THE MACKENZIE RIVER BASIN AS A SOURCE OF MERCURY TO THE BEAUFORT SEA

Dan Leitch[1,2], Jesse Carrie[1,2], Feiyue Wang[1], Gary Stern[2,1], David Lean[3], Robie MacDonald[4,1]

[1] Department of Environment and Geography, University of Manitoba, Winnipeg, Manitoba, R3T 2N2, Canada,
[2] Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba, R3T 2N6, Canada.
[3] Department of Biology, University of Ottawa, Ottawa, Ontario, K1N 5A8, Canada.
[4] Department of Fisheries and Oceans, Institute of Ocean Sciences, Sydney, British Columbia, V8L 4B2, Canada.

INTRODUCTION

• Mercury (Hg) levels in marine mammals in the Mackenzie Delta and Beaufort Sea are high and appear to be increasing (e.g., Hg in beluga liver has increased ~4x since 1981 [1]).

• The causes of the increasing Hg are currently under investigation.

HYPOTHESIS

• We suspect that climate change in the basin has played a role in this increasing trend.

• The Mackenzie River is the largest sediment and water source to the Mackenzie Delta and Beaufort Sea (4th largest riverine water discharge to the Arctic and 1st in terms of sediment).

• No dramatic increase of atmospheric Hg deposition has been observed over the last 20 years.

• An increase in temperature has been noted in the Mackenzie Basin over the past 150 years [2] with an accelerated rate of ~0.6°C per decade over the last 40 years [3].

• Higher temperatures could result in more Hg release due to:
  • Melted permafrost, increased erosion and forest fires
  • Increased Hg methylation rates
  • Possible changes in food web structure which may affect methylmercury (MeHg) biomagnification

OBJECTIVES

• To assess the current levels of total Hg (THg) and MeHg throughout the lower Mackenzie Basin in the water, sediment, and permafrost.

• To assess overall loading of Hg from the Mackenzie River to the Beaufort Sea on an annual basis.

• To probe the relation between Hg levels and climatic/environmental conditions that result in high Hg flux to the Arctic Ocean.

RESULTS & DISCUSSION

• *Annual Variation:* [THg] was much higher when water levels were higher (2003 and 2005), and lower when water levels were lower (2004). Similarly, much higher MeHg levels were observed during high water levels.

Annual Variation

Year	THg (ng/L)		MeHg (ng/L)	
	Range	Median	Range	Median
2003	1.7 - 29.7	7.6	<0.020 - 0.270	0.085
2004	0.2 - 9.2	1.1	<0.020 - 0.140	0.027
2005	1.2 - 31.5	5.5	-	-

• *Seasonal Variation:* [THg] was much higher during spring freshet than in the summer; in contrast, [MeHg] was lower in spring.

Seasonal Variation

Year	Season	THg (ng/L)		MeHg (ng/L)	
		Range	Median	Range	Median
2004	Freshet	10.2 - 22.5	16.2	<0.020 - 0.033	<0.020
	Summer	0.2 - 9.2	1.1	<0.020 - 0.140	0.027
2005	Freshet	8.9 - 22.0	17.5	-	-
	Summer	1.2 - 31.5	5.5	-	-

• *Spatial Variation:* In 2003 and 2005, the highest [THg] was found to be in the Norman Wells area, between the Wrigley and Ontaritue Rivers (with several values between 15 and 30 ng/L), suggesting potential geological enrichment, or possibly due to oil activity or recent forest fires in the area.

• *Fluxes:* Budget calculations suggest that approximately 1.8 ± 0.6 tons of THg are discharged annually by the Mackenzie into the Arctic Ocean. Suspended particulate Hg (Hg_{SPM}) accounts for 75-88% of total Hg discharged.

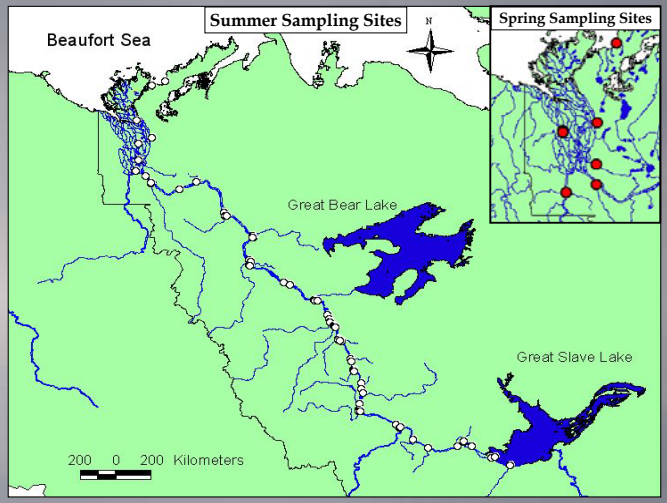
Year	Season	Discharge (km^3)	Concentration (ng/L)				Flux (kg)				Total Annual Flux (kg)	
			dTHg	Hg_{SPM}	THg	dMeHg	dHg	Hg_{SPM}	THg	dMeHg	THg	dMeHg
2003	Summer	298	2.8	5.4	8.2	0.098	828	1621	2450	29	**2450**	**29**
2004	Freshet*	46	1.9	14.9	16.8	0.020	86	680	766	1	**1168**	**7**
	Summer	206	0.3	1.7	2.0	0.029	54	348	401	6		
2005	Freshet*	46	2.5	15.0	17.5	-	113	685	799	-	**1925**	**-**
	Summer	206	1.8	3.7	5.5	-	371	755	1126	-		

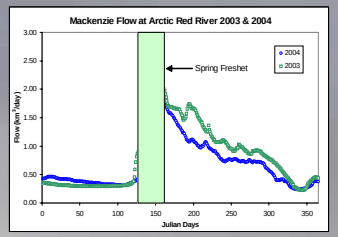
* Freshet defined as when flow magnitude exceeds 1.5x the average flow magnitude for the preceding 30 days, until the peak flow, and 10 days after that.
** discharge values for 2005 are not yet available so 2004 values were used.

• 40-65% of total annual THg flux occurs during freshet. This is a time of year when biota are especially vulnerable to the intrusion of a bioaccumulative contaminants.

• The Hg flux from the Mackenzie River is comparable with those by major Siberian rivers: the Lena (4.0 tons/yr), Ob (1.3 tons/yr), and Yenisei (0.7 tons/yr) [4], and is about ~11% of the atmospheric input of Hg to the entire High Arctic Ocean (estimated to be 17 tons) [5].

• MeHg flux: The annual flux of dissolved MeHg by the Mackenzie River ranged from 7 kg in 2004 to 29 kg in 2003. (2005 MeHg samples are currently being analysed)





CONCLUSIONS & FUTURE WORK

• There appears to be a strong correlation between [THg] and water levels, therefore "snapshot" monitoring is not sufficient. A long-term monitoring program is necessary.

• Further studies should be done to investigate the causes of hotspots.

• To further relate Hg biogeochemical cycles to climate change, permafrost samples have been collected from coastal areas and are currently being analyzed to estimate the potential flux of Hg from melting permafrost.

Fisheries and Oceans Canada (DFO Science Subvention) · NSERC CRSNG · University of Manitoba (University of Manitoba Graduate Fellowship) · Canadian Arctic Shelf Exchange Study · ArcticNet · FJMC · Indian and Northern Affairs Canada

Acknowledgements: We thank the following people for assisting in the field and lab work: Marcos Lemes, Scott Coughtrey, Neil Rentz, Terry Dick, Colin Gallagher, and the crews of the CCGS Dumit and CCGS Eckaloo.

References:
[1] Lockhart, W.L., et al., *Sci. Total Environ. In Press*
[2] Rouse, W.R., et al., 1997. *Hydrol. Proc.* 11, 873-902.
[3] Stewart, R.E., et al., 1998. *Bull. Am. Meteorol. Soc.* 79, 2665-2683.
[4] Coquery, M., et al., 1995. *Water. Air. Soil. Pollut.* 80: 653-664.
[5] Lu, J.Y., et al., 2001. *Geophys. Res. Lett.* 28: 3219-3222.