NSERC
CRSNG

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Overview

Network Goals

- New research addressing “pain points” in risk assessment for metals in the environment relative to human health, thus improving existing RA frameworks
- Build relationships and capacity among professionals who regulate/are regulated by public policy
- Train the next generation of “metals savvy” environmental scientists as advocates for correct assessment of risks from metals exposure

Sponsors

- Diverse!
- EcoToxicity Assessment Panel (IZA, NiPERA, ICA, ICMM, US Borax, Cobalt Development Association), Mining Association of Canada, Jacques Whitford Environmental Ltd, Agriculture and AgriFood Canada, Health Canada, Environment Canada, Natural Resources Canada, Ontario Ministry of Agriculture and Food, Ontario Ministry of the Environment, Canadian Grains Commission, Potash Phosphate Institute, American Water Services

Benefits to Canada

- development of guidelines including bioavailability/bioaccessibility which…
- allow regulators and land owners to focus on sites of highest real risk
- forum for industries, governments and universities to collaborate
- training of HQP
- responsible care + industry health

Science Plan

- **Aquatic Ecosystems**
  - P Campbell (INRS-ETE) and U Borgmann (NWRI)
- **Soils and Plants**
  - W Hendershot (McGill) and A Rencz (NRCan)
- **Food and Ingested Particles**
  - B Hale (Guelph) and R Garrett (NRCan)

<Aquatic> Science Plan

OVERALL APPROACH

- development and validation of mechanistic-type models to predict
  - the **uptake**, **accumulation** and **toxicity** of metals to aquatic biota
  - the potential for **trophic transfer** of metals

<Aquatic> Science Plan

ANTICIPATED BENEFITS

- **Improved ecological risk assessment for metals**
- **Improved links between metal exposure in the field and the incidence of metal-induced effects**
- **Better water and sediment quality guidelines for metals**
- **Ability to choose more cost-effective control strategies**

<Soils & Plants> Science Plan

OVERALL APPROACH

- development and validation of mechanistic models to predict
  - the **speciation** of metals in soil solutions
  - the **uptake** of metals from soils to plants
  - the **fate** of metals in soils over the long term as a function of soil management

<Soils & Plants> Science Plan

ANTICIPATED BENEFITS

- **Improved risk assessment for metal-plant interactions**
- **Improved strategies for decreasing metal uptake through the use of better crop management systems**
- **Better soil quality guidelines for metals**
- **Identification of more cost-effective strategies to manage risk associated with contaminated soils**
- **HQP trained in soil-plant interactions**

<Ingesteds> Science Plan

OVERALL APPROACH

- develop and validate models which characterize
  - how **speciation** of metals in food, dust and soil influences….
  - the **bioavailability** of metals in these media, allowing apportionment of exposure, and how this exposure influences...
  - **human biomarkers** of internal dose of metals

<Ingesteds> Science Plan

ANTICIPATED BENEFITS

- mechanistic bases for transfer factors (speciation, bioavailability, biological)
- determinations of transfer factors for existing metal-rich sites in Canada
- comparatively for inhalation and ingestion, of food, soil and dust

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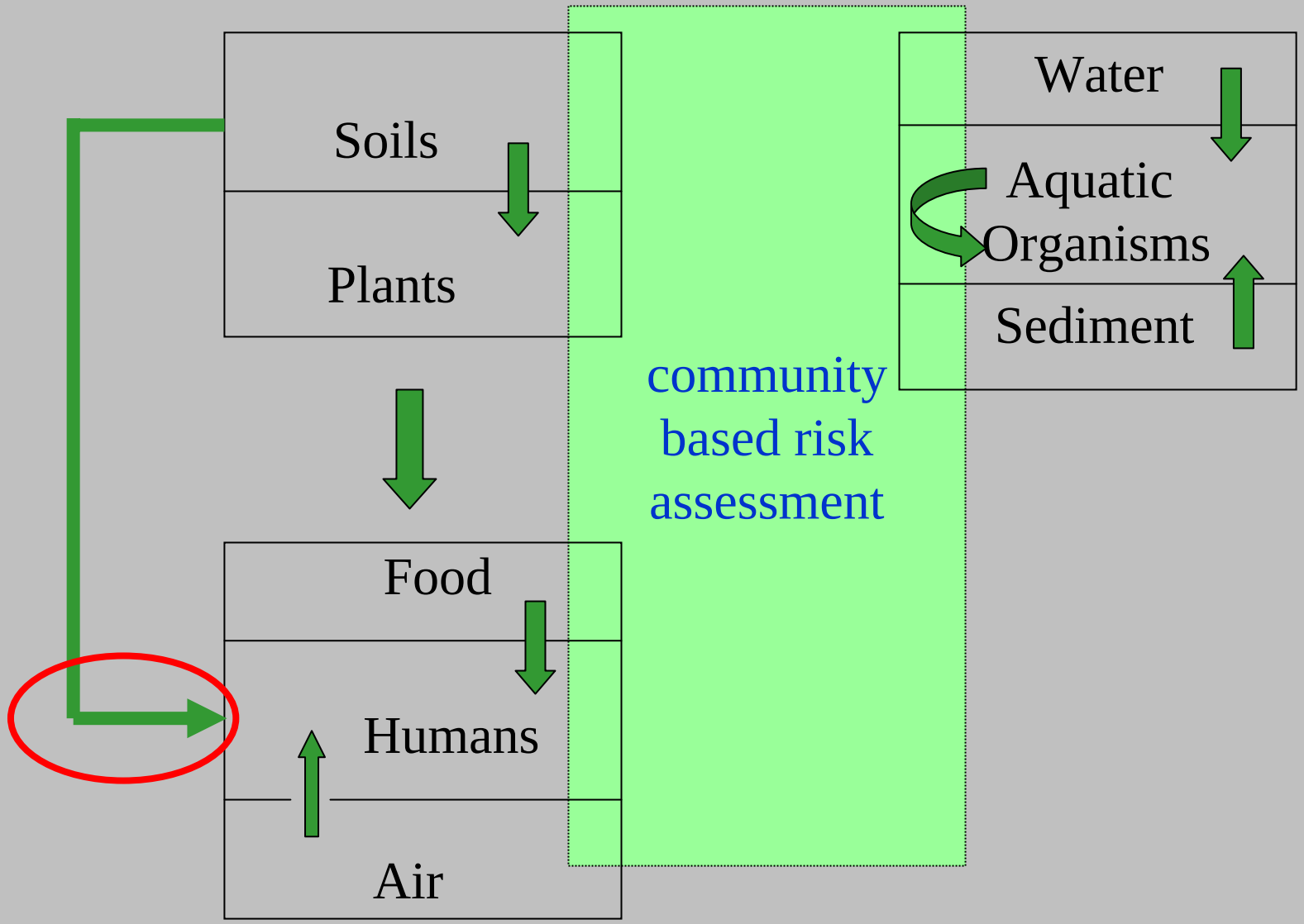
Details of One Project


Soils
Plants
Water
Aquatic
Organisms
Sediment
community
based risk
assessment
Food
Humans
Air

Determining bioavailability and bioaccessibility of Cu, Ni and Pb in field-contaminated soils

L. Vasiluk, D. Chan and B. Hale

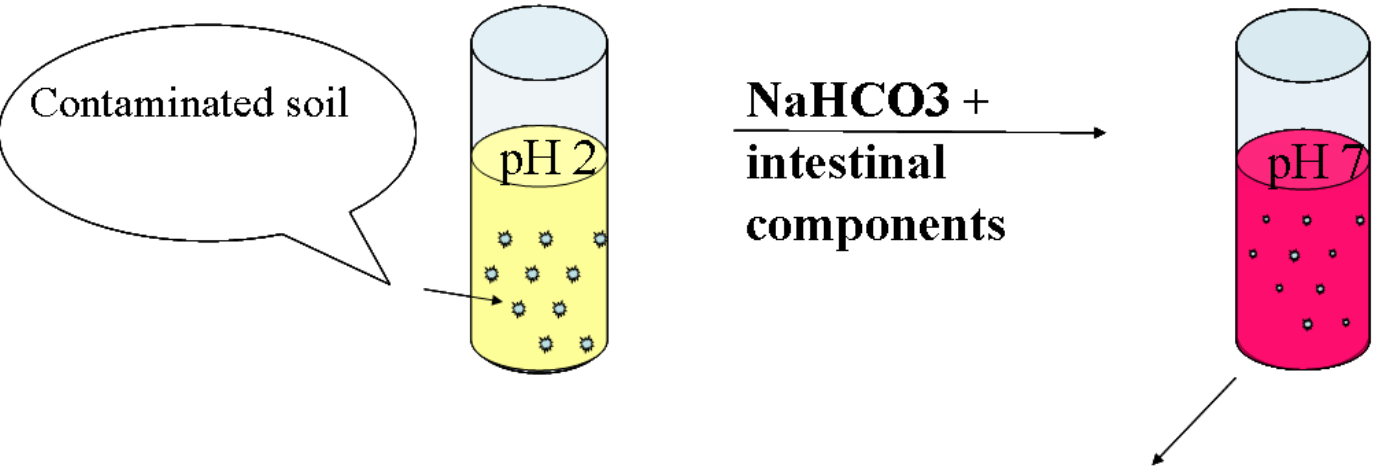
University of Guelph

Objectives

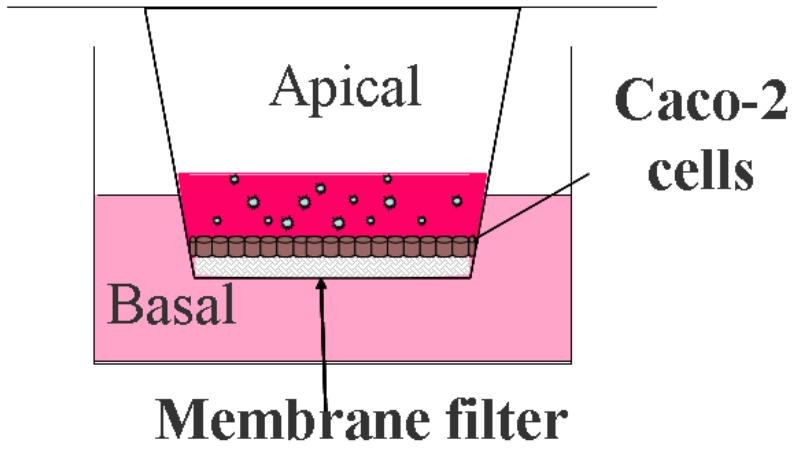
- To characterize a collection of field-contaminated soils and dusts for distribution of particle size classes as well as mineralogy of Cu, Pb and Ni
- To evaluate the bioaccessibility of Cu, Pb and Ni in these materials using simulated gastrointestinal digestion *in vitro* and then uptake from the digestate into human cultured enterocytes, Caco-2 cells.
- To evaluate the bioavailability of these elements using rats in a short-term feeding study of these materials

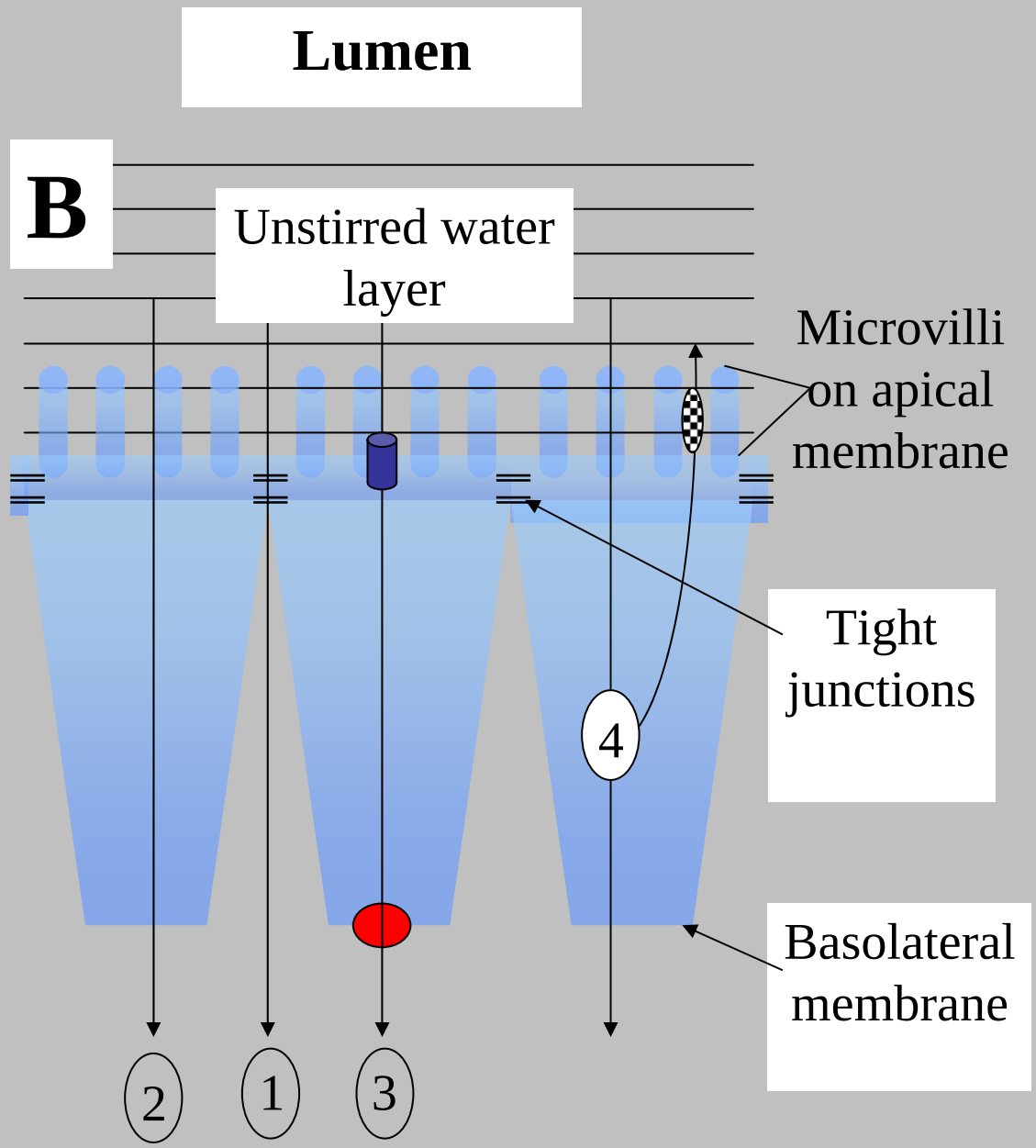
STEP 1. Gastric digestion

STEP 2. Intestinal digestion



STEP 3. Exposure to intestinal epithelium




Lumen
B
Unstirred water layer
Microvilli on apical membrane
Tight junctions
4
Basolateral membrane
2
1
3
Blood flow

Sudbury soils	Fraction, % from bulk	pH	TOC, %	Cu, mg/kg	Pb, mg/kg	Ni, mg/kg
S1B Bulk <250 mm		3.49	2.94	202.17±25.8	38.03±3.6	120.96±21.9
150-250mm	31.03		3.11	196.24±112	35.21±15.4	48.42±24
<70mm	46.99		2.16	140.35±15.4	33.56±4.3	137.25±44.2
S1E Bulk <250 mm		3.66	5.00	463.12±95.1	99.74±20.5	192.44±19.3
150-250mm	34.31		3.17	235.12±40.4	54.20±18	46.45±9.3
<70mm	36.38		6.24	123.20±120.4	125.84±17.5	360.62±42.3

Copper

Particle (µm)	Total Cu (in 10 mg)	PBET Cu (% of Total)	Caco2 Cu (% of Total)
150-250	2.26	51.7	7.67
<70	1.61	52.1	10.4
150-250	2.74	57.9	7.32
<70	3.83	56.4	5.59

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Nickel

Particle (µm)	Total Ni (in 10 mg)	PBET Ni (% of Total)	Caco2 Ni (% of Total)
150-250	0.56	27.8	13.4
<70	1.59	7.19	3.21
150-250	0.55	19.6	28.3
<70	3.92	3.66	1.33

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Lead

Particle (µm)	Total Pb (in 10 mg)	PBET Pb (% of Total)	Caco2 (% of Total)
150-250	0.41	26.7	17.4
<70	0.39	20.8	16.5
150-250	0.64	24.3	7.2
<70	1.37	8.59	4.94

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Conclusions

- Cu “bioaccessibility” might be more “homeostasis” – need greater variety of Cu concentrations to test
- Ni and Pb “bioaccessibility” decreases as concentration increases – is this saturation of the extraction or mineralogical differences?

Next Experiments

- Particle size fractions undergoing SEM for mineralogical characterization
- Sequential acid extraction method to confirm mineralogy
- In vivo feeding study using rats

How does this project meet the network goals?

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