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Biosolids in Western Canada: A Case Study on Public Risk Perception and Factors Influencing Public Attitudes

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Abstract

The land application of biosolids can be subject to questions and concerns, suggesting a gap exists with public perception of biosolids. There is opposition amongst a segment of the population regarding the land application of biosolids in the Southern Interior of British Columbia in Canada. Kamloops and Merritt communities were assessed through a mailout survey to understand better public perceptions of biosolids risks and factors that influence attitudes towards biosolids management. Two thousand surveys were distributed proportionately between the communities. Response rates for Kamloops and Merritt were 22 and 24 percent, respectively. Kamloops and Merritt respondents generally identified differing risk perceptions around biosolids management. Kamloops respondents relative to Merritt were more accepting of the risks associated with biosolids. This acceptance is a likely result of Merritt residents' recent experience with application sites and proximity to biosolids projects, and the associated negative local media attention. Results from Kamloops highlighted that there is general support to find a productive use of biosolids. This research supports the notion that the 'beyond compliance' approach of conducting early engagement to obtain community support proactively may be valuable for any potentially controversial natural resource project, such as with biosolids land application projects.

Keywords Community engagement · Legitimacy · Public opinion · Positive and negative statements · Community support · Trust

Introduction

As Canada's population grows, the amount of sewage sludge generated annually continues to rise, increasing the nation's dependence on effective wastewater treatment and management.[1] Despite this reliance, the overall public awareness of biosolids and their applications remains low (Beecher et al. 2004; Robinson et al. 2012; Youngquist et al. 2015; McCarthy and Loyo-Rosales 2015). There are treatment processes, strict standards, and quality controls intended to ensure biosolids application safety. In Canada, the Canadian Council of Ministers of the Environment (CCME) encourages the beneficial use of municipal biosolids, including composting, agricultural land application, and combustion for energy. However, in some municipalities, biosolids are disposed of in landfills or incinerated (CCME 2012). Biosolids are often used for soil amendment applications in British Columbia (BC) and across Canada (CCME 2012; McCarthy and Loyo-Rosales 2015). Using biosolids as a soil amendment offers advantages such as improving the quality of degraded soils through enabling increased plant productivity and improved soil carbon storage capacity (Robinson et al. 2012; Antonelli et al. 2018) as well as reducing the amount of material otherwise destined for landfilling or incineration and the greenhouse gas generation associated with these practices; however, despite the beneficial uses of biosolids, there is a generally negative perception regarding biosolids (National Research Council 2002; Beecher et al. 2004; McCarthy and Loyo-Rosales 2015). These opposing views include concerns about potential contaminants in biosolids

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[1] For a literature on biosolids and sludge management see Brisolara and Qi (2013) and Collivignarelli et al. (2019, 2020).

such as inorganic and organic contaminants, pathogens, and complaints regarding odor (Pritchard et al. 2010; Robinson et al. 2012; Youngquist et al. 2015).

A fruitful approach towards public acceptance of biosolids use is to avoid presenting these as sewage sludge or human waste and instead present them as a valuable reusable resource (Forste 1994). Framing of the topic by the media is also crucial in shaping public opinion about biosolids. Goodman and Goodman (2006) found that negative tones were three times more common than positive tones. Lindsay et al. (2000) argue that news media need to be accurate and obtain information from trustworthy sources for public acceptance to occur. Another recommended approach to increase communities' understanding, trust, and judgment of biosolids is to apply a customized strategic risk communication process (Eggers and Thorne 2017). The development of biosolids indicators for management following a stakeholder approach, the practice that managers formulate and implement processes that satisfy stakeholders' needs to ensure long-term success, is also a potential aid in creating public trust (Amajirionwu et al. 2008). Hebert (2007) calls for Canada to create a third-party certification and standardization process for biosolids and their usage. Moya et al. (2019) recommend certification and assurance schemes for changing the public's negative perceptions of biosolids use.

A promising institutional approach is the Australasian & New Zealand Biosolids Partnership, composed of academics, government bodies, consultants, utilities, and industry consultants collaborating for finding sustainable biosolids management practices (Gale 2007).[2] Goven and Langer (2009) argue for the need for "genuine public engagement" in workshops with the purpose of managers and public authorities not to pursue to gain public acceptance but to accept the public perception of risk and uncertainty and recognize that there are uncertainties as well as the importance of community values when making decisions.

The practice of the land application of biosolids is subject to public concerns about risks. Thus, the concept of "perception is reality" challenges biosolid managers. There are, however, processes for engaging concerned or impacted communities and other stakeholders to understand and review options regarding potentially controversial natural resource projects. One of these approaches is the "beyond compliance" approach of seeking proactive community support from stakeholders through meaningful early engagement. (Moffat and Zhang (2014), Lynch-wood and Williamson 2018).

Perception of risk is an essential element for risk communication as individuals exposed to biosolids do not know the risks involved and can overstate the likelihood of health and safety impacts (Beecher et al. 2005). Several studies examine the perceptions of risks and factors influencing public attitudes towards biosolids. Bordon et al. (2004) surveyed the Las Vegas Valley, comparing reactions from two cities. In general, respondents placed more importance on risks than on economic costs. Krogman et al. (2001) conducted semi-structured interviews with 50 New Jersey vegetable and fruit farmers and found that biosolids land application was not a common practice, but also farmers felt the risks outweighed the benefits. Framing of the interview questions on benefits and risks played a role in their answers. They were more concerned with their crops and land than the environmental impacts if the framing of the question was not associated with risks and benefits to the environment. Mason-Renton and Luginaah (2019) interviewed residents of a rural town (Southgate, Ontario) regarding their perceptions of a biosolids processing facility in their community. They found that perceptions can change from negative pre-survey to less threatening once the facility started operations and residents understood its purpose. Oberg and Mason-Renton (2018) contrast BC and Sweden's regulatory system with regards to biosolids and find that Sweden takes a precautionary approach with the presumption of potentially harmful effects and being cautious in the absence of scientific evidence. They argue that biosolids management is a "wicked" problem and that framing the issue as a technical problem without discussing scientific uncertainties, values, and social aspects will increase conflicts and polarization. Robinson and Robinson (2006) studied four-county metropolitan areas in the southeast United States to assess knowledge and attitudes towards eight biosolids' land recycling options. Most participants responded favorably to all options except the 65+ generation, who were more pessimistic.

This paper assesses community risk-perceptions of biosolids management in Kamloops and Merritt—two cities in the interior of BC where there is vocal opposition amongst a segment of the population regarding the land application of biosolids in their communities. The population of Kamloops (over 90,000 people) is much larger than the population of Merritt (just over 5000 people). A mailout survey was distributed to members of these communities[3] to assess their general knowledge, attitudes and actions, thoughts and feelings towards biosolids, and the factors that influence the public attitudes towards the management of biosolids.

The survey focussed on legitimacy and public trust. The following definitions were used for community support as suggested in a conceptual model of social license to operate (Boutilier et al. 2012). First, legitimacy is associated with the perception that the company/project benefits the receiver. Second, trust refers to the willingness to be vulnerable to risk or loss through others' actions. The survey contained a series of attitude statements about legitimacy and trust. The sentiment

[2] For further information see: https://www.biosolids.com.au/

[3] Surveys were also sent to individuals in the small community of Princeton, but no responses were received.

of the statement depends on the tone being positively or negatively framed. An example of a negatively framed trust sentiment statement is, "My family would be at a higher health risk if my neighbours applied animal manure to their land." Whereas a positive trust statement is: "I trust government regulatory agencies to monitor the safe use of biosolids." An example of a negative legitimacy statement is "The risks to public health of using biosolids as a fertilizer outweigh the benefits." Finally, a positive legitimacy statement is "Using biosolids as a fertilizer in our community will bring economic benefits." The study also examines how twelve positive and negative statements on legitimacy and trust depend on socio-economic and other explanatory variables. Finally, the study presents a framework to examine community support based on legitimacy and trust. This framework may aid in understanding how to address the gap between the public perception of biosolids most effectively and the promotion of the safety and sustainability of land application practices.

Results indicate that Kamloops and Merritt differ in risk perceptions around biosolids management practices. Kamloops was more accepting of biosolids in their overall perceptions. Merritt residents' may have been influenced by recent experiences with biosolids applications sites close to the city and the substantial local media attention. Results from Kamloops indicate that there is general support to find a productive use of biosolids but a lack in the overall trust necessary for a biosolids project to receive stable community support.

In more detail, Merritt respondents are significantly more concerned with waste management in general than Kamloops respondents and also are more familiar with the term biosolids. Kamloops respondents are on average against biosolids land application when the frame of the statement is negative. Perceived health risks from exposure to biosolids are more of a concern than animal manure for Merritt respondents, while the attitudes of Kamloops respondents are towards disagreeing that biosolids exposure would lead to increased health risks. Living on rural agricultural land in Kamloops helps in general to accept biosolids land application practices. Women perceive significantly higher health and safety risks, especially in Merritt. There is a lack of knowledge on biosolids in both cities and trust in government oversight for land application projects. Kamloops respondents support the general idea of recycling biosolids, but lack of trust is still an issue. Merritt respondents reported that biosolids do not pass a benefit-cost test. Also, in Merritt, respondents generally do not support land applications such as using biosolids as a fertilizer.

Background information

The study took place in Kamloops and Merritt. The two cities are in the interior of British Columbia (Appendix Fig. 6). Some groups have had vocal and steady opposition in this area since late 2014, as indicated by the grey literature[4] (see Appendix Fig. 7). Considering grey literature is of particular significance when evaluating the opposition against biosolids present within the Thompson-Nicola interior region of BC Concerns with biosolids management practices within the Thompson-Nicola interior region of BC appear to go back to 2008 where the concerns expressed are similar to the ones currently being communicated today.

In Sunshine Valley Estates just east of Merritt, BC, biosolids land application from the central Okanagan was at a site just uphill from housing development and close to their drinking water reservoir. As outlined in the local newspaper, the Merritt Herald, residents expressed concern over harm to their air quality, contamination of their drinking water source, and decreased property value (Potestio 2014 Dec 11). Residents were concerned the biosolids would potentially contaminate surface water that would in-turn contaminate the aquifer that the property development's shared well accesses; the well is around 2 km away from the land application site (Potestio 2014 Dec 11). After expressed local opposition, in December 2014, the First Nations Chiefs of the Nicola Valley submitted a letter to the Ministry of Environment demanding that all current biosolids applications cease and no new projects proceed until the Crown and ministry regulators establish a meaningful dialogue. As a result, a moratorium was enacted and stopped biosolids use in the Nicola Valley on Apr 24, 2015, by the five First Nations chiefs from Upper Nicola. While the moratorium is still in effect, there has been much discussion on applicable regulations and associated practices. Ultimately, a group of residents of Sunshine Valley Estates purchased the potential land application site that was causing the most concern and prevented it from being used (Potestio 2015 Dec 15), although there is still another existing land application site nearby. The purchase is an example of a property rights solution to a perceived negative externality in the spirit of Coase (1960).

Methodology

Survey Design

A mailout survey was distributed to Kamloops, Merritt, and Princeton, BC, to determine the factors that influence public attitudes and risk perception towards the use of biosolids.[5]

[4] Grey literature is material that is made public but not subject to the traditional academic peer-review processes (i.e. newspaper articles); this material is considered a valuable resource for understanding public perceptions and concerns for controversial matters (Beecher et al. 2004).

[5] Permission from the TRU Human Ethics Committee was required prior to making contact with potential survey respondents. Survey distribution and data handling was managed in a fashion approved by TRU's Research Ethics Board. Approval was received March 2016, File #: 101107.

The survey followed a standard methodology (Dillman 1991; Sanchez 1992; Dillman et al. 2014). The survey (see Supplementary File) starts with an introductory statement about the study and a brief explanation of biosolids.[6] Section 1 of the survey asked for sociodemographic information and questions related to their dwelling. Section 2 of the survey begins with a question to gauge respondents' level of concern with general issues, such as climate change, the state of the economy, and waste management. The remainder of the questions in this section pertain to respondents' general knowledge, attitudes, and actions with respect to biosolids management in their community. Finally, the survey included a series of attitude statements to assess attitude and risk perception towards biosolids management. The attitude statements capture individual perceptions about biosolids and can determine the influence of emotions by familiarity with biosolids risks and management. At the end of the survey, respondents could provide comments and feedback.[7]

Responses for general knowledge, attitudes, and actions were on a Likert scale of 1–5. Some questions had a scale from strongly disagree (1) to strongly agree (5) with neutrality (3) in the middle of the scale. Other questions have a continuous scale from not concerned (1) to very or extremely concerned (5); from not familiar (1) to extremely familiar (5); from not trustworthy (1) to very trustworthy (5); from very uncomfortable (1) to very comfortable (1); and not appropriate (1) to extremely appropriate (5).

Although online surveys may be advantageous given that they pose savings in both time and cost, they present challenges due to limiting access, difficulties in assuring anonymity and confidentiality, potential technical problems, and reportedly low response rates (Sax, Gilmartin, and Bryant 2003; Dillman et al. 2014). A mailout survey is the best approach for survey delivery based on several factors. First, it maintains the anonymity of respondents, given the controversial nature of the topic. Second, sample selection will represent a broader community (i.e., not limited to having internet access). Thus, this approach reduces voluntary response bias and eliminates the potential bias presented by an interviewer in phone surveys. It is worth noting that mailout surveys have demonstrated challenges in obtaining adequate response rates for certain groups, particularly of interest to the younger population who may not use the mail system readily (Dillman et al. 2014).

MailWorks, a third-party mailing service, was employed for random sample selection and survey distribution. Canadian consumer lists, available at https://infogroup.infocanada.ca/, were utilized for Kamloops, Merritt, and Princeton to select random samples within each community. MailWorks used the lists, ensuring the most up-to-date lists available, increasing the sample's representativeness. MailWorks delivered the survey entitled 'Biosolids: Community Engagement and Risk Perception' administered by TRU on May 20, 2016, to 2000 randomly selected households in three municipalities: Kamloops, Merritt, and Princeton. A proportional distribution for survey mailouts was used based on the Statistics Canada 2011 census data for population, resulting in Kamloops receiving 1761, Merritt 173, and Princeton 66 surveys. In order to reduce nonresponse bias, the surveys and cover letters were in envelopes containing a postage-paid return envelope stamped with postage and return address. The cover letter described the study's social usefulness, highlighting that biosolids are of high public interest locally, aiming to increase response further. In addition, a reminder postcard was mailed 14 days after the initial distribution of the survey.

Statistical Methods

Kamloops or Merritt sample was assumed to be from independent populations. Concerns with waste management and familiarity with biosolids use descriptive statistics for analysis and sample *t*-tests to compare two population means. The analysis of the attitude statements uses *t*-tests and examines if statements are different from neutral (3). Furthermore, Satterthwaite–Welch *t*-tests assess the mean responses between Kamloops and Merritt for all twelve attitude statements to determine if the communities demonstrated significantly different attitudes. In order to assess how emotions depend on a respondent's familiarity with biosolids risks and management, ordered logistic regression analysis on the twelve attitude statements examined their association with sociodemographic information, respondents' self-ranked familiarity with biosolids, and level of concern regarding waste management.

Results

The number of surveys mailed to Kamloops was 1761, while Merritt received 173. Surveys returned were 423 for a 22% return rate. The final analysis used a total of 421 surveys. Response rates for Kamloops and Merritt were 22 and 24 percent, respectively. The small community of Princeton did not respond to the survey.

General Knowledge

When asked, "What comes to mind when you think of biosolids?" respondents demonstrated general familiarity

[6] The survey was constructed to not lead the respondents to a specific response; did not provide too much information up front, which could potentially bias the respondents' attitudes; and used language suitable for the general public.

[7] The survey was piloted to a selected group of individuals aimed to cover a range of those in favor of and against the recycling of biosolids, as well as both experts and non-experts. The final survey was re-designed based on feedback from the pilot.

with the term.[8] This familiarity demonstration aligns with the individual community responses reporting average familiarity within the range of "Somewhat Familiar" to "Moderately Familiar," as demonstrated in Table 1.

Table 1 shows the respondents' level of concern regarding waste management in general. Because concern for waste management goes beyond the management of wastewater residuals, the communities' views are essential to investigate. Second, respondents identified their level of familiarity with the term biosolids. Respondents from both communities, on average, reported being somewhat to moderately concerned with waste management and somewhat to moderately familiar with biosolids. However, in general, Merritt respondents reported statistically different mean responses relative to Kamloops in both questions. *T*-tests identified Merritt respondents as significantly more concerned with waste management than Kamloops respondents ($p = 0.0058$). Merritt respondents also reported being significantly more familiar with the term biosolids ($p = 0.0201$). This response is a likely result of Merritt residents' recent experience with biosolids application. In general, Kamloops and Merritt identified differing risk perceptions around the management of biosolids. Kamloops respondents demonstrated more neutral-accepting perceptions relative to Merritt respondents.

Table 1 Before receiving this survey, how familiar were you with the term biosolids?

	Kamloops	Merritt
How do you feel about waste management? (1 = Not Concerned; 5 = Very Concerned)		
Not concerned	4.7%	0.0%
Slightly concerned	11.9%	5.0%
Somewhat concerned	41.1%	27.5%
Moderately concerned	27.2%	30.0%
Very concerned	15.1%	37.5%
average	3.5	4.0
Before receiving this survey, how familiar were you with the term "biosolids"? (1 = Not Familiar; 5 = Very Familiar)		
Not familiar	8.8%	2.5%
Slightly familiar	16.0%	10.0%
Somewhat familiar	27.4%	17.5%
Moderately familiar	39.1%	60.0%
Extremely familiar	8.8%	10.0%
Average	3.2	3.7

Attitude Statements

Table 2 shows results from the twelve attitude statements in the order in the survey. The sentiment of the statement is also listed, in addition to the assigned community support factor. There were four legitimacy and eight trust statements. Of the four legitimacy statements, two have a positive framing, and two have a negative. Of the eight trust statements, six were negative, and two were positive.

For the positive and negative legitimacy statements, Kamloops respondents perceived a greater value in the land application of biosolids relative to Merritt respondents. Kamloops respondents were more likely to agree with the positively framed statements than with the negatively framed ones. This response is the reverse for responses from Merritt residents. Kamloops respondents generally agreed with the statement, "Biosolids are a valuable resource that should be used as a fertilizer," in contrast to Merritt respondents who reported a general disagreement with the statement. These responses were similar for the statements "Using biosolids as a fertilizer is better than incineration or landfilling" and "Using biosolids as a fertilizer in our community will bring economic benefits." Conversely, Kamloops respondents were less likely to agree with the statement, "The risks to public health of using biosolids as a fertilizer outweigh the benefits," where Merritt respondents were more likely to agree with it. Of the twelve attitude statements, Kamloops respondents most strongly agreed with the statement, "Using biosolids as a fertilizer is better than incineration or landfilling," suggesting the community supports productive uses of biosolids.

In terms of eight positive and negative trust statements, Kamloops respondents displayed a higher level of trust regarding the land application of biosolids when compared to Merritt respondents. Kamloops respondents were generally more likely to agree with the positively framed statements and disagree with the negatively framed statements than Merritt respondents. Both communities reported to disagree with the statement equally, "My family would be at a higher health risk if my neighbours applied animal manure to their land." When assessing these responses against responses to the statement, "My family would be at a higher health risk if my neighbours applied biosolids to their land," Merritt respondents' agreement with this statement indicates that residents perceive a higher health risk from exposure to biosolids compared to exposure to manure. This response was not the same for Kamloops respondents. Although responses were generally in disagreement with the manure statement, weak disagreement with the biosolids exposure statement supports that the community may not distinguish between the health and safety risks from biosolids and manure exposure.

Surprisingly, responses to the statements, "Not enough is known about biosolids" and "Even if used properly, biosolids can still lead to land or water contamination," were not statistically different between the communities. "Not enough is

[8] As a method to understand the most predominant thoughts surrounding biosolids, a visual depiction of responses to the questions "What comes to mind when you think of biosolids?" was created using the online tool, WordleTM. This tool generates word clouds where greater prominence is given to words that appear more frequently in the text provided.

Table 2 Overview of thoughts and feelings statement variables and assigned sentiment and social capital indicator

Statement	Sentiment	Community support factor	Deviation from Neutral–Kamloops Response	Deviation from Neutral–Merritt Response	*t*-Test Comparison of Means–Kamloops and Merritt responses (*p* value)
S1: Biosolids are a valuable resource that should be used as a fertilizer	Positive	Legitimacy	0.62 (0.0000)	−0.51 (0.0276)	0.0000
S2: Not enough is known about biosolids	Negative	Trust	0.81 (0.0000)	0.85 (0.0000)	0.8138
S3: Using biosolids as a fertilizer is better than incineration or landfilling	Positive	Legitimacy	0.83 (0.0000)	−0.32 (0.1760)	0.0000
S4: The use of biosolids as a fertilizer makes me concerned about my surrounding environment	Negative	Trust	0.25 (0.0000)	0.95 (0.0000)	0.0005
S5: Biosolids receive adequate treatment at the wastewater treatment plant to protect public health	Positive	Trust	0.25 (0.0000)	−0.49 (0.0292)	0.0017
S6: My family would be at a higher health risk if my neighbours applied biosolids to their land	Negative	Trust	−0.15 (0.0101)	0.56 (0.0056)	0.0008
S7: My family would be at a higher health risk if my neighbours applied animal manure to their land	Negative	Trust	−0.66 (0.0000)	−0.75 (0.0000)	0.5909
S8: I trust government regulatory agencies to monitor the safe use of biosolids	Positive	Trust	−0.12 (0.0556)	−0.41 (0.0000)	0.0395
S9: The odor emitted by biosolids is harmful to my health when breathed	Negative	Trust	−0.05 (0.3569)	0.46 (0.0183)	0.0117
S10: The risks to public health of using biosolids as a fertilizer outweigh the benefits	Negative	Legitimacy	−0.38 (0.0000)	0.56 (0.0088)	0.0001
S11: Using biosolids as a fertilizer in our community will bring economic benefits	Positive	Legitimacy	0.14 (0.0046)	−0.63 (0.0004)	0.0000
S12: Even if used properly, biosolids can still lead to land or water contamination	Negative	Trust	0.19 (0.0013)	0.49 (0.0234)	0.1718

Community responses on a Likert scale of 1−5 (1 = Strongly Disagree, 5 = Strongly Agree). Reported as mean response deviation from neutral (neutral response = 3). The *P* value of the test for neutrality (mu = 3.0) is in parenthesis

known about biosolids" was also found to be the statement both Kamloops and Merritt reported the second strongest response. This result suggests that there is a perceived lack of information on the topic. Merritt respondents most strongly responded to the statement, "The use of biosolids as a fertilizer makes me concerned about my surrounding environment," and although Merritt respondents were significantly more likely to agree, Kamloops respondents also generally agreed with this statement. Similarly, both communities disagreed with the statement, "I trust government regulatory agencies to monitor the safe use of biosolids," however, Merritt respondents had a stronger negative response than Kamloops respondents ($p = 0.0192$). Conversely, Kamloops was generally more trusting regarding biosolids' perceptions. However, both communities agreed with the statements "Not enough is known about biosolids" and "Even if used properly, biosolids can still lead to land or water contamination" and disagree with "I trust government regulatory agencies to monitor the safe use of biosolids" demonstrating a general lack of trust in the current regulatory structure and scientific knowledge base.

The Determinants of Thoughts and Feelings

Table 3 describes the independent variables used for the regressions to examine the factors influencing biosolids' thoughts and feelings.

Legitimacy—positive statements

Figure 1 displays the coefficient estimates from the logistic regressions using the responses to the positive statements focused on legitimacy (Appendix Table 4). Results from the logistic regression for the Kamloops dataset indicate that the level of familiarity with the term biosolids significantly influences the responses to, "Biosolids are a valuable resource that should be used as a fertilizer," were those who were more familiar with the

Table 3 Independent variable for logistic regression of influencing factors of thoughts and feelings on biosolids

Variable	Name	Description
Gender	Gender	Gender of the Respondent (1 = Male, 0 = Female)
Age (base case: Age 18–50)	Age5064	Respondents who are of the age of 50-64 years old (1 = Yes, 0 = No)
	Age 65+	Respondents who are of the age of 65 years or older (1 = Yes, 0 = No)
Children	Child	Respondents who have children currently living at home (1 = Yes, 0 = No)
Education (base case: highest level of education some college or trade school graduate)	EduPTC	Respondents whose highest level of education is some college or trade school (1 = Yes, 0 = No)
	EduGTC	Respondents whose highest level of education is college or trade school graduate (1 = Yes, 0 = No)
	EduUni	Respondents whose highest level of education is university graduate (bachelors degree) (1 = Yes, 0 = No)
Environmentalist	Enviro	Respondents opinion of how applicable the term "Environmentalist" applies to them (1 = Strongly Disagree, 5 = Strongly Disagree)
Location (base case: residents live in Kamloops)	Merritt	Respondents whose residence was located in Merritt (1 = Yes, 0 = No)
Rural Residence (base case: Urban/Suburban)	RuralNF	Respondents who live in non-farm rural area (1 = Yes, 0 = No)
	RuralAg	Respondents who live in rural agriculture area (1 = Yes, 0 = No)
Home sewage system (base case: septic tank or other/don't know)	MuniSewer	Respondents whose home is connected to a municipal sewer system (1 = Yes, 0=No)
Community Biosolids Management	BioMngt	Respondents who know how biosolids are managed in their community (1 = Yes, 0 = No)
Income (base case: respondents for whom annual household income was less than $50,000)	Inc50100	Respondents for whom annual household income was in the range $50,000 to $100,000 (1 = Yes, 0 = No)
	Inc100+	Respondents for whom annual household income was $100,001 or more (1 = Yes, 0 = No)
Aboriginal	Aboriginal	Respondents who identify as Aboriginal (1 = Yes, 0 = No)
Waste Management	WasteMngt	Respondents level of concern regarding waste management (1 = Not Concerned, 5 = Very Concerned)
Biosolids Familiarity	BioEd	Respondents opinion of how familiar they were with the term "biosolids" prior to receiving the survey (1 = Not Familiar, 5 = Extremely Familiar)

term biosolids were more likely to agree that biosolids are a valuable resource ($p = 0.0005$). Interestingly, although Merritt respondents reported being more familiar with the term biosolids, familiarity was insignificant for the Merritt dataset. For the Kamloops respondents, additional significant variables included those who identified as living on rural agricultural land ($p = 0.025$) and those whose wastewater is part of a municipal sewer system ($p = 0.0362$) to be more likely to agree with the statement. Households with a municipal sewer system may understand that they are personally generating some of the biosolids used for land application, whereas people with septic systems may feel more independent and do not want the "big bad city" to place biosolids near their land. This conjecture assumes that those of the "general population" live in the urban/suburban center and that those on the septic system are in rural areas, where land application projects are more likely to occur.

Female Merritt respondents were significantly less likely to agree with the statement, "Using biosolids as a fertilizer is better than incineration or landfilling," than males ($p = 0.0308$). This result is consistent with the findings of Robinson et al. (2012), where women perceived higher health and safety risks regarding biosolids projects. Those concerned with waste management ($p = 0.0267$) or who have completed a college diploma or trades school ($p = 0.0360$) were also less likely to agree with the statement. Alternatively, for Kamloops respondents, neither gender nor familiarity was a significant factor. Those who were university graduates ($p = 0.0154$) or earned an annual household income over $100,000 ($p = 0.0183$) were more likely to agree with the statement.

Legitimacy—negative statements

For Kamloops respondents, income was the most significant variable ($p = 0.0544$) regarding the statement, "The risks to public health of using biosolids as a fertilizer outweigh the benefits." Those who earned an annual household income that ranged from $50,000–$100,000 were less likely to agree with this statement. Age ($p = 0.0547$), gender ($p = 0.0544$), and education ($p = 0.0711$) were also marginally significant

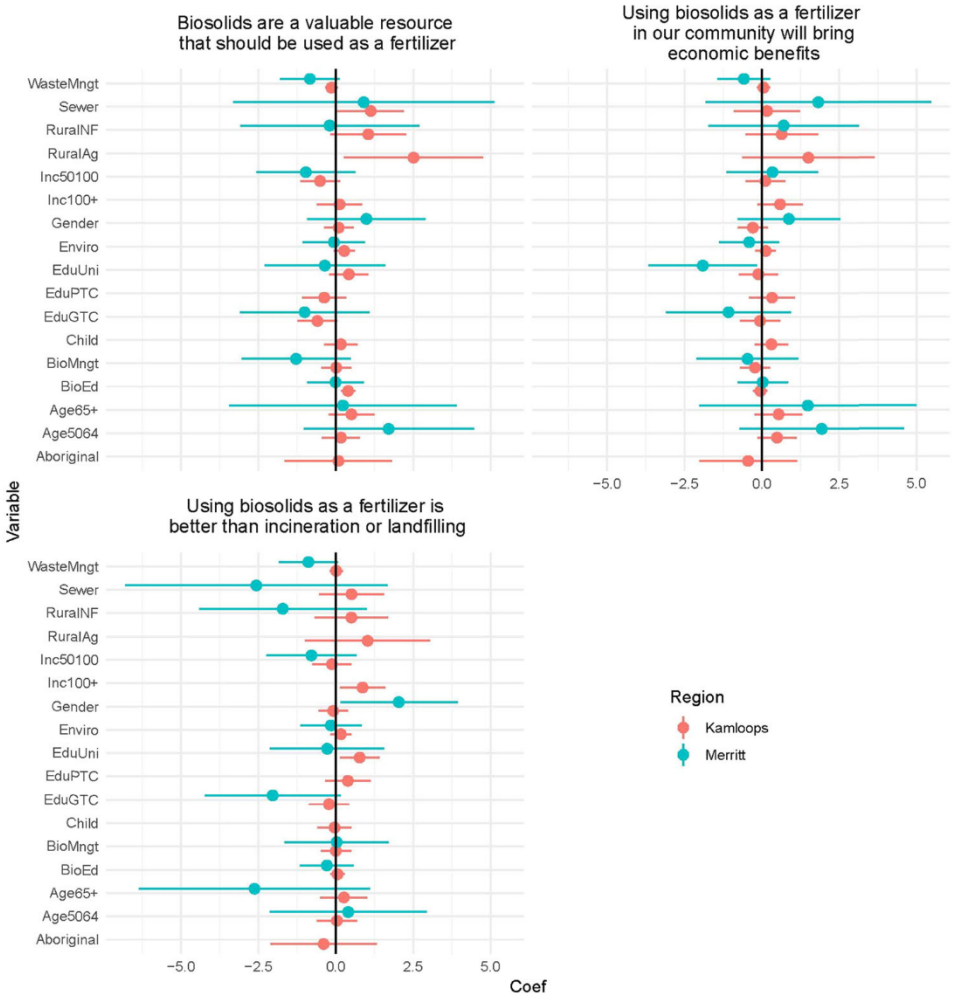

Fig. 1 Legitimacy: Positively Framed Statements—Ordered Logit regressions. Logistic regression coefficients in log-odds units with 95% confidence intervals. See Appendix Table 4 for more details

variables, where Kamloops respondents who are 65+ years old, female, or whose highest level of education is the completion of some college or trades school, were more likely to agree with the statement. Similarly, for Merritt respondents, gender ($p = 0.0108$), level of education (0.0285), and level of concern about waste management ($p = 0.0082$) were found to be significant. Those from Merritt and are female, have completed college or trade school, or are concerned about waste management were more likely to agree with this statement. The significance of gender continues to support the notion that women perceive higher health and safety risks for biosolids projects. See Fig. 2 (Appendix Table 5)

Trust—positive statements

For Kamloops respondents, there is only one significant variable for the statement, "Biosolids receive adequate treatment at the wastewater treatment plant to protect public health." Those who identified as living on rural

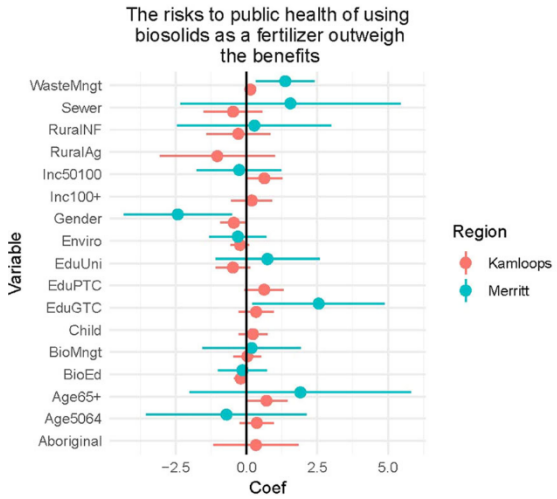

Fig. 2 Legitimacy: Negatively Framed Statements—Ordered Logit regressions. Logistic regression coefficients in log-odds units with 95% confidence intervals. See Appendix Table 5 for more details

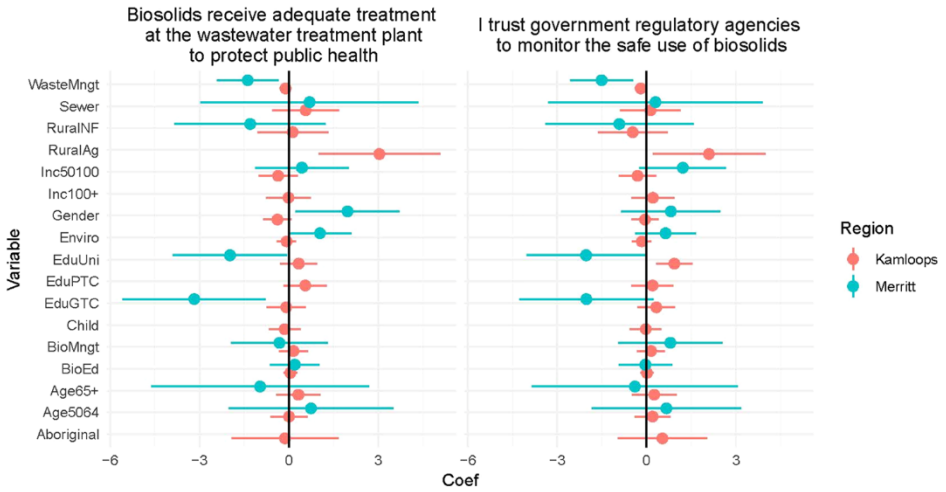

Fig. 3 Trust: Positively Framed Statements—Ordered Logit regressions. Logistic regression coefficients in log-odds units with 95% confidence intervals. See Appendix Table 6 for more details

agricultural land were significantly more likely to agree with the statement ($p = 0.0029$). In contrast to this, Merritt respondents who were female ($p = 0.0241$), had completed college, trade school ($p = 0.0081$), or a university degree ($p = 0.0386$), or were concerned about waste management ($p = 0.0074$) were less likely to agree to the statement. Interestingly, responses to "I trust government regulatory agencies to monitor the safe use of biosolids" reported conflicting results between the communities despite the aligned distrust in government oversight. Kamloops respondents who identified as living on rural agricultural land ($p = 0.0269$) or who had completed a university degree or higher ($p = 0.0023$) were significantly more likely to agree with the statement. This response is in stark contrast with Merritt respondents, where those who completed a university degree or higher were more likely to disagree ($p = 0.0407$) with the statement. Respondents concerned about waste management were also significantly more likely to disagree with Kamloops ($p = 0.0536$) and Merritt ($p = 0.0041$). Kamloops responses from those who identified as living on the rural agricultural land remain consistent, supporting the assumption that people with agricultural experience are more likely to understand and accept the practice of land application of biosolids as reported in the 2002 survey completed by Beecher et al. (2004). See Fig. 3 (Appendix Table 6).

Trust—negative statements

Interestingly, for all statements identified as negative and informing trust, Kamloops respondents concerned about waste management were significantly more likely to agree. For Kamloops respondents, this trend is only observed with these negative statements and potentially is consistent with the concept of loss aversion, where people tend to experience loss twice as painful as they experience gains and thus try to avoid a loss more than trying to pursue a similar gain (Samson et al. 2014). As described above, trust requires being vulnerable to risk or loss through actions of another, and framing statements in a way that poses potential harm to human health or contamination of the environment may warrant a more robust emotional response than a reciprocal positive statement. See Fig. 4 (Appendix Tables 7 and 8).

Consistent with both positively and negatively framed statements, Merritt respondents who identified as concerned about waste management were also significantly more likely to agree with the majority of the attitude statements identified as negative and informing trust.

Further to that, in alignment with the above results, Kamloops respondents who identified as living on rural agricultural land are significantly more likely to disagree with these negatively framed statements. The statement, "My family would be at a higher health risk if my neighbours applied animal manure to their land," is the one exception where the responses of Kamloops respondents on rural agricultural land were not significant. This statement, however, was included as a control to assess how respondents perceive animal manure compared to biosolids. Consistent with the above, Merritt female respondents were significantly more likely to agree with the statement. Gender was a significant variable for Kamloops respondents regarding the statement "Not enough is known about biosolids," where females were significantly more likely to agree with the statement than males ($p < 0.0000$). Additionally, those whose wastewater is part of the municipal sewer system and are from Kamloops are significantly more likely to disagree with the majority of the negative trust-related statements (Fig. 4).

Discussion

To assess these results in the context of community approval, we use the community support conceptual framework displayed in Fig. 5. This framework highlights that not only

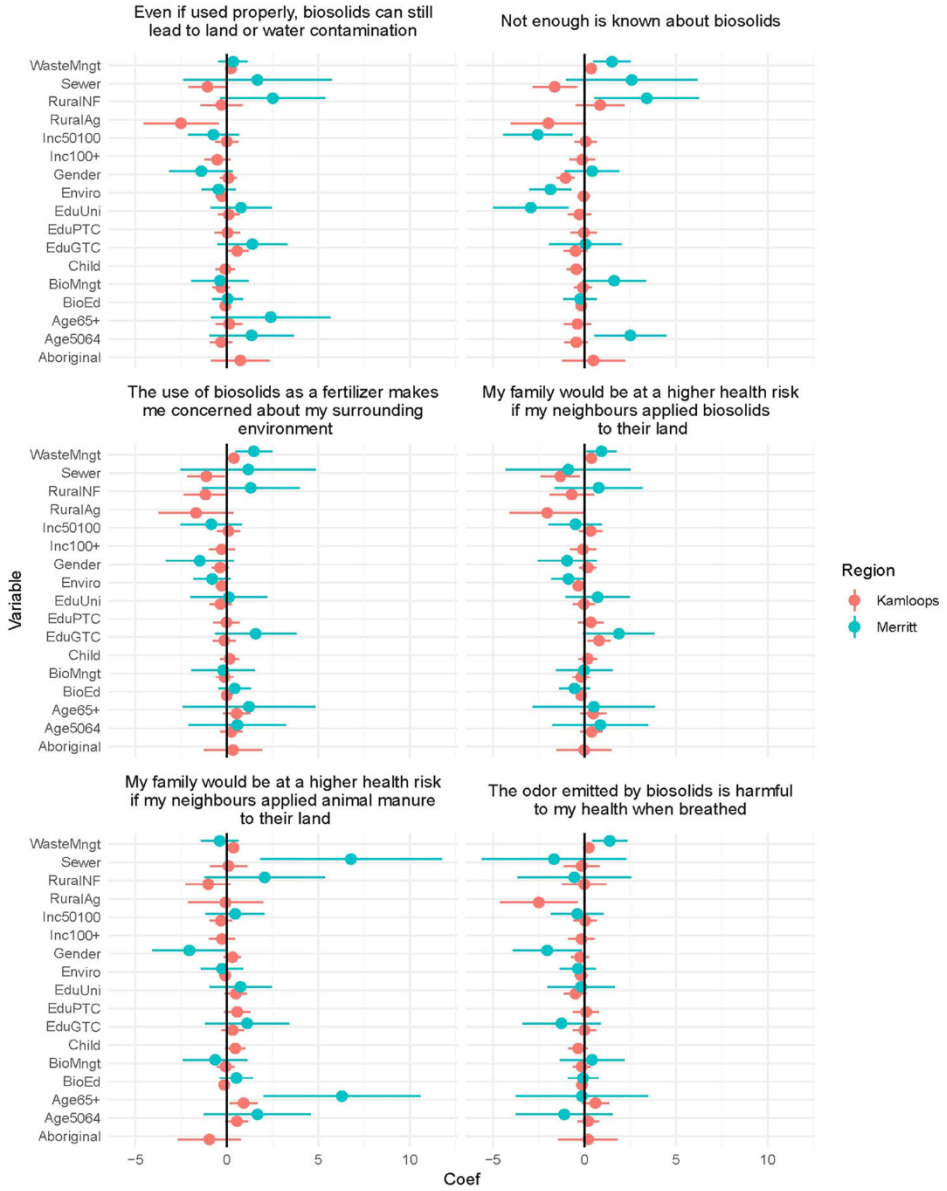

Fig. 4 Trust: Negatively Framed Statements—Ordered Logit regressions. Logistic regression coefficients in log-odds units with 95% confidence intervals. See Appendix Tables 7 and 8 for more details

does the community provide the necessary ongoing support as typically seen in social license models (Boutilier and Thomson 2011; Hall et al. 2015; Thomson 2016; Gehman et al. 2017), but also that the company/project seeks to obtain this support. Public risk perception and lack of transparency on risk management introduce challenges in establishing ongoing community support. Further to this challenge, proponents face social media, where a potential vocal minority uses it as a platform to publicly voice their differing expectations to a broad audience (Gehman et al. 2017).

When considering the roles of legitimacy and trust, legitimacy is necessary for acceptance, but trust is a requirement for approval (Boutilier and Thomson 2011; Goven et al. 2012; Lincoln 2015). Boutilier and Thomson (2011) propose that legitimacy is a necessary but not sufficient condition for trust and that weak community support needs legitimacy, but this introduces the potential for a project to fall through.

Hall et al. (2015) suggest a social gap between public support for the general goal of more "sustainable" practices and the level of local support for specific projects. While the general public remains favorable to the idea of new technologies, host communities are not as supportive. Kamloops and Merritt's responses to this survey support this proposed social gap. Kamloops is more supportive of biosolids projects than Merritt. It is in Merritt where the topic of biosolids had already become a somewhat controversial issue. Additionally, it is essential to consider the legal license (the legal permission to conduct the activity granted by the regulatory agency) as an input into the "Social Capital" required to obtain ongoing community support and the social license to operate. If community

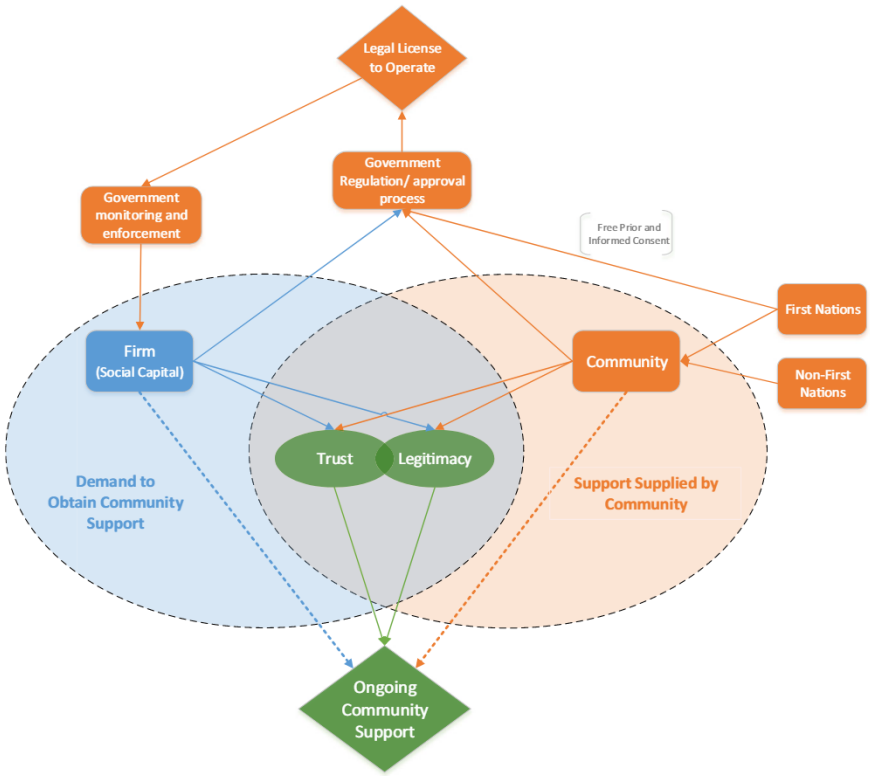

Fig. 5 Community support conceptual framework

members lose faith in the regulatory structure, increased pressure is placed on the project proponent to make up for this gap in their Social Capital.

Kamloops respondents provide a good example of what Boutilier and Thomson (2011) refer to as the basic level of community acceptance. Kamloops respondents prove to support productive uses of biosolids. However, response means for trust statements do not stray too far from "Neutral," suggesting that these views can change as new information is received. Kamloops residents' responses demonstrate this to the statement, "The odor emitted by biosolids is harmful to my health when breathed" ($p = 0.3569$) and "I trust government regulatory agencies to monitor the safe use of biosolids" ($p = 0.0556$), where responses were not different from neutral or where they were only marginally significantly different. This result is further evidence of the perceived lack of knowledge about biosolids.

The opposition exhibited by Merritt residents demonstrates an apparent lack of acceptance for biosolids land application projects. Merritt respondents generally perceived the land application of biosolids to offer unacceptable risk and a low level of value. As proposed above, the project will not even make it to the basic level of community acceptance without legitimacy.

In the case of Kamloops, where there is the potential for establishing legitimacy, projects are more acceptable. Trust, however, cannot be discounted. Without trust, there is a high probability of opposition within the host community.

Host community power, interest, and pressure are of particular interest concerning this region. Within Kamloops and the broader Thompson Nicola Regional District (TNRD), workshops and working groups have evolved to assess biosolids management options (Rothenburger 2018 a,b). While the TNRD has committed to assessing options to eliminate land application within the region, the Kamloops working group members have committed to considering the economic, environmental, and social impacts of different management options and establishing a long-term plan for the city's biosolids. This approach does not exclude the possibility of continued land application. These approaches are consistent generally by the outcomes of this research, where the Lower Nicola Region of the TNRD has placed increasing pressure on all levels of government to move away from the practice of biosolids land application. Although pressure is growing in Kamloops, the opportunity to conduct more proactive engagement on different management practices still exists.

Conclusions

This research supports the notion that the "beyond compliance" approach of conducting early engagement to

obtain community support may be valuable for any potentially controversial natural resource project, such as with biosolids land application projects. Thus, the findings of this survey can assist with designing stakeholder-centric engagement around potentially controversial natural resource projects. Although expectations of each community will differ, several general conclusions to support addressing risk perceptions associated with management and regulation follow next.

Merritt residents reported to be more familiar with biosolids, and subsequent related issues within their community, demonstrated significantly stronger attitudes opposing land application practices than the reportedly less familiar Kamloops residents. Kamloops respondents who were generally more familiar with the term biosolids demonstrated significantly stronger attitudes towards supporting the value biosolids offer as a fertilizer. Given the contrasting results between the two communities, this result suggests that familiarity with biosolids is not necessarily an indicator of support for the land application of biosolids; the context of the familiarity matters.

Kamloops residents who reported to be more concerned with waste management demonstrated significantly stronger attitudes against biosolids land application when attitude statements are in a negative frame. While Merritt respondents reported significantly more significant perceived health risks from biosolids than animal manure, Kamloops respondents generally disagreed that biosolids exposure would lead to increased health risks. Kamloops residents who lived on rural agricultural land had significantly stronger attitudes towards accepting biosolids' land application practices. Women generally perceived significantly higher health and safety risks; this was more prominent within the Merritt community where emotions influence attitudes. Neither community perceives there to be a strong enough body of knowledge on biosolids. There is a general lack of trust in government oversight for land application projects to ensure the safety of human health and the environment. Kamloops respondents support the general idea of recycling biosolids but lack the necessary overall trust for a biosolids project to receive stable social acceptance. Merritt respondents reported that the perceived benefits of biosolids do not outweigh the perceived health and safety risks and that biosolids do not offer value as a fertilizer highlighting a lack of overall community acceptance.

In general, Merritt respondents were polarized in this issue as some segment of their population was very vocal and had strong feelings against biosolids, while others were not as disturbed with biosolids for land applications. In Kamloops, while the media reported that a segment of the population had expressed strong opposition to the land application of biosolids, these concerns had not attracted the same level of community response. In turn, the same level of variability was not observed with Kamloops respondents. The relative size of the two cities may have played a role. This fact may also be a statistical artifact. The sample size of Kamloops was an order of magnitude greater than Merritt, and with greater sample size, the standard deviation will likely be smaller.

The survey results suggest the need for public education programs that clearly outline the potential risks and benefits of biosolids land application. In addition, there is a need for studies to be undertaken by trusted sources that consider the concerns of stakeholders. The proactive approaches are best with the formation of solid relationships amongst the parties. These proactive measures will provide community members the tools to assess the relative benefits and risks and comfort with their level of knowledge to decide on their position regarding biosolids management practices. Furthermore, proactive engagement by biosolids managers and regulators will likely reduce the impact of potentially negative media attention by enabling stakeholder support that is more resistant to ideas projected by critics.

The study's limitations were that some groups might not be evenly distributed within the survey region, thus not being equally represented in these results. In particular, survey respondents did not reflect the demographics in the region., Indigenous community members are underrepresented in this dataset. It is also worth noting that this study focused on the general public perceptions of biosolids management and not on the particular impacted community groups. Although this provides a good baseline for understanding the current state of knowledge, it may be of too broad focus to identify the key factors that resulted in the strong opposition experienced within the Lower Nicola Valley. In addition, Kamloops had a significantly larger dataset than Merritt, which may affect the conclusions due to Merritt's small sample size. Further limitations of the study were that it was conducted in one region and may not apply to areas outside the survey area.

Future work will use the contingent valuation section of our survey to measure the benefits of alternative uses of biosolids in dollar values at the individual level and then aggregated to the community level.

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Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

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Appendix

(Figures 6 and 7; Tables 4–8)

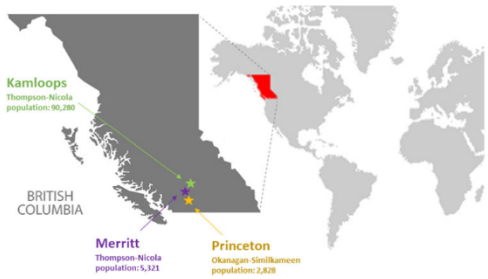

Fig. 6 Map of British Columbia, with the populations of the cities of Kamloops, Merritt and Princeton, within the respective Provincial regions of the Thompson-Nicola and the Okanagan-Similkameen

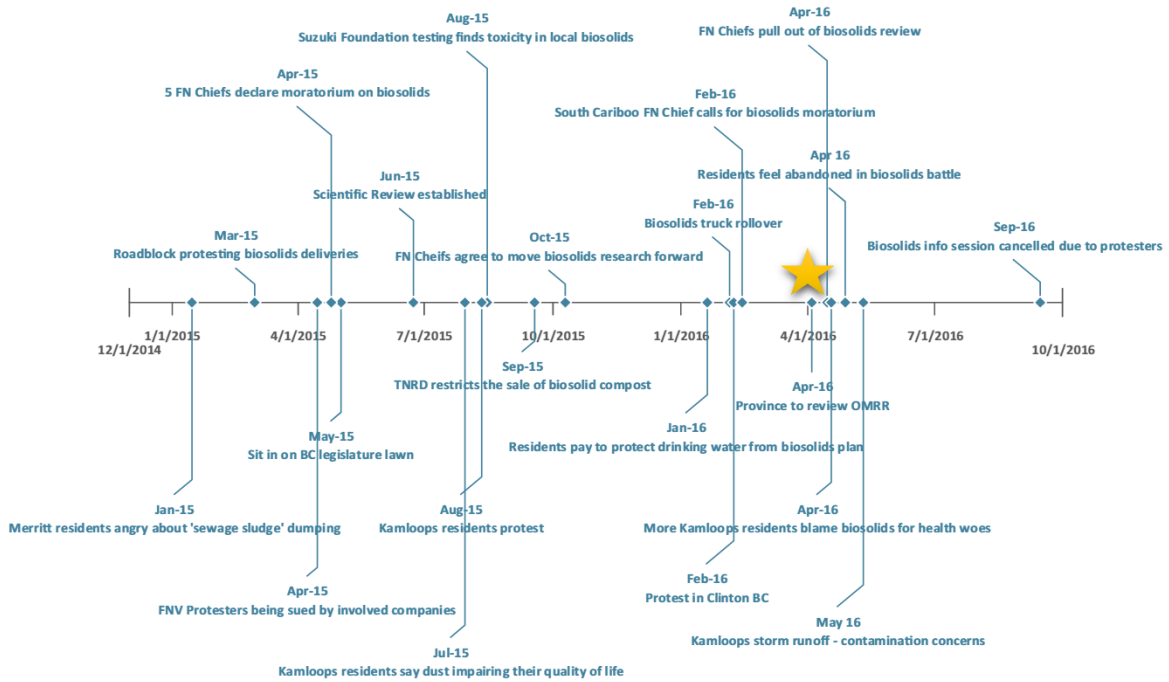

Fig. 7 Timeline of events during survey distribution. Survey distributed—May 2016 (response due June 15, 2016)

Table 4 Legitimacy: positively framed statements—ordered logit regression

Statement ID	Gender	Age5064	Age65+	Child	EduPTC	EduGTC	EduUni	Enviro	RuralNF	RuralAg	Muni-Sewer	Bio-Mngt	Inc50100	Inc100+	Aboriginal	Waste-Mngt	BioEd
Kamloops																	
S1	0.094 (0.237)	0.171 (0.308)	0.508 (0.369)	0.166 (0.265)	−0.372 (0.356)	**−0.594*** (0.322)	0.427 (0.314)	**0.278*** (0.166)	**1.053*** (0.610)	**2.514**** (1.121)	**1.131**** (0.540)	0.016 (0.241)	−0.507 (0.320)	0.124 (0.366)	0.086 (0.865)	−0.139 (0.102)	**0.397***** (0.115)
S3	−0.083 (0.239)	0.038 (0.320)	0.264 (0.378)	−0.038 (0.273)	0.392 (0.368)	−0.218 (0.327)	**0.775**** (0.320)	0.167 (0.167)	0.506 (0.594)	1.032 (1.009)	0.509 (0.523)	0.003 (0.246)	−0.123 (0.316)	**0.867**** (0.367)	−0.393 (0.858)	0.014 (0.104)	0.059 (0.116)
S11	−0.289 (0.239)	0.491 (0.314)	0.543 (0.381)	0.311 (0.272)	0.330 (0.371)	−0.059 (0.325)	−0.111 (0.312)	0.124 (0.165)	0.640 (0.584)	1.504 (1.065)	0.168 (0.534)	−0.220 (0.240)	0.114 (0.319)	0.589 (0.366)	-0.444 (0.789)	0.058 (0.102)	−0.048 (0.113)
Merritt																	
S1	0.993 (0.953)	1.713 (1.374)	0.232 (1.837)	NA	NA	−1.007 (1.046)	−0.353 (0.972)	−0.058 (0.500)	−0.197 (1.442)	NA	0.905 (2.107)	−1.283 (0.881)	−0.967 (0.802)	NA	NA	**−0.836*** (0.482)	−0.007 (0.458)
S3	**2.040**** (0.944)	0.401 (1.264)	–2.624 (1.865)	NA	NA	**−2.037*** (1.096)	−0.276 (0.922)	−0.156 (0.492)	−1.711 (1.350)	NA	−2.566 (2.118)	0.032 (0.839)	−0.787 (0.726)	NA	NA	**−0.885*** (0.475)	−0.287 (0.434)
S11	0.872 (0.826)	1.938 (1.330)	1.486 (1.751)	NA	NA	**−1.078** (1.005)	**−1.909**** (0.880)	−0.410 (0.480)	0.705 (1.215)	NA	1.823 (1.820)	−0.462 (0.824)	0.342 (0.742)	NA	NA	−0.579 (0.426)	0.029 (0.406)

Logistic regression coefficients in log-odds units. Standard errors are given in parenthesis

Description of independent variables can be found in Table 3. The dependent variables are Likert scale responses to the S1, S3, and S11 statements listed in Table 1; S1 refers to the statement "Biosolids are a valuable resource that should be used as a fertilizer"; S3 refers to the statement "Using biosolids as a fertilizer is better than incineration or landfilling"; S11 refers to the statement "Using biosolids as a fertilizer in our community will bring economic benefits". NA stands for "not available".

***$p < 0.01$; **$p < 0.05$; *$p < 0.10$

Table 5 Legitimacy: negatively framed statements—ordered logit regression

Statement ID	Gender	Age5064	Age65+	Child	EduPTC	EduGTC	EduUni	Enviro	RuralNF	RuralAg	Muni-Sewer	Bio-Mngt	Inc50100	Inc100+	Aboriginal	Waste-Mngt	BioEd
Kamloops																	
S10	**−0.449*** (0.233)	0.365 (0.302)	**0.707*** (0.368)	0.226 (0.255)	**0.624*** (0.346)	0.338 (0.311)	−0.478 (0.305)	−0.227 (0.163)	−0.292 (0.564)	−1.032 (1.014)	−0.474 (0.515)	0.029 (0.239)	**0.631**** (0.319)	0.188 (0.360)	0.335 (0.752)	0.136 (0.100)	**−0.204**** (0.113)
Merritt																	
S10	**−2.425**** (0.951)	−0.709 (1.418)	1.905 (1.957)	NA	NA	**2.549**** (1.164)	0.741 (0.919)	−0.305 (0.503)	0.277 (1.359)	NA	1.553 (1.942)	0.178 (0.870)	−0.257 (0.746)	NA	NA	**1.370***** (0.519)	−0.142 (0.431)

Logistic regression coefficients in log-odds units. Standard errors are given in parenthesis

***$p < 0.01$; **$p < 0.05$; *$p < 0.10$

[a]Variables did not cover enough respondents in the Merritt dataset. Description of independent variables can be found in Table 3. The dependent variables are Likert scale responses to the S10 statement listed in Table 1; S10 refers to the statement "The risks to public health of using biosolids as a fertilizer outweigh the benefits"

Table 6 Trust: positively framed statements—ordered logit regressions

Statement ID	Gender	Age5064	Age65+	Child	EduPTC	EduGTC	EduUni	Enviro	RuralNF	RuralAg	Muni-Sewer	Bio-Mngt	Inc50100	Inc100+	Aboriginal	Waste-Mngt	BioEd
Kamloops																	
S5	−0.381 (0.238)	0.010 (0.306)	0.321 (0.371)	−0.137 (0.263)	0.549 (0.362)	−0.084 (0.326)	0.333 (0.307)	−0.075 (0.163)	0.131 (0.593)	**3.037***** (1.019)	0.563 (0.557)	0.154 (0.240)	−0.360 (0.326)	−0.012 (0.372)	−0.130 (0.898)	−0.106 (0.102)	0.053 (0.112)
S8	−0.055 (0.230)	0.200 (0.302)	0.256 (0.375)	−0.028 (0.266)	0.199 (0.350)	0.326 (0.309)	**0.931***** (0.305)	−0.164 (0.160)	−0.467 (0.581)	**2.092**** (0.945)	0.132 (0.508)	0.151 (0.233)	−0.301 (0.316)	0.211 (0.358)	0.531 (0.746)	**−0.195*** (0.101)	0.013 (0.109)
Merritt																	
S5	**1.969**** (0.873)	0.743 (1.380)	−0.966 (1.827)	NA	NA	**−3.176***** (1.200)	**−1.976**** (0.955)	**1.043*** (0.534)	−1.297 (1.266)	NA	0.694 (1.827)	−0.315 (0.812)	0.437 (0.783)	NA	NA	**−1.379***** (0.515)	0.198 (0.410)
S8	0.813 (0.831)	0.665 (1.256)	−0.392 (1.727)	NA	NA	**−2.022*** (1.127)	**−2.030**** (0.992)	0.637 (0.505)	−0.913 (1.245)	NA	0.299 (1.797)	0.797 (0.871)	**1.216*** (0.726)	NA	NA	**−1.508***** (0.526)	-0.040 (0.447)

Logistic regression coefficients in log-odds units. Standard errors are given in parenthesis

***$p < 0.01$; **$p < 0.05$; *$p < 0.10$

[a]Variables did not cover enough respondents in the Merritt dataset. Description of independent variables can be found in Table 3. The dependent variables are Likert scale responses to the S5 and S8 statements listed in Table 1; S5 refers to the statement "Biosolids receive adequate treatment at the wastewater treatment plant to protect public health". S8 refers to the statement "I trust government regulatory agencies to monitor the safe use of biosolids"

Table 7 Trust: negatively framed statements—kamloops ordered logit regressions

Statement ID	Gender	Age5064	Age65+	Child	EduPTC	EduGTC	EduUni	Enviro	RuralNF	RuralAg	Muni-Sewer	Bio-Mngt	Inc50100	Inc100+	Aboriginal	Waste-Mngt	BioEd
S2	**−1.033***** (0.242)	−0.447 (0.317)	−0.384 (0.375)	**−0.450*** (0.267)	−0.035 (0.355)	−0.487 (0.319)	−0.275 (0.310)	−0.044 (0.171)	0.853 (0.659)	**−1.975*** (1.024)	**−1.627***** (0.600)	−0.093 (0.240)	0.067 (0.306)	−0.127 (0.349)	0.490 (0.855)	**0.363***** (0.104)	−0.176 (0.116)
S4	−0.374 (0.231)	0.237 (0.299)	0.531 (0.368)	0.151 (0.258)	−0.024 (0.352)	−0.141 (0.312)	−0.352 (0.298)	**−0.279*** (0.163)	**−1.173**** (0.578)	**−1.690*** (1.024)	**−1.126**** (0.507)	−0.126 (0.236)	0.084 (0.311)	−0.281 (0.354)	0.329 (0.796)	**0.379***** (0.101)	−0.002 (0.111)
S6	0.177 (0.231)	0.385 (0.299)	0.479 (0.357)	0.180 (0.254)	0.341 (0.343)	**0.795**** (0.312)	−0.037 (0.302)	**−0.329**** (0.164)	−0.697 (0.604)	**−2.039**** (1.030)	**−1.316**** (0.530)	−0.175 (0.237)	0.338 (0.312)	−0.079 (0.351)	−0.020 (0.747)	**0.379***** (0.101)	−0.178 (0.111)
S7	0.298 (0.233)	**0.542*** (0.310)	**0.916**** (0.373)	**0.460*** (0.266)	0.564 (0.351)	0.317 (0.308)	0.487 (0.304)	−0.094 (0.162)	**−1.022*** (0.611)	−0.077 (1.024)	0.091 (0.511)	−0.069 (0.234)	−0.329 (0.315)	−0.271 (0.355)	−0.962 (0.862)	**0.359***** (0.102)	−0.146 (0.109)
S9	−0.238 (0.235)	0.204 (0.299)	0.601 (0.370)	−0.340 (0.262)	0.088 (0.355)	−0.003 (0.317)	−0.496 (0.306)	−0.182 (0.174)	−0.015 (0.600)	**−2.496**** (1.054)	−0.152 (0.490)	−0.151 (0.239)	0.033 (0.312)	−0.171 (0.354)	0.200 (0.810)	**0.241**** (0.105)	−0.133 (0.109)
S12	0.086 (0.229)	−0.315 (0.299)	0.127 (0.364)	−0.082 (0.261)	0.030 (0.348)	**0.556*** (0.308)	0.106 (0.299)	**−0.275*** (0.162)	−0.297 (0.565)	**−2.504**** (1.019)	**−1.065**** (0.512)	−0.315 (0.240)	−0.006 (0.311)	−0.528 (0.355)	0.737 (0.789)	**0.224**** (0.098)	−0.085 (0.110)

Logistic regression coefficients in log-odds units. Standard errors are given in parenthesis

Description of independent variables can be found in Table 3. The dependent variables are Likert scale responses by Kamloops participants to the S2, S4, S6, S7, S9, and S10 statements listed in Table 1; S2 refers to the statement "Not enough is known about biosolids"; S4 refers to the statement "The use of biosolids as a fertilizer makes me concerned about my surrounding environment"; S6 refers to the statement "My family would be at a higher health risk if my neighbours applied biosolids to their land". S7 refers to the statement "My family would be at a higher health risk if my neighbours applied animal manure to their land". S9 refers to the statement "The odor emitted by biosolids is harmful to my health when breathed". S12 refers to the statement "Even if used properly, biosolids can still lead to land or water contamination"

***$p < 0.01$; **$p < 0.05$; *$p < 0.10$

Table 8 Trust: negatively framed statements—merritt ordered logit regressions

Statement ID	Gender	Age5064	Age65+	Child	EduPTC	EduGTC	EduUni	Enviro	RuralNF	RuralAg	Muni-Sewer	Bio-Mngt	Inc50100	Inc100+	Aboriginal	Waste-Mngt	BioEd
S2	0.419 (0.738)	**2.508**** (0.982)	NA[a]	NA	NA	0.052 (0.994)	**−2.932***** (1.024)	**−1.861***** (0.570)	**3.402**** (1.433)	NA	2.585 (1.788)	**1.622*** (0.859)	**−2.552***** (0.944)	NA	NA	**1.5067**** (0.5116)	−0.2319 (0.456)
S4	−1.482 (0.927)	0.569 (1.324)	1.209 (1.802)	NA	NA	1.576 (1.115)	0.109 (1.052)	−0.803 (0.501)	1.303 (1.334)	NA	1.168 (1.852)	−0.203 (0.870)	−0.854 (0.837)	NA	NA	**1.472***** (0.500)	0.421 (0.436)
S6	−0.951 (0.802)	0.864 (1.309)	0.513 (1.670)	NA	NA	**1.882*** (0.974)	0.722 (0.876)	**−0.879*** (0.463)	0.773 (1.198)	NA	−0.885 (1.710)	−0.017 (0.770)	−0.493 (0.726)	NA	NA	**0.929**** (0.416)	−0.541 (0.415)
S7	**−2.053**** (1.005)	1.673 (1.460)	**6.287***** (2.138)	NA	NA	1.107 (1.145)	0.739 (0.849)	−0.266 (0.566)	2.063 (1.640)	NA	**6.778***** (2.479)	−0.644 (0.875)	0.454 (0.804)	NA	NA	−0.393 (0.507)	0.517 (0.462)
S9	**−2.036**** (0.932)	−1.103 (1.317)	−0.143 (1.805)	NA	NA	−1.256 (1.068)	−0.189 (0.921)	−0.359 (0.484)	−0.552 (1.552)	NA	−1.667 (1.967)	0.410 (0.879)	−0.391 (0.718)	NA	NA	**1.376***** (0.484)	−0.076 (0.417)
S12	−1.400 (0.863)	1.350 (1.156)	2.398 (1.631)	NA	NA	1.393 (0.953)	0.767 (0.834)	−0.459 (0.462)	2.513 (1.437)	NA	1.669 (2.025)	−0.374 (0.785)	**−0.738*** (0.694)	NA	NA	0.334 (0.393)	0.044 (0.414)

Logistic regression coefficients in log-odds units. Standard errors are given in parenthesis

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

[a]Variables did not cover enough respondents in the Merritt dataset. The dependent variables are Likert scale responses by Merritt participants to the S2, S4, S6, S7, S9, and S10 statements listed in Table 1; S2 refers to the statement "Not enough is known about biosolids"; S4 refers to the statement "The use of biosolids as a fertilizer makes me concerned about my surrounding environment"; S6 refers to the statement "My family would be at a higher health risk if my neighbours applied biosolids to their land". S7 refers to the statement "My family would be at a higher health risk if my neighbours applied animal manure to their land". S9 refers to the statement "The odor emitted by biosolids is harmful to my health when breathed". S12 refers to the statement "Even if used properly, biosolids can still lead to land or water contamination"

References

Amajirionwu M, Connaughton N, McCann B, Moles R, Bartlett J, O'Regan B (2008) Indicators for managing biosolids in Ireland. J Environ Manag 88(4):1361–1372. https://doi.org/10.1016/j.jenvman.2007.07.003

Antonelli PM, Fraser LH, Gardner WC, Broersma K, Karakatsoulis J (2018) Long term carbon sequestration potential of biosolids-amended copper and molybdenum mine tailings following mine site reclamation. Ecol Eng 117:38–49

Beecher N, Harrison E, Goldstein N, McDaniel M, Field P, Susskind L (2005) Risk perception, risk communication, and stakeholder involvement for biosolids management and research. J Environ Qual 34(1):122–128. https://doi.org/10.2134/jeq2005.0122

Beecher N, Connell B, Epstein E, Filtz J, Goldstein N, Lono M (2004) Public Perception of Biosolids Recycling: Developing Public Participation and Earning Trust. Water Environment Research Foundation, Alexandria, VA

Borden GW, Devitt DA, Morris RL, Robinson ML, Lopez J (2004) Residential assessment and perception toward biosolids compost use in an urban setting. Compost Sci utilization 12(1):48–54. https://doi.org/10.1080/1065657X.2004.10702157

Boutilier RG, Black LD, Thomson I (2012) From Metaphor to Management Tool—How the Social License to Operate can Stabilise the Socio-Political Environment for Business. In: International Mine Management 2012 Proceedings. Australia Institute of Mining and Metallurgy, Melbourne, pp 227–237.

Boutilier RG, Thomson I (2011) Modeling and Measuring the Social License to Operate: Fruits of a Dialogue Between Theory and Practice. In: Internation Mine Management Conference. Queensland.

Brisolara KF, Qi Y (2013) Biosolids and sludge management. Water Environ Res 85(10):1283–1297. https://www.jstor.org/stable/25044907

Canadian Council of Ministers of the Environment (2012). Canada-wide Approach for the Management of Wastewater Biosolids, version PN 1477. https://ccme.ca/en/res/biosolids_cw_approach_e.pdf

Coase RH (1960) The problem of social cost. J Law Econ 3:1–44

Collivignarelli MC, Abbà A, Benigna I (2020) The reuse of biosolids on agricultural land: critical issues and perspective. Water Environ Res 92(1):11–25. https://doi.org/10.1002/wer.1196

Collivignarelli MC, Abbà A, Frattarola A, Carnevale Miino M, Padovani S, Katsoyiannis I, Torretta V (2019) Legislation for the Reuse of Biosolids on Agricultural Land in Europe: Overview. Sustainability 11(21):6015. https://doi.org/10.3390/su11216015

Dillman DA (1991) The design and administration of mail surveys. Annu Rev Sociol 17:225–249. https://doi.org/10.1146/annurev.so.17.080191.001301

Dillman DA, Smyth JD, Christian LM (2014) Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method. Fourth. Wiley, Hoboken, New Jersey

Eggers S, Thorne S (2017) Conducting Effective Outreach with Community Stakeholders About Biosolids: A Customized Strategic Risk Communications Process™ Based on Mental Modeling. In Mental Modeling Approach. Springer, New York, NY, p 153–177

Forste JB (1994) Gaining public acceptance for biosolids. Sewage Sludge: Land Utilization and the Environment, 81–85. https://doi.org/10.2134/1994.sewagesludge.c12

Gale, AJ (2007) The Australasian biosolids partnership and public perceptions. Water Practice and Technology, 2(4). https://doi.org/10.2166/wpt.2007.081

Goodman JR, Goodman BP (2006) Beneficial or biohazard? How the media frame biosolids. Public Underst Sci 15(3):359–375. https://doi.org/10.1177/0963662506062468

Gehman J, Lefsrud LM, Fast S (2017) Social license to operate: Legitimacy by another name? Canadian Public Administration 60:293–317

Goven J, Langer EL (2009) The potential of public engagement in sustainable waste management: designing the future for biosolids in New Zealand. J Environ Manag 90(2):921–930. https://doi.org/10.1016/j.jenvman.2008.02.006

Goven J, Langer ERL, Baker V, Ataria J, Leckie A (2012) Community engagement in the management of biosolids: lessons from four New Zealand studies. J Environ Manag 103:154–64. https://doi.org/10.1016/j.jenvman.2012.02.007

Hébert M (2007) Public acceptance and independent certification of biosolids in Canada. Water Practice and Technology, 2(4). https://doi.org/10.2166/wpt.2007.084

Hall N, Lacey J, Carr-cornish S, Dowd A (2015) Social licence to operate: understanding how a concept has been translated into practice in energy industries. J Clean Prod 86:301–310. https://doi.org/10.1016/j.jclepro.2014.08.020

Krogmann U, Gibson V, Chess C (2001) Land application of sewage sludge: perceptions of New Jersey vegetable farmers. Waste Manag Res 19(2):115–125. https://doi.org/10.1177/0734242X0101900204

Lincoln A (2015) Rethinking Social Licence to Operate—A Concept in Search of Definition and Boundaries. Bus Counc BC: Environ Energy Bull 7:1–10

Lindsay BE, Zhou H, Halstead JM (2000) Factors influencing resident attitudes regarding the land application of biosolids. Am J Alternative Agric 15(2):88–95. https://doi.org/10.1017/S0889189300008547

Lynch-wood G, Williamson D (2018) The Social Licence as a Form of Regulation for Small and Medium Enterprises. J Law Soc 34:321–341. https://www.jstor.org/stable/20109752

McCarthy L, Loyo-Rosales JE (2015) Risks Associated with Application of Municipal Biosolids to Agricultural Lands in a Canadian Context—Literature Review. Canadian Municipal Water Consortium, Canadian Water Network. 226 pp. https://cwn-rce.ca/wp-content/uploads/2015/08/McCarthy-Risks-Biosolids-2015.pdf

Mason-Renton S, Luginaah I (2016) Interfering with therapeutic tranquility: Debates surrounding biosolid waste processing in rural Ontario. Health place 41:42–49. https://doi.org/10.1016/j.healthplace.2016.07.004

Moffat K, Zhang A (2014) The paths to social licence to operate: An integrative model explaining community acceptance of mining. Resour Policy 39:61–70. https://doi.org/10.1016/j.resourpol.2013.11.003

Moya B, Parker A, Sakrabani R (2019) Challenges to the use of fertilisers derived from human excreta: The case of vegetable exports from Kenya to Europe and influence of certification systems. Food Policy 85:72–78. https://doi.org/10.1016/j.foodpol.2019.05.001

National Research Council (2002) Biosolids applied to land: Advancing standard practices. Crossgrove RE, editor. Washington, DC: National Academy Press.

Potestio M (2015) Group of 19 residents purchase BioCentral's Dry Lake property. Merritt Herald. Merritt, British Columbia, Canada. https://www.merrittherald.com/group-of-19-residents-purchase-biocentrals-dry-lake-property/

Pritchard DL, Penney N, McLaughlin MJ, Rigby H, Schwarz K (2010) Land application of sewage sludge (biosolids) in Australia: risks to the environment and food crops. Water Sci Technol 62 (1):48–57. https://doi.org/10.2166/wst.2010.274

Oberg G, Mason-Renton SA (2018) On the limitation of evidence-based policy: Regulatory narratives and land application of biosolids/sewage sludge in BC, Canada and Sweden. Environ Sci policy 84:88–96. https://doi.org/10.1016/j.envsci.2018.03.006

Potestio M (2014) Concern over biosolids spreading. Merritt Herald:1–3. https://issuu.com/merritt-herald/docs/dec._11_full_document/1

Robinson KG, Robinson CH (2006) Biosolids recycling: An assessment of public perception and knowledge. Proceedings of the Water Environment Federation, 2006(12), pp.1070–1077. https://d3pcsg2wjq9izr.cloudfront.net/files/5306/articles/8731/080.pdf

Robinson KG, Robinson CH, Raup LA, Markum TR (2012) Public attitudes and risk perception toward land application of biosolids within the south-eastern United States. J Environ Manag 98:29–36. https://doi.org/10.1016/j.jenvman.2011.12.012

Rothenburger M (2018a) BIOSOLIDS—Kamloops sets up committee on 'management options.' ArmchairMayor.ca, May 4, Kamloops, British Columbia, Canada

Rothenburger M (2018b) TNRD – All-day session to look at alternatives to putting biosolids on land. ArmchairMayor.ca, May 25, Kamloops, British Columbia, Canada

Samson A, Loewenstein G, Sutherland R (2014) The Behavioural Economics Guide 2014. First Edit. Samson A, editor. Retrieved from http://www.behavioraleconomics.com

Sanchez ME (1992) Effects of Questionnaire Design on the Quality of Survey Data. Public Opin Q 56:206–217. https://doi.org/10.1086/269311

Sax LJ, Gilmartin SK, Bryant AN (2003) Assessing response rates and nonresponse bias in web and paper surveys. Research in Higher Education 44:409–433

Statistics Canada (2011) Census of Population Data. [Data Visualization Tool]. https://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E

Thomson GC (2016) Management of socio-political risk arising from corporate transitions: the Mt. Milligan experience. University of British Columbia

Youngquist CP, Goldberger JR, Doyle J, Jones SS (2015) Public involvement in waste management research and decision-making: A case study. Regional Sci Policy Pract 7:103–161. https://doi.org/10.1111/rsp3.12061