Influence of Traffic Volume on the Distribution of Metals and PAHs in Soils and Plants along Roadways in Victoria, Canada

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Introduction

Background

Vehicles can potentially emit metals such as zinc (Zn), copper (Cu), lead (Pb), and cadmium (Cd) and organic pollutants including benzene, and polycyclic aromatic hydrocarbons (PAHs) (e.g., naphthalene, acenaphthylene, and anthracene) into the environment. Continuous deposition of these contaminants in a roadside environment can potentially impact plants and the surrounding ecosystems with the consumption of impacted plants such as blackberries adversely affecting both humans and animal health. The accumulation of contaminants in soils can destroy useful organisms and the natural ecological structure as well as biochemical processes ultimately resulting in adverse impacts on sustainable ecosystems.

Objective

- Determine the concentrations of metals and organic contaminants in soil, plant, and fruit samples collected from roadsides in residential areas and along the two major highways of Greater Victoria.

Research Questions

- What are the concentrations of metals and organic contaminants in soil, plant, and fruit samples from residential areas and the two major highways of Greater Victoria?
- Are the concentrations of contaminants in highway roadside samples significantly different from concentrations in residential areas?
- Does traffic volume influence contaminant concentrations in roadside soil and plants?

Research Approach

- Collect roadside soil samples along the two major highways and major residential areas of Victoria.
- Collect blackberry plant samples since they are most common plants along the highways.
- Analyze soil and plant samples for metals, PAHs and BTEX.
- Compare the concentration of contaminants between highways and residential area samples.
- Establish the relationship between contaminants in soil and plant samples.
- Examine the relationship between contaminant concentrations and traffic density.


Highway 1 (S-2)


Soil sampling


Blackberry sampling

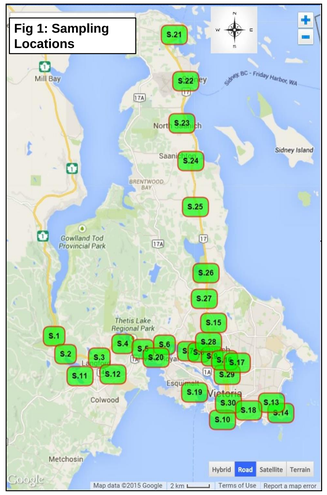

Blackberries

Methodology

Field Program

- Ten locations each were selected from Highway 1, Highway 17 and Residential Areas of Greater Victoria (Fig. 1).
- A composite soil samples was taken from the surface layer (0-10 cm) from both sides of the road at each location.
- About 40 healthy blackberry plant leaves obtained from different plants at each location
- Fruit samples from more than one blackberry plant collected at 10 locations.

Fig 1: Sampling Locations



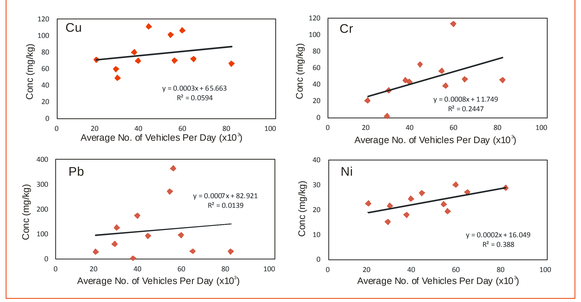
Traffic Data

- Traffic volume data was obtained from the BC Ministry of Transportation and Infrastructure.
- Data consisted of the average number of vehicles per day at specific locations closest to sampling sites

Analytical Program

- Soil pH was determined in water.
- Cd, As, Pb, & Sb were analyzed by GFAAS.
- Hg was analyzed by flow injection-cold vapor analysis.
- All other metals were analyzed by ICP-OES.
- Benzene, toluene, ethylbenzene and xylenes (BTEX) and PAHs were analyzed by GC/MS.
- QA/QC included the use of replicates, surrogate spikes and standard reference materials.

Fig 5. Relationship between Cu, Cr, Pb and Ni Concentrations and Traffic Count



Results

Metals in Soil Samples

- Cu, Cr, Pb, Sn and Zn concentrations in some highways samples and one residential area exceeded the CCME soil quality guideline for residential/parkland use (SQG R/P)[1].
- Metals related to motor emissions (Cd, Pb, Cr, Cu, Zn, Fe, & Sn) were significantly higher in the highway samples compared to the residential area samples (Figs. 2-4).
- Pb exceeded the CCME SQG R/P at four sites along Highway 1 (S-7, S-8, S-9, S-10) and three sites along Highway 17 (S-25, S-27, S-30): all these seven sites were high traffic areas.
- Metal concentrations increase with traffic volume (Fig 5).

Fig 2: Copper Distribution in Soil Samples

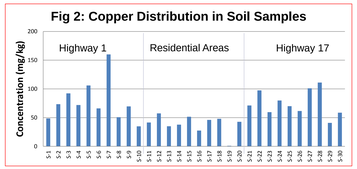


Fig 3: Lead Distribution in Soil Samples

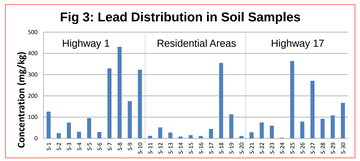
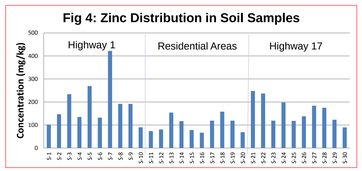


Fig 4: Zinc Distribution in Soil Samples



- Metal concentrations generally increased with decreasing pH.
- Pb, Zn and Cu in roadside soils higher than Victoria background levels but in the range of other cities (Table 1).

Table 1: Comparison of Average Metal Concentrations (mg/kg) between Victoria and other Cities

City	Cr	Cu	Cd	Ni	Pb	Zn
Victoria	41	64	1.08	24.5	118	153
Victoria, background[2]	53	45	0.17	37	18	123
Auckland, New zealand[3]	2.2	80	200	105	2200	Cr
Nevada, Spain[4]	1.8	4.7	3.1	2	11	7.6
Werri, Nigeria[5]	11	N/A	323	10.5	250	446
Hongkong[6]	3.7	N/A	173	N/A	181	1450
Deli Rd., China[7]	0.88	43	45	79	52	103

PAHs and BTEX in Soils

- BTEX below detection in all the samples.
- PAHs such as naphthalene, phenanthrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, and benzo(g,h,i)perylene in some samples exceeded the CCME SQGs R/P.
- Site S-21, the closest sampling location to the Swartz Bay Ferry terminal had the highest PAH concentrations.
- No significant differences in PAHs between residential areas and highways.

Results cont.

Plant Samples

- PAHs and BTEX in fruits samples were below detection limit
- Metal concentrations were higher in highways blackberry leaves compared to residential area plants (Table 2 & Fig 6).

Table 2: Mean Metal Concentrations (mg/kg) in Blackberry Leaves

Sites	Cd	Cr	Cu	Pb	Sn	Zn
Highway 1	0.04	0.89	6.16	0.46	2.23	40.4
Residential Areas	0.01	0.6	4.3	0.34	2.05	25.6
Highway 17	0.02	1.12	6.23	0.84	2.99	34.3

- Weak positive correlation between metal concentrations in soils and plants (Fig 7).
- The mobilization of contaminants from soil to pants and fruits very low - no evidence of bioaccumulation

Fig 6: Mean Metal Concentrations in Blackberry Leaves

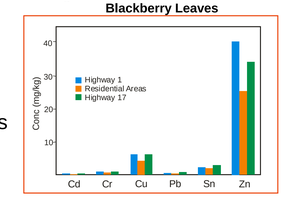
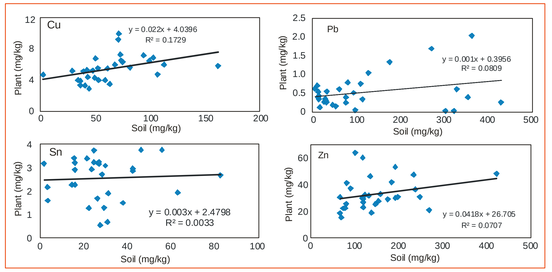


Fig 7: Relationship between Metal Concentrations in Blackberry Leaves and Soil



Conclusions

- Traffic volume influences the concentrations of metals and PAHs in roadside soils in Victoria.
- Roadside plants prevent the mobilization of metals and other contaminants into the environment.
- The human health risk associated with metals, PAHs and BTEX in blackberry plants at the sampling locations along the two highways and residential areas is deemed low based on the data from this investigation.

References

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