CHEMTrust
Protecting humans and wildlife from harmful chemicals

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Trifluoroacetic acid (TFA) – FAQ

Introduction

Trifluoroacetic acid (TFA) is a small, very persistent and mobile chemical that is widespread in the environment at increasing levels. TFA is one of many per- and polyfluoroalkyl substances (PFAS), known as 'forever chemicals' due to their persistence. TFA is a short chain perfluorocarboxylic acid (PFCA) (a subgroup of PFAS). TFA is found in groundwater, soil, plants, drinking water, and our drinks and food (see questions 6,7,8, & 9). Although TFA is manufactured by the chemical industry (see question 3) the largest source of TFA in the environment is as a breakdown product of other PFAS used as pesticides and fluorinated gases (F-gases) (see questions 1 & 2). Of about 10,000 PFAS around 2,000 have so far been identified as having the potential to form TFA.

Recent studies of TFA on mammals raise serious concerns about potential toxicity to the liver and reproductive systems (see question 11). Germany has submitted a proposal to the European Chemicals Agency (ECHA) for classification as a reprotoxic, and PMT (persistent, mobile and toxic) and vPvM (very persistent and very mobile) substance. ECHA has opened a public consultation on the proposal. TFA's persistence means that the more TFA is produced the more it will build up in the environment increasing exposure for generations to come (see question 6).

Significant toxicity to people or the environment (see questions 11 & 12) could be identified in the near future but there will be no effective way of removing the contamination. Despite solutions being sought to remove TFA from drinking water, for example, all methods have so far been ineffective and/or prohibitively expensive (see question 10).

The best way to stop the increase of TFA in the environment is to stop the production and use of the chemicals and products that break down into TFA. To this end the universal PFAS restriction currently being discussed by ECHA needs to be implemented as soon as possible without being watered down (see question 13). It is already backed by civil society, scientists and forward-thinking businesses.

More information about PFAS and how they should be regulated can be found here and here.

Questions about TFA

1. Is it right that F-gases used as refrigerants are the biggest sources of TFA?
2. Are Pesticides, biocides and pharmaceuticals also sources of TFA?
3. Are there other sources of TFA in the EU?
4. Can waste treatment also be a source of TFA?
5. Is it true that TFA is also formed naturally?
6. What's the evidence that TFA is contaminating our environment?
7. Is it true that TFA is commonly found in drinking water?
8. Should I be worried about levels of TFA in drinking water?
9. Is it true that TFA is also found in juices, wine, infant food and lentils?
10. Can't we just remove TFA from our water and environment?
11. TFA may be everywhere but is there any evidence that it will harm our health?
12. Will TFA harm nature?
13. How should TFA be regulated?

1. Is it right that F-gases used as refrigerants are the biggest sources of TFA?

TFA is a degradation product of several fluorinated gases (F-gases) that are used as refrigerants, for example, in supermarket chillers, car air conditioning, and heat pumps. We know that the use of these particular F-gases is increasing. Data shows that the trends of increasing TFA in the arctic ice core, tree leaves, and groundwater, coincide with the increase in use of F-gases [1][2] (also see question 6).

The increase in TFA production from F-gases is a case of regrettable substitution. Certain fluorinated refrigerants - hydrochlorofluorocarbons (HCFCs) and the more recently used hydrofluorocarbons (HFCs) are now being phased out due to their Global Warming Potential (GWP) and being replaced by Hydrofluoroolefins (HFOs) which have a relatively low GWP. However, the HFOs are PFAS chemicals, and when they are released into the air, they break down into TFA. Although there was some TFA formation with HFCs this is massively increased with HFOs [1].

One study predicts a 250-fold increase in TFA due to the transition from the F gas HFC-134a, to its replacement HFO-1234yf [3]. CHEM Trust considers it essential that alternatives to F gases are rapidly adopted in the green transition to avoid an increase in TFA. According to the industry group EFCTC, HFO-1234yf is currently used in almost all new cars in the EU for air conditioning and battery cooling in electric vehicles [4]. However, alternatives do exist and Volkswagen has already committed to using PFAS-free refrigerants in all its cars by 2030 [5] showing that a transition away from HFOs is perfectly possible. Similarly, heat pumps use F-gases as refrigerants to transform energy from the surrounding environment into heat but there are PFAS free alternatives such as propane heat pumps [6,7] (also see question 13).

More data is needed on the proportion of TFA produced by different sources. However, enough is known about the precursors to TFA, and the alternatives available, for policy makers to be able to act to restrict these to reduce TFA pollution (see question 13).

2. Are Pesticides, biocides and pharmaceuticals also sources of TFA?

There are 32 plant protection products (PPPs) approved in the EU that are PFAS and so are potential precursors for TFA. Pesticides have been identified as a major source of TFA to water resources even though uncertainties remain about exact formation rates of TFA from PPPs with the only data coming from studies that form part of the approval process in the EU and under review by the European Food Safety Authority (EFSA) [8].

However, the importance of PPP as a TFA source is supported by monitoring data from a study by the German Environment Agency – Umwelt Bundesamt (UBA). This data revealed a significant increase in TFA groundwater concentrations associated with agriculture compared to other land uses [2]. Levels of TFA in intensive farming areas were higher than could be explained by levels of TFA in precipitation, which affects all land irrespective of the use. Pesticides are therefore likely to be the main source of TFA in areas with intensive agriculture.

The herbicide flufenacet is the most used PFAS pesticide in many countries, including France and Germany. It has been identified by the UBA as a major source of TFA and the UBA also notes that flufenacet is one of the few substances for which the formation of TFA has been proven in laboratory studies. Flufenacet is now being banned in the EU. This follows the conclusion from EFSA that concluded that TFA meets the criteria as an endocrine disruptor and they also identified a very high potential for groundwater contamination [9]. Banning flufenacet removes a significant source of TFA (from when the ban comes into effect in December 2026)

but other PFAS pesticides will remain in use. For example, oxyfluorfen has been found to be used more than flufenacet in Southern Europe and diflufenican and fluopyram are still sold in many Member States. In addition, Bayer proposes to replace Flufenacet with other PFAS pesticides. That is why PAN Europe is calling for all PFAS pesticides to be banned [10] (also see question 13).

The UBA, in a further report published in 2023 [11], also considered fertilisers a possible source of TFA due to livestock consumption of plant-based feeds (TFA is found in plants—see question 9) but found them to be a less important source than PPP.

According to the UBA several biocidal products and veterinary pharmaceuticals are also potential precursors for TFA including fipronil which is widely used in pet flea treatments. However, in Germany, for example, the lack of sales data for biocidal products makes it difficult to estimate the TFA emission potential of biocides and veterinary pharmaceuticals.

For human pharmaceuticals, a recent study identified the antiviral medication nirmatrelvir/ritonavir (brand name: Paxlovid), as a precursor for TFA. It has been granted authorisation in several countries for the treatment of patients with COVID-19 [12]. Other pharmaceutical drugs which are precursors for TFA include antidepressants and cancer treatments. The use of sewage sludge in agriculture makes pharmaceuticals another source of TFA contamination of groundwater.

3. Are there other sources of TFA in the EU?

Direct emissions from industrial production and processes are another source of TFA in addition to being formed by degradation (see questions 1 & 2). In the EU, TFA is registered under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation as a substance that is manufactured in and/or imported into the European Economic Area (EEA). ECHA lists volumes of TFA ranging from 100 to 1000 tons a year [13]. It is also used as an intermediate in processing of pharmaceuticals, for example, but this usage does not require the registration of production volumes meaning that the use of TFA could be higher than the official data suggests.

Solvay, located in Salindres, France, is an example of a manufacturer of TFA within the EU which has resulted in high levels of groundwater contamination near the site [14], although this plant is now due to cease manufacture of TFA.

Although the lack of monitoring data can make it hard to identify the exact sources of TFA, links have been made between TFA contamination and fluorinated surfactants used in military bases and airports to extinguish fires and the production of fluoropolymers such as Teflon. For example, the UBA identified that high levels of pollution in the River Neckar were correlated with being downstream of industrial fluorochemical plants [2].

However, the main sources of TFA are F-gases and pesticides (questions 1 & 2).

4. Can waste treatment also be a source of TFA?

A recent data review of TFA lists leachate from landfills and wastewater from sewage treatment plants as sources of TFA but notes that the main sources are indicated to be F-gases (see question 1) [1]. Analysis of TFA sources in Germany published by UBA in 2023 [11] concluded that “municipal wastewater treatment plants are not a main input pathway for TFA and that their influence on concentrations in surface waters is rather low”. TFA has been found in high

concentrations in landfill leachate in Sweden [12] and recent research indicates that some fluoropolymers (plastics) could be a source of TFA leaching [13]. More data is needed to fully understand the significance of waste treatment as a source of TFA.

5. Is it true that TFA is also formed naturally?

The European Fluorocarbons Technical Committee, representing the F-gas and chemicals industry, says TFA occurs naturally in large quantities deep in the oceans. But these assertions of natural formation have been disproved. Manufactured chemicals can be deposited deep in the ocean so their presence there doesn't mean they are naturally occurring. In addition, studies of Arctic ice cores show TFA levels have been rising sharply since F-gases replaced CFCs in the 1990s. Another study found no TFA in pre-industrial samples from Greenland and Denmark leading the authors to suggest that TFA is not a naturally occurring trace component of the freshwater environment [18]. The evidence that TFA levels are rising in surface waters and have been associated with point sources also suggest that they are associated with human activity. Professor Hans Peter H. Arp of the Norwegian University of Science and Technology, who has published several papers on TFA, concludes that there is no evidence of natural formation of TFA and told a Belgian news channel that "*There is no plausible mechanism for a natural formation of TFA. The current consensus is that it is entirely anthropogenic.*" [19].

6. What's the evidence that TFA is contaminating our environment?

TFA is highly soluble in water, so it easily enters the water cycle. There is increasing evidence that TFA is contaminating surface and groundwater. TFA has also been found to accumulate in plants and data shows that levels are rising rapidly, for example, in tree leaves (also see question 9) [20].

Evidence of water pollution includes a study in 2022 that found that TFA accounted for 90% of the total PFAS mass in drinking water sources in Germany (of 46 PFAS analysed) [21]. In 2024 a study by a group of European environmental organizations, including the Swedish Society for Nature Conservation, found PFAS in all of the 23 surface water and six groundwater samples from ten EU countries. More than 98 per cent of the total PFAS detected were TFA. The authors concluded that the TFA levels found in surface and groundwater represent the largest known area-wide water contamination by a synthetic chemical [22].

TFA contamination in surface water and in groundwater is reflected in concentrations now being found in drinking water, as TFA cannot easily be removed from raw water by the drinking water suppliers (see question 7). The risk to drinking water is illustrated by the above study which found 79% of the samples of surface and groundwater had TFA levels exceeding the new EU PFAS limit for drinking water (see question 7).

TFA's mobility is such that it is also found far away from sources. A study published in 2023 in Svalbard found that TFA represented 71% of the total mass of shorter-chains perfluorocarboxylic acid (PFCAs) found in the ice core. The study points to HFCs and other CFC replacement compounds as the TFA precursors [23].

The full extent of TFA contamination is unknown even in PFAS pollution 'hotspots' due to a lack of monitoring. As noted by the UBA " it is usually unknown in these cases whether and to what extent soils and groundwater have also been polluted with TFA, as in most cases only PFAS with a longer carbon chain are analysed." [2]

However, there is enough evidence of the accumulation of TFA in the environment for scientists to have described it as a “global threat” [1]

7. Is it true that TFA is commonly found in drinking water?

Monitoring for TFA needs to be improved but as more analysis is undertaken, evidence of widespread presence of TFA in drinking water across Europe is emerging:

- A study carried out by the Société Wallonne des Eaux (SWDE) – the water company - on behalf of the Walloon Region shows that TFA is present in 598 of the 642 areas tested, with some concentrations exceeding the guideline value of at 2.2 micrograms per litre (µg/L)/2200 nanograms per litre (ng/L). The highest concentration was 3100 ng/L [24].

- Monitoring by PAN, Global 2000 and others published in 2024 found TFA in 34 of 36 European tap water samples (94 %) from eleven EU countries and in 12 of 19 bottled mineral and spring waters (63 %). TFA was the dominant PFAS in the water samples. TFA values in tap water ranged from "undetectable" (corresponding to < 20 ng/L1) to 4,100 ng/L, with an average of 740 ng/L. TFA values in mineral and spring waters ranged from "undetectable" (< 20 ng/L) to 3,200 ng/L, with an average of 278 ng/L [25].

- The same NGO study reported that TFA has been measured regularly by the water companies in the Netherlands since 2018. According to a 2022 water quality report, the average levels of TFA in Dutch drinking water range from around 1,200 nanograms, with peaks up to 1,600 nanograms per litre.

- In Germany, a study by TZW tested 19 tap water samples from various places in Germany with different sources of drinking water and measured TFA concentrations ranging from < 0.05 to 2.5 µg/L [26]. In Germany, strongly polluted raw waters are blended with water from different, less polluted sources to meet the legal requirements at the time [a precautionary health-based limit of 3 µg/L in place at the time of these results has now been replaced by a health-based guide value of 60 µg/L] [2].

- The Swedish Society for Nature Conservation (SSNC) has analysed PFAS in tap water, finding TFA in most of the samples up to 870 ng/L. There is no limit value for TFA in Sweden [27].

- Analysis carried out for Greenpeace Italy showed widespread occurrence of TFA in the drinking water of Italian municipalities, with TFA found in 40 per cent of the samples [28].

8. Should I be worried about levels of TFA in drinking water?

In general, the fact of TFA widespread contamination is very worrying. Individual health risks are very difficult to assess and depend on the location. Some TFA levels found in drinking water exceed guideline levels set by EU member states to protect health (see question 7). The guideline levels currently vary by member state, and monitoring is still limited. However, emerging evidence of risks to health (see question 11) suggests that a precautionary approach should be taken to reduce our exposure to TFA through drinking water.

To date, no limits have been set by the WHO or EU specifically for TFA in drinking water, and hence monitoring has not been required. The forthcoming EU Drinking Water Directive limit for total PFAS is either 0.1 µg/l (micrograms per litre) for the sum of 20 selected PFAS ("sum of PFAS") which does not include TFA or 0.5 µg/l for the "total PFAS" which would include TFA.

Data show that in some places the presence of TFA alone in drinking water could result in the "total PFAS" limit being exceeded (see question 7). Member States are required to comply with one of these parameters by 12 January 2026. Meanwhile, guidance values by authorities and expert groups worldwide on 'safe' exposure levels to PFAS are continuously lowered as new knowledge emerges and several Member States have already based their national drinking water thresholds on these stricter health guidelines [29].

Some member states have set specific guideline levels for TFA in drinking water, but these vary significantly. For example, Germany has a threshold of 60 µg/L but the Walloon and the Dutch thresholds for TFA are both at 2.2 µg/L. The Flemish government has announced a health advisory value 15.6 µg/L [30]. The German Environment Agency raised its guideline level from 3 µg/L based on toxicological data from a study by chemical company Solvay. It points out that the new guideline "does not mean that TFA concentrations of up to 60 µg/L in drinking water are acceptable, only that they are not a cause of health concerns" [2]. This level could be lowered if TFA is classified as a reprotoxic substance (see question 11).

It's also important to note that humans are exposed to TFA and other PFAS through multiple sources including other drinks and food (see question 9) and that levels of exposure will keep rising unless action is taken.

9. Is it true that TFA is also found in juices, wine, infant food and lentils?

TFA can be found at higher concentrations in some plant-based food and drinks, compared to levels in drinking water, because of its ability to accumulate in plants. For example, analysis carried out by Eurofins in Sweden in 2024 on 27 samples of juices, drinks and purees for infants found significant levels of TFA in most of the products. In some samples the TFA guideline/limit values for drinking water that have been set in The Netherlands (NL), Denmark (DK) and Germany (DE) were exceeded in these products [31].

A study in 2021 also found TFA as a common contaminant in beer and tea/herbal infusions. In this case the authors pointed out that as TFA is an extremely persistent, and highly water-soluble substance, the source of high concentrations in plant-based beverages is likely to be via rainwater on the leaves, grains or blossoms [32]. TFA concentrations in wine have found to have increased over time with more recently produced wines having higher levels reflecting the trend of increasing environmental contamination with TFA [33].

Analysis of over 1,600 plant origin foodstuffs by European Reference Laboratories in 2017 found the widespread presence of TFA including elevated levels in dry pulses (e.g. soybeans and lentils) and leafy vegetables, as reported in a review of TFA studies [17].

However, food crops could also be taking up TFA via their roots. There is a lack of tests for uptake of TFA in plants but one study has shown exceptionally high root uptake for TFA compared to other perfluorocarboxylic acids (PFCAs) in wheat [34].

In response to proposals from Germany to classify TFA as a reproductive toxin (see question 12), EFSA is currently re-assessing it's guidance on acceptable exposure to TFA through food including the Acceptable Daily Intake (ADI) which could result in new guideline levels being set later in 2025 [35]. It should also be noted that exposure to TFA through food and drinks is in addition to exposure from other sources such as drinking water (question 8).

10. Can't we just remove TFA from our water and environment?

One of the major concerns about TFA is that it is virtually impossible to clean up. The German Environment Agency notes that "Removing TFA from water takes great effort. In drinking water production, no practicable and economical method exists for its removal" [2]. TFA is so mobile that normal filter methods don't work.

Reverse osmosis can be used in the treatment of industrial wastewater to reduce TFA contamination to a minimum before it is discharged into the environment but so far this is barely practised and is prohibitively expensive [1]. In addition, scientists have warned that even if TFA can be removed from water in this way, the TFA is transferred to a brine which will still need to be disposed of and so may end up in landfill, leading to environmental pollution, or in some cases being released into the ocean. The alternative approach of incineration can result in harmful byproducts including fluoroform, a potent greenhouse gas [1].

It's important that policymakers consider how to clean up existing pollution with TFA and other chemicals, but the reality is that it is extremely difficult and prohibitively expensive. The only real solution is to phase out the production of TFA and its precursors (see question 13).

11. TFA may be everywhere but is there any evidence that it will harm our health?

Potential impacts on human health from exposure to TFA are not yet well studied. However, there are indications from mammalian toxicity studies that TFA is toxic to reproduction and that it exhibits liver toxicity.

For example, a study in 2023 cites mild liver hypertrophy (increased size of the liver) in rats [36]. This study found that TFA was less toxic than other PFAS such as Perfluorooctanoic acid (PFOA) which is already banned in the EU, but even then, the 'safe level' derived from this research and adopted in the Netherlands is already being exceeded in drinking water (2.2 micrograms per litre). In addition, the German Federal Institute for Occupational Safety and Health and the German Environment Agency have proposed to classify TFA as toxic to reproduction (under Category IB presumed human reproductive toxicant) and as a PMT (persistent and mobile) and vPvM (very persistent and very mobile) substance. This is now under consideration by ECHA and out for public consultation [37].

The lack of further research on impacts is not a reason for complacency over the health impacts of TFA, despite industry claims that there is no evidence of harm. The evidence that we do have is enough reason for a precautionary approach to minimise exposures, especially given the increasing levels of human exposure to TFA through multiple sources. Scientists are also concerned that the testing done so far has been inadequate in understanding the real risks to our health. Hans Peter H. Arp of the Norwegian University of Science and Technology has pointed to the lack of longer-term studies on the toxicity of TFA pointing out that while M*ammalian exposure tests only last 60 or 90 days* human and wildlife exposure will be for a lifetime [19].

Whilst more research takes place, TFA levels continue to rise, increasing our exposure. Enough is already known about potential health effects for preventative action to be taken now (see question 13).

12. Will TFA harm nature?

It is becoming clearer that there is widespread contamination of the environment but little is known about its environmental impacts on ecosystems. Under the EU Classification, Labelling and Packaging (CLP) Regulation TFA is classified as harmful to aquatic life with long-lasting

effects. This is not surprising, as reported in a recent publication on the increasing threat from TFA, most ecotoxicity data is for aquatic systems [1].

The paper's authors point out that fewer data are available for terrestrial plants, yet this is where TFA bioaccumulates most readily. There are some studies on crop plants which were tested for ecotoxicity in the dossier of evidence for the EU REACH regulation. The long-term NOEC (No Observed Effect Concentration) determined in crops is already similar to background concentrations of TFA already found in soil and much lower than in contaminated hotspots, indicating possible impacts on crops and other plants that would stop them growing well. Detrimental effects on soil have also been detected including on soil pH, microbial respiration, bacterial abundance and litter decomposition, the latter at TFA concentrations similar to current TFA hotspots.

In addition, the authors point out that "most efforts toward the determination of ecotoxicity are from the 1990s" and most testing was for acute toxicity with only a few studies investigating the chronic (long term) toxicity of TFA. Yet, as the authors point out, "Given the persistence of TFA, exposure to TFA should be considered chronic and lifelong for all species" [1].

13. How should TFA be regulated?

CHEM Trust considers that reducing TFA pollution will best be achieved by stopping its source and regulatory action on PFAS is long overdue . Fortunately, there is already a proposal to do this - the EU universal PFAS restriction [38] will restrict the PFAS that are TFA precursors. The restriction, backed by a robust dossier of evidence, was proposed by Denmark, Germany, Sweden, the Netherlands, and Norway and is now being considered by the scientific committees in ECHA.

The foreseen restrictions on PFAS will have long transition times. Alternatives are already available or in development for key TFA precursors such as F gases. A recent study set out a thorough analysis of alternatives to F-gas refrigerants in Europe [7]. Alternatives to F-gases and other uses of PFAS are also described in a CHEM Trust Q&A about PFAS in the Green Transition [6] and in a briefing [39] about F-gases from the European Environmental Bureau (EEB), Deutsche Umwelthilfe (DUH) and ChemSec. The proposed PFAS restriction allows for transition times for some PFAS, including F-gases, and so would prompt innovation to find solutions over this period. Evidence from a cross-border investigation [40] and from Corporate Europe Observatory [41] has shown that certain sectors of the industry have lobbied for delays and the weakening of the universal PFAS restriction, including the exclusion of F-gases.

Bans on PFAS pesticides (which are not covered by the universal PFAS restriction) will also be required, and more information on this is provided by PAN Europe [42]. Alternatives must also be found for PFAS pesticides as part of a shift towards nature friendly farming such as agroecology as promoted by PAN Europe [43].

CHEM Trust's position on regulating all PFAS can be found here.

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