Source management initiatives and factors influencing biosolids quality

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Abstract: The Greater Vancouver Regional District (GVRD) has five wastewater treatment plants (WWTP), treating 1,200 megalitres per day (MLD) of wastewater and producing 75,000 bulk tonnes of biosolids annually. As part of its Liquid Waste Management Plan, the GVRD sought to determine linkages between source management initiatives and biosolids quality. A study was conducted investigating biosolids quality achieved in similarly sized jurisdictions and the factors that influenced this quality. Eleven jurisdictions (nine from North America and one from both Australia and New Zealand) were selected for inclusion in the study. A survey was distributed to each jurisdiction, requesting information on wastewater treatment processes, biosolids management, regulatory and source management frameworks, source management initiatives and data on wastewater influent and effluent quality, biosolids and drinking water. Biosolids quality from the GVRD’s Annacis Island WWTP was generally comparable to other participating jurisdictions with the exception of elevated mercury and copper concentrations. A reduction in biosolids mercury concentration can be realized by dental industry specific initiatives. Several jurisdictions have experienced reductions of up to 50% in biosolids mercury concentrations by implementing source management initiatives requiring the separation of mercury-containing dental amalgam from wastewater. Continued buffering of drinking water should further decrease copper concentrations.

Keywords: Copper, mercury, regulations, source management, wastewater

INTRODUCTION

The Greater Vancouver Regional District is Canada’s third largest urban region, and is home to approximately 2 million people. The GVRD’s five wastewater treatment plants (WWTPs) treat an average of 1,200 megalitres (MLD) of wastewater and produce approximately 75,000 bulk tonnes of biosolids annually. The GVRD produces both Class A and Class B biosolids, as defined in the Organic Matter Recycling Regulation (OMRR), the regulation governing biosolids production and use in British Columbia (British Columbia Ministry of Water, Land and Air Protection, 2002).

The Nutrifor Program manages biosolids produced at the GVRD’s five WWTPs. The majority of the GVRD’s biosolids are produced as dewatered cake that is hauled directly to land application sites. Approximately 17% of the biosolids produced is stored in lagoons and land dried for future use. In 2005, 70% of the biosolids recycled was used for land reclamation at mine sites, 10% for ranch fertilization, 10% for landfill cover, and the remainder for gravel pit reclamation and development of soil products for urban landscaping. The GVRD’s largest biosolids recycling program is at Highland Valley Copper, Canada’s largest open-pit mining operation, located approximately 350 km (220 miles) northeast of Vancouver.

Improvement of biosolids quality is an ongoing challenge and priority of WWTP operators and biosolids generators. Higher quality biosolids are often subject to less stringent regulatory requirements. Eased regulations regarding land application and distribution; and site management restrictions increase biosolids management and recycling opportunities, including their use in value-added products such as compost, fabricated soils, and organic-based fertilizers. Stakeholder perception of biosolids improves if it can be demonstrated that biosolids are produced that comply with the most stringent standard applicable to the protection of human health and the environment.
Wastewater source management refers to initiatives or procedures that are undertaken to improve the quality and decrease the quantity of wastewater entering treatment works. Source management is viewed as an essential and sustainable feature of WWTP management. Specifically, goals of source management include (NRC, 2002):

- the management of demand through user fees, thereby delaying needs for infrastructure upgrades or expansion;
- the protection of sewerage and WWTP operators/employees by limiting the discharge of substances that pose flammable, explosive or toxic hazards;
- minimizing damage to collection systems by limiting the discharge of corrosive materials and/or materials that may constrict the sewer and cause blockages;
- limiting the discharge of environmentally deleterious materials or substances that may not be effectively removed by wastewater treatment (e.g. trace organics);
- the improvement in the quality of effluent discharges; and
- an improvement in the quality of biosolids.

The term trace element is used to refer to typically undesirable constituents in biosolids. Some trace elements are metals, others are metalloids, and some are neither (e.g. selenium is considered a “non-metal”). Source management initiatives seek to reduce or eliminate trace element discharge to wastewater in order to improve biosolids quality and effluent discharges to the environment. While other factors (e.g. trace organic compounds, fertility and microbiological parameters) contribute to biosolids quality, this project was limited to investigating factors influencing trace element concentrations in wastewater and biosolids.

Eleven trace elements are most commonly regulated under biosolids management regulations. They are: arsenic, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium and zinc. While most trace elements are essential micronutrients at varying concentrations, elevated concentrations in wastewater and biosolids are of concern for a number of reasons. Elevated concentrations of some trace elements can inhibit microbial processes and disrupt the wastewater treatment system (Metcalf and Eddy, 2003). Trace elements are an important determinant of biosolids quality. Regulations governing biosolids use typically categorize biosolids based, in part, on trace element concentrations. Trace element concentrations in biosolids can affect management decisions and beneficial recycling opportunities. Biosolids trace element concentrations can limit land application where post-application soil quality is regulated (McDougall, Van Ham et al., 2002) and/or where tracking of cumulative or annual trace element additions to soil is required.

Project Objectives

The GVRD has developed a Liquid Waste Management Plan (LWMP) (GVRD, 2001). One of the requirements in the LWMP included investigating the linkages between biosolids quality and the effectiveness of source management. This investigation, in combination with other initiatives, will augment the LWMP and assist the GVRD in managing its biosolids for the next 50 years.

Adhering to the principles of sound environmental stewardship and committed to regional sustainability, the GVRD is exploring opportunities to further improve biosolids quality by determining constituents of concern, understanding the sources of these constituents, and identifying opportunities and methodologies (initiatives) to reduce these constituents of concern in GVRD biosolids. The project had three primary objectives. The first objective was to complete a comprehensive review of biosolids quality achieved in other jurisdictions. This included a comparison of current biosolids quality and the identification of biosolids quality trends through the examination of historical biosolids quality data. The second objective was to identify factors that contributed to the biosolids quality reported by each jurisdiction. This involved the analysis and review of biosolids regulations, sewer use bylaws and other source management initiatives. Based on these findings, the third objective was to identify source management opportunities that the GVRD may pursue to improve biosolids quality.
METHODOLOGY
The first stage of the project identified jurisdictions for the investigation. At the outset of the project, consideration for inclusion in the project was given to those jurisdictions which:

- operated a source management program to protect or enhance the quality of biosolids for beneficial use or purpose;
- recycled or intended to recycle 30% or more of its biosolids production as fertilizer, fertilizer products, or soil products;
- engaged to some degree in biosolids management planning to anticipate future needs and develop sustainable biosolids management options; and
- preferably served a similar size community containing a mix of industrial and commercial activity.

Based on these requirements and conditions, 37 jurisdictions representing 7 countries were initially identified as candidates for the project. Many of these jurisdictions were successfully contacted and provided a short document that outlined the objectives of the project, identified the scope and extent of the data and information that would be requested, the timeline for submission of this material, the follow-up interview process and the opportunity for participants to obtain a copy of the final report. Seventeen jurisdictions were shortlisted as potential candidates. From this list a subset of 11 jurisdictions were selected for the final survey. The selected jurisdictions best met the requirements for participation. An important aspect of this project was the analysis and interpretation of drinking water, wastewater and biosolids data. The jurisdictions selected for the project best indicated their willingness to provide the requested data and supplemental information to achieve the objectives of the project. The participating jurisdictions are listed below.

- Greater Vancouver Regional District
- City of Edmonton, Alberta, Canada
- City of Toronto, Ontario, Canada
- City of Los Angeles, California, USA
- City of Philadelphia, Pennsylvania, USA
- City of Portland, Oregon, USA
- City of Tacoma, Washington, USA
- King County (Seattle, Washington, USA)
- Metropolitan Milwaukee Sewerage District (Milwaukee, Wisconsin, USA)
- Christchurch, New Zealand
- Perth, Australia

Information on source management initiatives and biosolids quality from the participating jurisdictions was collected through the distribution of a survey. The survey was comprehensive and was divided into sections to facilitate completion. The primary contact was able to distribute sections to colleagues and departments capable of providing the required information.

As most jurisdictions had more than one WWTP, they generally provided information and data associated with their largest WWTP. In instances where the jurisdiction had WWTPs of similar size, the jurisdiction provided the information for the WWTP that produced the highest quality biosolids and/or the WWTP whose wastewater and biosolids quality have been most influenced by source management initiatives.

The first part of the survey requested background information from the selected WWTP. Jurisdictions provided general information on wastewater collection and treatment. Wastewater collection information included average daily flow and wastewater composition (i.e. percent contribution of residential, industrial, commercial and institutional wastewater flow). Drinking water data from the most recent annual report and wastewater influent and effluent data from the most recent 5 years were requested. These data were provided for analysis and the observed reported quality considered as factors contributing to biosolids quality.
The GVRD’s Annacis Island WWTP (AIWWTP) was selected for comparison in this study. The AIWWTP treats approximately 460 MLD of wastewater and has a design capacity to treat 580 MLD of wastewater. The collection system serving AIWWTP is 90% separate sanitary sewers and 10% combined storm and sanitary sewers. The wastewater consists of 60% residential wastewater, 20% industrial/commercial/institutional (ICI) wastewater, with inflow and infiltration estimated at 20%. The ICI component is discharged primarily from forest products manufacturing, food processing, landfill operations, metal finishing facilities, chemical processing and petroleum distribution operations.

The second part of the survey focused on biosolids quality and source management. Information requested in this section of the survey included a description of regulations governing biosolids use in each jurisdiction, including biosolids trace element limits. The jurisdictions provided information on biosolids quality, including recent trace element concentration data for five consecutive years of monitoring. Generally, the jurisdictions submitted biosolids quality data from 2001-2005. A section on biosolids quality management requested information on long-term biosolids quality trends and the factors influencing quality. Jurisdictions submitted information on source management initiatives including the status of the initiative and the observed or expected effects on biosolids quality.

Information on the jurisdiction’s source management framework was provided. Each jurisdiction provided information on their sewer use bylaw (or similarly titled wastewater discharge regulation), including information on applicability, criteria for issuing wastewater discharge permits, rationale for discharge limits, assessment of user fees and information on audit sampling, monitoring, enforcement and compliance.

The synthesis of the information gained from the survey was the most vital component of this project. A large amount of data was received from the survey. The survey responses, including analytical results, were compiled into tabular form by jurisdiction. Outstanding technical reports, biosolids management plans, regulations and related documents were identified and obtained. Current biosolids quality was compared and biosolids quality trends were identified. Biosolids quality and source management initiatives were compared, as were current and potential regulatory initiatives. Analyses of the different constituents (trace elements and synthetic organic compounds) were compared with other studies in the context of biosolids quality improvements. Biosolids management planning initiatives were reviewed and summarized, including current challenges and initiatives to address these challenges. From the synthesis GVRD biosolids quality was compared against the biosolids quality provided by the participating jurisdictions, and biosolids improvement opportunities were identified based on the experiences of the other participating jurisdictions.

**RESULTS**

**Current Biosolids Quality**

GVRD AIWWTP biosolids is in compliance with the OMRR Class A biosolids trace element limits; Class A biosolids are the highest quality biosolids obtainable under the OMRR. With the exception of mercury, GVRD biosolids are generally well below the OMRR Class A limits. Variation in mercury levels to the upside can approach the 5 mg kg⁻¹ Class A limit. Molybdenum is also closer to the Class A limit than is the case with other trace elements. The annual mean trace element concentrations in AIWWTP biosolids are generally comparable with the biosolids generated by other participating jurisdictions with the exception of mercury and copper. Figures 1 and 2 present a comparison of current biosolids quality for mercury and copper respectively. Data points in the figures represent the mean annual average from the most recent year’s data provided by each jurisdiction. The mean reference line represents the average across all surveyed jurisdictions and the error bars represent minimum and maximum values to reflect variability (SYLVIS, 2007). Additional reference lines represent regulatory limits for Class A and/or B biosolids as defined in the OMRR, or pollutant concentration limits for biosolids as provided in the USEPA 40 CFR Part 503 – Standards for the use and disposal of sewage sludge (USEPA, 1993).
Oppportunities to Improve Biosolids Quality

The concentration of copper and mercury in AIWWTP biosolids are generally higher in comparison with other jurisdictions. Elevated concentrations of these trace elements in the AIWWTP biosolids present specific challenges to biosolids management. Besides nutrients, copper is a constituent in biosolids that limits application rates. Elevated mercury concentrations in AIWWTP biosolids are approaching the OMRR Class A limit of 5 mg kg⁻¹. Exceeding this limit would be detrimental, resulting in increased management requirements and reduced market opportunities.

The copper concentration in AIWWTP biosolids is currently trending downward and will be further reduced with ongoing pH adjustments to source water. A primary source of copper contamination in wastewater is from the corrosion of copper pipe used in the drinking water distribution system; corrosion of copper pipe is exacerbated.
by low pH water. Increasing the pH of the drinking water mitigates this corrosive process. The improvement opportunity for copper concentrations in AIWWTP biosolids remains significant. The current average copper concentration in AIWWTP biosolids of 1,130 mg kg\(^{-1}\) is considerably higher than the average concentration measured from the participating jurisdictions of approximately 700 mg kg\(^{-1}\) (SYLVIS, 2007).

The GVRD is proposing an amendment to its sewer use bylaw to require mandatory use of mercury amalgam separators in dental offices. Many jurisdictions have demonstrated the effectiveness of this source management measure in achieving mercury reductions in wastewater and biosolids. Similar regulatory initiatives in Toronto, Portland, King County and Christchurch have, in some cases, resulted in approximately 50% reductions in biosolids mercury concentrations 1-2 years following implementation. Table 1 summarizes mercury concentration trends in the GVRD and in jurisdictions that have recently implemented dental amalgam separation source management initiatives.

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>GVRD</td>
<td>3.20</td>
<td>3.00</td>
<td>3.30</td>
<td>3.40</td>
<td>3.20 Stable</td>
</tr>
<tr>
<td>Toronto</td>
<td>2.30</td>
<td>1.17</td>
<td>1.10</td>
<td>1.10</td>
<td>Decreasing</td>
</tr>
<tr>
<td>Portland</td>
<td>2.26</td>
<td>2.72</td>
<td>1.89</td>
<td>1.66</td>
<td>1.54 Decreasing</td>
</tr>
<tr>
<td>King County</td>
<td>2.35</td>
<td>2.40</td>
<td>2.19</td>
<td>1.42</td>
<td>1.37 Decreasing</td>
</tr>
<tr>
<td>Christchurch</td>
<td>4.20</td>
<td>4.08</td>
<td>1.94</td>
<td>1.21</td>
<td>1.78 Decreasing</td>
</tr>
</tbody>
</table>

Jurisdictional experiences indicated that voluntary programs combined with education and awareness have not been as effective as mandatory programs. As with copper, the opportunity to reduce mercury concentrations in AIWWTP biosolids is significant; the current mercury concentration in AIWWTP biosolids is 3.2 mg kg\(^{-1}\), while the average measured from the participating jurisdictions was 1.5 mg kg\(^{-1}\) (SYLVIS, 2007).

There are a number of initiatives implemented at jurisdictions surveyed that the GVRD could consider adding to its source management program. King County's mobile household hazardous waste collection program is credited with significantly reducing the inappropriate disposal of hazardous waste to both sewer and solid waste. Mobile collection provides a convenient option for residents who may be less motivated or who have quantities that, in their minds, do not justify a trip to the local hazardous waste depot.

Development and implementation of best management practices or regulatory Codes of Practice provide a direct means of providing guidance to industry and commercial businesses. Depending on the needs of the particular sector, the guidance documents can range from being performance-based to prescriptive, and may focus on waste discharges or move upstream to provide guidance on preferred raw materials, processing technologies and processing methods.

Expansion of user fees beyond the conventional parameters such as biological oxygen demand and total suspended solids to include trace elements may provide economic incentive to businesses to reduce the discharge of trace elements to sewer. Both Christchurch and Perth have developed a user fee structure that considers trace element concentrations in wastewater.

Of the jurisdictions surveyed, Toronto’s Ashbridges Bay WWTP produced biosolids with the lowest concentration of trace elements. A key feature of their source management program is the requirement for pollution prevention planning for industrial dischargers. Toronto is one of the first Canadian municipalities to incorporate pollution prevention planning into their sewer use regulations. Pollution prevention planning requires industrial dischargers to take inventory of potentially hazardous substances, identify current waste reduction and pollution prevention activities, evaluate other available waste reduction technologies, and set hazardous substance reduction or elimination targets. Investigation into pollution prevention planning as part of the current sewer use bylaw review may be warranted, including further evaluation of Toronto’s experiences.
Jurisdictions provided an evaluation of the effectiveness of several source management initiatives used in their jurisdiction. These initiatives were grouped under five categories: regulatory, monitoring, information/outreach, enforcement and fees.

The source management tools rated most effective generally fell under monitoring, enforcement and regulatory initiatives, and included the implementation of a sewer use bylaw and associated issuance of waste discharge permits, audit sampling, site inspection, prosecution and fines. Those rated least effective generally centered about information/outreach activities and included newspaper advertising, mail-out brochures and newsletters.

CONCLUSION
The production of biosolids with lower trace element concentrations generally increases the opportunity to use biosolids in recycling opportunities. Although it has been demonstrated that the GVRD’s AIWWTP biosolids meet the most stringent standards there are opportunities for further source management initiatives that can result in improvements in biosolids quality. Through networking and surveying other jurisdictions GVRD’s biosolids quality was compared against those produced in jurisdictions of similar sized who are engaged in similar source management and biosolids management activities. This provided the opportunity to learn from their initiatives and compare the resources provided and the effectiveness of source management in improving biosolids quality. Opportunities to improve biosolids quality, specifically in regards to copper and mercury concentrations, will be further investigated by the GVRD.

REFERENCES


