Additional Risk Characterization Document in Support of the Draft Screening Assessment for Zinc and its Compounds:

Pulp and paper sector exposure and risk characterization

Environment and Climate Change Canada

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Synopsis

A draft of the screening assessment for zinc and its compounds was published June 29, 2019. This document contains additional information to support the finalization of the screening assessment of zinc and its compounds and includes data identified or generated since the publication of the draft screening assessment.

The scope of this additional risk characterization document is limited to assessing potential ecological concerns from releases of zinc from pulp, paper, and paperboard mills in Canada. During the development of the draft screening assessment for zinc and its compounds, limited data on the releases of zinc to the environment from this sector were available. The data and analysis herein have been published to provide the opportunity for public comment on the new information prior to it being considered in the final screening assessment of zinc and its compounds, and if appropriate, the corresponding risk management approach document.

Zinc is a naturally occurring substance and is an essential element to plants and other forms of life. Zinc may be present in the organic matter feedstock used in pulp and paper processes, fuel sources (e.g., waste-derived fuels, gases, and oils) used in pulp and paper mills, or in substances used in pulp and paper processes (bleaching, fillers, additives, brighteners, etc.).

There were no responses to Notices issued under section 71 of the *Canadian Environmental Protection Act, 1999* (CEPA) for the import or manufacture of any surveyed zinc-containing substance associated with the North American Industrial Classification System (NAICS) Code 3221 (Pulp, paper, and paperboard mills). There were, however, responses that zinc-containing substances are found in paper products, mixtures or manufactured items.

Predicted environmental concentrations for surface water derived from effluent quality monitoring data were found to exceed the predicted no-effect concentrations at certain pulp and paper mills.

On the basis of the information available, a limited number of pulp and paper mills had elevated risk quotients, indicating the potential for ecological harm from zinc.

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1. Introduction

Pursuant to sections 68 or 74 of the *Canadian Environmental Protection Act, 1999* (CEPA), the Minister of the Environment and the Minister of Health conducted a screening assessment of zinc and its compounds. A draft of the screening assessment for zinc and its compounds was published June 29, 2019 (ECCC, HC 2019).

This document contains additional information to support the finalization of the screening assessment of zinc and its compounds. This includes data identified or generated since the publication of the draft screening assessment. Relevant data were identified up to April 2020. Targeted literature searches were conducted up to May 2020.

The scope of this additional risk characterization document is limited to assessing potential ecological concerns from releases of zinc from pulp, paper, and paperboard mills in Canada. During the development of the draft screening assessment for zinc and its compounds, limited data on the releases of zinc to the environment from this sector were available.

The data and analysis herein have been published to provide the opportunity for public comment on the new information prior to it being considered in the final screening assessment of zinc and its compounds, and if appropriate, the corresponding risk management approach document.

2. Sources and uses

Metals are naturally occurring and several are essential elements to plants and other forms of life, and thus metals may be present in the organic matter feedstock used in pulp and paper processes (Melanson 2000). Metals may also be present in fuel sources (e.g., waste-derived fuels, gases, and oils) used in pulp and paper mills (ECCC, HC 2017; Statistics Canada 2007), or metal-containing substances may be intentionally used in the process (bleaching, fillers, additives, brighteners, etc.). Pulp and paper mill effluent can therefore contain a number of metals, including zinc.

2.1 Information submitted in response to a CEPA section 71 survey

There were no responses to Notices issued under Section 71 of CEPA for the import or manufacture of any surveyed zinc-containing substance associated with the North American Industrial Classification System (NAICS) Code 3221 (Pulp, paper, and paperboard mills) (Canada 2009; Canada 2012; Canada 2017). There were, however, responses that zinc-containing substances are found in paper products, mixtures or manufactured items.

3. Releases to the environment

Pulp, paper and paperboard mills (e.g., as represented by the NAICS code 3221) were noted in the draft screening assessment as a sector releasing relatively large quantities of zinc to water, second only to releases from wastewater (ECCC, HC 2019). NPRI release data for 2016 and 2017 (NPRI 2020) became available after publication of the draft screening assessment and will be added to the final screening assessment. Additionally, effluent concentrations became available from the NPRI, where facilities reported direct discharge of substances to water in 2016 or 2017 as determined by continuous emission monitoring, predictive emission monitoring, or source testing.

4. Potential to cause ecological harm

Hazard characterization is described in section 7.3 of the draft screening assessment (ECCC, HC 2019). Briefly, the long-term Canadian Water Quality Guideline (CWQG) for the Protection of Aquatic Life, and Interim Sediment Quality Guidelines (ISQG), were selected as the predicted no-effect concentrations (PNECs) for aquatic and sediment compartment hazard characterization, respectively (CCME 2018a; CCME 2018b; CCME 1999). No extrapolations beyond the stated toxicity modifying factor (TMF) domain of the CWQG were made, consistent with analyses in the draft screening assessment for other sectors.

5. Ecological exposure assessment

The ecological exposure assessment considered exposure data from each of the four sources described below.

Pulp, paper and paperboard mills is one of the main sectors reporting releases of zinc and its compounds to the NPRI, and particularly to the aquatic compartment for the majority of facilities. Annual average effluent total zinc (Zn-T) concentrations were available for 2016 or 2017 from the NPRI for 11 facilities, determined by the source testing method (NPRI 2020).

The Canadian pulp and paper sector includes facilities (mills) that produce a range of products including paper, cardboard, newsprint, and pulp. These mills are subject to the *Pulp and Paper Effluent Regulations* (PPER) under the *Fisheries Act* (Canada 2018). However, zinc is not a required parameter for effluent monitoring under Schedule II part 1(1) of those regulations, nor is water quality monitoring required. However, a limited number of Environmental Effects Monitoring (EEM) interpretive report and study design documents were found to contain concentrations of zinc measured in effluent, or in surface waters of exposure and reference areas (e.g., as part of broader site characterization, or as part of an Investigation of Cause) (EEM 2020). Measured concentrations of dissolved zinc (Zn-D) and Zn-T in exposure areas and corresponding reference areas were limited to 4 and 5 facilities, respectively, with very limited sample sizes and limited temporal availability. Measured concentrations of Zn-T in effluent were

available for 14 facilities. Measured concentrations of Zn-T in sediment in an exposure area and corresponding reference area were identified for a single facility (EEM 2020).

Monthly (approximately) effluent Zn-T concentrations reported to the Quebec Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC) for 2013 to 2018 were also available for five facilities of interest identified from the PPER-EEM data set (MELCC 2020a). When discrepancies were noted between effluent concentrations found in PPER-EEM documents and effluent concentrations submitted to MELCC, data submitted to MELCC were taken as correct (personal communication, email from the Forest Products and Fisheries Act Division, Environment and Climate Change Canada, to the Ecological Assessment Division, Environment and Climate Change Canada, dated May 15, 2020; unreferenced). Additional TMFs were collected from the Banque de données sur la qualité du milieu aquatique (BQMA) (available for dissolved organic carbon (DOC) and pH only) as a refinement replacing ecozone geometric means. BQMA data were extracted from the MELCC Atlas interactif de la qualité des eaux et des écosystèmes aquatiques for monitoring stations identified as being in relevant proximity to the facilities or representing similar conditions to the exposure or reference areas (e.g., as identified by an EEM interpretive report or study design document) (MELCC 2020b). Annual average zinc concentrations in effluents (e.g., leachates) from pulp and paper landfill sites were also available from the MELCC Atlas des pressions sur le milieu aquatique (MELCC 2020c). Data were available for 13 effluent streams from 11 facilities between 2013 and 2018.

In addition, zinc exposure data were provided by the National Council for Air and Stream Improvement (NCASI), who designed, coordinated, and managed a sampling campaign (August 2018 to January 2019) of 30 facilities representing 2 mill process categories (mechanical and chemical), different wood fibre sources, and covering 4 ecozones (NCASI 2020). Zn-T and Zn-D concentrations in effluent, and Zn-T, Zn-D, pH, and hardness in ambient or intake waters were available from 17 chemical mills and 13 mechanical mills. PNECs were derived using pH and hardness for the corresponding ambient or intake water, and ecozone geometric mean DOC values, as TMFs.

For the exposure assessment, measured concentrations of zinc in exposure and reference areas, where available, were taken directly as predicted environmental concentrations (PECs) (EEM 2020). Measured concentrations of Zn-D were preferred for calculating PECs, with measured concentrations of Zn-T being used in their absence. When measured concentrations in the receiving environment (and corresponding reference environments) were not available, zinc concentrations were modeled from effluent concentrations. Effluent concentrations from each data source (NPRI 2020; EEM 2020; MELCC 2020a; MELCC 2020b; NCASI 2020) were used to calculate modelled PECs according to the equation below. Non-detect measurements were replaced with half of the method detection limit. Non-detects were prevalent in surface water measurements (>50% of samples), but were rare in effluent quality monitoring (~1% of samples).

$$PEC\ (\mu g/L) = C_b\ (\mu g/L) + \left(\frac{C_{eff}\ (\mu g/L) - C_b\ (\mu g/L)}{R_f\ (L/d)/R_{eff}\ (L/d)}\right)$$

Where C_b is the background concentration of zinc. For defining background concentrations, concentrations of zinc in the receiving water (upstream of the final discharge point) were preferred, followed by concentrations in the intake water and by the median ecozone background concentration. C_{eff} is the concentration of zinc in effluent. The term R_f/R_{eff} represents dilution of the effluent into the receiving water, where R_{eff} is the effluent flow rate and R_f is the 10th percentile of the receiving water flow. Data collected for other recent screening assessments indicate that the standard maximum effective dilution factor of 10 is applied to the vast majority of direct discharging pulp and paper mills. Therefore, the term R_f/R_{eff} was replaced with 10 to calculate PECs for this sector. Geometric means of ecozone TMFs were used to derive corresponding PNECs. The identification of ambient zinc concentrations and TMFs is described in section 7.4 of the draft screening assessment (ECCC, HC 2019) or were obtained from MELCC (2020b), as described above.

Calculated average PEC ranges for each data source described above are available in **Error! Reference source not found.**. Specific calculated Zn-D PECs from the NCASI dataset are shown in

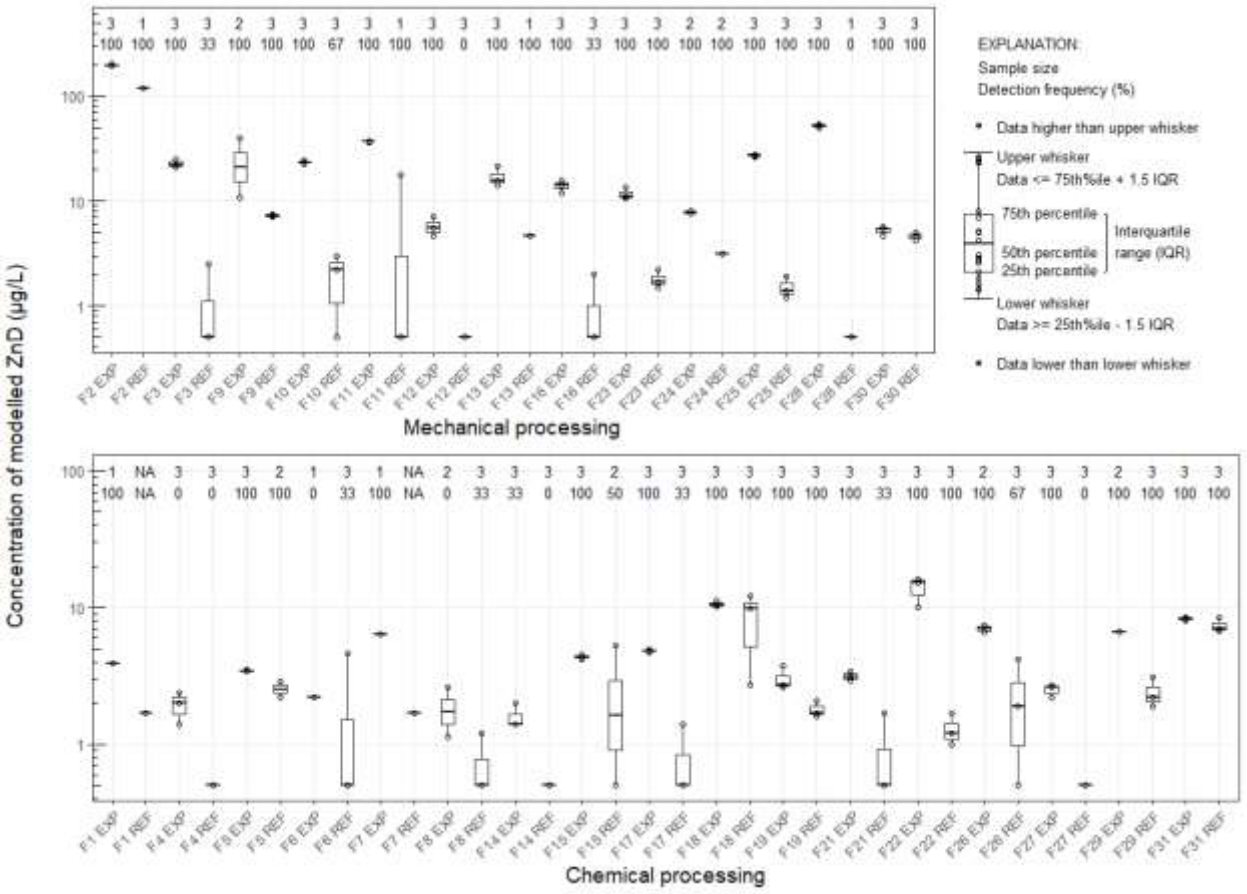

Figure 5-1 Box plots of modelled exposure concentrations (EXP) and corresponding measured reference concentrations (REF) for pulp and paper facilities (F) based on dissolved zinc (Zn-D) from samples collected between August 2018 and January 2019 (NCASI 2020)

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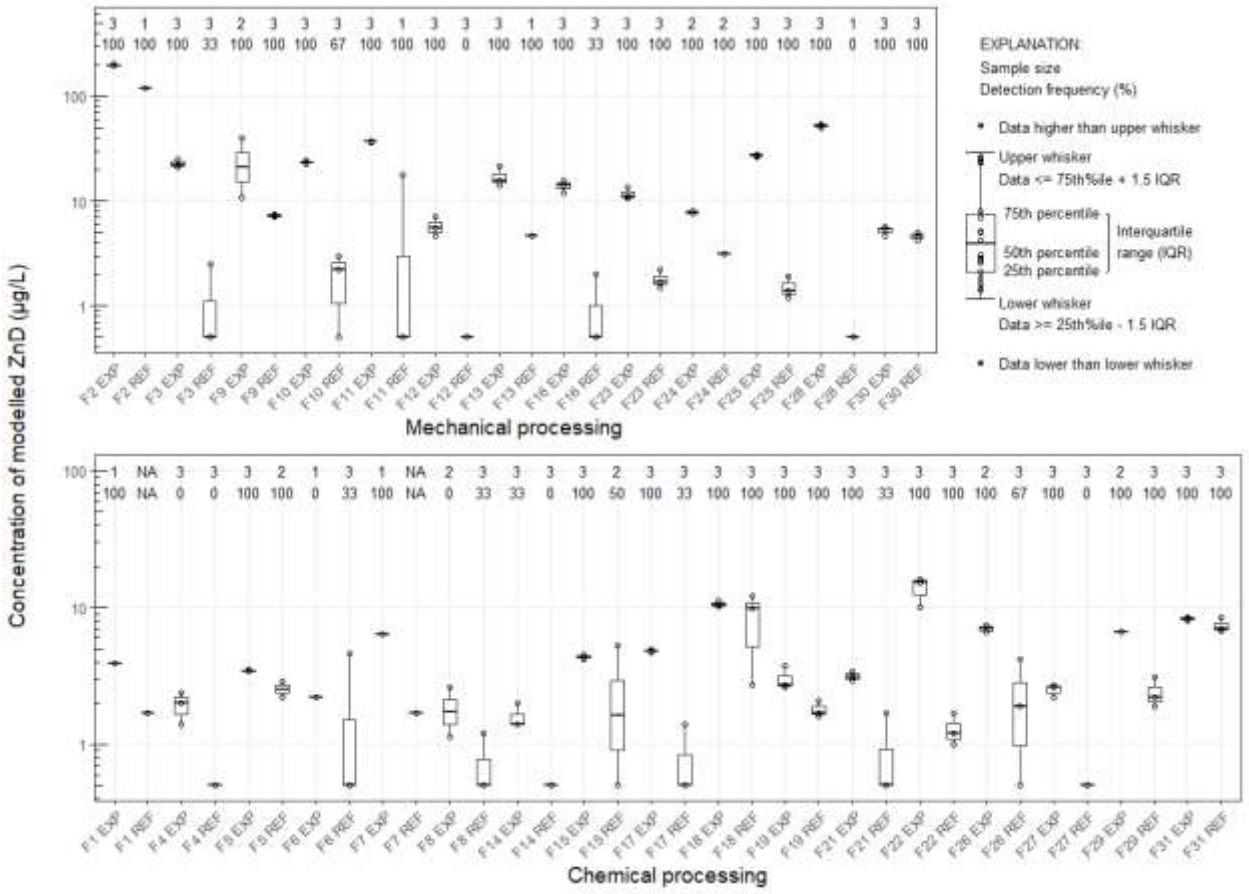


Figure 5-1 Box plots of modelled exposure concentrations (EXP) and corresponding measured reference concentrations (REF) for pulp and paper facilities (F) based on dissolved zinc (Zn-D) from samples collected between August 2018 and January 2019 (NCASI 2020)

6. Characterization of ecological risk

The approach to the characterization of ecological risk is described in section 7.5 of the draft screening assessment (ECCC, HC 2019).

6.1 Risk quotient analysis

Ecological risk characterization for the pulp and paper sector considered exposure data from each of the four sources described in section 5 of this report: reporting of zinc surface water measurements and effluent concentrations in interpretive reports submitted under the EEM provisions of the PPER (EEM 2020), average zinc effluent concentrations reported from source testing methods to the NPRI (NPRI 2020), effluent concentrations available from the Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC 2020a,c), and a voluntary sampling campaign and study organized by NCASI which collected zinc concentrations in effluent, and ambient and intake waters (NCASI 2020).

Environmental monitoring data gathered in the exposure areas of pulp and paper mills were limited to that found to be reported under the EEM provisions of the PPER (EEM 2020). Zn-D concentrations in exposure and corresponding reference areas of four facilities were low, with the largest median RQ equal to 0.09, and the maximum individual RQ equal to 0.23. Effluent Zn-T concentrations were somewhat more available in the EEM dataset. Effluent concentrations from EEM reports were replaced with equivalent effluent data submitted to MELCC for matching sample dates, when available, to address discrepancies for certain facilities. RQs calculated from effluent modelling were frequently elevated for 5 of 14 facilities where data were available. The frequency of PNEC exceedance across these five facilities ranged from 38% to 100%. However, of the facilities associated with elevated RQs, only 2 release their effluent to fresh water. The other 3 facilities release effluents to fluvial estuary or estuarine environments. Since "it is not appropriate to apply the zinc freshwater guideline to marine or estuarine environments" (CCME 2018), the strength of inference from RQs for these latter facilities may be reduced.

A potential TMF refinement was considered for the facilities associated with elevated PPER-EEM effluent modelling risk quotients using Banque de données sur la qualité du milieu aquatique (BQMA) monitoring data medians (available for DOC and pH only) as a local refinement replacing ecozone geometric means. However, in terms of the frequency of PNEC exceedances, the refinement of TMFs using BQMA data did not significantly change the outcome for any of the 5 facilities with elevated RQs (i.e., RQs remained elevated).

Elevated risk quotients were calculated from NPRI effluent concentrations for 4 of 11 facilities in 2016 or 2017. However, 3 of these facilities release their effluent to fluvial estuary or estuarine environments.

Risk characterization for the pulp and paper sector also considered effluent, ambient or raw intake monitoring of Zn-D, Zn-T, pH, and hardness, submitted for samples from 30 Canadian facilities from August 2018 to January 2019 (NCASI 2020). Facility-specific PNECs were calculated using pH and hardness data for respective ambient waters and representative ecozone DOC values. Zn-D RQs for modelled exposure and ambient waters are presented in Figure 6-1 (NCASI 2020).

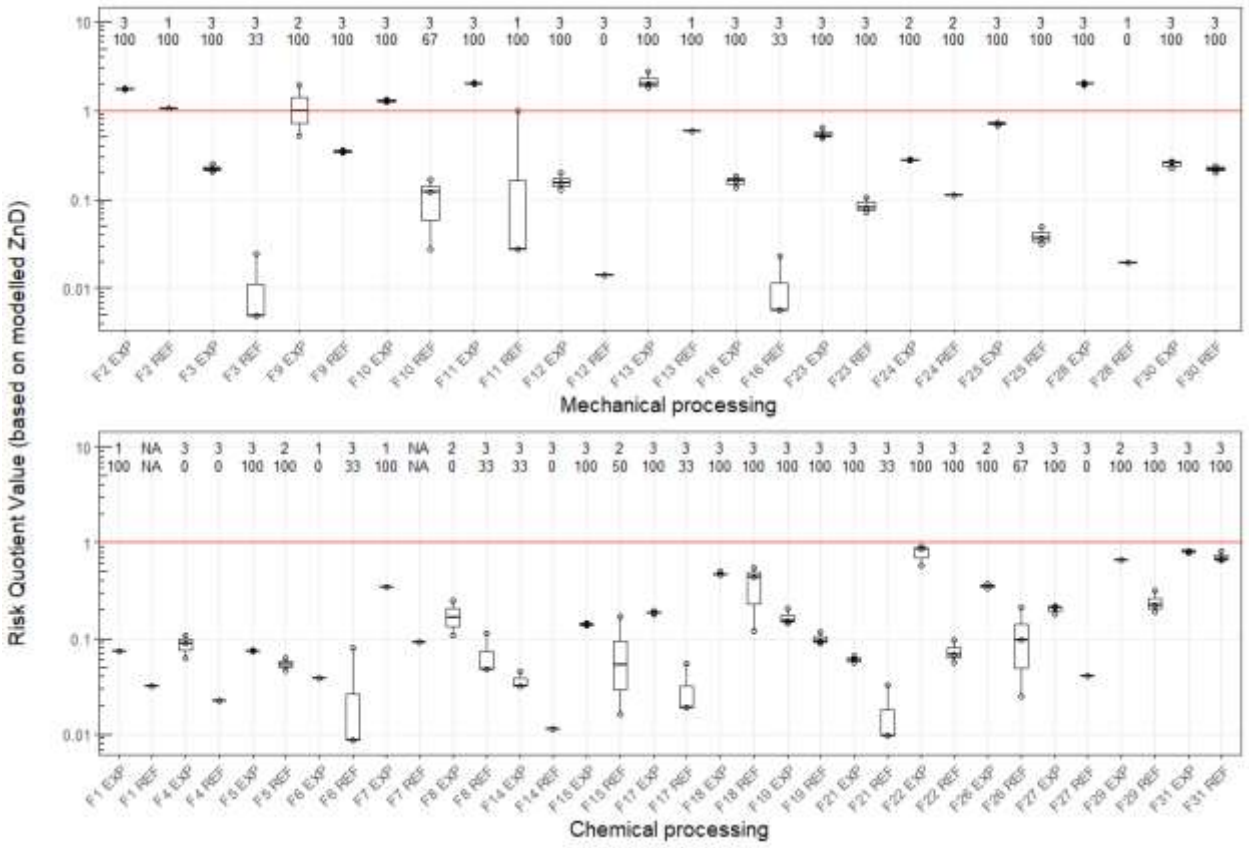


Figure 6-1 Risk quotients for modelled exposure concentrations (EXP) and corresponding measured reference concentrations (REF) for pulp and paper facilities (F) based on dissolved zinc (Zn-D) concentrations from samples collected between August 2018 and January 2019 (NCASI 2020)

Risk quotients calculated from MELCC pulp and paper landfill effluent data (MELCC 2020c) for 13 effluent streams reported by 11 facilities show a low frequency of PNEC exceedances, particularly in recent years.

Lastly, sediment data were also found to be reported to the PPER-EEM for a single facility (EEM 2020). Calculated sediment RQs for this facility were not elevated and were very similar in the exposure and reference area.

A summary of PECs, corresponding PNECs, and RQs for all data sources identified for the pulp and paper sector is presented in **Error! Reference source not found.**. Overall, a limited number of pulp and paper mills show potential for ecological harm from zinc based on effluent concentration modelling as evidenced by elevated risk quotients at some facilities, particularly from the NCASI dataset which contains the largest representation of facilities and reports the preferred fraction for risk characterization (i.e., Zn-D). Conversely, the limited amount of monitoring data available for both Zn-D and Zn-T in exposure and corresponding reference areas, and modelled

exposure from landfill effluent data, suggest a limited potential for ecological harm. Taken together, there is a potential for ecological harm from a limited number of facilities in the pulp and paper sector from zinc.

Table 6-1 Summary of zinc risk quotients from pulp, paper and paperboard mills

Dataset	Condition	Analyte	Number of facilities	Year	Range of average PECs	Range of average PNECs	Range of average RQs
NCASI	Ambient	Zn-D	30	2018	0.5 to 120[b]	7.8 to 110[b]	0.011 to 1.1
NCASI	Exposure	Zn-D	30	2018	1.6 to 200[b]	7.8 to 110[b]	0.036 to 2.2
NCASI	Ambient	Zn-T	30	2018	1.5 to 110[b]	7.8 to 110[b]	0.013 to 2.8
NCASI	Exposure	Zn-T	30	2018	3.7 to 120[b]	7.8 to 110[b]	0.063 to 3.2
NPRI	Exposure	Zn-T[a]	11	2016 and 2017	3.7 to 95[b]	6.0 to 48[b]	0.077 to 3.8
PPER-EEM Water quality	Reference	Zn-D	5	2012 to 2018 (non-continuous)	0.50 to 2.5[b]	11 to 36[b]	0.016 to 0.088
PPER-EEM Water quality	Exposure	Zn-D	4	2012 to 2018 (non-continuous)	0.73 to 2.5[b]	11 to 39[b]	0.016 to 0.10
PPER-EEM Water quality	Reference	Zn-T	6	2012 to 2018 (non-continuous)	2.4 to 24[b]	8.3 to 36[b]	0.065 to 0.80
PPER-EEM Water quality	Exposure	Zn-T	5	2012 to 2018 (non-continuous)	2.9 to 6.7[b]	9.1 to 39[b]	0.096 to 0.52
PPER-EEM Effluent	Exposure	Zn-D	4	2012 to 2018 (non-continuous)	2.1 to 4.2[b]	8.6 to 45[b]	0.047 to 0.48
PPER-EEM Effluent (supplemented with MELCC effluent data)	Exposure	Zn-T	14	2012 to 2018 (non-continuous)	3.4 to 63[b]	8.8 to 45[b]	0.16 to 4.3
PPER-EEM Sediment	Reference	Zn-T	1	2014 to 2015	96[c]	123[c]	0.78
PPER-EEM Sediment	Exposure	Zn-T	1	2014 to 2015	92[c]	123[c]	0.75
MELCC Landfill effluent	Exposure	Zn-T[a]	11	2013 to 2018	3.7 to 8.8[b]	16 to 18[b]	0.24 to 0.63

Abbreviations: PEC, predicted environmental concentration; PNEC, predicted no effect concentration; RQ, risk quotient; Zn-D, dissolved zinc; Zn-T, total zinc.

[a] Not explicitly reported, but assumed to represent total zinc concentrations.

[b] Units for these values are in µg Zn/L

[c] Units for these values are in mg Zn/kg

6.2 Consideration of the lines of evidence

The key lines of evidence supporting that releases of zinc from the pulp and paper sector show a potential for ecological harm are presented in Table 6-2. The level of confidence refers to the combined influence of data quality and variability, data gaps, causality, plausibility and any extrapolation required within the line of evidence. The relevance refers to the impact the line of evidence has when determining the potential to cause harm in the Canadian environment. Qualifiers used in the analysis ranged from low to high, with the assigned weight having five possible outcomes.

Table 6-2 Weighted lines of key evidence considered to determine the potential for zinc and its compounds to cause harm in the Canadian environment

Line of evidence	Level of confidence	Relevance in assessment	Weight assigned
PNECs derived with sample-specific TMF data	High	High	High
PNECs derived with ecozone TMF data	Moderate	High	Moderate to high
PNEC for benthic organisms in sediment	Moderate	Moderate	Moderate
PEC(s) based on measured data in surface water or sediments (PPER EEM reporting)	Low	High	Moderate
PEC(s) for surface waters based on effluent modelling (PPER EEM reporting; MELCC; NCASI; NPRI)	Moderate	High	Moderate to high
RQ(s) for surface waters based on measured PECs and PNECs derived with sample-specific TMF data	Low	High	Moderate
RQ(s) for surface waters based on modelled PECs and PNECs derived with ecozone TMF data	Moderate	High	Moderate to high
RQs for sediment	Low	Moderate	Low to moderate

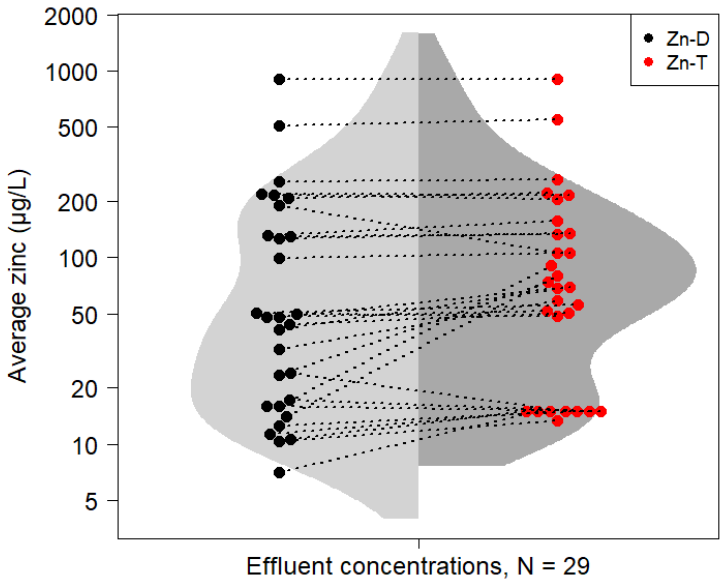
7. Uncertainties in the characterization of ecological risk

With ecological hazard characterization for zinc aligned with recent and robust CWQGs and the ISQG, most of the uncertainties in the characterization of ecological risk from the pulp and paper sector pertain to exposure characterization.

Water quality monitoring data from PPER-EEM interpretive reports and study design documents resulted in a sparse dataset representing a very small proportion of the sector. As this water quality monitoring dataset is very small, it is not robust enough to

meaningfully extrapolate to all Canadian mills, as the potential for risk may be of greater or less proportion. The low RQs cannot be read across or presumed for the facilities where only modelled RQs from effluent data are available, some of which are elevated (i.e., greater than 1). The absence of a systematic reporting requirement for zinc in the PPER introduces considerable sampling bias in the available EEM dataset that cannot be readily quantified. More certainty in this analysis was provided by the NCASI study, not only for its greater representation of facilities in the sector, but also for measuring both Zn-D and Zn-T in effluents, and measuring Zn-D, Zn-T, pH, and hardness in ambient waters (raw intake water or receiving stream water upstream of the discharge point).

Some uncertainty in risk characterization may be introduced by the comparison of Zn-T concentrations to PNECs, which are generally intended for comparison to the less frequently measured Zn-D. To explore this uncertainty further, average effluent Zn-D and Zn-T concentrations, and average ambient Zn-D and Zn-T concentrations, with the same sample codes (NCASI 2020) were compared in beanplots (Figure 7-1-1). The beanplots indicate that in most cases average Zn-D and Zn-T effluent concentrations were similar, with the ratio of Zn-D to Zn-T in effluent frequently close to unity. This suggests that risk quotient calculations based on Zn-T in effluent may represent a reasonable worst-case approach for risk quotient calculations when data for Zn-D are lacking.



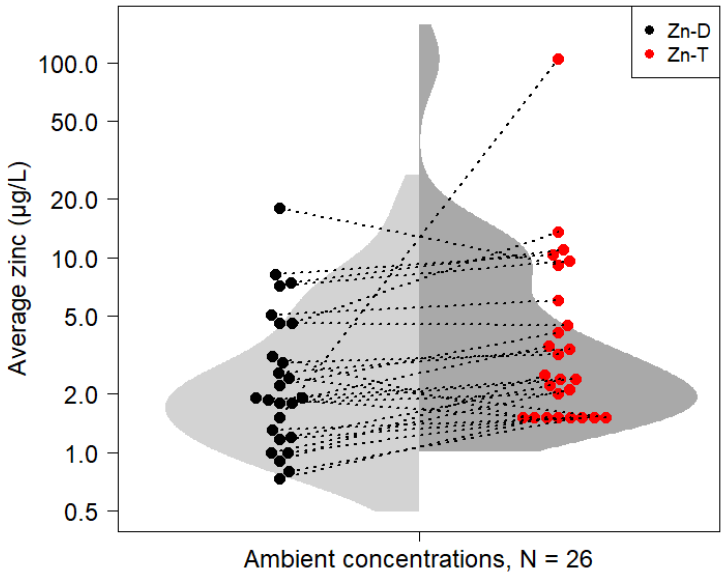


Figure 7-1 Beanplots comparing average dissolved zinc (Zn-D) to total zinc (Zn-T) effluent and ambient concentrations with the same sample codes (NCASI 2020)

References

Bajpai, P. 2017. Pulp and paper industry: Chemical recovery. Amsterdam (Netherlands): Elsevier. pp. 242.

Bajpai, P. 2018. Biermann's handbook of pulp and paper. 3rd edition. Amsterdam (Netherlands): Elsevier. pp. 648.

Canada. 2018. Fisheries Act: Pulp and Paper Effluent Regulations. P.C. 1992-961, SOR/92-269, last amended September 26, 2018.

Canada, Dept. of the Environment. 2009. *Canadian Environmental Protection Act, 1999: Notice with respect to certain inanimate substances (chemicals) on the Domestic Substances List* [PDF]. Canada Gazette, Part I, vol. 143, no. 40, p. 2945-2956.

Canada, Dept. of the Environment. 2012. *Canadian Environmental Protection Act, 1999*: *Notice with respect to certain substances on the Domestic Substances List* [PDF]. Canada Gazette, Part I, vol. 146, no. 48, Supplement.

Canada, Dept. of the Environment. 2017. *Canadian Environmental Protection Act, 1999*: *Notice with respect to certain substances included as part of the 2017 Inventory Update*. Canada Gazette, Part I, vol. 151, no. 2.

[CCME] Canadian Council of Ministers of the Environment. 1999. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life - zinc [PDF]. Winnipeg (MB). Canadian Council of Ministers of the Environment.

[CCME] Canadian Council of Ministers of the Environment. 2018a. Canadian Water Quality Guidelines for the Protection of Aquatic Life - zinc [PDF]. Winnipeg (MB): Canadian Council of Ministers of the Environment.

[CCME] Canadian Council of Ministers of the Environment. 2018b. Scientific criteria document for the development of the Canadian Water Quality Guidelines for the protection of aquatic life – zinc [PDF]. Winnipeg (MB): Canadian Council of Ministers of the Environment.

[ECCC, HC] Environment and Climate Change Canada, Health Canada. 2017. Screening assessment: Cobalt and cobalt-containing substances. Ottawa (ON): Government of Canada.

[ECCC, HC] Environment and Climate Change Canada, Health Canada. 2019. Draft screening assessment: Zinc and its compounds. Ottawa (ON): Government of Canada.

[EEM] Environmental Effects Monitoring. 2020. Measured concentrations of zinc in water, effluent, and sediments when incidentally reported in documents submitted under the *Pulp and Paper Effluent Regulations*. Gatineau (QC): Environment and Climate Change Canada. [restricted access]

Melanson, JB. 2000. Effluent Recycling in a Kraft Pulp Mill [master's thesis]. Edmonton (AB): University of Alberta, Department of Chemical and Material Engineering.

[MELCC] Ministère de l'Environnement et de la Lutte contre les changements climatiques. 2020a. Effluent monitoring data shared with the Forest Products and Fisheries Act Division, ECCC. Gouvernement du Québec: Québec.

[MELCC] Ministère de l'Environnement et de la Lutte contre les changements climatiques. 2020b. Atlas interactif de la qualité des eaux et des écosystèmes aquatiques [database]. Gouvernement du Québec: Québec [Accessed May 2020]

[MELCC] Ministère de l'Environnement et de la Lutte contre les changements climatiques. 2020c. Atlas des pressions sur le milieu aquatique – rejets d'eaux usées. Gouvernement du Québec: Québec [Accessed May 2020]

[NCASI] National Council for Air and Stream Improvement, Inc. 2020. Zinc in Canadian Pulp & Paper Mill Effluents and Ambient Waters. Unpublished report and data tables submitted to Environment and Climate Change Canada.

[NPRI] National Pollutant Release Inventory [database]. Downloadable datasets. 2020. Ottawa (ON): Government of Canada. [Accessed May 2020]

Statistics Canada. 2007. Analysis in brief: Heavy fuel oil consumption in Canada [PDF]. Ottawa (ON): Statistics Canada, Manufacturing, Construction and Energy Division. Catalogue No. 11-621-MIE No. 062.