

Chemical footprints in the snow – persistent and hazardous PFCs in remote mountain regions

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 adventurers¹ 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 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.² Greenpeace now wants to raise awareness among outdoor enthusiasts and the wider public with this unique, globally organized study tour.



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 See box 3, Footprints in the snow

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 and durable. Once released into the environment they break down very slowly; they remain in the environment for several hundred years and are dispersed over the entire globe. These pollutants are found in secluded mountain lakes, they accumulate in the livers of polar bears in the Arctic and also in human blood. 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 factories³ and in fish for consumption in China⁴. In other studies PFCs were even detected in drinking water.⁵ In reports from 2012 and 2013,^{6,7,8} Greenpeace found that PFCs are routinely present in outdoor clothing and shoes and showed that they can evaporate from these products into the air or be washed out.

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. Samples from all sites also contained so-called short chain PFCs⁹ - advertised by the industry as harmless and increasingly used by the outdoor industry instead of long chain PFCs. PFCs were found not only in snow but also in water samples collected from high mountain lakes in the visited areas.

³ **Greenpeace (2011).** Investigation of hazardous chemical discharges from two textile-manufacturing facilities in China http://www.greenpeace.to/greenpeace/wp-content/uploads/2011/07/Textilemanufacture_China.pdf

⁴ **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/>

⁵ **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

⁶ **Greenpeace e.V. (2012).** Chemistry for any weather, Greenpeace tests outdoor clothes for perfluorinated toxins, Manfred Santen, Ulrike Kallee, October 2012;
<http://www.greenpeace.org/romania/Global/romania/detox/Chemistry%20for%20any%20weather.pdf>

⁷ **Greenpeace e.V. (2013).** Chemistry for any weather, Part II, Executive Summary, Outdoor Report 2013, Manfred Santen, Ulrike Kallee, December 2013;
http://m.greenpeace.org/italy/Global/italy/report/2013/toxics/ExecSummary_Greenpeace%20Outdoor%20Report%202013_1.pdf

⁸ **Greenpeace e.V. (2014).** A red card for sportswear brands, Greenpeace tests shoes in the prerun of World Champion Ship, Madeleine Cobbing, Kirsten Brodde, May 2014,
<http://www.greenpeace.org/international/Global/international/publications/toxics/2014/Detox-Football-Report.pdf>

⁹ Short-chain PFC are chemical compounds with less than seven carbon atoms in the molecule chain, such as PFBA (C4) oder PFPeA (C5). Long-chain PFCs are compounds with seven and more carbon atoms in the molecule chain, eg. PFHpA (C7), PFOS und PFOA (C8) or PFDoA (C12).

Box 1 PFCs in remote areas

The long range transport of some PFCs to remote areas has been studied scientifically for several years. Particularly toxic PFCs such as the long chained perfluorinated alkyl acid PFOA or sulfonate PFOS are commonly found in snow and water¹⁰. Studies discuss three possible ways that PFCs are distributed in the environment.¹¹ 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.

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 production, transport, storage and use. They are present in wastewater from factories but also from domestic washing machines; not all PFCs can be filtered out in sewage treatment plants. Some PFCs can evaporate during production and to a lesser extent from the finished products. When products containing PFCs are disposed of, they could be released into the air when incinerated or end up in fly or bottom ash; they also can enter into groundwater and surface water when they are landfilled.

Per- and polyfluorinated chemicals (PFCs) are hazardous substances. They do not occur naturally, they degrade in nature very slowly, they are found in the most remote regions of the world in snow, water and soil, and some of these substances may cause cancer, reproductive harm or act as mutagens. They have been used without hesitation for 60 years and are found in many consumer and industrial products. Particularly dangerous are the toxic long-chain or C8 PFCs such as PFOA and PFOS. Although these two substances are now being taken out of production – as a result of increasing regulation - scientists predict that the concentrations of these substances will continue to rise beyond 2030.¹² On the one hand this is due to their durability and persistence leading to high concentrations building up in the environment, 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 its use of PFCs resulting in their elimination from production. This demand is supported by many scientists; more than 200 scientists

¹⁰ See for example: **Cai M, Yang H, Xie U, Zhao Z, Wang F, Lu Z, Sturm R, Ebinghaus R (2012)**. Per- and polyfluoroalkyl substances in snow, lake, surface runoff water and coastal seawater in Fildes Peninsula, King George Island, Antarctica J. Hazard. Mater. 209–210: 335–342.

also see chapter 2.1 PFCs – global travellers

¹¹ **Gawor A, Shunthirasingham C, Hayward SJ, Lei YD, Gouin T, Mmereki BT, Masamba W, Ruepert, Castillo LE, Shoeib M, Lee SC & Harner T, Wania F (2014)**. Neutral polyfluoroalkyl substances in the global Atmosphere. Environ. Sci.: Processes Impacts, 2014, 16, 404

¹² **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

from 38 countries signed the 'Madrid statement',¹³ which calls for the elimination of PFCs from the production of all consumer products, including textiles, in line with the precautionary principle.

1.2 The expeditions

Greenpeace organized these expeditions to 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 water and snow 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 the least likely to be influenced by such local sources of PFCs.

The teams collected snow and water samples from the following locations.

Country	Location	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	5053m	27°19'38.16" 100°6'24.00"	yes	5053m	27°20'57.19' 100°04'117.38"	Not analysable ¹⁴
Russia	Altai Republic, Siberia	08.06.2015	1778m	49°92'4450" 85°88'4698"	yes	1778m	49°92'4450" 85°88'4698"	yes
Italy	Lake of Pilato, Monti Sibillini, Umbria	28.05.2015	1943m	42°49'33" 13°15'56"	yes	1943m	42°49'33" 13°15'56"	yes
Switzerland	Lakes of Macun, Swiss National Park	19.06.2015	2641m	46°43'717" 10°07'549"	yes	2636m	46°43'729" 10°07'546"	yes
Slovakia	Žabia Bielowodská dolina, High	26.05.2015	1722m	49°11'73.2" 20°05'560"	yes	1700m	49°11'73.2" 20°05'560"	yes

¹³ **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>

¹⁴ PFC concentration in reference (field blank) is higher than in the sample

	Tatras, Carpathian Mountains							
Sweden	Kiruna, Övre Soppero	02.06.2015	511m	68°15'30.6" 22°01'55.9"	yes	N/A	no sample	Not sampled ¹⁵
Norway	Skibotridalen, Troms fylke	03.06.2015	616m	69°11'54.5" 20°32'01.0"	yes	N/A	no sample	Not sampled ¹⁵
Finland	Kilpisjärvi, Enontekiö	04.06.2015	742m	69°04'17.8" 20°41'28.5"	yes	N/A	no sample	Not sampled ¹⁵
Chile	Torres del Paine Nationalpark, Patagonia	10.06.2015	900m	-50°94'2886" -72°95'0042"	yes	900m	- 50°94'2882" - 72°95'0424"	yes
Turkey	Rize- Çamlıhemşin and Erzurum Moryayla- Yedigöller, Kaçkar Mountains	13.06.2015	3100- 3120m	40°45'27" 40°50'29"	Yes, but no field blank	2980m	40°45'60" 40°50'40"	Yes, but no field blank

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 across the globe and that contamination of these remote locations has occurred even as recently as the winter of 2015. PFCs do not occur in nature 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.

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, 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 PFCs PFNA (C9-PFC), with values between the limit of quantification and 0.755ng/l, and PFHpA (C7-PFC) which was detectable in significant concentrations of up to 0.319 ng/l in the snow.

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

Short-chain PFCs such as the fluorosulfonic PFBS (C4) are apparent in the snow samples from Treriksroset in Scandinavia (Norway, Finland, Sweden). The short-chain PFCs found in the samples

¹⁵ No remote lake in that area

from the expeditions to the Alps, the Appennines and the High Tatras were dominated by PFHxA, with concentrations of 0.087ng/l, 0.120ng/l and 0.161ng/l.

The levels found in our samples are comparable to other studies which analysed surface snow in the Tibetan mountains¹⁶ and Antarctica¹⁷

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 C4, C5 and C6 compounds are particularly clearly demonstrated with concentrations of up to 1.1ng/l.

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\$ 25billion in 2012,¹⁸

While PFCs are used in many industrial processes and consumer products, the outdoor industry uses PFCs in large quantities. It is also aware of the inherent contradiction of this practice and is worried about its 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), including PFOA and PFOS and replacing them with short-chain C4 to C6 PFCs. However, these chemicals are also persistent and may exacerbate the problem of PFC pollution; they need to be used in larger quantities to achieve comparable performance. They are also particularly volatile and therefore 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, it has side-stepped the repeated warnings from Greenpeace's Detox campaign and neglected the need to replace all PFC chemicals used as waterproofing in membranes and coatings.

The global spread of toxic 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.

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 Mammüt have shown little

¹⁶Wang et.al (2014). op.cit.

¹⁷Cai et. Al (2012). op.cit.

¹⁸VF 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>

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.

1.5 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 they are transformed into more dangerous and persistent PFCs, which will contaminate the environment for hundreds of 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 platform¹⁹ 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 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 short chain or volatile substitutes to transform into persistent PFCs, it is no longer enough to only regulate individual substances like PFOA and PFOS. Greenpeace calls on policy makers to fully implement the Precautionary Principle²⁰ by restricting the entire group of PFCs.

¹⁹ IPE – Chinese Institute for Environmental Affairs; which is the only credible global chemical discharge disclosure platform

²⁰ 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

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, leaving us with decades of pollution to deal with. The outdoor industry and the politicians need to hear your voices, to urge them to take action on the elimination of ALL PFCs.