What is the level of mercury in plants that form the diet of the Porcupine caribou?

Kym Rempel

Abstract

The main forage of the Porcupine caribou was sampled during the summer and fall of 2010 in both the summer and winter ranges of the herd. The purpose of this study was to determine methyl mercury and total mercury concentrations in each of the forage types in order to understand the main sources of mercury contamination for the herd. Vascular plants and northern locations showed higher concentrations of mercury suggesting contamination arrived via long range atmospheric transport. Baseline data on Porcupine caribou forage is important to understand how changes in atmospheric mercury will affect this important source of traditional food for many First Nations in the Yukon Territory.

Introduction

Although mercury (Hg) is a naturally occurring element on the planet, there is an increase in global mercury as a result of anthropogenic activities (Louis et. al 2005). The main anthropogenic sources of Hg are mining, burning of fossil fuels, and waste incineration (Lokken et. al 2008). Mercury from industrial areas is transported far from its source by way of long range atmospheric transport (Evans & Hutchinson 1996), with the highest levels of contamination in Arctic regions (Carigan & Sonke 2010). The concentration of

Hg in the Arctic may be caused in part by Atmospheric Mercury Depletion Events (AMDE) that occur in spring when polar sunrise begins (Carignan & Sonke 2010). AMDEs cause large quantities of Hg from the air to be deposited on snow and ice, and through seasonal melt transferred to the hydrological cycle. This subjects inorganic mercury to processes of methylation, thus increasing toxicity (Carignan & Sonke 2010).

Global pollution has been steadily increasing (Zhang et al. 1993), causing a heightened need for the monitoring of Hg contaminant levels, particularly in instances where Hg can be transferred to humans by way of their food source. As Porcupine caribou is an important food source for people living in the Yukon, particularly the Vuntut Gwich'in who on average consume caribou at least once per day (Wein & Freeman 1995), it is important to monitor levels of Hg that will be transferred from this source. Despite the importance of continued monitoring, current levels of Hg in terrestrial herbivores are very low, particularly in comparison to aquatic systems (Lokken et al. 2009). By monitoring Hg that bioaccumulates in the forage eaten by Porcupine caribou, we will be able to extrapolate levels of Hg in higher trophic levels. The purpose of this study was to provide baseline information on Hg levels in Porcupine caribou forage, noting Hg differences between forage types and locations.

Methods

Study locations were chosen in the calving (Yukon’s North Slope) and wintering (Chapman Lake) grounds of the Porcupine Caribou herd. Vegetation collection dates were based on presence of caribou in the area at time of collection. Caribou were seen during collection at all sites. The list of vegetation was based on caribou stomach contents analysis completed by caribou biologist Don Russell with the following 8 broad groups: deciduous shrubs, evergreen shrubs, Equisetum, graminoids, forbs, moss, lichen, mushrooms.

With the assistance of Dr. Scott Gilbert, sample collection at Shingle Point and Herschel Island took place June 8 – 9, 2010. With the assistance of 4 youth participating in the Yukon Youth Conservation Corps program sample collection at Chapman Lake on the southern Dempster Highway took place August 7 –8, 2010. We took samples from 2 sites at each location. The sites were a minimum of 1 km apart.

Sampling protocol for vegetation was drafted by Mary Gamberg for this project. Plant specimens were collected using trace element clean protocol. We ensured no specimens came in contact with human skin, clothing, or gear during collection. New latex gloves were worn to collect each sample, which was then placed in a clean Ziplock bag. If scissors were used to collect the sample, they were then rinsed with distilled water.

A minimum of 20g of each sample was collected. Each sample was collected from a variety of plant individuals for a more representative sample overall. Shrubs were collected with approximately 3 cm of the terminal twig. Any foreign material such as soil or other plant material was removed during sample collection. Further cleaning of the samples was done in the lab.

Samples were frozen on the day of collection and transported to the lab in a sealed cooler. Samples remained frozen at –20°C until analysis. Analysis was completed at NLET (Environment Canada) in Burlington, Ontario to determine levels of total mercury and methyl mercury using a Direct Mercury Analyser (DMA, Milestone Instruments).

Results

Due to funding restrictions, only twenty-three of the samples could be analyzed. We tried to choose samples within each broad category at each location to send for analysis. A few deciduous plant samples were not selected from the northern locations as they did not contain new growth from the current year and thus would not be considered a current food source for the Porcupine Caribou herd. Mushrooms and flowering plants were also not sent for analysis, as they were only collected at the Chapman Lake sites.

Table 1 Mercury concentrations in forage species collected from Chapman Lake, Shingle Point, and Herschel Island, listed in descending order of methyl mercury concentration followed by total mercury concentration

GROUP	SPECIES	SITE	MeHg (ng/g (dw) as Hg)	THg (ng/g (dw) as Hg)
Lichen	*Alectoria ochraluca*	Herschel Island - 2	5.9	66.2
Lichen	*Alectoria ochraluca*	Shingle Point - 1	2.9	41.9
Lichen	*Flavocetraria cucullata*	Herschel Island - 1	2.5	33.2
Moss	*Aulacomnium*	Shingle Point - 1	2.4	97
Moss	*Tomenthypnum*	Herschel Island - 1	1.8	35.9
Moss	*Drepanocladus*	Chapman Lake - 2	1.3	36.4
Lichen	*Flavocetraria cucullata*	Chapman Lake - 1	1.1	19.5
Moss	*Sphagnum*	Shingle Point - 2	1	38.6
Lichen	*Flavocetraria cucullata*	Chapman Lake - 2	1	18.7
Lichen	*Cladina mitis*	Chapman Lake - 1	1	11.9
Lichen	*Cladina stellaris*	Chapman Lake - 2	1	11.3
Moss	*Sphagnum*	Chapman Lake - 1	0.9	28.1
Moss	*Sphagnum*	Herschel Island - 2	0.8	30.3
Moss	*Sphagnum*	Chapman Lake - 2	0.8	23.7
Lichen	*Flavocetraria cucullata*	Shingle Point - 1	0.4	14.1
Evergreen Shrubs	*Ledum palustre*	Shingle Point - 1	0.4	13.1
Evergreen Shrubs	*Ledum palustre*	Shingle Point - 2	0.3	13.5
Evergreen Shrubs	*Vaccinium vitis-idaea*	Shingle Point - 1	0.3	10.2
Evergreen Shrubs	*Vaccinium vitis-idaea*	Herschel Island - 1b	0.3	9.9
Evergreen Shrubs	*Vaccinium vitis-idaea*	Chapman Lake - 2	0.2	15.2
Evergreen Shrubs	*Ledum palustre*	Chapman Lake - 2	0.2	10.4
Evergreen Shrubs	*Ledum palustre*	Chapman Lake - 1	0.2	9.2
Evergreen Shrubs	*Vaccinium vitis-idaea*	Chapman Lake - 1	0.2	8.8

All 23 samples show relatively low levels of both methyl mercury and total mercury (Table 1). Levels of mercury are similar between evergreen shrubs, with vascular species of moss and lichen showing higher mercury levels (Figure 1). Generally, species collected in northern locations show higher levels of methyl mercury than comparable species collected at Chapman Lake such as seen with the lichen *Flavocetraria cucullata*, with MeHg concentration on Herschel Island over double that of Chapman Lake. Total

Hg in this lichen is also considerably higher on Herschel Island with 33.2 ng/g (dw) compared to 18.7 and 19.5 ng/g (dw) found in Chapman Lake samples.

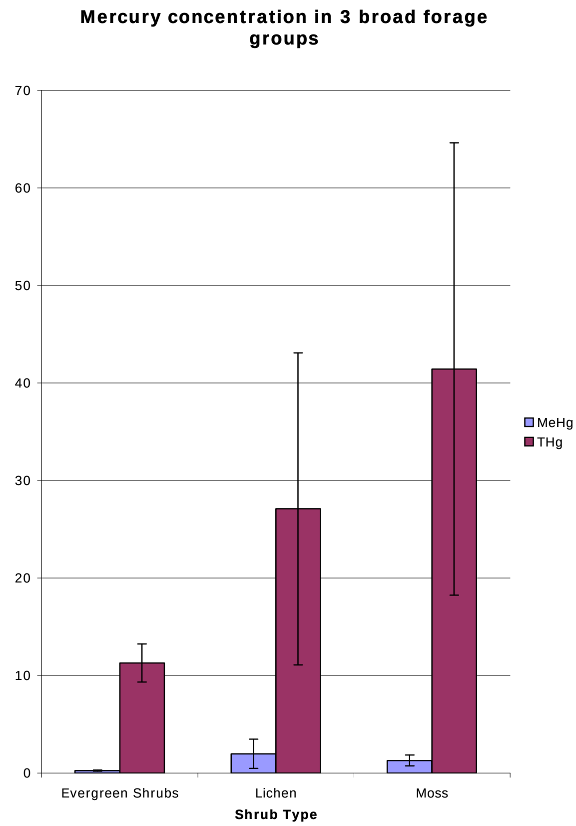

Fig. 1 Average of methyl mercury and total mercury concentrations from all locations in 3 broad forage groups with 95% CL (evergreen shrubs n=8, lichen n=8, moss n=7)

The lowest level of MeHg was seen in lowbush cranberry (*Vaccinium vitis-idaea*) with 0.2 ng/g (dw). Lowbush cranberry from Herschel Island has slightly higher levels of MeHg with 0.3 ng/g (dw). The highest levels of methyl mercury are shown in lichen species from Herschel Island and Shingle Point. The lichen *Alectoria ochraluca* shows the highest MeHg level at 5.9 ng/g (dw).

Discussion

Lichen and moss show higher levels of both methyl mercury and total mercury than evergreen shrubs. As lichen and moss are vascular, it is likely the majority of mercury accumulated in these species is acquired through atmospheric deposition, rather than obtained from the soil. This suggests that atmospheric deposition is the largest contributor of mercury in the range of the Porcupine caribou herd. As a result, changes in anthropogenic mercury pollution will be directly reflected in vegetation, predominantly vascular plant species, thus lending itself to bioaccumulation. This is not surprising, as lichen and moss are often used as indicator species for atmospheric pollution (Evans & Hutchinson 1996). It further illustrates why mercury levels are higher in caribou than other ungulates that feed mainly on shrubs and grasses such as moose (Lokken et al. 2009).

Changes in habitat and food availability as a result of changing climate will ultimately impact mercury uptake of Porcupine caribou. With a warmer, wetter climate species of lichen may be out-competed by sedge species changing both nutrient and contaminant accumulation in caribou (Lokken et al. 2009). We can monitor these changes in habitat, and the subsequent changes in availability of mercury for biomagnification. The knowledge of mercury levels in forage species may also shed light on differences in mercury concentrations between caribou herds based on habitat differences. As shown through the results of this study, northern locations are subject to higher levels of mercury concentration. Thus, as development increases and caribou herds such as the Porcupine are pushed northward they will also be subjected to these increases in mercury.

Having not analyzed mushrooms leaves a large gap in our understanding of mercury accumulation in caribou. No other studies were found that analyzed mercury concentrations in mushrooms. Thus, we have no indication of the mercury contribution mushrooms carry in the overall diet of Porcupine caribou. Furthermore, despite the use of composite samples, the small sample size in this study does not accurately convey differences in mercury concentration with high confidence.

The baseline data from this study can be utilized in the future to compare with levels of mercury in caribou tissue in order to form a correlation between intake and retention. This relationship can be used to determine dangerous levels of atmospheric mercury in the terrestrial food chain, with the potential to prevent caribou from acquiring levels of mercury that will put users of this food source in danger.

Acknowledgements

Research was supported in part by ACUNS, Royal Canadian Geographic Society, and Northern Research Institute. The support of Mary Gamberg, Scott Gilbert, Y2C2, Charlie Krebs and the Polar Continental Shelf Program (Project 632-10) is also greatly appreciated.

References

Carignan, J. & Sonke, J. (2010). The effect of atmospheric mercury depletion events on the net deposition flux around Hudson Bay, Canada. *Atmospheric Environment, 44*, 4372-4379.

Evans, C. & Hutchinson, T. (1996). Mercury accumulation in transplanted moss and lichens at high elevation sites in Quebec. *Water, Air, and Soil Pollution, 90*, 475-488.

Lokken, J., Finstad, G., Dunlap, K., & Duffy, L. (2009). Mercury in lichens and reindeer hair from Alaska: 2005-2007 pilot survey. *Polar Record, 45*(235), 368-374.

Louis, V., Sharp, M., Steffen, A., May, A., Barker, J., Kirk, J., Kelly, D., Arnott, S., Keatley, B., & Smol, J. (2005). *Environmental Science & Technology, 39*(8), 2686-2701.

Wein, E. & Freeman, L. (1995). Frequency of traditional food use by three Yukon First Nations living in four communities. *Arctic, 48*(2), 161-171.

Zhang, L., Qian, J., & Planas, D. (1995). Mercury concentration in tree rings of black spruce (Picea mariana Mill. B.S.P.) in boreal Quebec, Canada. *Water, Air, and Soil Pollution, 81*, 163-173.