Cleaner Bentham Briefing Note – Bentham Allotments

24th June 2026

Introduction

In the June 2026 edition of the Bentham news, the Bentham Allotments Association Ltd Committee provided a news article on PFAS testing of soils at the allotment.

It is understood that testing was privately commissioned following sustained public concern regarding PFAS contamination and in light of Environment Agency guidance identifying PFAS as an emerging contaminant requiring assessment in settings where home-grown produce is consumed.

They stated that:

- An independent laboratory did the testing
- A suite of 54 different PFAS were tested for
- At four sampling sites

Results reported

	Highest ug/kg	Average ug/kg	Lowest ug/kg
PFOA		1	
Four others – not specified PFAS	0.39		0.11

The news report used the following DEFRA screening values:

DEFRA derived safe values for land which is used for 'Residential with consumption of homegrown produce' are :

- PFOA - 7.6 ug/kg
- PFOS - 13.0 ug/kg

The news report also states that " a PFAS expert who supplied the crucial fact that long-chain PFAS (those that are most persistent and most damaging, including PFOS and PFOA) have NOT been found to accumulate in fruit and vegetables.

The news article concluded that data "confirmed the safety of eating food grown on our allotments site".

CB Assessment

Use of an independent laboratory is likely to have used suitable sampling methods and protocols to avoid cross contamination.

The size of the allotments is not specified, but four samples may be adequate for preliminary screening, although a larger number would normally be expected for a statistically robust risk assessment.

Importantly, the depth of the samples is not specified. Taking samples from 1m below ground would have very different results from samples taken from 0.0-0.05m below ground.

PFAS concentrations typically decrease with depth; therefore, shallow sampling (0.0–5 cm) is required to assess exposure relevant to gardening and ingestion pathways.

The suite of 54 PFAS chemicals is not specified but it probably reasonable. However, a consultant would have checked that the suite included the full range of PFAS chemicals identified at the Angus Bentham site in multiple phases of previous testing.

Screening Values

The DEFRA screening values quoted in the Bentham news are NOT DEFRA values.

These two numbers do NOT come from any published DEFRA, S4UL, or Environment Agency document. No DEFRA or Environment Agency publication contains these values.

The normal screening values to use in the U.K. would be the U.K. CL:AIRE 2024 interim Category 4 screening levels for allotments.

It is noted that the DEFRA values incorrectly quoted match the CL:AIRE C4SL values for residential with consumption of homegrown produce. Therefore, as well as being incorrectly attributed to DEFRA, the incorrect scenario for the screening values was used by the Allotments committee. CL:AIRE publishes C4SLs in mg/kg; the Bentham News article converted these to µg/kg but incorrectly attributed them to DEFRA.

Land Use Interim C4SLs (ug/kg)	PFOA	PFOS	PFHxS	PFNA
Residential with consumption of homegrown produce	7.6	13	8.1	7.3
Residential without consumption of homegrown produce	41	41	41	41
Allotments	1.4	2.7	1.5	1.3
Commercial	600	600	600	600
Public Open Space (Residential)	79	79	79	79
Public Open Space (Park)	170	170	170	170

Comparison of the published Bentham allotments concentrations with the CL:AIRE 2024 C4SLs is summarised in the table below:

	Highest ug/kg	Average ug/kg	Lowest ug/kg	CL:AIRE C4SL ug/kg	Notes
PFOA		1		1.4	Average is below
Four others – not specified PFAS	0.39		0.11	1.3 (conservative selected value)	All results below

Without identification of the specific PFAS, it is not possible to compare these values to the appropriate C4SLs for those compounds. C4SLs are risk-based screening values, not pass/fail safety limits. Exceedance triggers further assessment, not automatic prohibition.

It is noted that the PFOA average value was noted in the Bentham news, and no maximum concentration was reported. Because the maximum PFOA concentration was not reported, it remains possible that one or more samples exceed the 1.4 µg/kg CL:AIRE allotment C4SL.

Bioaccumulation

A literature review (see below) was undertaken regarding bioaccumulation of PFAS chemicals in vegetables grown in contaminated soils. This concluded that :

The current literature provides clear evidence that PFAS, including PFOS and PFOA, bioaccumulate in vegetables grown in PFAS contaminated soils.

Given that PFOS and PFOA bioaccumulate in vegetables at soil concentrations comparable to those measured at Bentham, the claim that long-chain PFAS do not accumulate in produce is not supported.

The Bentham allotment committee advise in the news report that they have been working with "a PFAS expert", but no name is specified. Given the incorrect attribution of the CL:ARE 2024 screening values to DEFRA, and the incorrect use of a residential scenario instead of the allotments scenario, the accuracy of the advice provided is questioned although it is not stated that the expert provided any advice on screening values.

Critically, the news report states that " a PFAS expert who supplied the crucial fact that long-chain PFAS (those that are most persistent and most damaging, including PFOS and PFOA) have NOT been found to accumulate in fruit and vegetables.

This reported crucial fact is not supported by the academic literature review provided below.

The use of an incorrect land-use scenario and incorrect attribution materially affects the interpretation of risk.

Recommendations

Discussion of the safety of the use of the allotments is not best discussed in the media.

It is regrettable that the allotment committee had to find funding for the testing and attempt to understand complex data and risk assessment themselves.

It is understood that at Thornton-Cleveleys, the Environment Agency commissioned testing of the allotments and the vegetables which it is assumed was supported by competent professional interpretation.

At the Bentham Town Hall public meeting in 2025, testing of the allotments was specifically called for, with the request directed to the panel, including the Environment Agency.

Targeted testing of edible plant tissues (leafy, root, and fruiting vegetables) should be undertaken to directly assess dietary exposure. This assessment should be undertaken before any definitive statements about the safety of produce are made.

In an email from the Bentham Allotments Association, they state: *"If an official scientific survey of PFAS in Bentham is commissioned, by a body democratically representative of the community, such as the Town or District Council, we would be happy to supply our testing report to add to the study."*

Considering the Bentham Town Council have written to the Environment Agency requesting the formation of a "Multi-disciplinary committee" (as verbally recommended by the MPs on the Parliamentary day in Lancaster, and as stated in their PFAS report to Parliament), it is recommended that further evaluation is required. A multi-disciplinary team should have the technical expertise to provide a definitive answer to the questions raised herein. Specifically:

- Do any soil samples exceed the CL:AIRE C4SL screening values for allotments.
- Do the PFAS chemicals bioaccumulate in the produce being grown.
- Is it "safe" to eat produce grown in the Bentham allotments.

A single authoritative communication should be issued once the multidisciplinary review is complete, to avoid conflicting or inaccurate public messaging. The current absence of an authorised body leaves public concern on this matter and many other related matters an ongoing concern which needs resolution for the benefit of the Bentham community.

It is noted that consumption of home grown produce is only one possible PFAS exposure pathway, when historically multiple pathways existed. Users should therefore consider, that if they have had a long history of PFAS exposure via these multiple pathways, if they wish to further expose themselves to even very low levels via consumption of home grown produce.

PFAS bioaccumulation in vegetables grown in contaminated soil: an academic literature review

1. Introduction

Per- and polyfluoroalkyl substances (PFAS), including perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), are highly persistent anthropogenic contaminants increasingly detected in agricultural soils via biosolid application, irrigation with contaminated water and atmospheric deposition (Ghisi et al., 2019). PFAS occurrence in edible crops has raised concern about dietary exposure as a significant pathway for human intake (Blaine et al., 2013; Zhao et al., 2014). This review synthesises current evidence on PFAS uptake and bioaccumulation in vegetables grown in PFAS-contaminated soils, with emphasis on PFOS and PFOA.

2. Mechanisms of plant uptake and internal distribution

2.1 Root uptake from soil pore water

PFAS are primarily taken up by roots from soil pore water and transported with the transpiration stream (Stahl et al., 2011; Ghisi et al., 2019). Their anionic character and surfactant properties favour movement in the apoplast, although specific membrane transporters have not yet been conclusively identified (Ghisi et al., 2019). Sorption to soil organic matter and mineral surfaces reduces the freely dissolved fraction, particularly for long-chain PFAS such as PFOS and long-chain perfluoroalkyl carboxylates, whereas short-chain PFAS exhibit weaker sorption and higher mobility, increasing their bioavailability for root uptake (Blaine et al., 2013; Navarro et al., 2017).

2.2 Translocation and tissue distribution

Translocation from roots to shoots is strongly chain-length dependent. Short-chain PFAS (e.g. PFBA, PFHxA) are more readily transported to above-ground tissues, while long-chain PFAS (e.g. PFOS, long-chain PFCAs) tend to accumulate in roots with limited upward movement (Stahl et al., 2011; Ghisi et al., 2019). Functional group also plays a role: sulfonates such as PFOS generally show stronger sorption and lower mobility than carboxylates such as PFOA of comparable chain length, resulting in higher root retention and lower shoot concentrations for PFOS relative to PFOA (Lechner and Knapp, 2011; Ghisi et al., 2019).

3. Bioaccumulation patterns in vegetables

3.1 Bioaccumulation factors and organ-specific trends

Across multiple studies, a consistent hierarchy of bioaccumulation factors (BAFs) within plants has been reported: root BAF > stem/straw BAF > grain/fruit BAF (Stahl et al., 2011; Ghisi et al., 2019). A recent synthesis of PFAS in crops indicates that leafy vegetables generally exhibit higher PFAS concentrations in edible tissues than root or fruiting vegetables grown under comparable contamination levels (Ghisi et al., 2019). This pattern reflects both higher translocation of more mobile PFAS to foliage and high transpiration rates in leafy species.

3.2 Leafy vegetables

Experimental work on lettuce, spinach and other leafy vegetables grown in PFAS-contaminated soils or irrigated with PFAS-contaminated water consistently shows substantial accumulation of PFAS in leaves (Blaine et al., 2013; Navarro et al., 2017). Short-chain PFAS such as PFBA often dominate the PFAS profile in foliage, but PFOA and PFOS are also frequently detected (Stahl et al., 2011; Ghisi et al., 2019). Given both elevated concentrations and high consumption rates, leafy vegetables are repeatedly identified as major contributors to dietary PFAS exposure in impacted agricultural systems (Blaine et al., 2013; Zhao et al., 2014).

3.3 Root vegetables

Root crops (e.g. carrots, potatoes, radishes) show significant accumulation of long-chain PFAS in below-ground tissues, reflecting strong sorption and limited translocation (Lechner and Knapp, 2011; Ghisi et al., 2019). PFOS concentrations are often higher in roots than in shoots, whereas PFOA tends to display a more even distribution between roots and above-ground tissues (Lechner and Knapp, 2011). Although concentrations in root vegetables may be lower than in leafy vegetables for some PFAS, they can still contribute substantially to dietary exposure where soil contamination is high (Zhao et al., 2014).

3.4 Fruits and grains

Translocation of PFAS into reproductive tissues (fruits and grains) is generally lower than into leaves and roots, resulting in smaller BAFs for these organs (Stahl et al., 2011; Ghisi et al., 2019). Nevertheless, measurable levels of PFOA, PFOS and other PFAS have been reported in cereals and fruiting vegetables in contaminated regions, indicating that reproductive tissues are not exempt from PFAS uptake (Zhao et al., 2014; Navarro et al., 2017).

4. PFOS and PFOA in vegetable tissues

4.1 PFOS

PFOS exhibits strong sorption to soil and plant tissues, leading to pronounced root accumulation and limited shoot translocation (Lechner and Knapp, 2011; Ghisi et al., 2019). Pot and field studies demonstrate detectable PFOS in roots, stems and leaves of vegetables grown on contaminated soils, confirming bioaccumulation despite its relatively low mobility (Stahl et al., 2011; Navarro et al., 2017). Root-to-shoot concentration ratios for PFOS are typically higher than for PFOA, consistent with its stronger sorption and lower xylem mobility (Lechner and Knapp, 2011).

4.2 PFOA

PFOA is more water-soluble and mobile than PFOS and is frequently reported as a predominant PFAS in both soil and plant tissues in contaminated agricultural environments (Lechner and Knapp, 2011; Blaine et al., 2013). Its higher translocation efficiency results in appreciable concentrations in leafy tissues and, to a lesser extent, fruits and grains (Stahl et al., 2011; Navarro et al., 2017). Consequently, PFOA is often a key driver in dietary exposure assessments involving vegetables grown on PFAS-impacted soils (Blaine et al., 2013; Zhao et al., 2014).

5. Determinants of bioaccumulation

5.1 Soil properties

Soil organic matter and clay content enhance sorption of long-chain PFAS, reducing their immediate bioavailability but potentially acting as long-term reservoirs that sustain plant exposure over time (Blaine et al., 2013; Ghisi et al., 2019). Soil pH and ionic strength further influence PFAS speciation and sorption behaviour; increased ionic strength can promote sorption and reduce plant uptake for some PFAS species (Ghisi et al., 2019).

5.2 Plant traits

Species-specific differences in root architecture, transpiration rate and tissue composition affect PFAS uptake and distribution (Stahl et al., 2011; Ghisi et al., 2019). High-transpiration leafy vegetables tend to accumulate more mobile PFAS in foliage, while deep-rooted species may access PFAS at greater soil depths (Navarro et al., 2017). Variability among species suggests that plant physiological traits and membrane transport characteristics play important roles, although mechanistic understanding remains incomplete (Ghisi et al., 2019).

5.3 PFAS structural diversity

Chain length and functional group jointly determine sorption, mobility and bioaccumulation. Short-chain perfluoroalkyl carboxylates are generally more mobile and more likely to reach edible leaves, whereas long-chain sulfonates such as PFOS are more strongly retained in roots and soil (Stahl et al., 2011; Ghisi et al., 2019). This structural dependence underpins observed differences in tissue distribution between PFOS, PFOA and other PFAS.

6. Dietary exposure and risk

Integrative assessments combining plant concentration data with food consumption patterns conclude that vegetables can be a significant PFAS exposure pathway in contaminated regions (Blaine et al., 2013; Zhao et al., 2014). Leafy vegetables often dominate estimated daily intake due to both higher PFAS concentrations and higher consumption rates (Blaine et al., 2013). PFBA, PFOA and PFOS are repeatedly highlighted as compounds of concern because of their environmental prevalence, plant uptake and toxicological relevance (Ghisi et al., 2019; Zhao et al., 2014).

7. Knowledge gaps

Despite substantial progress, several gaps remain:

- **Mechanistic understanding:** Molecular-level characterisation of PFAS transporters, binding sites and sequestration in plant tissues is limited (Ghisi et al., 2019).
- **Mixture and co-contaminant effects:** Most real soils contain complex PFAS mixtures and other contaminants; interactions and competitive uptake effects are poorly understood (Navarro et al., 2017).
- **Long-term field data:** Many available data derive from short-term pot experiments; long-term field studies under realistic agronomic conditions are comparatively scarce (Blaine et al., 2013; Ghisi et al., 2019).

8. Conclusion

The current literature provides clear evidence that PFAS, including PFOS and PFOA, bioaccumulate in vegetables grown in PFAS-contaminated soils. Root uptake from soil pore water is well established, and subsequent translocation leads to measurable concentrations in roots, stems and leaves (Stahl et al., 2011; Ghisi et al., 2019). Leafy vegetables generally show the highest PFAS levels in edible tissues, while root vegetables and fruits/grains also contain detectable PFAS (Blaine et al., 2013; Zhao et al., 2014). Structural properties of PFAS, soil characteristics and plant traits jointly determine bioaccumulation patterns. Consequently, PFAS-contaminated soils represent a credible and, in some settings, significant pathway for human exposure via vegetable consumption.

References

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