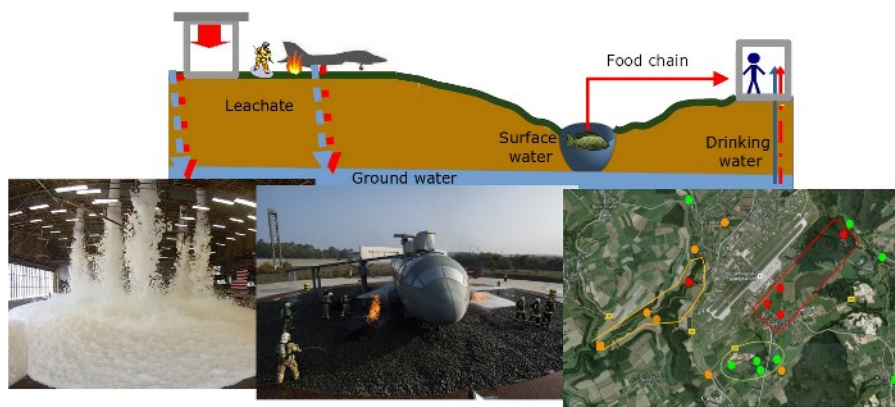


PFAS: A Time Bomb Underground

The military as the main responsible party
for a global environmental disaster

Karl-Heinz Peil



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Content

Introduction.....	4
1. PFAS: A short overview.....	6
1.1 Properties and toxic effects.....	6
1.2 Determination of limit values.....	7
1.3 Timeline.....	9
2. Use of PFAS for extinguishing foams (AFFF).....	14
3. Documented environmental impacts by AFFF.....	19
3.1 Civilian airports.....	19
3.2 Military bases in the USA.....	20
3.3 US-Military bases in Japan.....	21
3.4 US-Military bases in Germany.....	24
3.5 German Armed Forces Airbases.....	30
4. Environmental authorities and the military.....	31
4.1 The situation in the USA.....	31
4.2 Environmental protection on US bases abroad.....	33
4.3 Remarks on German Environmental Authorities.....	35
5. Consequences from a scientific viewpoint.....	38
6. Informing the public.....	42
6.1 PFAS general treatment.....	42
6.2 PFAS exposures with military cause.....	43
7. Conclusions.....	47
Appendix.....	49

Introduction

The contamination of drinking water, the food chain, and ultimately human health as it relates to chemicals has long been a topic of discussion. For several years now, the focus has been increasingly on a special group of substances, which is currently still circulating under several abbreviations. In the following text, the term PFAS (per- and polyfluoroalkyl substances) is used, as it has been used in technical literature for a significant period of time and has more recently been adopted by official authorities.¹

Although PFAS are a substance group used globally in a wide variety of ways, its environmental impact is primarily caused by PFAS-containing extinguishing foams at military airfields. However, the question of whether the military is the main cause of one of the biggest global environmental problems must be answered in a differentiated way.

As with other environmental problems, the authorities, environmental organizations and politicians give priority to what can be described as the 'tip of the iceberg.' For PFAS, this applies to the decades of excessive use in firefighting foams by the (US) military. The present analysis is less concerned with the detailed description of these environmental and health damages than with the options for action to eliminate contaminated sites.

While it is difficult to assess the relevance of the toxic effects of PFAS in civil applications, this does not apply to military-caused contaminated sites. Here it can be clearly shown that despite scientifically justified urgency at the political level, the real pressure to act is not yet perceived.

The infiltration of PFAS from extinguishing foams into the ground is above all a time bomb underground; only through continuous inactivity does a locally caused environmental problem become a regional and ultimately global catastrophe for human health.

¹ *In some countries, however, the abbreviation PFC (per- and polyfluorinated chemicals) is still predominantly used. An outdated and incorrect abbreviation PFT (per- and polyfluorinated surfactants) also exists. The abbreviation PFC was also previously used in connection with greenhouse gases, but this represents a completely different problem and can lead to confusion in the present context.*

The military must clearly be seen as the main obstacle here. There are two likely motives for this:

First: To openly address the civil security risk ostensibly created in the name of military security would call into question the legitimacy of the military apparatus. This would lead to a general perception of what has always been present in the peace movement as an exaggerated statement: the military kills even without war.

Secondly: The removal of the military-induced environmental legacy induces enormous costs, which must be understood in relation to the annual budgets for military expenditures. In other words: PFAS are an example of the fact that military expenditures can result in enormous follow-up costs of eliminating environmental damage, even without war.

PFAS pollution must also be seen in conjunction with other military-induced environmental burdens, which are also present today as ticking time bombs:

Worldwide, thousands of shipwrecks are rotting on the seabed, sunk mainly in the Second World War and still have more or less large quantities of toxic heavy oil in their rusting tanks.

In 1945, vast quantities of German *Wehrmacht* ammunition were dumped in the North and Baltic Seas, which will be washed to the surface in the coming years and decades.

In the South Pacific, U.S. nuclear waste from hundreds of nuclear weapons tests is stored in bunkers on the Marshall Islands, whose concrete covers may leak in the foreseeable future and contaminate the entire Pacific Ocean with plutonium.

In contrast, PFAS are a problem that – while certainly caused primarily by civilian applications – also offers opportunities for the necessary social movement pressure to avoid further future disasters by focusing on the military as the largest single contributor.

1. PFAS: A short overview

1.1 Properties and toxic effects

There is no other group of substances of practical importance that has such a high chemical stability as PFAS, which is why it occurs in large quantities in everyday products and is released into the environment after use. Chemically, PFAS are organic compounds, i.e. a hydrocarbon with smaller (short-chain) and larger (long-chain) molecules. In the chain of carbon and hydrogen atoms, the latter are mainly (polyfluorinated) or completely (perfluorinated) replaced by fluorine atoms.

Their versatile use is due to their unique properties: In addition to their surface activity (water and grease repellent at the same time), they have an extremely long life (persistence) due to their chemical structure and high thermal and chemical stability.² Environmental agencies assume that more than 4,700 individual substances of this substance group are now in circulation, which is a result of the large number of applications.

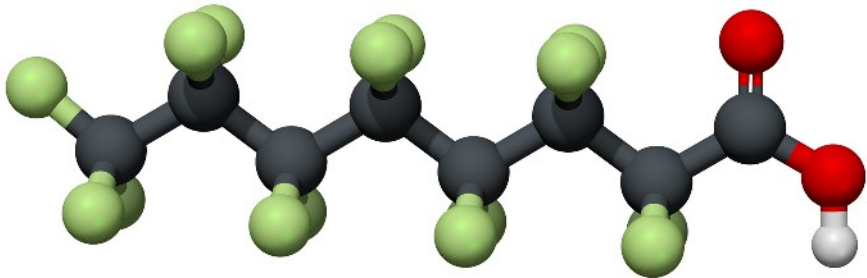


Figure 1: The molecular structure of PFAS consists of carbon atoms (dark grey), with bound fluorine atoms. Depending on their number, a distinction is made between short- and long-chain PFAS, which differ in terms of water solubility, which is important for remediation measures. A functional group is shown at the end right. For example, the substance name perfluorooctane sulphononic acid (PFOS) indicates that the perfluorinated chemical compound contains eight carbon atoms (octane), which is why this substance is also known as C-8. The additional functional group results in the designation "... sulphononic acid". Source: www.militarypoisons.org

² <https://www.umweltbundesamt.at/angebot/analysen/schadstoffe/pfas>

There is now no scientific controversy: PFAS can damage the liver and kidneys, raise cholesterol levels and blood pressure, trigger thyroid disease and immune deficiency. They have been linked to various types of cancer and can harm the foetus in the womb.

The variety of sources means that PFAS accumulate in the human body. In particular, they enter the groundwater and the human food chain via the soil. Consumer products treated with PFAS can also be absorbed directly into the body, although not in large quantities.

The distinction between short- and long-chain PFAS is essential for long-term toxic effects. Short-chain PFAS are excreted more quickly by the human or mammalian organism than those with longer carbon chains. Although short-chain PFAS are less likely to accumulate in the body, they are also more difficult to remove in filtration systems used to clean up contaminated water. For the two most important pollutants, PFOS and PFOA, it is true that these are already counted as "C-8" substances among the long-chain ones, but they are difficult to separate in filtration systems.

The concentration on these two pollutants does not mean that other PFAS substances are any less harmful. However, only the toxic effects of PFOS and PFOA, as the most common PFAS substances (at least in the past), have been studied thoroughly. In the USA, for example, the "Union of Concerned Scientists" recommends banning all PFAS substances in a Fact Sheet³ prepared in 2018.

A residue-free disposal of PFAS in contaminated soil material is only possible at combustion temperatures of 1,100°C. As conventional waste burning plants work with temperatures below 900°C, a complex special thermal treatment is necessary. However, the soil material loses its biological function and can then only be used as filling material. At normal burning temperatures, there is also the danger that long-chain PFAS are only broken down into short-chain PFAS. However, as these dissolve more easily in water, biological cleaning processes with activated carbon are therefore do not have any major effect.

1.2 Determination of limit values

Chemical analysis can only detect those substances that are specifically sought. For this reason, and due to the large number of individual substances, PFAS can only be detected to a limited extent with reasonable

³ <https://www.ucsusa.org/sites/default/files/attach/2018/09/a-toxic-threat-pfs-military-fact-sheet-ucs-2018.pdf>

analytical effort. However, the focus here is primarily on two individual substances which are currently defined as key parameters: perfluorooctane sulphonic acid (PFOS) and perfluorooctanoic acid (PFOA). Other PFAS, the number of which has been gradually increased in recent years to 20 individual substances, are currently listed as the "sum of PFAS" in the draft EU Drinking Water Directive (2020).

In the case of local soil contamination, the necessary analyses are very time-consuming because of the proportionally low volume of PFAS there. For the health assessment, the enrichment (bioaccumulation) in human organs via the food chain is ultimately decisive.

At this point, however, only the PFAS concentration in groundwater and surface water is to be treated in a simplified manner. To this end, a distinction must be made between several terms that are generally used by health and environmental authorities when assessing individual toxic substances. In most cases there is talk of limit values, which are regarded as "hard" limits of what is permissible on the basis of scientific studies, but this does not necessarily mean that falling below or complying with them is actually harmless to health. A limit value is usually defined as a threshold value for planned countermeasures. This term is not applicable to PFAS exposures because of the large number of substances in this group and the need to limit them to a (constantly increasing) number of "lead substances".

Because of this inadequacy, one also speaks of guide values as a yardstick for what results from so-called background pollution and must therefore be tolerated. The Federal Environment Agency in Germany (UBA) wrote in February 2020:

*"For the two lead substances PFOA/PFOS, many new studies have been published in recent years on possible health effects on humans and environmental fate. As a result, it is hardly possible to translate the latest scientific findings into toxicologically based guideline values."*⁴

The UBA uses the term "health orientation value" in reference to international organisations such as the WHO. This takes into account the accumulation of a substance in the human organism depending on the duration or frequency of the individual exposure and the cumulative effects to be expected.⁵

4 <https://www.umweltbundesamt.de/senkung-der-vorsorge-massnahmenwerte-fuer-pfoapfos>

With regard to the occurrence in water, we can only point to significant excess compared to measuring points that have "normal" PFAS values, i.e. those that can be called reference values. Technically correct, this is referred to as background contamination. The following exposure values can serve as a guide (in micrograms per litre):

- Tap water and rainwater <1 – 100 µg/l
- Open Sea: > 100 µg/l
- Landfill Leakage Water: > 2.000 µg/l
- Groundwater contaminated by military bases:
> 10.000 - 100.000 µg/l

The EU Drinking Water Directive, as amended in 2020, provides for a total quantity of PFAS of 0.5 µg/l as well as 0.1 µg/l for the sum of the 20 currently and particularly relevant individual substances, of which PFOS and PFOA account for the majority.

In the USA, the federal environmental agency (EPA) has been applying a "limit value" of 0.07 µg/l.⁶ Ultimately, the decisive factor for an assessment is not the environmental authority but the health authority. The US Toxic Substances and Poison Control Regulations (ATSDR), on the other hand, have set much lower limits for PFOS. This has now been followed by several states. In the US state of Maine, the limit values for PFOS in sewage sludge are set at 5.2 µg/l for PFOS, although environmentalists believe that these values already exceed ten times the acceptable level.

1.3 Timeline

In the early 1940s, PFAS were created in the laboratory as part of the Manhattan Project for developing the atomic bomb. Here, these materials were identified as optimal for the process engineering and handling of uranium enrichment. It is therefore an irony of history that today both nuclear weapons and PFAS are considered a global threat to mankind.

The substances PFOA and PFOS conquered the consumer goods sector after World War II through products of the US chemical companies DuPont and 3M and were praised as miracle cures in Teflon or impregnation spray.

5 <https://www.umweltbundesamt.de/themen/wasser/trinkwasser/trinkwasserqualitaet/toxikologie-des-trinkwassers/gesundheitslicher-orientierungswert-gow>

6 The EPA uses the unit ppt (parts per trillion = billion). The EPA limit for PFAS in drinking water is 70 ppt (corresponding to 0.07 µg/l).

However, the first knowledge of toxic effects was already available from these companies in the 1960s and 1970s. Corresponding studies involving animal experiments and blood tests by chemical workers were, however, kept under wraps for decades. It is only in the last 20 years, however, that intensive scientific research has been carried out, leading to the ban on PFOS in the 2000s and the gradual regulation and future widespread banning of PFOA in the 2010s.

Below are listed key historical events, some of which will be discussed in more detail in the following sections.⁷

1960's:

USA: Research by DuPont involving animal testing indicates toxic effects of PFAS.

USA: On request of the US Navy, 3M develops firefighting foam with PFAS (AFFF).

1970's:

USA: DuPont finds PFAS enrichments in the blood of chemical workers.

USA: A report by the US Navy highlights ecological problems and risks of AFFF. 3M conceals findings according to a memo from the US Navy; their own studies confirming the risks remain secret.

1980's:

USA: DuPont investigates PFAS contamination in drinking water in the area surrounding its factory in West Virginia.

USA: Air Force studies on animals confirm the toxic effects of AFFF.

1991:

USA: Army Corps of Engineers recommends stopping the use of AFFF.

1997:

USA: AFFF is declared as a hazardous substance by the US Army and the US Navy.

⁷ Detailed timeline (USA) available on <https://www.ewg.org/research/pfas-chemicals-contaminate-us-military-sites>

2000:

USA: For a PFAS-damaged party in West Virginia, attorney Rob Bilott forces the release of internal DuPont documents.

USA: 3M stops the production of PFOS. The US Environmental Protection Agency (EPA) informs the Pentagon about 3M studies on health risks.

2003:

Australia: In a study which was initially kept secret, the Australian Ministry of Defence presents in detail the advantages and disadvantages of AFFF after 3M stopped producing PFOS.

2006:

Germany: In the Upper Bavarian district of Altötting, where PFOA products were manufactured by the chemical company Dyneon until 2003, PFAS exposures are determined.

Germany: PFAS contamination by fertilisers is found on arable land in the Federal State of North Rhine-Westphalia.

EU: Ban on PFOS with transitional periods until 2011.

2011:

USA: A study conducted over 7 years with 70,000 participants indicates the causality of PFAS / PFOA in severe diseases.

USA: The Pentagon addresses the risks of AFFF

Germany: In the area surrounding Spangdahlem US Air Base, authorities start PFAS monitoring of individual surface waters.

2012:

Germany: In the drinking water catchment area of the Rastatt public utility company (South-west region of Germany) extremely high PFAS contamination is identified, which was mainly spread with compost on arable land from 2006 to 2008. PFAS is detected at a depth of 60 m. Years of extensive remediation have led to increases in water prices.



Figure 2: Warning sign in the US State of Michigan for PFAS exposure

Source: www.militarypoisons.org

Germany: In the district of Pfaffenhofen, PFS contamination is found in surface water outside the Bundeswehr (German military) airfield Manching.

2015:

Germany: Determination of PFAS exposures in the Western Palatinate (Spangdahlem, Bitburg) caused by US military bases.

2017:

USA: PFOS are mentioned in the US Army's updated "Performance Specification" with reference to its intended substitution.

EU: Extensive ban of PFOA with effect from 2020 with exceptions for extinguishing foams.

2018:

Germany: A local citizens' initiative is founded due to PFAS exposure around the Bundeswehr airfield in Manching (Bavaria).

2019:

USA: Following requests from the US Environmental Protection Agency (EPA), the Pentagon sets up a task force to identify PFAS exposures at military bases.

USA: The Pentagon plans to replace extinguishing foams containing PFOA and PFOS with other AFFFs.

EU: The European Food Safety Agency (EFSA) recommends using drastically lower health-related guide values for PFOS and PFOA.

2020:

Germany: PFAS problems caused by contaminated military sites at Frankfurt Airport (former location of US Air Base) and in Wiesbaden (existing location of the US Army's European Headquarters) lead to regional debate.

Germany: Stricter recommendations of the German Federal Environment Agency (UBA) on PFAS values in drinking water.

A glance into the future:

Within the next 10 years at least increasing PFAS contaminations in groundwater are to be expected, which can only be reduced within a few decades at the earliest.

2. Use of PFAS for extinguishing foams (AFFF)

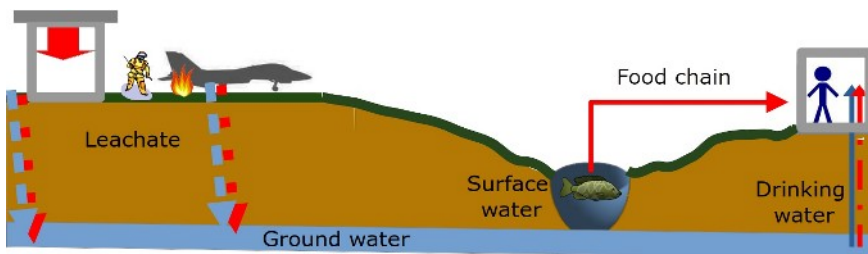


Figure 3: Sketch of exposure with, Source: own drawing

AFFF (aqueous film forming foams) have excellent extinguishing properties when fighting large area liquid fires due to their film forming properties. They are therefore added to the extinguishing water in a defined concentration and thus create large-area foam carpets which quickly extinguish the source of the fire. For decades, the most important substance here was the PFAS substance PFOS, which was, however, completely banned in 2011 in accordance with the EU regulation from 2006. The substitute substance PFOA is now also heavily regulated by the EU and may no longer be used from 2023.

PFAS-containing AFFFs were developed by 3M in the 1960s at the request of the US Navy. The accelerated demand by the US Navy is also strongly related to three major fires on US aircraft carriers in the 1960s.

The most serious occurred in 1967 during the Vietnam War on the USS Forrestal in the Gulf of Tonkin in connection with the wartime operations from this mobile military base. A misfired rocket set fire to an aircraft on the flight deck, which triggered a chain reaction. This was mainly due to the ammunition available in the immediate vicinity of the aircraft. In the end, 134 people were killed and 161 injured. In addition, 21 aircraft were destroyed and the aircraft carrier had to be repaired in its home port at great expense.

Similar accidents occurred on the USS Oriskany in 1966 (44 dead and 138 injured) and on the USS Enterprise in 1969 (28 dead and 314 injured).⁸ As a consequential measure, first in the US Navy and later in the

⁸ https://en.wikipedia.org/wiki/1967_USS_Forrestal_fire

US Air Force, mandatory and intensive firefighting training was introduced for all soldiers, including the use of special protective clothing, oxygen masks, identification of fire sources as well as permanently installed fire extinguishing systems and mobile fire extinguishing equipment.

For both mobile and stationary applications, the extinguishing water must be mixed with as much liquid concentrate as possible to form foam via a separate container.



Figure 4: This aerial photograph of the US aircraft carrier Ronald Reagan illustrates why aircraft carriers in particular, with their large number of fighter jets and their armaments in a confined space, are a fire hazard. New US fighter jets also have a unit price of around 100 million US dollars. Fires in their immediate surroundings therefore pose the risk of high material damage.

Today most military bases with airfields have fire training areas. In these areas, pits produce thousands of litres of foam per exercise. Depending on the structural engineering design, this can lead to contamination that can spread over kilometres.



*Figure 5: Fire drill of the US military at Ramstein Air Base, recorded on 11.10.2018. During the drill paraffin sinks into the ground, which is covered with a layer of gravel. This fuel is then inflamed and the floor is covered with a layer of foam. The resulting foam carpet inevitably ends up in the ground and possibly also in an existing sewage system.
Photo: www.ramstein.af.mil/News/Photos*

This results in an excessive amount of firefighting exercises, even on stationary military bases of the US Air Force.

There is no systematic record of the exact scope of these exercises. As an indication, reference can be made here to the statement made in the German radio programme *Deutschlandfunk* on 6 August 2020 about Spangdahlem US Air Base. One interviewee reported there that he used to record such exercises in the open air every other day during agricultural work in front of the fence of the air base.⁹

The AFFF deployment by the US military is not only carried out during mobile firefighting exercises in the field, but also with test runs of stationary firefighting systems in aircraft hangars where aircraft maintenance is carried out. The (empty) hangar is flooded once a year with firefighting foam to check the functionality of the system.¹⁰ A report from

⁹ http://umwelt-militaer.info/?Extraseiten/2020-08-06_DLF_Spangdahlem

¹⁰ In the YouTube Video <https://www.youtube.com/watch?v=dXGZHMkggzw> such an exercise is presented and the annual implementation is also described as necessary by a US military.

Ramstein Air Base via one of these hangars states that a quantity of 150,000 litres (150 m³) of water mixed with AFFF extinguishing foam is used per test.¹¹ However, the guidelines of FM Global, the largest US property insurer, only allow the use of test foam (for civil applications).¹²

For the use of AFFF by the US military, the "Performance Specification" MIL-PRF-24385F, first presented in 1992 and amended in 1994, applies. This specification defines the fire extinguishing properties that a manufacturer's product must meet. This includes a defined duration for extinguishing a precisely specified fire source, which requires special test procedures and corresponding proof. It was not until 2017 that a new version was presented with Amendment 2, which also explicitly refers to PFAS. Under item 6.6, only the declaration of intent is noted that a substitution of PFOA and PFOS is aimed for, but with the same "performance". Suppliers should thus be encouraged to offer substitute products. Research is being carried out, but it could take "several years" to find appropriate solutions.

The fire brigades of civil airports have been exchanging AFFF for fluorine-free extinguishing foams for some time now. One of the stragglers in this respect was the US Federal Aviation Administration (FAA), which arranged this in the USA on the basis of a law in Congress only in 2018.

The military forces of the NATO countries Norway and Denmark have also made this change. The German Armed Forces (Bundeswehr), on the other hand, still insists that AFFFs are indispensable, as can be seen from the "PFC Guidelines for Federal Real Estate".¹³ Unlike the US military, however, the Bundeswehr uses test foam for firefighting exercises, which was not the case in the past.

There are contradictory statements as to whether AFFF is still being used on US military bases in Germany today. This applies in particular to Ramstein Air Base, which will be discussed in more detail in section 4.2. It is claimed that all exercises with firefighting foam will be discontinued

11 <https://www.ramstein.af.mil/News/Article-Display/Article/726566/sprinklers-come-alive-in-hangar-five/>

Quotation from Sen. Master Sgt. Brian Eshleman: "We're doing everything we can to prevent pollution that could possibly spill into this hangar, exit the facility and enter the environment. We want to give the German community the confidence that we're doing everything we can do to ensure their landscape stays intact and healthy."

12 The Directive FM Data Sheet 2-81 (Fire Protection System Inspection) reads: „Discharge test foam-concentrate proportioning systems ..."

13 https://www.bfr-bogws.de/downloads/A-8.2_PFC-Leitfaden_Liegenschaften_des_Bundes.pdf

there as early as 2015 and that more environmentally friendly and harmless variants are now being used.¹⁴



Figure 6: Flooding a hangar with extinguishing foam.¹⁵ Original text: "PFAS appears in firefighting foam that has been routinely used on military bases nationwide" Photo: Department of Defense (DoD)

¹⁴ Regional Newspaper Rheinpfalz 16.9.2020 with the headline: „Hardly any danger from the Air Base" (Original: "Kaum Gefahr von der Air Base")

¹⁵ <https://wjla.com/news/spotlight-on-america/house-oversight-committee-grills-executives-about-pfas-forever-chemical-contamination>

3. Documented environmental impacts by AFFF

Contamination with AFFF can occur as a result of the following processes:

1. firefighting
2. firefighting exercises
3. technical faults and leakages
4. improper disposal

3.1 Civilian airports

Although fires are relatively rare in this context, they can have serious local effects. In 2014 at the Düsseldorf airport, a fire led to the use of PFOS-containing AFFF, which resulted in very costly rehabilitation measures in the catchment area of the adjacent drinking water supply, at a total cost of about EUR 100 million.¹⁶

More often, on the other hand, local environmental pollution is caused by technical defects and leaks. In 2008, a technical fault in a hangar at Amsterdam Schiphol Airport triggered the stationary extinguishing system, resulting in the emission of large quantities of PFOS. 50,000 m³ of contaminated excavated earth had to be disposed of in a complicated and costly manner during the subsequent extension of the airport with a new runway.

The fact that with these documented examples the AFFF-based PFAS emissions at civil airports are relatively low can also be attributed to the fact that their use - just like at chemical companies - is reserved for the respective plant fire brigades, which restricts the scope of firefighting exercises just as much as the fact that at civil airports there is not the fire-hazardous concentration of fighter jets with fuel supply and explosives in a very small space.

The only documented European exposure to PFAS from extensive fire drills at civil airports is from the Channel Island of Jersey, where extremely high levels of PFOS were found in wells in the 1990s, leading to very costly remediation measures in the early 2000s.

16 Study of the Nordic Council of Ministers (NCM) – see also section 5
<https://www.norden.org/en/publication/cost-inaction-1>

3.2 Military bases in the USA

In total, almost 40,000 sites in the USA are considered to be militarily contaminated by pollutants of various types and compositions. PFAS contamination by AFFF is therefore only a new chapter in a long history of extremely high pollution levels for people living in the vicinity of military bases and, in some cases, in their wider surroundings. Already in the past, military personnel, their family members and local residents were exposed to risks from toxic substances ranging from perchlorate and benzene to lead paint.

Nearly 900 military sites have been designated by the EPA as "Superfund" sites, meaning they require a high-cost clean-up due to varying levels of pollution, for which the government budget is provided.

PFAS drinking water pollution mostly affects residential areas in the immediate vicinity of military bases. Therefore the families of military personnel are particularly affected, not only those currently living there ("Affordable housing areas"), but also veterans who, after leaving service, are permanently exposed to health problems due to the bioaccumulation of PFAS.

An additional complicating factor for an analysis of existing pollution is that the USA is very fragmented in terms of housing areas, especially around military bases, and therefore the drinking water supply is provided to a much greater extent via a large number of smaller wells than is the case in Germany. Depending on the location and depth of the well bore, different layers of groundwater are tapped, which is why PFAS contamination can also vary greatly locally.

The number of PFAS-contaminated sites identified by a Pentagon task force set up in 2019 still lags considerably behind the cases documented by NGOs. In March 2020, it was admitted that 651 sites were contaminated, after the Pentagon had identified 401 sites in August 2017.¹⁷ Finally, the Pentagon increased their number to 704 in September 2020.

According to a new study, the Environmental Working Group (EWG) in the USA points out that more than 200 million Americans have PFAS-contaminated drinking water, i.e. with concentrations exceeding the marginal value. The EWG points out that the most and highest levels of PFAS contamination are found at or near military bases.¹⁸

¹⁷ <https://www.militarypoisons.org/pfas-task-force.html>

¹⁸ <https://www.ewg.org/release/update-toxic-forever-chemicals-likely-contaminate-more-700-military-sites>

PFAS risks to military communities remain high, largely due to the continued use of PFAS-containing firefighting foam by the military. Although the US military has replaced older AFFFs (containing PFOS) with other PFAS, it is not yet clear to what extent this will actually reduce environmental and health impacts. Of course, this does not change the problem of contaminated sites.

The Pentagon Says More Than 400 Military Sites Could Be Contaminated With PFAS Chemicals

Branch of service	Total sites with known or suspected release of PFOS/PFOA (as of 8/31/17)	Sites sampled where results exceeded EPA health guideline (as of 8/31/17)	Groundwater wells sampled	Groundwater wells that tested above the EPA guideline
Army	64	9	258	104
Navy/Marine Corps	127	40	1,368	784
Air Force	203	39	1,022	719
Defense Logistics Agency	7	2	20	14
Total	401	90	2,668	1,621

Source: *Department of Defense PowerPoint, March 2018*

Figure 7: PFAS exposure from military sites in the USA, Status as of 2018

Source: www.ewg.org (see also section 6)

3.3 US-Military bases in Japan

There are 78 US military properties in Japan, 21 of them in Okinawa alone. These are staffed by more than 35,000 military personnel and service providers. The Marine Corps Air Station Futenma and Kadena Air Base are considered the two largest US military facilities in the Far East and Pacific.

Environmental problems with contamination of drinking water by US military bases have been documented since the 1950s. The spectrum ranges from fuel leaks to nuclear radiation exposure from nuclear submarines. In addition, available data show that the local population in Okinawa has been exposed to PFAS for more than four decades.

PFAS Contamination in/around Kadena Air Base

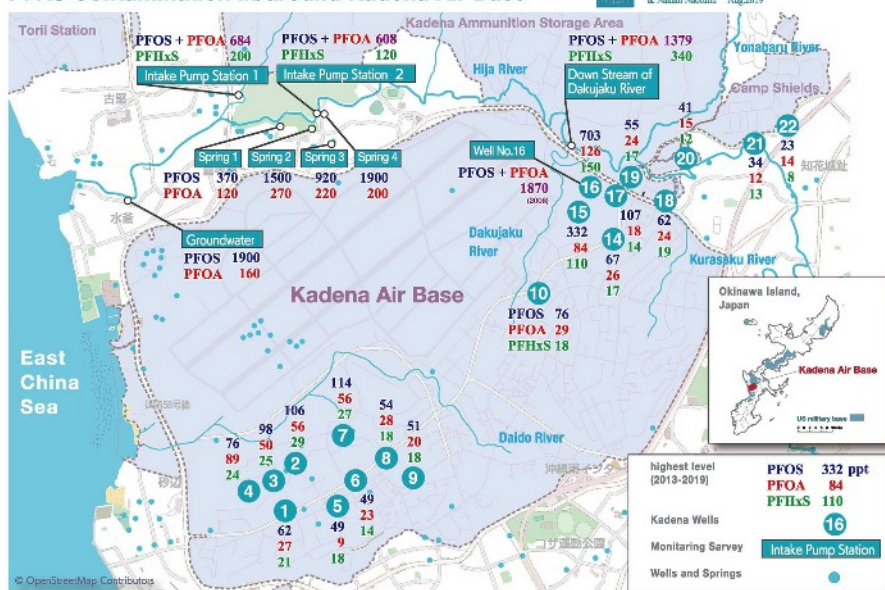


Figure 8: PFAS-contamination at the Kadena Air Base in Okinawa

Source: Infomod-Public Project, Okinawa, August 2019, Picture: truthout.org
100 ppt corresponds 1 µg/l (see section 1.2: EPA-threshold value is 70 ppt)

Internal documents of the US Air Force in Japan, which were issued later, show that the risks of PFAS application at Kadena Air Base had been known since 1992. Numerous accidents involving contamination that were not reported to the Japanese authorities have been documented from this site.¹⁹

However, due to the largest drinking water utility on the main island of Okinawa, PFAS contamination from wells in the vicinity of Kadena Air Base was first identified in 2008. However, this did not come into public awareness until 2016, after the prefecture had also identified PFAS contamination in the surrounding rivers. At the same time, the focus was directed to the PFAS contamination of fish from these rivers, which in some cases was 1000 times higher than the average contamination in Japan. This also marked the start of extensive investigations at other US sites, in groundwater, streams and farmland. However, the US Air Force

¹⁹ Jon Mitchell, *Poisoning the Pacific* (October 2020)

has not commented on the high PFAS loads determined in these investigations (as of August 2020) despite requests from the prefecture.

In addition to the PFAS pollution caused by firefighting drills, major accidents have been documented in Okinawa, where large quantities of firefighting foam were directed directly into surrounding rivers and were carried up into the air to a relevant extent.

Finally, there are other significant contaminations due to improper disposal. Documents released in 2019 in accordance with the Freedom of Information Act (see also section 6.2) show that in the period 2014 to 2015, 142 tons of AFFF concentrate were disposed of in a "normal" land-fill site by an external contractor, who had no information about the AFFF content.

The scale of smaller and larger environmental disasters, particularly on Okinawa, must also be seen in the context of the US military's freedom under the Status of Forces Agreement, which is discussed in section 4.2. This has led to the fact that, on the one hand, an investigation of the PFAS burden by the US military was agreed upon in Germany (e.g. in Ansbach-Katterbach, Bavaria) in 2016, but not in Okinawa.²⁰

For the sake of completeness, it should be noted that the PFAS burden of AFFF in Japan also exists among Japan's "self-defence forces", which also own large quantities of AFFF and announced in February 2020 that they would replace them. However, this is being done in the same way as for the US military – by replacing PFOS and PFOA with other PFAS substances.

***PFAS contamination of water supply
from the 1970s onwards:***

Yokota Air Base, Japan: 11,500 service members and dependents
Okinawa: >450,000 civilians; tens of thousands of service
members, and tourists

*Source: Jon Mitchell, Poisoning the Pacific;
(Table 9.1: Estimated Human Impact of Military Contamination in Japan ,
Okinawa and the Micronesia Region)*

²⁰ Jon Mitchell (indicated above)

3.4 US-Military bases in Germany

Numerous US military sites in Germany have been closed in recent decades and the remaining troops have been concentrated in a few locations, mainly in the Kaiserslautern area. This has also resulted in numerous conversion areas. Practically all former and current US military airfields are contaminated with PFAS. This applies in particular to the Federal state Rhineland-Palatinate. According to the response of the state government to a parliamentary request from 2018, the following sites are affected:²¹

- Ramstein Air Base
- US-NATO airfield Spangdahlem
- former US-NATO airfield Bitburg (US Air Force until 1994)
- former NATO airfield Hahn (US Air Force until 1993)
- Airfield Sembach (US Air Force until 1995)
- Airfield Zweibrücken (US Air Force until 1991)
- Airfield Mainz-Finthen (US Army until 1992)
- Airfield Büchel (German armed forces "Bundeswehr")

Spangdahlem Air Base and Bitburg conversion space

The largest PFAS contamination in the surroundings of a US airfield is likely found at Spangdahlem airfield. Environmental monitoring of the water management authorities for pollutants has been carried out there since 2000, after soil contamination, e.g. with mineral oils, had been detected in the mid-1990s in the course of construction measures (which, in terms of planning and costs, are assumed by German authorities in accordance with NATO troop statutes). This led to the establishment of about 80 measuring points on the air base and 20 further measuring points at the surface waters outside the air base. Since 2011, PFAS have also been specifically monitored on these sites. The regional environmental authority (SGD) is responsible for this.²²

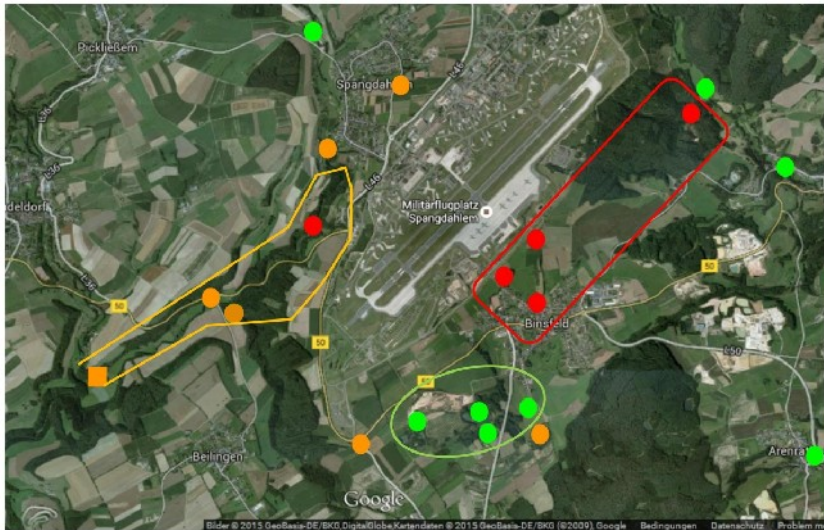
The sewage treatment plant near the US Air Base Spangdahlem in the Palatinate is also contaminated. In the area of the local municipality of Wittlich-Land, it is therefore no longer possible to spread sewage sludge on agricultural land. The municipality has the sewage sludge incinerated,

21 *Printed matter (Drucksache) 17/6329 of Landtag Rheinland-Pfalz (available online)*

22 <https://sgdnord.rlp.de/de/wasser-abfall-boden/wasserwirtschaft/gewaesserschutz/gewaesserguete/pft-belastungen/flugplatz-spangdahlem/>

which causes enormous additional costs and other environmental damage.

The associated municipality is therefore bringing an action against the Federal Government, represented by the “*Bundesanstalt für Immobilienaufgaben*” (BImA – Federal Authority for Property Tasks) as landlord of the US military bases, before the Regional Court of Trier. Although the BImA authority had agreed at an earlier stage to settle claims for damages amounting to 460,000 Euros, it then rejected further claims by the municipality.²³



PFT-Werte: grün = gering; orange = mittel; rot = hoch (<http://sgdnord.rlp.de/>) <https://www.google.de/maps/@49.9718418,6.6843993,5490m/data=!3m1!1e3> 14/20
Dr. Friederike Kremb-Wagner (16.10.2015)

Figure 9: Contamination in the surroundings of the air base Spangdahlem

A similar contamination of ground and surface water exists on the conversion area of the former US airport Bitburg. In addition, 80,000 m³ of PFAS-contaminated excavated soil is currently located there, the whereabouts of which have not yet been clarified. This also calls into question the conversion of the site into an industrial estate, as desired by the municipality of Bitburg.

²³ https://www.volksfreund.de/region/streit-um-giftstoffe-von-der-airbase-spangdahlem-landet-vor-gericht_aid-36504663

Ramstein Air Base



Among many other functions, Ramstein Air Base is also used as an international training centre for firefighting exercises. In 2010, a corresponding training area was constructed there for this purpose. It is managed by the 435th Construction and Training Squadron, which is responsible for construction measures as well as firefighting training. In addition to the continuous firefighting exercises, military personnel from other NATO states are therefore regularly invited to Ramstein for appropriate training.

Figure 10: Logo of the unit responsible for firefighting exercises in Ramstein
Source: www.ramstein.af

The annual "Drinking Water Quality Report of the air base administration" ²⁴ refers to the excellent water quality at the air base. With regard to PFOA and PFOS, the 2016 edition - but not the more recent reports - notes in a footnote that these substances occur "in everyday life". Only in the postscript does it say: "PFOS/PFOA were also present in Aircraft Firefighting Foam used extensively by the AF". However, the values at Ramstein Air Base are well below the EPA guideline values.²⁵ The commentary on PFOS/PFOA in 2016 can be understood due to the debate on the investigation of PFAS contamination that was fuelled in the USA at the time. However, as noted in the report, since 2007, the drinking water supply at the air base has been provided by the municipal utilities of Kaiserslautern. Several drinking water wells on the air base itself had to be closed due to high pollution levels. In order to prevent these from entering the adjacent drinking water protection area, a permanently operated pumping system is used to create a dynamic watershed. The existing total pollutant load, including mineral oils, is reduced by filter sys-

²⁴ <https://www.ramstein.af.mil/Portals/6/Ramstein%20Consumer%20Confidence%20Report%202019.pdf>

²⁵ Quotation: „The results for Ramstein were well below the EPA’s lifetime health advisory.“

tems with activated carbon in the internal water circulation, but PFOA/ PFOS remain as a permanent load because of the minimal separation in filter systems and can only be limited locally by the permanent operation of the technical water circulation.

Conversion area Sembach airfield

The former Sembach airfield in the district of Kaiserslautern was used by the US Air Force until 1995 and then converted into a business park. This is currently one of the largest conversion projects in the federal state Rhineland-Palatinate. Initial ground investigations have mainly revealed

mineral oil contamination. All contaminated soil was then dredged, spread on the old runway and cleaned up by biological treatment. Subsequently, the soil could be used further.²⁶ However, it was only later that the PFAS contamination was detected, which meant that the supposedly successful soil remediation turned out to be a serious mistake. In other words, this soil could have been well decontaminated and shielded in the past, but this was no longer possible now that it had spread over the entire area. The consequence is therefore that a large-scale sealing of all designated commercial areas is now necessary so that rainwater can be drained through the drainage system and does not penetrate PFAS-contaminated soil. Several drinking water wells in the vicinity have therefore already had to close.



Figure 11: Air Base Sembach 1982
Source: Wikipedia (German edition)

Ansbach-Katterbach

The PFAS contamination in the surroundings of the US barracks Ansbach-Katterbach (Federal state Bavaria) has been known since autumn 2014. The citizens' initiative "*Etz langt's*"²⁷, which has been protesting for many years mainly against the helicopter noise of this site, filed criminal

26 German Source: Article contribution by Jochen Marwede to "Conversion of military sites in the region Kaiserslautern" in: http://umwelt-militaer.info/userfiles/downloads/2020/2020-12_Konversion-KL_Web.pdf

27 Expression from regional dialect with the meaning: "It is enough to us"

charges for PFAS contamination at the beginning of 2020. The reason given was that due to years of inactivity on the part of the US Army and German authorities, the carcinogenic substances continued to seep away and thus contaminated wells, streams and soil. However, the public prosecutor's office in Ansbach discontinued the investigation on the grounds that US military personnel cannot be prosecuted under the NATO troop statute (SOFA). In addition, the public prosecutor's office considered that due to the complexity of the remediation measures, there was "not yet" any "reproachable inactivity" on the part of German authorities, but at the same time pointed out the urgent need for action.²⁸

US Site Wiesbaden

Wiesbaden-Erbenheim is currently home to the US Army Headquarters in Europe. In February 2020, the previously-known PFAS contamination at the US site in Wiesbaden was a major topic in regional media.²⁹ The PFAS were first detected in soil and groundwater in 2009. They likely originate from extinguishing foam used at the air base in the 1970s. However, a former, neighbouring paint factory is also being prosecuted as a contributory cause. The values currently measured in a well on adjacent agricultural land, which had to be closed by order of the authorities, are in some cases hundreds of times higher than the so-called background contamination. In two adjacent streams, too, values have been found to be up to fifty times higher in isolated cases for several years.

Conversion area at the airport Frankfurt Rhein-Main

Terminal 3 is currently being built at Frankfurt Rhine-Main Airport. The construction site is located on the part of the airport that was occupied by the US Air Base Rhein-Main until 2005, before it was moved to Ramstein and Spangdahlem. At present, 470,000 m³ of soil contaminated with PFAS is being temporarily stored on the construction site. The planned "final disposal" at various sites distributed over Germany - which is a condition imposed on the responsible regional environmental authority - is likely to prove to be a negative example of "waste tourism".³⁰

28 Facebook-page <https://www.facebook.com/etz.langts> from 25.4.2020

29 German source (regional public TV):
<https://www.hessenschau.de/gesellschaft/us-militaerstuetzpunkt-mit-giftigen-schadstoffen-belastet,pfc-belastung-erbenheim-100.html>

30 German source (local citizens' initiative against aircraft noise and airport expansion):
<http://blog.ausbaugegner.info/umweltbelastungen-durch-terminal-3/>

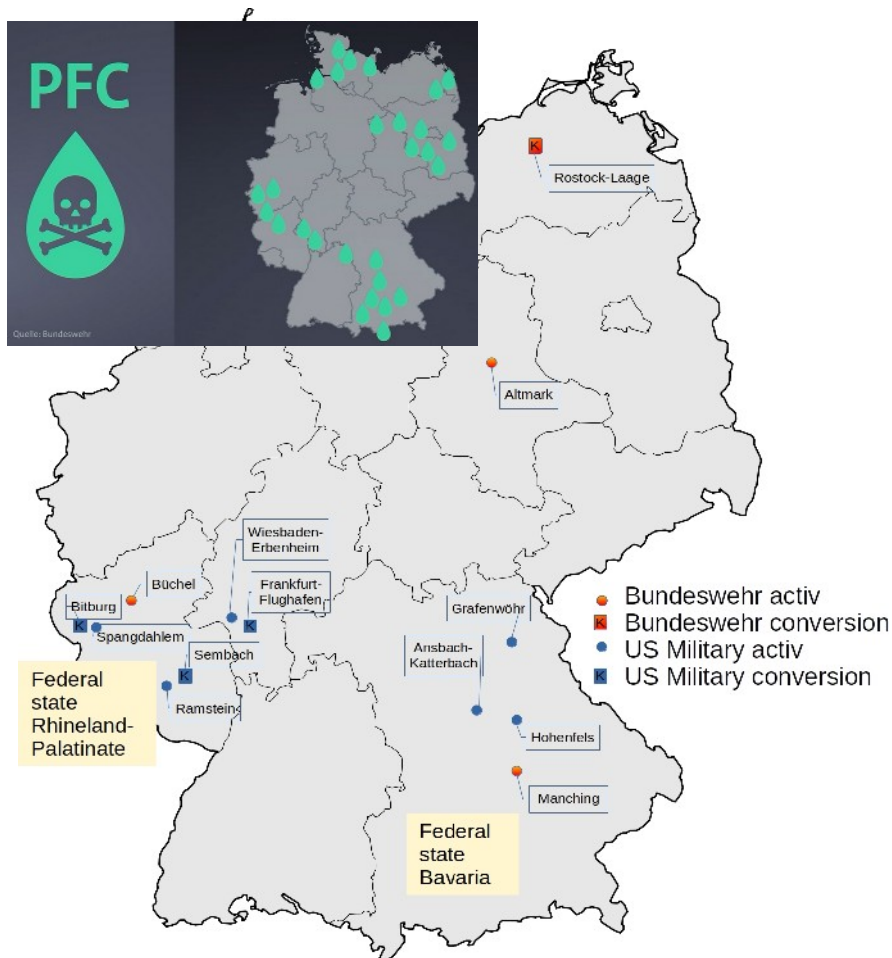


Figure 12: Map of Germany with selected hotspots. Not only airfields are affected, but also military training areas, Source: own drawing
 Top left: Screenshot from Bavarian TV broadcast from 20.7.2020 with the official 28 sites of the German armed forces with PFAS contamination. Additionally there are more than 100 "suspected" sites, corresponding to the official declaration.³¹

31 German source (from regional public TV):
<https://www.br.de/mediathek/video/manching-beginn-der-pfc-sanierungsarbeiten-av:5f16befcd1e38f0014868557>

3.5 German Armed Forces Airbases

Allegedly, the German Armed Forces, within the framework of its programme for contaminated sites, inspect all properties they use for possible PFAS contamination, at least according to an answer of the Federal Government to a parliamentary question in the German Bundestag. At present, this concerns about 120 properties where suspicion exists. The first PFOS contaminations with thousands of times exceeding the PFOS guideline values in groundwater became known in 2012 in the Federal State Bavaria (Region Middle Franconia).

The Rostock-Laage airport is included in documentation of the Contaminated Sites Programme that reveals PFAS contamination was carried out by the German Federal Armed Forces from 1990 onwards, which was disclosed in an existing report (published with redactions) in September 2019.³²

Airfield Manching (Bavaria)

In 2012, PFAS contamination was detected for the first time in a pond near the *Bundeswehr* airfield.³³ But it was not until 2015 that a connection was established with the firefighting foam used by the German Armed Forces at the airfield. It took another three years until the Bundeswehr submitted a comprehensive report and identified its own polluter-pays role. In the same year, a citizens' initiative "PFC Flugplatz Manching e.V." was formed there with over 200 members.

The mayor of Manching brought an action against the Federal Republic of Germany, which led to the first hearing at the Ingolstadt Regional Court in June 2020. In connection with this, the Bundeswehr started drilling a test well in July 2020 as the first stage of remediation measures. However In the opinion of the Mayor of Manching, this first attempt at remediation could have taken place two years earlier. He referred to a similar PFAS contamination on the site of a former refinery in Ingolstadt, which is currently being converted into a technology centre.

32 <https://www.bundeswehr.de/resource/blob/186022/03cbff142593031e6b442c64c6002448/download-pfc-untersuchungsergebnis-laage-flugplatz-data.pdf> (German Armed Forces)

33 <https://www.br.de/nachrichten/bayern/pfc-belastung-in-manching-bundesrepublik-steht-vor-gericht,S2jf0cZ> (regional public TV in Bavaria)

4. Environmental authorities and the military

4.1 The situation in the USA

Under pressure from the US Environmental Protection Agency (EPA), the Pentagon stopped the use of AFFF in January 2016 (at least officially) on military bases in the US during firefighting exercises.³⁴

However, it is understandable that the EPA can only be so active under difficult conditions. During the term of US President Trump in particular, the EPA was financially gutted and its management staff was replaced. An example of this is the fact that an 8-page "Technical Fact Sheet - PFOS and PFOA" from the EPA in November 2017 does not explicitly mention the military at all. What is most striking about this apparently politically motivated fading out, however, is that the paper contains half a dozen references to "DoD" (Department of Defense), and specifically to the Pentagon papers from the period 2013 to 2016 on this topic.³⁵

Several studies on environmental and health impacts of PFAS could only be made available to the public through the Freedom of Information Act (FOIA). These included a study by the Agency for Toxic Substances and Disease Registry (ASTD), a subdivision of the US Health Service, which in 2018 presented the toxic effects of 14 PFAS in detail in an 852-page report. As a result, this study called for the PFAS risk levels to be set 7 to 10 times lower than the EPA standard (see section 1.2).

As mentioned above, a Pentagon PFAS Task Force has been in place since July 2019 to meet the requirements of the EPA. One result of this task force is that, compared to earlier data such as those of August 2017 when 401 PFAS-contaminated sites had officially been identified, in March 2020, the number of contaminated military sites increased to 651 (see also section 3.2).

34 <https://www.defense.gov/Explore/News/Article/Article/1930618/dod-moving-forward-with-task-force-to-address-pfas/> Quotation: „To prevent future releases to the environment, DOD stopped land-based use of AFFF in training, testing and maintenance through a department-wide policy issued in January 2016.“

35 <https://www.epa.gov/fedfac/technical-fact-sheet-perfluorooctane-sulfonate-pfos-and-perfluorooctanoic-acid-pfoa-0>



Figure 13: Extract from a poster of the US state of Michigan, which is particularly affected by the AFFF exposures.³⁶

However, the corresponding report on the Pentagon's homepage also includes reference to the alleged necessity of AFFF to protect "catastrophic losses of people and material assets".³⁷ The report also states that since 2016, AFFF firefighting exercises on land-based military bases have been suspended. But it seems that AFFFs with PFAS are still used at least on US military bases in Germany. The regional public TV (Hessischer Rundfunk) for example, refers to this after its own research on PFAS loads at the US base Wiesbaden, which is currently used as a helicopter airfield, among other things.³⁸ It can also be assumed that this is the case at the US Air Base Ramstein as a firefighting training centre.

36 https://www.michigan.gov/documents/pfasresponse/Firefighting_Foam_Poster_655070_7.pdf

37 <https://www.defense.gov/Explore/News/Article/Article/1930618/dod-moving-forward-with-task-force-to-address-pfas/> - Complete quotation: „The foam is used by DOD and other firefighting organizations to rapidly extinguish fuel fires and protect against catastrophic loss of life and property.“

38 www.hessenschau.de (indicated above)

Noteworthy about the situation in the USA are the partly strict environmental regulations under the legal jurisdiction of federal states, which could also prohibit the AFFF deployment with PFAS on the military bases there. However, the Air Force insists that it is entitled to a "federal sovereign immunity". Such immunity also applies if U.S. soldiers commit crimes abroad, which are not prosecuted under the respective troop deployment agreements (SOFA) with the host countries.

4.2 Environmental protection on US bases abroad

US military bases abroad are subject to troop deployment agreements, also known as SOFA ("Status of Forces Agreement"). The resulting regulations for environmental protection on military bases vary widely.

In Japan, the US military is not accountable to the environmental authorities there. For this reason, Okinawa in particular is subject to extreme environmental pollution, which also results from the many years of careless disposal of pollutants. The prefecture of Okinawa has therefore been calling for a revision of the SOFA agreement for many years. So far, however, only a cosmetic reform called "Cooperation Concerning Environmental Matters" was implemented in 2015. Although this includes a claim in principle by Japanese authorities for access to US military bases, this is subject to a Pentagon decision in individual cases. It was only in April 2020 that such a permit was granted following an incident involving toxic substances.³⁹

Particularly serious, due to the dramatic PFAS burden on Okinawa, is the fact that the Japanese central government has so far refused to set limit values for PFAS pollution. The prefecture of Okinawa has therefore set the US EPA guideline value of 0.07 µg/l as a standard.

In South Korea, the situation is somewhat better. After the return of 23 bases without clean-up in 2007, the Korean government pushed for a joint environmental assessment procedure, which was established in 2009. Under this procedure, the US government is obliged to compensate the costs of necessary remediation of contaminated conversion sites. Following an incident in February 2000 when a US soldier dumped formaldehyde into the Han River in Seoul, the US Army also promised to spend \$100 million to improve its environmental activities. After PFAS

³⁹ Source: Jon Mitchell (indicated above)

contamination was identified at four military bases in South Korea in 2017, the US military responded by closing several wells.⁴⁰

In 2018, the Pentagon published data on PFAS exposures at foreign military bases in Belgium, Honduras and South Korea. Information on PFAS exposures on the restricted areas of military bases in Japan is based on the forced release of documents under the US Freedom of Information Act (FOIA) by the British journalist Jon Mitchell (see also section 6.2).

In the case of Germany, a supplementary agreement to the NATO troops statute (SOFA) is in force, which according to Article 54 also includes environmental obligations of the "guest forces". On the one hand, these consist of cooperation with German environmental authorities in order to avoid environmental damage, and an agreement (in principle) that environmental damage that has occurred must be largely borne by the host country. This has already been confirmed by two separate enquiries of the parliamentary group Die LINKE in 2015 on the PFAS impacts from the US sites Spangdahlem and Ansbach-Katterbach. It says:

„According to international agreements, German law, and in particular environmental law, applies to the properties transferred. The US forces are responsible for the environmental pollution they cause and are obliged to investigate and remove it at their own expense. The monitoring of compliance with environmental law is also the responsibility of the competent regulatory authorities on the US properties, and a right of access agreed under international law enables them to perform their duties on these properties as well.“⁴¹

Additionally, the parliamentary group Die LINKE obtained an expert opinion from the Scientific Service in the Bundestag, where this statement was specified more precisely with reference to procedural regulations and passages contained therein:⁴²

„If the Federal Republic of Germany compensates the third party (letters b and d), it may make a binding proposal to the authorities of the foreign armed forces for an equitable apportionment of the

⁴⁰ Jon Mitchell: *Poisoning the Pacific* (indicated above)

⁴¹ BT-Drucksache 18/04570: *Polyfluorierte Chemikalien im Umfeld der Militärbasis der Vereinigten Staaten von Amerika in Ansbach-Katterbach*

⁴² German document WD 2 – 3000 – 057/15: *Accountability for environmental damage near military training areas under the NATO Force Status and its Supplementary Agreement* (Original: "Haftung für Umweltschäden nahe Truppenübungsplätzen nach dem NATO-Truppenstatut und seinem Zusatzabkommen" (available online: www.bundestag.de))

amount of compensation. The rules of paragraph 5 letter of the SOFA apply here, according to which the Federal Republic of Germany must bear at least 25 percent and at most 50 percent of the sum. If the US force or its members were demonstrably solely responsible, the US would have to pay 75 percent of the amount of the damages."

The BImA (Federal Institute for Property Tasks) with three regional offices for the settlement of claims is responsible for environmental damage.

While this clearly regulates liability for environmental damage, in the opinion of the (Bundestag) Scientific Service, this does not apply to the passage in Article 54A of the SOFA Supplementary Agreement, wherein cooperation with German environmental authorities is formulated with the aim of "avoiding environmental pollution and compensating for unavoidable environmental damage by appropriate measures". The above-mentioned comment by the Scientific Service states:

„Due to the vague wording, it is assumed that this provision is not a directly binding regulation, but rather expresses an intention or objective (so-called programme clause). "

The fact that there is no lack of good will declarations or formal environmental certifications is demonstrated, for example, by the 86th Air Wing based at Ramstein Air Base's (as well as other units such as Spangdahlem Air Base) "Environmental Commitment Statement" which refers, among other things, to the environmental management system in place at the site. The US military is committed to important environmental principles such as the sustainable use of natural resources, reduced emissions, limited use of hazardous substances, and waste avoidance.

4.3 Remarks on German Environmental Authorities

The Federal Environment Agency (UBA) is certainly presenting the topic of PFAS in a scientifically based manner. The same applies to the environmental agencies of the German federal states, although the extent to which they deal with this topic naturally varies, depending on proximity to regional hotspots.

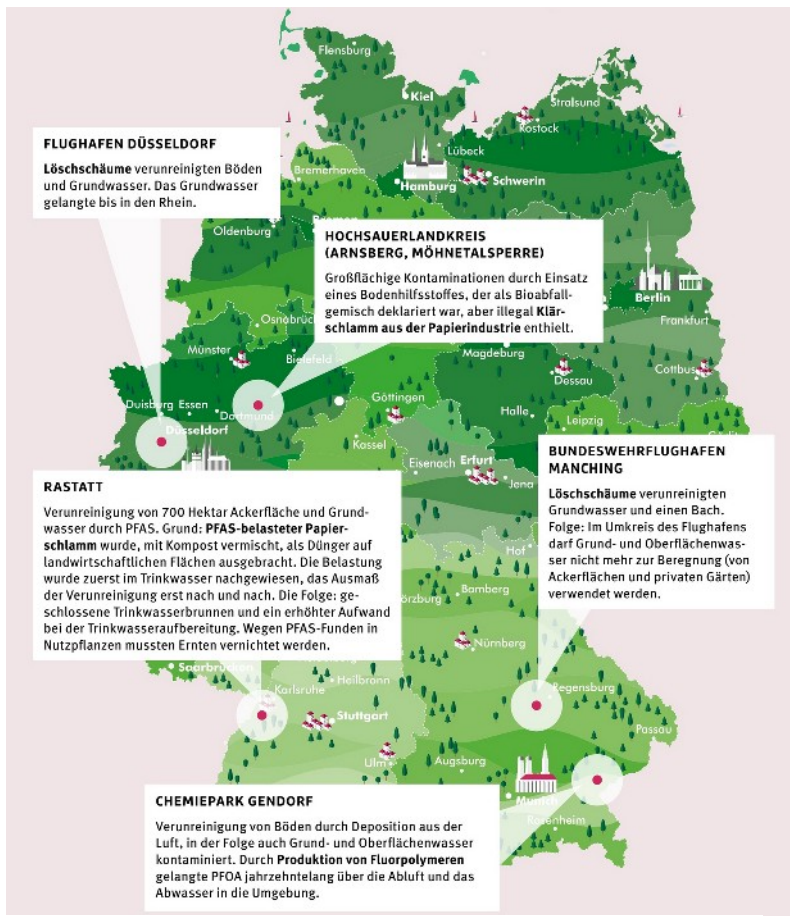


Figure 14: from UBA- magazine "Schwerpunkt" No. 1/2020

A critical point to note is that the relevance of military causes remains generally underexposed. For example, the Bavarian State Government and the Bavarian State Environmental Agency have published a very informative booklet entitled "The Environmentally-Friendly Use of Firefighting Foams", but the special military use is practically unmentioned, being referred to only in the context of civil airports.⁴³

⁴³ German Original title: *Umweltschonender Einsatz von Feuerlöschschäumen*

A recent publication by the Federal Environment Agency (UBA) identifies a number of significant hotspots in Germany in a figure, but only the *Bundeswehr* airfield in Manching appears as a military polluter.⁴⁴

While the environmental agencies of the Federal Government and the Federal States essentially have only an advisory function, the regional authorities of the Federal States (in Rhineland-Palatinate: SGD North and South) are administratively responsible for hotspots of PFAS pollution in their function as higher nature and environmental protection authorities.

In the Federal state Rhineland-Palatinate, the PFAS problems in the region around Bitburg and the US Air Base are currently presented and communicated in a comparatively transparent manner by the SGD North authority, as there are "civil" exposures in the surroundings of the Air Base and the conversion areas in Bitburg. The handling of PFAS contamination at Ramstein US Air Base, however, is different. Here, the existing loads are shielded from the outside by active hydraulic measures under the technical supervision by the SGD South authority and formally by permits granted to BimA as the owner of the military properties. So far, however, this has not been communicated to the outside.

Freedom of Information Act as a starting point

There is a method in Germany for obtaining information similar to the FOIA in the USA – a tool for civil society that should not be underestimated. In principle, information can be obtained under the Environmental Information Act, but due to its complexity this is essentially only relevant for environmental NGOs. In addition, there is the Freedom of Information Act, which applies nationwide and is supplemented by specific laws of the federal states, such as the State Transparency Act in Rhineland-Palatinate.

Independently of or in conjunction with this, efforts should also be made to provide parliamentary information in the Bundestag and the federal state parliaments.

44 *Remarks to the content of the German figure (on the left side):*
Flughafen Düsseldorf: 2014 accident mentioned in section 3.1
Hochsauerlandkreis: Contamination by fertilisers on arable land 2006
Rastatt: Contamination similar to above
Chemiepark Gendorf: Chemical industry with company Dyneon and PFOA production until 2003
Bundeswehrflughafen Manching: German armed forces in Bavaria

5. Consequences from a scientific viewpoint

In general, the following problems can be seen in terms of necessary consequences:

1. A scientifically justified demand must be made for a ban on all of the approximately 4700 PFAS, but this can only be implemented in the long term. Otherwise, there is a risk that the mere prohibition of PFOS and PFOA will lead to a shift towards other PFAS whose environmental presence and toxic effects have not yet been sufficiently researched and evaluated.
2. The large number of everyday civilian products that can lead to PFAS contamination in the environment obscures the view of the military as the largest single poisoner.
3. The large number of existing PFAS makes it difficult to focus on what can be analytically detected with reasonable expense while at the same time perceiving the totality of all PFAS.
4. The enormous problems of cleaning up polluted soil and drinking water have not yet reached political decision-makers and thus have not produced budgetary consequences.
5. The reasons for the military use of AFFF are still not sufficiently questioned.

Long-term costs due to inactivity

According to the study "The Costs of Inaction", which was commissioned by the Nordic Council of Ministers (NCM) at the beginning of 2019, the costs of the necessary monitoring and subsequent remediation measures for PFAS contamination can run into billions - every year.⁴⁵ For the first time, the study has roughly estimated PFAS follow-up costs in the European Economic Area.⁴⁶ To do so, groups of scientists from different disciplines evaluated studies on the diffusion, pollution, production and harmfulness of PFAS and, based on five case studies, estimated the socio-economic costs of PFAS use.⁴⁷

45 <https://www.norden.org/en/publication/cost-inaction-1>

46 *European Economic Area: EU member countries plus Norway, Iceland and Greenland*

47 <https://www.norden.org/en/news/fluorinated-substances-pollute-billions-euros-every-year>

This includes a case study specifically dealing with AFFFs. Among the case studies of civil airports already mentioned in section 3, the costs incurred for clean-up measures are also explored in this study, which allows for an extrapolation to the large number of existing contaminations on and neighbouring military airfields.

This would also make it possible to estimate the costs of necessary remediation for PFAS contamination on current and former military areas in individual countries like Germany. However, the dynamic cost development must be taken into account, because years and decades of inactivity shift the problem.

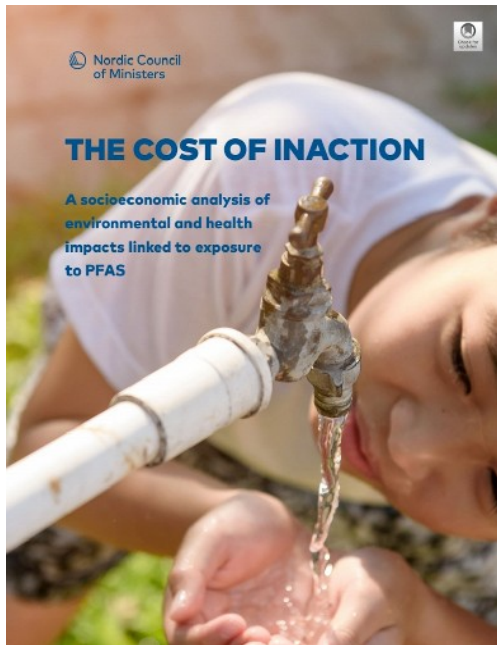


Figure 15: Front page of NCM study

In the long term, as PFAS enter into the groundwater, the source of contamination can no longer be clearly proven, which is why the BImA authority in Germany can thus evade its obligation, as is already the case in the legal dispute over the former Bitburg airfield and the US Air Base Spangdahlem.

Inactivity or slow processing drastically increases the socioeconomic costs of PFAS burdens and ultimately constitutes a mortgage for future generations.

These costs can be roughly calculated, whereby existing inaccuracies are mainly due to the described cost progression. Above all, there is a fundamental difference in cost when PFOS and PFOA are still in the soil as opposed to when they have already contaminated the groundwater. Even if, as in the case of Frankfurt Airport, it appears to be a gigantic task to dispose of 470,000 m³ of PFAS-contaminated soil properly, the problems with entry into the groundwater are even more serious. The time frame in which this takes place varies greatly based on soil conditions in different locations.

The concept of the "essential" criteria

Since a complete ban of PFAS can only be enforced in the long term at best, there is an increasing demand among scientists internationally for a pragmatic approach, including considering what is politically feasible. In May 2019, a concept entitled "The concept of essential use for determining when uses of PFAS can be phased out" was presented as a critical review in the Journal of the Swedish Royal Society of Chemistry (RSC). It proposes defining three categories of PFAS applications, with classifications from today's perspective:

(1) „Non-essential“: Uses that are not essential for health and safety, and the functioning of society. The use of substances is driven primarily by market opportunity.

(2) „Substitutable“: Applications due to important functions, but where functionally comparable alternatives (without PFAS) are now available. This concerns most applications of AFFF and water repellent textiles.

(3) „Essential“: Health and safety applications where alternatives are not yet established. This concerns in particular medical devices and protective clothing.

A fundamental statement of this concept is that AFFF are functionally equivalent in use without PFAS, with reference to the practice of civil airports worldwide. There is criticism of the US military's refusal to accept this reality. For this reason, the concept also lists in a further table the use of PFAS for military purposes as belonging to category "2 or 3", as well as military clothing.

IPEN: AFFF are unnecessary

The International POPs Elimination Network (IPEN) is a global, civil society network of over 600 non-governmental organizations that was established in Sweden in 1998 with the aim of regulating and banning persistent organic pollutants, or so-called POPs. IPEN played a key role in the Stockholm Convention against POPs.

As early as 2018, an IPEN scientific panel stated in a "white paper" on AFFF that acceptable alternatives were available without exception. The position paper explicitly criticised the "performance specification" of the US military (see section 2).

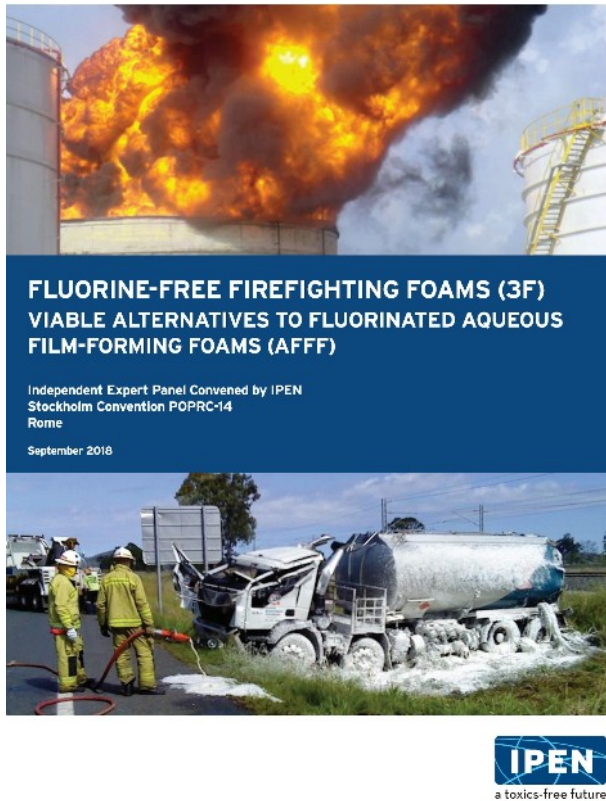


Figure 16: Front page of „White Paper“ to AFFF

6. Informing the public

6.1 PFAS general treatment

At the end of 2019, a movie called "Dark Waters" was released in the USA. As an adaptation of a real-life event, it depicts the decades-long struggle of a lawyer from 1998 onwards. He sued the chemical company DuPont on behalf of a farmer from his home town, whose land and water was extremely contaminated with toxins from a landfill site. As the film also shows, this led to considerable pressure on the US Environmental Protection Agency (EPA) and thus to the establishment of regulatory measures. Apart from its enlightened content, the movie can also be described as a very well made Hollywood production. In the credits, reference is made to the amount of \$671 million that DuPont was prepared to pay out to more than 3,000 PFAS-damaged class action lawsuits by 2017. Although the military relevance of PFOA is not addressed, the film must be seen as a quantum leap in the public perception of the PFAS issue. In Germany, the film was released in October 2020.⁴⁸

Greenpeace International has been dealing with the PFAS problem for some years now. A study published in 2018, entitled "Microplastics and Persistent Fluorinated Chemicals in the Antarctic", gives a fairly detailed account on the global distribution of PFAS. This problem is seen here as being of equal importance to the littering of the oceans by microplastics.

The worldwide network Friends of the Earth and their national member organisations are also dealing with this issue, but in very different ways. In Australia, the issue addresses the Australian military as the source of the problem.⁴⁹ The US section of Friends of the Earth, however, does not yet focus on this issue, but on a number of other environmental problems in the USA, such as the soil and groundwater pollution caused by the fracking industry or the fight against new oil pipelines. The largest contribution of an NGO in the USA against PFAS contamination by the military is from the "Environmental Working Group (EWG)", which has been active for two decades and has specialised in the relationship between the environment, food and human health.

⁴⁸ German title "Vergiftete Wahrheit" (Poisoned truth)

⁴⁹ https://www.foe.org.au/pfas_legal_settlement Quotation: „Friends of the Earth (Australia) fears that the impact of the PFAS extends far wider than military bases. PFAS has been detected over hundreds of locations across Australia, even drinking water.“

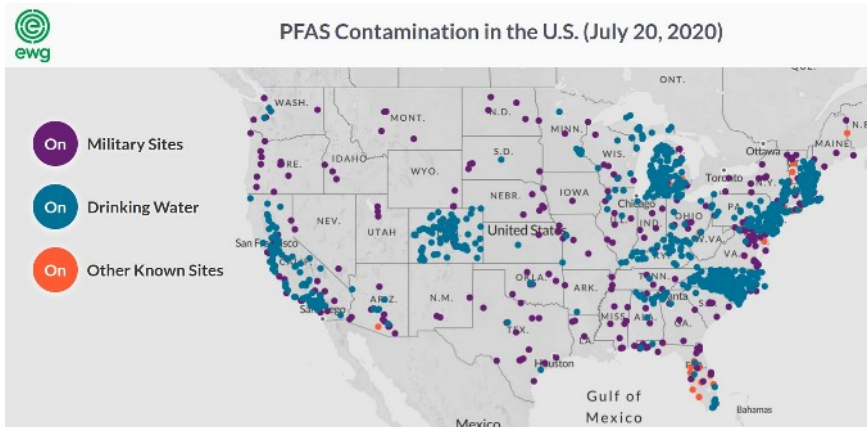


Figure 17: Interactive US map with PFAS-Hotspots (see also section 4.1)

Source: www.ewg.org/interactive-maps/pfas_contamination/map/

The German section of Friends of the Earth has taken the above-mentioned movie "Dark Waters" as an opportunity to reaffirm earlier demands for a complete ban on PFAS and to highlight Germany's special responsibility as the world's leading location for the chemical industry.⁵⁰

6.2 PFAS exposures with military cause

From the peace movement's point of view, the topic is mainly present in the USA, which can be traced back to the peace and environmental activist Pat Elder, who not only has a significant share in the internet documentation of contaminated sites, but has also presented this in numerous lecture events. In Germany, Pat Elder also commented on the PFAS contamination as early as 2019 as part of the Ramstein Campaign Action Days.

For many of the US sites affected, the PFAS exposures are well documented on several websites by both Pat and others. This is mainly done on the websites www.militarypoisons.org (with Pat Elder as editor) and www.civilianexposure.org (with contributions from Pat Elder).

⁵⁰ <https://www.bund.net/themen/aktuelles/detail-aktuelles/news/filmtipp-der-kampf-gegen-giftstoffe-im-kino/>



Figure 18: Screenshot with Pat Elder from the event of the Stop Air Base Ramstein campaign on 28.6.2019 in Kaiserslautern ("Church event").
Source: [www.weltnetz.tv](https://weltnetz.tv)⁵¹

Jon Mitchell is a British journalist who has lived in Okinawa for more than 10 years and has undertaken extensive investigations into the full range of environmental threats from the US military. In August 2020, he and two co-authors published a book on PFAS exposures in Japanese. An English summary of the content is available online⁵² (see also references in sections 3 and 4).

In his publication "Poisoning the Pacific" from October 2020, he describes the terrifying history of the systematic pollution and destruction of the US military in the Pacific region since 1945. The PFAS contamination is only one part of this story compared to the more serious dumping of remaining nuclear and chemical warfare agents. Okinawa was particularly affected, which - as already described - is also struggling with the consequences of the PFAS contamination.

51 <https://weltnetz.tv/video/1976-livestream-stop-air-base-ramstein-abendveranstaltung-28-juni-2019> (Start at minute 30)

52 <https://apjif.org/2020/16/JMitchell.html>



Figure 19: Screenshot from the video recording of an event on 1.8.2018 with Jon Mitchell, in which he presents the possibilities for using the Freedom of Information Act (FOIA). Based on the information he received, together with interviews from US veterans, whistleblowers, and residents on Okinawa, he was able to conduct an extensive investigation into criminal environmental destruction by US troops.

In Germany, the "Stop Air Base Ramstein" campaign, among others, calls for the termination of the troop deployment agreement with the USA. The reason given for this is that the US government has been concealing the use of Ramstein Air Base for the US drone warfare for several years, which was originally disclosed by whistleblower Edward Snowden and is contrary to the German constitution as well as international law. This was also connected to the fact that the German Federal Government only admitted knowledge about this several years later. As of yet, there have been no consequences connected to this, and some strictly reject any consequence.

A similar problem arises with environmental pollution caused by the US military in Germany, as clearly applicable German standards and even US standards are not complied with. A special role is played here by the real estate authority BimA's questioning of the uniqueness of the military causes wherever possible. The US military claims that sites that are still

actively used, such as the Ramstein Air Base, are adhering to the "Final Governing Standards for Germany", which is practically not provable.

With regard to the environmental impact of the US military, the focus is mostly on aircraft noise caused by the very loud Galaxy transport aircraft during take-offs and landings in Ramstein, as well as the use of the Kaiserslautern area for fighter jet training flights. In recent years, there has also been an increase in fuel dumping over the Palatinate Forest. Although this is mainly attributable to civil aircraft on the approach to Frankfurt Rhine-Main, military air traffic at Ramstein Air Base is also aggravating the situation by dumping paraffin, which is not authorised by the air navigation authority.

Internationally, resistance to environmental damage by the US military has much greater relevance, especially as an approach to international networking of the peace movement. Several "International Congress[es] against Military Bases" have already been organised through the "Stop Air Base Ramstein" campaign, most recently on the 25th of September 2020 as a hybrid online-physical event in Berlin. These have always taken place with the participation of partners in Okinawa and South Korea, and include a focus on the environmental pollution there.



Figure 20:
Poster from the Peace
for Okinawa Coalition.
Source:
www.PeaceForOkinawa.org

7. Conclusions

From a scientific point of view, the military is the largest single contributor to the global PFAS burden and at the same time the main obstacle to urgent action. The denial and marginalisation of this fact is ultimately responsible for the socio-economic dimension of the problem. The total annual costs of 52 to 84 billion Euros for the whole European Economic Area, as estimated in the NCM study entitled "The Costs of Inaction", require immediate and comprehensive remedial action. Otherwise the problem will be shifted into the future at dramatically higher costs.

The US military has also acknowledged the problem, but the Pentagon is only moving in triple steps towards clarification. It is at least questionable whether there are serious intentions to substitute AFFF, which continue to cause environmental contamination by US military bases in Germany as well. Similarly, the German Federal Government and its subordinate authorities are dealing with the issue slowly and with delay. Just as with the US Pentagon, the principle "we will continue to work on it" applies here.

If serious treatment of the problem were really intended, very large budgets would have to be drawn up in short periods of time. It is certainly scientifically justified that PFAS exposures at any location first require thorough and time-consuming investigations. However, it must be assumed that during the years of these preliminary investigations and chemical analysis, the problems are significantly worsened by the lack of protection against the infiltration of PFAS-contaminated leachate into the groundwater.

What can realistically be expected from German policy - barring massive pressure from civil society - is also shown by an exemplary comparison with the World War munitions dumped into the North and Baltic Seas, a time bomb of comparable magnitude. In 2019, a parliamentary request was submitted to the German Bundestag under the title "Legacy munitions from war - Germany's naval and terrestrial challenges in ordnance disposal". The answers of the Federal Government could be described roughly in this way: *We have commissioned various expert reports; we have to coordinate this with the responsible federal states, because that is their task; we have formed a working group for this purpose; we need further research and studies; we are examining the further procedure ...*

The critical review entitled "The concept of essential use...", published in the Swedish RSC Journal, provides a pragmatic and workable approach based on scientific evidence. It also highlights the central role of the (US) military, although only with cautious criticism. It would be desirable for this concept to be taken up first and foremost by international NGOs like Greenpeace and Friends of the Earth, because necessary consequences and measures cannot be expected without considerable pressure from civil society, as illustrated by the above example.

Beyond such concepts of a pragmatic approach, the demand for a complete ban of PFAS substances must of course be strengthened in environmental policy terms. This is also necessary because otherwise it is feared that the military will merely substitute the "lead substances" PFOS and PFOA with other (PFAS) substances whose toxic effects and long-term presence in the environment have not yet been sufficiently researched.

The deployment of AFFF at military airports was and is in no way due to fire protection requirements. The excessive firefighting exercises with AFFF are based on military, fictitious exercise scenarios and measures derived from them, which at the same time pose a real threat to civilisation. The relaxed handling of toxic substances is part of a long history worldwide, especially of the US military and the mentality prevailing there.

The fact that in Germany the role of the military in PFAS environmental pollution is still completely underexposed, not only by politicians but also by environmental agencies and authorities, requires joint efforts by the environmental and peace movement. This is the only way to raise awareness of the military's responsibility in the case of existing and still to be feared environmental disasters, so that inactivity in scientifically based countermeasures no longer becomes a time bomb.

Appendix

Abbreviations of substance names

AFFF aqueous film forming foam
PFAS per- and polyfluoroalkyl substances
PFC per- and polyfluoroalkyl chemicals (outdated term)
PFOA perfluorooctanoic acid
PFOS perfluorooctane-sulfonic acid
PFT perfluorocarbon tracers (outdated term)

Abbreviations of institutions

BImA Real Estate authority of (Federal) military sites
(Bundesanstalt für Immobilienangelegenheiten)
UBA German Federal Environmental Agency (Umweltbundesamt)
SGD Regional authority in environmental issues (Federal state
Rhineland-Palatinate)
EFSA European Food Safety Authority
NCM Nordic Council of Ministers
RSC Royal Society of Chemistry (Schweden)
ASTDR Agency for Toxic Substances and Disease Registry
(Subdivision of US health authority)
EPA Environmental Protection Agency (USA)

Other abbreviations

SOFA Status of Forces Agreement
FOIA Freedom of Information Act (USA)

NGO websites in the USA

www.militarypoisons.org (Editor: Pat Elder)
www.civilianexposure.org (unter Mitwirkung von Pat Elder)
www.ewg.org Environmental Working Group (EWG)

Publications online available as PDF

The Costs of Inaction - A socioeconomic analysis of environmental and health impacts linked to exposure to PFAS, Nordic Council of Ministers (2019)

Critical Review: The concept of essential use for determining when uses of PFASs can be phased out, Journal of (Swedish) Royal Society of Chemistry (2019)

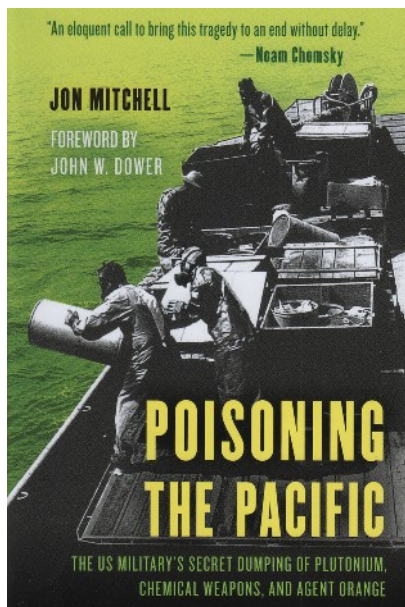
Fact Sheet: A Toxic Threat – Government Must Act Now on PFAS Contamination at Military Bases (2018), (US-)Center for Science and Democracy at the Union of Concerned Scientists

Jon Mitchell: PFAS Contamination from US Military Facilities in Mainland Japan and Okinawa, Asia-Pacific Journal, 5.8.2020

IPEN 2018/POPRC-14, White paper, Fluorine-free firefighting foams (3F) – Viable alternatives to fluorinated aqueous film-forming foams (AFFF)

Book publication

Poisoning the Pacific - The US Military's Secret Dumping of Plutonium, Chemical Weapons, and Agent Orange, Author: Jon Mitchell, available as print and eBook (Oct. 2020)



List of figures

Cover page: own display from figure 3, 5, 6 and 9

Figure 1: Chemical structure of PFAS (P. 6)

Figure 2: Warning plate to anglers in US federal state Michigan (P. 12)

Figure 3: Drawing with AFFF emission and immission (P.14)

Figure 4: Aircraft carrier Ronald Reagan with war fighters (P. 15)

Figure 5: Fire drill on Ramstein Air Base (P. 16)

Figure 6: Flooding a hangar with extinguishing foam (P. 18)

Figure 7: Table with PFAS exposure from military sites in USA (P. 21)

Figure 8: PFAS-contamination at Kadena Air Base (P. 22)

Figure 9: Contamination at Spangdahlem Air Base (P.25)

Figure 10: Logo of firefighting unit in Ramstein (P. 26)

Figure 11: Former Air Base Sembach 1982 (P. 27)

Figure 12: German map with military PFAS-Hotspots (P. 29)

Figure 13: Poster of US Federal state Michigan to AFFF (P. 32)

Figure 14: Picture from UBA-Brochure with PFAS-Hotspots (P. 36)

Figure 15: Front page of NCM-Study (P. 39)

Figure 16: Front page of „White Paper“ IPEN (P. 41)

Figure 17: Interactive map with PFAS-Hotspots in the USA (P. 43)

Figure 18: Event with Pat Elder in Kaiserslautern (P. 44)

Figure 19: Event with Jon Mitchell in Japan (P. 45)

Figure 20: Poster of Peace for Okinawa Coalition (P. 46)

Military kills - even without war. This booklet outlines very clearly the problem of PFAS pollutants, whose long-term effects have been increasingly addressed in recent years. These contaminants enter drinking water and the human food chain via soil and groundwater, causing serious health problems.

What has remained highly underexposed is that above all the US military is to be regarded as primarily responsible actor for this global environmental problem, which has also led to corresponding regional hotspots in Germany, in the surroundings of both former and active military bases.

This booklet contains the necessary basic information on PFAS and their military application in a compact form, as well as examples of military-caused exposures and pre-existing scientific and NGO activities.