Science of the Total Environment 424 (2012) 97–103

Contents lists available at SciVerse ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Chemical contaminants and parasites: Assessment of human health risks associated with consumption of whitefish (*Coregonus clupeaformis*) from two boreal lakes in northern Saskatchewan, Canada

Olesya Hursky [a], Michael Pietrock [a,b,*]

[a] Toxicology Centre, University of Saskatchewan, 44 Campus Drive, Saskatoon, SK, Canada S7N 5B3
[b] Department of Veterinary Biomedical Sciences, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK, Canada S7N 5B3

ARTICLE INFO

Article history:
Received 15 October 2011
Received in revised form 24 February 2012
Accepted 27 February 2012
Available online 21 March 2012

Keywords:
Whitefish
Contaminants
Parasites
Mercury
Human health risk
Saskatchewan

ABSTRACT

In Canada there is increasing concern about potential effects of industrial activities on wildlife and human health. In an interdisciplinary study concentrations of inorganic (metals, metalloids) and organic (PCBs, organochlorine pesticides) contaminants, and parasitic infections of lake whitefish (*Coregonus clupeaformis*) from Montreal and Reindeer lakes, Saskatchewan, were investigated to assess human health risk related to fish consumption. In both lakes contamination of fish with chemical substances and compounds, respectively, were very low and often close to detection limits. Lake whitefish parasite communities consisted of 15 (Montreal Lake) and 12 (Reindeer Lake) species most of which were found in the intestinal tract. Many parasite species showed seasonal differences in prevalence and/or mean intensity of infection. None of the identified parasites are known to be human-pathogenic and overall, whitefish from both locations can be considered safe and healthy food. Nevertheless, women of child-bearing age and young children should limit their consumption to 3 and 2 meals, respectively, of Reindeer Lake whitefish per week to minimize potentially harmful exposure to mercury. As well, intestines of Montreal Lake fish should be removed prior to fish consumption if large parasite cysts containing a yet unidentified cestode species are detected.

1. Introduction

In the past two decades industrial and economic development in western Canada has seen tremendous growth. The natural resources sector such as oil, gas, and metal mining industries, in particular, have been the major drivers of this development. Oil sand deposits in the Athabasca Basin of Alberta are considered to be the second largest in the world and production has risen to about 1.3 million barrels per day (CAPP, 2011). Similarly, the province of Saskatchewan has grown into a global leader in uranium production, supplying about 20% of the world's demand (CNA, 2010). Despite benefits associated with economic growth there is increasing concern about environmental impacts related to expanding industrial activities. Once released into the environment, chemicals can contaminate habitats where they may bioaccumulate in organisms and biomagnify in the food chain, potentially causing adverse effects on organisms and populations. Recent studies have shown that oil sands mining and processing releases over a dozen elements considered priority pollutants (PPE) under the US Environmental Protection Agency's Clean Water Act into the surrounding environment (Kelly et al., 2009, 2010). Moreover, field investigations have found increasing numbers of diseased fish sampled near oil sands mining sites (Timoney and Lee, 2009) and laboratory experiments have revealed that fish exposed to effluents or sediments from oil sands and uranium mining sites, respectively, develop increased rates of malformations and mortalities (Colavecchia et al., 2006; Muscatello and Janz, 2009).

Over the last few years Indigenous communities in northern Saskatchewan have been observing an increase in fish disease and parasitism. Concerns were expressed that this increase may be related to accelerated industrial activities in Canada's North and the neighboring province of Alberta, and subsequent airborne contamination of Saskatchewan waters. Indeed, airborne transmission of pollutants occurs around the globe and toxic pollutants released into the environment through anthropogenic activities are rapidly becoming ubiquitous in most freshwater ecosystems (UNEP, 2002). Environmental pollutants can affect the immune system of fish either directly or by causing changes in water quality that subsequently reduce fish immunity to parasites and pathogens, and make fish more susceptible to disease (Khan and Thulin, 1991; Poulin, 1992). Interactions between pollution, immunity, and susceptibility to pathogens are complex though (Hoole, 1997) and there are numerous investigations which have demonstrated that parasitism can also increase the susceptibility of fish to environmental toxicants (Marcogliese and Pietrock, 2011).

* Corresponding author at: Toxicology Centre, University of Saskatchewan, 44 Campus Drive, Saskatoon, SK, Canada S7N 5B3. Tel.: +1 306 966 4067; fax: +1 306 931 1664.
E-mail address: michael.pietrock@usask.ca (M. Pietrock).

0048-9697/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.scitotenv.2012.02.071

In Canada water quality is monitored by federal and provincial authorities but data availability in many Saskatchewan watersheds is rather poor (SWA, 2010). Similarly, despite the abundance of myriad lakes, ponds, and rivers in Saskatchewan, the current knowledge on the regional occurrence of fish parasites in these water bodies is extremely limited. Larval stages (so-called plerocercoids) of the cestode *Triaenophorus crassus* infecting fish muscle are a known esthetic problem in some western Canadian waters (Miller, 1952). More importantly, however, human-pathogenic parasite species including the broad fish tapeworm *Diphyllobothrium latum* (Eaton, cited in Unruh et al., 1973) and the fluke *Metorchis conjunctus* (Unruh et al., 1973) have also been reported in Saskatchewan water bodies. Heavy infections of humans by either of these species can manifest themselves in abdominal pain, nausea, diarrhea, anorexia, fever, and weakness (MacLean et al., 1996; Roberts and Janovy, 2005). Therefore, in order to address the concerns of the Indigenous people a study was initiated to investigate chemical contamination and parasitic infection of fish from two large lakes situated in northern Saskatchewan. The investigations focused on lake whitefish (*Coregonus clupeaformis*) which inhabits larger lakes and rivers across Canada. In Saskatchewan lake whitefish play a significant role in the diet of Indigenous people. Local commercial fishermen harvest approximately 1000 t of whitefish per year (Ashcroft et al., 2006) which, after processing, are also sold throughout North America as well as to Europe and the Middle East (Freshwater Fish, 2010). Using a combination of chemical and biological approaches, the specific objectives of the present study were to *i*) determine levels of inorganic and organic contaminants in whitefish, *ii*) identify whitefish parasites and obtain information on seasonal infection levels, and *iii*) to assess health risks for northern Indigenous people and other consumers related to whitefish consumption.

2. Material and methods

2.1. Sampling sites

This study was conducted in Montreal and Reindeer lakes which are located in northern Saskatchewan, Canada.

Montreal Lake is situated at 54° 4.59′ N and 105° 49.0′ W within the Boreal Plain ecozone (Goode et al., 1996). Located at an elevation of 490 m, Montreal Lake covers an area of 447 km^2 (Natural Resources Canada, 2010). The lake is relatively shallow with a maximum depth of 8.5 m and a mean depth of 2.2 m. The fish community consists of northern pike (*Esox lucius*), walleye (*Sander vitreus*), lake whitefish (*C. clupeaformis*), cisco (*C. artedii*), yellow perch (*Perca flavescens*), and burbot (*Lota lota*) (Anonymous, 2009).

Reindeer Lake is an oligotrophic lake of early Precambrian age. Located across the Saskatchewan–Manitoba border, it is near the northern limit of the coniferous forest (57.0°N, 102.0° W). At an elevation of 337 m, it is Saskatchewan's second largest lake, covering 5569 km^2 with a maximum length of 245 km, a maximum width of 56 km, and a maximum depth of 215 m (Rawson, 1960). Common fish from this lake include lake trout (*Salvelinus namaycush*), lake whitefish, cisco, northern pike walleye, white sucker (*Catostomus commersonii*), yellow perch, and burbot (Dean, 1975).

2.2. Fish sampling

Adult whitefish from both lakes were sampled by local Indigenous fishermen in October 2008, June–July 2009, and October 2009 using gill nets. All fish were sacrificed in the field, put on ice, and transported to the laboratory at the University of Saskatchewan, where they were stored frozen until further examination. The number of examined fish/sample as well as their morphometric data are provided in Table 1.

2.3. Metal analysis

For analysis of heavy metals 5.0 g muscle (without skin and bones) from each fish were sampled, dried in an oven for 24 h and ground together for each lake/time point. Three 0.1 g subsamples were then taken for each lake/time point and digested in 6.0 ml of 69% HNO_3 and 1.6 ml of 30% H_2O_2. Subsamples were then evaporated down to approximately 1 ml at 70 °C. After adding 5 ml of 2% HNO_3 to each subsample their final weight was determined. Afterwards all sample digests were filtered with 0.45 μm filters and were stored prior to analysis. All subsamples were analyzed for concentrations of 22 metals by Inductively Coupled Plasma Mass Spectrometry (ICP-MS, Thermo Fisher Scientific X-Series, Waltham, MA, USA) at the Toxicology Centre, University of Saskatchewan, Canada. Analytical blanks and certified reference materials (0.1 g of TORT-2, National Research Council of Canada), were prepared in an identical manner as described above to verify the accuracy of metal analyses (3 blanks and 3 certified reference materials were analyzed in total).

2.4. Analysis for organic contaminants

Muscle samples (5.0 g without skin and bones) from each fish dissected were taken for analysis of organic contaminants. All muscle samples from the respective lake/time point were ground together, and then three 5.0 g subsamples were taken separately for each lake/time point. The subsamples were combined with 20.0 g of Na_2SO_4 and left to dehydrate overnight. A multilayer cleanup column was created for each subsample by first adding anhydrous Na_2SO_4 into the bottom of a glass column and then the dehydrated sample/Na_2SO_4-mixture. Column was eluted with 200 ml of hexane. A laboratory blank and a control sample each consisting of 20.0 g of Na_2SO_4 were analyzed along with the sample batch. The laboratory control samples were spiked with a mixture of the PCB congeners of interest to confirm the accuracy and precision of the analysis. All samples were spiked with a mixture of internal standards.

After extraction, the hexane was removed from the extract by rotary evaporation until the final extract volume was approximately 1 ml. Each extract was applied to a column consisting of $AgNO_3$ silica gel, KOH silica gel and H_2SO_4 silica gel which was eluted with 200 ml of hexane. Hexane was removed from the extract by rotary evaporation and under a stream of nitrogen to dryness. The extract was then dissolved in a final volume of 50.0 μl of nonane.

Extracts were analyzed on an Agilent 7890 Gas Chromatograph interfaced to an Agilent 5975 Mass Spectrometer. Samples were analyzed on a 60 m DB5ms column. Organochlorine pesticides were determined by comparison to a commercial standard mixture containing 16 of the most commonly detected persistent organochlorine pesticides (Heptachlor, Heptachlor-epoxide, Mirex, Aldrin, Endrin, Dieldrin, α-BHC, β-BHC, γ-BHC (Lindane), δ-BHC, 2,4′-DDE, 4,4′-DDE, 2,4′-DDD, 4,4′-DDD, 2,4′-DDT, 4,4′-DDT). PCB congeners were identified by comparison to a PCB congener mixture containing 62 individual PCB congeners. Two ions were monitored for each congener and ion ratios and retention times were used to determine quality matches for congener

Table 1
Number and morphometric data of sampled whitefish (Mean ± SD).

	Montreal Lake			Reindeer Lake		
	Fall 2008	Summer 2009	Fall 2009	Fall 2008	Summer 2009	Fall 2009
Number of whitefish	21	20	30	31	30	30
Mean body mass, kg	1.00 (0.13)	1.03 (0.41)	0.95 (0.22)	1.16 (0.28)	1.17 (0.18)	0.99 (0.18)
Mean body length, cm	44.14 (0.23)	42.25 (7.98)	42.55 (2.87)	47.18 (3.70)	45.57 (2.46)	44.25 (3.18)