The Berries are Safe to Eat!

Results of the 2001 study of arsenic in plants collected from Montana Mountain

A non-technical summary

Presented to the Carcross/Tagish First Nation

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October 2002

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Table of Contents

List of Tables

List of Figures

List of Appendices

The Berries are Safe to Eat

Results of the 2001 study of arsenic in plants collected from Montana Mountain

Why is this study important?

The Venus Mine tailings and the Arctic Gold and Silver tailings are situated on Montana Mountain, south of Carcross in the Yukon. Both mining properties are located in the traditional territory of the Carcross/Tagish First Nation (CTFN), who still actively hunt and gather in this area. The mines operated at a time when proper environmental management was not required. Tailings produced during this period were not properly stored, and before recent clean-up programs took place, they affected the surrounding environment. At both the Venus and Arctic Gold and Silver sites, windblown tailings accumulated on nearby shrubs such that the Carcross/Tagish First Nation was warned away from certain traditional berry-picking areas. The problem had to do with the high arsenic levels in the tailings. The tailings have now been capped, and recent questions have been raised about whether people can return to picking at these sites. This led to the current study looking at arsenic concentrations in berries from both tailing sites in order to see how arsenic concentrations have changed since the caps were constructed.

What is the study trying to do?

- To help see if berries gathered around the mine sites are safe to eat
- To look at trends of arsenic levels in soil and berries over space and time
- To determine the form of arsenic most commonly found in soil and in different plant species
- To find out which plants are important to the Carcross/Tagish First Nation and why they are important

Introduction to arsenic

Arsenic is an element that is found naturally in water, air, rocks, and soils. It can be released into the environment when wind and water act naturally on soils and rocks to erode them, as well as from human-made sources such as sewage, herbicides, mining, and

burning fossil fuels such as coal. Arsenic is not an essential nutrient for plants or humans. It can enter plants through the leaves, but the more common pathway is through the roots. Because one form of arsenic (arsenate) is chemically similar to an important nutrient (phosphate) that is needed by plants to grow, the plant can be "tricked" into believing it is taking in the nutrient when it is really taking in arsenate. The form of arsenic is important to know, as certain forms are more toxic than others. For example, "inorganic arsenic" (the kind typically found in soils or water) is more toxic than "organic arsenic", which is usually found in seafood or mushrooms. The word "organic" is used because the arsenic element is attached to a carbon element; inorganic arsenic compounds have no carbon in them.

Arsenic concentrations in plants are generally much lower than concentrations of arsenic in soil. For example, plants growing on uncontaminated sites usually have arsenic levels less than 0.2 ppm[1] (see note at bottom) (Cullen and Reimer, 1989) while typical soil concentrations range from <1 to 95 ppm (Kabata-Pendias and Pendias, 2001). An exception to this statement is a plant called brake fern (*Pteris vittata*) – researchers recently discovered the concentration of arsenic in the fern could be 200 times (!) that of the soil it was growing in (Ma *et al.*,[2] 2001).

Plants deal with high soil arsenic concentrations in different ways. For example, once the arsenic is inside the plant, it can be attached to another chemical so that it is not free to do any damage. Or it can be stored in the leaves, so that when the leaves fall off, the arsenic is not in the plant anymore. Clearly, some plants (such as brake fern) are better than others for being able to tolerate the element. A plant that does not deal well with high arsenic concentrations will show changes in colour, stunted growth, tissue death, and will bring in fewer nutrients or water (NRC, 1977).

Arsenic enters the human body on a daily basis. It is brought in through the water we drink, food we eat, air we breathe, cigarettes, and even soil/dirt particles. Most of the arsenic entering the human body is non-toxic and quickly removed by urine. When the more toxic (inorganic) form is taken in, the body can detoxify ~40-80% of it (NRC, 1999). The remaining arsenic is stored in the body, particularly in the skin, bone, and muscle (FPSDW, 1996). The hair, skin, lungs, and nails are the parts where the element is stored the longest (NRC, 1999).

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[1] Concentrations are often written in "ppm" which means "parts per million". In everyday language, 1 ppm equals 1 drop of food dye in an Olympic sized swimming pool filled with water.

Because certain forms of arsenic can cause cancer, government organizations have studied arsenic for a number of years and have set some guideline levels for concentrations of arsenic. For example, Health Canada has set a "tolerable daily intake" (an amount of arsenic that is safe to eat every day for the rest of a person's life): 2.0 micrograms/kilogram of body weight/day (Lo, personal communication, 2002). This value is multiplied by a person's body weight, so that it can account for increases in weight as people get older.

No contamination guidelines have been set for plants – their unique response to arsenic would make this a very difficult task. However, soil quality guidelines have been set by several organizations for inorganic arsenic. The Canadian Council of Ministers of the Environment suggests that soil levels be less than 50 ppm (CCME, 2001). According to the Yukon Contaminated Sites Regulation (CSR), the soil concentration that is toxic to plants is 150 ppm (Department of Renewable Resources, 1996). Both of these guidelines are general values that do not apply to all sites and every situation - the organizations realize that some uncontaminated areas have natural arsenic levels higher than these values, and the vegetation growing there is healthy. For example, Yukon soils are often high in arsenic, particularly if the type of rock underneath is arsenopyrite (such as with Montana Mountain).

Past studies of arsenic in vegetation at the two study sites

The Venus Mine site had been mined for close to a century and in 1995, its tailings were capped. The total arsenic content of raspberries was examined before and after the cap was in place.

In 1983, raspberries were picked from two sites at the Venus tailings site and on impulse, sent for analysis (Cruikshank, personal communication, 2001). The fresh berries showed 4.7 ppm and 15 ppm arsenic content, while a sample of preserved jam picked 1.5 km away had <0.20 ppm (results from a Whitehorse newspaper article mentioned in Godin and Osler (1985)). Further testing of vegetation, water, and sediments by the Environmental Protection Service revealed one of five sites with consistent contamination (2.3 to 40 ppm); sand was visible on all samples with elevated arsenic (Godin and Osler, 1985). Signs were put up to warn berry pickers away from the area due to high arsenic levels, and clinics were set up to test hair and fingernails for arsenic exposure in local

[2] "*et al.*" is a Latin term that means "and others". See the end of the report under "References" for information about the research done by these and other authors referred to in this report.

residents - the results of which were negative (Godin and Osler, 1985). In 1984, a thorough study of the vegetation, water, and soil in the vicinity of the Venus tailings was done (Godin and Osler, 1985). The results of the vegetation survey suggested that windblown contamination by sand and dust was happening. Non-rinsed raspberries had significantly greater arsenic concentrations than rinsed raspberries at the two sample sites around the tailings pond (36.6 versus 9.6 ppm, and 93.3 versus 33.3 ppm). Rosehips and gooseberries collected at these same sites also had higher concentrations, as did the leaves of raspberry, rosehip, and gooseberries shrubs. 1984 soil data showed high total arsenic levels that ranged from 7000 ppm to 83000 ppm for samples taken from a field north (downwind) of the tailings pond, and 30 ppm to 45000 ppm for samples collected near the opening of a drainage culvert located 20 m southeast of the tailings pond.

After the cap was installed, raspberries sampled at the Venus tailings showed a decrease in arsenic levels. Samples collected in 1995 had an average wet weight concentration of 134.5 ppm (Roach, 1995), while a 2001 sample was 0.1 ppm (Roach, personal communication, 2002).

The Arctic Gold and Silver mill and tailings site operated between 1967 and 1969. In 1999, vegetation was collected from the site and analysed for arsenic (Roach and Cunningham, 2000). They found that samples collected in the drainage area in between the tailings and the beaver pond had high total arsenic concentrations for willow (43.9 ppm) and sedge grass (4.3 ppm), while bearberry had only 0.6 ppm. Samples collected nearby (off-site along Tank Creek) had the following total arsenic results: willow (1.95 ppm), sedge (4.56 ppm), bearberry (0.3 ppm), alder (2.5 ppm), and raspberry (4.6 ppm). Due to the arsenic being mostly in inorganic form, local residents were recommended to avoid picking raspberries. The Arctic Gold and Silver tailings were capped in 2000.

How was the current study done?

In summer 2001, some Carcross and Tagish residents were interviewed to find out which plants were important to study, and why they were important. Interview comments about the species chosen for analysis in this study and ways of preparing plant medicine are provided later on; comments are combined with information found in books and articles. Many more plants were mentioned than the number that could be analysed during this study, for example: birch, caribou horn, sage, Labrador tea, blackberries, rosehips,

gooseberries, balsam, and others. Some of these were available in certain locations around the tailing sites, and therefore collected. However, they had to be left out of the final analysis because of A) budget constraints or B) there were not enough samples collected to run a statistical analysis on them. The type of berry eventually chosen for analysis at the study sites was one that was repeatedly mentioned by community members, commonly found in the study area, and available (ripe) during July/August. A list showing the total number of berry samples collected at each site is shown in Table 1.

Table 1. Plants analysed from the Venus Mine tailings study area and the Arctic Gold and Silver study area during 2001.

Type of Plant	Tissue Type	Arctic Gold and Silver	Venus Mine
Soapberries (*Shepherdia canadensis*)	Berry	10	0
Raspberries (*Rubus acaulis*)	Berry	0	12
Soil	N/A	10	9
Total		**20**	**21**

Sampling took place around the capped tailings, sites 1-3 km away, and background sites where the influence of mining was thought to be low or not present (see Figure 1). Plant samples were placed in Ziploc bags, and soil samples[3] were collected from a 10 cm depth using plastic scoops and bags. A photograph of the sampling site was then taken and the geographical location was recorded using a Global Positioning System unit. Samples were stored and shipped frozen until they were analysed by Enviro-test Laboratories in Edmonton, Alberta. This laboratory was chosen because they had analysed forms of arsenic in plant tissue collected at both sites in earlier years. Enviro-test Laboratories found total arsenic by using an Inductively Coupled Plasma Mass Spectrometry (ICP-MS) instrument that was able to detect arsenic at levels down to 0.05 ppm for plants, and 0.1 ppm for soils. They used hydride generation Atomic Absorption Spectroscopy (AAS) to find inorganic arsenic concentrations, and then calculated organic arsenic by subtracting the inorganic values from the total.

[3] Soil was collected in order to compare the amount of arsenic in plants to the amount of arsenic in the soil underneath

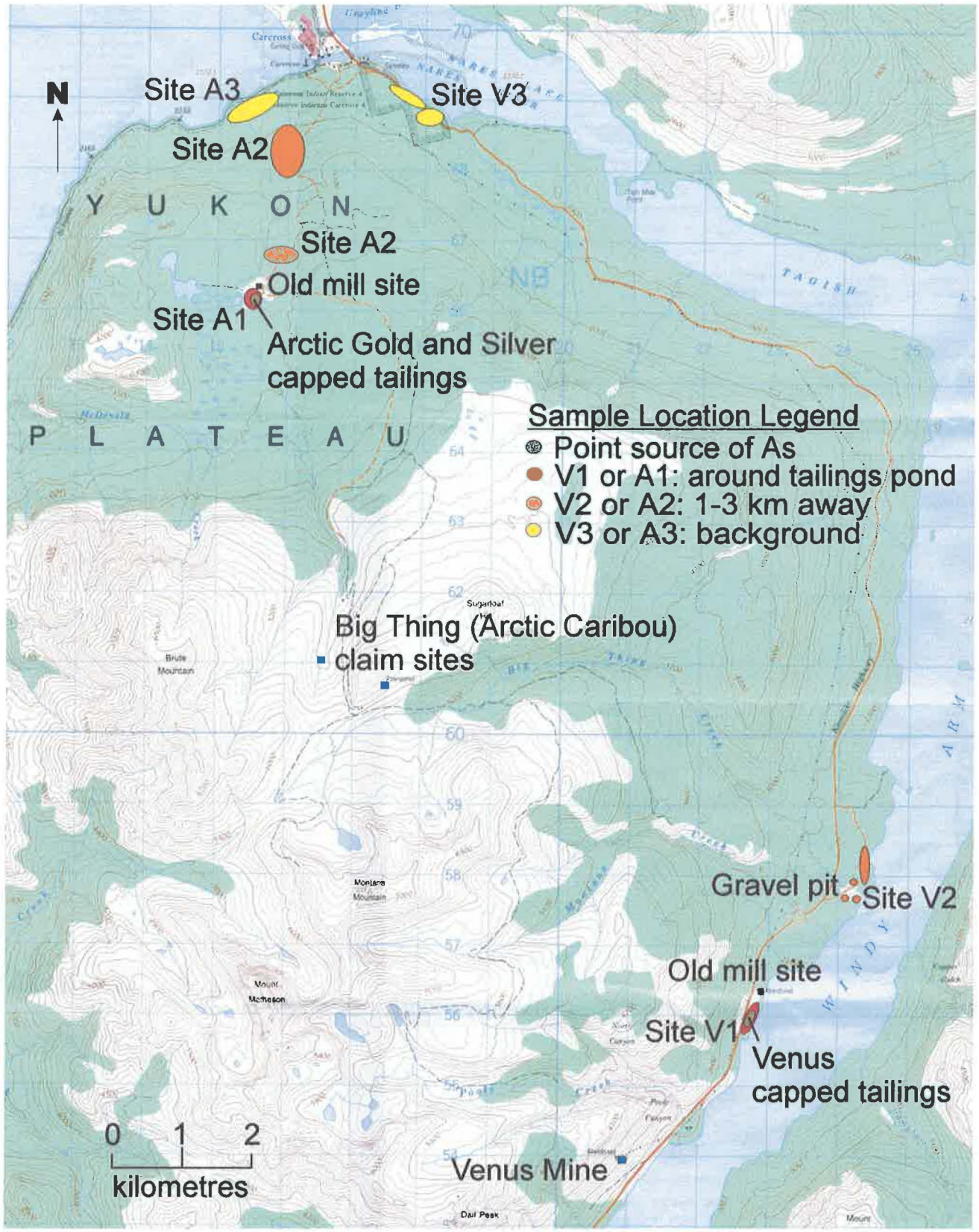

Figure 1. Map of the sampling locations for the 2001 study.

Descriptions of Some Important Local Plants

The following section describes the two berries analysed during this study, plus several other important plants. Descriptions include identifying where the vegetation is found, any unusual chemicals found in the plant, plus any food and medicinal uses. Though berries are most often used for food (as raw fruit, preserved, and in jam, muffins, and cookies), the shrubs also have medicinal uses. Yukon interviewees are identified using the numbers A1 to A8. A table showing the scientific, Tlingit, Tagish, and common names of some local plants is found in Appendix 1. Nutritional information about the plants can be seen in Appendix 2 and some useful definitions are listed in Appendix 3.

Soapberry – food, medicine, soap.

Shepherdia canadensis is a shrub whose bright red berries are dotted with gold. It usually grows 1-2 m in the south (60 cm further north), and is found in open dry spruce stands, along rivers, and on alpine slopes (Cody, 2000; Andre and Fehr, 2001).

Kershaw (2000) mentions the berries are a source of vitamin C and iron, though was not indicated by nutrient tables listed in either Kuhnlein and Turner (1991) or Medical Services Branch (1994). Berries also contain saponin, which acts like a detergent when the berries are stirred. Consuming too many berries can cause diarrhea, vomiting, and cramps as this substance irritates the stomach (Kershaw, 2000; Marles *et al.*, 2000).

Willard (1992) writes that the bitter flavour of the soapberry is improved if berries are picked after the first frost and by adding other ingredients. When combined with sugar and water and whipped, a frothy "ice cream" dessert is created. A6 mentions a typical ratio might be a "heaping tablespoon of berries, 4 tablespoons of water, and 1 tablespoon of sugar", and warns that the "mixture will not rise if there is any butter or oil on the beater or bowl". In Tlingit culture, soapberries were the most celebrated type of berries produced at a feast, and the whipped dessert was served last (Thornton, 1999). Soapberries are most popular eaten as ice cream (A3, A4). They are also eaten with bannock (A4), and by mixing with grease (A2) and salmon eggs (A2, A4). A source suggests that one should pick only a few berries because there are not very many – they can be kept for Christmas and used as a delicacy (A4).

Boiled juice is good for ulcers (A1, A3, A4), for washing out the stomach (A1), and for constipation (Kershaw, 2000). A mixture of soapberry juice, sugar and water is used for

acne, boils, digestion problems, and gallstones (Turner, 1997). Stems are boiled and drunk for a laxative (Kershaw, 2000). The tea also can help prevent miscarriages, treat tuberculosis and venereal disease, or be used as a wash for cuts and swellings (Marles *et al.*, 2000). Bark tea aids problems with eyes (Kershaw, 2000). A tea made from stems and roots is said to relieve stomach pains and diarrhea, while raw berries or berry tea is recommended for colds or sore throats (Andre and Fehr, 2001). Berries can improve flu and indigestion conditions; crushed or boiled, the raw berries can also be used as soap (Kershaw, 2000). One source mentioned the berries were a good medicine; a diabetic woman ate them and her blood sugar was level for a week (A6).

Raspberry – food, medicine

Rubus acaulis (dwarf raspberry/nagoonberry) and *Rubus idaeus* (wild red raspberry/tall raspberry) are common in the Yukon. *R. acaulis* is a low-growing shrub (> 30 cm) that is found in shaded wooded regions surrounding lakes (Andre and Fehr, 2001). *R. idaeus* is found in disturbed sites such as alongside roads, and open woodland clearings - they are usually less than 1.5 m high (Cody, 2000).

Raspberry leaves contain fragarine, which acts to both relax and stimulate the uterus wall muscles (Kershaw, 2000). Leaves also contain tannins, flavonoids and vitamin C (Marles *et al.*, 2000). The berries are mildly laxative (Willard, 1992).

Berries are eaten raw, and used for making raspberry jams and jellies. Flowers can be added to salads, and peeled shoots are also consumed (Willard, 1992).

Berries are good for nerves, while roots can be powdered to make into a tea for arthritis (A5). Leaves and stalks are used for treating burns (A3). Raspberry stems and roots are boiled and drunk to treat diarrhea and fevers, gargled for sore throats, or used as an astringent/wash for wounds (Viereck, 1985; Marles *et al.*, 2000). Raspberry leaf tea is also given to pregnant women for nausea and menstruating women who have cramps or high flows (Willard, 1992; Kershaw, 2000).

Blackberry – food, medicine

Empetrum nigrum grows in moist, mossy regions on the forest floor, in swamps, heathlands, and on tundra (Cody, 2000). The plants are generally less than 15 cm (Andre and Fehr, 2001).

These black berries are eaten raw, used for jam (A6), or fried with grease and placed in a jar with bannock (A3). Their flavour is improved if berries are picked after the first frost and by adding other ingredients such as lemon and sugar (Willard, 1992). One can get constipated if too many are eaten (A1).

Blackberry shoots are boiled and drunk to improve diarrhea, colds, kidney problems, and tuberculosis, while the roots or berries can be boiled and used to treat sore eyes (Viereck, 1987; Willard, 1992). A tea from berries, stems, and roots treats stomach-aches (Andre and Fehr, 2001). Shoots can be chewed or applied to skin to treat fevers (Marles *et al.*, 2000).

Blueberry – food, medicine

Types of blueberries found in the Yukon include the abundant *Vaccinium uliginosum* (bog blue/bilberry), and *V. caespitosum* (dwarf blue/bilberry) and *V. ovalifolium* (oval-leaf blue/huckleberry) which are found only in the south. *V. uliginosum* is typically 20-60 cm tall, and grows in wet acidic areas such as swamps and muskegs, as well as in woodlands, heath, and on alpine slopes (Cody, 2000). *V. caespitosum* grows to ~20 cm, and is found in alpine and subalpine areas as well as meadows while *V. ovalifolium* is 20-100 cm high, and grows on subalpine slopes (Cody, 2000).

The berries contain vitamin C. Blueberry leaves contain tannins, flavonoids, alkaloids, and iridoids (Marles *et al.*, 2000).

Blueberries are eaten raw or used for jam (A3).

Eating berries improves acne, while consuming syrup can treat vomiting (Marles *et al.*, 2000). Leaves and roots are both boiled and drunk to treat diarrhea: leaf tea (and dried berries) are also taken for urinary tract infections, and the tea is used by some diabetics to moderate sugar levels (Kershaw, 2000). Stems are boiled and drunk to help prevent pregnancy (Marles *et al.*, 2000) while stems and leaf tea is drunk to improve colds (Andre and Fehr, 2001). Root tea is gargled for sore throats, or used to treat sores (Kershaw, 2000).

Cranberry – food, medicine

Vaccinium vitis-idaea (lowbush cranberry) is a shrub that resembles *Arctostaphylos uva-ursi* (bearberry, stoneberry, or kinnikinnick). They can be told apart by looking for small black spots on the underside of the cranberry leaves (Brown, personal communication,

2001), or by opening up a berry to see if has a seed and the characteristic whitish flesh of a bearberry (Hargrave, 1997). Growing in bogs and other open acidic areas, the shrubs are usually only 5 – 20 cm tall (Cody, 2000).

Lowbush cranberry leaves and berries contain arbutin, a substance that prevents certain bacteria from sticking to bladder and urinary tract walls such that an infection is caused (Kershaw, 2000; Marles *et al.*, 2000). The berries also contain benzoic acid therefore keep well in storage (Willard, 1992). Diarrhea can occur after eating large amounts of berries (Kershaw, 2000).

Eaten raw, the berries are best picked in autumn after the first frost. Cranberry jam is sometimes made: berries are added to flour and sugar and then boiled (A3).

Berries are boiled and the juice is saved (A1). Cranberry juice is used for kidney problems, colds, stimulating the appetite, reducing heartburn, and as a dye (Willard, 1992; Andre and Fehr, 2001). A crushed or boiled cranberry mash can be used as a poultice (i.e. for measles rash), and the berries are eaten for nausea, sore throats, cramps, childbirth pains, and convulsions (Kershaw, 2000; Viereck, 1987). Cranberry leaf tea is a general tonic (Viereck, 1987). Oily skin and hair can be treated using a rinse (Willard, 1992). A tea made from boiled roots and stems is used for bladder problems (Marles *et al.*, 2000).

Labrador tea - medicine

Ledum groenlandicum (common Labrador tea, also known as *L. palustre* spp. *groenlandicum*) and *L. palustre* (northern or marsh Labrador tea, also known as *L. palustre* spp. *decumbens*) are the two types of Labrador tea found in the Yukon. *L. palustre* is found in dwarf shrub and moss-lichen heaths, and grows to 50 cm, while *L. groenlandicum* is common in peatlands, bogs, and meadow with a typical growth of 30-60 cm (Cody, 2000). Both species have leaves that are green on top, and fuzzy orange underneath.

Labrador tea contains toxins (ledol), and narcotic compounds (Kershaw, 2000). Leaves contain tannins, flavonoids, volatile oils, and small amounts of poisonous andromedotoxin (Marles *et al.*, 2000). For this reason, Kuhnlein and Turner (1991) recommend that the plant be consumed infrequently, and in dilute tea form.

Labrador tea is drunk daily as a tonic, and has many more medicinal uses than those mentioned here. Shoots are boiled, stored in a jar in the fridge, and drunk as a tea (A3), served hot or cold. The liquid is good for heart attacks and the stomach (A2), chest pain, bad colds, and for washing faces with (to improve acne) (A4). Marles *et al.* (2000)

mentions that leaves have been put on wounds, chewed to treat flu, diarrhea, and bad breath, and powdered to treat burns. Despite treating diarrhea, Labrador tea is a slight laxative (Viereck, 1987). It makes one relax when one is depressed. This source called it a "sleeping pill, though the flowers are no good; just the leaves are used" (A4). The tea can also treat alcoholism: shrubs are picked, boiled for 1 hour, put in a jar, and drunk tea four to five times per day – "no alcohol from then on" (A2). Willard (1992) mentions that Labrador tea has been used to wash out lice, treat insect bites, and repel insects.

Bolete "orange capped" mushroom – food, medicine

Leccinum insigne (aspen scaber stalk), *L. aurantiacum* (orange birch bolete or red-capped scaber stalk), and *L. scabrum* (birch bolete or common scaber stalk) are three members of the Bolete family of mushrooms found in the Yukon. All three can be misidentified due to their similar appearance: *L. insigne* has a reddish to orange-brown cap and grows under aspen or mixed aspen and birch stands, *L. aurantiacum* has an orange-red cap and grows under coniferous and deciduous trees, and *L. scabrum* has a brown cap and is found under birch trees (Lincoff, 1981). All have black scales on their white stalks and the undersides of the caps have spongy pore surfaces rather than gills (Parker, 1994).

Nutrition information specific to this family was not available, but Kuhnlein and Turner (1991) write that mushrooms generally have high moisture content, few vitamins, and minor levels of carbohydrates, fibre, protein, and lipids. One can get diarrhea from eating too many Bolete mushrooms (A3).

Bolete stems are typically eaten and the cap discarded, though the latter is consumed if no maggots are present. Mushrooms are picked whenever it rains. They are then cut up and placed in the freezer or dried - a delicacy for elders. Added to fish soup, fish chowder, or frying onions (A4), mushrooms are eaten raw, roasted, or fried. They can also be rolled around in the campfire to blacken. The black part is then removed and the remainder eaten (A2). These "orange tops" have been used to make mushroom soup to entice anorexics to eat (A4). They are also eaten by moose (A3) and bears (A8).

Caribou moss – animal fodder, medicine, soup thickener

Caribou moss is found in wet and dry coniferous forests, and in peatlands. These plants are lichens that form clumped mats, often in late snow-melt regions (Andre and Fehr, 2001). Plants most often identified as caribou moss (or "reindeer lichen") include the yellow

kind (*Cladina mitis*), and the grey/green kind (*Cladina rangiferina*), though many other *Cladonia* and *Cetraria* species have the characteristic branchlets (Vitt *et al.*, 1988)

These lichens contain polysaccharides, proteins, and acids that may cause stomach upsets if not cooked well (Kuhnlein and Turner, 1991). Some people are sensitive to usnic acid, which may cause lichen dermatitis – seen as red, itchy skin (Kershaw, 2000).

Partially digested lichens from the caribou stomach were once mixed with a variety of other plants and eaten (Kuhnlein and Turner, 1991). They are still regularly eaten by grouse, ptarmigan, gopher, caribou, porcupine, and buffalo (A1). They are also eaten by bears, birds, mice, and dogs (A4).

The plant is boiled and fluid drunk for medicinal purposes - any bad disease can be cured (A4). Drinking either the tea or dried and powdered lichen soaked in water can help treat intestinal worms (Marles *et al.*, 2000). The tea also relieves stomach and chest pains, and is drunk to maintain energy, while lichen itself can be eaten fried, after being boiled twice and strained, or dried and added to soup as a thickener (Andre and Fehr, 2001). Tea made from grey reindeer lichen (as opposed to green reindeer lichen) is taken for fevers, diarrhea, jaundice, tuberculosis, and convulsions (Kershaw, 2000).

Willow – medicine, tools, animal fodder, and fuel

Salix species are common in Yukon's wet muskeg areas, on floodplains and alongside creeks, and in well-drained open birch, aspen, and spruce stands (Cody, 2000). Their height ranges from growing along the ground to up to 7 m tall (Andre and Fehr, 2001). There are 34 known species of *Salix* in the Yukon; the most abundant of which include *S. arbusculoides*, *S. arctica* (dwarf willow), *S. glauca* (blue-green willow), *S. myrtillifolia, S. planifolia*, and *S. reticulata* (net-veined willow) (Cody, 2000).

Willow bark contains flavonoids, tannins, aldehydes, and salicylates such as salicin (Marles *et al.*, 2000). Some parts of willow have high ascorbic acid content (Kuhnlein and Turner, 1991).

Young shoots of this shrub are food for moose, caribou, and some horses (A4). Bears eat pussy willows, and beavers eat the bark (A6). Moose eat leaves in wintertime (A3); grouse, ptarmigan and moose eat the soft parts of willow (A1).

Willow branches and roots are used for shelter, fuel, and many household items. For example, the plant is used for making baskets, dream catchers, picture frames, lounges for babies, and frames for babies' faces so they are not smothered while sleeping; the

frames are also placed over the mouth to avoid mosquitoes or germs (A4). Other willow items include snowshoes, smokehouses, sweat lodge frames, canoes, nets, rope, and mats (Marles *et al.*, 2000; Andre and Fehr, 2001).

Willow is used for medicinal purposes (A5) and is collected in spring and fall (A4). Used as a substitute for aspirin, willow is a pain remedy for headaches (A4, A5), and is also good for osteoporosis, and arthritis (A4). The bark is peeled off, boiled, and the liquid drunk, though the stem can also be cut off and sucked (A4). Willow can help bee stings: leaves are chewed, balled up and placed on stung area (A2).

Willow leaf tea can be used as a wash for skin infections and willow bark tea is drunk to relieve diarrhea, digestion, rheumatism, and urinary tract infections (Kershaw, 2000). Crushed leaves or peeled roots can treat rashes, cuts, ulcers, and toothaches (Marles *et al.*, 2000; Andre and Fehr, 2001). Kershaw (2000) mentions these conditions (along with ulcers, corns, and cancers) that are improved using bark tea or bark strips. A poultice of powdered bark in cream can be applied externally to treat gangrene (Hutchens, 1991). Tea made from the root helps treat internal bleeding, throat constriction, and venereal disease (Willard, 1992).

Preparation of Plant Medicine

First Nation people (usually older women) follow specific steps for harvesting medicines that have been passed down through generations. The steps have spiritual connections, as shown below in the list of suggestions mentioned by one highly respected Elder (A5) interviewed during summer 2001. Direct quotes are italicized.

- *It is important to always give a gift – my grandma said it doesn't matter what, as long as it is important to you. Beads and silk and tobacco are examples. Tobacco is mostly still used.*
- *Say prayers before you ever pick medicines. If you're picking medicine for someone else, you say who you are picking medicine for, and ask the spirits to help you and ask blessings.*
- *Always pick from plenty – never pick from any place that doesn't have many. Leave some behind.*
- *Have a little on hand. Never stockpile it. It's good to pick it fresh.*

- *Most of plants can be picked just about anytime. Plants growing on the ground - I like to get in summer months. Picking usually based on someone needing it.*
- *For women, it's really important that you're not on moon time* [menstruation] *when picking medicines, as women have ability to give life and at that time, you're very strong. Medicines picked at that time goes into you and are not patient.* [This is] *taboo to do in our culture.* [This isn't an issue when you] *become an Elder and no longer have moon times.*

Clearly, harvesting dates for berries and other seasonal plant parts coincide with the time of year when the plant is ripe. This differs according to shifts in seasonal climate and micro-site conditions, but the following timeframe fits the southern Yukon: currents and strawberries appear in early summer (late June), blueberries, raspberries, and Saskatoon berries are usually picked mid to late summer, and cranberries, blackberries, and rosehips tend to be harvested after the first frost in September (Hargrave, 1997).

Careful steps are also followed when preparing medicine. This is revealed in the following description of preparing tea from the bark of a medicinal tree species (i.e. red alder, balsam, or Jack Pine), as provided by A5.

Pick bark from the north side of the plant because the sun is too hot on the morning side (east). Take a sharp knife and peel 2-3 slices off tree (18"x2" wide) – then you know you don't kill the tree and that it is there for you to use again some other time. Put them in an enamel or Pyrex pot. Put a gallon and a half of water in. Once it comes to full boil, turn the heat down and boil gently for 25-35 min (no longer). Strain as soon as it cools off. Take all of the water out and store it cold. [The medicine is ready to be drunk. If the receiver of the medicine is still sick after one week], *next week, put 1 branch* [slice] *in. Lay under bush when* [the medicine is no longer needed] *and say prayers. Or use a good burning barrel. Never put it in garbage and destroy it like that.*

Another respected Elder had these pieces of advice for knowing when to take and when to stop taking medicine: *take a teaspoon first to see if it* [medicine] *agrees with you. If you take it against your will, it's not going to help you… your body craves it and when it doesn't crave it anymore, that's when it's enough* (A6). This source also pointed out the importance of picking and preparing medicine well: *if you don't treat medicine right, it goes away and doesn't grow there anymore… medicines have to be nice and clean – no dirt… use the same pot* (A6).

Family members and local Elders taught many of the people interviewed for this project about medicines at an early age. Some continue to prepare only the medicines passed down to them, while others communicate with knowledgeable people in other communities to exchange ideas, and occasionally consult books.

What was found?

The following general observations were found (specific results are recorded later):

- The levels of arsenic in berries were low or absent compared to levels found in soil
- The type of arsenic found in berries (Figure 2) and soils (Figure 3) was primarily inorganic
- Smaller amounts of arsenic were found in berries and soils further away from point sources
- Berries had low to undetectable arsenic concentrations

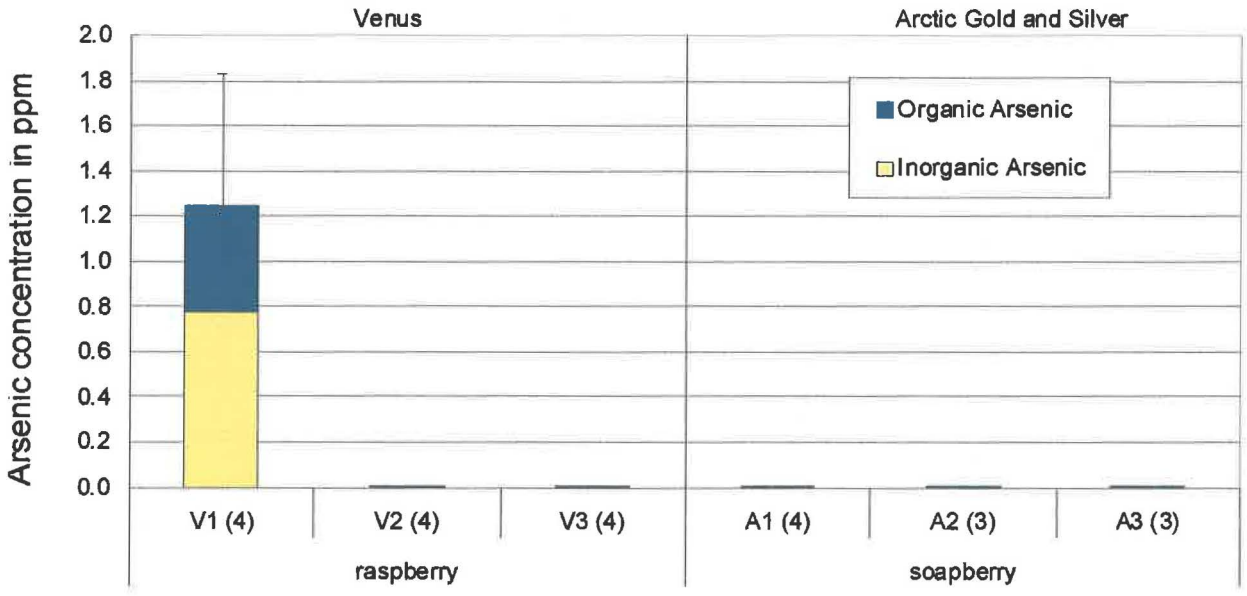

Figure 2. Average arsenic concentrations in berries collected from both sites at each sampling location (1, 2, or 3: increasing distance from point source). Concentrations are given in dry weight. The number of samples is shown in brackets. Bars show the standard error (a measure of how the data varies).

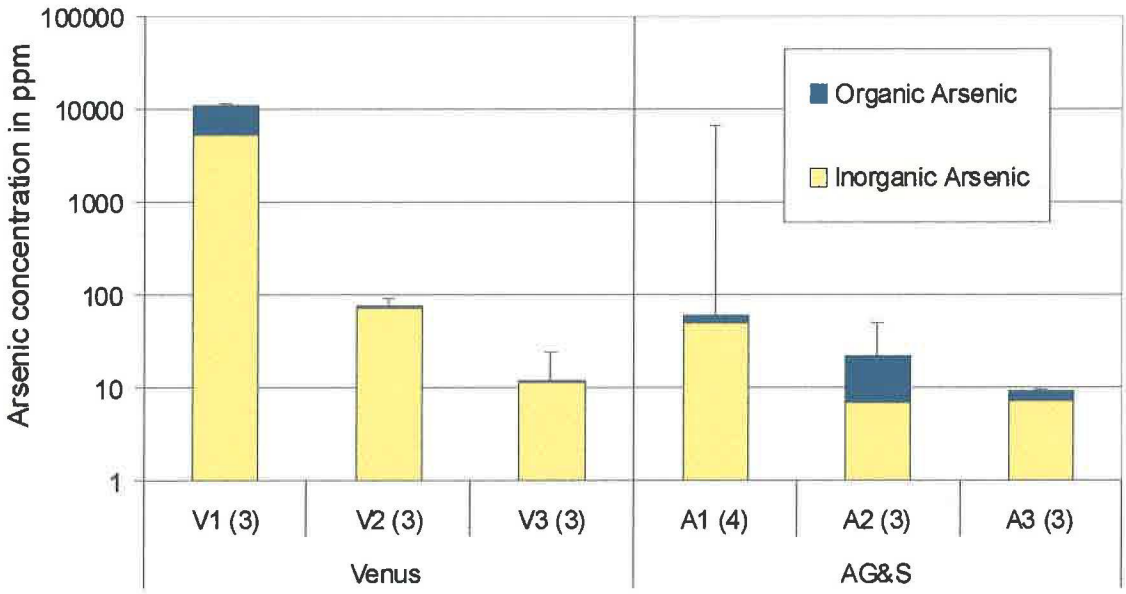

Figure 3. Average arsenic concentrations in soils collected from both sites at each sampling location (1, 2, or 3: increasing distance from point source). Note that the vertical scale is logarithmic (increases in multiples of ten). Concentrations are given in dry weight. The number of samples is shown in brackets. Bars show the standard error.

Specific results are summarized below. When a location is mentioned, use Figure 1 to see the general area where the sample was collected.

Arctic Gold and Silver Property

Soapberries

Arsenic could not be found in any of the nine soapberry samples (see blank values in Figure 2).

Soil

Arsenic concentrations in soil were generally quite low (Figure 3). They ranged from 4.9 ppm (A3) to 83.2 ppm (an A1 site located on a vegetated mound in the east centre of the capped tailings). The average total arsenic concentration for A1 samples collected around the tailings (50.5 ppm) did not exceed the 150 ppm Yukon CSR guideline; the four concentrations were quite similar to one another.

Soil

Venus soil arsenic data ranged from 11.5 ppm (V3) to 23970 ppm (V1), and three of the nine samples were higher than the 150 ppm CSR guideline. The top two soil arsenic concentrations were collected from the same general areas where the two highest raspberry concentrations were sampled: the highest found about 2 m from a stream located at the south end of the cap, and the second-highest (9040 ppm) was collected along the northeast edge of the cap. The third V1 sample was 1109 ppm. These results are much lower than the 1984 results (Figure 4).

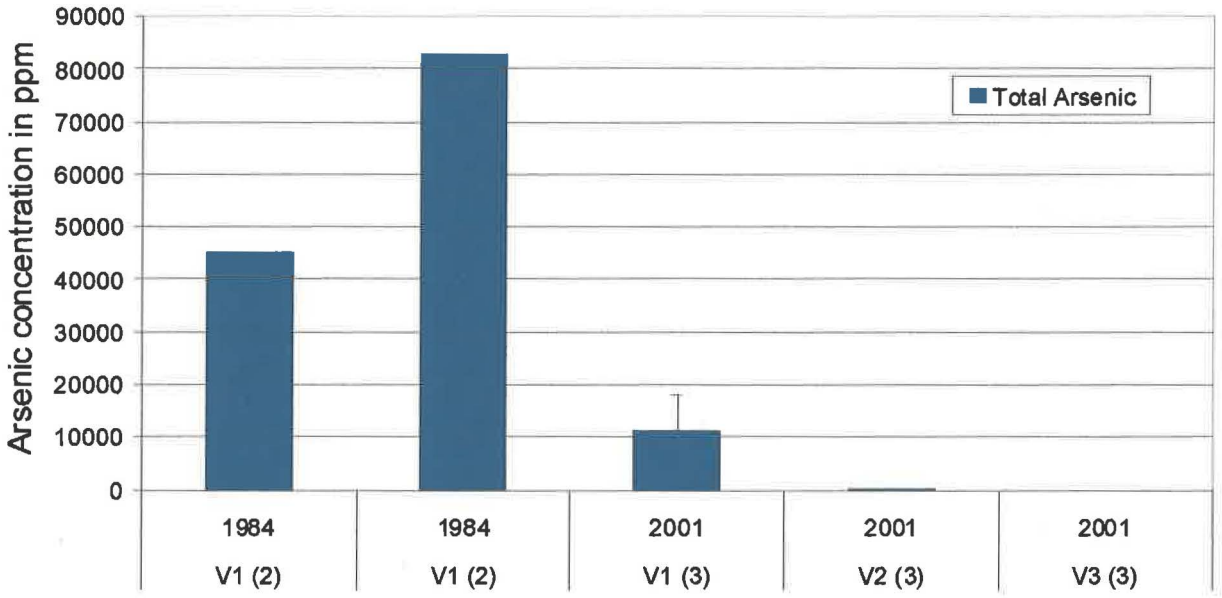

Figure 4. Total arsenic concentrations in soil samples collected from the Venus mine tailings site in 1984 and 2001. Concentrations are given in dry weight. The number of samples is shown in brackets. Bars show the standard error.

Raspberries

Arsenic was not found in raspberries collected from the gravel pit (V2) or from the edge of the highway just south of Carcross (V3). Some arsenic was found in berries sampled around the capped tailings pond. Concentrations of these four samples were low; they ranged from 0.4 ppm to 2.9 ppm, with an average of 1.25 ppm. Of these total concentrations, inorganic arsenic content ranged from 0.4 ppm to 1.2 ppm, with a mean of 0.78 ppm. There is a very noticeable decrease in arsenic levels since the cap was constructed in September 1995 (Figure 5).

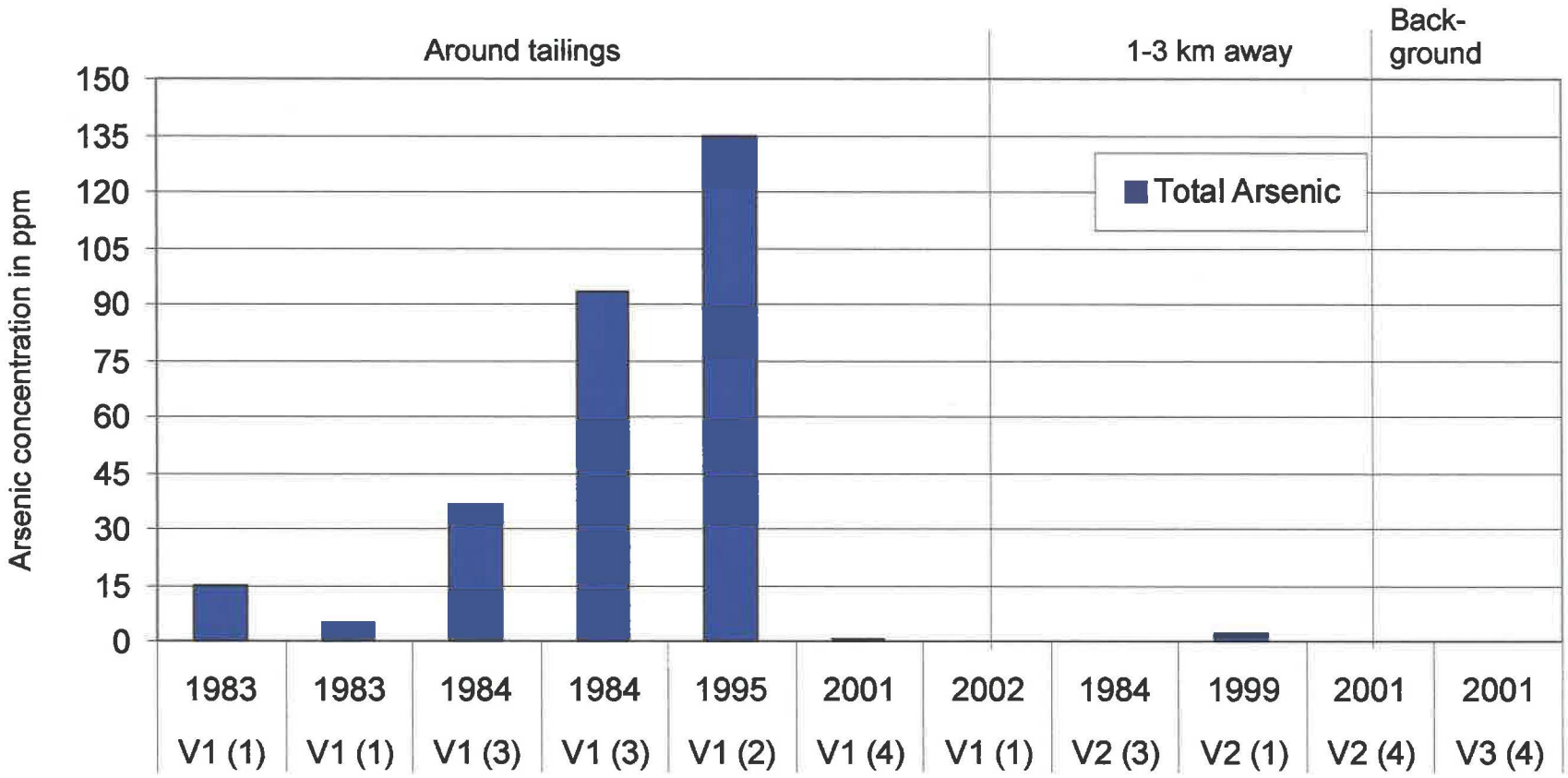

Figure 5. Total arsenic concentrations in raspberry samples collected from the Venus Mine tailings in different years. Some data were only recorded in wet weight so concentrations are reported in wet weight here. The number of samples is shown in brackets.

What do the results mean?

Soapberry data does not exist for the Arctic Gold and Silver property before the tailings were capped. While other berries (bearberry and raspberry) had detectable inorganic arsenic in the 1999 study by Roach and Cunningham (2000), different types of berries cannot be compared like this over time. However, the windblown tailings are no longer the issue they may have been during the 1999 study, suggesting that if there was an impact from dust on local soapberries, it is now not seen.

Although Arctic Gold and Silver soil concentrations exceed the 50 ppm CCME guideline, naturally higher soil arsenic levels are believed to be the major explanation. Montana Mountain bedrock has a lot of arsenic in it, which leads to more arsenic in the soil.

Arsenic concentrations in raspberry samples from the Venus site have decreased by a large amount since the tailings pond was capped. This indicates that the dust problem prior to capping has been reduced.

The high total arsenic concentrations in the three soil samples collected from the Venus tailing site suggest that there are a few locations with arsenic levels higher than the natural soil levels, in spite of the site being on a mountain made of arsenic-rich rock. The wind direction at the Venus site is mostly from the south. The locations with high soil concentrations may be the result of windblown tailings that were not capped in the 1995 capping project, or may be tailings that escaped from the pond many years ago when it had a poor drainage system.

The results are similar to other studies. Arsenic was not found in soapberries or raspberries collected from other Yukon communities in studies carried out by CINE and the Yukon Contaminants Committee in the 1990's (Receveur *et al.*, 1998; Gamberg, 2000).

Recommendations

Based on the low levels of arsenic found in the only plant species (raspberries) analysed at this site, high soil concentrations do not appear to be a concern. Local residents can consider picking berries here once again.

The 2001 data can be converted into safe daily amounts of raspberries, using calculations based on Health Canada guidelines for inorganic arsenic. The conversions are described in two different ways: grams eaten per day (Table 2) and buckets of raspberries

eaten per year. Table 2 shows the calculation details and breakdown of age groups. The chart is based on the mean, minimum, and maximum concentrations of inorganic arsenic found in the four samples collected at the Venus tailings site. Calculations are based on the wet weight concentrations (in ppm) shown in bold.

Table 2. Safe quantities of Venus raspberries (in grams) that can be picked and consumed per day by different age groups (based on Canadian Tolerable Daily Intake guidelines).

Age	Body weight (kg)	TDI (g/d)		
		Mean (wet) **0.17**	Maximum (wet) **0.25**	Minimum (wet) **0.11**
0 to <6 months	7	81.2	56.0	127.3
6 months to <5 years	13	150.7	104.0	236.4
5 to <12 years	27	313.0	216.0	490.9
12 to <20 years	57	660.9	456.0	1036.4
20+ years	70	811.6	560.0	1272.7

The following information converts the above table into a more understandable format. Conversions are based on estimates of a 4L ice cream bucket containing 2.78 kg of raspberries (or 10 cups of fresh raspberries, or 12 jars of 250 mL of raspberry jam).

- Adults can safely eat 106 buckets of raspberries each year
- Teenagers can safely eat 86 buckets of raspberries each year
- Children can safely eat 41 buckets of raspberries each year
- Toddlers can safely eat 19 buckets of raspberries each year
- Babies can safely eat 10 buckets of raspberries each year

It is suggested that raspberries and other plants are periodically sampled to ensure that arsenic concentrations remain low. Willow, soapberries, gooseberries, and black currents were also collected from the same locations during the 2001 field season and are in storage at UBC should further analysis be required.

Since arsenic could not be found in soapberries collected during the 2001 field season, this suggests that these berries are safe to eat, and residents can return to this berry-picking site. No conclusions could be made about other species at this mining property, although a full collection of blackberries, Labrador tea, and willow leaves and stems were also sampled during 2001 and are available for analysis if requested.

Arsenic concentrations in soil from the Arctic Gold and Silver property are of low concern.

Acknowledgements

Many thanks to my two awesome field assistants (Jennifer Joe and Ernest Richards) who worked long hours in beautiful Carcross sunshine in order to get the work done. I'm extremely grateful to Dan Cresswell and Harold Gatensby for their assistance and advice throughout the study, and for taking me on field trips around Carcross. Equally as important are the following people who provided technical assistance: Al Doherty, Mary Gamberg, Brett Hartshorne, Murray Lundberg, William Mann, Doris McLean, Pat Roach, and Dick Stillwell.

Special thanks to Winnie Atlin and Ida Calmegane from the Carcross/Tagish First Nation for their important contributions of plant uses and medicines to this project

Funding support by the organisations listed below is gratefully acknowledged:

- Northern Contaminants Program (DIAND) – Local Contaminants Concerns
- Mining Environment Research Group (Yukon Territory)
- Arctic Institute of North America Grant-in-Aid
- Natural Sciences and Engineering Research Council of Canada
- Northern Scientific Training Program (DIAND)

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Appendix 1. Scientific, Tlingit, Tagish, and common names of some Yukon plant species (from Thornton, 1999; McClellan, 2001). Hopefully blanks can be filled in by the CTFN!

Scientific name Latin	Aboriginal tongue		
	Tagish	Tlingit	English common names
Arctostaphylos Uva-Ursi	djI' djE' łoni	t'Ínx	bearberry, stoneberry, kinnikinick
Cladina and Cetraria spp.			caribou moss, reindeer lichen
Empetrum nigrum	nEn djI' jUR'	xitłi w As'i	blackberry, crowberry, mossberry
Fragaria glauca		tłEtk'i	strawberry, spiderberry, groundberry
Juniperus spp.	tc'ecgE' ^{E} da$^{n'}$ElE	yeł'łEq$^{w'}$ wAs'i	juniper berry, crowberry, crowpaint berry
Leccinum spp.	dlÌRa ji		bolete mushroom, orange top, squirrel grub, squirrel food
Ledum spp.		s'Ixt ciłtin	Labrador tea, Hudson's Bay tea, Trapper's tea, muskeg tea
Lycoperdon spp.		xyetł łEq $^{w'}$, ts'AgEx q'awu łeq$^{w'}$	puffball mushrooms, thunderbird paint, dead people paint
Picea		'As'gox' (pitch)	spruce
Ribes hudsonianum, R. lacustre			black current, bristly black current
Ribes oxyacanthoides			gooseberry
Rosa spp.		q'a^{n} yeł w As'i	rosehips
Rubus acaulis			raspberry, bear kidney, salmon eggs
Rubus chamaemorus	cAc tc'EcI'	t'á qahágu'	salmonberry, cloudberry
Rubus parviflorus		nEx$^{w'}$	thimbleberry
Salix spp.		tcatł da^{i}	willow
Shepherdia Canadensis	cwA ^{x} djI'	xÁqł'i wAs'i	soapberry, soopolallie, mooseberry, Canada buffaloberry
Sphagnum			peat moss, red moss
Vaccinium spp.	nana' dza	łÁx ^{w} łu	blueberry
Vaccinium vitis-idaea		q'Ec qahágu'	lowbush cranberry, lingonberry, mountain cranberry
Viburnum edule		kAx wÉx	highbush cranberry

Appendix 2. Nutritional table for important plant foods and medicines used in the Yukon (from Kuhnlein and Turner (1991) unless indicated). Data based on 100 g fresh (wet) weight. Dashes represent unavailable information.

Scientific name	Common name	Part used	Food energy kcal	Water g	Protein g	Fat g	Carbo-. hydrate g	Crude fiber g	Vit. C mg	Vit. A RE	Ca mg	K mg
Vaccinium ovalifolium	oval-leafed blueberry	berry	49	87	1.1	0.5	11.3	3.3	6.2	1	16	-
Vaccinium uliginosum	bog blueberry	berry	45	88	0.7	0.6	10.6	3.3	-	-	19	-
Vaccinium caespitosum	dwarf blueberry	fruit	-	-	-	-	-	-	15	-	-	-
V. vitis-idaea	lowbush cranberries	fruit	62	82	0.7	0.7	14.9	1.4	21.2	-	13	98
Ledum groenlandicum	common Labrador tea	dry leaves	-	42	4.2	0.7	-	-	98.2	-	215	-
L. decumbens	northern Labrador tea	dry leaves	-	47	4.4	-	8.7	-	13.8	-	-	-
Salix arctica	arctic willow	leaves	-	-	6.9	-	-	-	-	-	170	-
S. reticulata	net veined willow	leaves	-	67	3.8	2	25.9	-	-	-	267	-
Salix species	willow	leaves	-	66	5.1	-	28	3.3	41	1830	268	472
Empetrum nigrum	crowberry	fruit	35	89	0.2	0.7	9.5	5.9	51	-	9	87
Shepherdia canadensis	soapberry	fruit	72	81	1.8	0.7	6.6	1.1	-	-	16	-
Rubus arcticus	dwarf raspberry	berry	-	-	-	-	-	-	38.8	11	-	-
Rubus chamaemorus	cloudberry	berry	50	84	2	1	9.6	6	130	-	17	231
Rubus species	raspberry	berry	49	86	0.9	0.6	11.6	3	25	13	22	152
Rubus idaeus	wild raspberry	fruit	65	83	0.6	0.8	15.8	4.5	22.3	13	36	-
Rubus strigosis	wild raspberry	berry	67	79	1.6	1.1	14.6	-	-	-	47	176
Arctostaphylos uva-ursi	bearberry (stoneberry)	berry	92	75	0.7	1.1	22.4	14.8	-	-	37	-
Fragaria species	wild strawberry	fruit	-	89	0.7	0.6	-	2.1	5.9	8	43	164
Ribes hudsonianum	black current	fruit	-	-	-	-	-	-	41	-	-	-
Ribes lacustre	bristly black current	berry	59	86	1.5	2.3	9.7	3.5	58.2	3	68	-
Ribes oxyacanthoides	gooseberry	berry	58	82	1	0.3	14.6	1.9	-	-	91	613
Rosa acicularis	prickly rose (hips)	fruit	55	65	2.4	0.7	21.3	-	1481	263	-	-
Viburnum edule	highbush cranberry	fruit	39	89	0.1	0.4	9.4	3.8	13.4	6	24	-
Ribes triste	red current	fruit	-	-	-	-	-	-	51.5	-	-	-
Arctostaphylos rubra	bearberry (red)	berry	-	85	0.5	-	5.9	-	82.3	-	-	-
Juniperus spp.	juniper	leaves	-	-	12.8	-	-	-	167	-	-	-
Abies balsamea	fir	greens	-	-	8.8	11.8	-	21.7	243	-	75	46
Picea mariana	black spruce	needles	-	49	2.5	-	11.8	-	120	-	-	-
Epilobium angustifolium	fireweed	leaves	-	76	6.5	-	2.9	1.4	88	22	175	404
Betula papyrifera	birch	twigs/leaves	-	48	4.9	5.5	-	11.6	-	157	434	-

Scientific name	Common name	Part used	Food energy kcal	Water g	Protein g	Fat g	Carbo-. hydrate g	Crude fiber g	Vit. C mg	Vit. A RE	Ca mg	K mg
Alnus crispa	red willow (alder)	bark	270	50	4.3	-	-	-	-	-	-	-
Betula glandulosa	dwarf birch	leaves	-	58	8.1	-	8.5	-	-	-	-	-
Betula glandulosa	dwarf birch	inner bark	-	43	3.1	-	14	-	11	-	-	-
Hedysarum alpinum	bear root	roots	-	-	-	-	-	-	29	-	-	-
Allium schoenoprasum	wild chives/onions	greens	27	-	2.7	0.6	-	-	32	-	83	-
Populus balsamifera	balsam poplar	bark	230	49	1.9	-	-	-	-	-	-	-
Populus tremuloides	trembling aspen	bark	-	41	1.3	-	-	31.7	-	-	684	130
Rumex arcticus	arctic dock	greens	-	90	2.3	0.7	6.5	1.1	-	-	2	-
Taraxacum officinale	dandelion	greens	45	85	2.7	0.7	9.2	1.6	35	1400	209	422
Achillea millefolium	yarrow	leaves	-	79	3.8	-	-	-	-	-	225	645
Morchella species*	morel mushroom	?	13	92.6	1.8	0.5	0.4	3.4	1	-	6	320

* from Holland *et al*. (1991)

Species data not available for the following common Yukon plants:

Scientific name	Common name
P. glauca	white spruce
Leccinum spp.	Bolete mushrooms
Cladina/Cetraria species	caribou moss (lichen)
Artemisia tilesii	sage
Polygonum alaskanum	"wild rhubarb"
Lycoperdon	puffballs
Taraxacum	dandelion

Appendix 3. Glossary of common plant compounds (from Marles *et al.* (2000))

alkaloid – bitter tasting compounds produced naturally by plants and used for herbivore defense (affects their nervous system)

flavonoid – important antioxidant

iridoid – deters herbivores and helps prevent bacterial infections

salicylate – type of compound from which acetylesalicyclic acid (ASA or aspirin) was originally synthesized. Relieves pain, reduces fever, and acts as an anti-inflammatory.

saponin – chemical that acts like detergent, which froths if shaken in water.

tannin – acts as an astringent (causing tissue to shrink and fluids to be retained); is effective at stopping bleeding and preventing infection when applied topically to cuts and sores. Ingesting large doses (i.e. strong tea) is damaging to the throat lining.

volatile/essential oil – aromatic oils with medicinal, industrial, and cosmetic uses (for example, ingredients in cleaning supplies and aromatherapy). They evaporate easily.