Vancouver Community Gardeners Perceptions on Soil Health and Contamination

Jason Murillo[1], Bobby Sidhu[2]
1 Lead Author, B. Tech Student, School of Health Sciences, British Columbia Institute of Technology, 3700 WIllingdon Ave. Burnaby, BC V5G 3H2
2 Supervisor, School of Health Sciences, British Columbia Institute of Technology, 3700 Willingdon Ave. Burnaby, BC V5G 3H2

Abstract

Background: Reclaiming and converting brownfields into green spaces, such as community gardens, is a growing trend especially in Vancouver, British Columbia. Although community gardens provide a wide amount of benefits: health, social, and environmental, there are potential risks when growing and eating food from contaminated soil. Gardeners must take the proper precautions to reduce their exposure to such contaminants such as having their soil tested.

Methods: The researcher gathered information via an online survey from 23 community gardens in Vancouver, British Columbia. Survey participants were asked questions regarding garden site history, soil contamination and overall gardening knowledge.

Results: A total of 101 community gardeners participated in the study. The typical survey respondent was female, 30-49 years old, had less than 10 years of gardening experience with Bachelor degrees. It was found that no association exists between having soil testing and the location of the garden, park vs. non-park ($p = 0.89712$). Again, there is no association between the location of the community garden and gardeners' feelings that their soil is safe and contaminant-free ($p= 0.39521$).

Conclusion: Gardening in soil that has previously been contaminated through industrial processes poses a potential health concern. Despite this concern, community gardeners refrained from soil testing and remain confident in the safety of their garden's soil. The absence of soil testing indicates a gap in the safety standards for community gardens. Therefore, mandatory and annual soil testing should be implemented with Vancouver's community gardens to ensure the health and safety of gardeners.

Keywords: soil contamination, soil health, community gardens, Vancouver, brownfield, green space, healthy communities.

Introduction

For many Vancouverites, brownfields are a new concept. In fact, many people may not even be aware that the community garden they grow vegetables in was previously an oil tank storage farm 100 years ago. This redevelopment of abandoned, vacant, derelict or underutilized commercial or industrial properties into useable land, like community gardens and green spaces, is known as brownfield redevelopment (DiFrancesco, n.d.).

Brownfields are scattered throughout all of Canada. There are roughly 100,000 located in Canada, and 4,000 - 6,000 in British Columbia (Hayek, Arku & Gilliland, 2010a & British Columbia Ministry of Environment, 2007). Also, the majority of brownfields in Canada are overwhelmingly concentrated in larger, urban areas. In addition to this, according to Benazon, it is estimated that as much as 25% of the land area in major urban centers is potentially contaminated because of previous industrial activities (De Sousa, 2000). Examples of brownfields include decommissioned refineries, former railway yards, old industrial waterfronts and riverbanks, abandoned service stations, and former dry cleaners (British Columbia Ministry of Environment, 2007).

However, brownfields are not necessarily contaminated sites. Contaminated sites are pieces of land exposed to some sort of pollution that infiltrated soils and groundwater. Where brownfields differ is their active potential for re-imagined land uses, like urban agriculture.

Urban agriculture is where food is grown in a city's community gardens, shared garden plots, and edible landscapes, and then sold at farmers' markets (City of Vancouver, 2013b). While popular, this land use competes with pressures of urban densification and demand for limited space.

Redeveloping brownfields into vegetable and fruit gardens may pose public health risks, particularly on issues of soil quality (Iverson, 2011). Gardeners may not be fully aware of a site's past history or remediation, thereby increasing their risk of exposure to soil contaminants. The focus of this study is to determine prospective gardeners' awareness of such activities.

Literature review

Brownfield concerns

Brownfields were created through two concurrent factors: downsizing and closing manufacturing plants like automobile facilities and the passing of legislation to hold responsible parties liable for cleanup costs contaminated sites (Alberini, Longo, Tonin, Trombetta, & Turvani, 2002). According to Siikmaki and Wernstedt, there are many issues involved with brownfield redevelopment: cost of remediation, future maintenance, limited funding available, and the negative stigma already associated with brownfields (Campbell, 2012). Depending on the intended use of the brownfield, improper remediation can cause major potential for contamination issues. In addition, developers fear future liability - environmental and legal (Alberini et al., 2002). In an effort to combat such liability risks, laws at the provincial and municipal levels have been implemented to help protect developers and or the municipality.

Case study #1: Montreal

Montreal has the largest community gardening program in Canada with 97 gardens and 8195 allotments (Reid, 2006). However, of the 97 gardens, 5 are constructed on former garbage dumps. This case involved a former quarry and garbage dump that was transformed into community garden 20 years ago. Vegetables grown in the garden had lead and arsenic concentrations five to ten times greater than vegetables found in stores (CTV news,

2006). City officials told residents that the lead levels were safe. While the soil is being tested, those with contaminated gardens had the option of transferring to non-affected gardens or having their soil replaced. If soil tests come back positive, the gardens must close until decontamination is complete.

Brownfield successes

Brownfield redevelopments offer environmental, social, and economic benefits. According to De Sousa (2002 & 2003) they can:

- Expand a city's property tax base
- Turn contaminated sites into an aesthetically pleasing places
- Lead to job creation
- Promote a revitalized and positive image of urban life
- Restore natural habitats
- Enhance recreational opportunities.

Case study #2: Vancouver Winter Olympics

Vancouver's status as Olympic Host City in July 2003 catalyzed the redevelopment of many Vancouver and Whistler brownfields. One site was the Athletes Village in Vancouver's Southeast False Creek (SEFC) area where 18 acres of land near downtown would house over 3,000 athletes (Toderian, 2009). This land was previously used by coal gasification, wood treatment, and metalwork industries, resulting in significant soil and groundwater contamination (McCammon, 2007). The goal of this redevelopment was to create a mixed-use community with green building innovations, goods and services within walking distance, and housing and jobs linked to transit (Benfield, 2010). Since the Olympics, SEFC is now home to more than 15,000 residents, restaurants, a community center, playgrounds, parks, and community gardens. Although there have been no known reports of health effects from this redevelopment, the Athletes village has come under scrutiny in recent years due to the poor building design and construction.

Brownfield legislation

In Canada, provincial, territorial, and local governments bear the most responsibility for administering brownfield redevelopment – creating policies, programs, and incentives – whereas the private sector undertakes the redevelopment process (Hayek et al., 2010a). Currently all provinces and territories have brownfield legislation in place. In fact, the Federation of Canadian Municipalities has brownfield roadmaps for groups looking to redevelop brownfields in their communities. These roadmaps provide a high-level overview of the brownfield redevelopment process in each province and territory, and link each process step to relevant legislative requirements and potential sources of funding (Federation of Canadian Municipalities, 2014).

In British Columbia there is the Environmental Management Act and the Contaminated Sites Regulation. Specifically, the Contaminated Sites regulation provides more clarity on when a site profile or assessment is required, what the definition of a contaminated site is, where liability falls, and what are the remediation standards.

Financial incentives

Because municipal governments see value in redeveloping brownfields for better purposes, financial incentives through grants, tax assistance, and rebate programs have been promised to developers. For example, the municipal government in London, Ontario has steadily increased their financial support since 2006 from $100,000 to $500,000 in 2010 (Hayek et al., 2010a). According to Hayek et al. (2010a), although governments are willing to support the brownfield redevelopment process, developers are still wary of taking on such

projects for two reasons: cost of remediation varies depending on the type and size of the property and little financial data exists on the market value of contaminated sites.

Brownfield remediation process

Brownfields require an environmental site assessment (ESA) prior to remediation. According to Alberta Environment (2001) ESAs are reports prepared about a piece of real estate, which identifies actual or potential environmental contamination liabilities. There are three types of ESAs:

- Phase 1 – researches site history to determine the likelihood of contamination
- Phase 2 – confirms the presence of and characterizes substances of concern
- Phase 3 – planned remediation of contaminants found

If phase 1 indicates potential problems, phase 2 is necessary if remediation is to happen. However, if phase 1 indicates no problems, phase 2 and 3 are not needed and brownfield redevelopment can begin.

Brownfield remediation is the responsibility of the seller. Depending on the size and type of the brownfield, remediation costs can run upwards of $840,000 for a phase 2 site remediation (Hayek et al., 2010a). However, although municipal governments provide financial incentives, they are only useful for developers wanting to redevelop, not for sellers wanting to remediate (Hayek et al., 2010a). In many cases the owner/seller is not the developer and ultimately, a developer will decide not to take on the financial responsibility of a brownfield if there is no chance to maximize profit from their investment.

Urban agriculture in Vancouver

The growth of urban agriculture, particularly with community gardens is evident in the number garden plots developed over the years in Vancouver. According to the City of Vancouver in 2006, the city was home to just over 25 reported community gardens. By December 2010, the city reported over 2000 plots in just over 50 gardens, and in summer 2011, there were 74 community gardens comprising approximately 3260 garden plots (Seto, 2011). As of June 2012, there are now 3700 garden plots (City of Vancouver, 2012). However, extensive wait lists exist, such as the 150 people waiting for allotments at Pine Street Community Garden (Pine Street Gardens, n.d.).

For interested gardeners wanting an allotment in a community garden, annual membership fees are typical and cost between $5 and $25. The fee covers garden materials and expenses (Seto, 2011). Governance of community gardens in Vancouver depends on land ownership:

- Gardens in city parks are overseen by the Vancouver Parks Board
- Gardens on city land are overseen by the City of Vancouver
- Gardens on private land (churches, schools, hospitals, co-ops) are overseen by private property owners (City of Vancouver, 2013a)

Community garden benefits

Community gardens are collaborative projects on shared open spaces where people gather in, maintain, and harvest the garden (CDC, 2010). They are fundamentally about reconnection to: community, food, and the environment. These gardens stem out of community demand, and active community support is essential to their success. The involvement of the community must start from the beginning, from the planning stage and seen through until its completion - promoting healthy and strong communities. Food systems today are about profit. Community gardens on the other hand help to improve food security for people by increasing the physical and

economic access to healthy food. Lastly, community gardens also help to improve the local environment by preserving and growing green space. Also, contact with the environment - air, water, soil changes the behaviour of how people view the environment (Iverson, 2011).

Lack of a brownfields database

Canada lacks an up-to-date, cohesive brownfield database. The general assumption is that the majority of brownfields in the database are large, industrial complexes, however, very little is known about smaller sites like gas stations and machine shops (Hayek, Novak & Gilliland, 2010b). Community gardens are known to reside in the latter, in little plots of roughly $35m^2$ (Iverson, 2011). Therefore, starting a community garden becomes more difficult if these databases do not correctly identify brownfields and are not accessible to the general public (Hayek et al., 2010b).

A survey study by Kim et al. (2014) looked at the urban community gardeners' knowledge and perceptions of soil contaminants in their community gardens. They found 73% of community gardeners knew the site history of their gardens. The importance of knowing the site history of a community garden was agreed upon by nearly all of the surveyed gardeners (99%).

If the site history is unavailable, soil testing is another option for gardeners. However, Kim et al. (2014) found that cost was a prohibitive factor, particularly if gardeners wanted to test outside the scope of usual metals, like asbestos. Kessler (2013) reported that a lab in United States charges $65 to test one sample for cadmium, copper, lead, nickel, chromium and zinc. If the gardener also wanted to have their soil sample checked for arsenic, mercury, molybdenum and selenium, the price rises to $160, and for polychlorinated biphenyls an extra $80 is added. This only takes into account one sample provided by the gardener and for a representative soil sample of an allotment, more than one sample is necessary. Gardening then becomes a financial strain and alternative solutions are implemented like building raised beds with imported clean and safe soil.

Environmental health and healthy communities

Healthy communities are an emerging field within environmental health. The U.S. Department of Health and Human Services (2010) describes a healthy community as one that continuously creates and improves both its physical and social environments, helping people to support one another in aspects of daily life and to develop to their fullest potential. This means that the health of the community is affected by the social determinants of health and development. In comparison, environmental health studies the health effects of physical and social environment, which include housing, urban development, land use and transportation, industry and agriculture. By looking at these factors, environmental health and healthy communities both aim to improve the health status and long-term quality of life of the public.

Role of the Environmental Health Officer

Creating healthy communities requires a multi-disciplinary team serves to improve the quality of life. One important aspect of this team is the Environmental Health Officer (EHO). Normally, the EHO's primary role is to safeguard the public from health hazards. For example, with brownfield redevelopment, the EHO deals with physical hazards (people in nearby neighbourhoods breathing in dust and debris from remediation), and chemical hazards (heavy metals, solvents of petroleum products leaching into the soil and contaminating ground or drinking water supply). However, EHO involvement in building healthy communities is slowly evolving. EHOs understand that community

gardens and green spaces play significant roles in enhancing the physical, and emotional wellbeing necessary to build healthy and socially sustainable communities. Being advocates for green spaces like parks and community gardens has shown positive impacts on mental and physical fitness, chronic disease, obesity and injury (PHSA, 2014). As a result, EHOs now consult and advise with various city officials, engineers, architects and urban planners on constructing healthy built environments and communities.

Research question

The purpose of this study was to determine in community gardens located on Vancouver brownfield sites, if soil remediation was conducted and, if so, are garden members aware of it and their associated health risks.

Materials and methods

Description of standard methods

This study was conducted in early 2015 by means of a standardized, self-administered, electronic survey via Fluidsurvey.com. It was disseminated to gardeners with garden plots located in Vancouver via e-mail. The e-mail list was generated through the City of Vancouver's open data catalogue. This catalogue is a comprehensive list of all Vancouver's community gardens which includes their location, contact e-mail addresses and the number of plots in the garden. The survey consisted of 15 questions in the following topic areas: demographics, community garden site history, and soil contamination.

Reliability and validity of measures

To increase reliability and validity of a survey, the survey was administered in a consistent fashion and pilot tested before dissemination (Heacock & Sidhu, 2013). Specifically, reliability was improved with clarity and word choice. This ensured the instructions and the questions posed were written so the respondents had a clear understanding of what is being asked of them. Also, the same questions were used for each survey. With validity, the questions were created to reflect the issue being researched and not anything else.

Inclusion and exclusion criteria

To be eligible to participate, gardeners had to be at least 18 years of age with a garden plot in a community garden in Vancouver. Exclusion criteria were members of public who do not garden in a community garden in Vancouver.

Ethical considerations

Survey ethics include procedures that are intended to guide all survey researchers and respondents. Informed and voluntary consent was obtained via a cover letter and a consent form prior to the participants taking the survey. These two documents addressed the purpose of the study, the benefits and/or risks of participation, confidentiality and privacy. The respondents were assured that no personally identifiable information was reported back to the requestor unless they voluntarily offer personal contact in any of the comment fields.

The British Columbia Institute of Technology Environmental Health Research Supervisors thoroughly examined the survey to ensure that no harm was be done to any survey respondent and that no survey respondent was unduly pressured or made to feel obligated to participate in a survey.

Pilot study

Environmental health instructors and students at the British Columbia Institute of Technology evaluated the survey. Feedback and criticism was welcomed and changes to the survey were made accordingly to achieve higher validity and reliability.

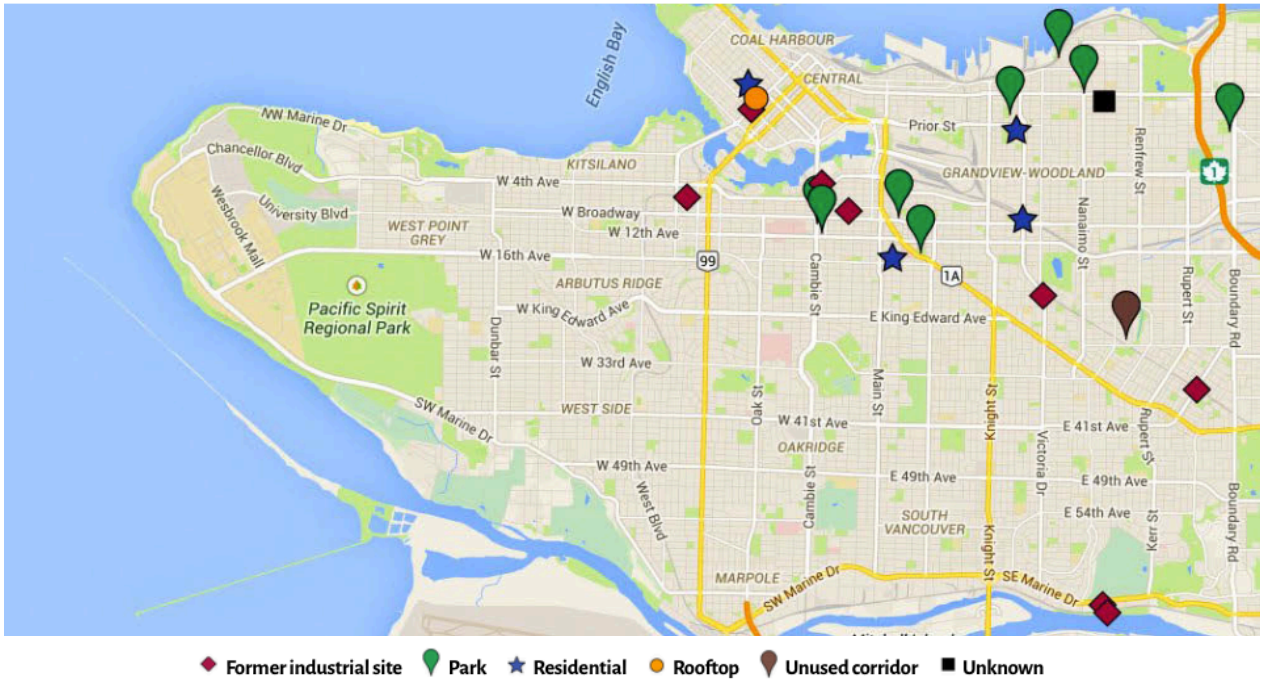


Figure 1: Map of surveyed Vancouver community gardens

Results

Gardener demographics

A total of 101 responses were received from 23 community gardens (see Figure 1). Of that, 92 respondents fully completed the survey. The majority of respondents was female (71%), 30-49 years old (60%) with less than 10 years of gardening experience (57%) and has bachelor degrees (41%).

Gardener knowledge

57% of gardeners don't know whether or not their soil has been tested for contaminants (see Figure 2). 35% have not had their soil tested and only 8% of gardeners have had testing done. In a follow up question, of the 8% that have had soil testing done, 7 gardeners found no contaminants in their soil and 1 gardener did not know the soil test results.

Only 43% are concerned about the effects of soil contamination with their health (see Figure 3). Conversely, 41% are not concerned about soil contamination in their garden.

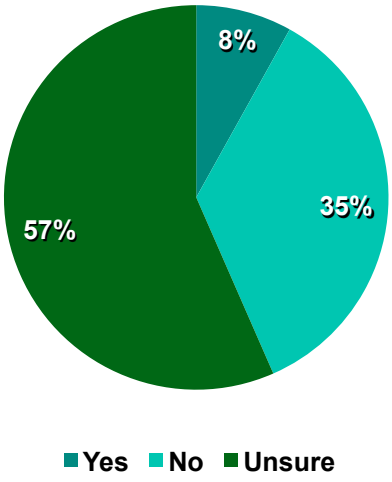


Figure 2: Responses to "Has your ever been tested for contaminants?"

Surveyed gardeners were asked to list the soil contaminants that concerned them the most (see Figure 5). Of the 29 respondent responses, 64% mentioned heavy metals (lead and arsenic). Other contaminants of concern included: pesticides, airborne contaminants, and hydrocarbons (oil and gas).

60% of gardeners strongly agree and agree that the soil they garden in is safe to grow plants, fruits and vegetables (see Figure 4).

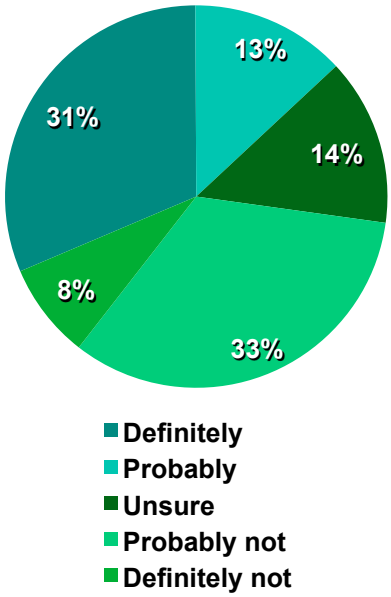


Figure 3: Responses to "Regarding your health, how concerned are you with soil contamination in your garden?"

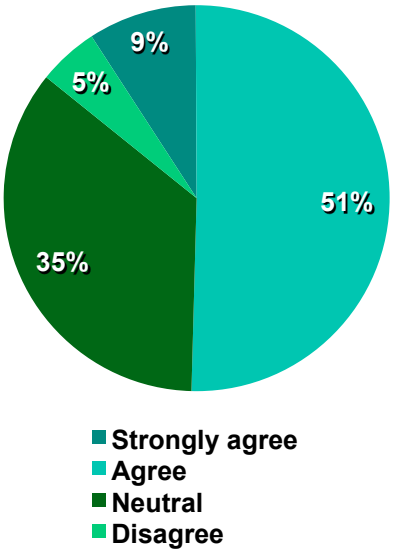


Figure 4: Responses to "Do you agree that your garden's soil is safe and contaminant free?"

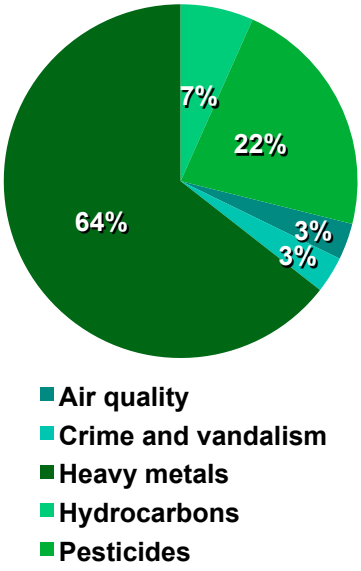


Figure 5: Responses to "If you're concerned, what contaminants concern you, exactly?"

According to Table 1, gardeners were asked to rank their preference of how to deal with oil contamination. For their first choice, the top three methods were:

1. Remove contaminated soil (44%)
2. Grow in raised bed and containers (29%)
3. Stop eating crops (13%)

For their ninth choice, the top three methods were:

1. Stop eating crops (44%)
2. Wear gloves and wash hands (20%)
3. Install a barrier over contaminated soil (11%)

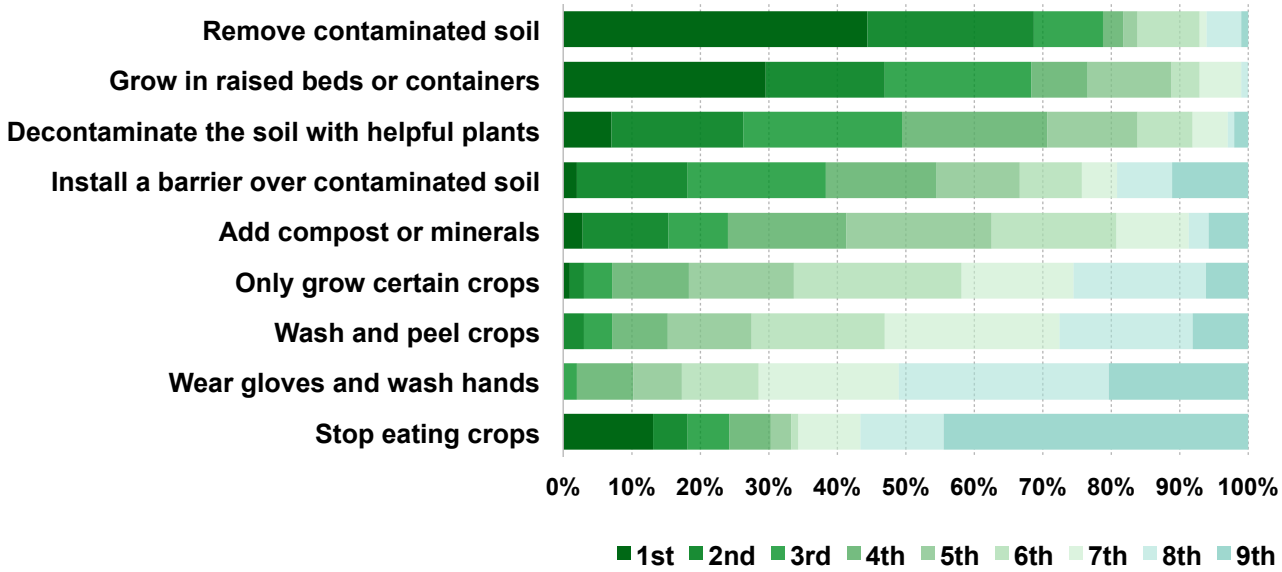
Interpretation of results

Microsoft Excel was used to record and to manipulate survey data and to generate descriptive statistical graphs and charts. NCSS, a statistical analysis program, was then used to analyze the data using multiple chi-square tests.

Statistical test 1

H_o: There is no association between the site history of community garden and gardeners' feelings that their soil is safe and contaminant-free.

Table 1: Responses to ranking question: "Here's a list of methods that community gardeners use to deal with soil contamination. Based on your preference, how would you rank them?



H_A: There is an association between land use prior to it being a community garden and gardeners' feelings that their soil is safe and contaminant-free

P = 0.39521, therefore accept H_o and conclude that there is no association between the prior land use of the community garden and gardeners' feelings that their soil is safe and contaminant-free. Gardeners in non-parks and gardeners in public parks agree that their soil is safe and contaminant-free. The chance of beta error is low because of a sample size greater than 30.

Statistical test 2

H_o: There is no association between the site history of the community garden and if soil testing was done.

H_A: There is an association between the site history of the community garden and if soil testing was done

P = 0.89712, therefore accept H_o and conclude that there is no association between gardeners in non-parks and parks and if soil testing was done. Gardeners in non-parks and gardeners in public parks have either tested or not tested their soil.

Statistical test 3

H_o: There is no association between gender and the level of concern that gardener's soil is contaminated.

H_A: There is an association between gender and the level of concern that gardener's soil is contaminated.

P = 0.55118, therefore accept Ho and conclude that there is no association between gender and the level of concern that gardeners have towards their soil being contaminated. The level of concern of soil contamination is consistent despite gender.

Statistical test 4

H_o: There is no association between gardening experience, in years, and the level of concern that gardener's soil is contaminated.

H_A: There is an association between gardening experience, in years, and the level of concern that gardener's soil is contaminated.

P = 0.20296, therefore accept Ho and conclude that there is no association between gardening experience in years and the level of concern that gardeners have towards their soil being contaminated. The level of concern of soil contamination is consistent despite gardening experience.

Discussion

Under the local food goal of Vancouver's Greenest City Action Plan 2020, Vancouver hopes to increase citywide and neighbourhood food assets by a minimum of 50%. Food assets include community kitchens, farmers markets and community garden plots. Vancouver has seen exponential growth with community gardens especially. These gardens have been created in various ways by: converting brownfields, using parks, and building on rooftops.

However, with such development, there are concerns about soil contamination particularly with gardens once located on brownfields and nearby high-traffic corridors. It was found that community gardeners, on the whole, refrained from soil testing, although many gardeners knew the prior site history of their garden. Also, common themes were identified between community gardeners when comparing different methods on how to reduce exposure to contamination. The results of this survey demonstrate Vancouver's community gardeners' perception on soil health and contamination.

Soil testing

The findings suggest that Vancouver community gardeners generally feel safe about their soil being contaminant-free, despite a lack of soil testing. Of the 101 respondents, only 8 gardeners had their soil tested (4 gardens from parks and 1 from a former railway line). According to the community gardeners who had their tested, the test results showed no evidence of contaminants in their soil, thereby confirming their lack of concern of soil contamination. Prior to 2014, the Vancouver Park Board community gardens policy did not require soil testing before creating community gardens in parks. The new guidelines will now require that edible plants grown in community gardens be planted in soil free from urban contaminants.

The lack of soil testing is continued evidence and that the majority of gardeners still trust in the safety of their soil, otherwise any worries of unsafe soil would be addressed with testing. Community gardeners could also lower their chances of coming into contact with contaminants present in their soil by building in raised beds or using soil amendments to stabilize contaminants in the soil. One reason why gardeners may refrain from soil testing is cost. However, in December 2014, the Vancouver Park Board revamped their community garden policy to include mandatory soil testing for all community gardens located in parks.

In fact, the Park Board will provide 30 cm of new soil for each garden plot (Vancouver Park Board, 2014). The new soil will only be used where the quality of the existing soil is not known. If the garden already utilizes the site's existing soil, the garden will be required to perform a soil test prior to growing food. The Park Board will ensure that affordable soil testing is available to growers, although there has been no mention of the actual cost.

Because city parks are pieces of land presumed to have safe soil, this could attribute to a gardener's false sense of security - thinking that their soil is safe when it is not. Although soil contamination has yet to be found in community gardens on park land, several gardens on former industrial land have been implicated (Oka, Thomas, & Lavkulich, 2014). For example, soil analysis on the Davie Village, Oak and

16th, Hastings and Glen Drive gardens, has determined that heavy metal contamination has occurred.

Despite their relative assurance of contaminant-free soil, gardeners expressed more of a concern with how soil contamination can affect their health. The contaminants of concern, as mentioned in the survey, include heavy metals (primarily lead and arsenic), hydrocarbons, pesticides and automobile emissions from high-traffic roadways. This contradicts the earlier question addressing their level of agreement that their soil is contaminant-free. One would expect that if gardeners agree that their soil is safe, then they should not be concerned about soil contaminants affecting their health. However, this was not the case. Gardeners expressed more of a concern when their health was taken into account.

Site history

The findings suggest that gardeners recognize the importance of knowing a garden site's prior to use. 74% of respondents knew of their garden's site history. This can be due to asking other gardeners within the same plot, obtaining information from the City of Vancouver, or from personal experience if they have lived in the area (Oka et al., 2014). On the other hand, 26% of gardeners did not know the site history of their garden. The relative gardening experience from survey respondents suggests that only 57% have less than 10 years of gardening experience. Also, 50% of respondents have lived in Vancouver for less than 20 years. These two variables, in combination with each other, are possible reasons for why this gap in knowledge exists.

Furthermore, even within the same gardens, gardeners exhibited discrepancies with prior land use of their garden. For example, in the Cedar Cottage community garden, located at Hull Street and Victoria Drive, gardeners had several ideas of how the land was used prior to it being a community garden: a railway line, undeveloped BC Hydro land, under utilized green space and a small factory.

Reducing exposure to contaminants

Gardeners were asked to rank their preferred methods on how to mitigate the exposure of contaminants in their community garden soil. Despite the majority of gardeners having less than 10 years of gardening experience, there seemed to be a consensus with what methods were preferred to help reduce exposure to contaminants: removing contaminated soil and growing in raised beds.

The majority of respondents would physically remove the soil if their soil was found to be contaminated (44%). This is the most conventional way of dealing with contamination – an approach often called "dig and dump" (Tuhus-Dubrow, 2014). In the aforementioned study by Oka, a few of Vancouver community gardens were found to have soil contaminants, however, Kessler (2013) stated that fruits and vegetables tend to be relatively safe, provided the soil was not heavily contaminated. Additionally, most food crops tend not to absorb contaminants (Kessler, 2013). The uptake of contaminants would depend on several factors: the physical/chemical properties of the compound, the environmental conditions including sun light, humidity, wind speed and temperature and the plant's physiological characteristics (Orita, 2012). For example, root vegetables such as beets and carrots and leafy green vegetables such as lettuce and spinach are more likely to uptake lead than fruit-bearing plants like tomatoes or melons (Bildersee, n.d). The other method gardeners' felt was important was growing in raised beds and containers (29%). This method involves building beds with clean soil to grow food or plants. Generally, a layer of landscape fabric will

prevent plant roots from entering the contaminated soil below the bed.

Comparing gardeners in parks and non-parks

Statistical analysis for test 1 compared gardens in city parks and non-parks based on whether or not gardeners believe their soil is safe and contaminant-free. Non-parks included gardens on previous industrial sites and housing, in addition to a garden located on the rooftop of St. Paul's Hospital. It showed that no association exists between prior land use of the garden and feelings that their soil is safe and contaminant-free. This may be due to gardeners mitigating the risks of soil contamination through researching methods and consulting other gardeners on how to garden safely. In addition, if contamination is known, gardeners may not want to grow edible produce. Instead, they may grow ornamental plants for decorative purposes, or produce that is less likely to uptake toxic substances.

Statistical analysis for test 2 again compared gardens in city parks and non-parks regarding whether or not soil testing was done. It was found that no association exists between prior land uses of gardens and if soil testing was completed. This may be due to gardeners placing trust and sharing knowledge amongst each other. It is possible that a gardener may have already completed soil testing and if the result was negative for soil contamination, then other gardeners would feel confident that they too had safe soil.

Limitations

Firstly, by relying on an Internet-based survey, some segments of the population (e.g., low-income individuals lacking access to computers) may have been under-represented. This would create a gap in the analysis, as ideally, a mixture of survey methods are recommended. Consequently, there was an inconsistency between the results of two survey questions. According to these results, gardeners that agreed that their soil is safe and contaminant-free, should therefore not be concerned about soil contamination in regards to their health. However, it was found the opposite – gardeners are in fact concerned about how soil contamination affects their health. This could have been better addressed with an in-person interview.

Secondly, brownfield sites were not validated and confirmed through city hall records. The prior land use of gardens was determined through the survey question, "How was your community garden's land used before it began a garden." Parks could have been used for industrial activity in the past; therefore, they do not necessarily constitute a safe or contaminant-free growing environment. Again, this would have to be confirmed through city records.

Lastly, the findings are unique to Vancouver. The results may be difficult to generalize to the greater population of community gardeners outside of Vancouver.

Conclusion

There is a growing need for more community garden development in Vancouver as referenced by long wait lists within particular community gardens. Ready access to these spaces has been shown to foster and strengthen healthy communities. In addition, community gardens help to improve food security by providing an opportunity for people to grow their own food, thereby increasing access to affordable, nutritious food. Vancouver has recognized this need by converting brownfields into community gardens. However, gardening in soil that has previously been contaminated through industrial processes poses a potential health concern. Although gardens located in brownfields are at a greater risk of soil contamination than those located in public

parks, there was no difference in their perceptions of soil contamination. The researcher identified soil testing as a need for community gardens, judging from the amount of gardeners who were unsure if soil testing was completed. Despite any soil contamination concerns, Vancouver gardeners place plenty of trust in garden's soil.

Recommendations

This study will help increase the awareness of soil contamination with new community gardeners. Gardeners with less experience may not know the inherent risks of gardening in contaminated soil or how to mitigate the risk of soil contamination if it is present. In fact, the Vancouver Park Board has already responded with mandatory soil testing for community gardens in parks after lead and zinc were found in a Vancouver community garden. Unfortunately, contaminants can persist in the soil for years, despite the location of the garden. Although gardeners feel more safe gardening on park land, a city park has not always been a park. For all intents and purposes, the park could have been occupied by industry 100 years ago. This is another reason that soil testing must be conducted prior to the creation of a community garden. The next step is then to have mandatory soil testing or to have fresh soil brought in for community gardens in brownfields as these gardens are more susceptible to soil contamination.

Further research

1. Compare gardening knowledge of community gardeners versus at-home, backyard gardeners.
2. Chemical analysis of vegetables and fruit grown in community gardens. Is there a difference in uptake of contaminants like hydrocarbons?
3. Conduct a survey about the public perceptions of brownfields. Should they be converted into housing?
   community gardens?
4. Conduct a similar survey in another city in Metro Vancouver.

Acknowledgements

This research would not have been possible without the help of Vancouver's community coordinators and gardeners. Thank you for taking the time to participate in the survey and helping raise awareness of soil contamination. Lastly, thank you to the Environmental Health faculty for their support and contributions.

Competing interests

The author declares that they have no competing interests.

References

Alberta Environment. (2001). Phase 1 Environmental Site Assessment Guideline for Upstream Oil and Gas Sites. Retrieved October 16, 2014 from http://environment.gov.ab.ca/info/library/6821.pdf

Alberini, A., Longo, A., Tonin, S., Trombetta, F., & Turvani, M. (2002). The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers. Retrieved October 9, 2014 from http://ageconsearch.umn.edu/bitstream/28582/1/wp02-21.pdf.

Bildersee, J. (n.d.). Brownfields for community gardens and urban agriculture. Retrieved February 1, 2015 from http://www.epa.gov/brownfields/urbanag/pdf/bildersee.pdf

Benfield, K. (2010, February 12). Vancouver's medal-worthy Olympic Village, one of the greenest neighborhoods anywhere. *Switchboard: Natural Resources Defense Council Staff Blog*. Retrieved October 15, 2014, from http://switchboard.nrdc.org/blogs/kbenfield/

British Columbia Ministry of Environment. (2007). Brownfields and brownfield redevelopment Retrieved October 1, 2014 from http://www.elp.gov.bc.ca/epd/remediation/fact_sheets/pdf/fs38.pdf.

Campbell, J N.M. (2012). *New urbanism and brownfields redevelopment: complications and public health benefits of brownfield rescue as a community garden.* Unpublished master's thesis, Georgia State University. Retrieved October 2, 2014 from http://scholarworks.gsu.edu/cgi/viewcontent.cgi?article=1233&context=iph_theses.

CDC. (2010). Community gardens. Retrieved on October 16, 2014 from http://www.cdc.gov/healthyplaces/healthtopics/healthyfood/community.htm.

City of Vancouver. (2012). Community gardens growing at a record pace across the city. Retrieved October 7, 2014 from http://vancouver.ca/news-calendar/community-gardens-growing-at-record-pace-across-the-city.aspx.

City of Vancouver. (2013a). Join a community garden in your neighbourhood. Retrieved October 7, 2014 from http://vancouver.ca/people-programs/community-gardens.aspx.

City of Vancouver. (2013b). Urban agriculture guidelines. Retrieved on October 7, 2014 from http://vancouver.ca/people-programs/urban-agriculture-guidelines.aspx.

CTV news. (2006). Contamination closes community garden in Montreal. Retrieved October 10, 2014 from http://www.cityfarmer.org/MontrealCGclosed.html.

De Sousa, C.A. (2000). *The brownfield problem in urban Canada: Issues, approaches and solutions.* Unpublished doctoral dissertation, University of Toronto. Retrieved October 3, 2014 from https://tspace.library.utoronto.ca/bitstream/1807/14656/1/NQ49892.pdf.

De Sousa, C.A. (2002). Brownfield redevelopment in Toronto: an examination of past trends and future prospects. *Land Use Policy.* 50 (3), 297-309. Retrieved October 3, 2014 from http://www.relascmex.org/pdfs/pdf-

brownfields/Brownfield-redevelopment-in-Toronto.pdf.

De Sousa, C.A. (2003). Turning brownfields into green space in the City of Toronto. *Landscape and Urban Planning.* 62, 181-198. Retrieved October 3, 2014 from https://www4.uwm.edu/milwaukeeidea/ceo/brownfields/pdf/lup_624_2003.pdf.

DiFrancesco, R.J. (n.d.). *Brownfields and planning: A primer for architects and planners*. Canadian Mortgage and Housing Company Retrieved October 7, 2014, from http://www.cmhcschl.gc.ca/en/inpr/bude/himu/coedar/upload/OAA_Planning_Brownfields_EN_-w.pdf.

Federation of Canadian Municipalities. (2014). Green municipal fund: British Columbia brownfield roadmap Retrieved October 7, 2014 from http://www.fcm.ca/Documents/tools/GMF/British_Columbia_Brownfields_Roadmap_Legislation_and_Funding_Programs_EN.pdf.

Hayek, M., Arku, G., & Gilliland, J. (2010a). Assessing London, Ontario's brownfield redevelopment effort to promote urban intensification. *Local Environment*, *15*(4), 389-402. Retrieved October 2, 2014 from http://www.theheal.ca/uploads/pdf/2010%20assessLondonsredevelopment.pdf.

Hayek, M., Novak M., & Gilliland, J. (2010b). Mapping industrial legacies: Building a comprehensive brownfield database in geographic information systems. *Planning, Practice & Research,* 25(2), 461-475. Retrieved October 2, 2014 from http://www.theheal.ca/uploads/pdf/2010%20-Mapping-Industrial-Legacies-using-GIS.pdf.

Iverson, M.A. (2010). *Assessing urban brownfields for community gardens in Vancouver, British Columbia*. Unpublished master's thesis*,* University of British Columbia. Retrieved October 1, 2014 from https://circle.ubc.ca/bitstream/handle/2429/27784/ubc_2010_fall_iverson_melissa.pdf?sequence=1.

Kessler, R. (2013). Urban gardening: managing the risks of contaminated soil. *Environmental Health Perspectives,* 121, A326–A333. Retrieved October 2, 2014 from http://dx.doi.org/10.1289/ehp.121-A326.

Kim, B.F., Poulsen, M.N., Margulies, J.D., Dix, K.L., Palmer, A.M., & Nachman, K.E. (2014). Urban community gardeners' knowledge and perceptions of soil contaminant risks. *PLoS ONE.* 9(2), Retrieved October 3, 2014 from http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0087913.

McCammon, A. (2007). The road to 2010. *Building: Real Estate Development, Construction, Architecture.* 22-23. Retrieved October 1, 2014 from http://www.env.gov.bc.ca/epd/remediation/brownfields/pdf/building_juneju ly07.pdf.

Oka, G.A., Thomas, L., and Lavkulich. (2014). Soil assessment for urban agriculture: a Vancouver case study. Journal of Soil Science and Plant Nutrition. 14, (3), 657-669. Retrieved December 1, 2015 from www.scielo.cl/pdf/jsspn/v14n3/aop5214.pdf.

Orita, N. (2012*). Root uptake of organic contaminants into plants: Species differences.* Unpublished master's thesis*,* Utah State University. Retrieved February 2, 2014 from http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2282&context=etd

PHSA. (2014). Healthy built environments. Retrieved on October 17, 2014 from http://www.phsa.ca/HealthProfessionals/Population-Public-Health/Healthy-Built-Environment/default.htm.

Pine Street Community Gardens. (n.d.). *Pine Street Community Gardens*. Retrieved October 14, 2014, from http://pinestreetgardens.org/questions/.

Reid, D. (2006). Montreal's community gardening program. Retrieved October 15, 2014 from http://ville.montreal.qc.ca/pls/portal/docs/page/librairie_en/documents/Montreal_Community_Gardening_Program.pdf.

Swarthmore College. (2009). Brownfields remediation in Delaware county, PA. Retrieved October 15, 2014 from http://www.swarthmore.edu/sites/default/files/assets/documents/environmental-studies/BrownfieldsReport.pdf.

Seto, D. (2011). *Diversity and engagement in alternative food practice: community gardens in Vancouver, B.C*. Unpublished master's thesis. University of British Columbia. Retrieved October 1, 2014 from http://www.collectionscanada.gc.ca/obj/thesescanada/vol2/BVAU/TC-BVAU-39820.pdf.

Toderian, B. (2009, August 12). The 2010 winter olympics athletes village: Vancouver's next city building model, part 1. *Planetizen Blog*. Retrieved October 15, 2014, from http://www.planetizen.com/node/39507.

Tuhus-Dubrow, R. (2014). Grow a mushroom, get less toxic tomatoes in your community garden? Retrieved February 20, 2015 from http://nextcity.org/daily/entry/community-garden-how-to-fix-toxic-soil-contamination

U.S. Department of Health and Human Services. Healthy People. (2010). *Part 7: Educational and community based programs.*Retrieved January 19, 2015 from http://healthypeople.gov/2020/topicsobjectives2020/DataDetails.aspx?topicId=11

Vancouver Park Board. (2014). Park board urban agriculture policy. Retrieved February 14, 2015 from https://www.scribd.com/doc/254859480/Park-Board-Urban-Agriculture-Policy-Draft-December-2014