POWERFUEL

Portland energy recovery facility

Environmental statement
Second addendum
Appendices

5.2

5.2 Impact of Metals Using the TDI Approach

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Impact of metals using the TDI approach

1 Introduction

As part of the consultation process on the planning application for the Portland Energy Recovery Facility (ERF), Public Health England (PHE) has requested that the impact of releases of dioxins and dioxin like furans, and dioxins like PCBs (collectively referred to as dioxins), and metals are assessed against the tolerable daily intake (TDI).

A separate technical note has been produced which details the impact of dioxins using the TDI approach. This technical note details the impact of metals using the TDI approach.

Fichtner Consulting Engineers (Fichtner) has carried out this assessment which supplements the Human Health Risk Assessment (HHRA) carried out to support the planning application by ERM.

2 Assessment criteria

The Environment Agency document "Human Health Toxicological Assessment of Contaminants in Soil", defines a Tolerable Daily Intake as "an estimate of the amount of a contaminant, expressed on a bodyweight basis, which can be ingested daily over a lifetime without appreciable health risk." A Mean Daily Intake (MDI) is also defined, which is the typical intake from background sources (including dietary intake) across the UK. In order to assess the impact of the Portland ERF, the predicted intake of a substance due to emissions from the Facility is added to the MDI and compared with the TDI.

Substances can reach the body either through inhalation or through ingestion (oral exposure) and the body handles chemicals differently depending on the route of exposure. For this reason, different TDIs are defined for inhalation and oral exposure.

The following table outlines the MDIs (the typical intake from existing background sources) for the metals released from the Portland ERF for which there is a TDI set. These figures are defined in the "Contaminants in soil: updated collation of toxicology data and intake values for humans" series of toxicological reports, available from the Environment Agency's website. The values for nickel have been taken from the Environment Agency's August 2015 document following the publication of the new expert opinion by the European Food Safety Authority.

Table 1: Mean Daily Intake of Each Substance

Substance	Mean Daily Intake, 70 kg adult (µg/kg bw/day)		Mean Daily Intake, 20 kg child (µg/kg bw/day)	
	Intake Ingestion	Intake, Inhalation	Intake Ingestion	Intake, Inhalation
Arsenic	0.07	0.0002	0.19	0.0005
Cadmium	0.19	0.0003	0.5	0.0007
Chromium	1.81	0.0009	4.70	0.002
Chromium (VI)	0.18	-	0.47	-
Methyl mercury	0.007	-	0.019	-
Mercuric chloride	0.014	-	0.037	-
Nickel	1.9	0.0037	4.96	0.0096

Table 2: Tolerable Daily Intake of Each Substance (µg/kg bw/day)

Substance	TDI, Ingestion	TDI, Inhalation
Cadmium	0.36	0.0014
Chromium	3	-
Chromium VI	3	-
Methyl mercury	0.23	0.23
Mercuric chloride	2	0.06
Nickel	2.8	0.006

The following table presents the MDI from existing sources for an adult and child as a proportion of the TDI.

Table 3: Mean Daily Intake of Each Substance as a % of the TDI

Substance	Mean Daily Intake, 70 kg adult (µg/kg bw/day)		Mean Daily Intake, 20 kg child (µg/kg bw/day)	
	Intake Ingestion	Intake, Inhalation	Intake Ingestion	Intake, Inhalation
Cadmium	53.2%	20.4%	**137.7%**	52.9%
Chromium	60.5%	-	**156.6%**	-
Chromium (VI)	6.0%		15.7%	
Methyl mercury	3.1%	-	8.0%	-
Mercuric chloride	0.7%	-	1.9%	-
Nickel (screening)	68.4%	61.7%	**177.1%**	**159.7%**
Nickel (based on monitoring data)	-	12.9%	-	33.3%

The TDI for each pollutant has been set at a level which can be ingested daily over a lifetime without appreciable health risk. Therefore, if the total exposure is less than the TDI for a pollutant, it can be concluded that the impact of the Facility is negligible and the effect is not significant.

As shown, the MDI of cadmium, chromium and nickel from existing sources exceeds the TDI for children. The implications of the MDI exceeding the TDI for these pollutants are discussed below.

2.1 Chromium

The MDI for chromium is set for chromium III and taken from the DEFRA report "Contaminants in Soil: Collation of Toxicological Data and Intake Values for Humans. Chromium". This states that there are no published reports on the adverse effects in humans resulting from ingested chromium III. Almost all toxicological opinion is that chromium III compounds are of low oral toxicity, and indeed the UK Committee on Medial Aspects of Food Policy recommends chromium III in the diet. The World Health Organisation (WHO) have reviewed the daily intake of chromium from foods and found that existing levels do not represent a toxicity problem. The WHO conclude that "in the form of trivalent compounds, chromium is an essential nutrient and is relatively non-toxic for man and other mammalian species".

The DEFRA report explains that the TDI has been derived from the USEPA's Reference Dose of 3 µg/kg bw/day for chromium (VI). This is the only explicitly derived safety limit for oral exposures of chromium. DEFRA recommends that the USEPA Reference Dose is applied to all the chromium content as a starting point. Therefore, the TDI presented in Table 2 is actually the TDI for chromium (VI), not total chromium. Assessing the total dietary intake of chromium against this TDI is highly conservative.

2.2 Cadmium

The key determinant of cadmium's toxicity potential is its chronic accumulation in the kidney The Environment Agency in their toxicology report "Contaminants in Soil: Collation of Toxicological Data and Intake Values for Humans. Cadmium" explains that chronic exposure to levels in excess of the TDI might be associated with an increase in kidney disease in a proportion of those exposed, but (small) exceedances lasting for shorter periods are of less consequence. Therefore, assessing a lifetime exposure is appropriate. If we assess the exposure of a receptor over a lifetime (i.e. a period as a child and adult) the lifetime MDI is below the TDI.

2.3 Nickel

The MDI and TDI (oral) for nickel have been revised following the publication by the European Food Safety Authority of new expert opinion relating to the reproductive and developmental effects in experimental animals. The MDI exceeds the TDI for children for both inhalation and ingestion. The updated MDI for inhalation is 0.259 µg/day for an adult which, assuming an inhalation rate of 20 m^3/day, equates to an atmospheric concentration of 13.0 ng/m^3. A review of the monitoring data of nickel across the UK between 2015 and 2019 has shown that concentrations at urban background locations (excluding the sites at Sheffield Tinsley and Swansea Coedgwilym which are close to significant sources of nickel) were 1.23 ng/m^3 on average, with a maximum of 2.70 ng/m^3, whilst at rural location they were 0.53 ng/m^3 on average, with a maximum of 1.30 ng/m^3. Therefore, the recommended MDI for inhalation is extremely conservative for locations for both urban and rural areas away from significant sources of nickel, like the application site. Applying the maximum background concentration from an urban site of 2.70 ng/m^3, the MDI would be 0.05 µg/day or

12.9% of the inhalation TDI for an adult and 33.3% of the TDI for a child. This has been used as the value of the MDI for inhalation for the remainder of this analysis.

3 Approach

The IRAP model used for the HHRA includes all the outputs to determine the concentration of dioxins in the air, and in the different ingestion routes. Therefore, to carry out this additional analysis no changes have been made to the model used for the HHRA and the input assumptions are as detailed in the HHRA.

The only additional assumptions needed to carry out this analysis are as follows:

- The inhalation rates for adults and children:
  - adults - 20m³/day; and
  - children – 7.2m³/day.

4 Results

The following tables present the impact of emissions from the Portland ERF at the maximum impacted receptor (R1 – Fortuneswell Portland). Where appropriate a comparison has been made to the TDI. Details results for each receptor are provided at the end of this note.

Results have only been presented for scenario 2 which assumes home grown produce – fruit and vegetables, chicken, eggs (no home grown milk, beef or pork). Scenario 1, as detailed in the HHRA, does not include any ingestion of home grown produce or soil ingestion; therefore the process contribution to ingestion is zero.

Table 4: Impact Analysis – TDI – Maximum Impacted Receptor - Adult

Substance	MDI (% of TDI)		Process Contribution (% of TDI)		Overall (% of TDI)	
	Inhalation	Ingestion	Inhalation	Ingestion	Inhalation	Ingestion
Cadmium	20.41%	53.17%	1.64%	0.029%	22.05%	53.20%
Chromium	-	60.48%	-	0.005%	-	60.48%
Chromium (VI)	-	6.05%	-	0.00007%	-	6.05%
Methyl mercury	-	3.11%	-	0.006%	-	3.11%
Mercuric chloride	-	0.71%	-	0.005%	-	0.72%
Mercury	1.19%	-	0.05%	-	1.24%	-
Nickel	14.48%	68.37%	0.39%	0.00%	14.87%	68.37%

Table 5: Impact Analysis – TDI – Maximum Impacted Receptor - Child

Substance	MDI (% of TDI)		Process Contribution (% of TDI)		Overall (% of TDI)	
	Inhalation	Ingestion	Inhalation	Ingestion	Inhalation	Ingestion
Cadmium	52.86%	137.72%	2.07%	0.07%	54.93%	137.79%
Chromium	-	156.63%	-	0.015%	-	156.65%

Substance	MDI (% of TDI)		Process Contribution (% of TDI)		Overall (% of TDI)	
	Inhalation	Ingestion	Inhalation	Ingestion	Inhalation	Ingestion
Chromium (VI)	-	15.66%	-	0.0002%	-	15.66%
Methyl mercury	-	8.04%	-	0.014%	-	8.06%
Mercuric chloride	-	1.85%	-	0.014%	-	1.86%
Mercury	3.08%	-	0.06%	-	3.14%	-
Nickel	37.49%	177.07%	0.49%	0.01%	37.99%	177.08%

The TDI is an estimate of the amount of a contaminant, expressed on a bodyweight basis, which can be ingested daily over a lifetime without appreciable health risk. As shown in Table 4 and

, for the maximum impacted receptor the overall impact (including the contribution from existing dietary intakes) is less than the TDI for chromium (VI), and mercury (including compounds). Therefore, there would not be an appreciable health risk based on the emission of these pollutants.

For a child receptor the cadmium, chromium and nickel MDI (that sourced from existing dietary intake) exceeds the TDI. However, the process contribution is exceptionally small and the exceedance is a reflection of the fact the MDI is over 100% of the TDI. On this basis it is not considered that the Portland ERF would increase the health risks from cadmium, chromium or nickel for children significantly. A discussion of the impact from each of these pollutants is provided below.

4.1.1 Cadmium

For cadmium, the MDI for ingestion exceeds the TDI for the child receptor. However, this is a reflection of the fact the MDI is over 100% of the TDI. The process contribution is exceptionally small at only 0.07% of the ingestion TDI for a child at the maximum impacted receptor. As noted in Section 2.2, the key determinant of cadmium's toxicity potential is its chronic accumulation in the kidney. The Environment Agency explains that chronic exposure to levels in excess of the TDI might be associated with an increase in kidney disease in a proportion of those exposed, but (small) exceedances lasting for shorter periods are of less consequence. When lifetime exposure is assessed (i.e. a period being a child and an adult), the overall impact is well below the TDI. Therefore, there would not be an appreciable health risk based on the emission of cadmium over a lifetime of an individual.

4.1.2 Chromium

For chromium, the MDI for ingestion exceeds the TDI for the child receptor. However, this is a reflection of the fact the MDI is over 100% of the TDI.

Almost all toxicological opinion is that chromium (III) compounds are of low oral toxicity and the WHO state that "in the form of trivalent compounds, chromium is an essential nutrient and is relatively non-toxic for man and other mammalian species". Although the TDI is predicted to be exceeded, this is due to existing dietary intake. The WHO have reviewed the daily intake of chromium from foods and found that existing levels do not represent a toxicity problem, and state that "in the form of trivalent compounds, chromium is an essential nutrient and is relatively non-toxic for man and other mammalian species".

The TDI is based on the USEPA's Reference Dose for chromium (VI). Assessing the total dietary intake of chromium against this TDI is highly conservative. As the process contribution is small, the existing levels of chromium do not represent a toxicity problem and the TDI is highly conservative, there would not be an appreciable health risk based on the emissions of chromium over the lifetime of an individual.

4.1.3 Nickel

For nickel, the MDI for ingestion exceeds the TDI for the child receptor. However, this is a reflection of the fact the MDI is over 100% of the TDI. The process contribution is exceedingly small at 0.01% of the TDI for ingestion for a child at the maximum impacted receptor. On this basis, it is not considered that the Portland ERF would increase the health risks from nickel for children significantly.

5 Conclusions

This analysis has been carried out to supplement the HHRA submitted with the planning application for the Portland ERF. This has shown that the predicted impact of emissions of metals from the Portland ERF at the identified sensitive receptors are well below the TDI. As such there would not be an appreciable health risk based on the emission of metals, and it can be concluded that the impact is 'negligible', and the effect is not significant.

A Detailed Results Tables

Table 6: Comparison with TDI Limits for Adult Receptors – Ingestion - Scenario 2

Receptor	Ingestion (% of ID)					
	Cadmium	Chromium	Chromium (VI)	Methyl Mercury	Mercuric Chloride	Nickel
MDI of TDI (%)	**53.17%**	**60.48%**	**6.05%**	**3.11%**	**0.71%**	**68.37%**
R1 – Fortuneswell, Portland	53.203%	60.482%	6.0477%	3.111%	0.719%	68.371%
R2 – East Weare Road, Portland	53.184%	60.478%	6.0476%	3.107%	0.716%	68.369%
R3 – Castletown, Portland	53.186%	60.478%	6.0476%	3.108%	0.716%	68.369%
R4 – Property on Hamm Beach Road, Portland	53.181%	60.477%	6.0476%	3.107%	0.715%	68.368%
R5 – Smallmouth Close, Weymouth	53.177%	60.477%	6.0476%	3.106%	0.715%	68.368%
R6 – Downman Place, Weymouth	53.177%	60.477%	6.0476%	3.106%	0.715%	68.368%
R7 – Redcliffe View, Rodwell	53.177%	60.477%	6.0476%	3.106%	0.715%	68.368%
R8 – Old Castle Road, Weymouth	53.177%	60.477%	6.0476%	3.106%	0.715%	68.368%
Note: Assumes home grown produce – fruit and vegetables, chicken, eggs (no home grown milk, beef or pork)						

Table 7: Comparison with TDI Limits for Child Receptors – Ingestion - Scenario 2

Receptor	Ingestion (% of ID)					
	Cadmium	Chromium	Chromium (VI)	Methyl Mercury	Mercuric Chloride	Nickel
MDI of TDI (%)	**137.72%**	**156.63%**	**15.66%**	**8.04%**	**1.85%**	**177.07%**
R1 – Fortuneswell, Portland	137.791%	156.648%	15.664%	8.057%	1.864%	177.080%
R2 – East Weare Road, Portland	137.745%	156.638%	15.663%	8.048%	1.855%	177.074%
R3 – Castletown, Portland	137.749%	156.639%	15.663%	8.049%	1.855%	177.075%
R4 – Property on Hamm Beach Road, Portland	137.738%	156.637%	15.663%	8.047%	1.853%	177.074%
R5 – Smallmouth Close, Weymouth	137.728%	156.635%	15.663%	8.045%	1.851%	177.072%
R6 – Downman Place, Weymouth	137.728%	156.635%	15.663%	8.045%	1.851%	177.072%
R7 – Redcliffe View, Rodwell	137.727%	156.634%	15.663%	8.044%	1.851%	177.072%
R8 – Old Castle Road, Weymouth	137.728%	156.635%	15.663%	8.045%	1.851%	177.072%
Note: Assumes home grown produce – fruit and vegetables, chicken, eggs (no home grown milk, beef or pork)						

Table 8: Comparison with TDI Limits for Adult Receptors – Inhalation

Receptor	Inhalation (% of TDI)		
	Cadmium	Mercury	Nickel
MDI of TDI (%)	**20.41%**	**1.19%**	**14.48%**
R1 – Fortuneswell, Portland	22.051%	1.229%	14.869%
R2 – East Weare Road, Portland	20.957%	1.203%	14.608%
R3 – Castletown, Portland	21.051%	1.205%	14.630%
R4 – Property on Hamm Beach Road, Portland	20.790%	1.199%	14.568%
R5 – Smallmouth Close, Weymouth	20.550%	1.194%	14.510%
R6 – Downman Place, Weymouth	20.543%	1.194%	14.508%
R7 – Redcliffe View, Rodwell	20.525%	1.193%	14.504%
R8 – Old Castle Road, Weymouth	20.550%	1.194%	14.510%

Table 9: Comparison with TDI Limits for Child Receptors – Inhalation

Receptor	Inhalation (% of TDI)		
	Cadmium	Mercury	Nickel
MDI of TDI (%)	**52.86%**	**3.08%**	**37.49%**
R1 – Fortuneswell, Portland	54.927%	3.132%	37.988%
R2 – East Weare Road, Portland	53.549%	3.099%	37.659%
R3 – Castletown, Portland	53.667%	3.102%	37.687%
R4 – Property on Hamm Beach Road, Portland	53.338%	3.095%	37.609%
R5 – Smallmouth Close, Weymouth	53.035%	3.087%	37.536%
R6 – Downman Place, Weymouth	53.027%	3.087%	37.534%
R7 – Redcliffe View, Rodwell	53.004%	3.087%	37.528%
R8 – Old Castle Road, Weymouth	53.036%	3.088%	37.536%