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PFAS in Biota:
Risk Context & Robust Analytical Solutions

The analysis of biota (all living organisms) as an indicator of environmental pollution is a fundamental practice known as **biomonitoring** or **bioindication**. This approach assesses environmental quality (air, water, soil) by studying the responses of living organisms (bioindicators) to environmental pollution. Because of a persistence and bioaccumulative potential of PFAS, fish and shellfish are crucial subjects in this practice, serving as bioaccumulators whose tissue concentrations reflect the level of PFAS contamination in the environment.

Figure 1: Illustrative picture

Current and Future EU Legislation

The EU's regulatory approach to PFAS in biota is generally tightening. Under Directive 2013/39/EU 1 only PFOS is listed as a priority substance in the aquatic environment, with a biota (fish) Environmental Quality Standard (EQS) of 9.1 µg/kg wet weight. However, food safety standards have tightened significantly. Since 2023, Regulation (EU) 2023/915 2 has set maximum levels for the sum of four PFAS (PFOA, PFOS, PFNA, and PFHxS) in various foodstuffs. While the default maximum level for fish meat is generally set at 2.0 µg/kg wet weight, the regulation accounts for the significant inter-species variability in bioaccumulation and environmental exposure. Contamination limits are tiered by species to reflect varying levels of bioaccumulation. For instance, while Atlantic salmon is set at 5.0 µg/kg, thresholds for other species like whitefish or burbot can reach up to 45 µg/kg. These variations account for different habitats and positions in the food chain.

Looking ahead, the EU is moving toward a group-based approach to environmental protection. A proposed amendment to the Water Framework Directive would expand monitoring to PFAS as a group. This shift reflects EFSA's latest scientific findings on the bioaccumulation and combined toxicity of these "forever chemicals." It marks a transition from regulating individual substances to managing the entire chemical class, to ensure a high level of protection for both human health and aquatic ecosystems.

LINK 1 LINK 2

How PFAS Contaminate Biota

Water and Soil Contamination:

PFAS are released into the environment from various sources, including industrial facilities, landfills, and firefighting foams. Short chain PFAS are highly mobile and persist in surface water and groundwater, whereas many long chain PFAS sorb to organic matter and accumulate in sediments.

Bioaccumulation in the Aquatic Food Chain:

Aquatic organisms such as fish and shellfish absorb PFAS from the water and contaminated food sources, accumulating them in their tissues. This accumulation is often magnified along the food chain (biomagnification), particularly for long chain PFAS (e.g., PFOS) in predatory fish.

Contamination of Terrestrial Animals:

In affected areas, animals are exposed through drinking water, feed, and soil or dust. PFAS bind to proteins and accumulate primarily in the blood and liver. Transfer to animal derived products (e.g., milk and eggs) may occur.

Crop Contamination:

Plants grown in contaminated soil or irrigated with contaminated water can absorb PFAS. Uptake rates vary; shorter chain PFAS are generally taken up more readily by roots, facilitating their entry into the terrestrial food chain.

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(How PFAS Contaminate Biota)

Additional Pathways and Considerations:

PFAS precursors can transform into persistent perfluoroalkyl acids (PFAAs), such as PFOS and PFOA, increasing body burdens in biota over time. Sediments and benthic organisms represent key exposure pathways in aquatic systems. Atmospheric transport and deposition contribute to soil and water contamination; additionally, land application of biosolids and the use of contaminated irrigation water can introduce PFAS into agricultural systems.

Impact on Biota

Accumulation Over Time:

Because of their chemical stability and slow elimination, many long chain PFAS persist in organisms, and their concentrations can increase over time. They bind to proteins and tend to accumulate in the blood and liver, as well as in eggs. Biomagnification can occur at higher trophic levels.

Potential Health Effects:

PFAS exposure in wildlife is associated with immune suppression; endocrine and thyroid disruption; altered lipid metabolism and liver toxicity; and developmental and reproductive effects (e.g., reduced hatching success). With respect to cancer, the International Agency for Research on Cancer (IARC) classifies PFOA as carcinogenic to humans (Group 1) and PFOS as possibly carcinogenic to humans (Group 2B).

Maternal Transfer and Life Stage Sensitivity:

PFAS can be transferred from adults to offspring through eggs and lactation, making early life stages particularly vulnerable.

Monitoring and Biomagnification Patterns

Wild fish and invertebrates across the EU have measurable PFAS body burdens (PFOS and PFCAs) in the tens to low hundreds of µg/kg (wet weight). Marine top predators often exhibit elevated PFOS levels relative to biota EQS values. Biomagnification patterns vary among compounds, but several long chain PFAS bioaccumulate.

Analytical Methods

ALS Laboratories uses ISO/IEC 17025 accredited LC–MS/MS method to determine PFAS in biota, which serve as critical indicators of environmental contamination. This method have been rigorously validated across a wide range of matrices, including fish and other seafood (bivalves, crustaceans, cephalopods), meat, eggs, milk, and various plant tissues.

Sample Logistics and Handling:

To preserve analyte integrity and prevent biological degradation, strict transport protocols are followed. Samples should be shipped via overnight courier. If shipped frozen, they must be transported in a way that ensures they remain frozen throughout transit.

Sample Weight:

Although the laboratory can process as little as 10 g, we recommend submitting 50 g of sample to ensure representativeness. To obtain a stable, uniform test portion, samples are freeze-dried (lyophilized) and then thoroughly homogenized. This process stabilizes the matrix and preconcentrates analytes, enabling trace-level detection.

Extraction and Analysis:

The analytical workflow uses a modified QuEChERS extraction to ensure efficient analyte recovery, followed by a solid phase extraction (SPE) cleanup to remove matrix interferences. Final separation and detection are performed on state of the art UHPLC–MS/MS instrumentation (ExionLC™ coupled to a SCIEX QTRAP® 6500).

Quantitation:

The concentration of each PFAS is determined by internal standard calibration. Response ratios are related to the concentration ratios of the native analytes and their corresponding isotopically labeled internal standards, providing robust correction for potential matrix effects and ensuring high accuracy and precision.

▶ **Continues on the next page**
(List of Target PFAS)

References

LINK Teunen et al.: PFAS accumulation in indigenous and translocated aquatic organisms from Belgium, with translation to human and ecological health risk. Environ Sci Eur (2021) 33:39

LINK Byns et al.: Bioaccumulation and trophic transfer of perfluorinated alkyl substances (PFAS) in marine biota from the Belgian North Sea: Distribution and human health risk implications. Environmental Pollution 311 (2022) 119907

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List of Target PFAS

LOQ: Limit of Quantification (µg/kg)

Parameter	Abbreviation	LOQ (µg/kg)
Perfluoroalkyl Carboxylic Acids		
Perfluorobutanoic acid	PFBA	1
Perfluoropentanoic acid	PFPeA	0.1
Perfluorohexanoic acid	PFHxA	0.1
Perfluoroheptanoic acid	PFHpA	0.1
Perfluorooctanoic acid	PFOA	0.1
Perfluorononanoic acid	PFNA	0.1
Perfluorodecanoic acid	PFDA	0.1
Perfluoroundecanoic acid	PFUnDA	0.1
Perfluorododecanoic acid	PFDoDA	0.1
Perfluorotridecanoic acid	PFTrDA	0.1
Perfluorotetradecanoic acid	PFTeDA	0.1
Perfluorohexadecanoic acid	PFHxDA	0.1
Perfluoroalkane Sulfonic Acids		
Perfluorobutane sulfonic acid	PFBS	0.1
Perfluoropentane sulfonic acid	PFPeS	0.1
Perfluorohexane sulfonic acid	PFHxS	0.1
Perfluoroheptane sulfonic acid	PFHpS	0.1
Perfluorooctane sulfonic acid	PFOS	0.1
Perfluorononane sulfonic acid	PFNS	0.1
Perfluorodecane sulfonic acid	PFDS	0.1
Perfluoroundecane sulfonic acid	PFUnDS	0.1
Perfluorododecane sulfonic acid	PFDoDS	0.1
Perfluorotridecane sulfonic acid	PFTrDS	0.1
Perfluoroalkyl Sulfonamides		
Perfluorooctane sulfonamide	PFOSA	0.1
Fluorotelomer Sulfonic Acids		
4:2 Fluorotelomer sulfonic acid	4:2 FTS	0.1
6:2 Fluorotelomer sulfonic acid	6:2 FTS	0.1
8:2 Fluorotelomer sulfonic acid	8:2 FTS	0.1
Other PFAS		
2,3,3,3-Tetrafluoro-2-(heptafluoropropoxy) propanoic acid	HFPO-DA (GenX)	0.1
7H-Perfluoroheptanoic acid	HPFHpA	0.1
Perfluoro-3,7-dimethyloctanoic acid	P37DMOA	0.1