FACT SHEET

EPA Study Shows Aluminum Foil is an Unlikely Source of Mercury, PFAS, or PCB Contamination in Field-wrapped Fish Samples

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Fish tissue contaminant studies require careful sample handling, wrapping, and storage to reduce the chance of cross-contamination. For more than 20 years, the Environmental Protection Agency (EPA) instructed partners of its human health fish tissue studies to wrap fish specimens in solvent-rinsed aluminum foil (Figure 1) before packing them in a polyethylene bag and freezing them until they could be analyzed. However, the precautionary step of rinsing the foil with methylene chloride before providing it to field crews costs up to $100 per sampling site and may not be necessary to reduce the chance of cross-contamination. The objective of this study was to test whether "untreated" heavy-duty food-grade aluminum foil can be used instead of solvent-rinsed foil.



Figure 1: A field biologist wraps a fish in aluminum foil

Results: The results of this study indicate that aluminum foil used to wrap fish samples is not a likely source of mercury, per- and polyfluoroalkyl substances (PFAS), or polychlorinated biphenyl (PCB) contamination, whether the foil is solvent-rinsed or not. Therefore, the substantial costs of providing solvent-rinsed foil for wrapping fish samples could be avoided, with no loss of data quality, by providing a roll of off-the-shelf heavy-duty foil to each field team. The cost savings could be more than $50,000 for a national-scale study.

Background: The decision to require fish to be wrapped in solvent-rinsed foil may have originated because the EPA's early fish tissue studies tested for semivolatile organic compounds and there were concerns that some of those chemicals might have been used as lubricants during the aluminum foil manufacturing process, which could potentially contaminate fish samples. Due to that concern, the EPA took the cautious approach of providing solvent-rinsed foil to the field crews because these chemicals would likely be removed by the organic solvent.

The EPA's standard operating procedure for foil preparation states that each piece of foil must be rinsed in methylene chloride, oven dried at 450 °C in a fume hood, carefully folded, and sealed in a plastic bag. Methylene chloride was chosen as the solvent because the semivolatile organic compounds that were of concern at the time are highly soluble in that commonly used solvent. The cost of foil preparation has risen sharply over time, reaching nearly $20 per sheet or $100 per sampling site. It has become increasingly difficult to find laboratories willing to devote the space, equipment, and labor for the solvent-rinsing process, as well as managing the health risks and disposal costs associated with using methylene chloride. Because very few semivolatile organic compounds have been detected in fish samples, the EPA's fish tissue studies no longer test samples for these analytes, and the original concerns may not be relevant.

To obtain the information to justify eliminating the added step of solvent-rinsing foil, the EPA initiated a study in 2023 to evaluate whether solvent-rinsed foil is necessary for future fish tissue studies (i.e., to reduce the chance of cross-contamination of total mercury, PFAS, or PCBs), with the goal of completing the evaluation before the 2025 National Coastal Condition Assessment sampling season.

What were the objectives of the aluminum foil rinsate study?

The EPA investigated whether the use of solvent-rinsed foil is necessary for future fish tissue studies to avoid cross-contamination or whether the use of "untreated" food-grade aluminum foil can provide reliable results instead. The study provided valuable information that can be used by monitoring program managers and academic researchers to reduce field supply costs.

How were the aluminum foil rinsate samples prepared and analyzed?

The study compared three replicate rinsate samples produced from three different types of aluminum foil for three analyte classes. Equal-sized sections of aluminum foil (6" x 6") from each of three foil types were placed in glass dishes and immersed in solvents to produce 27 rinsate samples which were analyzed for mercury, PFAS, and PCBs (i.e., 3 foil types x 3 analyte classes x 3 replicate rinsates using a solvent specific to each analyte class). Samples of the three solvents were also analyzed (as solvent blank samples) for mercury, PFAS, and PCBs to screen for background contaminant levels (Figure 2).

- **Three foil types** were compared: 1) prerinsed name-brand heavy-duty foil that had been rinsed with methylene chloride and dried in an oven, 2) untreated name-brand heavy-duty foil, and 3) untreated generic heavy-duty foil.
- **Three analyte-specific solvents** were used to prepare separate (replicate) rinsate samples for each foil type and for each of three analyte classes by immersing each individual sheet of foil for one minute in the solvent specific to the analyte class. The three solvents were chosen because of their ability to solubilize the three classes of analytes on interest.
- **Twenty-seven rinsate samples** were analyzed to screen for background contaminant levels: deionized water rinsate samples were analyzed for the presence of mercury (EPA Method 1631E), methanol rinsate samples were analyzed for 40 PFAS (EPA Method 1633), and methylene chloride rinsate samples were analyzed for 209 PCB congeners (EPA Method 1668C).

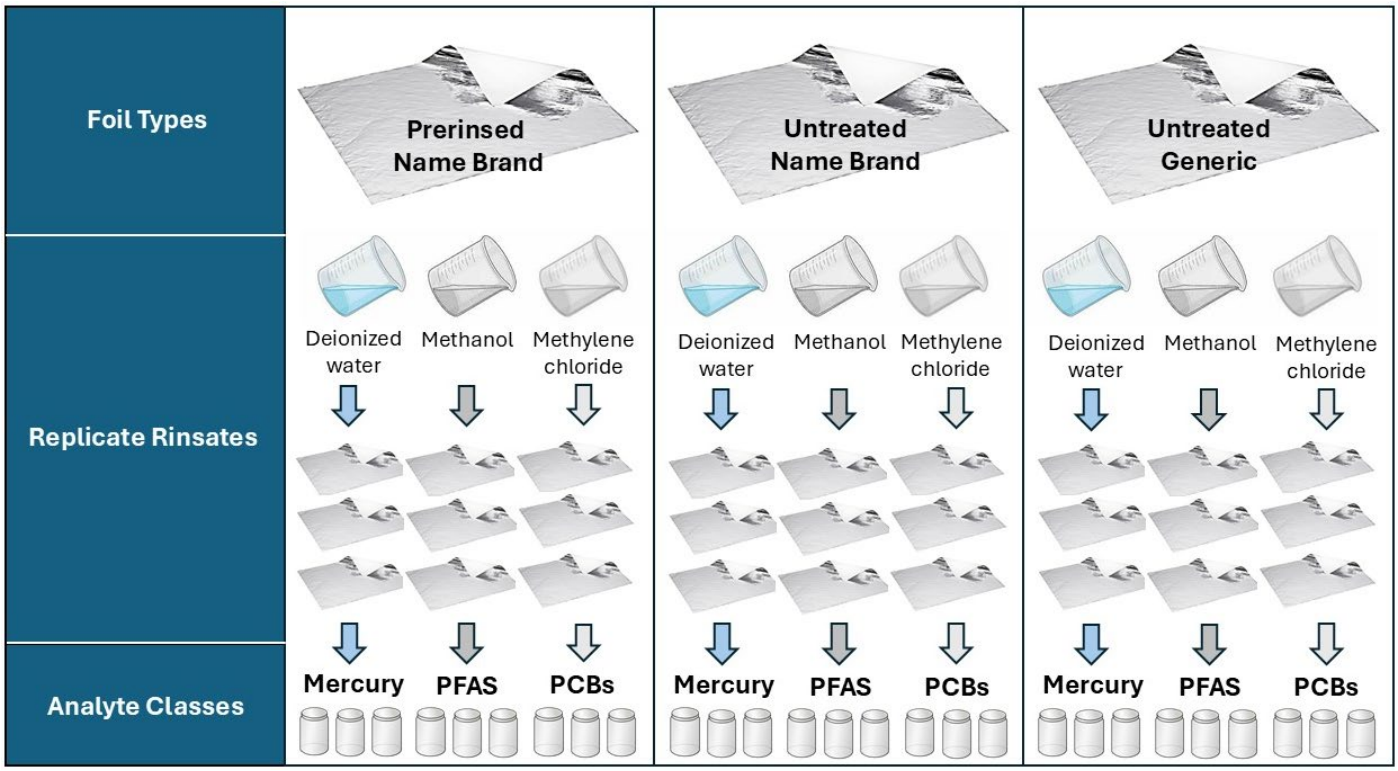


Figure 2: Process of making 27 rinsate samples composed of three sample replicates for each combination of foil type and solvent specific to each analyte class (mercury, PFAS, and PCBs).

Were mercury, PFAS, and PCB results similar between solvent-rinsed foil and untreated foil?

The study was designed to evaluate whether the rinsates for all three types of foil have similar concentrations of mercury, PFAS, and PCBs. Results from the treated foil were compared to results from both types of untreated foil to determine whether there was a significant difference in concentrations of the target contaminants (if present). As described further below, the study results showed that there were no notable differences between the analyte concentrations in the rinsates from the three types of foil.

Mercury: Low levels of mercury were detected in all nine rinsate samples with some variability across the samples, but mercury was not detected in the solvent blank sample. An analysis of variance (ANOVA) was used to compare the mean concentrations from each of the groups of rinsate samples associated with each foil type. Results showed that there was no significant difference between the mercury concentrations in the rinsates from the three types of foil (Table 1).

PFAS: Of the 40 target PFAS, only six were detected in any of the rinsate or solvent blanks samples: PFBA, PFPeA, PFHxA, PFHpA, PFOA, and PFNA. The remaining 34 PFAS, including PFOS, were never detected. The PFAS solvent blank results were sometimes higher than the rinsate results suggesting that the methanol used to rinse the foil may have been the source of low levels of five of the six PFAS detected in the rinsates and necessitating a blank subtraction. ANOVAs for the six detected PFAS showed similar results to those for mercury with no significant differences between the rinsates from the three types of foil using either the original rinsate results or the blank-subtracted rinsate results (Table 1).

PCBs: Only one of the 209 PCB congeners was found in any of the nine foil rinsate samples using a method with PCB detection limits at single-digit picogram levels. PCB-178 was reported at 2.97 pg in one rinsate sample from the untreated generic foil. No other congeners were found in *any* of the nine rinsate samples. Therefore, no statistical analyses of the PCB results were necessary to compare the three types of foil.

Table 1: ANOVA Results for Mercury and Detected PFAS

	Source of Variation	Sum of Squares	Degrees of Freedom [1]	Mean Squares	F ratio [2]	P-value	$F_{critical}$
Mercury	Between Groups	0.23	2	0.12	4.40	0.07	5.14
	Within Groups	0.16	6	0.03			
	Total	0.39	8				
PFBA	Between Groups	788.67	2	394.33	1.26	0.35	5.14
	Within Groups	1879.87	6	313.31			
	Total	2668.54	8				
PFPeA	Between Groups	95.82	2	47.91	1.10	0.39	5.14
	Within Groups	260.62	6	43.44			
	Total	356.44	8				
PFHxA	Between Groups	18.09	2	9.04	1.06	0.40	5.14
	Within Groups	51.03	6	8.51			
	Total	69.12	8				
PFHpA	Between Groups	3.23	2	1.61	0.96	0.44	5.14
	Within Groups	10.10	6	1.68			
	Total	13.33	8				
PFOA	Between Groups	2.27	2	1.13	1.37	0.32	5.14
	Within Groups	4.97	6	0.83			
	Total	7.24	8				
PFNA	Between Groups	0.42	2	0.21	0.43	0.67	5.14
	Within Groups	2.90	6	0.48			
	Total	3.32	8				

[1] Degrees of freedom "between groups" refers to the number of groups being compared (i.e., 3) minus one. Degrees of freedom "within groups" represents the total observations (i.e., 9) minus the number of groups being compared (i.e., 3).

[2] The calculated values for the F ratio are less than the $F_{critical}$ values, so there is no statistically significant difference between the mercury and PFAS concentrations in rinsates from the three types of foil that might be used to wrap fish samples.

The null hypothesis was that the rinsates for all three types of foil would have the same contaminant concentrations. For all seven contaminants, the calculated value for F (ratio of mean squares) was less than the $F_{critical}$ value, so the null hypothesis could not be rejected, and the conclusion was that **there was no statistically significant difference** between the contaminant concentrations in the rinsates from the three types of foil.

Based on the mercury and PFAS rinsate sample results, the EPA estimated the "worst-case" amounts of mercury and PFAS that could be present on the larger 18"x48" sheets of foil provided to field crews assuming all of the contaminant was transferred to 50 grams of fish fillet tissue. Even under those conservative assumptions, any mercury transferred from the foil to the tissue would be too low to be detected. Among the six PFAS found in the rinsates, only PFPeA would be barely detectable in the tissue (the other five PFAS would be too low to be detected). Since PFPeA has rarely been detected in fish fillet tissue samples in previous studies, the EPA concluded that PFPeA contamination from foil was not likely to occur. Given the lack of PCB congeners detected in the rinsates, the EPA also concluded that PCB contamination from foil was not likely to contribute additional PCBs to those detected in the fillet tissue.

What are the implications for future fish tissue contaminant studies?

The results of this study indicate that the aluminum foil used to wrap fish samples is not a likely source of mercury, PFAS, or PCB contamination of the fish, whether the foil is solvent-rinsed or not. Therefore, the substantial costs of providing solvent-rinsed foil for wrapping fish samples can be avoided with no loss of data quality by providing a roll of off-the-shelf heavy-duty foil to each field team. The expected cost savings could be as high as $100 per sampling site, and more than $50,000 for a national-scale study. As a result of this study, the EPA revised its field sampling procedures, replacing solvent-rinsed foil with a roll of generic-brand heavy-duty foil.

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