Footprints in the snow

Hazardous PFCs in remote locations around the globe

Executive Summary

GREENPEACE

www.greenpeace.de

Imprint **Published September 2015** by Greenpeace e. V., Hongkongstraße 10, 20457 Hamburg, mail@greenpeace.de, www.greenpeace.de **Editor** Simone Miller
Authors Madeleine Cobbing, Therese Jacobson, Manfred Santen **Acknowledgements** Annekatrin Dreyer, Kevin Brigden, Ulrike Kallee, Iryna Labunska, David Santillo and Melissa Wang
Production Birgit Matyssek **Design** spiegel grafik_raum_konzept, Hamburg **Photos** front cover: Roberto Isotti, p. 2: Christian Breitler, p. 3: Tomas Halasz, back cover: Roman Zaykovskiy,
all © Greenpeace **Illustration** Latte Creative, © Greenpeace

1. Executive Summary

1.1 Searching for Clues

Outdoor brands and their suppliers rely upon stunning natural images of lonely, pristine mountain lakes and remote snowy mountain ranges climbed by famous outdoor adventurers[1] for their advertising. Yet the chemicals used to make their products weatherproof are leaving an indelible footprint in the remote mountainous regions so loved by outdoor enthusiasts.

To search for clues about the extent that these chemicals are contaminating these pristine environments, Greenpeace undertook eight expeditions to remote mountainous areas on three continents. Snow, and in some places water samples, were taken at a total of 10 locations and analysed for the presence of environmentally hazardous per and poly-fluorinated chemicals (PFCs).

An array of scientific studies suggests that the PFC problem is nowhere near to being solved. Greenpeace now wants to raise awareness among outdoor enthusiasts and the wider public with this unique, globally organized study tour.

PFCs are used in many industrial processes and consumer products, and are well known for their use by the outdoor apparel industry in waterproof and dirt-repellent finishes. They are used for their unique chemical properties, especially their stability and their ability to repel both water and oil.

However, PFCs are environmentally hazardous substances, which are persistent in the environment.[2] Once released into the environment they break down very slowly; they can remain in the environment for many years after their release and are dispersed over the entire globe. These pollutants are found in secluded mountain lakes and snow from remote locations, they accumulate in living organisms such as the livers of polar bears in the Arctic and also in human blood.[3] For some PFCs there is evidence that they cause harm to reproduction, promote the growth of tumors and affect the hormone system. Previous Greenpeace research found PFCs in the wastewater of Chinese textile factories,[4] in wild fish that are caught for consumption in China[5] and in eels from

1 W. L. Gore & Associates GmbH (2014). GORE FABRICS RESPONSIBILITY Update **http://www.gore-tex.com/remote/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1289388191609&ssbinary=true**

2 OECD (2013). Synthesis Paper On Per- and Poly-fluorinated Chemicals (PFCs) **http://www.oecd.org/env/ehs/risk-management/PFC_FINAL-Web.pdf**

3 OECD (2013), op.cit.

4 Greenpeace (2011). Investigation of hazardous chemical discharges fromtwo textile-manufacturing facilities in China **http://www.greenpeace.to/greenpeace/wp-content/uploads/2011/07/Textilemanufacture_China.pdf**

5 Greenpeace (2010). Swimming in Chemicals, Perfluorinated chemicals, alkylphenols and metals in fish from the upper, middle and lower sections of the Yangtze River, China, 25 August, 2010 **http://www.greenpeace.org/international/en/publications/reports/Swimming-in-Chemicals/**

eleven European countries.[1] In other studies PFCs were even detected in drinking water.[2, 3] In reports from 2012 and 2013,[4, 5, 6]

Box 1: PFCs in remote areas

The long range transport of some PFCs to remote areas has been studied scientifically for several years. Particularly those PFCs known to have toxic properties such as the long chained perfluorinated alkyl acid PFOA or sulfonate PFOS are commonly found in snow and water. Studies discuss three possible ways that PFCs are distributed in the environment. Some PFCs can bind to suspended particulate matter which is transported through the atmosphere and washed out and deposited in rain and snow. Volatile compounds such as polyfluorinated fluorotelomer alcohol (FTOH) and sulfonates can be transported in the atmosphere over long distances. They are called precursor substances, as during their transport they are subject to atmospheric oxidation, transforming them into accumulative perfluorinated alkyl acids or sulfonates which can then be deposited in high mountains, for example. Finally, ocean currents may play an important role by transporting PFCs globally, for example to the Arctic and Antarctic.

Greenpeace found that PFCs are routinely present in outdoor clothing and shoes and showed that volatile PFCs can evaporate from these products into the air.

In this new study, Greenpeace finds that these hazardous chemicals have left their mark in the most remote and pristine places on earth. Traces of PFCs were found in snow samples from all sites that the Greenpeace teams visited. They are present in the snow that fell last winter, as well as in water from mountain lakes where these substances have accumulated over several years. Amongst the PFCs detected, samples from all sites contained so-called short chain PFCs[7] – increasingly used by many outdoor brands as if they were less harmful instead of long chain PFCs.[8] PFCs were found not only in snow but also in water samples that were collected from high mountain lakes in all but one of the areas visited.

The outdoor industry is not the only source of PFCs, but is a very visible example of how PFCs are used and can be a source of contamination of the environment. These substances can be released during manufacturing, transport, storage and use of the chemicals themselves and the products that contain them. They can be present in wastewater from factories but also from domestic washing machines;[9] not all PFCs can be removed from wastewater in sewage treatment plants.[10] Some PFCs have the potential to evaporate during production and to a lesser extent from the finished products. When products containing PFCs are disposed of PFCs can enter into groundwater and surface water when such products are landfilled.

Per- and polyfluorinated chemicals (PFCs) are hazardous substances. They do not occur naturally and many degrade in nature very slowly; examples are found in the most remote regions of the world in snow, water and soil, and some of these substances may cause reproductive harm, can

1 Santillo, D., Allsopp, M., Walters, A., Johnston, P. & Perivier, H. (2006)The presence of PFOS and other perfluorinated chemicals in eels (Anguilla anguilla) from 11 European countries. Greenpeace Research Laboratories Technical Note07/2006, September 2006 **http://www.greenpeace.to/greenpeace/?p=789**

2 Wilhelm et al (2012). Occurrence of perfluorinated compounds (PFCs) in drinking water of North Rhine-Westphalia, Germany and new approach to assess drinking water contamination by shorter-chained C4-C7 PFCs, Int J Hyg Environ Health. 2010 Jun; 213(3):224-32

3 OECD (2013), op.cit.

4 Greenpeace e.V. (2012). Chemistry for any weather, Greenpeace tests outdoor clothes for perfluorianted toxins, October 2012 **http://www.greenpeace.org/romania/Global/romania/detox/Chemistry%20for%20any%20weather.pdf**

5 Greenpeace e.V. (2013). Chemistry for any weather, Part II, Executive Summary, December 2013 **http://m.greenpeace.org/italy/Global/italy/report/2013/toxics/ExecSummary_Greenpeace%20Outdoor%20Report%202013_1.pdf**

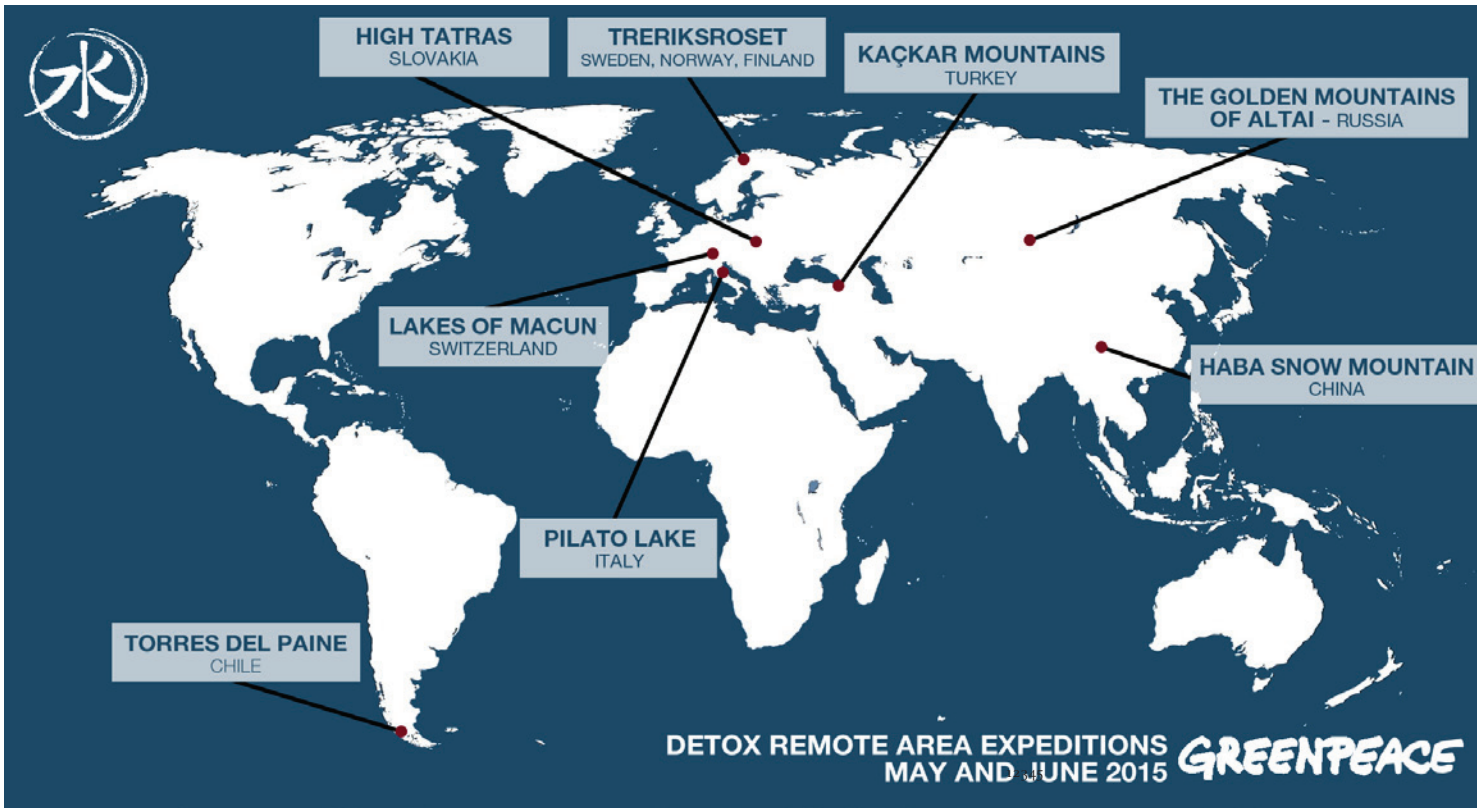
6 Greenpeace e.V. (2014). A red card for sportswear brands, Greenpeace tests shoes in the prerun of World Champion Ship, May 2014 **http://www.greenpeace.org/international/Global/international/publications/toxics/2014/Detox-Football-Report.pdf**

7 "Long-chain perfluorinated compounds" refers to Perfluorocarboxylic acids (PFAC) with carbon chain lengths C8 and higher, including perfluorooctanoic acid (PFOA); Perfluoroalkyl sulfonates (PFAS) with carbon chain lengths C6 and higher, including perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonate (PFOS)
from: **http://www.oecd.org/ehs/pfc**
this definition implies: short chain Perfluorocarboxylic acids are compounds with chain length C7 (PFHpA) and shorter
short chain Perfluorosulfonic acids are compounds with chain length C5 (PFPeS) and shorter

8 **https://www.patagonia.com/pdf/en_US/pfoa_and_flourochemicals.pdf**

9 German Federal Environment Agency (Umweltbundesamt, 2009), op.cit.

10 Busch J.(2009): Analysis of poly- and perfluorinated compounds (PFCs) in landfill effluent using HPLC-MS/MS, GKSS report, Helmholtz-Gesellschaft, Geesthacht 2009



enhance the development of cell tumours[1, 2] or are suspected to act as mutagens.[3] They have been used with little hesitation for 60 years and are found in many consumer and industrial products. Of particular concern are the toxic long-chain or C8 PFCs PFOA and PFOS. Although these two substances are now being taken out of production in many countries – as a result of increasing regulation – some scientists predict that the concentrations of these substances in the environment will continue to rise beyond 2030.[4] On the one hand this is due to their persistence leading to increasing concentrations building up in the environment as a result of ongoing releases, but they can also be formed unintentionally as degradation products from other PFCs that continue to be used in large quantities as substitutes.

Since the beginning of its Detox campaign in 2011, Greenpeace has been calling on the clothing industry to eliminate all hazardous chemicals from its supply chain by 2020. The outdoor industry needs to urgently initiate concrete action plans to drastically reduce and ultimately eliminate its use of PFCs resulting in their elimination from production. This demand is supported by many scientists; more than 200 scientists from 38 countries signed the ‚Madrid statement',[5] which calls for the elimination of PFCs from consumer products where they are not essential and when safer alternatives exist.

1 German Federal Environment Agency (Umweltbundesamt, 2009):op.cit The development of cell tumours has been observed in animal tests.
2 Madrid Statement (2015). **http://greensciencepolicy.org/madrid-statement/**
The Madrid Statement is based on: M. Scheringer, X. Trier, I. Cousins, P. de Voogt, T. Fletcher e, Z. Wang, T. Webster: Helsingør Statement on poly- and perfluorinated alkyl substances (PFASs), Chemosphere, Volume 114, November 2014, Pages 337–339 **http://www.sciencedirect.com/science/article/pii/S004565351400678X**
3 Liu C, Chang VW, Gin KY, Nguyen VT (2014): Genotoxicity of perfluorinated chemicals (PFCs) to the green mussel (Perna viridis), Sci Total Environ. 2014 Jul 15;487:117-22
4 Li L, Liu J, Hao X, Wang J, Hu J (2015). Forthcoming increase of total PFAS emissions in China, Poster at Fluoros 2015 International Symposium on Fluorinated Organics in the Environment, Colorado 2015
5 Madrid Statement (2015). Op.cit.

Country		Date of Expedition	Altitude Snow sample point	GPS Snow sample point	PFC evidence in snow	Altitude Water sample point	GPS Water sample point	PFC evidence in water
China	Haba Snow Mountain, Shangri-la county	26./27.05.2015	5053 m	27°19'38.16" 100°6'24.00"	yes	5053 m	27°20'57.19" 100°04'117.38"	no*
Russia	Altai Republic, Siberia	08.06.2015	1778 m	49°92'4450" 85°88'4698"	yes	1778 m	49°92'4450" 85°88'4698"	yes
Italy	Lake of Pilato, Monti Sibillini, Umbria	28.05.2015	1943 m	42°49'33" 13°15'56"	yes	1943 m	42°49'33" 13°15'56"	yes
Switzerland	Lakes of Macun, Swiss National Park	19.06.2015	2641 m	46°43'717" 10°07'549"	yes	2636 m	46°43'729" 10°07'546"	yes
Slovakia	Žabia Bielovodská dolina, High Tatras, Carpathian Mountains	26.05.2015	1722 m	49°11'73.2" 20°05'560"	yes	1700 m	49°11'73.2" 20°05'560"	yes
Sweden	Kiruna, Övre Soppero	02.06.2015	511 m	68°15'30.6" 22°01'55.9"	yes	N/A	Keine Probe	not sampled**
Norway	Skibotridalen, T roms fylke	03.06.2015	616 m	69°11'54.5" 20°32'01.0"	yes	N/A	Keine Probe	not sampled**
Finland	Kilpisjärvi, Enontekiö	04.06.2015	742 m	69°04'17.8" 20°41'28.5"	yes	N/A	Keine Probe	not sampled**
Chile	Torres del Paine Nationalpark, Patagonia	10.06.2015	900 m	-50°94'2886" -72°95'0042"	yes	900 m	-50°94'2882" -72°95'0424"	yes
Turkey	Rize-Çamlıhemşin and Erzurum Moryayla-Yedigöller, Kaçkar-Mountains	13.06.2015	3100 bis 3120 m	40°45'27" 40°50'29"	yes, but no field blank	2980 m	40°45'60" 40°50'40"	yes, but no field blank

* PFC concentrations in the reference sample (field blank) were higher than in the sample
** No remote lake in that area

1.2 The expeditions

Greenpeace organized these expeditions to some of the most beautiful and unspoilt regions on three continents to draw attention to a long standing, but little-known and certainly unsolved problem.

In May and June 2015, eight Greenpeace teams were equipped with PFC-free clothing and undertook expeditions to remote mountainous areas on three continents in their respective regions, to take snow, and in most cases water, samples for laboratory analysis.

For the selection of sampling sites remote but accessible locations were chosen. One key criterion for snow to be sampled was that the snow had been recently deposited (this winter). Another key criterion was for the snow to have been untouched since it fell. The snow must not have had the potential to be influenced by local sources of PFC, such as settlements, skiing activities, hiking paths, cattle, industry, traffic etc.

For water sampling, lakes were selected that were not influenced by such local sources of PFCs, as far as could be determined.

1.3 Key findings

The eight Greenpeace expeditions in 10 countries took place in May and June 2015. They show clearly that PFC chemicals are widely detected in remote locations across the globe and that inputs to these remote locations have occurred even as recently as the winter of 2015. PFCs do not occur naturally and should therefore not be found in remote wilderness regions. Nevertheless, they can travel around the world in the atmosphere, either as gas or bound to dust particles, until they are washed out in rain or snow.

The Cycle of PFC

PFCs

PFCs are environmentally hazardous substances, which are persistent. Once released into the environment they break down very slowly; they remain in the environment for several hundred years and can spread over the entire globe.

Industries

PFCs are used in several industries, and are released to the environment during manufacturing processes and during the use and disposal of products containing PFCs. Once in the environment, PFCs spread globally.

Environment

PFCs are released into the environment during the manufacturing of textiles, as well as during the use and disposal of products containing PFCs. These substances can reach our bodies when we breathe air containing PFCs or when we ingest food, drink water, or through exposure to house dust.

Outdoor-gear

Apart from textile and outdoor products, PFCs are used in a variety of other products. But for volatile PFCs (FTOHs), information summarized by the Danish Ministry of Environment shows that "about 50 % of the production (5,000 t) goes to the impregnation of textile consumer products".

It is noteworthy that PFCs were detected in snow samples from all the sites. The highest concentrations were in the samples from the High Tatras in Slovakia, the Sibillini Mountains near Lago Pilato in the Italian Apennines and the Alps (Macun Lakes in the Swiss National Park).

The substances with the highest concentrations in snow were the long-chain PFCAs PFNA (C9-PFC), with values up to 0.755 ng/l, and PFHpA (C7-PFC) which was detectable in significant concentrations of up to 0.319 ng/l in the snow.

The levels found (0.034 – 0.319 ng/l of PFHpA, and up to 0.755 ng/l for PFNA) are comparable to other studies which analysed surface snow in the Tibetan mountains (PFHpA: 0.241 – 0.982 ng/l)[1] and Antarctica (PFNA: 0.024 – 1.14 ng/l).[2]

Comparable studies of snow in European remote areas in Europe show that levels in snow Sweden[3] were 0.0021 ng/l for PFHpA, 0.0269 ng/l for PFNA, 0.0665 ng/l for PFOA while snow from the Alps[4] contained up to 0.31 ng/l for PFNA and 0.23 – 0.63 ng/l for PFOA.

In this current study PFOA was detected in samples from Slovakia (0.107 and 0.348 ng/l), Switzerland (0.087 ng/l) and Italy (0.209 ng/l). PFOS was detected in samples from Italy (0.024 ng/l)

The snow sampled at an altitude of over 5000 m in the Haba Snow Mountains in China contained the lowest concentrations, with only the sulfonate 8:2 FTS clearly detectable.

1 Wang et.al (2014). op.cit.
2 Cai et. Al (2012). op.cit.
3 Codling G, Halsall C, Ahrens L, Del Vento S, Wiberg K, Bergknut M, Laudon H &Ebinghaus R (2014). The fate of per- and polyfluoroalkyl substances within a melting snowpack of a boreal forest. Environmental Pollution 191: 190–198
4 Kirchgeorg T, Dreyer A, Gabrieli J, Kehrwald N, Sigl M, Schwikowski M, Boutron C, Gambaro A, Barbante C, Ebinghaus R (2013): Temporal variations of perfluoroalkyl substances and polybrominated diphenyl ethers in alpine snow, Environmental Pollution 178 (2013) 367-374

Short-chain PFCs were found in snow samples from six of the locations. For example, the fluorosulfonic acid PFBS (C_4) was detected in the snow samples from Treriksroset in Scandinavia (Norway, Finland, Sweden). The short-chain PFCs found in the samples from the expeditions to the Alps, the Appennines and the High Tatras were dominated by PFHxA, with concentrations of 0.087 ng/l, 0.120 ng/l and 0.161 ng/l.

Seven out of eight expedition teams also took water samples from mountain lakes. These showed perfluorinated chemicals that have accumulated over the years, resulting in concentrations that are significantly higher than the snow samples.

The concentrations of short-chain PFCs in the water of most remote lakes is higher than that of long-chain PFCs; in water samples from Patagonia, Russia and Switzerland, the short-chain C_4, C_5 and C_6 compounds are particularly clearly demonstrated with concentrations of up to 1.1 ng/l.

These findings are within the range of concentrations reported in previous studies from lake water analysis in the USA[1] or in Austria /Alps[2] However, in these studies the concentrations found are predominantly higher than in the samples collected by Greenpeace; one reason could be that these expeditions took samples in more remote areas.

1.4 The 'great outdoors' – a growth industry

Positive images of beautiful mountain landscapes, majestic forests, freshly fallen snow and clean rivers, are heavily promoted by manufacturers of all-weather clothing to market their products. The growing interest in nature and outdoor activities means that outdoor clothing is the fastest-growing segment of the global sports apparel market, with the global market estimated in 2012 at US$ 25 billion in 2012.[3]

While PFCs are used in many industrial processes and consumer products, a major use is in protective treatments for textiles, used throughout the outdoor industry.[4] Outdoor clothing companies are also aware of the inherent contradiction of this practice and are worried about their image. The manufacturers claim to have made an appropriate response to the problem by phasing out particularly harmful substances such as the long-chain PFCs (C8 and longer, including PFOA and PFOS) and replacing them with short-chain C_4 to C_6 PFCs. However, these chemicals are also persistent and may exacerbate the problem of PFC pollution; they need to be used in larger quantities than the equivalent C8 compounds to achieve comparable performance. Many of them are more volatile and mobile and therefore have the potential to disperse rapidly in water and air across the globe. The limited steps taken by the outdoor industry so far are nowhere near sufficient to protect the remote natural areas so loved by their customers. So far, these companies have side-stepped the repeated warnings from Greenpeace's Detox campaign and neglected the need to replace all PFCs used as waterproofing in membranes and coatings.

The global spread of toxic and hazardous chemicals in the textile industry is the focus of the Greenpeace's Detox My Fashion campaign. Clothing companies that commit to Detox, undertake to eliminate hazardous chemicals from their production and products by 2020. More than 30 international fashion brands, sportswear brands and discounters such as Lidl and Penny have published credible Detox Commitments with Greenpeace. This corresponds to about 15 percent of global textile production revenue.

Some smaller outdoor companies such as Paramo, Pyua, Rotauf, Fjällräven and R'ADYS already have entire collections of functional weatherproof clothing that are PFC-free. In contrast leading outdoor companies such as The North Face, Columbia, Patagonia, Salewa and Mammut have shown little sense of responsibility. They currently make products that are almost exclusively weatherproofed with large amounts of PFCs, while Jack Wolfskin and Vaude have a small selection of PFC-free products in their collections.

1 Furdui VI, Stock NI, Ellis D, Butt CM, Whittle DM, Crazier PW, Reiner EJ, Muir DCG, Mabury SA (2007): Spatial Distribution of Perfluoralkyl Contaminants in Lake Trout from the Great Lakes. Environ.Schi.Technol. 41 (5) 1554-1559

2 Clara M, Weiss S, Sanz-Escribano D, Scharf, Scheffknecht C (2009): Perfluorinated alkylated substances in the aquatic environment: An Austrian case study, Water Research 43: 4760-4768

3 VF Corporation (2013). Presentation, 17x17, Powerful Brands/Powerful Platforms, June 11, 2013 New York City page 33 (NPD Global sports market estimate)
http://vf17x17.com/pdf/2013%20VFC%20Investor%20Day-Presentation.pdf

4 Danish Ministry of Environment (2013), Survey of PFOS, PFOA and other perfluoroalkyl and polyfluoroalkyl substances, part of the LOUS-review, 29-04-2013, Environmental Project No. No. 1475, 2013; p. 58
http://mst.dk/service/publikationer/publikationsarkiv/2013/apr/survey-of-pfos-pfoa-and-other-perfluoroalkyl-and-polyfluoroalkyl-substances-part-of-the-lous-review/ - main page
http://eng.mst.dk/topics/chemicals/assessment-of-chemicals/lous-surveys-and-strategies/

1.5 Reducing the chemical footprint of the outdoor industry

As this report demonstrates, volatile PFCs are being transported and deposited in cold and remote mountainous regions. On their way, some are transformed into more dangerous and persistent PFCs, which will contaminate the environment for many years. Once released, it is impossible to control PFCs. Volatile PFCs are being used by outdoor brands today to make their products weather resistant. These brands use images of pristine nature in their advertising and promote their "sustainable" products. At the same time, they are contributing to the distribution of hazardous chemicals such as PFCs to the furthest corners of the planet.

Both the outdoor industry and political decision makers urgently need to ensure that the well-known and controversial long chain PFC chemicals are not substituted with larger quantities of the lesser known volatile or short chain PFCs. There is no need to risk greater contamination of the environment with PFC chemicals as alternatives that completely avoid the use of any PFCs are already available for many applications in outdoor clothing, as demonstrated by their use in these expeditions.

Outdoor brands must make a genuine and credible Detox commitment to stop using hazardous chemicals – with ambitious schedules and concrete measures that match the urgency of the situation and short-term deadlines for completely phasing out the use of all PFCs in products and production processes. This will send an important signal to the chemical industry to increase its efforts on the further development of non-hazardous alternatives.

To be credible, the commitment to eliminate PFCs must include transparency, to ensure that data on the discharge of hazardous chemicals into waterways by suppliers is published on a global online platform[1] and to demonstrate the progressive reduction of their use. This kind of data is being published by other companies so there is no excuse for outdoor brands not to make sure that their suppliers disclose this kind of data and allow everyone, including local populations, the right to find out which chemicals are being released.

Political decision-makers must also take action. In view of the hazardous properties of many PFCs, including the potential for volatile substitutes to transform into persistent PFCs, it is no longer enough to only regulate a small number of individual substances such as PFOA and PFOS. Greenpeace calls on policy makers to fully implement the Precautionary Principle[2] by restricting the entire group of PFCs.

To make this happen, pressure from the public is vital – from nature lovers, outdoor and wilderness enthusiasts such as climbers, skiers and walkers, to city dwellers and families – anyone who cares about the future of our wild places and our own health and environment. If we don't act now to stop the spread of PFCs across the planet, contamination could build up to much greater levels, adding to the pollution that will need to be dealt with in the decades to come. The outdoor industry and the politicians need to hear your voices, to urge them to take action on the elimination of ALL PFCs.

1 IPE – Chinese Institute for Environmental Affairs; which is the only credible global chemical discharge disclosure platform

2 Precautionary Principle: This means taking preventive action before waiting for conclusive scientific proof regarding cause and effect between the substance (or activity) and the damage. It is based on the assumption that some hazardous substances cannot be rendered harmless by the receiving environment (i.e. there are no 'environmentally acceptable'/'safe' use or discharge levels) and that prevention of potentially serious or irreversible damage is required, even in the absence of full scientific certainty. The process of applying the Precautionary Principle must involve an examination of the full range of alternatives, including, where necessary, substitution through the development of sustainable alternatives where they do not already exist

2

Table 1 results PFC (in ng/l) in snow samples from Greenpeace expedtions into remote areas

Country	NRO sample number	Sample type	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFU
Russia Altay Mountains	RUAS1 + RUAS2	snow	< 0,185	< 0,024	< 0,018	**0,036**	**0,040**	< 0,030	< 0,009	**0**
	RUAS0	field blank	< 0,392	**0,102**	< 0,038	**0,053**	< 0,077	< 0,065	< 0,021	**0**
China Haba Snow Mountains	HBSNOW01	snow	< 0,298	< 0,039	< 0,029	**0,016**	< 0,058	< 0,049	< 0,016	<
	HBSNOW04	snow	< 0,299	< 0,039	**0,034**	**0,020**	< 0,059	< 0,049	< 0,016	<
	HBSNOW BLANK	field blank	< 0,502	< 0,065	< 0,049	< 0,026	< 0,099	< 0,083	< 0,027	<
Sweden Kiruna/Övre	S1S + S2S	snow	< 0,171	**0,064**	< 0,016	**0,050**	< 0,033	< 0,028	< 0,009	**0**
	SFBS	field blank	< 0,532	< 0,069	< 0,052	< 0,028	< 0,105	< 0,088	< 0,028	<
Norway Troms fylke		snow 1	< 0,274	**0,066**	< 0,027	**0,058**	< 0,054	< 0,045	< 0,014	**0**
		snow 2	< 0,290	< 0,038	< 0,028	**0,034**	< 0,057	< 0,048	< 0,015	**0**
	NFBS	field blank	< 0,505	< 0,066	< 0,050	< 0,026	< 0,099	< 0,084	< 0,027	<
Finland Kilpisjärvi	F1S + F2S	snow	**0,163**	**0,055**	< 0,015	**0,050**	**0,034**	< 0,026	< 0,008	**0**
	FFBS	field blank	< 0,516	< 0,067	< 0,051	< 0,027	< 0,102	< 0,086	< 0,027	<
Slovakia High Tatras	S1A	snow	< 0,325	**0,078**	**0,067**	**0,221**	**0,107**	**0,722**	**0,183**	**0**
	S1B	snow	< 0,389	**0,065**	**0,161**	**0,282**	**0,348**	**0,659**	**0,137**	**0**
	SFB	field blank	< 0,503	**0,071**	< 0,049	**0,031**	< 0,099	< 0,084	**0,047**	<
Switzerland Alps/Lake Macun	Macun_ GPCH_Snow No. 1	snow	< 0,301	**0,051**	< 0,029	**0,199**	< 0,059	**0,321**	**0,031**	**0**
	Macun_ GPCH_Snow No. 2	snow	< 0,335	**0,150**	**0,087**	**0,319**	**0,087**	**0,479**	**0,045**	**0**
	Macun_ GPCH_Snow No. 3FB	field blank	< 0,312	**0,076**	**0,035**	**0,058**	< 0,061	< 0,052	**0,023**	<
Chile Patagonia /Torres del Paine	SS1 + SS2	snow	< 0,521	< 0,068	< 0,051	**0,094**	< 0,103	< 0,087	< 0,028	**0**
	SS3	field blank	< 0,346	< 0,045	< 0,034	< 0,018	< 0,068	< 0,057	< 0,018	<
Italy Appennines Sibillini Mountains	ISS1	snow	< 0,351	< 0,046	**0,120**	**0,240**	**0,209**	**0,755**	**0,170**	**0**
	ISS2	field blank	< 0,344	< 0,045	< 0,034	< 0,018	< 0,068	< 0,057	< 0,018	<
Turkey Kackar Mountains	TUR02	snow	< 0,262	**0,044**	**0,070**	**0,118**	**0,219**	**0,059**	**0,042**	<

Annex 1: Results

UnA	PFDoA	PFTrA	PFTA	PFBS	PFHxS	PFHpS	PFOS	PFDeS	H4PFOS	8:2 FTS	PFOSA
,049	**0,008**	**0,212**	**0,270**	< 0,007	< 0,038	**0,058**	**0,009**	< 0,003	< 7,233	< 0,024	**0,100**
,029	< 0,015	< 0,059	**0,013**	< 0,016	< 0,082	< 0,051	< 0,012	< 0,008	< 15,30	< 0,050	< 0,101
0,021	< 0,011	< 0,045	< 0,009	< 0,012	< 0,062	< 0,038	< 0,009	< 0,006	< 11,65	**0,092**	< 0,077
0,021	< 0,011	< 0,045	< 0,009	< 0,012	< 0,062	< 0,039	< 0,009	< 0,006	< 11,68	**0,045**	< 0,077
0,036	< 0,020	< 0,076	< 0,016	< 0,020	< 0,105	< 0,065	< 0,016	< 0,010	< 19,61	< 0,065	< 0,129
,072	< 0,006	**0,051**	**0,050**	**0,040**	< 0,035	< 0,022	**0,007**	**0,006**	< 6,694	< 0,022	**0,123**
0,038	< 0,021	< 0,080	< 0,017	< 0,021	< 0,111	< 0,069	< 0,017	< 0,011	< 20,78	< 0,068	< 0,137
,063	< 0,010	< 0,041	**0,035**	**0,038**	< 0,057	< 0,035	**0,009**	< 0,005	< 10,73	< 0,035	< 0,071
,048	< 0,011	**0,115**	**0,045**	**0,036**	< 0,060	< 0,037	**0,011**	< 0,006	< 11,34	< 0,037	< 0,075
0,036	< 0,020	< 0,076	< 0,016	< 0,020	< 0,106	< 0,066	< 0,016	< 0,010	< 19,74	< 0,065	< 0,130
,064	< 0,006	< 0,024	**0,058**	**0,038**	< 0,033	< 0,020	**0,023**	**0,008**	< 6,269	< 0,020	**0,061**
0,036	< 0,020	< 0,078	< 0,016	< 0,021	< 0,108	< 0,067	< 0,016	< 0,011	< 20,15	< 0,066	< 0,133
,067	**0,056**	< 0,049	< 0,010	**0,070**	**0,161**	< 0,042	< 0,143	< 0,006	< 12,68	**0,330**	**0,157**
,092	**0,021**	< 0,058	< 0,012	**0,022**	< 0,081	< 0,050	**0,015**	< 0,008	< 15,19	**0,052**	< 0,100
0,036	**0,021**	< 0,076	< 0,016	< 0,020	< 0,105	< 0,065	< 0,016	< 0,010	< 19,66	< 0,065	< 0,130
,040	< 0,012	< 0,045	< 0,009	< 0,012	< 0,063	< 0,039	< 0,009	< 0,006	< 11,75	< 0,039	< 0,077
,061	< 0,013	< 0,050	< 0,010	< 0,013	< 0,070	< 0,043	< 0,010	< 0,007	< 13,07	**0,055**	< 0,086
0,022	< 0,012	< 0,047	< 0,009	< 0,012	< 0,065	< 0,040	< 0,010	< 0,006	< 12,18	**0,067**	< 0,080
,090	< 0,020	**0,305**	**0,021**	**0,029**	< 0,109	< 0,068	< 0,016	< 0,011	< 20,35	< 0,067	< 0,134
0,024	< 0,013	< 0,052	< 0,011	< 0,014	< 0,072	< 0,045	< 0,011	< 0,007	< 13,52	< 0,044	< 0,089
,194	**0,046**	< 0,053	**0,020**	< 0,014	< 0,073	< 0,045	**0,024**	< 0,007	< 13,71	< 0,045	< 0,090
0,024	< 0,013	< 0,052	< 0,011	< 0,014	< 0,072	< 0,044	< 0,011	< 0,007	< 13,43	< 0,044	< 0,088
0,018	< 0,010	< 0,039	< 0,008	< 0,010	< 0,054	< 0,034	< 0,008	< 0,005	< 10,23	**0,038**	< 0,067

2

Table 2 results PFC in water samples from Greenpeace expedtions into remote areas

Country	Sample type	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
Russia Altay Mountains	water	**0,605**	< 0,034	< 0,025	**0,174**	**0,173**	**0,151**	**0,039**	**0,037**	< 0,01
	field blank	< 0,495	< 0,065	< 0,049	< 0,026	**0,170**	< 0,082	< 0,026	< 0,035	< 0,01
China Haba Snow Mountains	water	< 0,233	< 0,030	< 0,023	< 0,012	< 0,046	< 0,038	< 0,012	< 0,016	< 0,00
	field blank	< 0,526	**0,732**	**0,062**	**0,179**	**0,338**	< 0,087	**0,030**	< 0,037	< 0,02
Slovakia High Tatras	water	< 0,521	**0,216**	**0,083**	**0,137**	**0,191**	**0,117**	**0,047**	**0,051**	< 0,02
	water	< 0,526	**0,121**	**0,087**	**0,096**	**0,190**	**0,118**	**0,048**	**0,052**	**0,024**
	field blank	< 0,526	< 0,069	< 0,052	< 0,027	**0,470**	< 0,087	< 0,028	< 0,037	< 0,02
Switzerland Alps/Lake Macun	water	**0,773**	< 0,062	**0,156**	**0,326**	**0,561**	**0,233**	**0,051**	< 0,033	< 0,01
	water	< 0,481	< 0,063	**0,127**	**0,225**	**0,355**	**0,140**	**0,048**	< 0,034	< 0,01
	field blank	< 0,477	< 0,062	< 0,047	< 0,025	**0,248**	< 0,079	< 0,025	< 0,034	< 0,01
Chile Patagonia Torres del Paine	water	**1,118**	< 0,038	**0,038**	**0,025**	< 0,057	< 0,048	< 0,015	< 0,020	< 0,01
	field blank	< 0,538	< 0,070	< 0,053	< 0,028	< 0,106	< 0,089	< 0,028	< 0,038	< 0,02
Italy Appeninnes Lago di Pilato	water	< 0,468	< 0,061	< 0,046	**0,084**	< 0,092	< 0,078	**0,035**	< 0,033	< 0,01
	field blank	< 0,532	< 0,069	< 0,052	< 0,028	< 0,105	< 0,088	< 0,028	< 0,038	< 0,02
Turkey Kaçkar Mountains	water	< 0,495	< 0,065	**0,070**	**0,100**	**0,113**	< 0,082	**0,041**	< 0,035	< 0,01

	(PFTrA	PFTA	PFBS	PFHxS	PFHpS	PFOS	PFDeS	H4PFOS	8:2 FTS	PFOSA
0	< 0,039	< 0,008	< 0,010	< 0,054	< 0,034	**0,010**	< 0,005	< 10,17	< 0,033	< 0,067
9	< 0,075	< 0,015	< 0,020	< 0,104	< 0,064	< 0,015	< 0,010	< 19,36	< 0,064	< 0,128
9	< 0,035	< 0,007	< 0,009	< 0,048	< 0,030	< 0,007	< 0,004	< 9,100	< 0,030	< 0,060
1	< 0,079	< 0,016	< 0,021	< 0,110	< 0,068	0,020	< 0,011	< 20,57	< 0,068	< 0,136
0	< 0,078	< 0,016	< 0,021	< 0,109	< 0,068	**0,030**	< 0,011	< 20,35	< 0,067	< 0,134
4	< 0,079	**0,021**	< 0,021	< 0,110	< 0,068	< 0,016	< 0,011	< 20,57	< 0,068	< 0,136
1	< 0,079	< 0,016	< 0,021	< 0,110	<0,068	< 0,016	< 0,011	< 20,57	< 0,068	< 0, 136
8	< 0,071	< 0,015	**0,075**	< 0,099	< 0,061	**0,089**	< 0,010	< 18,45	< 0,061	< 0,122
9	< 0,072	< 0,015	**0,056**	< 0,101	< 0,062	**0,053**	< 0,010	< 18,80	< 0,062	< 0,124
9	< 0,072	< 0,015	< 0,019	< 0,100	< 0,062	< 0,015	< 0,010	< 18,62	< 0,061	< 0,123
1	< 0,044	< 0,009	< 0,012	< 0,061	< 0,038	< 0,009	< 0,006	< 11,41	< 0,037	< 0,075
1	< 0,081	< 0,017	< 0,022	< 0,112	< 0,070	< 0,017	< 0,011	< 21,00	< 0,069	< 0,139
8	< 0,070	< 0,014	**0,031**	< 0,098	< 0,061	< 0,015	< 0,009	< 18,28	< 0,060	< 0,120
1	< 0,080	< 0,017	< 0,021	< 0,111	< 0,069	< 0,017	< 0,011	< 20,78	< 0,068	< 0,137
9	< 0,075	< 0,015	**0,034**	< 0,104	< 0,064	< 0,015	< 0,010	< 19,36	< 0,064	< 0,128