BIOACCUMULATION of URANIUM in MUSSELS IN THE KETTLE RIVER, BRITISH COLUMBIA

Al Grant, [1] William Floyd, [2] George Floyd, [3] Mark Grant, [4] Robert W Plotnikoff [5]

STUDY PURPOSE

The geologic setting surrounding the Kettle River drainage is rich in naturally-occurring metals including uranium. This study was conducted in order to obtain information on aquatic organisms most susceptible to bioaccumulation of contaminants from both natural and anthropogenic sources. One of the most sensitive aquatic species is the Western Pearlshell (*Margaritifera falcata*) mussel distributed throughout the Kettle River drainage. *M.falcata* was used to determine the uranium concentrations in tissue in order to describe current status of bioaccumulation and serve as a reference for future studies, assess presence and magnitude of bioaccumulation (bioconcentration), and to determine from this initial sampling effort whether a more extensive effort for describing potential biological impacts from bioaccumulative toxics like uranium and other harmful toxics is warranted. Laboratory results from tissue analysis showed bioaccumulation (bioconcentration) up to 158 times the average uranium concentration in surface waters of the Kettle River. The average concentration for surface water was acquired from monitoring sites maintained by Environment Canada at two locations on the Kettle River[6]. Tissue analysis results in *M. falcata* confirmed uranium concentrations of 9 times greater than the Federal Drinking Water Guideline of 0.02mg/L (equivalent to ppm).

Margaritifera falcata is the scientific name for our common Western Pearlshell freshwater mussel. It is one of the longest living creatures on this planet, sometimes living for more than a hundred years. All of its life it sits quietly on the river bottom filtering all sorts of material from the water and converting a great deal of it into pseudo-faeces which in turn is food for other minute creatures in the river. It is a vital link in the food chain. M. Falcata has many enemies which include natural predators such as river otters, raccoons, grizzly bears and muskrats. It is also seriously affected by man's pollutants such as fertilizer, insecticides and pesticides. They manage to avoid serious depletion from Spring floodwaters by carefully selecting their anchor spots, usually behind large boulders so their home lies in back eddies. They replenish their kind by attaching new larvae to fish fins and gills and they thus hitchhike a ride to their new home. Mankind also damage the stock, sometimes for food and often for curiosities and souvenirs. Historically, the valves(each side of the shell) of Western Pearshell mussels was used to make buttons until replaced with plastics. Both practices should be discouraged as these mussels perform a very valuable service just sitting on the river bottom constantly filtering the water. An adult M. falcata can filter up to seven gallons of water a day and they mostly measure only 7 to 9cm long.

BACKGROUND

"The Kettle River flows from its headwaters in the Christian Valley, located in the Southern Interior of British Columbia, Canada to the Columbia River in Washington State, USA. The Kettle has two notable tributaries, the West Kettle River and Boundary Creek.

With its headwaters being Keefer Lake in the Monashee Mountains, the Kettle River drains an area of 9800 km2 in the Okanagan region of Southern British Columbia and Northern Washington State. It flows south until Rock Creek, BC and then turns East-Southeast and begins a series of large meanders. It crosses the international border at Midway, leaving Canada only to re-enter again near Grand Forks, BC and flow for another 45

kilometres before leaving Canada for a second time and joining the Columbia River in Washington. Of its 9800 km2 drainage basin, 8300 km2 are in Canada.[7] This is the only river in the world that crosses an international boundary three times.

In the 1970's a Regional Geochemical Survey of the Kettle and Okanagan drainages by the Provincial Mines Ministry sampled all creeks for as many as 90 parameters. That survey showed numerous "hotspots" of levels for uranium and thorium on both drainages. Uranium is a naturally occurring radionuclide in granite and other mineral deposits.[8] This is a region known as the Idaho Batholith geologic formation and known for the high content of metal-bearing ore. As a consequence, uranium and other elements are naturally occurring in groundwater. As groundwater passes through bedrock it picks up elements as dissolved particles, these can then be consumed by people through their drinking water.[9]

Numerous claims have been staked in "hotspot" areas with particular concentrations south of Big White and north of Beaverdell, British Columbia. Drainage from these claims flows either to the Kettle River or Okanagan River drainages. Two companies have stated intent to mine uranium in areas that drain to the Kettle; one of these companies claims to have the largest uranium deposit in B.C. An "Order in Council" issued by the Provincial Government, presently prevents them from doing so.

The incidence of high radon readings found in the Kettle basin and the levels of uranium found in the Kettle are indicators of high natural levels of radioactive materials throughout the basin.

- There are no present known "point sources" of uranium going into the Kettle therefore it is assumed that uranium levels in the Kettle are from "natural sources", however two considerations are worth further study.
- According to Environment Canada water records taken at Midway and at Carson, the points where the Kettle leaves Canada and returns to Canada after a 35 km detour across the international boundary, uranium levels are sometimes up to 40% higher at Carson compared to the concentration prior to entering the United States. Several mines, perhaps three or more, on the U.S. side, are potential point sources however we have no information on the proximity of those mines to the Kettle or of practices that could impact Kettle water.
- Ground disturbances, e.g. roads, rails, mines and excavations that disturb bedrock can expose radioactive materials to weathering and leaching into groundwater or streams. The metals aggregate along "seams" between weathered granitic bedrock and sedimentary deposits and are easily mobilized once exposed by extraction methods. An example of the long-term effects of such exposure is evident on sections of the old Kettle Valley Railway. In parts of that rail-bed , constructed more than 100 years ago, places where material

was “cut” and then used as fill, still have elevated radioactive readings over similar undisturbed areas.[10]

Several recent years have seen record low flows in the Kettle. In 2009 the Ministry of Environment issued an unprecedented request to water-licence holders in the Okanagan & Kettle basins to curtail licensed water withdrawals due to new record low flows. Some combination of decreased snow-pack, excessive water withdrawals and higher evaporation have contributed to these low flows which result in higher stream temperatures and reduced dissolved oxygen, both threats to mussels, fish and other organisms.

Freshwater mussels (*M. falcata*) successfully maintain viable populations when all stages of the life cycle can be completed without major loss or mortality. When environmental conditions are changed that compromise resources or biological populations important for survival of a life cycle stage, recruitment of young age classes is diminished leaving an aging, localized population. When the stressors like metals pollution, extirpation of important host fish species, or factors that cause a decline in host fish species occur, it will limit the success of localized populations. Environmental conditions like reduced water flow, increased surface water temperatures, and reduced dissolved oxygen are interrelated; all affecting the survivability of *M. falcata*.

SAMPLING

Oct 11 2009 a sampling team[11], led by field tech George Floyd obtained samples at two locations, Spraggett Bridge, Grand Forks and Cox’s Bridge, Christian Valley. (see field sampling forms attached for GPS locations and details). Individual mussels were visually located with a viewing mask and tube and placed in a bucket filled with river water prior to preparation for transport to the laboratory.

No specimens were found at two other locations, where sightings had been made in the summer. One location, near Rock Creek had questionable directions, the other approx 10km upstream from Westbridge on the West Kettle, required that ice be broken to view river bottom. Several days of lows to minus 10^{o}C made for difficult search conditions and likely resulted in mussels going into aestivation (type of hibernation) period when they become difficult to observe as they have retreated into and are almost completely buried in sandy substrate. Samples were bagged, stored in ice and delivered to a Vancouver Laboratory for further processing.

CONCLUSIONS

The two samples obtained were tested using standardized laboratory protocol approved by Environment Canada confirm bioaccumulation (bioconcentration) of uranium in mussel tissue. Laboratory results (attached) at Spraggett Bridge showed uranium concentrations of 0.18 µg/g (equivalent to ppm) and of 0.17µg/g at Cox’s Bridge (upper Kettle drainage). These uranium concentrations were then compared against the average concentrations of uranium in Kettle River

surface water using Environment Canada's biweekly (every other week) sampling at Midway and Carson Bridge.[12] Comparison results were as follows:

Spraggett Bridge Site, 135.25 times average river uranium content at nearby Carson.

Cox's Bridge Site, 158 times average river uranium content at Midway, some distance downstream.

Levels found are up to 9 times the Canadian Drinking Water MAC limit of 0.02 mg/L (equivalent to ppm)

We recommend that further counts and sampling to repeat this study be conducted during low water conditions in late July or August prior to aestivation of the adult mussel life stage. Freshwater mussels will be actively feeding and metabolizing filtered food from the water column and siphoning overlying surface water. Surface water containing high concentrations of uranium (as reported by sampling conducted by Environment Canada) has been recorded repeatedly during August and September corresponding with peak potential exposure of the freshwater mussel population.

These initial results from tissue analysis of *M. falcata* at two locations in the Kettle River drainage identify potential problems that may prompt extirpation of the most important "charismatic" species of interior British Columbia freshwater life. The longevity of the freshwater mussel is greater than the average life span of humans and serves as the most important indicator of the river's environmental health and protection of people who enjoy the beauty of the Kettle.

QUESTIONS RAISED, AREAS FOR FURTHER STUDY

- What levels of bioconcentration are occurring in organisms (including humans) other than mussels?
- Bioaccumulation demonstrated in mussels, given existing uranium levels in Kettle River water, what health implications for other bioaccumulators, e.g. humans?
- What bioaccumulation of other toxins in Kettle River mussels & health implications for humans?
- Effects of frequent record low water levels, with resultant higher water temperatures and reduced dissolved oxygen, on mussels and fish populations on which they depend?
- Levels of uranium in mussels before and after aestivation? Some literature suggests that levels drop during aestivation; however shedding of toxins in organisms is usually accompanied by increased rate of metabolism, rather than lower.
- Are freshwater mussels (*M. falcata*) in the Kettle River drainage more tolerant to bioaccumulation of high concentrations of uranium than other populations in drainages that do not have naturally high concentrations of metal-bearing ores?
- Do older freshwater mussels (*M. falcata*) in the Kettle River drainage have higher bioaccumulated concentrations of uranium than younger age classes?
- If background uranium concentrations are naturally high in this region, is additional release of mined uranium a greater threat to aquatic life due to potential for greater bioaccumulation in tissues?

- Mussel populations? Little information available except from anecdotal evidence. In order to facilitate further study, Willy Floyd is recording reported locations to assist us or others in future studies. See contact numbers below.

CONTACTS

Al Grant [13] 250 446 2372 Willy Floyd 250 446 224

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[1] Proposed and initiated this project on behalf of Boundary Environmental Alliance, partnering with Willy Floyd of Committee for a Clean Kettle Valley, to organize and carry out the project.

[2] Willy Floyd, Researcher for Committee for a Clean Kettle Valley, has been documenting radioactive occurrence on land and on streams for 20 years.

[3] George Floyd, BSc (marine biology) Led our sampling and delivered samples to Vancouver Lab.

[4] Mark Grant, BASc (geological engineering) BSc (Physics) data recorder & occasional cameraman on sampling.

[5] Robert W Plotnikoff, Senior Aquatic Ecologist, Tetra Tech-Surface Water Group in Seattle, Washington. Charter Member of the Pacific Northwest Native Freshwater Mussel Workgroup. Robert provided much of the information on ecology of freshwater mussels which led to our curiosity about bioaccumulative potential of uranium in mussels. We thank him for his input, advice and guidance and for introducing us to the fascinating life of mussels, in the Kettle and elsewhere.

[6] Kettle River, Midway,
http://waterquality.ec.gc.ca/waterqualityweb/stationOverview.aspx?stationId=BC08NN0011.
Kettle River, Carson Bridge
http://waterquality.ec.gc.ca/waterqualityweb/stationOverview.aspx?stationId=BC08NN0021

[7] Kettle River Watershed Analysis, Robert Maciuk, Trevor Ford, Jenn Schroeder.
http://www.boundaryalliance.org/kettleriverstudy.pdf

[8] Canadian Medical Association publication Mar 2004 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC359425/

[9] Interior Health Dept, information sheet.
http://www.interiorhealth.ca/uploadedFiles/Health_and_Safety/Drinking_Water/Uranium_InfoSheet.pdf

[10] Personal comment, Willy Floyd, data collected by and in his unpublished records.

[11] George Floyd, Al Grant, Willy Floyd, Mark Grant and for the first stage, Falco Tilgner, Taryn Tilgner & Geoff Deacon

[12] Kettle River, Midway,
http://waterquality.ec.gc.ca/waterqualityweb/stationOverview.aspx?stationId=BC08NN0011.
Kettle River, Carson Bridge
http://waterquality.ec.gc.ca/waterqualityweb/stationOverview.aspx?stationId=BC08NN0021 records available are for period March 2003 to May 20

[13] Became involved in environmental issues, particularly water and stream protection, in the Fraser Valley 25 years ago. Formed West Creek Watershed Protection Group (WCWPG) to create public awareness of threats to West Creek, & organized salmon-fry releases in Partnership with the Federal Salmon Enhancement Program and participation of local schools.
Initiated and funded pilot project, and partnered with Langley Township to place "yellow fish" signs on West and Nathan Creeks to mark the creeks as an ecological resource and as salmon habitat. Langley Township subsequently expanded the program throughout the Municipality. West Creek and Nathan Creek have since been designated as "sensitive streams" by the Provincial Fish Protection Act & Riparian Area Regulations, a designation on 15 BC streams defined as "a source that requires particular attention to protect the watersheds fisheries resource". WCWPG similarly initiated signage on Nathan Creek, partnered with Matsqui Municipality who later expanded the program to other Matsqui streams. WCWPG later initiated a plan and raised funding for GPS & GIS mapping (early days for both technologies and a first in the Fraser Valley) of West Creek, by Langley Environmental Partners, an entity operating out of Municipal offices. As representative of WCWPG, was involved in several Municipal Planning Processes, including *Rural Plan* and *Langley Tomorrow*. Appointed by Langley Township to the Municipalities first Environment Committee. In that capacity led a process and authored a report to Council, *Water Quality & Preservation of Natural Resources & Wildlife*, that led to Council contracting University Of B.C. Westwater Dept, to complete a comprehensive study on *Township's Environmentally Sensitive Areas* (ESA) and means to protect them.

The ESA study highlighted particular problems in the Salmon River, problems that had mostly been identified 12 years earlier by consultant Howard Paish in a report to the Municipality that recommended specific remedies and an overall Co-operative Management Model (Watershed Management Plan) for the Salmon River. Twelve years after that report, Paish's recommendations had been mostly ignored and forgotten. After Westwater's report the Municipality, Westwater and NGO's all agreed a new process was needed for a Watershed Management Plan. The Salmon River Watershed Management Plan (SRWMP) began with high level representatives from the Municipality and various Federal & Provincial Gov't agencies, some "stakeholders" with vested interests in promoting a drainage plan to provide benefits to their land and a few public members interested in protecting or enhancing the resource. When it became apparent to the public members that little co-operative progress was being made on a plan thanks to agencies advocating for their own narrow interests, public members mostly split from the process and formed the Salmon River Enhancement Society (SRES, in which writer was a founding member). The SRES water quality testing/monitoring program which the writer set up in 1995 still continues with Trinity Western U, and SRES is still in operation. The writer continued as a member of SRWMP until leaving the area in 1996. Some years later SRWMP shrivelled and dissolved with no Watershed Management Plan in place. The SRWMP is mentioned as a cautionary tale for "public" members of such processes who might wish to determine at a very early stage whether the "terms of reference" and "powers" ceded to a Watershed Management Plan will result in any meaningful protection of the resource.
Setup website, www.boundaryalliance.org in 2007 as a platform for several organizations working to protect the natural resources of the Boundary; Committee for a Clean Kettle Valley, Boundary Environmental Alliance, Gilpin Grasslands Saga.

Al Grant (foreground) & George Floyd on West Kettle photo mark grant

Collection, Margaritifera falcata, at Spraggett Bridge, Grand Forks photo al grant

George Floyd on West Kettle, collection bucket already on ice. Photo al grant

L to R: Mark Grant, George Floyd, Willy Floyd near Rock Creek photo al grant

George Floyd, West Kettle, “Breaking Ice” photo al grant

Analysis Report

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REPORT ON: Analysis of Tissue Samples

REPORTED TO: Sage Farm
1770 Johnstone Creek
Box 187
Rock Creek, BC
V0H 1Y0

Att'n: Al/Sue Grant

CHAIN OF CUSTODY: 2178575

NUMBER OF SAMPLES: 2

REPORT DATE: October 20, 2009

DATE SUBMITTED: October 13, 2009

GROUP NUMBER: 101013118

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Metals in Tissue - samples were digested using a nitric acid-hydrogen peroxide digestion procedure based on EPA Method 200.3. Analysis was performed using Inductively Coupled Argon Plasma Spectroscopy (ICP), or ICP Mass Spectrometry (ICP/MS).

Metals Analysis in Tissue

CLIENT SAMPLE IDENTIFICATION:	SAMPLE DATE	CANTEST ID	Uranium U
Sample A	Oct 13/09	910130402	0.18
Sample B	Oct 13/09	910130403	0.17
REPORTING LIMIT			0.04
UNITS			µg/g

µg/g = micrograms per gram, dry basis

CANTEST LTD.

Anna Becalska, PhD
Coordinator, Trace Metals

MUSSEL SAMPLING

SAMPLE ID: Name....A Colour tag...Pink tape.

DATE:....Oct 11 2009. TIME:..0925 hrs

LOCATION:..Spraggett Bridge, Grand Forks UTM's....30679N 92417E (google)

SAMPLE OBTAINED BY:..George Floyd. Biologist

COLLECTED SIZES: (Length).....6 to 8 cm. 10 mussels TOTAL EST WEIGHT:..10.5 oz.

WEATHER CONDITIONS: (Today and previous weeks)..sunny, clear, minus 8C, no wind.

.lows about -10C past few days, no precipitation past 3 weeks..

RIVER CONDITIONS: (depth, visibility, flow rate, temperature, ph, conductivity, TDS, dissolved oxygen

Depth , 2 to 3 feet. Visibility, clear. Flow, slow. Water temp, 2.7C. Conductivity, 220 micro Siemens.

PH, 9.09. TDS, 110 ppm?.

MUSSEL BED Estimated Size :.couldn't estimate, sparse in areas where found, general area 60 yds upstream of bridge

POPULATION DENSITY: sparse

CLASSIFICATION of above: small (under 6cm)—medium 6 to 10cm—large, 10cm & over (as per BCC field form)

All found medium category, 6 to 8 cm

LIVE OBSERVED:..10

SHELLS OBSERVED:...1..

DEPTH of MUSSELS:.18" to 24 " water depth, mostly tips out of sand between cobbles, 0.5" tips showing.

SUBSTRATE TYPE: (As per BC Conservation Field Survey Form)...cobble (tennis ball to basketball size)

PHOTOS : .. to come.

OTHER COMMENTS:. All samples classified as Western Pearlshell (Margaritifera falcata).

MUSSEL SAMPLING

SAMPLE ID: Name..C. Colour tag...orange tape

DATE:.. Oct 11 2009 TIME:..1400 hours

LOCATION:. Cox's Bridge & 500' upstream UTM's.63771E, 71643N

SAMPLE OBTAINED BY:... George Floyd, Biologist

COLLECTED SIZES: (Length)..7 x 6 to 8 cm, 2 x 3 to less than 6 cm. TOTAL EST WEIGHT:. 8 oz

WEATHER CONDITIONS: (Today and previous weeks).. Sunny, plus 1C, light wind

Lows about –10C for past three days, no precipitation past 3 weeks

RIVER CONDITIONS: (depth, visibility, flow rate, temperature, ph, conductivity, TDS, dissolved oxygen

Depth, 2 to 3' in middle. Visibility, clear. Flow, medium to slow. Water temp, 3.8C. Conductivity, 101 micro Siemens. PH, 8.67. TDS, 50 ppm.

MUSSEL BED Estimated Size : couldn't estimate, sparse where found

POPULATION DENSITY: sparse

CLASSIFICATION of above: small (under 6cm)—medium 6 to 10cm—large, 10cm & over (as per BCC field form)

Small 2, 7 medium

LIVE OBSERVED: 9

SHELLS OBSERVED:. nil

DEPTH of MUSSELS: 18" to 24" water depth, mostly tips out of sand between cobbles. 0.5" tips showing

SUBSTRATE TYPE: (As per BC Conservation Field Survey Form).. cobble (tennis ball to basketball size)

PHOTOS : ....to come.

OTHER COMMENTS: most found where sampling crew member Willy Floyd saw grizzly feeding on mussels 20 years ago

All samples classified as Western Pearlshell (Margaritifera falcata)