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Nonylphenol ethoxylates (NPE) in imported textiles

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Produced by:

Chemical Compliance Team

Environment Agency

Quadrant 2, 99 Parkway Avenue

Sheffield S9 4WF

Email: chemicalrestrictions@environment-agency.gov.uk

www.environment-agency.gov.uk

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Abstract

Nonylphenol is a priority hazardous substance under the Water Framework Directive (WFD) due to its potential impact upon the aquatic environment.

Water quality monitoring continues to detect nonylphenol (NP) and nonylphenol ethoxylate (NPE) in waterways across the UK. Evidence shows that NPE can degrade in the environment to form NP. It is proposed that one possible source of NP in the environment is the presence of NPE on imported textiles.

Studies have demonstrated that NPE continues to be used in both European and non-European countries during textile/garment processing. Residual NPE may remain on the item when it reaches the end consumer, and this has the potential to be released into the environment through washing.

NP and NPE are currently restricted under the REACH Regulation¹ for use in textile processing within the EU except where there is no release to waste water at the site. However, there are no restrictions concerning the NP/NPE content of finished textiles. NP/NPE is not subject to international controls, so imported textiles in particular are believed to be a source of NPE in the environment.

This study examines cotton textiles and aims to establish if they are a source of NP/NPE. These items were assessed to determine:

- presence and concentration of NPE
- volume of NPE that may be entering the UK on these items
- how much NPE can be released when laundered
- how much of the NP/NPE in rivers could be due to the presence of NPE on these items

Analysis² was undertaken to determine the presence and concentration of NPE in 100 samples of cotton textiles. Further analysis was conducted on six of the 100 samples to establish if NPE is released when the articles are laundered and if so, how much and how quickly this occurs.

Twenty-eight of the 100 samples analysed contained NPE above the detection limit of 3mg/kg, ranging from 3.3mg/kg to 1759.7 mg/kg. Further testing on six samples showed that NPE was released from all samples during washing, with an average release of over 99.9% after two washes at 40°C using liquid biological detergent. More testing is recommended for establishing wash-out rates with greater confidence as only six samples were analysed.

Using import data, information was gathered to establish the volume of cotton underwear imported into the UK from outside Europe; this data was then used to estimate the potential volume of NPE entering the UK on these items. It was calculated that they could have accounted for up to 173kg of NPE emissions to the water environment in 2011. The same calculations were applied to other textile items using information from studies conducted by other organisations.

¹ EC 1907/2006 (as amended)

² NPE was extracted and then analysed using Liquid Chromatography-Photodiode Array-Mass Spectrometry (LC-UV-MS) in positive ion mode.

Of the one hundred samples purchased, 96% were found to be non-EU manufactured; this demonstrates that the majority of cotton underwear available in the UK are manufactured in countries where there are no restrictions regarding the use of NPE.

A number of sample characteristics (price, country of manufacture, retailer type, colour, intended end consumer) were assessed to establish if there is any relationship between these and concentration of NPE. No clear relationship was established between any of these factors and the presence or concentration of NPE.

If the results of this testing are representative of how NPE is released from all textiles, it can be expected that the majority of any NPE present in a new garment is highly likely to be removed during washing throughout the lifetime of the garment, and has the potential to enter the aquatic environment.

There are concerns over the ability of waste water treatment works (WWTWs) to fully remove all NPE prior to discharge of treated effluent. Further work is recommended to establish the true impact of NPE on the aquatic environment from imported textiles.

As well as meeting the Environmental Quality Standard (EQS) for NP, WFD also requires that NP emissions are eliminated. Evidence suggests that the UK industry is generally compliant with the REACH restrictions for NP/NPE but these chemicals are still being released into the environment. This study demonstrates that imported textiles could be a major contributing factor in this.

Contents

1	Introduction	1
1.1	Background	1
1.2	NPE use in textile processing	3
1.3	Research aims	4
2	Method	6
2.1	Sample selection	6
2.2	Analysis	8
2.3	Import Data	8
3	Results	10
3.1	Quantitative analysis	10
3.2	Wash-out analysis	11
3.3	Import Data	12
3.4	Estimated NPE emissions	12
4	Discussion	14
4.1	Quantitative analysis	14
4.2	Wash-out rates	21
4.3	Estimation of NPE emissions	21
4.4	Legalities of items containing NPE	21
4.5	Other research	22
4.6	Future research	22
4.7	Industry influence	22
5	Conclusion	23
	Appendix 1: Legislation affecting NP/NPE use and emissions	25
	Appendix 2: Swedish Society for Nature Conservation (SSNC) research	27
	Appendix 3: Greenpeace research	29
	Appendix 4: Summary of SSNC and Greenpeace research	31
	Appendix 5: Detailed sample information (Environment Agency)	32
	Appendix 6: Estimated NPE emissions calculations - Underwear (Environment Agency)	42
	Appendix 7: Estimated NPE emissions calculations - Underwear (Greenpeace)	47
	Appendix 8: Estimated NPE emissions calculations - T-shirts (SSNC)	49
	Appendix 9: Estimated NPE emissions calculations - T-shirts (Greenpeace)	51
	Appendix 10: Estimated NPE emissions calculations - towels (SSNC)	54
6	References	57

1 Introduction

1.1 Background

1.1.1 Water Framework Directive (WFD)

Nonylphenol (NP) is a priority hazardous substance under the Water Framework Directive (WFD). This means that Member States of the European Union are required to:

- aim to meet the environmental quality standard (EQS); and then to
- eliminate all emissions and discharges to water;
- ensure no deterioration from the current position; and
- ensure that the presence of nonylphenol does not compromise achievement of objectives for protected areas or good chemical status for groundwater bodies.

The Environment Agency is the lead competent authority in England and Wales for implementing the Water Framework Directive (WFD).

1.1.2 Nonylphenol (NP) and nonylphenol ethoxylates (NPE)

Nonylphenol (NP) is a man-made organic compound with the chemical formula $C_6H_4(OH)C_9H_{19}$. Neat NP is a viscous liquid with a clear to yellow appearance.

Nonylphenol ethoxylates (NPE) are man-made compounds with the chemical formula $(C_2H_4O)_n C_{15}H_{24}O$. They are compounds of nonylphenol [$C_{15}H_{24}O$] with one or more groups of ethoxylates [$(C_2H_4O)_n$] attached. The number (n) of ethoxylate groups varies between NPE compounds, imparting different properties to the chemical substance. Neat NPEs with fewer ethoxylate groups tend to be viscous liquids, becoming waxy solids when more ethoxylate groups are added. They are generally clear to light amber in appearance.

NP is primarily used in the production of other substances such as NPEs, plastics stabilisers, and phenol-, formaldehyde- and epoxy resins.

NPEs belong to a group of chemicals called alkylphenol ethoxylates (APEs); they are non-ionic surfactants. The wetting properties of NPEs lend themselves particularly well to degreasing activities, whilst their dispersant properties mean that they may also be used where chemical formulations need to be distributed evenly within a product or throughout a component. Hence, NPE has been used in cleaning products, paints, ink dispersants, textiles and leather processing, manufacture of pulp and paper, metalworking, cosmetics and personal care products. NP and NPE are able to affect the cells of living organisms and have been used in pesticides, production of certain medicines and as spermicides. Many of these applications are now restricted.

The presence of NP in the environment is believed to be largely a result of the break down of NPEs. Ethoxylate groups degrade slowly and NPEs containing more ethoxylate groups may not be broken down entirely during wastewater treatment. The NP group is particularly stable and a significant amount can remain intact throughout normal wastewater processing. Data from the Environment Agency's Pollution

Inventory shows that both NP and NPEs continue to be discharged from wastewater treatment works in England and Wales.

NP has a tendency to accumulate in the tissues of plants and animals – this may be the result of direct environmental exposure or from consuming contaminated food or fluids. NP has also been shown to act as an ‘endocrine disruptor’ in living organisms, meaning that it has the potential to mimic hormones – in this case, oestrogen. Therefore, exposure to NP may interfere with breeding patterns and the reproductive success of animals.

Research findings have also shown that NP can harm land-dwelling organisms. Toxicity tests of NP on plants show effects on growth, while tests on invertebrates have resulted in impacts on reproduction and mortality.

1.1.3 Environment Agency data

The Environment Agency conducts river monitoring for a number of parameters, one of which is NP. The current Environmental Quality Standard (EQS) value for NP is 0.3 ug/l. Monitoring data indicates that NP concentrations in rivers are below the EQS. It is vital that this continues to be met in order to ensure no deterioration from the current position.

The WFD also requires that all NP emissions and discharges to water are eliminated. Major sewage works, industrial and larger waste management installations are required to report emissions of certain chemicals, including NP and NPE, to the Environment Agency’s Pollution Inventory (PI) on an annual basis. In 2011 a combined total of 23.8 tonnes of NP and NPE emissions to controlled water was reported to the Pollution Inventory. This was made up of mainly NPE (22.9 tonnes). Of these releases, 99.2% of NP and 92.6% of NPE was released from WwTWs. The remaining emissions are from a small number of permitted sites whose emissions have reduced significantly over the last few years.

The PI data clearly shows that NP and NPE continue to be discharged to the UK’s rivers. The source of NP and NPE must now be established and action taken to reduce and eliminate these.

The marketing and use of NP and NPE is restricted for a number of different applications and uses by entry 46 in Annex XVII of Regulation (EC) 1907/2006 (as amended) concerning the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH).

The Environment Agency is one of the enforcing authorities in England & Wales for marketing and use restrictions under REACH. The Chemical Compliance Team (CCT) has conducted a number of campaigns to assess English and Welsh companies’ compliance with NP/NPE restrictions. Limited evidence of non-compliance has been found, suggesting the restrictions are generally being adhered to.

See Appendix 1 for an overview of how REACH and the WFD affect the use of NP/NPE.

1.2 NPE use in textile processing

Research has been on-going to determine the source of NP/NPE in the UK's rivers and, it is proposed that one possible source is the presence of NPE³ on imported cotton textiles.

The manufacturing process for textiles and clothing can be long and complicated. There are many different processes and chemicals involved which may take place in several different locations around the world.

Traditionally NPE has been used in textile processing for the following purposes:

- washing and scouring of raw cotton
- fibre lubrication
- dye levelling
- emulsifier
- dispersion agent
- surface active agent

Within the EU there should be no emissions from sites still using NP/NPE for textile processing⁴ as REACH restricts the marketing and use of NP/NPE for this purpose. The restriction is also likely to have caused a general reduction in their usage.

Research undertaken by the CCT did not find any products marketed in the UK for textile processing purposes which contained NP/NPE. Assessment of the Environment Agency's pollution inventory data shows that there are no reported releases of NP/NPE from English and Welsh sites that operate within the textiles sector. This indicates that either the use of NPE in England and Wales has been phased out within the textiles sector, or that there is effective removal of NP/NPE from effluent prior to discharge.

Although textile manufacturing and processing sites in the UK do not appear to contribute to NP/NPE in the environment, there are currently no restrictions on the levels of NPE in finished textiles. A number of studies have demonstrated that NPE continues to be used in other parts of the world during textile/garment processing:

- Swedish Society for Nature Conservation (SSNC) - Towels with a dirty past (2007)
- Swedish Society for Nature Conservation - T-shirts with a murky past (2008)
- Greenpeace - Dirty Laundry (2011)
- Greenpeace - Dirty Laundry 2: hung out to dry (2011)
- Greenpeace - Dirty Laundry: Reloaded (2012)

This research (summarised in Table 1) shows that NPE is present on a wide range of textiles imported into the EU which have been manufactured in non-EU countries.

³ NPE eventually breaks down to NP.

⁴ Except where there is no release to wastewater or the product is <0.1% NP/NPE

Table 1: Summary of relevant research

Organisation	Textile articles tested	Number articles tested	% articles containing NPE	Range of NPE (mg/kg)*
SSNC	Cotton towels	20	90%	1.6 - 10,608
SSNC	T-shirts	17	94%	3 - 940
Greenpeace	Various	78	67%	1.1 -27,000

*excludes articles where NPE was not detected

Following on from Dirty Laundry 2, Greenpeace conducted tests to establish how much NPE is released from clothing during laundering. Fourteen items containing NPE were washed; removal rates of NPE after washing the items was variable. Some items showed very high rates of NPE removal (94%) whilst others showed very low rates (9%).

Further details of these studies can be found in Appendices 2, 3 and 4.

Textiles processed using NPE may or may not be rinsed at the end of the manufacturing process to remove the NPE; in either case residues may remain on the item when it is imported into the UK and reaches the end consumer. There is the potential for the residual NPE to be released during subsequent washing of the textiles by the consumer. This wash water may then be released to the sewer for treatment at waste water treatment works (WwTW). However, it is known that not all NPE is being removed by WwTWs, resulting in the release into the water environment of both NP and NPE partial degradation products which may then further degrade into NP.

In 2011, 1.5 million tonnes of textile and textile articles worth £15.7 billion were imported into the UK from non-EU sources⁵. NPE present on these items could account for some of the NP present in the UK's rivers. This study aims to investigate this further.

1.3 Research aims

Taking into account previous research and information that has been gathered, this research focussed on cotton underwear. These items were selected for the following reasons:

- research conducted by other organisations has identified NPE in cotton towels - cotton underwear are manufactured and processed in a similar way to towels;
- previous research has not looked at NP/NPE use in these items in detail;
- they are readily available and relatively low cost;
- they are frequently washed.

This study examines cotton underwear and aims to establish if they are a source of NP/NPE. These items were assessed to determine:

- presence and concentration of NPE

⁵ www.uktradeinfo.com (commodity codes 60, 61, 62, 63, 64, 65)

- volume of NPE that may be entering the UK on these items
- how much NPE can be released when laundered
- how much of the NP/NPE in rivers could be due to the presence of NPE on these items

2 Method

2.1 Sample selection

To establish if imported cotton textiles could be a major source of NP/NPE in the UK's rivers, analysis was undertaken to determine the presence and concentration of NPE on 100 samples of cotton underwear.

The samples were purchased from a wide range of UK retailers. The aim was to obtain a representative cross-section of those available on the UK market regardless of where they were manufactured. The following criteria were considered when selecting the samples:

- Material - 90% cotton or more; this was to reduce the number of variables when carrying out the analysis;
- Intended end consumer - to include men's, women's and children's;
- Price - all price ranges (the cost of samples purchased ranged from 50p to £43);
- Retailer - these were split into categories; catalogue, designer, discount, high street, online, sport and supermarket to ensure the full range of retailer types were included;

The resulting 100 samples were made up of a wide variety of colours, styles and sizes and were manufactured in a range of countries.

Tables 2 to 5 summarise the characteristics of the 100 samples.

Table 2: Number of samples by retailer type and price

Type of retailer	Number of samples	Minimum cost per sample	Maximum cost per sample	Average cost per pair
Designer	23	£5.99	£43.00	£19.39
High Street	25	£1.50	£27.00	£7.60
On-line	13	£2.50	£16	£7.15
Supermarket	13	£1.20	£9.59	£4.43
Catalogue	10	£8.00	£18.00	£11.32
Sport	8	£1.50	£18.00	£5.93
Discount	8	£0.50	£4.19	£1.90

Table 3: Number of samples by country of manufacture

Country of manufacture ⁶	Number of samples
China	42
India	8
Bangladesh	5
Thailand	5
Turkey	4
Sri Lanka	4
England	2
Portugal	2
Cambodia	1
China and India	1
Egypt	1
Pakistan	1
Unknown origin ⁷	24

Table 4: Number of samples by colour

Colour	Number of samples
White	31
Black	19
Blue	12
Grey	12
Pink	8
Green	4
Red	4
Purple	3
Yellow	3
Various	3
Orange	1

⁶ The country of origin was not known at the time of purchase as many samples were purchased on-line. Four samples were manufactured within the EU (England and Portugal).

⁷ Retailers were contacted to establish 'unknown' countries of origin; some retailers did not have this information while others did not respond to our request.

Table 5: Number of samples by intended end consumer

Intended end consumer	Number of samples
Men	46
Women	54

2.2 Analysis

The laboratory⁸ conducted different extraction experiments to determine the most appropriate method for extraction of NPE from the samples. Acetonitrile extraction showed good recovery from spiked samples and detectable NPE in unspiked samples. The conclusion of these experiments was that Soxhlet extractions in acetonitrile for 4 hours was the optimum extraction technique.

Tergitol (Sigma-Aldrich) was the analytical standard that was used in the experiments.

Analysis was conducted using Liquid Chromatography-Photodiode Array-Mass Spectrometry (LC-UV-MS) in positive ion mode. The limit of detection was <3 mg/kg. A total concentration of NPE (up to 30 ethoxylate groups) was measured.

Further investigations were conducted on six of the 100 samples to establish if the NPE is released when the articles are laundered and if so, how much and how quickly this occurs. The six samples that were found to contain the highest concentration⁹ of NPE from the quantitative analysis were selected and washed twice in a conventional washing machine at 40°C with biological liquid detergent. The samples were dried in between washes to replicate the normal laundering process. NPE concentrations present in the samples were determined before and after each wash to calculate the amount of NPE released during washing.

2.3 Import Data

Relevant commodity codes¹⁰ were identified from Her Majesty's Revenue and Customs (HMRC)¹¹ and information was gathered to establish the volume of cotton underwear imported into the UK from non-EU sources. Calculations were conducted to estimate the potential volume of NPE entering the UK on these items.

Three commodity codes were selected to assess imports into the UK from non-EU sources during 2011. The following commodity codes were used:

- 6107 1100 - cotton men's and boys underpants and briefs (knitted or crocheted)
- 6207 1100 - cotton men's and boys underpants and briefs (not knitted or crocheted)

⁸ Analysis was conducted by Hall Analytical Ltd.

⁹ One sample in the top 6 containing highest concentration of NPE was not used as there was insufficient sample remaining.

¹⁰ Commodity codes classify goods for import and export

¹¹ www.uktradeinfo.com

- 6108 2100 - cotton women or girls briefs and panties¹²

Information gathered in other research projects (SSNC and Greenpeace) was also evaluated. This aimed to estimate the emissions of NPE from other imported textiles. In addition to the commodity codes listed above, the following codes were used:

- 6109 - t-shirts, singlets and other vests (knitted or crocheted)
- 6302 9100 - cotton toilet and kitchen linen

¹² There are two relevant commodity codes for men's underwear (knitted and non-knitted), for women's underwear there is only one relevant commodity code.

3 Results

3.1 Quantitative analysis

Twenty-eight of the 96 samples of non-EU manufactured samples¹³ analysed contained NPE. Sixty-eight samples were below the analytical detection limit of 3 mg/kg of NPE. Table 6 summarises the samples containing NPE - further details of all samples are available in Appendix 5.

Table 6: Summary of samples containing NPE

Sample Number	End Consumer	Country of Manufacture	Main Colour	NPE mg/kg
LH/10/85	Children	Unknown	Black	1759.7
LH/10/64	Men	China	Various	1118.6
LH/10/98	Men	India	Grey	898.7
LH/10/96	Children	China	Pink	443.3
LH/10/71	Women	Sri Lanka	White	407.2
LH/10/86	Women	Pakistan	Pink	392
LH/10/61	Women	China	White	331.5
LH/10/66	Women	China	White	259.3
LH/10/26	Men	China	Black	206
LH/10/36	Men	India	Grey	146.1
LH/10/25	Men	China	White	135.5
LH/10/56	Children	China	White	99.6
LH/10/46	Men	China	Pink	96.2
LH/10/06	Men	China	Blue	73.1
LH/10/95	Women	Thailand	Pink	67.4
LH/10/59	Women	China	Pink	54.7
LH/10/45	Men	China	Grey	52.3
LH/10/88	Women	Unknown	Black	50.4
LH/10/17	Men	Turkey	Blue	44.5
LH/10/34	Women	Unknown	White	41.7
LH/10/76	Children	Unknown	Red	38.7
LH/10/24	Men	Egypt	Black	24.4
LH/10/12	Men	India	Green	19
LH/10/43	Women	China	White	17.7
LH/10/35	Women	Unknown	Black	17.1
LH/10/23	Men	India	Blue	8.4
LH/10/47	Women	China	White	8.4
LH/10/33	Men	China	Blue	3.3

The average¹⁴ NPE in all 96 samples is 7.9 mg/kg, ranging from 5.6 to 11.3 mg/kg (95% confidence interval).

The data is positively skewed over an order of magnitude, so a geometric mean has been used. This has been calculated by taking the mean of the natural log of the data,

¹³ The 4 samples manufactured within the EU were analysed and found to not contain NPE but are excluded from this report.

¹⁴ Geometric mean

then reversing the log using the exponential. The confidence interval has been estimated by following the same process.

Statistical analysis showed that the log of the data was not returning a normal distribution. As this could cause problems with the confidence interval estimate, the results were rechecked with a bootstrap procedure (generating new samples from the existing data). In this case, bootstrapping was used to produce a distribution of the means of logged data. The 2.5th and 97.5th percentile of that distribution provide the confidence interval and the exponential reverses the log to provide useable values. The bootstrap agrees with the original calculation (7.9mg/kg ranging from 5.6 to 11.2 mg/kg).

This data contains 68 'non-detects'. That means NPE is less than 3 mg/kg, but could be anywhere below that, including 0mg/kg. While calculating the mean, all non-detect values have been treated as 3mg/kg. The calculated mean is therefore a conservative value.

In the 28 samples where NPE was detected, the average NPE was 243.4 mg/kg.

3.2 Wash-out analysis

Six samples were selected for further testing to establish if NPE is released from the samples during washing. Analysis showed that NPE was released from all samples with an average release of over 99.9% after two washes. Table 7 summarises the results of this analysis.

Table 7: Wash-out rate analysis summary

Sample Number	Initial NPE (mg/kg)	NPE in sample after 1 wash (mg/kg)	% NPE removed after 1 wash	NPE in sample after 2 washes (mg/kg)	% NPE removed after 2 washes
LH/10/61	331.5	0	100	0	100
LH/10/86	392	0	100	0	100
LH/10/66	259.3	0.3	99.9	0	100
LH/1098	898.7	33.6	96.3	0	100
LH/10/64	1118.6	109.7	90.2	4.5	99.6
LH/10/85	1759.7	84	95.2	1.2	99.9
Average	793.3	37.9	96.9	1.0	99.9

3.3 Import Data

Import data was obtained for relevant commodity codes, these are summarised in Table 8.

Table 8: UK imports of textiles from non-EU sources 2011

Commodity code	Commodity code description	Quantity (kg)
6107 1100	cotton men's and boys underpants and briefs (knitted or crocheted)	11,867,620
6207 1100	cotton men's and boys underpants and briefs (not knitted or crocheted)	801,157
6108 2100	cotton women or girls briefs and panties	9,196,353
6109	t-shirts, singlets and other vests (knitted or crocheted)	15,858,867
6302 9100	cotton toilet and kitchen linen	1,119,026

3.4 Estimated NPE emissions

Using the analysis data and import data, calculations were conducted to estimate the amount of NPE entering the UK in 2011 in cotton underwear. This is summarised in Table 9. Further detailed data can be viewed in Appendix 6. These calculations estimated that they could have accounted for up to 173kg of NPE emissions to the water environment in 2011.

Table 9: Estimated NPE emissions 2011

Data source	Amount
Number of items tested	96
Number of items containing NPE	28
Mean NPE/item (mg/kg)	7.9
Total weight of cotton underwear imported 2011 (kg)	21,865,130
Total weight of NPE in imported cotton underwear 2011 (kg)	173.2
Average wash-out rate (%)	99.9
Total emissions from imported cotton underwear 2011 (kg)	173.0

The principles used to estimate NPE emissions were then applied to other garments that have been tested for NPE by SSNC and Greenpeace. These calculations are summarised in Table 10. Further detailed data can be viewed in Appendices 7, 8, 9 and 10.

Table 10: Estimated NPE emissions from imported textiles 2011

Garment	Source of NPE data	Annual NPE emissions estimate (kg)
Underwear	Greenpeace	160.3
T-shirts	SSNC	498.7
T-shirts	Greenpeace	158.9
Towels	SSNC	26.6

Other types of textiles were tested by Greenpeace and SSNC; emissions from these items have not been calculated due to low sample numbers, but they will also contribute.

4 Discussion

4.1 Quantitative analysis

The analysis showed that of the 96 samples tested, 28 contained NPE. Concentration of detected NPE ranged from 3.3 mg/kg to 1759.7 mg/kg. The average overall NPE concentration per sample was 7.9 mg/kg (95% confidence interval 5.6 to 11.2 mg/kg).

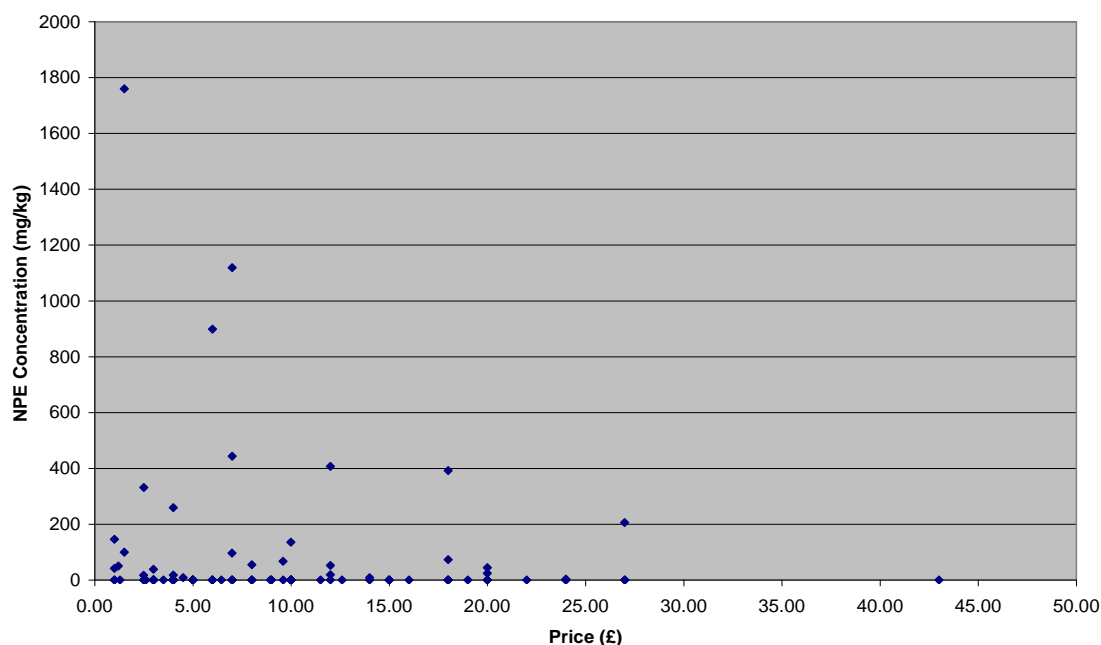
These results were assessed in relation to a number of factors to establish any relationships between these and the presence and concentration of NPE. Factors assessed included:

- Price
- Country of manufacture
- Retailer type
- Colour
- Intended end consumer

4.1.1 Price

Figure 1 shows there is no clear relationship between price and the amount of NPE present, although it should be noted that the samples containing the most NPE were the least expensive items.

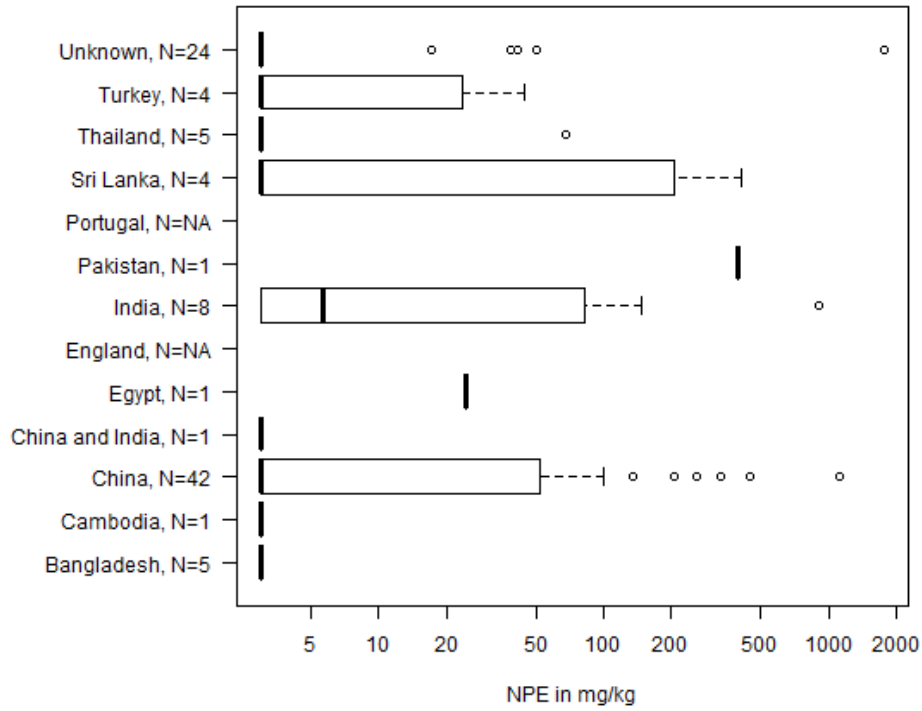
Figure 1: Relationship between the cost of cotton textiles and NPE concentration



4.1.2 Country of manufacture

Figure 2 and Table 11 summarise NPE concentrations in relation to the country of manufacture.

Figure 2: Relationship between country of manufacture and NPE concentration



Box plot key:

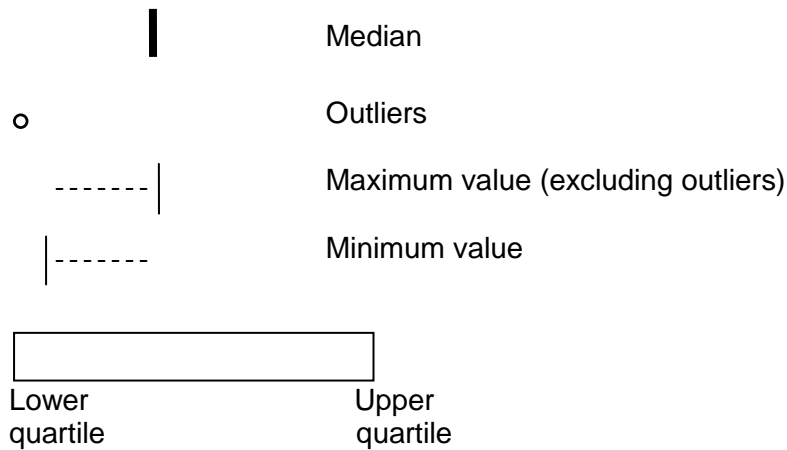


Table 11: Relationship between country of manufacture and NPE concentration

Country of manufacture	Number of samples	Number of samples containing NPE	NPE minimum (mg/kg) ¹⁵	NPE maximum (mg/kg)
China	42	14	3.3	1118.6
Unknown	24	5	17.1	1759.7
India	8	4	8.4	898.7
Thailand	5	1	67.4	67.4
Sri Lanka	4	1	407.2	407.2
Turkey	4	1	44.5	44.5
Egypt	1	1	24.4	24.4
Pakistan	1	1	392	392
China/India	1	0	n/a	n/a
Portugal	2	0	n/a	n/a
England	2	0	n/a	n/a
Bangladesh	5	0	n/a	n/a
Cambodia	1	0	n/a	n/a

Four of the samples analysed were manufactured within the EU (two samples in England and two in Portugal). None of these samples were found to contain NPE. This is a very small number of samples; greater sample numbers are needed to establish if this is indicative compliance with the restrictions under REACH.

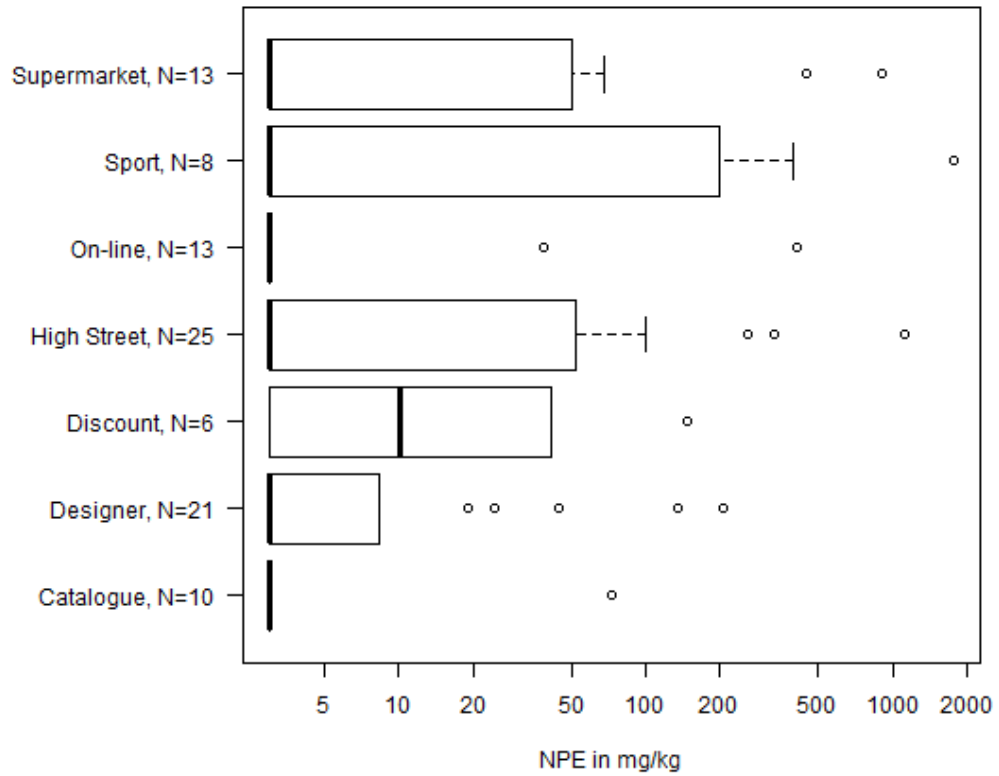
Of the 100 samples purchased, 96% were non-EU manufactured. No attempt was made to ensure that the final 100 samples were non-EU manufactured; the aim was to purchase a representative sample of cotton textiles available on the UK market. The large proportion of the final 100 samples that were non-EU manufactured demonstrates that the majority of cotton underwear that are available in the UK are manufactured in countries where there are no restrictions regarding the use of NPE.

¹⁵ Data excludes samples where NPE was < 3mg/kg LOD

4.1.3 Retailer Category

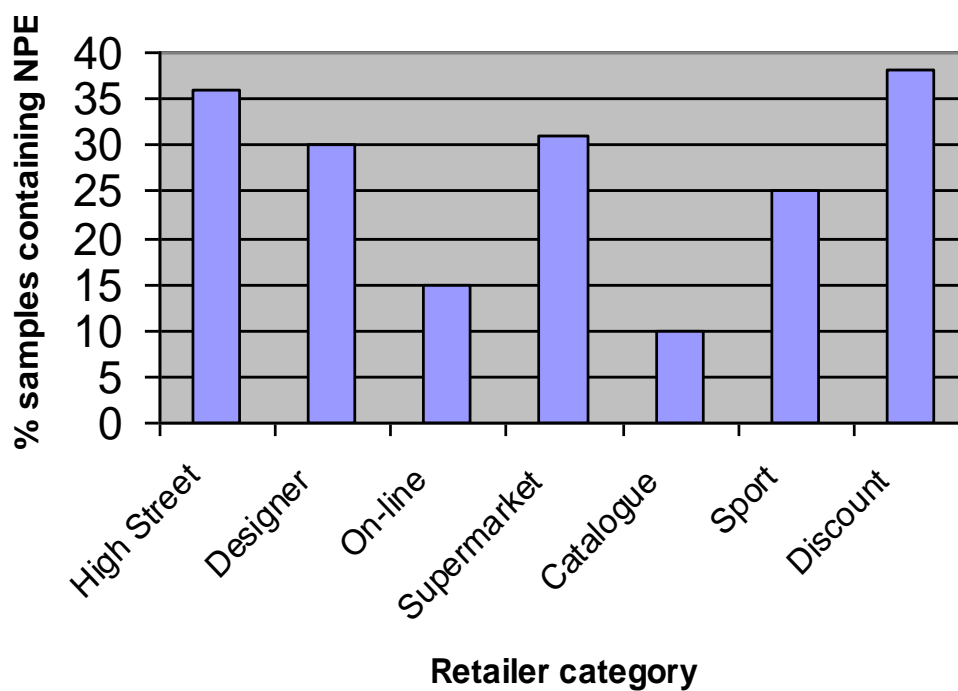
Figure 3 summarises the NPE concentrations detected in the samples in relation to retailer category.

Figure 3: Relationship between retailer type and NPE concentration



All seven retailer categories contained samples where NPE was present. Figure 4 shows that the discount and high street retailer categories contained the highest percentage of samples where NPE was detected.

Figure 4: Samples containing NPE by retailer category



The sample containing the most NPE was from the sport retailer category with a value of 1759.7 mg/kg.

4.1.4 Colour

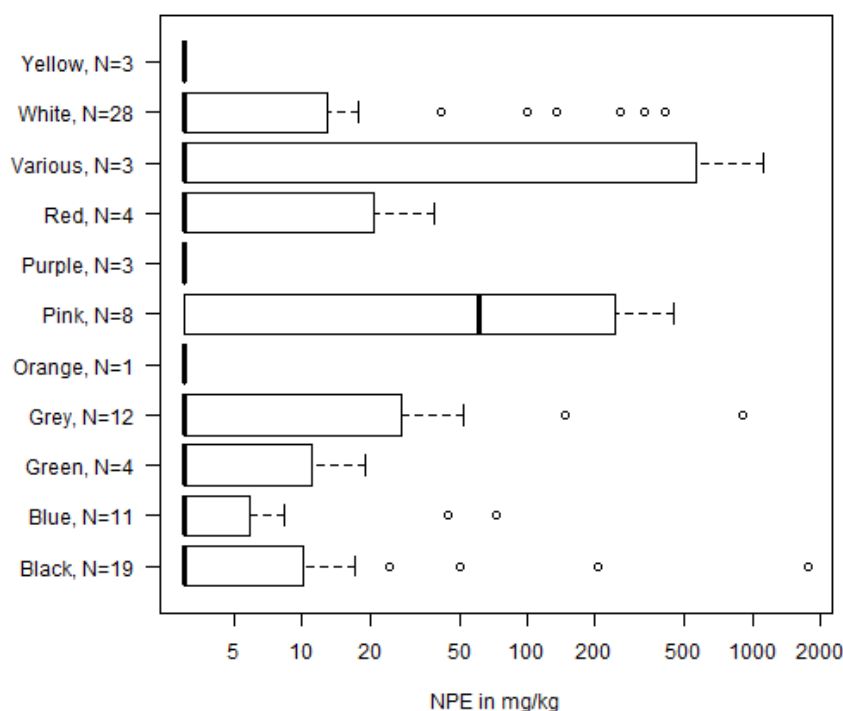
Table 12 and Figure 5 show the relationship between NPE and the colour of the samples.

Table 12: Relationship between NPE and colour

Colour	Number of samples	% of samples containing NPE	NPE min (mg/kg)	NPE max (mg/kg)	Average NPE (mg/kg) ¹⁶
White	31	26	8.4	407.2	162.6
Black	19	26	17.1	1759.7	411.5
Blue	12	33	3.3	73.1	32.3
Grey	12	25	52.3	898.7	365.7
Pink	8	63	54.7	443.3	210.7
Red	4	25	38.7	38.7	38.7
Green	4	25	19	19	19
Various	3	33	1118.6	1118.6	1118.6
Purple	3	0	n/a	n/a	n/a
Orange	1	0	n/a	n/a	n/a
Yellow	3	0	n/a	n/a	n/a

¹⁶ Samples containing <3mg/kg (LOD) were excluded from the average.

Figure 5: Relationship between colour and NPE concentration



No relevance was attached to the colour of the samples when they were purchased. However, 31 of the samples were white; most probably because this is a common colour choice for these types of items.

Samples of three colours tested did not contain NPE (purple, orange, yellow). However, the number of samples in these colours was low which could explain why no NPE was found. Sixty-three percent of pink samples were found to contain NPE, the highest for any colour. This may be due to chance or it could relate to the manufacturing process; further investigation would be required to determine this.

4.1.5 Intended end consumer

Table 13: Relationship between intended end consumer and NPE concentration

Intended end consumer	Number of samples	% of samples containing NPE	NPE min (mg/kg)	NPE max (mg/kg)	Average NPE (mg/kg)
Male	52	28.8	3.3	1759.7	308.3
Female	44	29.5	8.4	443.3	168.5

There is no apparent relationship between the presence of NPE and the type of intended end consumer; between 28 and 30% of samples from both categories contained NPE.

4.2 Wash-out rates

Analysis was conducted to determine if NPE would be released from the samples during washing and if so, how quickly this would occur. The results of this analysis were conclusive with over 99.9% of the NPE being released after just two washes.

The methodology was developed to replicate the washing of cotton textiles by end consumers; a domestic washing machine on a standard 40°C wash using liquid biological detergent.

Six samples were tested, which is a relatively low number. More testing would be required with a larger number of samples to establish a clear and accurate relationship. However, this testing does provide very useful information.

If the results of this testing are representative of how NPE is released from all textiles, it can be expected that any NPE present in a new garment is highly likely to be removed during washing. The NPE released throughout the lifetime of the garment may potentially enter the aquatic environment.

4.3 Estimation of NPE emissions

Analysis data and import data were used to calculate the possible emissions of NPE from imported cotton underwear and other textiles.

Estimated emissions of NPE arising from imported underwear during 2011 were calculated to be 173 kg. This is the amount of NPE released from the items and into the sewerage system for treatment at a waste water treatment works (WwTW). When other garments are taken into account, it is clear that textile washing is an important source of NPEs in sewage influent.

A variety of studies have looked at the efficiency of different types of treatment in removing NPE at WwTWs. This is not discussed as part of this report but could be looked at to establish the true impact that NPE from imported textiles has on the aquatic environment.

Estimation of NPE emissions has been conducted using a variety of information from different sources. The final estimated emissions calculations should be used with caution. Finding the correct commodity code for a particular type of article can be difficult, especially if there is limited information about the material type and weave of the article. Some textile articles have their own specific commodity code, whereas others are less specific or require a number of different commodity codes to be used. It is also unclear how much care is taken by importers when selecting commodity codes for goods they are bringing into the UK. For these reasons, the import figures quoted in this report should only be used as a guide and as a tool for estimating.

4.4 Legalities of items containing NPE

The samples for this research were selected to ensure a representative range of cotton underwear available in the UK. This research has shown that some of these contain NPE. The import and supply of textiles in the UK which contain NPE is not currently an offence, and no laws have been broken.

4.5 Other research

As discussed, Greenpeace and SSNC have conducted similar research to this study. Although each study has looked at different types of textile articles, their findings are comparable. All studies have found a significant proportion of imported textile articles that contain NPE.

However, the resulting calculations of NPE contributions to UK rivers are tentative estimations. The validity, accuracy and reproducibility of the source studies have not been evaluated by the authors of this document.

4.6 Future research

This study shows that NPE could be a major contributor to the NP/NPE present in the UK's rivers. Additional work is required to gather more data about this issue. This could include:

- Analysis of a wider range of other textile articles in large numbers
- Research to establish the type and location of common NPE users
- Establishing the treatment capabilities of WwTW to determine the proportion of NPE entering and leaving the works
- Consideration to extend the scope of REACH restriction 46 to include imported textiles

4.7 Industry influence

This research demonstrates that NPE continues to be used in non-EU countries in the processing of textiles destined for the UK market. Washing textile articles containing NPE offers a pathway for NPE to enter the water environment.

The use of NPE in textile processing in non-EU countries and the import into the UK of such items is not currently restricted. However, companies involved in the supply of textiles to the UK are in a position where they can influence non-EU manufacturers to take responsible action to eliminate NPE use and look to more environmentally friendly alternatives.

5 Conclusion

This study demonstrates that the majority of cotton underwear available in the UK market are manufactured in countries where there are no restrictions concerning the use of NPE in textile processing. The research indicates that 29% of imported cotton underwear contain NPE and that over 99.9% of this is released during the first two washes by the consumer. Other studies have also demonstrated that NPE is present on a variety of other imported textile articles.

River monitoring data shows NP and NPE emissions continue to be released into the water environment. Whilst this is currently not an issue for meeting the EQS, it does remain a concern for ensuring that NP/NPE emissions are eliminated as required by WFD. This study demonstrates that textiles could be a major contributing factor in this and steps should be taken to investigate this further.

Appendices

Appendix 1: Legislation affecting NP/NPE use and emissions

Over the last few years the marketing, use and emissions of nonylphenol (NP) and nonylphenol ethoxylates (NPE) has been affected as new legislation has come into force. There are two main pieces of legislation that are relevant as described below.

REACH - Registration, Evaluation, Authorisation and restriction of CHemicals

REACH Regulation (EC) 1907/2006 (as amended)¹⁷ came into force in the UK in 2007 and is the system for controlling chemicals in Europe. There are a few elements of REACH that impact upon the supply chain for NP:

Registration

Manufacturers, importers and users of nonylphenol in excess of 1 tonne per year are required to register with the Health & Safety Executive (HSE) who are the UK Competent Authority for REACH¹⁸

Marketing and use restrictions

Annex XVII of REACH lists restrictions on a number of chemicals. Restriction 46 concerns NP and NPE. This states NP or NPE cannot be used in a number of applications above 0.1%. One of these applications is textile processing.

The restriction means that UK (and EU) companies cannot use NP or NPE products for textile processing if the NP or NPE content exceeds 0.1% unless there is no release to waste water. There is currently no restriction on the import of textile articles that have been processed with NP or NPE in non-EU countries.

Substances of very high concern (SVHCs)

NP is classed as SVHC due to its endocrine disrupting properties.

Water Framework Directive (WFD)

The Water Framework Directive (WFD) requires Member States to set out actions to achieve good water status in all waters by 2015. It requires that, as a matter of priority, causes of pollution be identified and emissions dealt with at source in the most economically and environmentally effective manner.

Pollutants presenting 'a significant risk to or via the aquatic environment, including risks to waters used for drinking water abstraction' are designated at European level as priority substances and priority hazardous substances. Other pollutants of national concern are designated as specific pollutants. In brief, the key requirements of the WFD for these substances are to:

¹⁷ Further guidance about REACH can be found at: www.hse.gov.uk/reach

¹⁸ Further guidance about REACH can be found at: www.hse.gov.uk/reach

- prevent the deterioration of surface and groundwater quality and ensure that existing levels of contamination in biota and sediments do not significantly increase;
- aim to achieve the Environmental Quality Standards (EQSs) set by the European Commission (in the Environmental Quality Standards Directive for priority substances and priority hazardous substances) and nationally for specific pollutants;
- progressively reduce pollution from priority substances and cease or phase-out emissions, discharges and losses of priority hazardous substances (recognising this may not be possible for substances occurring naturally or through natural processes);

Nonylphenol (CAS number 25154-52-3) and 4-(para)nonylphenol (CAS number 104-40-5) are Water Framework Directive *Priority Hazardous Substances*.

Appendix 2: Swedish Society for Nature Conservation (SSNC) research

Towels with a dirty past

Research conducted by the Swedish Society for Nature Conservation (SNCC)¹⁹ tested 20 bath towels for the presence of NPE and all but two were found to contain it, some in very high levels (10,608 mg/kg). All were purchased in Sweden. A sample from the towel was extracted and then analysed using liquid chromatography and mass spectrometry. The maximum ethoxylate groups found were eight. This indicated the NPE has originated from detergents used in the manufacture of the towel; NP used in dispersing dyes usually has NPE with ethoxylate groups over 30. The amount of NPE found in a particular towel was not linked in any way to the cost of the towel.

Sample selection: seven main retailers were selected that sold textiles – two towels were purchased from each retailer. A towel was also purchased from a discount shop and from an ‘expensive’ brand of towel.

Analysis method: sample extraction followed by analysis using reversed phase liquid chromatography linked to tandem mass spectrometry.

The results of the analysis are shown below:

Retailer/brand	NPE mg/kg	Retailer/brand position
Coop	10608	Main retailer
Ica	1277	Main retailer
Ica	577	Main retailer
Ellos	517	Main retailer
Jysk	239	Main retailer
Ellos	190.5	Main retailer
Hemtex	150.7	Main retailer
IKEA	94.6	Main retailer
OB	12.6	Discount retailer
Jysk	11.1	Main retailer
Duka	7	Main retailer
Ahlens	6.1	Main retailer
Rusta	3.6	Main retailer
Coop	3.4	Main retailer
Rusta	2.6	Main retailer

¹⁹ Towels with a dirty past - 2007

Retailer/brand	NPE mg/kg	Retailer/brand position
Lexington	2.2	Expensive
Ahlens	2	Main retailer
Hemtex	1.6	Main retailer
IKEA	<1	Main retailer
Duka	<1	Main retailer

The average value of towels containing NPE above the detection limit was 761 mg/kg.

T-shirts with a murky past

The SSNC also tested 17 t-shirts for the presence of NPE. All but one was found to contain NP and the highest NP values originated from Turkey and China.

Sample selection: seventeen samples. Long and short sleeved, male and female, various price ranges, purchased from a selection of medium sized companies that sell well known brands or have their own clothing label.

Analysis method: sample extraction with an acetonitrile-water mixture and analysed with reversed-phase HPLC liquid chromatography and mass spectrometry.

The results of the analysis are shown below:

Retailer/brand	NPE mg/kg	Country of manufacture
Cheap Monday	940	China
Identity	430	Unknown
Selected Homme	270	Turkey
Batistini	230	Turkey
Just a ****ing t-shirt	120	Unknown
Emilio	63	Unknown
Puma	45	Poland
Bondelid	43	Unknown
Zoul	33	Unknown
Nike	22	Turkey
Nike	16	Thailand
Tierra	13	Unknown
Filippa K	4	Portugal
Peak Performance	4	Lithuania
Gina Tricot	3	Unknown
East West	1	Unknown
Soc	<1	Unknown

The average value of t-shirts containing NPE above the detection limit was 149 mg/kg.

Appendix 3: Greenpeace research

Dirty Laundry, the toxic secret behind global textile brands

A report by Greenpeace²⁰ highlighted the discharge of NP in waste water from two factories in China that manufacture clothing for many well known brands sold in the UK. Many of these brands claim to have Corporate Responsibility programmes to address the environmental impacts of their supply chains.

Dirty Laundry 2: hung out to dry

A second report by Greenpeace²¹ focussed on the testing of a variety of types of clothing and brands for the presence of NPE. Seventy-eight articles of sports and recreational clothing and shoes bearing the logos of 15 leading clothing brands were tested. Clothing was purchased from 18 countries, and was manufactured in 13 countries. It included both natural and synthetic fabrics designed for men, women and children. Fifty-two of the 78 articles were found to have NPE above the detection limit of 1 mg/kg.

Brands tested:

Abercrombie & Fitch	Lacoste
Adidas	Li-Ning
Calvin Klein	Nike
Converse	Puma
G Star RAW	Ralph Lauren
Gap	Uniqlo
H&M	Youngor
Kappa	

Five garments were purchased in the UK:

Brand	Garment	NPE (mg/kg)
Abercrombie & Fitch	T-shirt	18
Adidas	Sweatshirt	<1
Converse	Sneakers	17
Gap	T-shirt	<1
Uniqlo	Jeans	<1

²⁰ Greenpeace. Dirty Laundry, the toxic secret behind global textile brands. July 2011

²¹ Greenpeace. Dirty Laundry 2: hung out to dry. August 2011

Four items of underwear were purchased from non-UK countries:

Brand	Country of purchase	Country of manufacture	NPE (mg/kg)
Calvin Klein	Argentina	Thailand	29
Calvin Klein	Japan	Egypt	9.1
Calvin Klein	China	China	<1
G Star RAW	Netherlands	China	<1

Dirty Laundry: Reloaded

Following on from Dirty Laundry 2: hung out to dry, Greenpeace published the report Dirty Laundry: Reloaded in 2012. This study took 14 of the items of clothing identified as containing NPE in the Dirty Laundry 2 study and carried out further tests. The 14 samples were washed in a domestic washing machine and the amount of NPE concentration in the items was measured before and after. Removal rates of NPE after washing the items was variable; some items showed very high rates of NPE removal (94%) whilst others showed very low rates (9%).

Appendix 4: Summary of SSNC and Greenpeace research

Garment type	Number of samples	Number of samples NPE		NPE range (mg/kg)
		< 1 mg/kg	> 1 mg/kg	
T-shirt	19	1	95	1.2 - 27000
T-shirt	17	1	94	3 - 940
Towels	20	2	90	1.6 - 10608
Jeans shorts	1	0	100	1100
Sport shirt	2	1	50	680
Polo shirt	10	1	90	1.2 - 530
Tracksuit	1	0	100	240
Pyjama trousers	1	0	100	160
Sneakers	3	0	100	17 - 140
Jeans	4	2	50	25 - 51
Football shirt	5	1	80	1.8 - 47
Underwear	4	1	75	9.1 - 29
Tank top	2	1	50	21
Shirt	2	0	100	3.1 - 19
Sport shoes	1	0	100	14
Dress	1	0	100	14
Tracksuit jacket	3	1	66	2 - 12
Sweatshirt	2	1	50	3.6
Tracksuit trousers	2	1	50	1.1

Appendix 5: Detailed sample information (Environment Agency)

SAMPLE NUMBER	LH/10/01	LH/10/02	LH/10/03	LH/10/04	LH/10/05
Sample type	Women's	Men's	Women's	Women's	Men's
Type	Catalogue	Catalogue	Catalogue	Catalogue	Catalogue
Material	100% cotton	100% cotton	95% cotton, 5% elastane	90% cotton, 10% elastane	100% cotton
Country of manufacture	Unknown	China	China	Unknown	China
Price of product	£10	£9	£9	£10	£12.60
Pack of	4	3	10	3	2
Amount of NPE (ppm)	<3	<3	<3	<3	<3

SAMPLE NUMBER	LH/10/06	LH/10/07	LH/10/08	LH/10/09	LH/10/10
Sample type	Men's	Women's	Women's	Men's	Women's
Type	Catalogue	Catalogue	Catalogue	Catalogue	Catalogue
Material	100% cotton	95% cotton, 5% elastane	95% cotton, 5% elastane	100% cotton	95% cotton, 5% elastane
Country of manufacture	China	China	Unknown	China	Unknown
Price of product	£18.00	£9.60	£8.00	£12.00	£15.00
Pack of	5	4	2	5	3
Amount of NPE (ppm)	73.1	<3	<3	<3	<3

SAMPLE NUMBER	LH/10/11	LH/10/12	LH/10/13	LH/10/14	LH/10/15
Sample type	Men's	Men's	Men's	Women's	Men's
Type	Designer	Designer	Designer	Designer	Designer
Material	95% cotton, 5% elastane	95% cotton, 5% elastane	100% cotton	100% cotton	95% cotton, 5% elastane
Country of manufacture	Thailand	India	China	Unknown	China
Price of product	£43.00	£12.00	£5.99	£18.00	£19.00
Pack of	1	1	1	2	1
Amount of NPE (ppm)	<3	19.0	<3	<3	<3

SAMPLE NUMBER	LH/10/16	LH/10/17	LH/10/18	LH/10/19	LH/10/20
Sample type	Men's	Men's	Men's	Men's	Men's
Type	Designer	Designer	Designer	Designer	Designer
Material	100% cotton	95% cotton, 5% elastane	95% cotton, 5% elastane	95% cotton, 5% elastane	95% cotton, 5% elastane
Country of manufacture	China	Turkey	Thailand	China	China
Price of product	£24.00	£20.00	£24.00	£20.00	£17.99
Pack of	1	1	1	2	1
Amount of NPE (ppm)	<3	44.5	<3	<3	<3

SAMPLE NUMBER	LH/10/21	LH/10/22	LH/10/23	LH/10/24	LH/10/25
Sample type	Men's	Men's	Men's	Men's	Men's
Type	Designer	Designer	Designer	Designer	Designer
Material	95% cotton, 5% elastane	95% cotton, 5%elastane	100% cotton	100% cotton	95% cotton, 5% elastane
Country of manufacture	Portugal	Thailand	India	Egypt	China
Price of product	£20.00	£20.00	£14.00	£20.00	£9.99
Pack of	1	2	1	1	1
Amount of NPE (ppm)	<3	<3	8.4	24.4	135.5

SAMPLE NUMBER	LH/10/26	LH/10/27	LH/10/28	LH/10/29	LH/10/30
Sample type	Men's	Men's	Women's	Men's	Men's
Type	Designer	Designer	Designer	Designer	Designer
Material	95% cotton, 5% elastane	95% cotton, 5% elastane	95% cotton, 5% elastane	95% cotton, 5% elastane	95% cotton, 5% elastane
Country of manufacture	China	China	India	Cambodia	China
Price of product	£26.99	£10.00	£22.00	£14.00	£27.00
Pack of	2	1	6	2	1
Amount of NPE (ppm)	206.0	<3	<3	<3	<3

SAMPLE NUMBER	LH/10/31	LH/10/32	LH/10/33	LH/10/34	LH/10/35
Sample type	Men's	Men's	Men's	Women's	Women's
Type	Designer	Designer	Designer	Discount	Discount
Material	95% cotton, 5% elastane	95% cotton, 5% elastane	100% cotton	90% cotton, 10% elastane	100% cotton
Country of manufacture	India	Portugal	China	Unknown	Unknown
Price of product	£14.99	£19.00	£24.00	£1.00	£2.49
Pack of	1	1	1	1	4
Amount of NPE (ppm)	<3	<3	3.3	41.7	17.1

SAMPLE NUMBER	LH/10/36	LH/10/37	LH/10/38	LH/10/39	LH/10/40
Sample type	Men's	Kids (girls)	Women's	Women's	Kids (boys)
Type	Discount	Discount	Discount	Discount	Discount
Material	100% cotton	100% cotton	100% cotton	100% cotton	100% cotton
Country of manufacture	India	England	Turkey	Unknown	Unknown
Price of product	£1.00	£0.50	£1.00	£1.00	£3.99
Pack of	1	1	1	1	1
Amount of NPE (ppm)	146.1	<3	<3	<3	<3

SAMPLE NUMBER	LH/10/41	LH/10/42	LH/10/43	LH/10/44	LH/10/45
Sample type	Women's	Men's	Women's	Women's	Men's
Type	Discount	High Street	High Street	High Street	High Street
Material	100% cotton	100% cotton	100% cotton	100% cotton	100% cotton
Country of manufacture	Unknown	China	China	China	China
Price of product	£4.14	£27.00	£4.00	£4.00	£12.00
Pack of	1	2	1	5	4
Amount of NPE (ppm)	<3	<3	17.7	<3	52.3

SAMPLE NUMBER	LH/10/46	LH/10/47	LH/10/48	LH/10/49	LH/10/50
Sample type	Men's	Women's	Kids (boys)	Women's	Women's
Type	High Street	High Street	High Street	High Street	High Street
Material	95% cotton, 5% elastane	95% cotton, 5% elastane	100% cotton	95% cotton, 5% elastane	100% cotton
Country of manufacture	China	China	China	Turkey	China
Price of product	£6.99	£4.50	£10.00	£4.00	£6.00
Pack of	1	1	7	1	3
Amount of NPE (ppm)	96.2	8.4	<3	<3	<3

Sample number	LH/10/51	LH/10/52	LH/10/53	LH/10/54	LH/10/55
Sample type	Kids (girls)	Women's	Women's	Women's	Men
Type	High Street	High Street	High Street	High Street	High Street
Material	100% cotton	95% cotton, 5% elastane	95% cotton, 5% elastane	100% cotton	100% cotton
Country of manufacture	Thailand	Bangladesh	Bangladesh	China	Sri Lanka
Price of product	8.95	£5.99	£10.00	£4.00	£18.00
Pack of	3	3	5	1	3
Amount of NPE (ppm)	<3	<3	<3	<3	<3

Sample number	LH/10/56	LH/10/57	LH/10/58	LH/10/59	LH/10/60
Sample type	Kids (girls)	Kids (baby)	Men's	Women's	Men's
Type	High Street	High Street	High Street	High Street	High Street
Material	95% cotton, 5% elastane	100% cotton	95% cotton, 5% elastane	95% cotton, 5% elastane	90% cotton, 10% elastane
Country of manufacture	China	India	China	China	Turkey
Price of product	£1.50	£4.00	£9.99	£8.00	£14.99
Pack of	2	2	3	3	1
Amount of NPE (ppm)	99.6	<3	<3	54.7	<3

Sample number	LH/10/61	LH/10/62	LH/10/63	LH/10/64	LH/10/65
Sample type	Women's	Women's	Women's	Men's	Women's
Type	High Street	High Street	High Street	High Street	High Street
Material	95% cotton, 5% elastane	95% cotton, 5% elastane	100% cotton	95% cotton, 5% elastane	95% cotton, 5% elastane
Country of manufacture	China	China	Unknown	China	China
Price of product	£2.50	£4.99	£2.50	£7.00	£4.99
Pack of	1	3	4	1	1
Amount of NPE (ppm)	331.5	<3	<3	1118.6	<3

Sample number	LH/10/66	LH/10/67	LH/10/68	LH/10/69	LH/10/70
Sample type	Women's	Women's	Men's	Kids (boys)	Kids (girls)
Type	High Street	On-line	On-line	On-line	On-line
Material	97% cotton, 3% elastane	100% cotton	100% cotton	100% cotton	100% cotton
Country of manufacture	China	China	Unknown	India	Unknown
Price of product	£4.00	£16.00	£4.99	£7.00	£2.60
Pack of	1	2	3	5	3
Amount of NPE (ppm)	259.3	<3	<3	<3	<3

Sample number	LH/10/71	LH/10/72	LH/10/73	LH/10/74	LH/10/75
Sample type	Women's	Kids (girls)	Women's	Men's	Kids (boys)
Type	On-line	On-line	On-line	On-line	On-line
Material	95% cotton, 5% elastane	100% cotton	100% cotton	100% cotton	95% cotton, 5% elastane
Country of manufacture	Sri Lanka	China	Bangladesh	Unknown	China
Price of product	£12.00	£7.00	£2.50	£6.99	£8.00
Pack of	5	5	3	3	3
Amount of NPE (ppm)	407.2	<3	<3	<3	<3

Sample number	LH/10/76	LH/10/77	LH/10/78	LH/10/79	LH/10/80
Sample type	Kids (boys)	Women's	Women's	Men's	Men's
Type	On-line	On-line	On-line	On-line	Sport
Material	100% cotton	95% cotton, 5% elastane	100% cotton	100% cotton	95% cotton, 5% elastane
Country of manufacture	Unknown	Sri Lanka	Unknown	Unknown	Unknown
Price of product	£2.99	£11.50	£4.99	£6.45	£3.99
Pack of	5	3	3	10	1
Amount of NPE (ppm)	38.7	<3	<3	<3	<3

Sample number	LH/10/81	LH/10/82	LH/10/83	LH/10/84	LH/10/85
Sample type	Men's	Men's	Men's	Kids (boys)	Kids (boys)
Type	Sport	Sport	Sport	Sport	Sport
Material	95% cotton, 5% elastane	100% cotton	95% cotton, 5% elastane	95% cotton, 5% elastane	100% cotton
Country of manufacture	Unknown	Unknown	China	Unknown	Unknown
Price of product	£4.99	£2.99	£9.99	£2.99	£1.50
Pack of	1	1	1	1	1
Amount of NPE (ppm)	<3	<3	<3	<3	1759.7

Sample number	LH/10/86	LH/10/87	LH/10/88	LH/10/89	LH/10/90
Sample type	Women's	Kids (boys)	Women's	Kids (boys)	Men's
Type	Sport	Sport	Supermarket	Supermarket	Supermarket
Material	95% cotton, 5% elastane	100% cotton	95% cotton, 5% elastane	100% cotton	100% cotton
Country of manufacture	Pakistan	Unknown	Unknown	Unknown	Bangladesh
Price of product	£18.00	£2.99	£1.20	£3.00	£3.50
Pack of	2	3	3	3	1
Amount of NPE (ppm)	392.0	<3	50.4	<3	<3

Sample number	LH/10/91	LH/10/92	LH/10/93	LH/10/94	LH/10/95
Sample type	Women's	Kids (girls)	Men's	Women's	Women's
Type	Supermarket	Supermarket	Supermarket	Supermarket	Supermarket
Material	95% cotton, 5% elastane	100% cotton	100% cotton	95% cotton, 5% elastane	95% cotton, 5% elastane
Country of manufacture	China	Sri Lanka	China	Bangladesh	Thailand
Price of product	£3.00	£4.00	£8.00	£4.00	£9.59
Pack of	1	5	5	4	6
Amount of NPE (ppm)	<3	<3	<3	<3	67.4

Sample number	LH/10/96	LH/10/97	LH/10/98	LH/10/99	LH/10/100
Sample type	Kids (girls)	Kids (boys)	Men's	Women's	Men's
Type	Supermarket	Supermarket	Supermarket	Supermarket	Supermarket
Material	100% cotton	100% cotton	100% cotton	100% cotton	95% cotton, 5% elastane
Country of manufacture	China	Unknown	India	China	Unknown
Price of product	£7.00	£1.29	£6.00	£4.00	£2.99
Pack of	5	3	3	7	1
Amount of NPE (ppm)	443.3	<3	898.7	<3	<3

Appendix 6: Estimated NPE emissions calculations - Underwear (Environment Agency)

Sample details - Underwear (Environment Agency)

NPE mg/kg	Item	Male or female	Material	Country of manufacture	EU or non-EU
1759.7	Underwear	Male	Cotton	Unknown	Unknown
1118.6	Underwear	Male	Cotton	China	Non-EU
898.7	Underwear	Male	Cotton	India	Non-EU
443.3	Underwear	Female	Cotton	China	Non-EU
407.2	Underwear	Female	Cotton	Sri Lanka	Non-EU
392	Underwear	Female	Cotton	Pakistan	Non-EU
331.5	Underwear	Female	Cotton	China	Non-EU
259.3	Underwear	Female	Cotton	China	Non-EU
206	Underwear	Male	Cotton	China	Non-EU
146.1	Underwear	Male	Cotton	India	Non-EU
135.5	Underwear	Male	Cotton	China	Non-EU
99.6	Underwear	Female	Cotton	China	Non-EU
96.2	Underwear	Male	Cotton	China	Non-EU
73.1	Underwear	Male	Cotton	China	Non-EU
67.4	Underwear	Female	Cotton	Thailand	Non-EU
54.7	Underwear	Female	Cotton	China	Non-EU
52.3	Underwear	Male	Cotton	China	Non-EU
50.4	Underwear	Female	Cotton	Unknown	Unknown
44.5	Underwear	Male	Cotton	Turkey	Non-EU
41.7	Underwear	Female	Cotton	Unknown	Unknown
38.7	Underwear	Male	Cotton	Unknown	Unknown
24.4	Underwear	Male	Cotton	Egypt	Non-EU
19	Underwear	Male	Cotton	India	Non-EU
17.7	Underwear	Female	Cotton	China	Non-EU
17.1	Underwear	Female	Cotton	Unknown	Unknown

NPE mg/kg	Item	Male or female	Material	Country of manufacture	EU or non-EU
8.4	Underwear	Male	Cotton	India	Non-EU
8.4	Underwear	Female	Cotton	China	Non-EU
3.3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	China & India	Non-EU
3	Underwear	Female	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Thailand	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Male	Cotton	Thailand	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	India	Non-EU
3	Underwear	Male	Cotton	Cambodia	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Male	Cotton	India	Non-EU
3	Underwear	Female	Cotton	Turkey	Non-EU
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Male	Cotton	China	Non-EU

NPE mg/kg	Item	Male or female	Material	Country of manufacture	EU or non-EU
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Thailand	Non-EU
3	Underwear	Female	Cotton	Bangladesh	Non-EU
3	Underwear	Female	Cotton	Bangladesh	Non-EU
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Sri Lanka	Non-EU
3	Underwear	Female	Cotton	India	Non-EU
3	Underwear	Male	Cotton	Thailand	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Turkey	Non-EU
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Unknown	Unknown
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	India	Non-EU
3	Underwear	Female	Cotton	Unknown	Unknown
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Bangladesh	Non-EU
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Unknown	Unknown

NPE mg/kg	Item	Male or female	Material	Country of manufacture	EU or non-EU
3	Underwear	Female	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Unknown	Unknown
3	Underwear	Male	Cotton	Bangladesh	Non-EU
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Sri Lanka	Non-EU
3	Underwear	Male	Cotton	China	Non-EU
3	Underwear	Female	Cotton	Bangladesh	Non-EU
3	Underwear	Male	Cotton	Sri Lanka	Unknown
3	Underwear	Female	Cotton	China	Non-EU
3	Underwear	Male	Cotton	Turkey	Non-EU

Number of items tested	96
Number of items containing NPE	28
% of items containing NPE	29
Geometric mean NPE/item (mg/kg)	7.9
Arithmetic mean NPE/item* (mg/kg)	243.4

*excludes samples where NPE <3 mg/kg

Estimation of NPE emissions - Underwear (CCT)

Commodity codes	61071100:cotton men's & boys' Underpants & briefs, (knitted or crocheted)
	62071100: cotton men's & boys' Underpants & briefs, (not knitted or crocheted)
	61082100: cotton women or girls briefs and panties
Total weight of underwear imported 2011 from non-EU (kg)	21865130
Geometric mean NPE/item (mg/kg)	7.9
Total NPE in all imported underwear (kg)	173.2
Average wash out rate (%)	99.9
Total emissions of NPE from imported underwear 2011 (kg)	173.0

Notes

LOD = 3 mg/kg. All samples <LOD are shown as 3 mg/kg

Appendix 7: Estimated NPE emissions calculations - Underwear (Greenpeace)

Sample details - Underwear (Greenpeace)

NPE mg/kg	Item	Material	Country of manufacture	EU or non-EU
29	Underwear	Unknown	Thailand	Non-EU
9.1	Underwear	Unknown	Egypt	Non-EU
1	Underwear	Unknown	China	Non-EU
11	Underwear	Unknown	China	Non-EU

Number of items tested	4
Number of items containing NPE	3
% of items containing NPE	75
Geometric mean NPE/item (mg/kg)	7.3

Estimation of NPE emissions - Underwear (Greenpeace)

	61071100:cotton men's & boys' underpants & briefs, (knitted or crocheted)
	61082100: cotton women or girls briefs and panties
Commodity code*	62071100: cotton men's & boys' underpants & briefs, (not knitted or crocheted)
Total weight of underwear imported 2011 from non-EU (kg)	21865130
Geometric mean NPE/item (mg/kg)	7.3
Total NPE in all imported underwear (kg)	160.5
Average wash out rate (%)	99.9
Total emissions of NPE from imported underwear 2011 (kg)	160.3

Notes

LOD = 1 mg/kg. All samples <LOD are shown as 1 mg/kg

*the material of the underwear analysed is not known; for comparative purposes, the same commodity code (for cotton pants) has been used as this was used for estimates based on CCT underwear analysis

Appendix 8: Estimated NPE emissions calculations - T-shirts (SSNC)

Sample details - T-shirts (SSNC)

NPE (mg/kg)	Item	Material	Country of manufacture	EU or non-EU
940	T-shirt	Cotton	China	Non-EU
430	T-shirt	Cotton	Unknown	Unknown
270	T-shirt	Cotton	Turkey	Non-EU
230	T-shirt	Cotton	Turkey	Non-EU
120	T-shirt	Cotton	Unknown	Unknown
63	T-shirt	Cotton	Unknown	Unknown
45	T-shirt	Polyester	Poland	EU
43	T-shirt	Cotton	Unknown	Unknown
33	T-shirt	Cotton	Unknown	Unknown
22	T-shirt	Cotton	Turkey	Non-EU
16	T-shirt	Polyester	Thailand	Non-EU
13	T-shirt	85% dri-release, 15% cotton	Unknown	Unknown
11	T-shirt	Cotton	Unknown	Unknown
4	T-shirt	Cotton	Portugal	EU
4	T-shirt	91% polybromide, 9% elastane	Lithuania	EU
3	T-shirt	92% cotton, 8% elastane	Unknown	Unknown
1	T-shirt	Cotton	Unknown	Unknown

Number of items tested	17
Number of items containing NPE	16
% of items containing NPE	94.1
Geometric mean NPE/item (mg/kg)	31.5

Estimation of NPE emissions - T-shirts (SSNC)

Commodity code	6109: t-shirts, singlets and other vests (knitted or crocheted)
Total weight of t-shirts imported 2011 from non-EU (kg)	15858867
Geometric mean NPE/item (mg/kg)	31.5
Total NPE in all imported t-shirts (kg)	499.2
Average wash out rate (%)	99.9
Total emissions of NPE from imported t-shirts 2011 (kg)	498.7

Notes

LOD = 1 mg/kg. Samples < LOD are shown as 1 mg/kg

Appendix 9: Estimated NPE emissions calculations - T-shirts (Greenpeace)

Sample details - T-shirts (Greenpeace)

NPE (mg/kg)	Item	Material	Country of manufacture	EU or non-EU
27000	T-shirt	Unknown	Philippines	Non-EU
970	T-shirt	Unknown	Bangladesh	Non-EU
810	T-shirt	Unknown	China	Non-EU
660	T-shirt	Unknown	China	Non-EU
530	Polo shirt	Unknown	China	Non-EU
470	T-shirt	Unknown	Thailand	Non-EU
220	T-shirt	Unknown	Philippines	Non-EU
210	T-shirt	Unknown	China	Non-EU
190	Polo shirt	Unknown	China	Non-EU
41	T-shirt	Unknown	Bangladesh	Non-EU
39	T-shirt	Unknown	China	Non-EU
35	Polo shirt	Unknown	Indonesia	Non-EU
19	Polo shirt	Unknown	China	Non-EU
18	T-shirt	Unknown	Cambodia	Non-EU
18	Polo shirt	Unknown	Thailand	Non-EU
13	T-shirt	Unknown	Bangladesh	Non-EU
12	T-shirt	Unknown	Turkey	Non-EU
9.8	Polo shirt	Unknown	China	Non-EU
8.7	Polo shirt	Unknown	China	Non-EU
7.1	T-shirt	Unknown	China	Non-EU
5	T-shirt	Unknown	Turkey	Non-EU
4.4	T-shirt	Unknown	Bangladesh	Non-EU
3.6	Polo shirt	Unknown	Thailand	Non-EU
2.8	Polo shirt	Unknown	Malaysia	Non-EU
2.2	T-shirt	Unknown	China	Non-EU

NPE (mg/kg)	Item	Material	Country of manufacture	EU or non-EU
1.6	T-shirt	Unknown	Turkey	Non-EU
1.2	T-shirt	Unknown	China	Non-EU
1.2	Polo shirt	Unknown	Cambodia	Non-EU
1	T-shirt	Unknown	China	Non-EU
1	T-shirt	Unknown	Turkey	Non-EU
1	T-shirt	Unknown	Bangladesh	Non-EU
1	T-shirt	Unknown	China	Non-EU
1	T-shirt	Unknown	Vietnam	Non-EU
1	T-shirt	Unknown	Bangladesh	Non-EU
1	T-shirt	Unknown	China	Non-EU
1	T-shirt	Unknown	Turkey	Non-EU
1	T-shirt	Unknown	China	Non-EU
1	T-shirt	Unknown	Turkey	Non-EU
1	Polo shirt	Unknown	unknown	Non-EU
1	Polo shirt	Unknown	unknown	Non-EU
1	Polo shirt	Unknown	unknown	Non-EU
1	Polo shirt	Unknown	China	Non-EU

Number of items tested	42
Number of items containing NPE	28
% of items containing NPE	67
Geometric mean NPE/item (mg/kg)	10.0

Estimation of NPE emissions - T-shirts (Greenpeace)

Commodity code*	6109: t-shirts, singlets and other vests (knitted or crocheted)
Total weight of t-shirts imported 2011 from non-EU (kg)	15858867
Geometric mean NPE/item (mg/kg)	10.0
Total NPE in all imported t-shirts (kg)	159.0
Average wash out rate (%)	99.9
Total emissions of NPE from imported t-shirts 2011 (kg)	158.9

Notes

LOD = 1 mg/kg. All samples <LOD are shown as 1 mg/kg

*the material of the t-shirts analysed is not known; for comparative purposes, the same commodity code has been used as this was used for estimates based on SSNC analysis

Appendix 10: Estimated NPE emissions calculations - towels (SSNC)

Sample details - Towels (SSNC)

NPE (mg/kg)	Item	Material	Country of manufacture	EU or non-EU
10608	Towels	Cotton	Unknown	unknown
1277	Towels	Cotton	Unknown	unknown
577	Towels	Cotton	Unknown	unknown
517	Towels	Cotton	Unknown	unknown
239	Towels	Cotton	Unknown	unknown
190.5	Towels	Cotton	Unknown	unknown
150.7	Towels	Cotton	Unknown	unknown
94.6	Towels	Cotton	Unknown	unknown
12.6	Towels	Cotton	Unknown	unknown
11.1	Towels	Cotton	Unknown	unknown
7	Towels	Cotton	Unknown	unknown
6.1	Towels	Cotton	Unknown	unknown
3.6	Towels	Cotton	Unknown	unknown
3.4	Towels	Cotton	Unknown	unknown
2.6	Towels	Cotton	Unknown	unknown
2.2	Towels	Cotton	Unknown	unknown
2	Towels	Cotton	Unknown	unknown
1.6	Towels	Cotton	Unknown	unknown
1	Towels	Cotton	Unknown	unknown
1	Towels	Cotton	Unknown	unknown

Number of items tested	20
Number of items containing NPE	18
% of items containing NPE	90
Geometric mean NPE/item (mg/kg)	23.8

Estimation of NPE emissions - Towels (SSNC)

Commodity code	6302 9100: cotton toilet and kitchen linen
Total weight of towels imported 2011 from non-EU (kg)	1119026
Geometric mean NPE/item (mg/kg)	23.8
Total NPE in all imported towels (kg)	26.7
Average wash out rate (%)	99.9
Total emissions of NPE from imported towels 2011 (kg)	26.6

Notes

LOD = 1 mg/kg. All samples <LOD are shown as 1 mg/kg

6 References

Greenpeace - Dirty Laundry (2011)

Greenpeace - Dirty Laundry 2: hung out to dry (2011)

Greenpeace - Dirty Laundry: Reloaded (2012)

Swedish Society for Nature Conservation (SSNC) - Towels with a dirty past (2007)

Swedish Society for Nature Conservation - T-shirts with a murky past (2008)

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