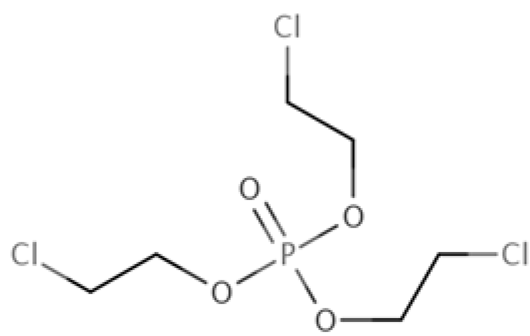
United States
Environmental Protection Agency

December 2023
Office of Chemical Safety and
Pollution Prevention

Draft Risk Evaluation for
for Tris(2-chloroethyl) Phosphate (TCEP)

Supplemental File:

Exposure Monitoring Tornado Figures, Supplemental Tables and Data Integration Methods and Approach for TCEP
CASRN: 115-96-8



December 2023

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1 ENVIRONMENTAL MONITORING CONCENTRATIONS REPORTED BY MEDIA TYPE

1.1 Ambient Air

1.1.1 Ambient Air (ng/g) – Particulate Fraction

Measured concentrations of TCEP in Ambient Air with unit of ng/g, extracted from one source, are summarized in Figure 1-1 and supplemental information is provided in Table 1-1. Overall, concentrations were 300 ng/g from 18 samples collected in 2018 in one country, PL. Location types were categorized as General Population (Background). Reported detection frequency was 0.11.

Figure 1-1. Concentrations of TCEP (ng/g) in the Particulate Fraction of Ambient Air in General Population (Background) Locations in 2018

Table 1-1. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Particulate Fraction of Ambient Air

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Fabiańska et al. (2019)	PL	General Population (Background)	2018	18 (0.11)	N/R	Medium
Abbreviations: N/R, Not reported						

1.1.2 Ambient Air (ng/m^3) – All Fractions

Measured concentrations of TCEP in Ambient Air with unit of ng/m^3, extracted from 17 sources, are summarized in Figure 1-2 and supplemental information is provided in Table 1-2. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Combined Vapor/Gas and Particulate ranged from not detected to 58.4 ng/m^3 from 152 samples collected between 2000 and 2018 in 11 countries, AR, BO, BR, CA, CL, CO, CR, JP, MX, NO and US. Location types were categorized as General Population (Background), Near Facility (Highly Exposed) and Remote (Not Near Source). Reported detection frequency ranged from 0.55 to 0.94.

Overall, concentrations for Particulate ranged from not detected to 3.532 ng/m^3 from 855 samples collected between 2002 and 2019 in seven countries, AQ, CA, ES, FI, JP, SE and US. Location types were categorized as Unknown/Not Specified, General Population (Background), Near Facility (Highly Exposed) and Remote (Not Near Source). Reported detection frequency ranged from 0.0 to 1.0.

Overall, concentrations for Vapor/Gas ranged from not detected to 0.143 ng/m^3 from 49 samples collected in 2014 in two countries, AQ and TR. Location types were categorized as General Population (Background), Near Facility (Highly Exposed) and Remote (Not Near Source). Reported detection frequency ranged from 0.8 to 1.0.

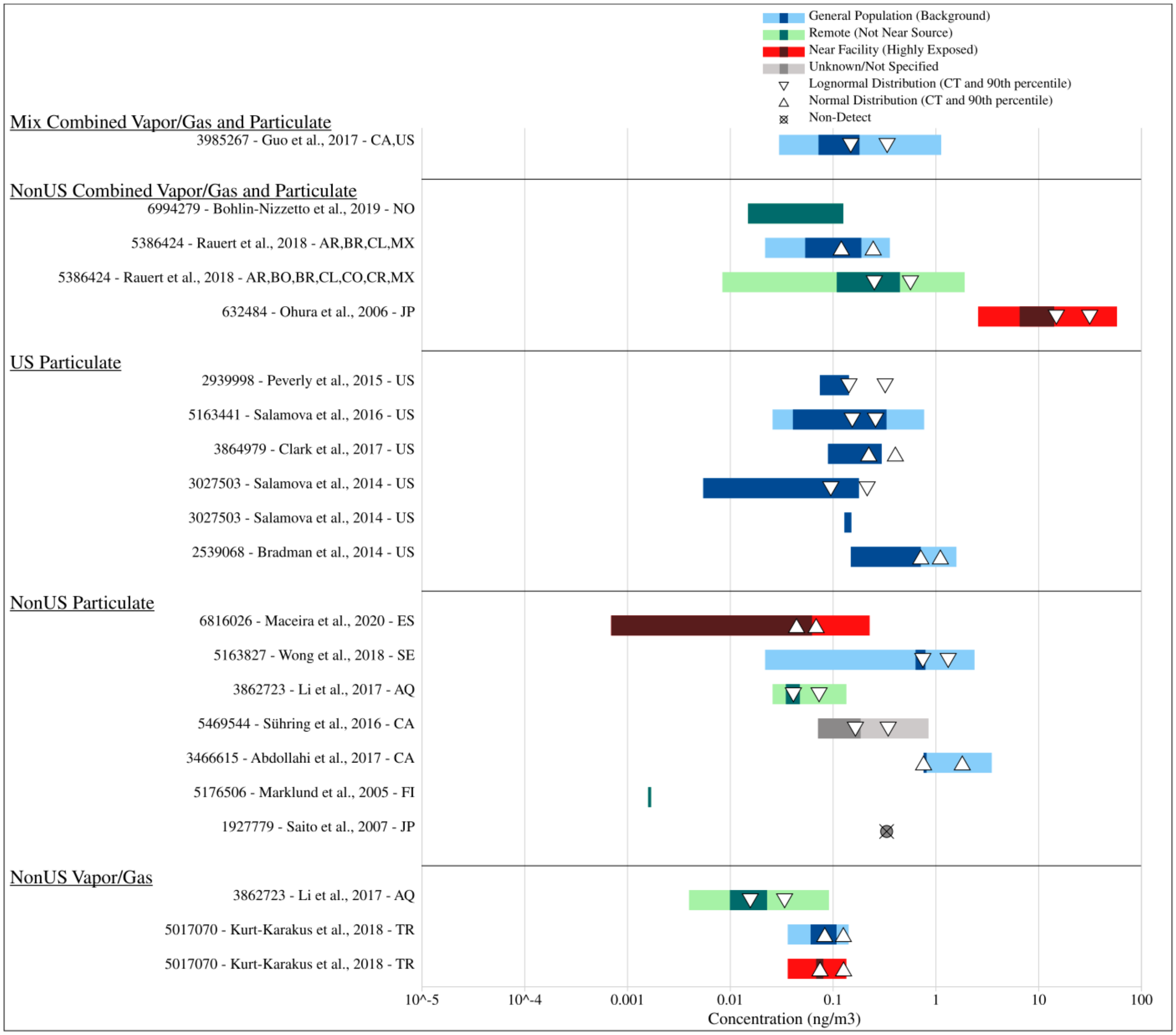


Figure 1-2. Concentrations of TCEP (ng/m^3) in Ambient Air from 2000 to 2019

Table 1-2. Summary of Peer-Reviewed Literature that Measured TCEP (ng/m^3) Levels in Ambient Air

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/m^3)	Overall Quality Level
Combined Vapor/Gas and Particulate						
Guo et al. (2017)	CA, US	General Population (Background)	2013	20 (0.55)	0.0602	High
Bohlin-Nizzetto et al. (2019)	NO	Remote (Not Near Source)	2017–2018	36 (0.56)	0.045	Medium
Rauert et al. (2018)	AR, BR, CL, MX	General Population (Background)	2014–2016	14 (0.93)	0.08	High
Rauert et al. (2018)	AR, BO, BR, CL, CO, CR, MX	Remote (Not Near Source)	2014–2016	36 (0.94)	0.05	High
Ohura et al. (2006)	JP	Near Facility (Highly Exposed)	2000–2001	46 (0.91)	N/R	Medium
Particulate						
Peverly et al. (2015)	US	General Population (Background)	2012–2014	161 (0.87)	N/R	High
Salamova et al. (2016)	US	General Population (Background)	2012–2014	359 (0.60)	N/R	Medium
Clark et al. (2017)	US	General Population (Background)	2013	45 (0.93)	N/R	High
Salamova et al. (2014)	US	General Population (Background)	2012	81 (0.74)	N/R	Medium
Salamova et al. (2014)	US	General Population (Background)	2012	16 (0.62)	N/R	Medium
Bradman et al. (2014)	US	General Population (Background)	2010-2011	14 (0.50)	0.3	High

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/m^3)	Overall Quality Level
Maceira et al. (2020)	ES	Near Facility (Highly Exposed)	2018–2019	24 (0.62)	0.0014	High
Wong et al. (2018)	SE	General Population (Background)	2014-2015	24 (0.96)	0.044	Medium
Li et al. (2017)	AQ	Remote (Not Near Source)	2014	9 (1.00)	0.0038	High
Sühring et al. (2016)	CA	Unknown/Not Specified	2007–2013	92 (0.87)	N/R	Medium
Abdollahi et al. (2017)	CA	General Population (Background)	2010	21 (N/R)	0.0003	High
Marklund et al. (2005b)	FI	Remote (Not Near Source)	2003	1 (1.00)	N/R	Medium
Saito et al. (2007)	JP	Unknown/Not Specified	2002	8 (0.00)	0.67	Medium
Vapor/Gas						
Li et al. (2017)	AQ	Remote (Not Near Source)	2014	9 (1.00)	0.0012	High
Kurt-Karakus et al. (2018)	TR	General Population (Background)	2014	30 (0.80)	0.073	High
Kurt-Karakus et al. (2018)	TR	Near Facility (Highly Exposed)	2014	10 (0.80)	0.073	High
Abbreviations: N/R, Not reported						

1.2 Aquatic Organisms – Fish

1.2.1 Aquatic Organisms – Fish (ng/g) – All Fractions

Measured concentrations of TCEP in Aquatic Organisms – Fish with unit of ng/g, extracted from eight sources, are summarized in Figure 1-3 and supplemental information is provided in Table 1-3. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Lipid ranged from not detected to 187.0 ng/g from 55 samples collected between 2003 and 2016 in five countries, CA, ES, NO, SE and US. Location types were categorized as General Population (Background), Near Facility (Highly Exposed) and Remote (Not Near Source).

Reported detection frequency ranged from 0.21 to 1.0.

Overall, concentrations for Wet ranged from not detected to 26.0 ng/g from 186 samples collected between 2004 and 2015 in four countries, CA, KR, NL and NO. Location types were categorized as General Population (Background), Near Facility (Highly Exposed) and Remote (Not Near Source). Reported detection frequency ranged from 0.12 to 1.0.

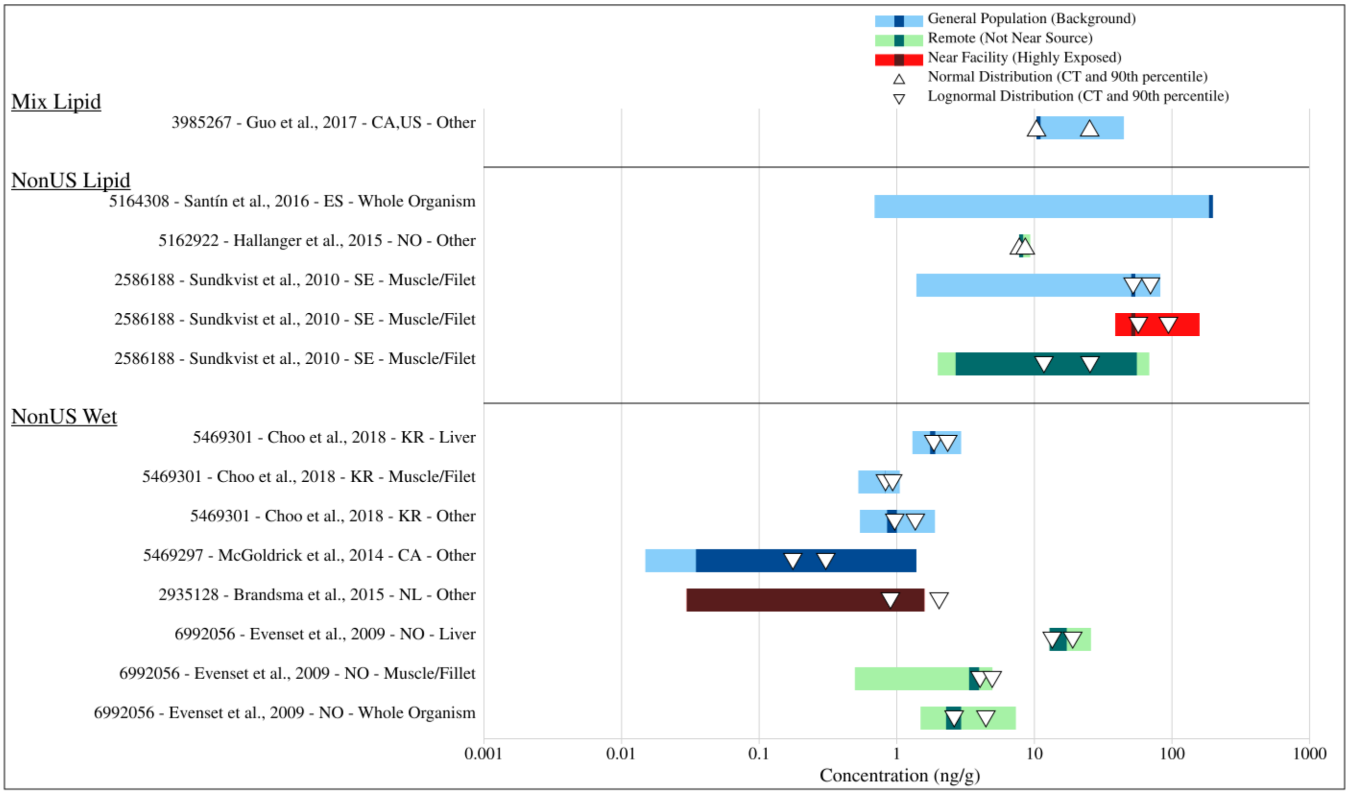


Figure 1-3. Concentrations of TCEP (ng/g) in Aquatic Organisms – Fish from 2003 to 2016

Table 1-3. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in Aquatic Organisms – Fish

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Lipid						
Guo et al. (2017)	CA, US	General Population (Background)	2010	14 (0.21)	20.9	High
Santín et al. (2016)	ES	General Population (Background)	2016	12 (0.25)	1.39	High
Hallanger et al. (2015)	NO	Remote (Not Near Source)	2009	10 (0.70)	N/R	High

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Sundkvist et al. (2010)	SE	General Population (Background)	2007	7 (0.57)	2.8	High
Sundkvist et al. (2010)	SE	Near Facility (Highly Exposed)	2003–2007	4 (1.00)	2.8	High
Sundkvist et al. (2010)	SE	Remote (Not Near Source)	2005–2007	8 (1.00)	2.8	High
Wet						
Choo et al. (2018)	KR	General Population (Background)	2015	20 (1.00)	0.22	High
Choo et al. (2018)	KR	General Population (Background)	2015	30 (1.00)	0.06	High
Choo et al. (2018)	KR	General Population (Background)	2015	20 (1.00)	0.09	High
McGoldrick et al. (2014)	CA	General Population (Background)	2009–2010	72 (0.12)	0.03	High
Brandsma et al. (2015)	NL	Near Facility (Highly Exposed)	2008	19 (0.42)	0.21	High
Evenset et al. (2009)	NO	Remote (Not Near Source)	2004–2008	3 (1.00)	N/R	Medium
Evenset et al. (2009)	NO	Remote (Not Near Source)	2004–2008	5 (1.00)	0.47	Medium
Evenset et al. (2009)	NO	Remote (Not Near Source)	2008	17 (0.94)	N/R	Medium
Abbreviations: N/R, Not reported						

1.3 Aquatic Organisms – Mammal

1.3.1 Aquatic Organisms – Mammal (ng/g) – Lipid Fraction

Measured concentrations of TCEP in Aquatic Organisms – Mammal with unit of ng/g, extracted from two sources, are summarized in Figure 1-4 and supplemental information is provided in Table 1-4. Overall, concentrations ranged from not detected to 115.0 ng/g from 63 samples collected between 2004 and 2010 in two countries, ES and NO. Location types were categorized as General Population (Background) and Remote (Not Near Source). Reported detection frequency ranged from 0.0 to 0.44.

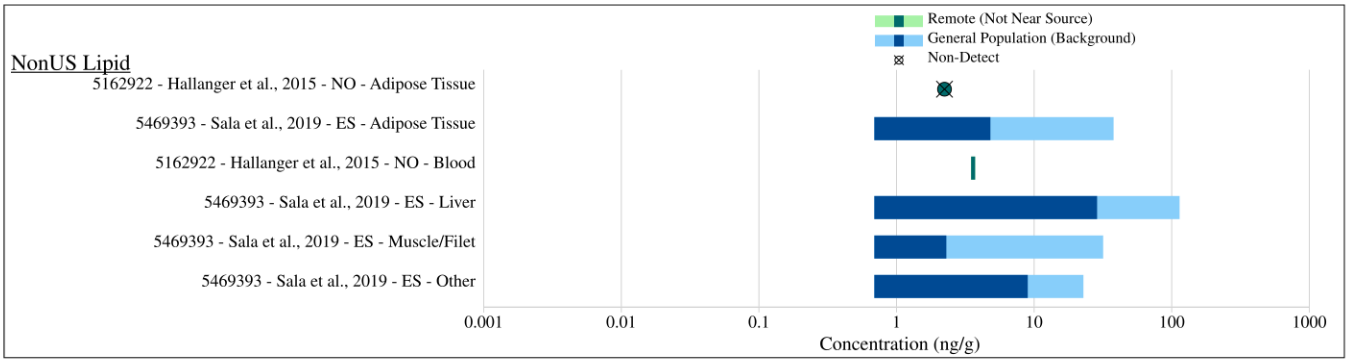


Figure 1-4. Concentrations of TCEP (ng/g) in the Lipid Fraction of Aquatic Organisms – Mammal from 2004 to 2010

Table 1-4. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Lipid Fraction of Aquatic Organisms – Mammal

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Hallanger et al. (2015)	NO	Remote (Not Near Source)	2010	10 (0.00)	4.5	High
Sala et al. (2019)	ES	General Population (Background)	2004–2010	9 (0.11)	1.39	Medium
Hallanger et al. (2015)	NO	Remote (Not Near Source)	2009	10 (0.10)	N/R	High
Sala et al. (2019)	ES	General Population (Background)	2004–2010	9 (0.44)	1.39	Medium
Sala et al. (2019)	ES	General Population (Background)	2004–2010	10 (0.10)	1.39	Medium
Sala et al. (2019)	ES	General Population (Background)	2004–2010	15 (0.13)	1.39	Medium
Abbreviations: N/R, Not reported						

1.4 Aquatic Organisms – Mollusk

1.4.1 Aquatic Organisms – Mollusk (ng/g) – All Fractions

Measured concentrations of TCEP in Aquatic Organisms – Mollusk with unit of ng/g, extracted from two sources, are summarized in Figure 1-5 and supplemental information is provided in Table 1-5. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Lipid were not detected ng/g from 80 samples collected between 2016 and 2017 in one country, PT. Location types were categorized as Near Facility (Highly Exposed). Reported detection frequency was 0.25.

Overall, concentrations for Wet ranged from not detected to 0.82 ng/g from five samples collected in 2008 in one country, NL. Location types were categorized as Near Facility (Highly Exposed). Reported detection frequency was 0.4.

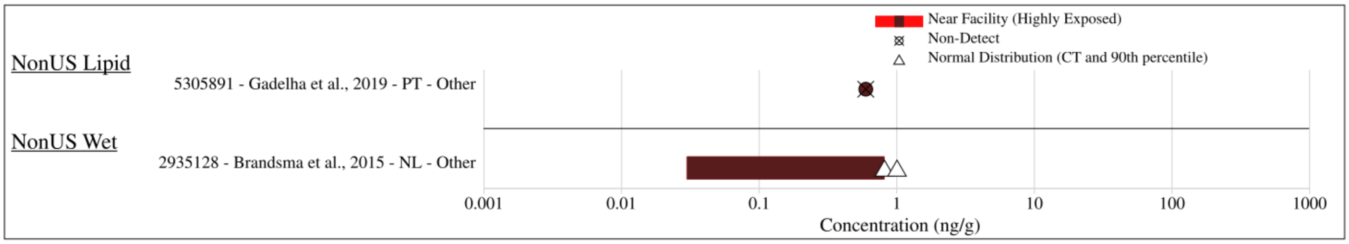


Figure 1-5. Concentrations of TCEP (ng/g) in Aquatic Organisms – Mollusk in Near Facility (Highly Exposed) Locations from 2008 to 2017

Table 1-5. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in Aquatic Organisms – Mollusk

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Lipid						
Gadelha et al. (2019)	PT	Near Facility (Highly Exposed)	2016–2017	80 (0.25)	1.2	High
Wet						
Brandsma et al. (2015)	NL	Near Facility (Highly Exposed)	2008	5 (0.40)	0.2	High

1.5 Aquatic Organisms – Other

1.5.1 Aquatic Organisms – Other (ng/g) – Wet Fraction

Measured concentrations of TCEP in Aquatic Organisms – Other with unit of ng/g, extracted from two sources, are summarized in Figure 1-6 and supplemental information is provided in Table 1-6. Overall, concentrations ranged from not detected to 0.33 ng/g from 61 samples collected between 2008 and 2018 in two countries, NL and NO. Location types were categorized as General Population (Background) and Near Facility (Highly Exposed). Reported detection frequency ranged from 0.0 to 0.2.

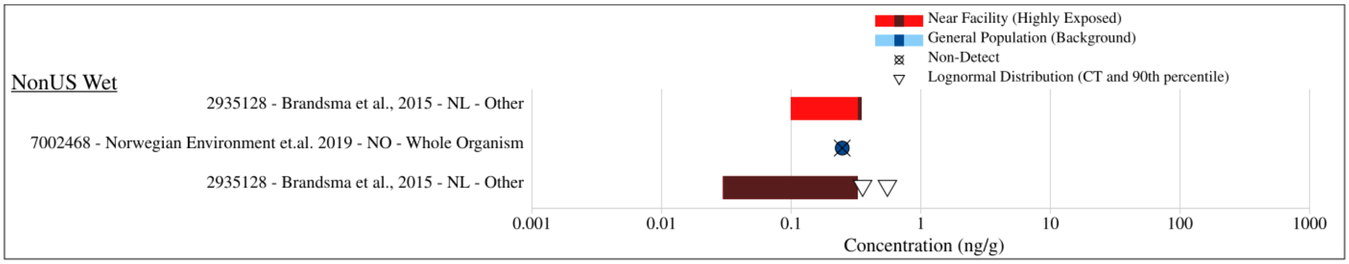


Figure 1-6. Concentrations of TCEP (ng/g) in the Wet Fraction of Aquatic Organisms – Other from 2008 to 2018

Table 1-6. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Wet Fraction of Aquatic Organisms – Other

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Brandsma et al. (2015)	NL	Near Facility (Highly Exposed)	2008	5 (0.20)	0.2	High
Norwegian Environment (2019b)	NO	General Population (Background)	2018	51 (0.00)	0.5	High
Brandsma et al. (2015)	NL	Near Facility (Highly Exposed)	2008	5 (0.20)	0.42	High

1.6 Dietary

1.6.1 Dietary (ng/g) – Wet Fraction

Measured concentrations of TCEP in Dietary with unit of ng/g, extracted from four sources, are summarized in Figure 1-7 and supplemental information is provided in Table 1-7. Overall, concentrations ranged from not detected to 113.0 ng/g from 363 samples collected between 1982 and 2018 in four countries, AU, BE, SE and US. Location types were categorized as fruit, dairy, grain, baby food-infant formula, vegetables, other, non-dairy beverages, meat, fish and shellfish and fats and oils. Reported detection frequency ranged from 0.0 to 0.67.

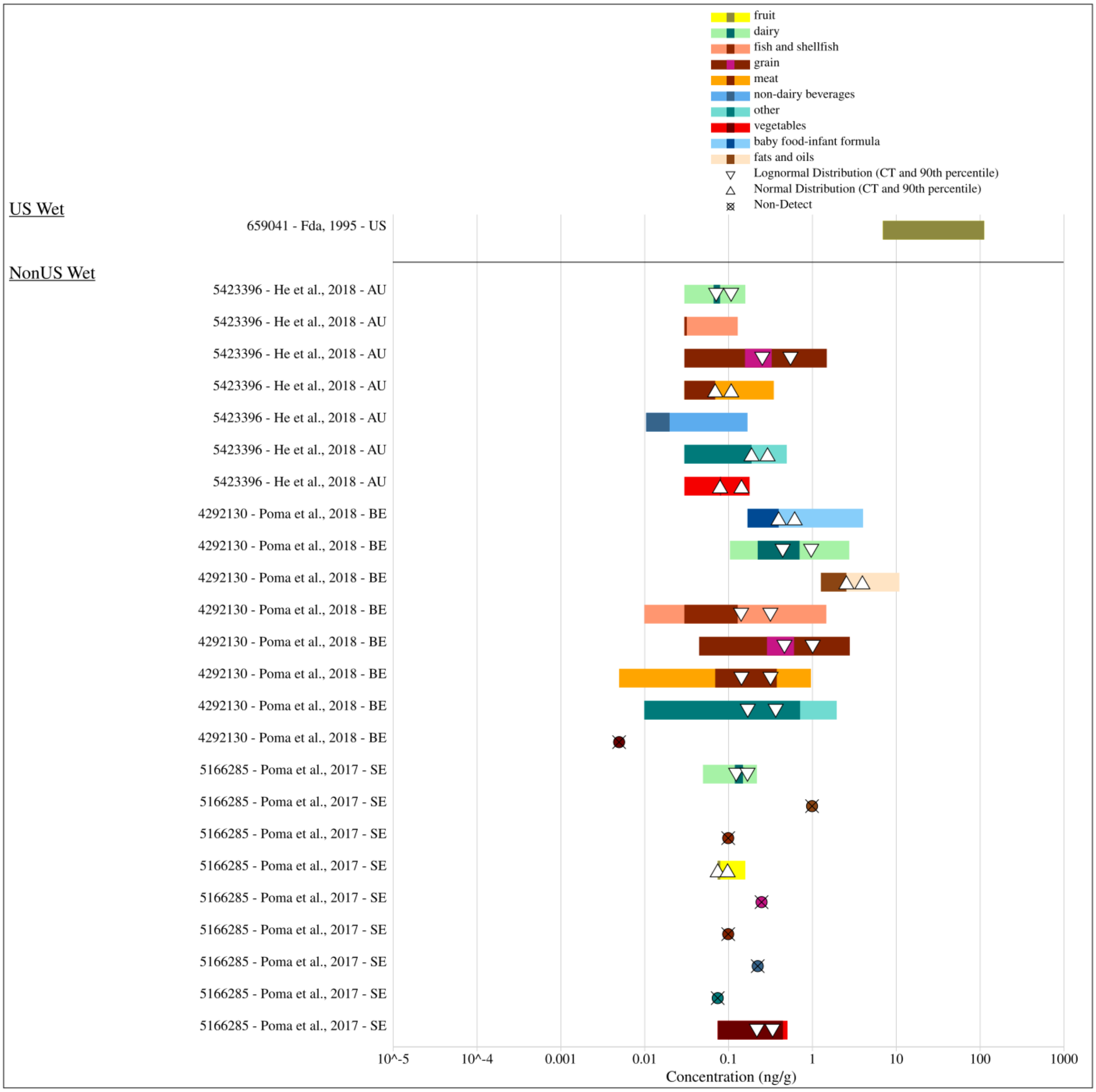


Figure 1-7. Concentrations of TCEP (ng/g) in the Wet Fraction of Dietary from 1982 to 2018

Table 1-7. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Wet Fraction of Dietary

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
FDA (1995)	US	fruit	1982–1991	74 (0.04)	N/R	Medium
He et al. (2018b)	AU	dairy	2018	9 (0.56)	0.06	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
He et al. (2018b)	AU	fish and shellfish	2018	9 (0.22)	0.06	Medium
He et al. (2018b)	AU	grain	2018	12 (0.67)	0.06	Medium
He et al. (2018b)	AU	meat	2018	12 (0.25)	0.06	Medium
He et al. (2018b)	AU	non-dairy beverages	2018	12 (0.08)	0.021	Medium
He et al. (2018b)	AU	other	2018	3 (0.33)	0.06	Medium
He et al. (2018b)	AU	vegetables	2018	15 (0.60)	0.06	Medium
Poma et al. (2018)	BE	baby food-infant formula	2015–2016	17 (N/R)	0.34	High
Poma et al. (2018)	BE	dairy	2015–2016	27 (N/R)	0.45	High
Poma et al. (2018)	BE	fats and oils	2015–2016	10 (0.40)	2.55	High
Poma et al. (2018)	BE	fish and shellfish	2015–2016	53 (N/R)	0.07	High
Poma et al. (2018)	BE	grain	2015–2016	7 (N/R)	0.09	High
Poma et al. (2018)	BE	meat	2015–2016	38 (N/R)	0.14	High
Poma et al. (2018)	BE	other	2015–2016	11 (N/R)	0.44	High
Poma et al. (2018)	BE	vegetables	2015–2016	2 (0.00)	0.01	High
Poma et al. (2017)	SE	dairy	2015	9 (0.22)	0.3	High
Poma et al. (2017)	SE	fats and oils	2015	4 (0.00)	2.0	High
Poma et al. (2017)	SE	fish and shellfish	2015	5 (0.00)	0.2	High

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Poma et al. (2017)	SE	fruit	2015	5 (0.20)	0.15	High
Poma et al. (2017)	SE	grain	2015	5 (0.00)	0.5	High
Poma et al. (2017)	SE	meat	2015	5 (0.00)	0.2	High
Poma et al. (2017)	SE	non-dairy beverages	2015	2 (0.00)	0.45	High
Poma et al. (2017)	SE	other	2015	8 (0.00)	0.5	High
Poma et al. (2017)	SE	vegetables	2015	9 (0.67)	0.3	High
Abbreviations: N/R, Not reported						

1.6.2 Dietary (ng/g) – Wet Fraction

Measured concentrations of BCEP in Dietary with unit of ng/g, extracted from one source, are summarized in Figure 1-8 and supplemental information is provided in Table 1-8. Overall, concentrations ranged from not detected to 10.0 ng/g from 85 samples collected in 2018 in one country, AU. Location types were categorized as fruit, dairy, grain, vegetables, other, non-dairy beverages, meat and fish and shellfish. Reported detection frequency ranged from 0.0 to 0.33.

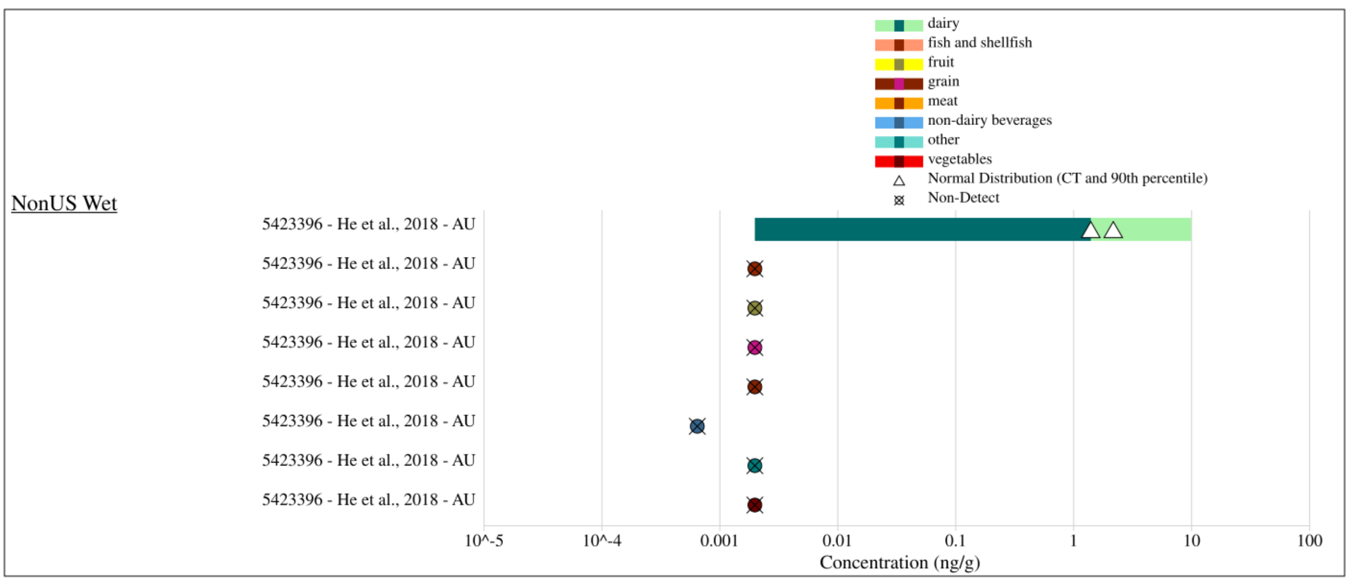


Figure 1-8. Concentrations of BCEP (ng/g) in the Wet Fraction of Dietary in 2018

Table 1-8. Summary of Peer-Reviewed Literature that Measured BCEP (ng/g) Levels in the Wet Fraction of Dietary

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
He et al. (2018b)	AU	dairy	2018	9 (0.33)	0.004	Medium
He et al. (2018b)	AU	fish and shellfish	2018	9 (0.00)	0.004	Medium
He et al. (2018b)	AU	fruit	2018	15 (0.00)	0.004	Medium
He et al. (2018b)	AU	grain	2018	12 (0.00)	0.004	Medium
He et al. (2018b)	AU	meat	2018	12 (0.00)	0.004	Medium
He et al. (2018b)	AU	non-dairy beverages	2018	10 (0.00)	0.0013	Medium
He et al. (2018b)	AU	other	2018	3 (0.00)	0.004	Medium
He et al. (2018b)	AU	vegetables	2018	15 (0.00)	0.004	Medium

1.7 Drinking Water

1.7.1 Drinking Water (ng/L) – Not Specified Fraction

Measured concentrations of TCEP in Drinking Water with unit of ng/L, extracted from nine sources, are summarized in Figure 1-9 and supplemental information is provided in Table 1-9. Overall, concentrations ranged from not detected to 1,400.0 ng/L from 675 samples collected between 1982 and 2014 in six countries, CA, ES, JP, KR, PR and US. Location types were categorized as General Population (Background) and Unknown/Not Specified. Reported detection frequency ranged from 0.0 to 0.88.

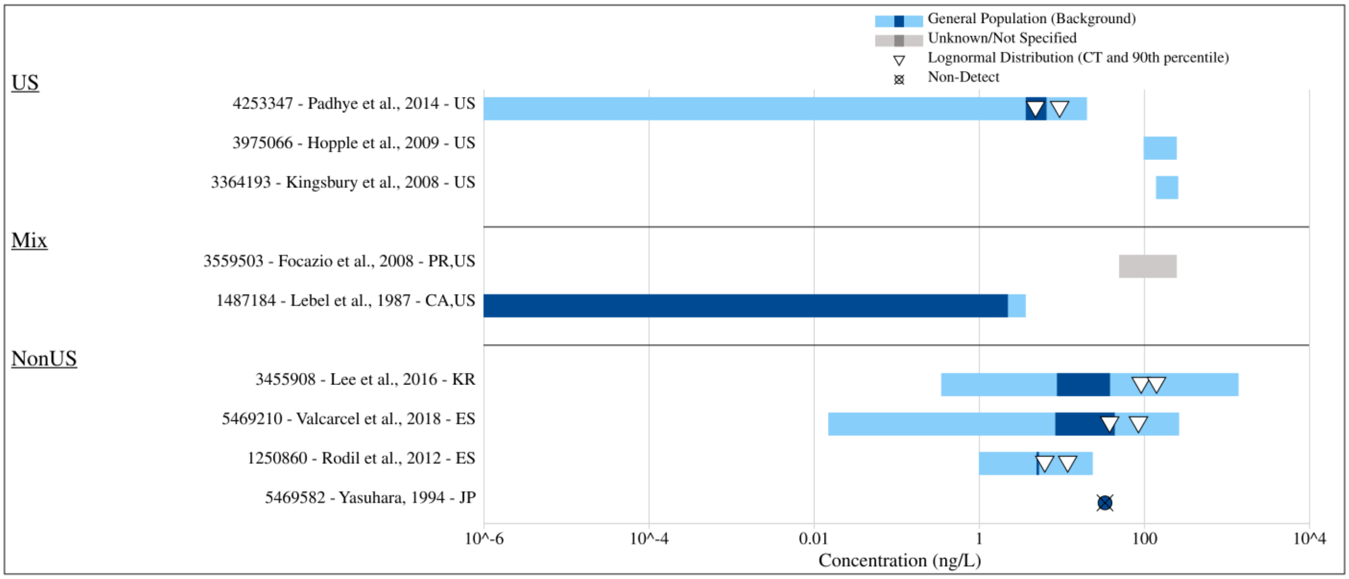


Figure 1-9. Concentrations of TCEP (ng/L) in the Not Specified Fraction of Drinking Water from 1982 to 2014

Table 1-9. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Not Specified Fraction of Drinking Water

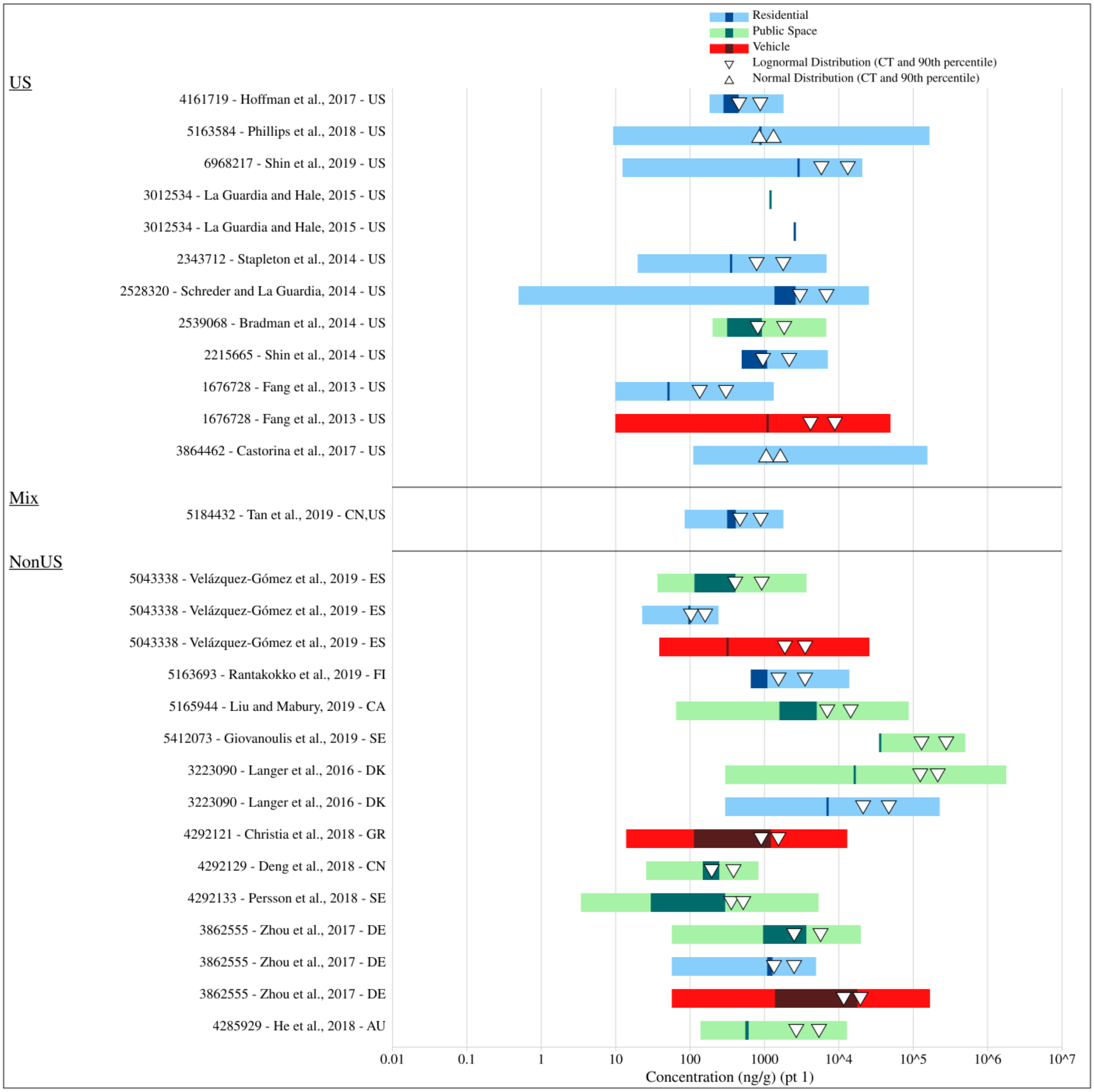
Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Padhye et al. (2014)	US	General Population (Background)	2009–2010	8 (0.88)	N/R	Medium
Hopple et al. (2009)	US	General Population (Background)	2004–2005	57 (0.02)	500.0	High
Kingsbury et al. (2008)	US	General Population (Background)	2002–2004	337 (0.33)	500.0	High
Focazio et al. (2008)	PR, US	Unknown/Not Specified	2001	73 (0.21)	100.0	Medium
Lebel et al. (1987)	CA, US	General Population (Background)	1982–1983	20 (0.55)	N/R	Medium
Lee et al. (2016)	KR	General Population (Background)	2014	127 (0.75)	0.7	Medium
Valcarcel et al. (2018)	ES	General Population (Background)	2013	28 (0.75)	0.03	Medium

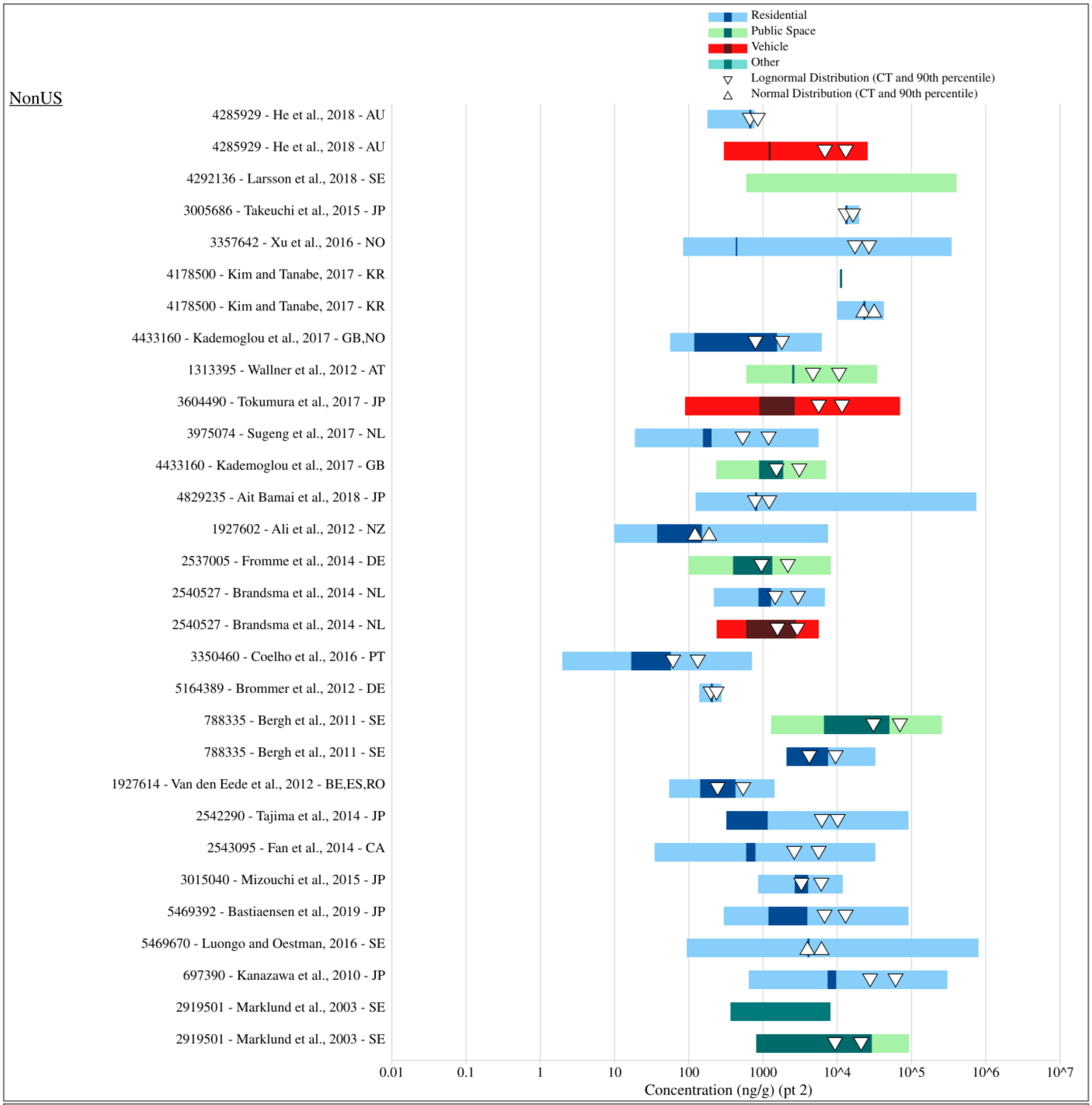
Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Rodil et al. (2012)	ES	General Population (Background)	2007–2008	24 (0.71)	4.0	Medium
Yasuhara (1994)	JP	General Population (Background)	1994	1 (0.00)	67.5	Medium
Abbreviations: N/R, Not reported						

1.8 Dust (Indoor)

1.8.1 Dust (Indoor) (ng/g) – Dry Fraction

Measured concentrations of TCEP in Dust (Indoor) with unit of ng/g, extracted from 45 sources, are summarized in Figure 1-10 and supplemental information is provided in Table 1-10. Overall, concentrations ranged from not detected to 1,800,000.0 ng/g from 4,578 samples collected between 2000 and 2019 in 20 countries, AT, AU, BE, CA, CN, DE, DK, ES, FI, GB, GR, JP, KR, NL, NO, NZ, PT, RO, SE and US. Location types were categorized as Vehicle, Other, Public Space and Residential. Reported detection frequency ranged from 0.17 to 1.0.


Residential
Public Space
Vehicle
Lognormal Distribution (CT and 90th percentile)
Normal Distribution (CT and 90th percentile)
US
4161719 - Hoffman et al., 2017 - US
5163584 - Phillips et al., 2018 - US
6968217 - Shin et al., 2019 - US
3012534 - La Guardia and Hale, 2015 - US
3012534 - La Guardia and Hale, 2015 - US
2343712 - Stapleton et al., 2014 - US
2528320 - Schreder and La Guardia, 2014 - US
2539068 - Bradman et al., 2014 - US
2215665 - Shin et al., 2014 - US
1676728 - Fang et al., 2013 - US
1676728 - Fang et al., 2013 - US
3864462 - Castorina et al., 2017 - US
Mix
5184432 - Tan et al., 2019 - CN,US
NonUS
5043338 - Velázquez-Gómez et al., 2019 - ES
5043338 - Velázquez-Gómez et al., 2019 - ES
5043338 - Velázquez-Gómez et al., 2019 - ES
5163693 - Rantakokko et al., 2019 - FI
5165944 - Liu and Mabury, 2019 - CA
5412073 - Giovanoulis et al., 2019 - SE
3223090 - Langer et al., 2016 - DK
3223090 - Langer et al., 2016 - DK
4292121 - Christia et al., 2018 - GR
4292129 - Deng et al., 2018 - CN
4292133 - Persson et al., 2018 - SE
3862555 - Zhou et al., 2017 - DE
3862555 - Zhou et al., 2017 - DE
3862555 - Zhou et al., 2017 - DE
4285929 - He et al., 2018 - AU
0.01
0.1
1
10
100
1000
10^4
10^5
10^6
10^7
Concentration (ng/g) (pt 1)



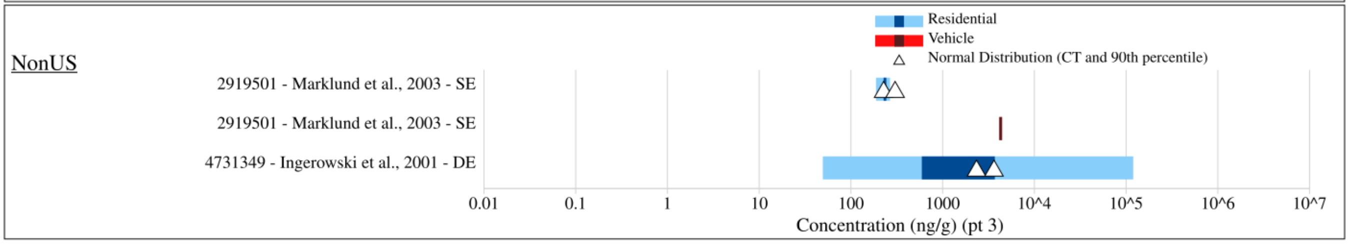


Figure 1-10. Concentrations of TCEP (ng/g) in the Dry Fraction of Dust (Indoor) from 2000 to 2019

Table 1-10. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Dry Fraction of Dust (Indoor)

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Hoffman et al. (2017)	US	Residential	2014–2016	140 (N/R)	N/R	Medium
Phillips et al. (2018)	US	Residential	2014–2016	188 (0.98)	18.7	High
Shin et al. (2019)	US	Residential	2015–2016	38 (0.97)	25.0	Medium
La Guardia and Hale (2015)	US	Public Space	2013	4 (1.00)	100.0	Medium
La Guardia and Hale (2015)	US	Residential	2013	4 (1.00)	100.0	Medium
Stapleton et al. (2014)	US	Residential	2012	30 (1.00)	N/R	High
Schreder and La Guardia (2014)	US	Residential	2011–2012	20 (0.95)	1.0	High
Bradman et al. (2014)	US	Public Space	2010–2011	39 (1.00)	1.0	High
Shin et al. (2014)	US	Residential	2009–2010	30 (1.00)	1.0	High
Fang et al. (2013)	US	Residential	2009	20 (0.50)	20.0	Medium
Fang et al. (2013)	US	Vehicle	2009	20 (0.95)	20.0	Medium
Castorina et al. (2017)	US	Residential	2000–2001	125 (1.00)	27.9	High
Tan et al. (2019)	CN, US	Residential	2019	47 (1.00)	10.0	High
Velázquez-Gómez et al. (2019)	ES	Public Space	2019	33 (1.00)	N/R	Medium
Velázquez-Gómez et al. (2019)	ES	Residential	2019	11 (1.00)	N/R	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Velázquez-Gómez et al. (2019)	ES	Vehicle	2019	14 (1.00)	N/R	Medium
Rantakokko et al. (2019)	FI	Residential	2019	40 (1.00)	3.0	Medium
Liu and Mabury (2019)	CA	Public Space	2018	85 (1.00)	0.4	High
Giovanoulis et al. (2019)	SE	Public Space	2018	20 (1.00)	34.0	High
Langer et al. (2016)	DK	Public Space	2016	151 (0.78)	600.0	High
Langer et al. (2016)	DK	Residential	2016	497 (0.69)	600.0	High
Christia et al. (2018)	GR	Vehicle	2016	25 (0.80)	N/R	High
Deng et al. (2018)	CN	Public Space	2015–2016	22 (1.00)	N/R	Medium
Persson et al. (2018)	SE	Public Space	2015–2016	31 (0.58)	6.9	High
Zhou et al. (2017)	DE	Public Space	2015	48 (0.83)	115.0	High
Zhou et al. (2017)	DE	Residential	2015	15 (0.80)	115.0	High
Zhou et al. (2017)	DE	Vehicle	2015	11 (0.82)	115.0	High
He et al. (2018c)	AU	Public Space	2015	30 (1.00)	10.0	High
He et al. (2018c)	AU	Residential	2015	40 (1.00)	10.0	High
He et al. (2018c)	AU	Vehicle	2015	15 (1.00)	10.0	High
Larsson et al. (2018)	SE	Public Space	2015	100 (0.61)	1200.0	High

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Takeuchi et al. (2015)	JP	Residential	2013–2014	19 (0.95)	N/R	High
Xu et al. (2016)	NO	Residential	2013–2014	122 (0.76)	170.0	Medium
Kim and Tanabe (2017)	KR	Public Space	2014	6 (0.17)	N/R	High
Kim and Tanabe (2017)	KR	Residential	2013–2014	14 (1.00)	N/R	High
Kademoglou et al. (2017)	GB,NO	Residential	2013–2014	20 (1.00)	44.1	Medium
Wallner et al. (2012)	AT	Public Space	2012–2013	36 (1.00)	N/R	Medium
Tokumura et al. (2017)	JP	Vehicle	2013	37 (1.00)	180.0	High
Sugeng et al. (2017)	NL	Residential	2013	28 (0.82)	N/R	Medium
Kademoglou et al. (2017)	GB	Public Space	2013	12 (1.00)	44.1	Medium
Ait Bamai et al. (2018)	JP	Residential	2013	296 (0.84)	N/R	Medium
Ali et al. (2012)	NZ	Residential	2012	50 (0.98)	20.0	Medium
Fromme et al. (2014)	DE	Public Space	2011–2012	63 (1.00)	200.0	Medium
Brandsma et al. (2014)	NL	Residential	2012	16 (1.00)	70.0	High
Brandsma et al. (2014)	NL	Vehicle	2012	16 (1.00)	70.0	High
Coelho et al. (2016)	PT	Residential	2010–2011	28 (0.82)	4.0	Medium
Brommer et al. (2012)	DE	Residential	2010–2011	6 (N/R)	80.0	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Bergh et al. (2011b)	SE	Public Space	2010	20 (N/R)	N/R	Medium
Bergh et al. (2011b)	SE	Residential	2010	10 (N/R)	N/R	Medium
Van den Eede et al. (2012)	BE,ES,RO	Residential	2006–2010	12 (1.00)	110.0	Medium
Tajima et al. (2014)	JP	Residential	2009–2010	256 (0.51)	1000.0	High
Fan et al. (2014)	CA	Residential	2010	268 (0.96)	70.0	High
Mizouchi et al. (2015)	JP	Residential	2009–2010	10 (1.00)	10.0	High
Bastiaensen et al. (2019a)	JP	Residential	2009–2010	196 (0.59)	N/R	High
Luongo and Oestman (2016)	SE	Residential	2008	62 (0.97)	190.0	Medium
Kanazawa et al. (2010)	JP	Residential	2006	82 (0.95)	1300.0	Medium
Marklund et al. (2003)	SE	Other	2003	5 (1.00)	N/R	Medium
Marklund et al. (2003)	SE	Public Space	2003	9 (1.00)	N/R	Medium
Marklund et al. (2003)	SE	Residential	2003	2 (1.00)	N/R	Medium
Marklund et al. (2003)	SE	Vehicle	2003	1 (1.00)	N/R	Medium
Ingerowski et al. (2001)	DE	Residential	2001	983 (N/R)	400.0	Medium
Abbreviations: N/R, Not reported						

1.8.2 Dust (Indoor) (ng/g) – Dry Fraction

Measured concentrations of BCEP in Dust (Indoor) with unit of ng/g, extracted from one source, are summarized in Figure 1-11 and supplemental information is provided in Table 1-11. Overall, concentrations were not detected ng/g from 47 samples collected in 2019 in two countries, CN and US.

Location types were categorized as Residential. Reported detection frequency was 0.0.

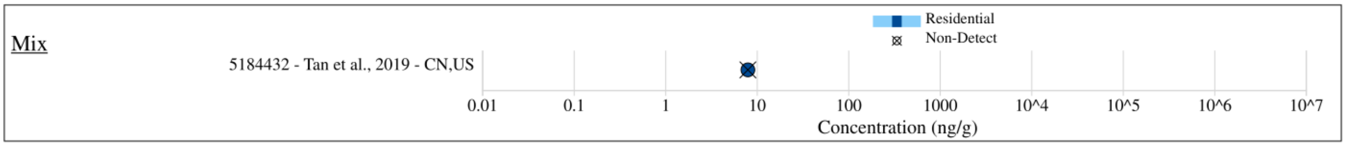


Figure 1-11. Concentrations of BCEP (ng/g) in the Dry Fraction of Dust (Indoor) in Residential Locations in 2019

Table 1-11. Summary of Peer-Reviewed Literature that Measured BCEP (ng/g) Levels in the Dry Fraction of Dust (Indoor)

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Tan et al. (2019)	CN,US	Residential	2019	47 (0.00)	16	High

1.8.3 Dust (Indoor) (ng/m²) – Dry Fraction

Measured concentrations of TCEP in Dust (Indoor) with unit of ng/m², extracted from four sources, are summarized in Figure 1-12 and supplemental information is provided in Table 1-12. Overall, concentrations ranged from not detected to 1,243,900.0 ng/m² from 180 samples collected between 2000 and 2016 in two countries, SE and US. Location types were categorized as Public Space, Unknown and Residential. Reported detection frequency ranged from 0.0 to 1.0.

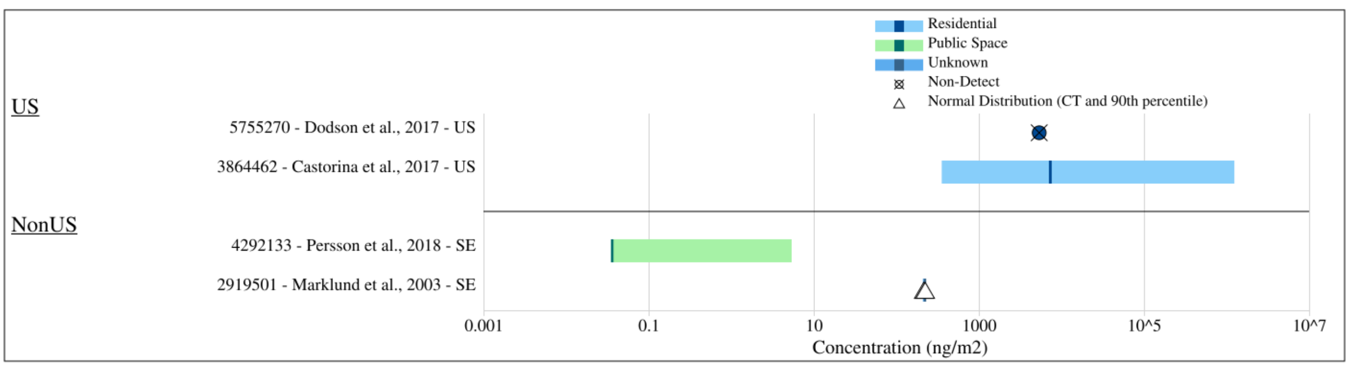


Figure 1-12. Concentrations of TCEP (ng/m²) in the Dry Fraction of Dust (Indoor) from 2000 to 2016

Table 1-12. Summary of Peer-Reviewed Literature that Measured TCEP (ng/m²) Levels in the Dry Fraction of Dust (Indoor)

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/m²)	Overall Quality Level
Dodson et al. (2017)	US	Residential	2013–2014	37 (0.00)	10,763.91042	High

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/m²)	Overall Quality Level
Castorina et al. (2017)	US	Residential	2000–2001	125 (1.00)	27.9	High
Persson et al. (2018)	SE	Public Space	2015–2016	16 (0.44)	0.07	High
Marklund et al. (2003)	SE	Unknown	2003	2 (1.00)	N/R	Medium
Abbreviations: N/R, Not reported						

1.9 Groundwater

1.9.1 Groundwater (ng/L) – Not Specified Fraction

Measured concentrations of TCEP in Groundwater with unit of ng/L, extracted from 11 sources, are summarized in Figure 1-13 and supplemental information is provided in Table 1-13. Overall, concentrations ranged from not detected to 810.0 ng/L from 582 samples collected between 1978 and 2017 in four countries, DE, JP, SE and US. Location types were categorized as General Population (Background) and Near Facility (Highly Exposed). Reported detection frequency ranged from 0.0 to 1.0.

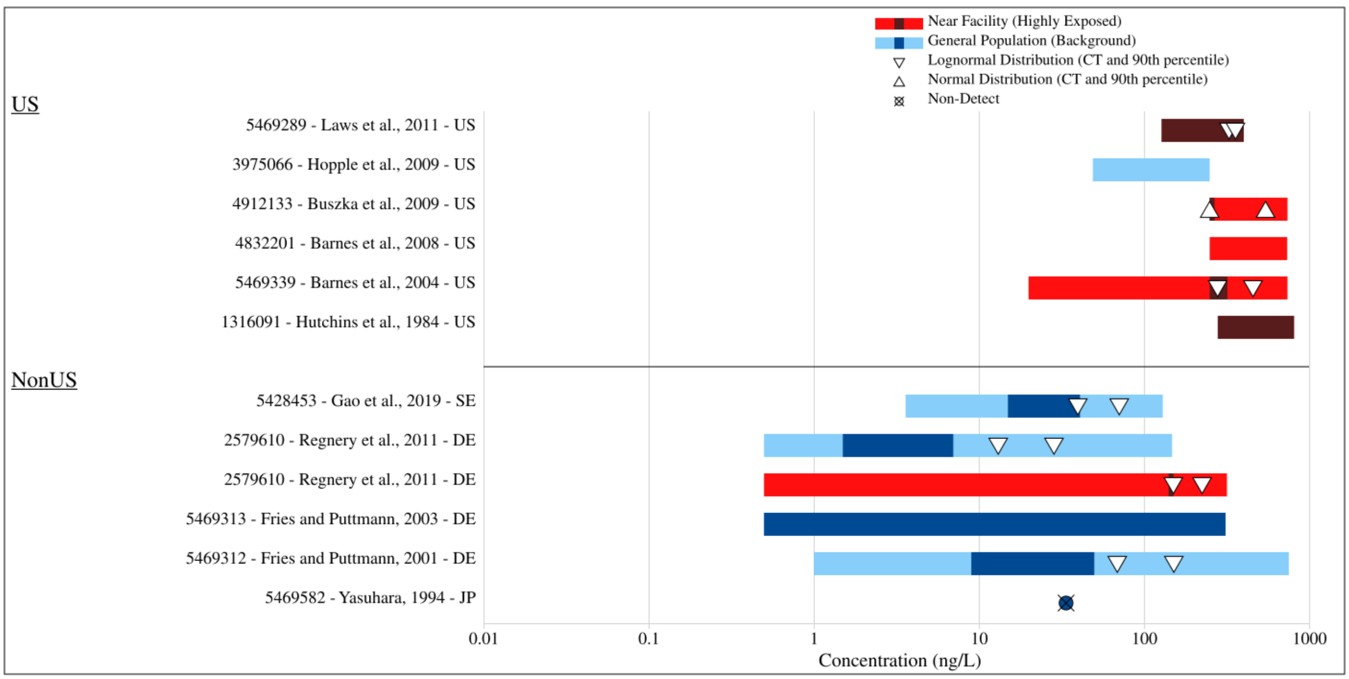


Figure 1-13. Concentrations of TCEP (ng/L) in the Not Specified Fraction of Groundwater from 1978 to 2017

Table 1-13. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Not Specified Fraction of Groundwater

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Laws et al. (2011)	US	Near Facility (Highly Exposed)	2009	11 (1.00)	10.0	Medium
Hopple et al. (2009)	US	General Population (Background)	2002–2005	276 (0.02)	500.0	High
Buszka et al. (2009)	US	Near Facility (Highly Exposed)	2000–2002	6 (0.33)	500.0	Medium
Barnes et al. (2008)	US	Near Facility (Highly Exposed)	2000	47 (0.30)	500.0	Medium
Barnes et al. (2004)	US	Near Facility (Highly Exposed)	2000	5 (1.00)	40.0	Medium
Hutchins et al. (1984)	US	Near Facility (Highly Exposed)	1978	4 (N/R)	N/R	Medium
Gao et al. (2019)	SE	General Population (Background)	2016–2017	30 (0.83)	7.2	High
Regnery et al. (2011)	DE	General Population (Background)	2009	25 (0.56)	1.0	High
Regnery et al. (2011)	DE	Near Facility (Highly Exposed)	2009	11 (0.91)	1.0	High
Fries and Puttmann (2003)	DE	General Population (Background)	2000–2001	76 (N/R)	1.0	Medium
Fries and Puttmann (2001)	DE	General Population (Background)	2000	90 (N/R)	1.0	Medium
Yasuhara (1994)	JP	General Population (Background)	1994	1 (0.00)	67.5	Medium

Abbreviations: N/R, Not reported

1.10 Human Biomonitoring – Breastmilk

1.10.1 Human Biomonitoring – Breastmilk (ng/L) – wet Fraction

Measured concentrations of TCEP in Human Biomonitoring – Breastmilk with unit of ng/L, extracted from one source, are summarized in Figure 1-14 and supplemental information is provided in Table 1-14. Overall, concentrations ranged from not detected to 470 ng/L from three samples collected between 2014 and 2015 in one country, AU. Location types were categorized as General Population (Background). Reported detection frequency was 0.67.

Figure 1-14. Concentrations of TCEP (ng/L) in the wet Fraction of Human Biomonitoring – Breastmilk in General Population (Background) Locations from 2014 to 2015

Table 1-14. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the wet Fraction of Human Biomonitoring – Breastmilk

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
He et al. (2018a)	AU	General Population (Background)	2014–2015	3 (0.67)	260	High

1.10.2 Human Biomonitoring – Breastmilk (ng/g) – Lipid Fraction

Measured concentrations of TCEP in Human Biomonitoring – Breastmilk with unit of ng/g, extracted from 2 sources, are summarized in Figure 1-15 and supplemental information is provided in Table 1-15. Overall, concentrations ranged from not detected to 512.0 ng/g from 93 samples collected between 1997 and 2011 in four countries, JP, PH, SE and VN. Location types were categorized as General Population (Background) and Near Facility (Highly Exposed). Reported detection frequency was 1.0.

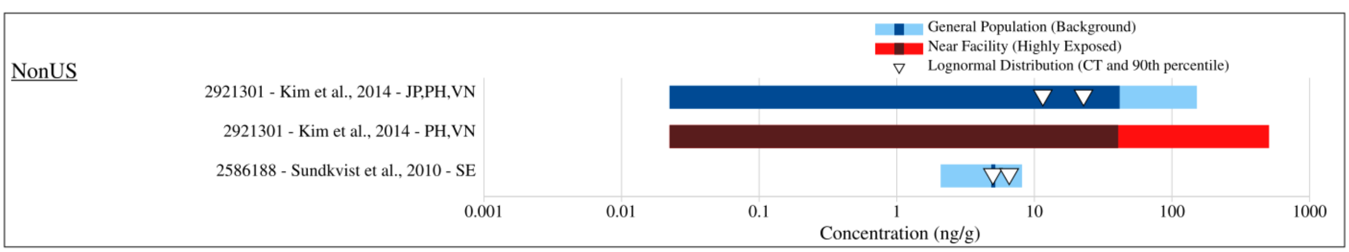


Figure 1-15. Concentrations of TCEP (ng/g) in the Lipid Fraction of Human Biomonitoring – Breastmilk from 1997 to 2011

Table 1-15. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Lipid Fraction of Human Biomonitoring – Breastmilk

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Kim et al. (2014)	JP, PH, VN	General Population (Background)	2008–2011	46 (N/R)	0.045	Medium
Kim et al. (2014)	PH, VN	Near Facility (Highly Exposed)	2008	41 (N/R)	0.045	Medium
Sundkvist et al. (2010)	SE	General Population (Background)	1997–2006	6 (1.00)	0.4	High
Abbreviations: N/R, Not reported						

1.11 Human Biomonitoring – Hair

1.11.1 Human Biomonitoring – Hair (ng/g) – Dry Fraction

Measured concentrations of TCEP in Human Biomonitoring – Hair with unit of ng/g, extracted from two sources, are summarized in Figure 1-16 and supplemental information is provided in Table 1-16. Overall, concentrations ranged from 37.5 to 2,740 ng/g from 55 samples collected between 2014 and 2015 in one country, US. Location types were categorized as General Population (Background). Reported detection frequency ranged from 0.68 to 0.8.

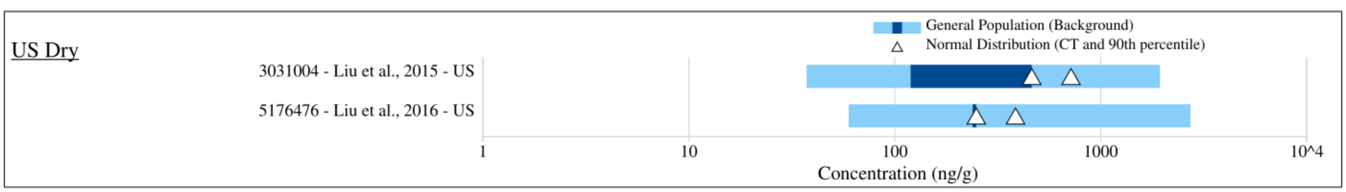


Figure 1-16. Concentrations of TCEP (ng/g) in the Dry Fraction of Human Biomonitoring – Hair in General Population (Background) Locations from 2014 to 2015

Table 1-16. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Dry Fraction of Human Biomonitoring – Hair

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Liu et al. (2015)	US	General Population (Background)	2015	5 (0.80)	75.0	Medium
Liu et al. (2016)	US	General Population (Background)	2014	50 (0.68)	N/R	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Abbreviations: N/R, Not reported						

1.12 Human Biomonitoring – Nails

1.12.1 Human Biomonitoring – Nails (ng/g) – Dry Fraction

Measured concentrations of TCEP in Human Biomonitoring – Nails with unit of ng/g, extracted from two sources, are summarized in Figure 1-17 and supplemental information is provided in Table 1-17. Overall, concentrations ranged from not detected to 1860.0 ng/g from 105 samples collected between 2014 and 2015 in one country, US. Location types were categorized as General Population (Background). Reported detection frequency ranged from 0.0 to 0.14.

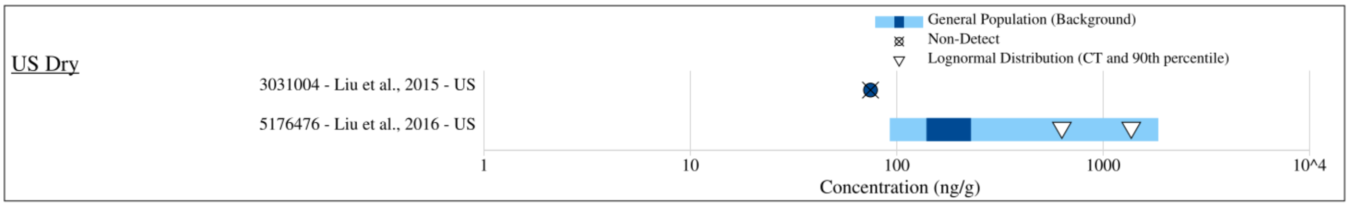


Figure 1-17. Concentrations of TCEP (ng/g) in the Dry Fraction of Human Biomonitoring – Nails in General Population (Background) Locations from 2014 to 2015

Table 1-17. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Dry Fraction of Human Biomonitoring – Nails

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Liu et al. (2015)	US	General Population (Background)	2015	5 (0.00)	150.0	Medium
Liu et al. (2016)	US	General Population (Background)	2014	100 (0.14)	N/R	Medium
Abbreviations: N/R, Not reported						

1.13 Human Biomonitoring – Other

1.13.1 Human Biomonitoring – Other (ng/g) – Dry Fraction

Measured concentrations of TCEP in Human Biomonitoring – Other with unit of ng/g, extracted from one source, are summarized in Figure 1-18 and supplemental information is provided in Table 1-18. Overall, concentrations ranged from 0.055 to 41.8 ng/g from 100 samples collected between 2014 and 2016 in one country, CN. Location types were categorized as General Population (Background). Reported detection frequency was 0.66.

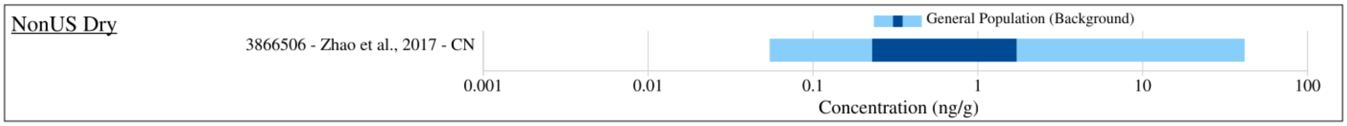


Figure 1-18. Concentrations of TCEP (ng/g) in the Dry Fraction of Human Biomonitoring – Other in General Population (Background) Locations from 2014 to 2016

Table 1-18. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Dry Fraction of Human Biomonitoring – Other

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Zhao et al. (2017)	CN	General Population (Background)	2014–2016	100 (0.66)	0.11	High

1.13.2 Human Biomonitoring – Other (ng/g) – Dry Fraction

Measured concentrations of BCEP in Human Biomonitoring – Other with unit of ng/g, extracted from one source, are summarized in Figure 1-19 and supplemental information is provided in Table 1-19. Overall, concentrations ranged from 0.44 to 1,180 ng/g from 50 samples collected between 2014 and 2016 in one country, CN. Location types were categorized as General Population (Background). Reported detection frequency was 0.88.

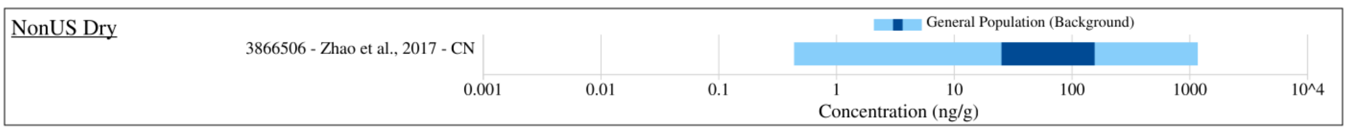


Figure 1-19. Concentrations of BCEP (ng/g) in the Dry Fraction of Human Biomonitoring – Other in General Population (Background) Locations from 2014 to 2016

Table 1-19. Summary of Peer-Reviewed Literature that Measured BCEP (ng/g) Levels in the Dry Fraction of Human Biomonitoring – Other

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Zhao et al. (2017)	CN	General Population (Background)	2014–2016	50 (0.88)	0.88	High

1.14 Human Biomonitoring – Plasma

1.14.1 Human Biomonitoring – Plasma (ng/L) – Wet Fraction

Measured concentrations of TCEP in Human Biomonitoring – Plasma with unit of ng/L, extracted from one source, are summarized in Figure 1-20 and supplemental information is provided in Table 1-20. Overall, concentrations ranged from not detected to 230 ng/L from 25 samples collected between 2014 and 2016 in one country, CN. Location types were categorized as General Population (Background).

Reported detection frequency was 0.48.

Figure 1-20. Concentrations of TCEP (ng/L) in the Wet Fraction of Human Biomonitoring – Plasma in General Population (Background) Locations from 2014 to 2016

Table 1-20. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Wet Fraction of Human Biomonitoring – Plasma

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Zhao et al. (2017)	CN	General Population (Background)	2014–2016	25 (0.48)	90	High

1.15 Human Biomonitoring – Serum

1.15.1 Human Biomonitoring – Serum (ng/g) – Lipid Fraction

Measured concentrations of TCEP in Human Biomonitoring – Serum with unit of ng/g, extracted from one source, are summarized in Figure 1-21 and supplemental information is provided in Table 1-21. Overall, concentrations ranged from 3.12 to 3.69 ng/g from 20 samples collected in 2016 in one country, ES. Location types were categorized as General Population (Background). Reported detection frequency was 1.0.

Figure 1-21. Concentrations of TCEP (ng/g) in the Lipid Fraction of Human Biomonitoring – Serum in General Population (Background) Locations in 2016

Table 1-21. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Lipid Fraction of Human Biomonitoring – Serum

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Henríquez-Hernández et al. (2017)	ES	General Population (Background)	2016	20 (1.00)	N/R	High
Abbreviations: N/R, Not reported						

1.16 Human Biomonitoring – Skin_Dermal Wipe

1.16.1 Human Biomonitoring – Skin_Dermal Wipe (ng/g) – Dry Fraction

Measured concentrations of TCEP in Human Biomonitoring – Skin_Dermal Wipe with unit of ng/g, extracted from one source, are summarized in Figure 1-22 and supplemental information is provided in Table 1-22. Overall, concentrations ranged from 20 to 6,920 ng/g from 30 samples collected in 2012 in one country, US. Location types were categorized as General Population (Background). Reported detection frequency was 1.0.

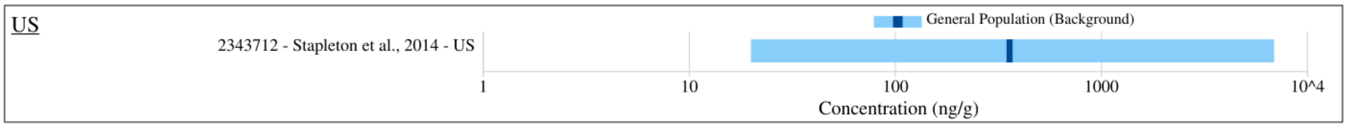


Figure 1-22. Concentrations of TCEP (ng/g) in the Dry Fraction of Human Biomonitoring – Skin_Dermal Wipe in General Population (Background) Locations in 2012

Table 1-22. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Dry Fraction of Human Biomonitoring – Skin_Dermal Wipe

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Stapleton et al. (2014)	US	General Population (Background)	2012	30 (1.00)	N/R	High
Abbreviations: N/R, Not reported						

1.16.2 Human Biomonitoring – Skin_Dermal Wipe (ng/wipe) – Dry Fraction

Measured concentrations of TCEP in Human Biomonitoring – Skin_Dermal Wipe with unit of ng/wipe, extracted from four sources, are summarized in Figure 1-23 and supplemental information is provided in Table 1-23. Overall, concentrations ranged from not detected to 3,216 ng/wipe from 400 samples collected between 2012 and 2016 in three countries, NO, SE and US. Location types were categorized as General Population (Background). Reported detection frequency ranged from 0.47 to 0.87.

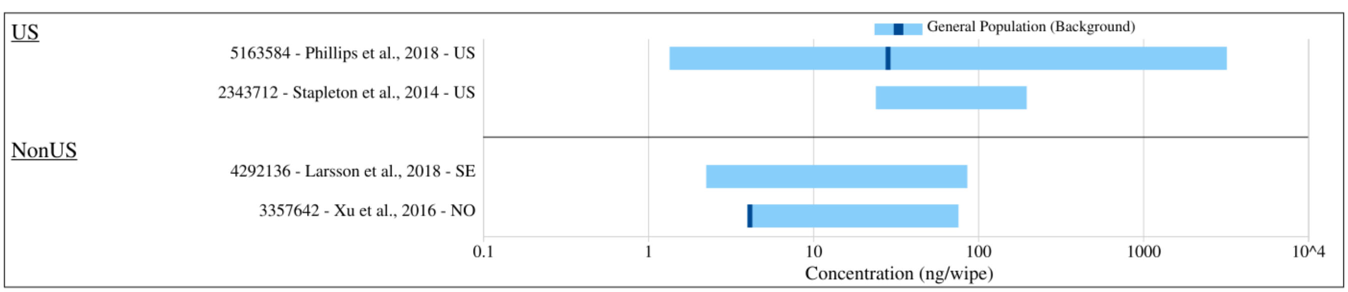


Figure 1-23. Concentrations of TCEP (ng/wipe) in the Dry Fraction of Human Biomonitoring – Skin_Dermal Wipe in General Population (Background) Locations from 2012 to 2016

Table 1-23. Summary of Peer-Reviewed Literature that Measured TCEP (ng/wipe) Levels in the Dry Fraction of Human Biomonitoring – Skin_Dermal Wipe

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/wipe)	Overall Quality Level
Phillips et al. (2018)	US	General Population (Background)	2014–2016	202 (0.87)	2.7	High
Stapleton et al. (2014)	US	General Population (Background)	2012	43 (0.47)	24.0	High
Larsson et al. (2018)	SE	General Population (Background)	2015	100 (0.51)	4.5	High
Xu et al. (2016)	NO	General Population (Background)	2013–2014	55 (0.49)	N/R	Medium
Abbreviations: N/R, Not reported						

1.17 Human Biomonitoring – Urine

1.17.1 Human Biomonitoring – Urine (ng/g) – Creatinine Adjusted Fraction

Measured concentrations of BCEP in Human Biomonitoring – Urine with unit of ng/g, extracted from one source, are summarized in Figure 1-24 and supplemental information is provided in Table 1-24. Overall, concentrations ranged from not detected to 1900 ng/g from 213 samples collected in 2018 in one country, US. Location types were categorized as General Population (Background). Reported detection frequency was 0.87.

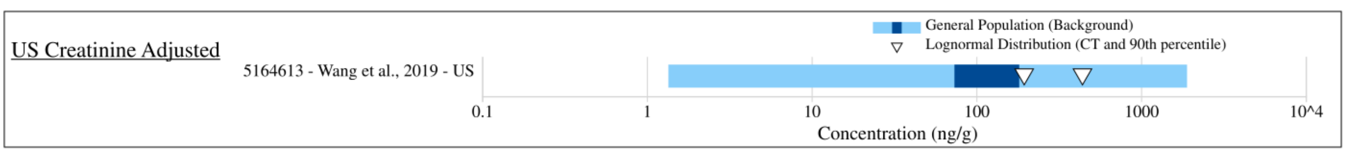


Figure 1-24. Concentrations of BCEP (ng/g) in the Creatinine Adjusted Fraction of Human Biomonitoring – Urine in General Population (Background) Locations in 2018

Table 1-24. Summary of Peer-Reviewed Literature that Measured BCEP (ng/g) Levels in the Creatinine Adjusted Fraction of Human Biomonitoring – Urine

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Wang et al. (2019)	US	General Population (Background)	2018	213 (0.87)	2.7	High

1.17.2 Human Biomonitoring – Urine (ng/L) – Unadjusted Fraction

Measured concentrations of TCEP in Human Biomonitoring – Urine with unit of ng/L, extracted from three sources, are summarized in Figure 1-25 and supplemental information is provided in Table 1-25. Overall, concentrations ranged from not detected to 24500 ng/L from 594 samples collected between 2010 and 2015 in two countries, AU and BE. Location types were categorized as General Population (Background). Reported detection frequency ranged from 0.11 to 0.55.

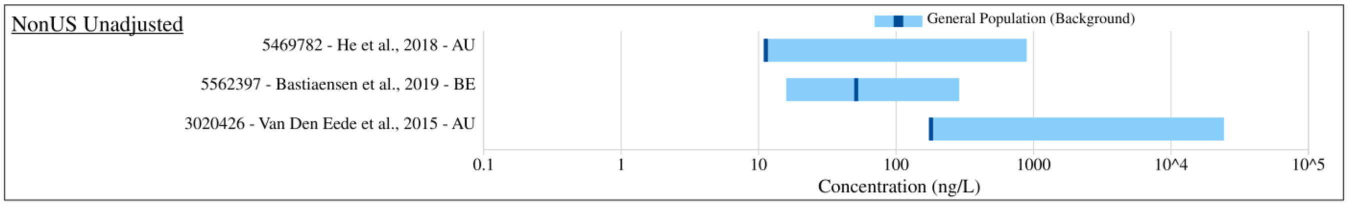


Figure 1-25. Concentrations of TCEP (ng/L) in the Unadjusted Fraction of Human Biomonitoring – Urine in General Population (Background) Locations from 2010 to 2015

Table 1-25. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Unadjusted Fraction of Human Biomonitoring – Urine

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
He et al. (2018a)	AU	General Population (Background)	2014–2015	400 (0.45)	22.0	High
Bastiaensen et al. (2019b)	BE	General Population (Background)	2015	99 (0.55)	32.0	Medium
Van Den Eede et al. (2015)	AU	General Population (Background)	2010–2013	95 (0.11)	350.0	Medium

1.17.3 Human Biomonitoring – Urine (ng/L) – All Fractions

Measured concentrations of BCEP in Human Biomonitoring – Urine with unit of ng/L, extracted from four sources, are summarized in Figure 1-26 and supplemental information is provided in Table 1-26. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Creatinine Adjusted ranged from not detected to 13.5 ng/L from 213 samples collected in 2018 in one country, US. Location types were categorized as General Population (Background). Reported detection frequency was 0.87.

Overall, concentrations for Unadjusted ranged from not detected to 13100.0 ng/L from 728 samples collected between 2011 and 2015 in three countries, AU, DE and US. Location types were categorized as General Population (Background). Reported detection frequency ranged from 0.15 to 0.75.

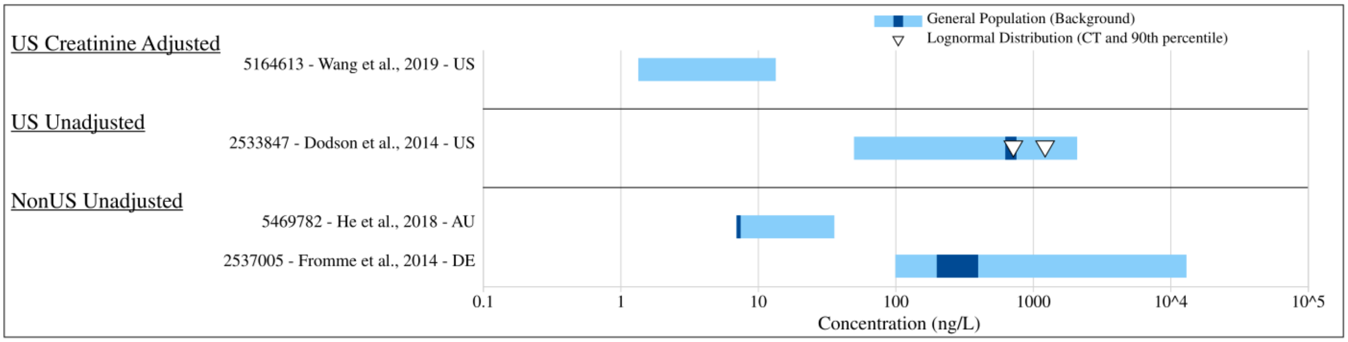


Figure 1-26. Concentrations of BCEP (ng/L) in Human Biomonitoring – Urine in General Population (Background) Locations from 2011 to 2018

Table 1-26. Summary of Peer-Reviewed Literature that Measured BCEP (ng/L) Levels in Human Biomonitoring – Urine

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Creatinine Adjusted						
Wang et al. (2019)	US	General Population (Background)	2018	213 (0.87)	2.7	High
Unadjusted						
Dodson et al. (2014)	US	General Population (Background)	2011	16 (0.75)	100.0	High
He et al. (2018a)	AU	General Population (Background)	2014–2015	400 (0.15)	14.0	High
Fromme et al. (2014)	DE	General Population (Background)	2011–2012	312 (0.65)	200.0	Medium

1.18 Human Biomonitoring – Silicone Wristbands

1.18.1 Human Biomonitoring – Silicone Wristbands (ng/g) – Not Specified Fraction

Measured concentrations of TCEP in Human Biomonitoring – Silicone Wristbands with unit of ng/g, extracted from two sources, are summarized in Figure 1-27 and supplemental information is provided in Table 1-27. Overall, concentrations ranged from not detected to 719.0 ng/g from 140 samples collected between 2012 and 2015 in one country, US. Location types were categorized as General Population (Background). Reported detection frequency ranged from 0.83 to 0.89.

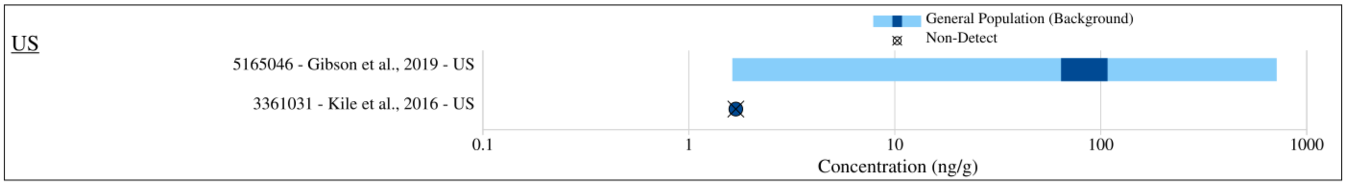


Figure 1-27. Concentrations of TCEP (ng/g) in the Not Specified Fraction of Human Biomonitoring – Silicone Wristbands in General Population (Background) Locations from 2012 to 2015

Table 1-27. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Not Specified Fraction of Human Biomonitoring – Silicone Wristbands

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Gibson et al. (2019)	US	General Population (Background)	2015	76 (0.83)	3.27	High
Kile et al. (2016)	US	General Population (Background)	2012–2013	64 (0.89)	3.4	Medium

1.19 Indoor Air

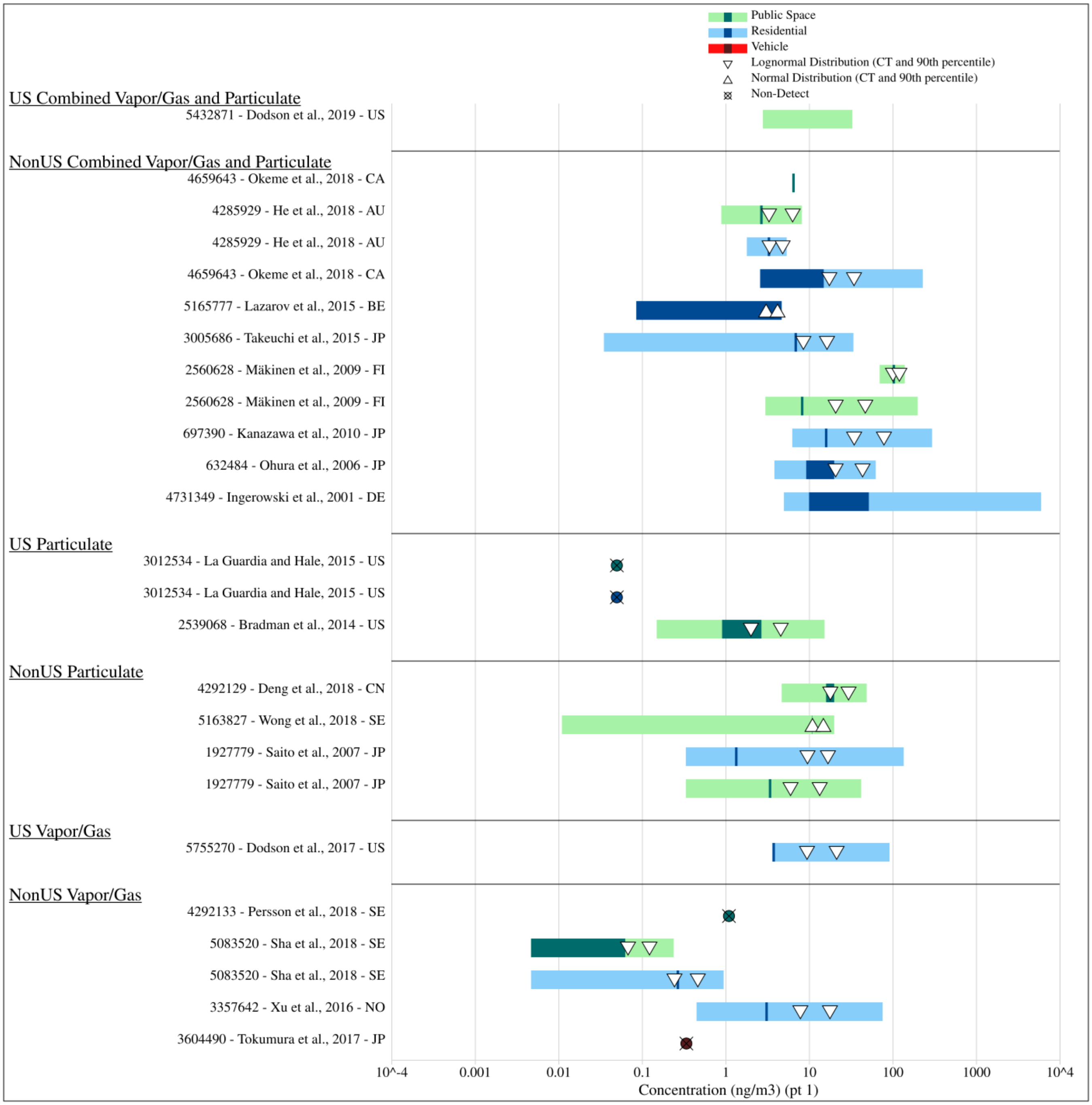
1.19.1 Indoor Air (ng/m^3) – All Fractions

Measured concentrations of TCEP in Indoor Air with unit of ng/m^3, extracted from 27 sources, are summarized in Figure 1-28 and supplemental information is provided in Table 1-28. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Combined Vapor/Gas and Particulate ranged from not detected to 6,000.0 ng/m^3 from 440 samples collected between 2000 and 2016 in seven countries, AU, BE, CA, DE, FI, JP and US. Location types were categorized as Public Space and Residential. Reported detection frequency ranged from 0.32 to 1.0.

Overall, concentrations for Particulate ranged from not detected to 136.0 ng/m^3 from 133 samples collected between 2002 and 2016 in four countries, CN, JP, SE and US. Location types were categorized as Public Space and Residential. Reported detection frequency ranged from 0.0 to 1.0.

Overall, concentrations for Vapor/Gas ranged from not detected to 7,100.0 ng/m^3 from 677 samples collected between 2000 and 2016 in six countries, CH, DE, JP, NO, SE and US. Location types were categorized as Vehicle, Public Space and Residential. Reported detection frequency ranged from 0.0 to 1.0.


Public Space
Residential
Vehicle
Lognormal Distribution (CT and 90th percentile)
Normal Distribution (CT and 90th percentile)
Non-Detect
US Combined Vapor/Gas and Particulate
5432871 - Dodson et al., 2019 - US
NonUS Combined Vapor/Gas and Particulate
4659643 - Okeme et al., 2018 - CA
4285929 - He et al., 2018 - AU
4285929 - He et al., 2018 - AU
4659643 - Okeme et al., 2018 - CA
5165777 - Lazarov et al., 2015 - BE
3005686 - Takeuchi et al., 2015 - JP
2560628 - Mäkinen et al., 2009 - FI
2560628 - Mäkinen et al., 2009 - FI
697390 - Kanazawa et al., 2010 - JP
632484 - Ohura et al., 2006 - JP
4731349 - Ingerowski et al., 2001 - DE
US Particulate
3012534 - La Guardia and Hale, 2015 - US
3012534 - La Guardia and Hale, 2015 - US
2539068 - Bradman et al., 2014 - US
NonUS Particulate
4292129 - Deng et al., 2018 - CN
5163827 - Wong et al., 2018 - SE
1927779 - Saito et al., 2007 - JP
1927779 - Saito et al., 2007 - JP
US Vapor/Gas
5755270 - Dodson et al., 2017 - US
NonUS Vapor/Gas
4292133 - Persson et al., 2018 - SE
5083520 - Sha et al., 2018 - SE
5083520 - Sha et al., 2018 - SE
3357642 - Xu et al., 2016 - NO
3604490 - Tokumura et al., 2017 - JP
10^-4
0.001
0.01
0.1
1
10
100
1000
10^4
Concentration (ng/m3) (pt 1)

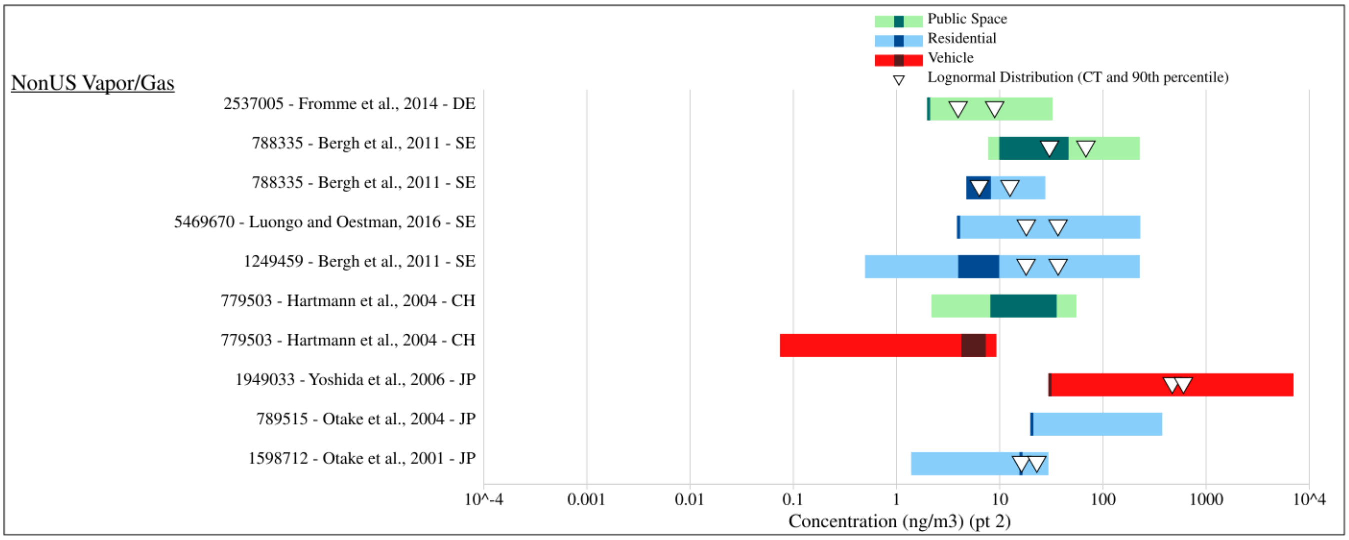


Figure 1-28. Concentrations of TCEP (ng/m³) in Indoor Air from 2000 to 2016

Table 1-28. Summary of Peer-Reviewed Literature that Measured TCEP (ng/m³) Levels in Indoor Air

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/m³)	Overall Quality Level
Combined Vapor/Gas and Particulate						
Dodson et al. (2019)	US	Public Space	2013–2015	37 (0.32)	5.6	High
Okeme et al. (2018b)	CA	Public Space	2016	51 (0.80)	N/R	Medium
He et al. (2018c)	AU	Public Space	2015	40 (1.00)	0.06	High
He et al. (2018c)	AU	Residential	2015	40 (1.00)	0.06	High
Okeme et al. (2018b)	CA	Residential	2015	102 (0.77)	N/R	Medium
Lazarov et al. (2015)	BE	Residential	2015	6 (N/R)	0.171	Medium
Takeuchi et al. (2015)	JP	Residential	2013–2014	21 (0.90)	0.07	High
Mäkinen et al. (2009)	FI	Public Space	2008	3 (1.00)	N/R	Medium
Mäkinen et al. (2009)	FI	Public Space	2008	4 (0.50)	3.0	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/m^3)	Overall Quality Level
Kanazawa et al. (2010)	JP	Residential	2006	40 (0.60)	12.6	Medium
Ohura et al. (2006)	JP	Residential	2000–2001	46 (0.89)	N/R	Medium
Ingerowski et al. (2001)	DE	Residential	2001	50 (1.00)	N/R	Medium
Particulate						
La Guardia and Hale (2015)	US	Public Space	2013	8 (0.00)	0.1	Medium
La Guardia and Hale (2015)	US	Residential	2013	8 (0.00)	0.1	Medium
Bradman et al. (2014)	US	Public Space	2010–2011	40 (0.65)	0.3	High
Deng et al. (2018)	CN	Public Space	2015–2016	22 (1.00)	N/R	Medium
Wong et al. (2018)	SE	Public Space	2014–2015	23 (1.00)	0.022	Medium
Saito et al. (2007)	JP	Residential	2002	18 (N/R)	0.67	Medium
Saito et al. (2007)	JP	Public Space	2002	14 (N/R)	0.67	Medium
Vapor/Gas						
Dodson et al. (2017)	US	Residential	2013–2014	35 (0.17)	7.3	High
Persson et al. (2018)	SE	Public Space	2015–2016	56 (0.00)	2.2	High
Sha et al. (2018)	SE	Public Space	2016	36 (N/R)	0.0094	Low
Sha et al. (2018)	SE	Residential	2016	9 (N/R)	0.0094	Low
Xu et al. (2016)	NO	Residential	2013–2014	58 (0.93)	0.9	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/m^3)	Overall Quality Level
Tokumura et al. (2017)	JP	Vehicle	2013	9 (0.00)	0.68	High
Fromme et al. (2014)	DE	Public Space	2011–2012	63 (0.17)	4.0	Medium
Bergh et al. (2011b)	SE	Public Space	2010	20 (N/R)	N/R	Medium
Bergh et al. (2011b)	SE	Residential	2010	10 (N/R)	N/R	Medium
Luongo and Oestman (2016)	SE	Residential	2008	62 (0.65)	N/R	Medium
Bergh et al. (2011a)	SE	Residential	2006–2007	169 (N/R)	1.0	Medium
Hartmann et al. (2004)	CH	Public Space	2004	12 (1.00)	0.15	Medium
Hartmann et al. (2004)	CH	Vehicle	2004	4 (0.75)	0.15	Medium
Yoshida et al. (2006)	JP	Vehicle	2004	101 (0.80)	N/R	Medium
Otake et al. (2004)	JP	Residential	2000	27 (N/R)	N/R	Medium
Otake et al. (2001)	JP	Residential	2000	6 (1.00)	N/R	Medium
Abbreviations: N/R, Not reported						

1.20 Leachate

1.20.1 Leachate (ng/L) – Not Specified Fraction

Measured concentrations of TCEP in leachate with unit of ng/L, extracted from three sources, are summarized in Figure 1-29 and supplemental information is provided in Table 1-29. Overall, concentrations ranged from 6 to 5,430,000,000,000.0 ng/L from 20 samples collected between 1994 and 1995 in one country, JP. Location types were categorized as Unknown/Not Specified and Near Facility (Highly Exposed). Reported detection frequency was 1.0.

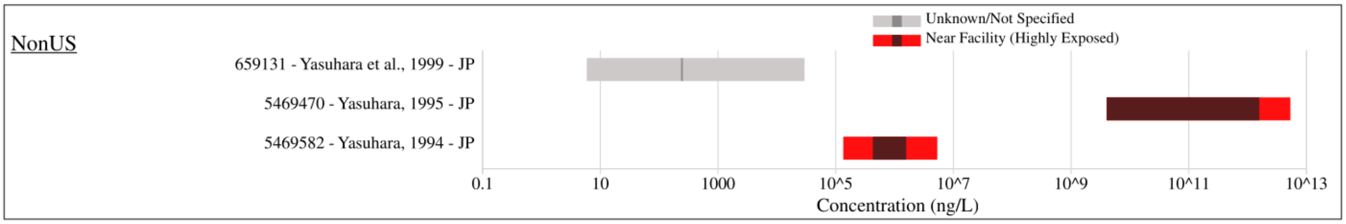


Figure 1-29. Concentrations of TCEP (ng/L) in the Not Specified Fraction of Leachate from 1994 to 1995

Table 1-29. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Not Specified Fraction of Leachate

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Yasuhara et al. (1999)	JP	Unknown/Not Specified	1995	11 (1.00)	N/R	Medium
Yasuhara (1995)	JP	Near Facility (Highly Exposed)	1995	5 (1.00)	N/R	Low
Yasuhara (1994)	JP	Near Facility (Highly Exposed)	1994	4 (1.00)	67.5	Medium
Abbreviations: N/R, Not reported						

1.21 Other

1.21.1 Other (ng/g) – Dry Fraction

Measured concentrations of TCEP in Other with unit of ng/g, extracted from one source, are summarized in Figure 1-30 and supplemental information is provided in Table 1-30. Overall, concentrations ranged from 0.007 to 0.039 ng/g from six samples collected in 2003 in one country, SE. Location types were categorized as Unknown/Not Specified. Reported detection frequency was 1.0.

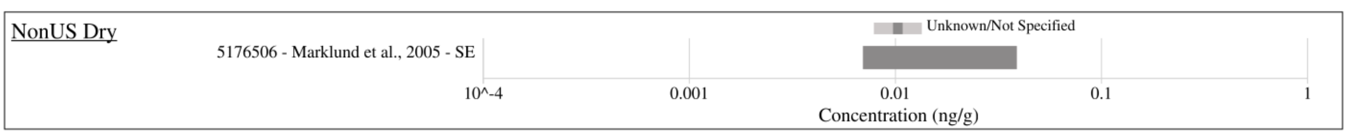


Figure 1-30. Concentrations of TCEP (ng/g) in the Dry Fraction of Other in Unknown/Not Specified Locations in 2003

Table 1-30. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Dry Fraction of Other

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Marklund et al. (2005b)	SE	Unknown/Not Specified	2003	6 (1.00)	N/R	Medium
Abbreviations: N/R, Not reported						

1.21.2 Other (ng/g) – All Fractions

Measured concentrations of TCEP in Other with unit of ng/g, extracted from three sources, are summarized in Figure 1-31 and supplemental information is provided in Table 1-31. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Particulate ranged from 0.007 to 68,000,000.0 ng/g from 12 samples collected between 2001 and 2003 in two countries, DE and SE. Location types were categorized as General Population (Background) and Unknown/Not Specified. Reported detection frequency was 1.0.

Overall, concentrations for Wet ranged from not detected to 0.55 ng/g from three samples collected in 2008 in one country, NL. Location types were categorized as Near Facility (Highly Exposed). Reported detection frequency was 0.67.

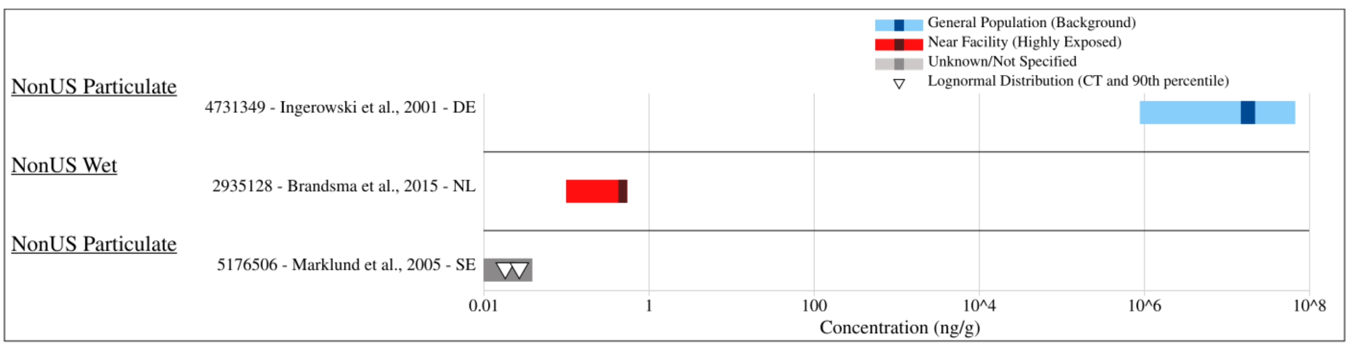


Figure 1-31. Concentrations of TCEP (ng/g) in Other from 2001 to 2008

Table 1-31. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in Other

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Particulate						
Ingerowski et al. (2001)	DE	General Population (Background)	2001	6 (1.00)	400.0	Medium
Marklund et al. (2005b)	SE	Unknown/Not Specified	2003	6 (1.00)	N/R	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Wet						
Brandsma et al. (2015)	NL	Near Facility (Highly Exposed)	2008	3 (0.67)	0.2	High
Abbreviations: N/R, Not reported						

1.21.3 Other (ng/L) – Not Specified Fraction

Measured concentrations of TCEP in Other with unit of ng/L, extracted from one source, are summarized in Figure 1-32 and supplemental information is provided in Table 1-32. Overall, concentrations ranged from 2.5 to 293 ng/L from 42 samples collected in 2016 in one country, AU. Location types were categorized as General Population (Background). Reported detection frequency was not reported.

Figure 1-32. Concentrations of TCEP (ng/L) in the Not Specified Fraction of Other in General Population (Background) Locations in 2016

Table 1-32. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Not Specified Fraction of Other

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Teo et al. (2016)	AU	General Population (Background)	2016	42 (N/R)	5	High
Abbreviations: N/R, Not reported						

1.22 Personal Inhalation

1.22.1 Personal Inhalation (ng/m^3) – All Fractions

Measured concentrations of TCEP in Personal Inhalation with unit of ng/m^3, extracted from three sources, are summarized in Figure 1-33 and supplemental information is provided in Table 1-33. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Particulate ranged from not detected to 77.8 ng/m^3 from 21 samples collected between 2015 and 2016 in two countries, CA and US. Location types were categorized as General Population (Background). Reported detection frequency ranged from 0.44 to 1.0.

Overall, concentrations for Vapor/Gas ranged from 0.5 to 8.1 ng/m^3 from 31 samples collected between 2013 and 2014 in one country, NO. Location types were categorized as General Population (Background). Reported detection frequency was 0.77.

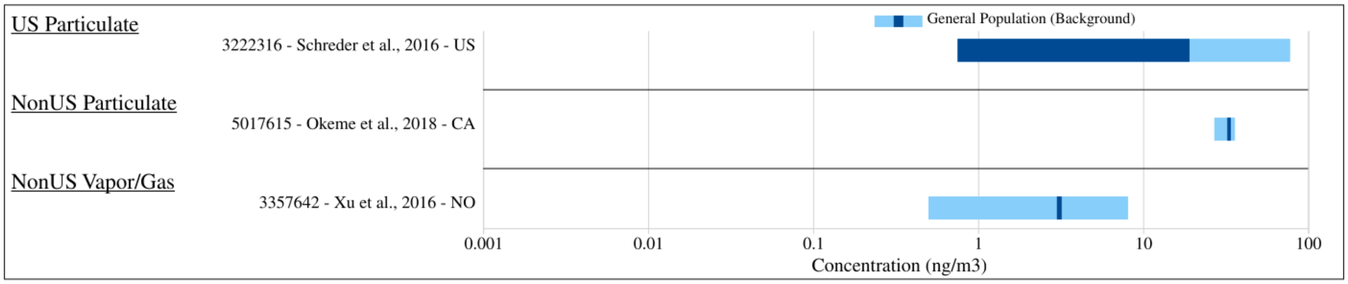


Figure 1-33. Concentrations of TCEP (ng/m^3) in Personal Inhalation in General Population (Background) Locations from 2013 to 2016

Table 1-33. Summary of Peer-Reviewed Literature that Measured TCEP (ng/m^3) Levels in Personal Inhalation

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/m^3)	Overall Quality Level
Particulate						
Schreder et al. (2016)	US	General Population (Background)	2015	18 (0.44)	1.5	High
Okeme et al. (2018a)	CA	General Population (Background)	2016	3 (1.00)	0.012	Medium
Vapor/Gas						
Xu et al. (2016)	NO	General Population (Background)	2013–2014	31 (0.77)	1.0	Medium

1.23 Precipitation

1.23.1 Precipitation (ng/L) – Wet Fraction

Measured concentrations of TCEP in Precipitation with unit of ng/L, extracted from six sources, are summarized in Figure 1-34 and supplemental information is provided in Table 1-34. Overall, concentrations ranged from not detected to 488.0 ng/L from 313 samples collected between 1994 and 2014 in three countries, AQ, DE and US. Location types were categorized as General Population (Background) and Remote (Not Near Source). Reported detection frequency ranged from 0.6 to 1.0.

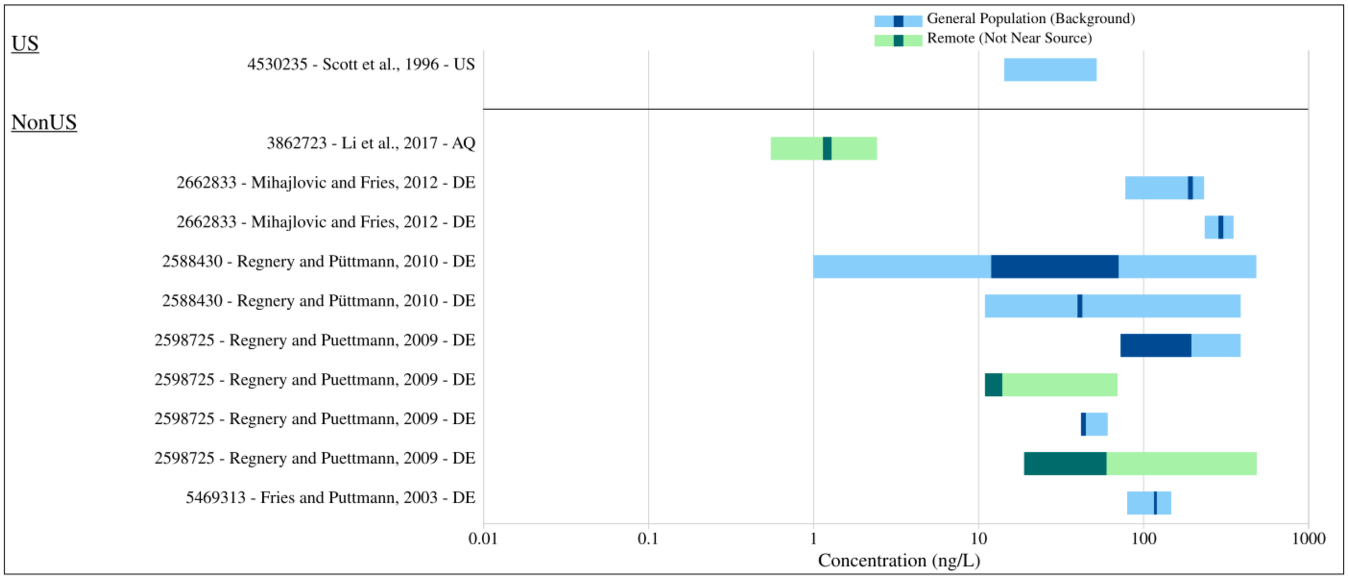


Figure 1-34. Concentrations of TCEP (ng/L) in the Wet Fraction of Precipitation from 1994 to 2014

Table 1-34. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Wet Fraction of Precipitation

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Scott et al. (1996)	US	General Population (Background)	1994	5 (0.60)	N/R	Low
Li et al. (2017)	AQ	Remote (Not Near Source)	2014	6 (1.00)	0.21	High
Mihajlovic and Fries (2012)	DE	General Population (Background)	2011	4 (N/R)	N/R	High
Mihajlovic and Fries (2012)	DE	General Population (Background)	2010	4 (N/R)	N/R	High
Regnery and Püttmann (2010b)	DE	General Population (Background)	2007–2009	167 (N/R)	2.0	High
Regnery and Püttmann (2010b)	DE	General Population (Background)	2007–2009	29 (1.00)	2.0	High
Regnery and Puettmann (2009)	DE	General Population (Background)	2007–2008	30 (N/R)	2.0	High

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Regnery and Puettmann (2009)	DE	Remote (Not Near Source)	2007-2008	23 (N/R)	2.0	High
Regnery and Puettmann (2009)	DE	General Population (Background)	2007-2008	8 (N/R)	2.0	High
Regnery and Puettmann (2009)	DE	Remote (Not Near Source)	2007-2008	34 (N/R)	2.0	High
Fries and Puttmann (2003)	DE	General Population (Background)	2001	3 (1.00)	1.0	Medium
Abbreviations: N/R, Not reported						

1.24 Sediment

1.24.1 Sediment (ng/g) – All Fractions

Measured concentrations of TCEP in Sediment with unit of ng/g, extracted from seven sources, are summarized in Figure 1-35 and supplemental information is provided in Table 1-35. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Dry ranged from not detected to 41.0 ng/g from 91 samples collected between 1980 and 2017 in seven countries, CZ, DE, JP, KR, PT, US and ZA. Location types were categorized as General Population (Background), Near Facility (Highly Exposed) and Unknown/Not Specified. Reported detection frequency ranged from 0.75 to 1.0.

Overall, concentrations for Wet ranged from not detected to 0.35 ng/g from three samples collected in 2008 in one country, NL. Location types were categorized as Near Facility (Highly Exposed). Reported detection frequency was 0.67.

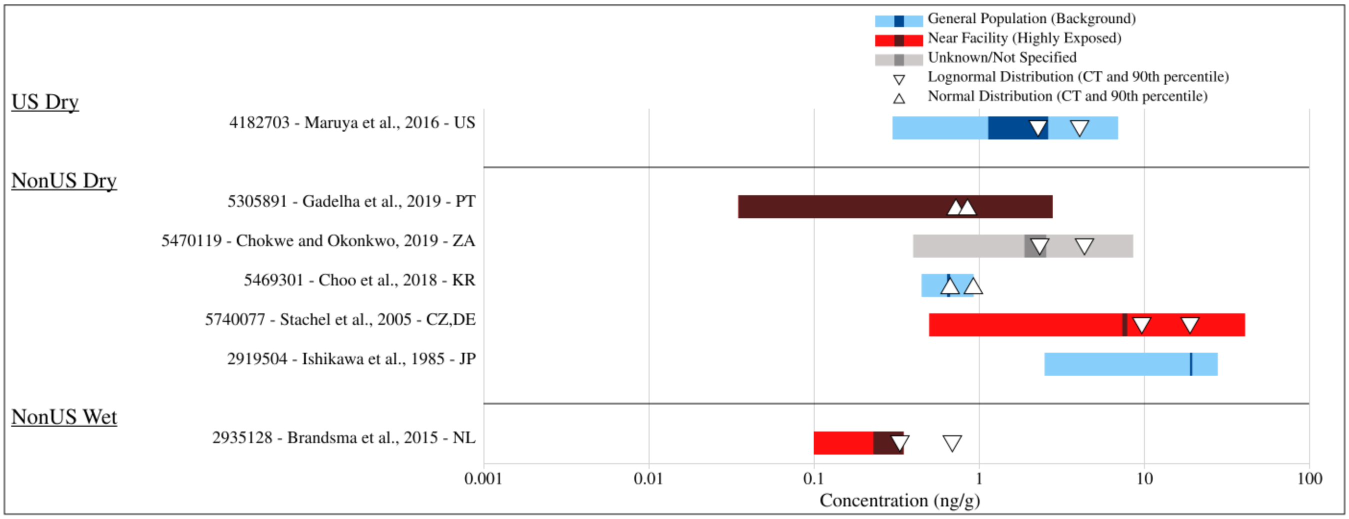


Figure 1-35. Concentrations of TCEP (ng/g) in Sediment from 1980 to 2017

Table 1-35. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in Sediment

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Dry						
Maruya et al. (2016)	US	General Population (Background)	2013	16 (0.75)	N/R	High
Gadelha et al. (2019)	PT	Near Facility (Highly Exposed)	2016–2017	12 (N/R)	0.07	High
Chokwe and Okonkwo (2019)	ZA	Unknown/Not Specified	2017	16 (0.88)	0.24	High
Choo et al. (2018)	KR	General Population (Background)	2015	4 (1.00)	0.01	High
Stachel et al. (2005)	CZ,DE	Near Facility (Highly Exposed)	2002	37 (N/R)	1.0	Medium
Ishikawa et al. (1985)	JP	General Population (Background)	1980	6 (0.83)	5.0	Medium
Wet						

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Brandsma et al. (2015)	NL	Near Facility (Highly Exposed)	2008	3 (0.67)	0.2	High
Abbreviations: N/R, Not reported						

1.25 Soil

1.25.1 Soil (ng/g) – Dry Fraction

Measured concentrations of TCEP in Soil with unit of ng/g, extracted from three sources, are summarized in Figure 1-36 and supplemental information is provided in Table 1-36. Overall, concentrations ranged from not detected to 23.48 ng/g from 18 samples collected between 2010 and 2014 in two countries, DE and TR. Location types were categorized as General Population (Background). Reported detection frequency was not reported.

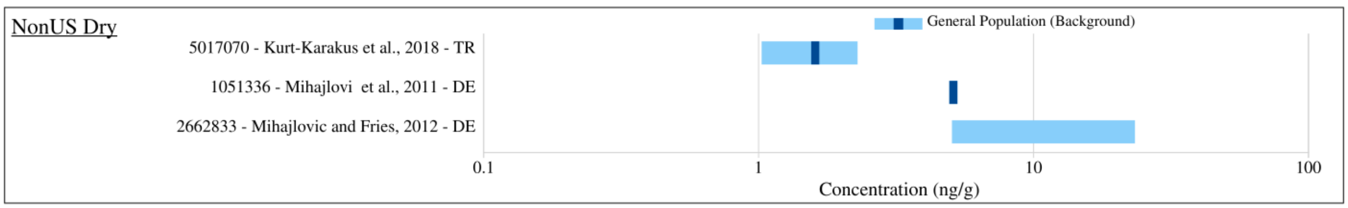


Figure 1-36. Concentrations of TCEP (ng/g) in the Dry Fraction of Soil in General Population (Background) Locations from 2010 to 2014

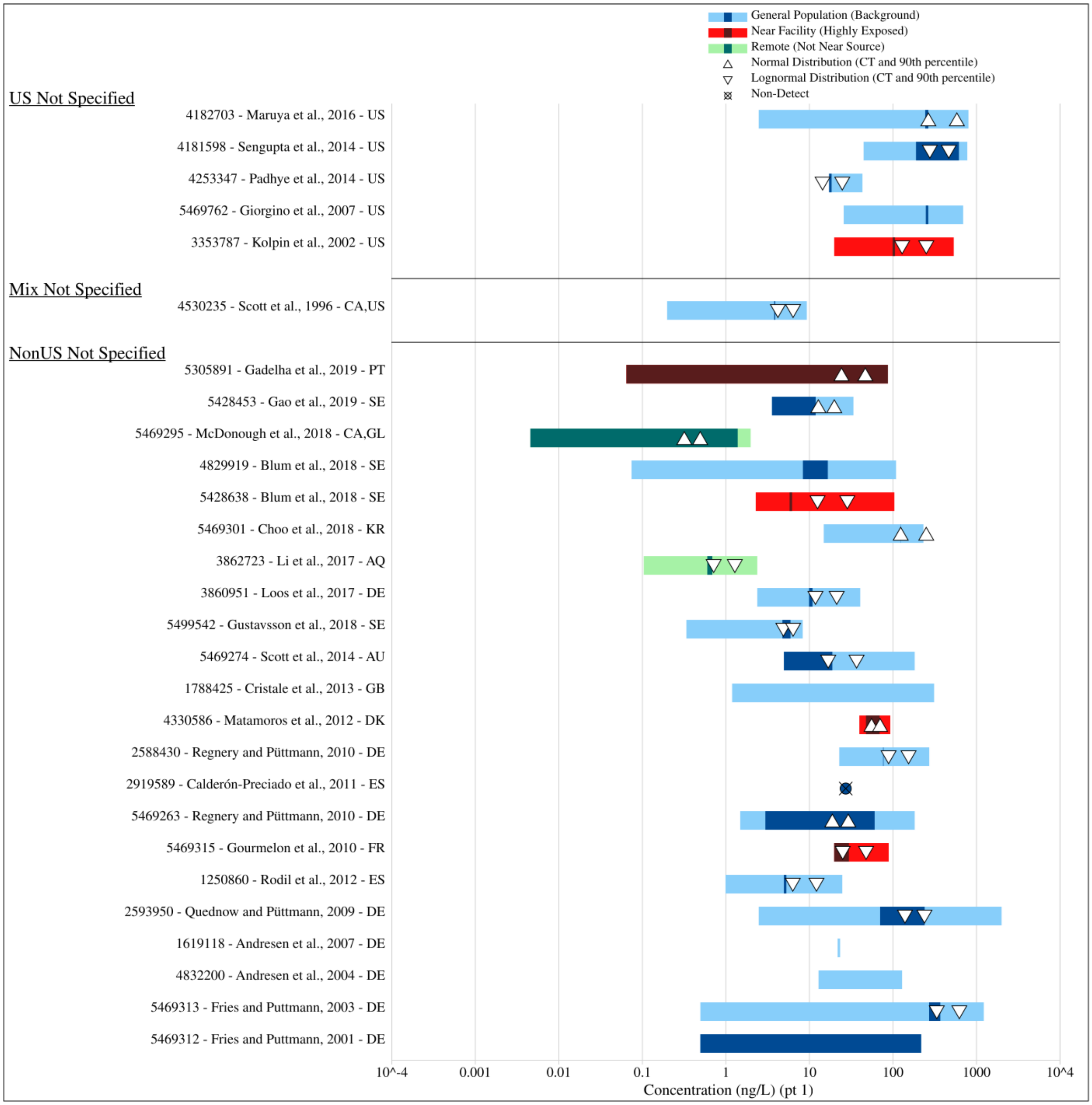
Table 1-36. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Dry Fraction of Soil

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Kurt-Karakus et al. (2018)	TR	General Population (Background)	2014	8 (N/R)	3.4	High
Mihajlović et al. (2011)	DE	General Population (Background)	2011	6 (N/R)	0.2	Medium
Mihajlovic and Fries (2012)	DE	General Population (Background)	2010–2011	4 (N/R)	0.2	High
Abbreviations: N/R, Not reported						

1.26 Surface Water

1.26.1 Surface Water (ng/L) – Not Specified Fraction

Measured concentrations of TCEP in Surface Water with unit of ng/L, extracted from 29 sources, are summarized in Figure 1-37 and supplemental information is provided in Table 1-37. Overall, concentrations ranged from not detected to 2,019.0 ng/L from 3,283 samples collected between 1980 and 2017 in 14 countries, AQ, AU, CA, DE, DK, ES, FR, GB, GL, JP, KR, PT, SE and US. Location types were categorized as General Population (Background), Near Facility (Highly Exposed) and Remote (Not Near Source). Reported detection frequency ranged from 0.0 to 1.0.



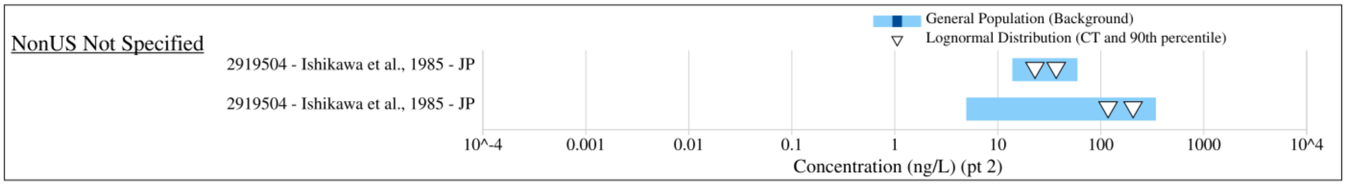


Figure 1-37. Concentrations of TCEP (ng/L) in the Not Specified Fraction of Surface Water from 1980 to 2017

Table 1-37. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Not Specified Fraction of Surface Water

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Maruya et al. (2016)	US	General Population (Background)	2013	17 (0.65)	5.0	High
Sengupta et al. (2014)	US	General Population (Background)	2011	30 (1.00)	N/R	Medium
Padhye et al. (2014)	US	General Population (Background)	2009–2010	8 (N/R)	N/R	Medium
Giorgino et al. (2007)	US	General Population (Background)	2002–2005	14 (0.36)	500.0	High
Kolpin et al. (2002)	US	Near Facility (Highly Exposed)	1999–2000	85 (0.58)	40.0	High
Scott et al. (1996)	CA, US	General Population (Background)	1994	43 (1.00)	N/R	Low
Gadelha et al. (2019)	PT	Near Facility (Highly Exposed)	2016–2017	12 (N/R)	0.13	High
Gao et al. (2019)	SE	General Population (Background)	2016–2017	8 (0.25)	7.2	High
McDonough et al. (2018)	CA,GL	Remote (Not Near Source)	2014–2016	13 (0.46)	0.22	High
Blum et al. (2018a)	SE	General Population (Background)	2014–2015	16 (0.88)	0.15	High

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Blum et al. (2018b)	SE	Near Facility (Highly Exposed)	2014–2015	20 (0.60)	N/R	High
Choo et al. (2018)	KR	General Population (Background)	2015	4 (1.00)	0.24	High
Li et al. (2017)	AQ	Remote (Not Near Source)	2014	25 (0.88)	0.21	High
Loos et al. (2017)	DE	General Population (Background)	2013	71 (1.00)	0.29	High
Gustavsson et al. (2018)	SE	General Population (Background)	2013	28 (0.57)	0.68	High
Scott et al. (2014)	AU	General Population (Background)	2011–2012	285 (0.44)	10.0	High
Cristale et al. (2013)	GB	General Population (Background)	2011	13 (1.00)	2.4	Medium
Matamoros et al. (2012)	DK	Near Facility (Highly Exposed)	2010	29 (1.00)	N/R	High
Regnery and Püttmann (2010b)	DE	General Population (Background)	2008–2009	52 (1.00)	2.0	High
Calderón-Preciado et al. (2011)	ES	General Population (Background)	2008–2009	8 (0.00)	55.0	Medium
Regnery and Püttmann (2010a)	DE	General Population (Background)	2007–2009	151 (N/R)	1.0	High
Gourmelon et al. (2010)	FR	Near Facility (Highly Exposed)	2009	20 (0.25)	40.0	Medium
Rodil et al. (2012)	ES	General Population (Background)	2007–2008	28 (0.64)	0.004	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Quednow and Püttmann (2009)	DE	General Population (Background)	2003–2006	1,650 (0.91)	5.0	High
Andresen et al. (2007)	DE	General Population (Background)	2005	14 (N/R)	0.3	High
Andresen et al. (2004)	DE	General Population (Background)	2002	44 (N/R)	N/R	Medium
Fries and Puttmann (2003)	DE	General Population (Background)	2000–2001	9 (0.89)	1.0	Medium
Fries and Puttmann (2001)	DE	General Population (Background)	2000	561 (N/R)	1.0	Medium
Ishikawa et al. (1985)	JP	General Population (Background)	1980	9 (1.00)	10.0	Medium
Ishikawa et al. (1985)	JP	General Population (Background)	1980	16 (0.88)	10.0	Medium
Abbreviations: N/R, Not reported						

1.27 Terrestrial Organisms – Bird

1.27.1 Terrestrial Organisms – Bird (ng/g) – All Fractions

Measured concentrations of TCEP in Terrestrial Organisms – Bird with unit of ng/g, extracted from seven sources, are summarized in Figure 1-38 and supplemental information is provided in Table 1-38. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Wet ranged from not detected to 39.0 ng/g from 160 samples collected between 2000 and 2012 in four countries, CA, NL, NO and US. Location types were categorized as General Population (Background), Near Facility (Highly Exposed) and Remote (Not Near Source). Reported detection frequency ranged from 0.0 to 1.0.

Overall, concentrations for Dry ranged from not detected to 3,000.0 ng/g from 40 samples collected between 2008 and 2016 in three countries, ES, NL and NO. Location types were categorized as General Population (Background), Near Facility (Highly Exposed) and Remote (Not Near Source). Reported detection frequency ranged from 0.0 to 1.0.

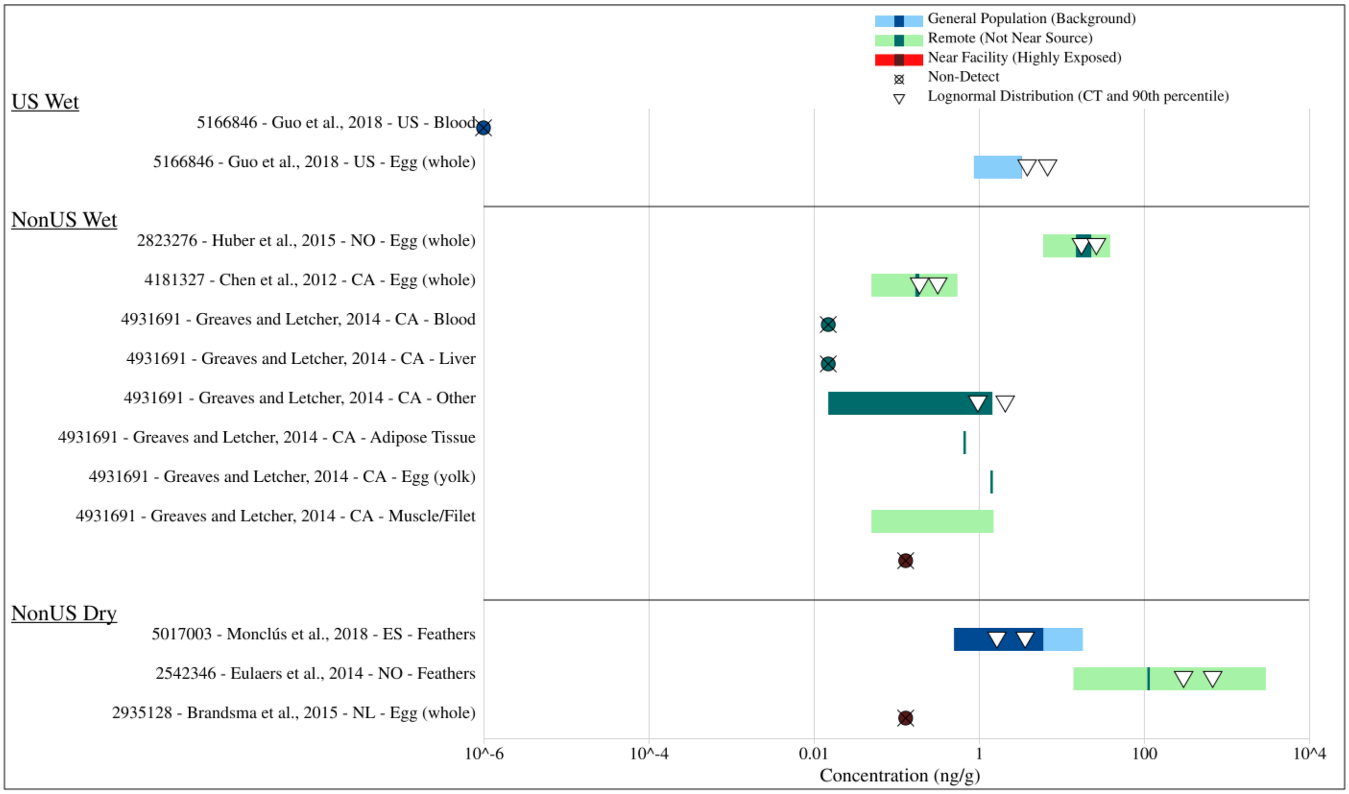


Figure 1-38. Concentrations of TCEP (ng/g) in Terrestrial Organisms – Bird from 2000 to 2016

Table 1-38. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in Terrestrial Organisms – Bird

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Wet						
Guo et al. (2018)	US	General Population (Background)	2000–2012	24 (0.00)	N/R	High
Guo et al. (2018)	US	General Population (Background)	2000–2012	22 (0.55)	1.74	High
Huber et al. (2015)	NO	Remote (Not Near Source)	2012	16 (1.00)	N/R	High
Chen et al. (2012)	CA	Remote (Not Near Source)	2010	13 (0.77)	0.1	Medium
Greaves and Letcher (2014)	CA	Remote (Not Near Source)	2010	16 (0.00)	0.03	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Greaves and Letcher (2014)	CA	Remote (Not Near Source)	2010	8 (0.00)	0.03	Medium
Greaves and Letcher (2014)	CA	Remote (Not Near Source)	2010	24 (N/R)	0.03	Medium
Greaves and Letcher (2014)	CA	Remote (Not Near Source)	2010	8 (N/R)	0.03	Medium
Greaves and Letcher (2014)	CA	Remote (Not Near Source)	2010	16 (N/R)	0.03	Medium
Greaves and Letcher (2014)	CA	Remote (Not Near Source)	2010	8 (0.38)	0.03	Medium
Brandsma et al. (2015)	NL	Near Facility (Highly Exposed)	2008	5 (N/R)	0.26	High
Dry						
Monclús et al. (2018)	ES	General Population (Background)	2016	14 (0.43)	1.0	High
Eulaers et al. (2014)	NO	Remote (Not Near Source)	2011	21 (1.00)	1.0	High
Brandsma et al. (2015)	NL	Near Facility (Highly Exposed)	2008	5 (0.00)	0.26	High
Abbreviations: N/R, Not reported						

1.27.2 Terrestrial Organisms – Bird (ng/g) – Wet Fraction

Measured concentrations of BCEP in Terrestrial Organisms – Bird with unit of ng/g, extracted from one source, are summarized in Figure 1-39 and supplemental information is provided in Table 1-39. Overall, concentrations ranged from 0.38 to 26 ng/g from 21 samples collected between 2000 and 2012 in one country, US. Location types were categorized as General Population (Background). Reported detection frequency was 1.0.

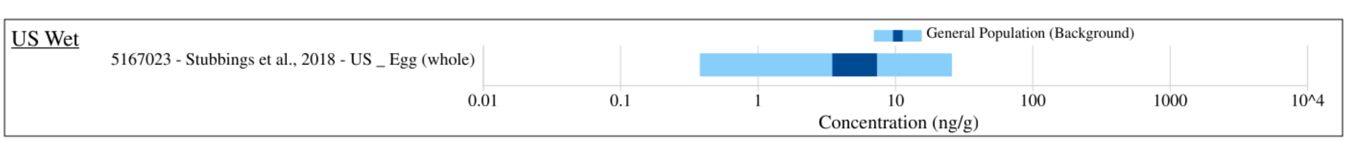


Figure 1-39. Concentrations of BCEP (ng/g) in the Wet Fraction of Terrestrial Organisms – Bird in General Population (Background) Locations from 2000 to 2012

Table 1-39. Summary of Peer-Reviewed Literature that Measured BCEP (ng/g) Levels in the Wet Fraction of Terrestrial Organisms – Bird

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Stubbings et al. (2018)	US	General Population (Background)	2000–2012	21 (1.00)	N/R	High
Abbreviations: N/R, Not reported						

1.28 Terrestrial Organisms – Mammal

1.28.1 Terrestrial Organisms – Mammal (ng/g) – All Fractions

Measured concentrations of TCEP in Terrestrial Organisms – Mammal with unit of ng/g, extracted from two sources, are summarized in Figure 1-40 and supplemental information is provided in Table 1-40. More than one weight fraction was reported and summarized separately below:

Overall, concentrations for Lipid ranged from 1.91 to 52.5 ng/g from 20 samples collected between 2008 and 2010 in one country, NO. Location types were categorized as Remote (Not Near Source). Reported detection frequency was 0.1.

Overall, concentrations for Wet ranged from not detected to 0.115 ng/g from 21 samples collected between 2017 and 2018 in one country, NO. Location types were categorized as General Population (Background). Reported detection frequency was 0.0.

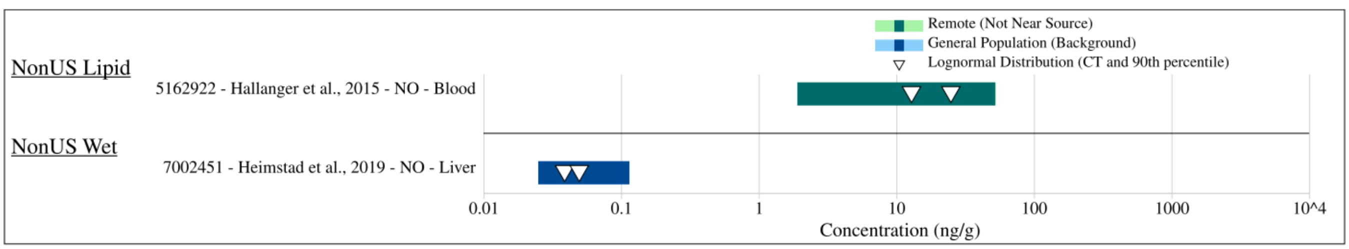


Figure 1-40. Concentrations of TCEP (ng/g) in Terrestrial Organisms – Mammal from 2008 to 2018

Table 1-40. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in Terrestrial Organisms – Mammal

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Lipid						

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Hallanger et al. (2015)	NO	Remote (Not Near Source)	2008–2010	20 (0.10)	N/R	High
Wet						
Heimstad et al. (2019)	NO	General Population (Background)	2017–2018	21 (0.00)	0.23	High
Abbreviations: N/R, Not reported						

1.29 Terrestrial Organisms – Plant

1.29.1 Terrestrial Organisms – Plant (ng/g) – Wet Fraction

Measured concentrations of TCEP in Terrestrial Organisms – Plant with unit of ng/g, extracted from one source, are summarized in Figure 1-41 and supplemental information is provided in Table 1-41. Overall, concentrations ranged from 1.25 to 1950 ng/g from nine samples collected between 1993 and 1994 in one country, US. Location types were categorized as Remote (Not Near Source). Reported detection frequency was 0.67.

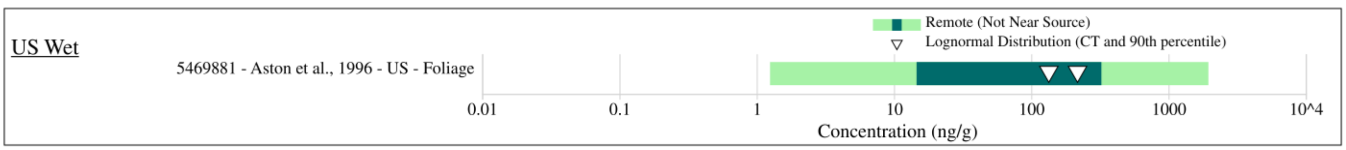


Figure 1-41. Concentrations of TCEP (ng/g) in the Wet Fraction of Terrestrial Organisms – Plant in Remote (Not Near Source) Locations from 1993 to 1994

Table 1-41. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Wet Fraction of Terrestrial Organisms – Plant

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Aston et al. (1996)	US	Remote (Not Near Source)	1993–1994	9 (0.67)	2.5	Medium

1.30 Wastewater

1.30.1 Wastewater (ng/g) – Wet Fraction

Measured concentrations of TCEP in Wastewater with unit of ng/g, extracted from three sources, are summarized in Figure 1-42 and supplemental information is provided in Table 1-42. Overall, concentrations ranged from 0.5 to 198.0 ng/g from 74 samples collected between 2013 and 2018 in three countries, CA, NO and US. Location types were categorized as Raw Influent and Treated Effluent. Reported detection frequency ranged from 0.5 to 1.0.

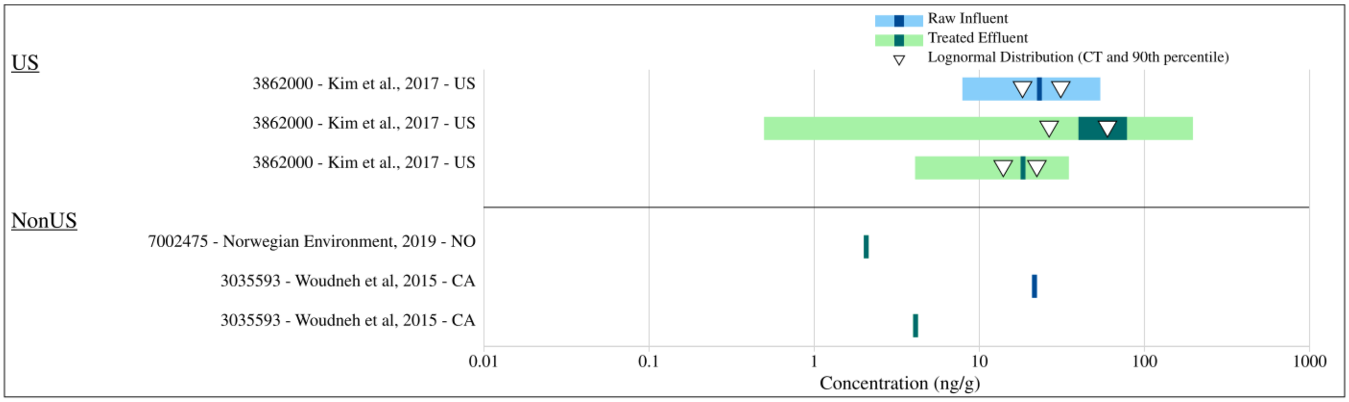


Figure 1-42. Concentrations of TCEP (ng/g) in the Wet Fraction of Wastewater from 2013 to 2018

Table 1-42. Summary of Peer-Reviewed Literature that Measured TCEP (ng/g) Levels in the Wet Fraction of Wastewater

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/g)	Overall Quality Level
Kim et al. (2017)	US	Raw Influent	2013–2015	16 (1.00)	1.0	High
Kim et al. (2017)	US	Treated Effluent	2013–2015	38 (0.50)	1.0	High
Kim et al. (2017)	US	Treated Effluent	2013–2015	16 (1.00)	1.0	High
Norwegian Environment (2019a)	NO	Treated Effluent	2018	2 (N/R)	N/R	Medium
Woudneh et al. (2015)	CA	Raw Influent	2015	1 (1.00)	0.1	Medium
Woudneh et al. (2015)	CA	Treated Effluent	2015	1 (1.00)	0.1	Medium
Abbreviations: N/R, Not reported						

1.30.2 Wastewater (ng/L) – Wet Fraction

Measured concentrations of TCEP in Wastewater with unit of ng/L, extracted from 16 sources, are summarized in Figure 1-43 and supplemental information is provided in Table 1-43. Overall, concentrations ranged from not detected to 42800.0 ng/L from 305 samples collected between 2001 and 2018 in eight countries, AU, BE, DE, ES, FR, NO, SE and US. Location types were categorized as Untreated Combined Sewer Overflow, Raw Influent, Treated Effluent and Untreated Effluent at Discharge Origin. Reported detection frequency ranged from 0.0 to 1.0.

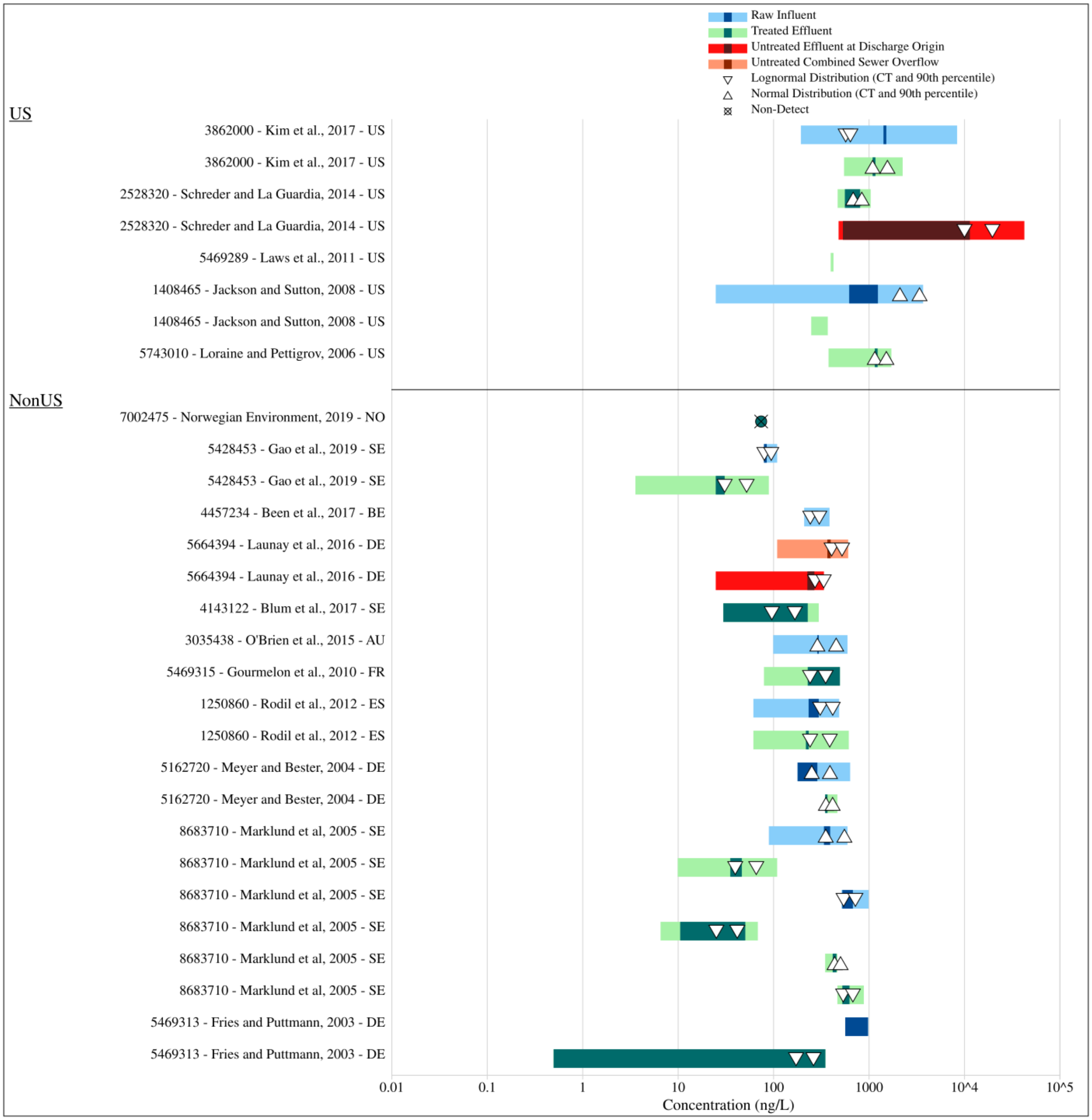


Figure 1-43. Concentrations of TCEP (ng/L) in the Wet Fraction of Wastewater from 2001 to 2018

Table 1-43. Summary of Peer-Reviewed Literature that Measured TCEP (ng/L) Levels in the Wet Fraction of Wastewater

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Kim et al. (2017)	US	Raw Influent	2013–2015	16 (1.00)	50.0	High

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
Kim et al. (2017)	US	Treated Effluent	2013–2015	16 (1.00)	50.0	High
Schreder and La Guardia (2014)	US	Treated Effluent	2011–2012	2 (1.00)	1.0	High
Schreder and La Guardia (2014)	US	Untreated Effluent at Discharge Origin	2011–2012	21 (1.00)	1.0	High
Laws et al. (2011)	US	Treated Effluent	2009	1 (1.00)	200.0	Medium
Jackson and Sutton (2008)	US	Raw Influent	2006	10 (0.20)	6250.0	Medium
Jackson and Sutton (2008)	US	Treated Effluent	2006	3 (0.67)	N/R	Medium
Loraine and Pettigrov (2006)	US	Treated Effluent	2001–2002	6 (0.50)	760.0	Medium
Norwegian Environment (2019a)	NO	Treated Effluent	2018	2 (N/R)	N/R	Medium
Gao et al. (2019)	SE	Raw Influent	2017	4 (1.00)	7.2	High
Gao et al. (2019)	SE	Treated Effluent	2016–2017	8 (0.88)	7.2	High
Been et al. (2017)	BE	Raw Influent	2015–2016	8 (1.00)	1.1	Medium
Launay et al. (2016)	DE	Untreated Combined Sewer Overflow	2014	9 (N/R)	50.0	High
Launay et al. (2016)	DE	Untreated Effluent at Discharge Origin	2014	7 (N/R)	50.0	High
Blum et al. (2017)	SE	Treated Effluent	2013	10 (0.80)	N/R	Medium

Citation	Country	Location Type	Sampling Year	Sample Size (Frequency of Detection)	Detection Limit (ng/L)	Overall Quality Level
O'Brien et al. (2015)	AU	Raw Influent	2011	15 (0.93)	200.0	High
Gourmelon et al. (2010)	FR	Treated Effluent	2009	14 (1.00)	40.0	Medium
Rodil et al. (2012)	ES	Raw Influent	2007–2008	11 (1.00)	10.0	Medium
Rodil et al. (2012)	ES	Treated Effluent	2007–2008	11 (1.00)	10.0	Medium
Meyer and Bester (2004)	DE	Raw Influent	2003	0 (N/R)	6.1	Medium
Meyer and Bester (2004)	DE	Treated Effluent	2003	18 (0.00)	6.1	Medium
Marklund et al. (2005a)	SE	Raw Influent	2002–2003	18 (N/R)	N/R	Medium
Marklund et al. (2005a)	SE	Treated Effluent	2002–2003	17 (N/R)	N/R	Medium
Marklund et al. (2005a)	SE	Raw Influent	2002–2003	9 (N/R)	N/R	Medium
Marklund et al. (2005a)	SE	Treated Effluent	2002–2003	34 (N/R)	N/R	Medium
Marklund et al. (2005a)	SE	Treated Effluent	2002–2003	18 (N/R)	N/R	Medium
Marklund et al. (2005a)	SE	Treated Effluent	2002–2003	9 (N/R)	N/R	Medium
Fries and Puttmann (2003)	DE	Raw Influent	2001	4 (1.00)	1.0	Medium
Fries and Puttmann (2003)	DE	Treated Effluent	2001	4 (0.75)	1.0	Medium
Abbreviations: N/R, Not reported						

2 METHODS AND APPROACH

2.1 Data Integration Methods and Approach

Extracted study data required further processing to allow for the standardization and integration of TCEP data across all studies. Where studies reported data values for metabolites of TCEP, including BCEP (bis(2-chloroethyl) phosphate, CAS No. 4050-56-0, these values were extracted separately in DistillerSR and data summaries are reported separately in this report for TCEP and its individual metabolites.

To enable comparison of data across studies, all extracted environmental monitoring and biomonitoring concentrations were converted to common unit by medium (*i.e.*, ng/L for aqueous media, ng/g for solid phase media, ng/m^3 for air media). Study-reported summary statistics were used, as available, to characterize the concentrations for all unique scenarios including minimums and maximum concentrations, measures of central tendency, percentiles, measures of variance, frequencies of detection, and reported limits of detection (LOD) and/or limits of quantitation (LOQ). In cases where point data were available, summary statistics were calculated for each unique scenario depending on the number of point values. If only one point value was reported per unique scenario, it was treated as an arithmetic mean. For unique scenarios with 2–9 point values, arithmetic means, medians, standard deviations, and minimum and maximums were calculated. For unique scenarios with 10 or more point values, the 25th, 50th, and 90th percentiles also were calculated.

A left-censoring protocol was applied to impute the lower bound of concentration ranges in cases where the reported frequency of detection (FOD) was less than 100 percent, meaning that TCEP, or metabolite, was not detected in at least one sample. Specifically, a value of one-half the highest reported LOD or LOQ (if no LOD available) was imputed as the minimum value for each unique scenario. In cases where authors reported values as "not detected" (*e.g.*, "ND", "<LOD", "BLOD") without providing a value, the same left-censoring protocol was applied. In the case where values were reported with an indicator that the values were estimated (*e.g.*, typically above LOD and below LOQ), those values were used in the data aggregation directly. Where no LOD or LOQ were provided, no substitution was possible. If the FOD was zero, and no limits were reported, the study aggregate was dropped from consideration. Other issues in study reported detection limits included when a range of detection limits were reported across all chemicals in the analytical method. These limits were dropped since no concentration could be attributed to the TSCA chemical specifically.

Data were first aggregated by like media (*e.g.*, surface water, ambient air) and then generally by unit and sampling phase (*e.g.* particulate or vapor phases in air) or weight fraction type (*e.g.* wet versus dry weights). Media-specific aggregations were employed as appropriate (*e.g.*, microenvironments for inhalation of indoor air, taxa and tissue type for terrestrial and aquatic organisms), and further aggregation was performed to group data by pollution source receptor type (*i.e.*, General Population (Background), Near Facility (Highly Exposed), Remote (Not Near Point Source)).

All data aggregation, unit conversion, range and central tendency standardization, and estimation of derived exposures were performed computationally with a workflow, data management system, and computational pipeline developed specifically to support EPA risk evaluations. All data and statistical analyses were performed on DistillerSR reports of quality control reviewed data. The data computational pipeline was prepared using scripts in Python 3.9 using the pandas, scipy and xlrd libraries and visualized with services developed in NodeJS and D3.

Section **Error! Reference source not found.** of this supplement provides a data summary plot for each m edia by unit. Each plot presents summary statistics for each study aggregated by pollution source receptor type and setting or microenvironment (*i.e.*, General Population (Background), Near Facility (Highly Exposed), Remote (Not Near Point Source)). Because individual studies often present multiple unique scenarios that can be grouped into a single representative aggregate for the study, available statistics were combined and the ranges observations (*e.g.*, minimum, maximum, and percentiles) and central tendencies (*e.g.* arithmetic mean, geometric mean, and median), and overall FOD where possible were calculated.

Within each plot, data are separated by unit basis of sampling fraction, then monitoring data from the U.S. are presented first, followed by studies with data from mixed locations (*i.e.*, U.S. and other countries), finally by studies with data from non-U.S. sources. For each grouping, data are presented from newest to oldest, based on latest year of sampling. Differentiation by tissue type for ecological monitoring media is indicated in the tick label. The lighter region of each bar represents the overall range of data and the darker region represents the range of central tendency reported in each study. Triangles indicate the arithmetic mean and 90th percentile estimates are plotted over the bars for study aggregates that reported enough statistical results to reconstruct a lognormal or normal distribution. The statistical methods used to calculate the central and high-end estimates are described in the following section. The tables that follow each plot provide summary information for each study aggregate such as the sampling location and dates, sample size and FOD, maximum LOD or LOQ (if no LOD was reported), and overall study quality judgement from data evaluation.

2.2 Statistical Approach of Exposure Estimates Derived from Measured Concentrations

Following the aggregation and standardization of reported study data from DistillerSR, the statistical methods described were applied to enhance the comparability and informative value of the available information. All statistical calculations were performed with Python scripts included as steps within the computational pipeline of the methodology.

2.2.1 Aggregation of Statistical Estimates

Studies were aggregated as described in the previous section. Based on this aggregation and study-reported statistics, normal and lognormal distributions were estimated based on available data. In cases where more than one statistic type (*i.e.*, mean, median, minimum, maximum, percentile, and variability measures) each type was handled as described in Table 2-1 below.

Table 2-1. Statistics and Methods for Data Aggregation

Statistic Type	Description of Calculation Method for Aggregate Estimate
Arithmetic means	$\sum_{J=1}^{K} w_J \bar{x}_J$, where $\bar{x}_J = \sum_{i=1}^{N_J} x_{J,i}$
Medians	$\sum_{J=1}^{K} w_J \cdot med_J$, where med_J is the median of dataset J
Percentiles	$\sum_{J=1}^{K} w_J \cdot perc_J$, where $perc_J$ is the percentile of dataset J
Minimums	$\min\{m_1, \ldots, m_K\}$, where $m_J = \min\{x_{J,1}, \ldots, x_{J,N_J}\}$
Maximums	$\max\{M_1, \ldots, M_n\}$, where $M_J = \max\{x_{J,1}, \ldots, x_{J,N_J}\}$
Geometric means	$exp\left(\sum_{J=1}^{K} \mathrm{w_J} \cdot \ln(GM_J)\right)$, where $GM_J = \exp\left(\frac{1}{n}\sum_{i=1}^{N_J} \ln(x_{J,i})\right)$
Geometric standard deviations	$\exp(\sqrt{(\frac{1}{K-1}(\sum_{J=1}^{K} \ln(GSD_J))))}$, where $GSD_J = \exp\left(\sqrt{\sum_{i=1}^{N_J}\left(\ln\left(\frac{x_{J,i}}{GM_J}\right)\right)^2 / N_J}\right)$
Variances	$\frac{1}{K-1}\sum_{J=1}^{K} V_J$, where $V_J = \frac{1}{N_J-1}\sum_{i=1}^{N_J}(x_{J,i} - \bar{x}_J)^2$
Standard deviations	$\sqrt{\frac{1}{K-1}\sum_{J=1}^{K} \sigma_J^2}$, where $\sigma_J = \sqrt{\frac{1}{N_J-1}\sum_{i=1}^{N_J}(x_{J,i} - \bar{x}_J)^2}$

In cases where measures of variability were provided, no fitting was required to build a distribution. If geometric means and geometric standard deviations (GSDs) were provided they were used directly to construct a lognormal distribution by using the mean of geometric means (exp(μ)) and the sample weighted mean of GSD (σ). Using this distribution, the central tendency was estimated by calculating the arithmetic mean and 90th percentile using the equations below.

- Equation for arithmetic mean estimates from lognormal distribution: $e^{(\mu+\frac{\sigma^2}{2})}$
- Equation for estimating 90th percentile from lognormal distribution: $e^{(\mu+\sigma*1.282))}$

If arithmetic means and standard deviations (SDs) or variance were provided and no other statistics indicate that the data are not normally distributed, then a normal distribution was derived using the available statistics. If arithmetic means, medians, and SDs were provided and means and medians were within 5 percent relative percent difference, then a normal distribution was assumed and derived using the provided arithmetic mean and measure of variation. When a normal distribution was assumed the arithmetic mean (assumed to be median) and 90th percentile was calculated using the equations below.

- Equation for arithmetic mean for normal distribution: μ
- Equation for 90th percentile from normal distribution: $\mu + 1.282\sigma$

If a variation was not provided or a normal distribution was not assumed, Table 2-2 describes the preferred distributions used based on the available statistics in the study aggregate. In some cases, the preferred distribution was not used, see the Quality Control section (Section 2.2.4) for this justification.

Table 2-2. Distributions Preferred Depending on Available Reported Statistics

Case Type	Description of Available Statistics Per Study Aggregate	Distribution Type Preferred
Case 0A	Geometric mean and GSD	lognormal
Case 0B	Median and GSD	lognormal
Case 1A	(Mean == Median) and SD	normal
Case 1B	Mean and SD (no Median provided)	normal
Case 2A	Median and (min or max or percentile)	lognormal
Case 2B	Median and (FOD<1 and LOD/LOQ)	lognormal
Case 3A	Mean only and (min or max or percentile)	lognormal
Case 3B	Mean only and (FOD<1 and LOD/LOQ)	lognormal
Case 4	Median and mean only	lognormal
All other cases	Not enough data to build distribution	n/a

GSD = geometric standard deviation; SD = standard deviation; FOD = frequency of detection; LOD = limit of detection; LOQ = limit of quantitation

2.2.2 Fitting Lognormal Distributions

In cases where the study data provided median values, the average median was substituted for geometric mean, and the remaining statistics were used to estimate the GSD by minimizing the sum of squared errors for all provided statistical estimates. Sum of squared errors was calculated by comparing the mean of the residual statistic to the estimated value produced by the fitted distribution, based on the assumptions in Table 2-3 that defined the percentiles assumed for each statistic type.

Table 2-3. Assumed Percentile for Calculating Error by Statistical Estimate Type

Mean of Statistical Estimate by Type	Assumed Percentile for Calculating Error
Maximum	0.99
Minimum	0.01
nth percentile (eg. 25th percentile)	n/100 (*e.g.*, 0.25)
Half limit of quantitation substituted minimum	0.005
Half limit of detection substituted minimum	0.0025

This methodology requires a central tendency estimate and at least one data point on the distribution in order to fit a lognormal distribution. Thus, lognormal distributions were fitted for studies that provided an arithmetic mean and at least one data point on the curve. In these cases, both the geometric mean and the GSD were derived by minimizing the sum of the squared errors for all estimates.

2.2.3 Fitting Normal Distributions

Normal distributions also were constructed for all study aggregates using an approach similar to the approach for geometric distributions described in Section 2.2.1. Study-reported means were assumed to be medians, and standard deviations were calculated by minimizing the sum of squares error of all available estimates.

2.2.4 Quality Control of Derived Exposure Estimates

As a quality control measure, the estimated medians and arithmetic means were evaluated to verify that the estimated values fell within the range of the reported data. Estimates were not used if they fell outside of the range of the reported data, typically an indicator of anomalous data. In addition, derived GSDs were not used if they exceeded 10 for the lognormal distributions, mean estimates were not used if they exceeded 100% relative percent difference from residual means. In these cases, the estimates from the normal distributions were used when normal distributions could be derived.

2.2.5 Final Exposure Estimates by Media and Pollution Source Receptor Type

Central tendency exposure values that carried forward to risk evaluation after passing the QC process were summarized for each media aggregate by taking the sample weighted mean of the arithmetic mean estimates from the selected distribution (*i.e.*, lognormal or normal). Similarly, the 90th percentile estimates carried forward to risk evaluation were calculated as the sample weighted mean of 90th percentile estimates.

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