb_2O_3 as a polymerisation catalyst in the
216 manufacture of polyethylene terephthalate, a constituent polymer of polyester (Lacasse and
217 Baumann, 2004). Significantly, four items of clothing (a child's fancy dress outfit and three sports
218 shirts) contained Sb at a concentration exceeding the Ecolabel limit for textiles of 260 ppm
219 (European Commission, 2009).

220 Concentrations of Br were more variable among the clothing samples but reasons for its presence
221 are less clear. A common use of brominated compounds in textiles and furnishings is as flame
222 retardants but only certain items of clothing, including young children's night apparel, are flame-
223 retarded, and organophosphate compounds appear to be the most favourable choice on health
224 grounds (Lacasse and Baumann, 2004). Moreover, brominated flame retardants are generally used
225 for flame retardancy at much higher concentrations and in conjunction with Sb-based synergists; no
226 statistical association between Br and Sb was observed in the clothing samples (Figure 3) and the
227 majority of Br-Sb data for the samples lie below the line defining the mass ratio of these elements in
228 common, commercial flame retardant mixtures (Papazoglou, 2004). In a recent study of brominated
229 compounds in household dust, Peng et al. (2016) found that the majority of brominated compounds
230 were not flame retardants but azo dyes employed as textile colourants. It is surmised, therefore,
231 that Br in clothing samples analysed in the present study results from a complex assortment of dyes
232 used in both natural and synthetic materials.

233 With respect to dryer lint, the absence of detectable Br and Sb in three dryer lint samples arising
234 from the laundering of cotton towels suggests that there are no significant sources of these
235 elements from the drying equipment itself. Rather, the presence of Sb and Br among remaining
236 samples may be largely attributed to the shedding of fibres during washing and drying and,
237 potentially, the dissolution of dyes during washing and their subsequent recombination with other
238 solids; presumably, therefore, the concentration of Sb or Br in dryer lint reflects the relative
239 abundance of synthetic fibre-based or Br-dyed articles in the loading. In addition, it is possible that
240 both Br and Sb may be present in dryer lint as brominated flame retardants and flame retardant
241 synergists, respectively, derived indirectly from formulations added to soft household furnishings
242 like sofas, mattresses, carpets and curtains, and that have gradually accumulated in household dust
243 (Stapleton et al., 2005).

244 In contrast, neither As nor Pb were detected in articles of clothing or linen indicating that potential
245 phyto-accumulation by natural products or contamination during manufacture are not significant.
246 The frequent detection of Pb in lint, therefore, may be attributed to the contamination of clothing
247 and linen by extraneous sources. These include household dust and material external to the

248 household that is associated with certain activities and occupations and that is readily accumulated
249 by clothing and at least partially resistant to washing. Specifically, Pb may be derived from internal
250 and external paint flakes while both Pb and As may be derived from contaminated soil or road dust
251 (Hu et al., 2011; Nezat et al., 2016).

252 Remaining elements (Cu, Fe, Ni and Zn) display an intermediate profile in that they were present in
253 both clothing-linen, presumably as constituents of dyes, pigments or antimicrobial compounds
254 (Rovira et al., 2015), and dryer lint. However, that the frequency of their detection was greater in lint
255 (see also the semi-quantitative ratios in Table 2) suggests that extraneous, internal and external
256 sources are more important than clothing-linen itself.

257 The precise trace elemental profile of dryer lint from a given household is likely to reflect a complex
258 number of factors. These include age, location and condition of the property, its proximity to roads
259 or industries, the presence of a garden, the demographics, occupations and activities of its
260 occupants, the presence of any pets, types of flooring and furnishings, frequency of cleaning, and
261 the types of clothes laundered. In a few cases, such factors could be linked to elemental lint profiles
262 in the present study. For example, Pb concentrations were usually (but not always) higher in older
263 properties where lead paint was more likely to be present, high Br was often associated with
264 households with teenage children, possibly because of the prevalence of a certain type or colour/s of
265 clothing, and Fe and Zn were elevated in a house where its occupants spent considerable periods
266 outdoors and on bare soil. In other cases, however, it was not possible to attribute elemental
267 profiles to any particular factors. For instance, it was unclear why As was persistently present in just
268 one household (and in six lint samples) and why concentrations of Cu above $100 \mu\text{g g}^{-1}$ were only
269 returned for another household (and in three lint samples).

270 Variations in lint elemental profiles within the same household likely reflect temporal variations in
271 activities and clothing type laundered, as well as the occurrence of isolated practices like decorating
272 and remodelling work or the bulk washing or drying of specific articles. For example, Br was never
273 detected in lint when towels or tablecloths were laundered but was always present for washes
274 containing articles of clothing, Pb concentrations were high in one household when external
275 paintwork was being removed, and the highest concentration of Pb overall was returned when
276 clothes used on fieldwork around historic mine sites were laundered.

277 In addition to providing information on trace element contamination and exposure, the composition
278 of lint samples (and clothing-linen samples) can be used to estimate elemental discharges to the
279 environment via waste water treatment plants through laundering operations. Thus, here it is
280 assumed that the elemental profiles, but not necessarily quantities, of lint (and/or clothing) are

281 representative of the elemental profiles of fibres and other material discharged from a domestic
282 washing machine. For elements having a strong extraneous signal in lint, like As, Fe and Pb,
283 discharges are likely to be small compared with other natural and anthropogenic emissions;
284 however, for elements serving as proxies for chemicals whose uses are more specific to textiles and
285 household dust (i.e. Br and Sb), discharges are predicted to be more significant.

286 There exist various estimates for the amount of fibrous microplastics discharged during clothes
287 washing but on a mass basis, it is assumed that 0.3% of the loading is lost through wash water
288 (Hartline et al., 2016). An average washing load of 2.6 kg, a typical annual number of washes per
289 individual of 79 (Sillanpää and Sainio, 2017) and a population of 60.02 million yields an emission of
290 just over 40 million kg of fibrous material for the UK per year. Combining this with a lint
291 concentration of Sb (largely as Sb_2O_3) of $25 \mu\text{g g}^{-1}$ based on concentrations returned by the XRF
292 (Table 2), its detection frequency and its detection limit, results in an annual discharge of about 1000
293 kg. For Br (as brominated compounds), an equivalent figure of about 1200 kg is derived from an
294 average Br concentration in lint of $30 \mu\text{g g}^{-1}$ (Table 2). Alternative estimates may be derived from a
295 representative mass of polyester lost per wash (340 mg; Sillanpää and Sainio, 2017) and the
296 respective concentrations of Sb and Br in synthetic or part-synthetic clothing of $160 \mu\text{g g}^{-1}$ and 170
297 $\mu\text{g g}^{-1}$, respectively; here, computed annual discharges are fourfold lower than previous estimates at
298 260 kg for Sb and 275 kg for Br.

299 The discrepancies in these estimates clearly reflect significant inter-sample variations in chemical
300 makeup, limitations in the assumptions about the relationship between washing machine discharge
301 and lint composition, the presence of additional (non-clothing) sources of Sb and Br (e.g. flame
302 retardants in household dust) and uncertainties associated with estimates of fibre loss during
303 washing (which appears to have a complex dependency on washing conditions and type and age of
304 garments). Nevertheless, they illustrate that the loss of Sb and brominated compounds through this
305 route and in association with microfibers is potentially significant. The ultimate fate of these
306 compounds will depend on the type and efficiency of waste water treatment but in the UK current
307 practices ensure that varying fractions are discharged into the aquatic environment and retained for
308 agricultural sludge.

309 In conclusion, portable XRF has proved to be a rapid and convenient means of determining various
310 trace elements in dryer lint as a proxy for contamination in the household or arising from activities
311 of its occupants and for evaluating the elemental composition of microfibres discharged to the
312 environment from laundering activities. Specifically, Br and Sb appear to reflect the nature of

313 clothing being laundered while As and Pb appear to be more representative of contamination that is
314 both internal and external to the household.

315

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320

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369 portable-XRF. *Talanta* 159, 262-271.

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372 Table 1: The number of cases in which the different trace elements were detected in dryer lint (*n*)
 373 and summary statistics of elemental concentrations, where detected, in $\mu\text{g g}^{-1}$ dry weight. Note that
 374 data are shown in terms of both number of households (19) and number of samples (70) where
 375 elements were detected.

	As	Br	Cu	Fe	Ni	Pb	Sb	Zn
<i>n</i> (houses)	1	19	17	19	6	10	7	19
mean	67.2	33.8	69.8	631.0	44.7	27.5	56.5	340
sd		48.4	53.0	640.1	16.7	29.7	17.9	469
median		18.0	60.7	323.4	41.0	14.9	51.6	239
min		8.6	33.8	128.3	29.5	8.3	39.2	39.7
max		213	264	2397	72.8	108	89.4	2160
<i>n</i> (samples)	6	62	46	65	6	20	8	70
mean	67.2	27.2	70.4	544.5	44.7	23.4	55.2	282.3
sd	90.5	33.4	65.4	637.4	16.7	22.6	17.1	555.5
median	33.0	16.2	57.9	264.9	41.0	15.1	50.5	96.9
min	10.8	5.5	28.7	76.1	29.5	7.5	39.2	24.2
max	249	213	456	3590	72.8	108	89.4	3540

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379 Table 2: The number of samples of clothing-linen in which trace elements were detected (*n*) and
 380 summary statistics of elemental concentrations, where detected, in $\mu\text{g g}^{-1}$ dry weight. Also shown is
 381 the ratio of the sum of concentrations in clothing-linen and dryer lint for each element.

	As	Br	Cu	Fe	Ni	Pb	Sb	Zn
<i>n</i>	0	32	5	25	1	0	35	9
mean		169	43.0	135	13.3		164	964
sd		297	16.5	216			85.7	1090
median		36.4	39.0	89.2			146	882
min		3.5	22.2	42.1			44.0	33.4
max		13,400	67.2	1150			476	3310
$\frac{\Sigma[\text{clothing-linen}]}{\Sigma[\text{dryer lint}]}$	0	3.2	0.07	0.10	0.05	0	13.0	0.44

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384 Figure 1: A selection of dryer lint samples in 21-mm diameter XRF cups that had been collar-sealed
385 with polyester film.



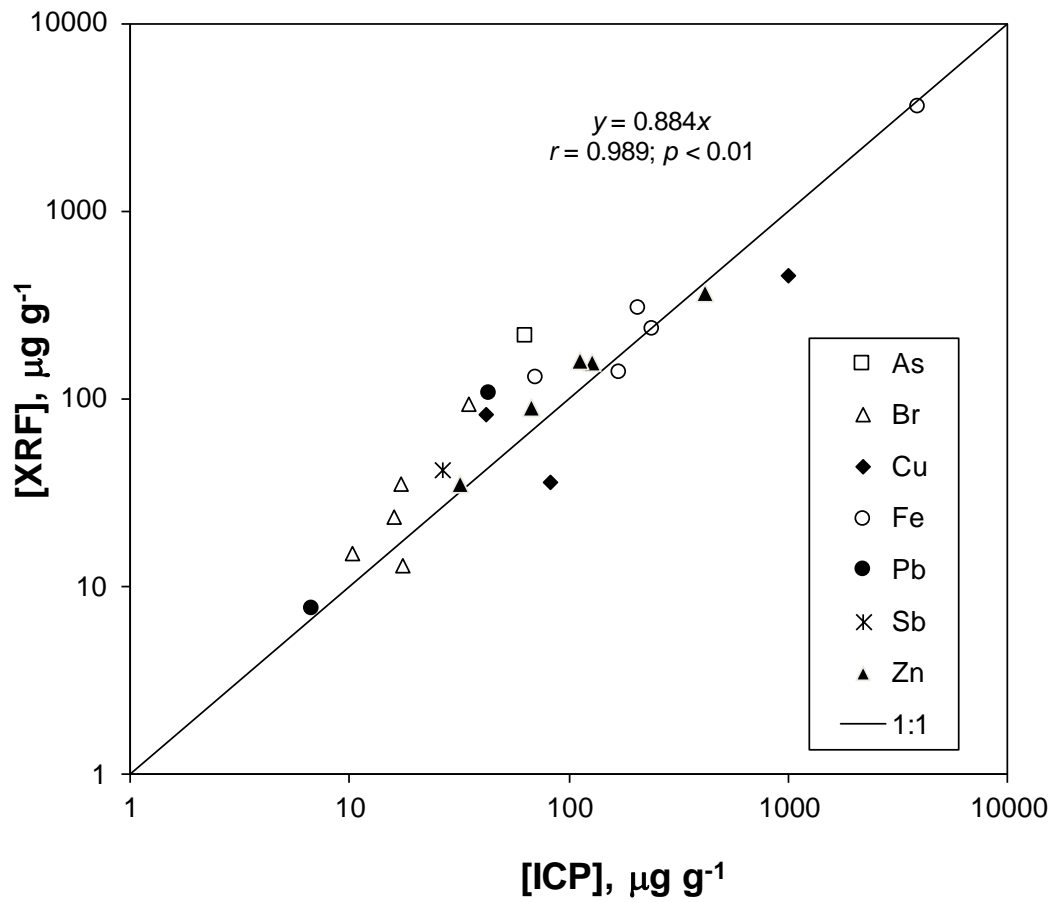
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389 Figure 2: A comparison of elemental concentrations in five samples of dryer lint determined by XRF
390 and by ICP following acid digestion. Note that As, Cu, Ni, Pb and Sb were not detected by XRF in
391 some or all samples.

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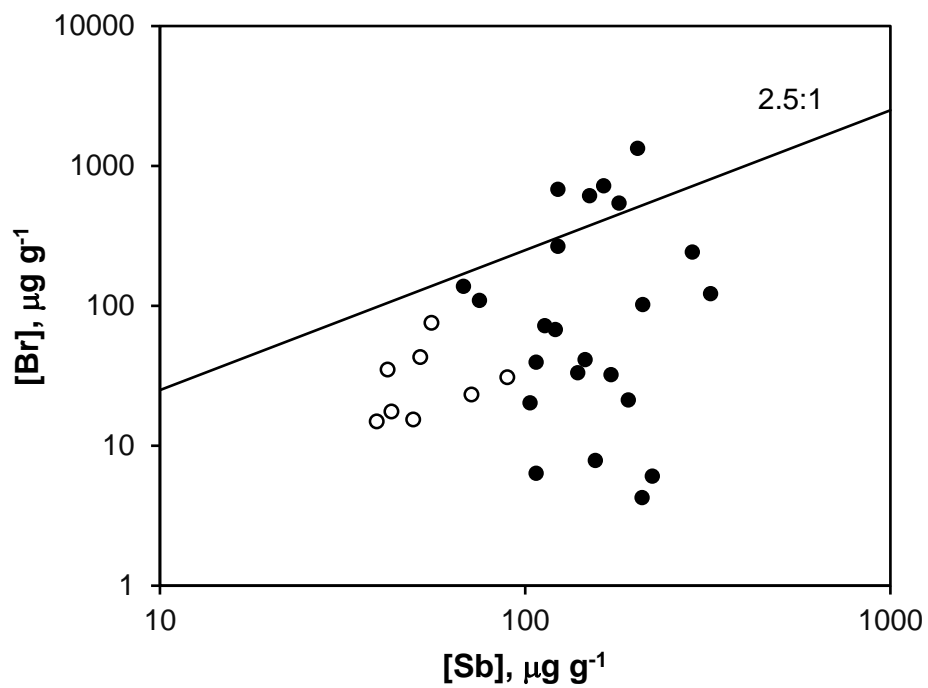
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405 Figure 3: Concentrations of Br versus concentrations of Sb in articles of clothing (●) and samples of
406 dryer lint (o). The solid line shows the representative mass ratio of Br to Sb in common brominated
407 flame retardant mixtures (Papazoglou, 2004).



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