

Addendum to the risk assessment of PFAS and PBDEs in FOGO and GO composts (2020–21)

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1. Background and objective

In August 2021, the Environment, Energy and Science Group¹ – Contaminants and Risk Team (C&R) of the NSW Department of Planning and Environment completed a draft human health risk assessment for per and polyfluoroalkyl substances (PFAS) and polybrominated diphenyl ethers (PBDEs) in food organic and garden organic (FOGO) compost and garden organic (GO) compost, the *Risk assessment of PFAS and PBDEs in food organics and garden organics composts (2020–21)* (referred to hereafter as the original risk assessment; DPE 2023). The original risk assessment focused on key exposure pathways of egg, meat and milk consumption. In the original risk assessment, each of these exposure pathways was assessed for 3 land application scenarios:

- Scenario 1 – surface application (assumes application to the soil surface with no incorporation)
- Scenario 2 – incorporation into the top 2 cm of soil (assumes application to the soil surface and cattle movements trample material into the upper layer of soil)
- Scenario 3 – incorporated into the top 10 cm of soil (assumes application to the soil surface and is mechanically incorporated).

Based on previous assessments, the exposure pathway of home-grown fruit/vegetable consumption was considered to pose a lower risk than the key exposure pathways of egg, meat and milk consumption, and therefore the risks for this pathway were not included in the main report. For completeness, the NSW Environment Protection Authority (EPA) asked C&R to undertake an additional risk assessment for the use of FOGO and GO compost in home-grown fruit/vegetable gardens. This addendum contains the risk assessment for the home-grown fruit/vegetable consumption exposure pathway using Scenario 1, assuming surface application (no incorporation). The worst-case and conservative assessment is considered by assessing risk for surface application of FOGO and GO compost in home gardens, as long as there are no other contaminants present at the property or introduced. C&R notes that limitations listed in the previously completed risk assessment (DPE 2023, Section 1.1) remain valid in this addendum.

¹ now known as the Environment and Heritage Group

2. Risk assessment for PFAS and PBDEs in FOGO and GO for use in home fruit/vegetable gardens

2.1 Approach to the risk assessment

C&R undertook the additional risk assessment using a similar approach as outlined in the original risk assessment (DPE 2023).

In the original risk assessment, Scenario 1 resulted in the highest risk quotients (RQs) out of the 3 scenarios for egg, meat and milk exposure pathways. Thus, Scenario 1 was chosen for the assessment of the home-grown fruit/vegetable exposure pathway. The concentrations of the compounds in the FOGO and GO samples were assumed to be the soil exposure concentrations for Scenario 1.

As discussed in the original risk assessment report, all facilities were assessed separately due to the statistical differences between facilities. The risks were assessed for the average, maximum and minimum concentrations for each facility. In the original risk assessment, PFOA concentrations were summed with PFHxA concentrations due to the high proportion of PFHxA in FOGO and GO samples. The average PFHxA concentrations across the facilities ranged from <0.1–16 µg/kg, whilst the average PFOA concentrations across the facilities ranged from <0.1–2.2 µg/kg. For consistency, C&R followed the same approach and summed the PFOA and PFHxA (PFOA+PFHxA) concentrations in this addendum to compare with PFOA criteria.

As mentioned in the original risk assessment, the assessment for PBDEs was done separately for the sum of Br1–Br9 compounds and Br10. Literature indicates that the toxicity and environmental fate of Br10 are different from those of Br1–Br9. As a result, the Agency for Toxic Substances and Disease Registry (ATSDR) recommends separating Br10 from the other PBDEs when assessing risks (NEPC 2013a).

C&R notes that the assessment in this addendum differs to the risk assessment for other key exposure pathways (egg, meat and milk consumption), where daily intake was estimated and compared to background adjusted toxicity reference values (e.g. tolerable daily intakes, TDIs) to calculate RQs. Instead, risks were assessed using the screening criteria from the PFAS National Environmental Management Plan (PFAS NEMP) and the National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM) health investigation levels (HILs) (reproduced in Table 1). Specifically, HIL-A is a soil screening value for residential areas with garden accessible soil, and is protective of exposure via multiple pathways, which include:

- incidental ingestion of surface soil/dust
- indoor and outdoor inhalation of dust
- dermal contact with surface soil and dust particles
- consumption of home-grown fruit/vegetables grown in the soil (this assumed 10% of total fruit and vegetable consumption comes from home gardens (NEPC 2013b)).

For PFOS+PFHxS and PFOA, the HIL-A assumes 80% of the TDI is attributed to other exposure pathways (e.g. consumption of other home-grown produce such as poultry eggs and recreational activities) as well as background exposure.

For Br1–Br9, 80% of the TDI is attributed to background exposure. This means that the HIL-A value was calculated based on 20% of the TDI, which adds another level of conservatism in a risk assessment.

C&R notes that using the HIL-A screening value is considered a conservative assessment². An exceedance of HIL-A values does not constitute a risk if other pathways that are not covered in the HIL-A (e.g. home consumption of chicken eggs and/or meat and dairy) are controlled. Therefore, it is important that this assessment using the HIL screening value forms part of an overall assessment of potential risk in different pathways and scenarios that have already been assessed in the original risk assessment.

There are no HIL screening criteria available for Br10. C&R notes that Br10 is not a key contaminant of concern for home-grown fruit/vegetable consumption since the RQs for other pathways previously assessed in the original risk assessment were significantly below 1.

Table 1 Human health screening criteria applied to the original risk assessment relevant to this addendum

Scenario	Compound	Value	Source/Comment
Residential	PBDE Br1–Br9	1 mg/kg	HIL-A from ASC NEPM (NEPC 2013c)
	PFOS+PFHxS	0.01 mg/kg	HIL-A from NEMP (HEPA 2020)
	PFOA ^a	0.1 mg/kg	HIL-A from NEMP (HEPA 2020)

^a the PFOA screening criterion was used for the sum of PFOA and PFHxA in this assessment

2.2 Outcomes from the risk assessment

Consistent with the original risk assessment, the soil exposure concentrations of PFOS+PFHxS, PFOA+PFHxA and Br1–Br9 for each facility are shown in Table 2. The RQs calculated for home-grown fruit/vegetable consumption are presented in Figure 1 to Figure 3. All RQs are provided in Table 3.

The key outcomes from the risk assessment for the home-grown fruit/vegetable pathway for Scenario 1 were:

- The RQs for PFOS+PFHxS, PFOA+PFHxA and Br1–Br9 were below 1 for all facilities, indicating that the risk is low and acceptable. C&R noted that the RQs were calculated assuming that 10% of fruit/vegetables ingested come from home gardens where FOGO and GO have been applied to the soil surface with no incorporation. The use of 10% is consistent with the ASC NEPM.
- Risk for the home-grown fruit/vegetable pathway was not assessed for Br10 for this scenario, as no HIL-A criterion for Br10 was available. C&R notes that the RQs from previously assessed key exposure pathways (eggs, meat and milk) were all below 1 (with a maximum RQ of 0.05 for human exposure via egg consumption). Thus, due to the low and acceptable RQs for Br10 for the other pathways assessed in the original risk assessment, Br10 is not considered a key contaminant of concern in this instance.

² According to the ASC NEPM, HILs are scientific, risk-based guidance levels developed based on generic assessment criteria and designed to be used for a tier 1 (screening) assessment of potential risks to human health from chronic exposure to contaminants. They are generally used to determine the need for further assessment or development of an appropriate management strategy on a contaminated site (NEPC 2013b). As such, the HILs values are intentionally conservative and based on a worst-case scenario for 4 different generic land-use settings (i.e. residential with garden/accessible soil, residential with minimal opportunities for soil access, public open space/recreational areas and commercial/industrial premises).

2.3 Additional considerations

C&R notes the following additional considerations in the risk assessment for the use of FOGO and GO compost in home-grown fruit/vegetable gardens:

- The risk assessment uses the assumptions in the ASC NEPM, and therefore is considered conservative for the scenario of residential areas with garden accessible soil. In settings where a higher percentage (i.e. >10%) of fruit /vegetables ingested are sourced from the residential backyard where FOGO and GO have been applied, the RQs will increase. There is a potential that such scenarios for the home consumption of produce may occur in rural/agricultural properties; for example, if 50% instead of 10% of fruit/vegetables are home grown and consumed, the RQ would be 5-fold higher. Therefore, for facilities where contaminant concentrations have a low margin of safety, an RQ of 1 could be exceeded. This is particularly the case for PFOS+PFHxS, where a 5-fold increase would result in 5 facilities (facilities C, D, G, M, N) with average RQs above 1, and 8 facilities (facilities C, D, F, G, H, M, N, Q) with maximum RQs above 1. The example for 50% is included for demonstrative purposes, to indicate how the RQ can be considered if such a site-specific circumstance is encountered.

Note: the increase in RQ if a higher percentage (i.e. >10%) of fruit /vegetables ingested are sourced from the residential backyard will also apply to all other contaminants with a HIL-A value.

- The outcomes presented in Figure 1 to Figure 3 are for Scenario 1 (surface application of FOGO and GO compost with no incorporation). Incorporating FOGO and GO compost into the top soil would result in lower RQs. This assumes that the soil the compost is incorporated into contains no PFAS or PBDEs. If these contaminants were present in the soil, the overall RQs would increase depending on the background soil concentrations.
- Blending FOGO and GO with other material or products (e.g. sand, bark, cow manure) to create a compost blend before application is likely to result in lower RQs than Scenario 1 (noting that the type of material used to mix with the FOGO could either bind or result in further mobilisation of the contaminants, based on organic content and sand/clay properties), assuming that no PFAS or PBDEs are present in the products blended with the FOGO and GO. The RQs would be the same or higher than the RQs for Scenario 1 if the same or higher concentrations of PFAS or PBDEs are present in the products blended with the FOGO and GO.
- The assessment of the home-grown fruit/vegetable pathway did not consider the consumption of herbs grown in the home garden. In general, herbs are not considered to be consumed in sufficient quantities in the home garden to warrant concern.

2.4 Results tables and graphs

Table 2 Average soil exposure concentrations ($\mu\text{g}/\text{kg}$) for PFOS+PFHxS, PFOA+PFHxA and Br1–Br9 for Scenario 1 (information from Table 1 – Table 3 in the original risk assessment)

Waste type	Facility	PFOS+PFHxS	PFOA+PFHxA	Br1–Br9
FOGO	A	1.3	2.3	11
	B	1.4	0.83	3.3
	C	2.8	6.2	14
	D	3.6	3.8	18
	E	1.7	1.8	4.8
	F	1.3	2.2	7.2
	G	4.0	3.3	20
	H	1.9	16	8.7
	I	1.4	3.5	18
	J	1.1	6.5	15
	K	1.5	2.0	9.5
	L	1.6	1.4	6.6
	M	3.4	0.83	15
GO	N	2.1	0.43	1.2
	O	1.2	0.77	150
	P	1.4	1.3	4.8
	Q	1.9	1.5	3.2
	R	0.1	0.1	1.3

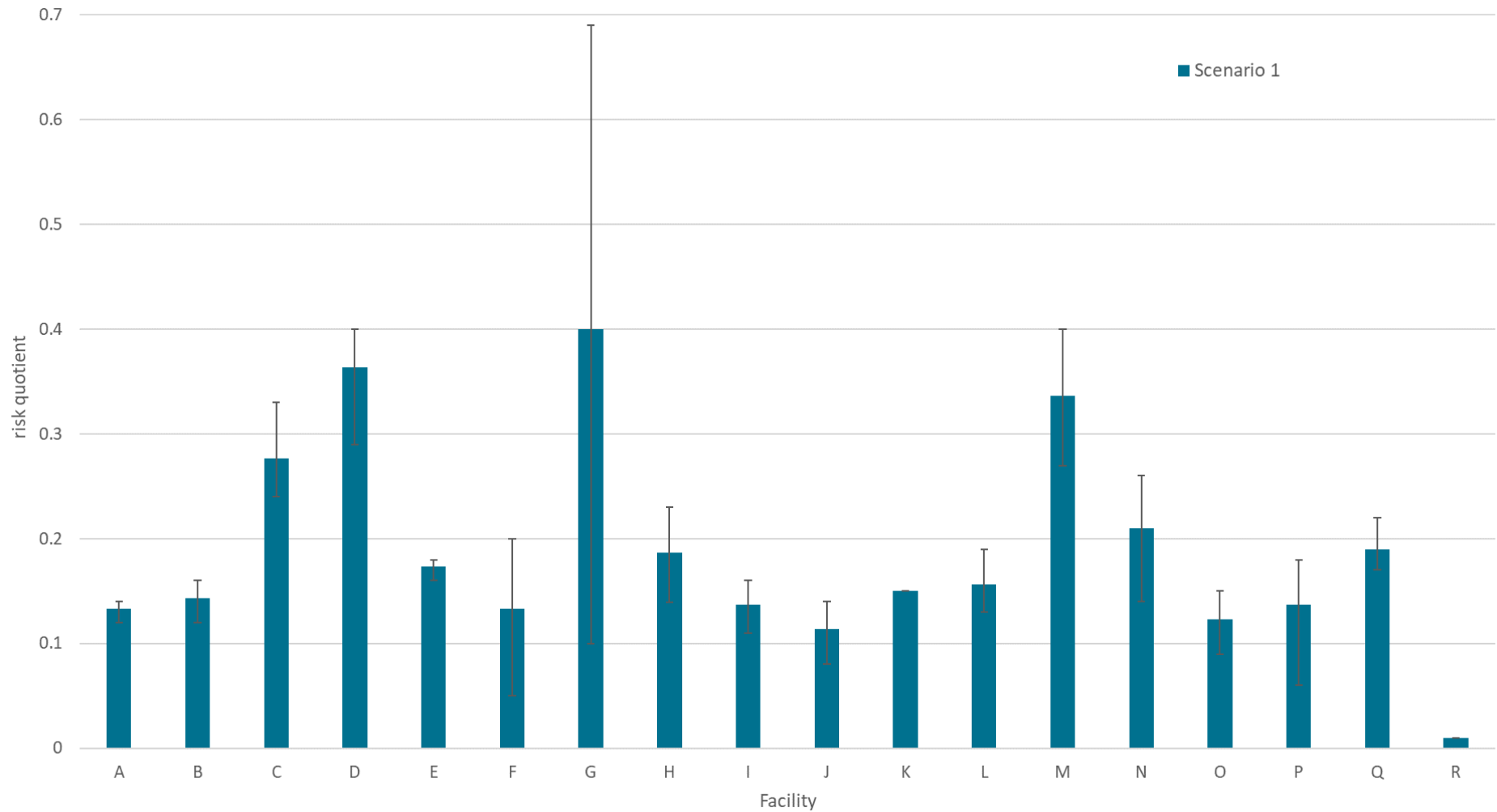


Figure 1 Summary of PFOS+PFHxS RQs for human exposure via home-grown fruit/vegetable consumption from land application of FOGO (A–M) and GO (N–R) compost to the soil surface with no incorporation
 Bars represent average RQs and error bars represent maximum and minimum RQs. Scenario 1 = surface application.

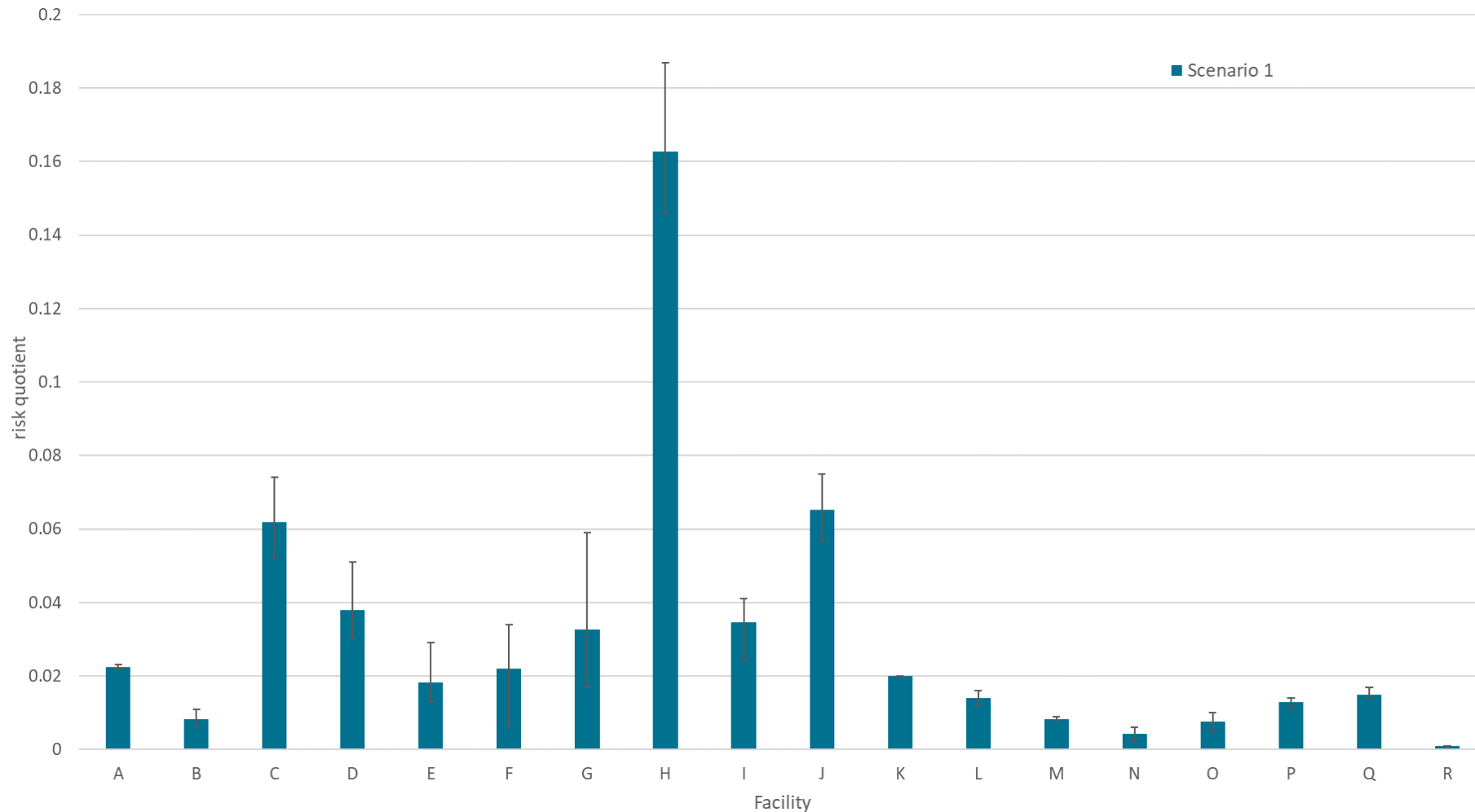


Figure 2 Summary of PFOA+PFHxA RQs for human exposure via home-grown fruit/vegetable consumption from land application of FOGO (A–M) and GO (N–R) compost to the soil surface with no incorporation
 Bars represent average RQs and error bars represent maximum and minimum RQs. Scenario 1 = surface application.

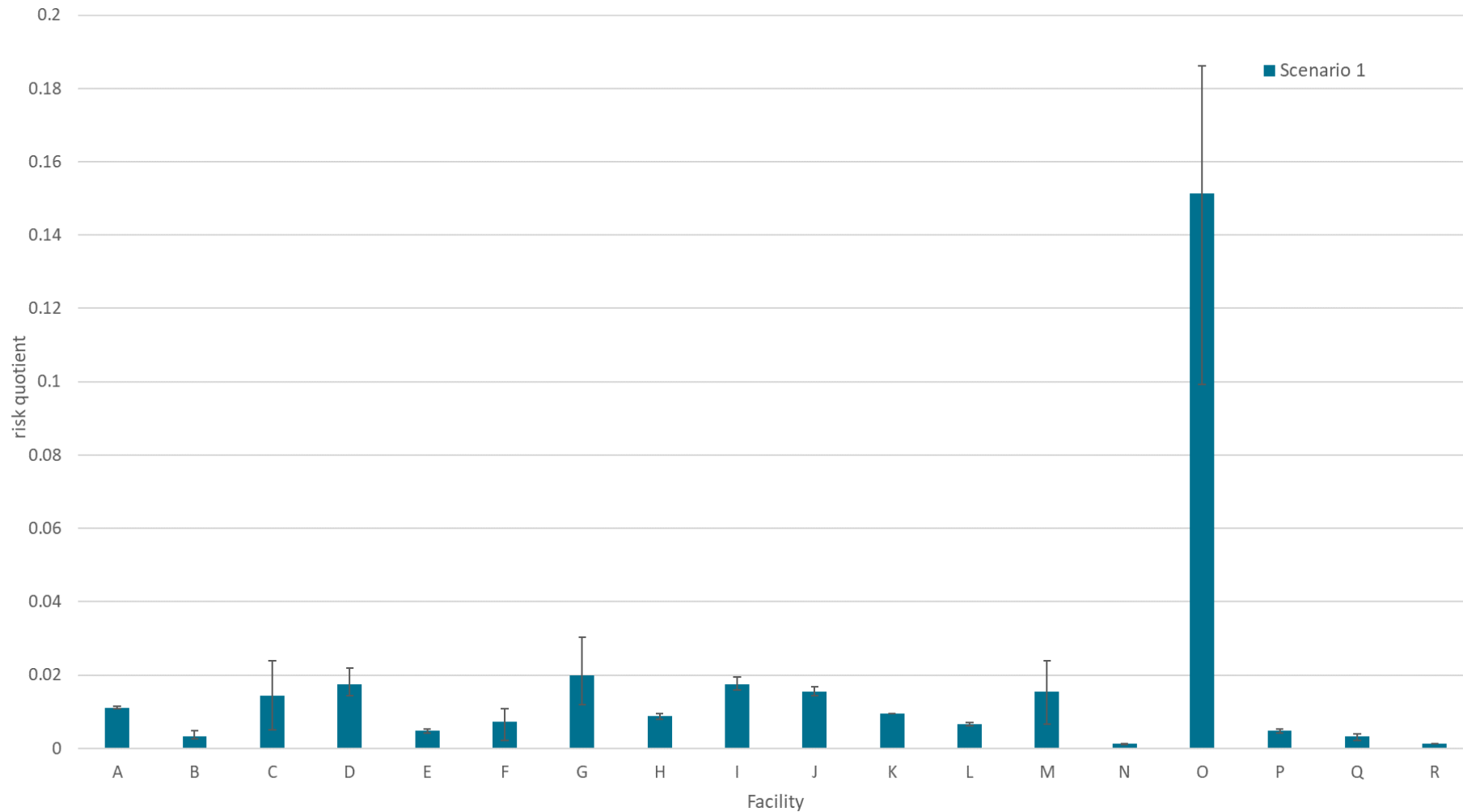


Figure 3 Summary of Br1–Br9 RQs for human exposure via home-grown fruit/vegetable consumption from land application of FOGO (A–M) and GO (N–R) compost to the soil surface with no incorporation
 Bars represent average RQs and error bars represent maximum and minimum RQs. Scenario 1 = surface application.

Table 3 RQs (children) presented in Figure 1, Figure 2 and Figure 3

Facility	PFOS+PFHxS			PFOA+PFHxA			Br1-Br9		
	average	min	max	average	min	max	average	min	max
A	0.13	0.12	0.14	0.022	0.022	0.023	0.011	0.011	0.011
B	0.14	0.12	0.16	0.0083	0.0060	0.011	0.0033	0.0026	0.0047
C	0.28	0.24	0.33	0.062	0.052	0.074	0.014	0.0051	0.024
D	0.36	0.29	0.40	0.038	0.030	0.051	0.018	0.014	0.022
E	0.17	0.16	0.18	0.018	0.013	0.029	0.0048	0.0041	0.0052
F	0.13	0.05	0.20	0.022	0.0060	0.034	0.0072	0.0021	0.011
G	0.40	0.10	0.69	0.033	0.017	0.059	0.020	0.012	0.030
H	0.19	0.14	0.23	0.16	0.15	0.19	0.0087	0.0079	0.010
I	0.14	0.11	0.16	0.035	0.024	0.041	0.018	0.016	0.020
J	0.11	0.08	0.14	0.065	0.057	0.075	0.016	0.014	0.017
K	0.15	0.15	0.15	0.020	0.020	0.020	0.0095	0.0095	0.0095
L	0.16	0.13	0.19	0.014	0.012	0.016	0.0066	0.0062	0.0071
M	0.34	0.27	0.40	0.008	0.0080	0.0090	0.015	0.0067	0.024
N	0.21	0.14	0.26	0.0043	0.0020	0.0060	0.0012	0.0011	0.0012
O	0.12	0.090	0.15	0.0077	0.005	0.010	0.15	0.099	0.19
P	0.14	0.060	0.18	0.013	0.011	0.014	0.0048	0.0041	0.0052
Q	0.19	0.17	0.22	0.015	0.014	0.017	0.0032	0.0021	0.0039
R	0.010	0.010	0.010	0.0010	0.0010	0.0010	0.0013	0.0013	0.0013

3. References

DPE (Department of Planning and Environment) *Risk assessment of PFAS and PBDEs in FOGO and GO composts (2020–21)*, prepared for the NSW Environment Protection Authority, NSW Department of Planning and Environment, Parramatta.

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NEPC (National Environment Protection Council) (2013b) *National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended, Schedule B7: Guideline on derivation of health-based investigation levels*, Table 5: Exposure parameters, National Environment Protection Council.

NEPC (National Environment Protection Council) (2013c) *National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended, Schedule B1: Investigation levels for soil and groundwater*, National Environment Protection Council.