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Current status of sludge processing and biosolids disposition in Ontario

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ABSTRACT

Sludge processing and biosolids management represent significant ongoing activities for the wastewater treatment industry. Historically, a substantial inventory of sludge processing technologies and operating practices have been developed within regions to manage sludges and produce products that meet disposition requirements. However, access to system-wide information on sludge handling practices that would be of interest to a variety of wastewater industry stakeholders is often not available. As an example, there is little system-wide information available on the types of sludge processing technologies employed and the quantity and quality of biosolids produced at wastewater treatment plants in Ontario. In the present study quantitative data on sludge handling over the period 2014–2016 was gathered for Wastewater treatment plants (WWTPs) with a hydraulic capacity greater than 1000 m^3/day. The types of technologies employed were sorted by the design hydraulic capacity (DHC) of the WWTPs. Data on key biosolids properties (i.e. solids content, pathogen indicators, metals, nitrogen and phosphate) were sorted by WWTP DHC and related regulations. Drivers that are expected to impact biosolids handling practices in Ontario in the future are proposed and discussed in context of the current practices.

1. Introduction

Most wastewater treatment facilities generate sludges that contain the excess solids generated in either physical (i.e. settling) or biological wastewater treatment processes (Burton et al., 2014). The sludge streams typically receive additional treatment for the purposes of stabilization, volume and mass reduction, and pathogen reduction to meet regulatory standards for disposition. Once treated the materials are commonly referred to as biosolids (Cieślik et al., 2015; Smith, 2009). Sludge processing and biosolids management represent a significant ongoing activity for the wastewater treatment industry. In Canada, more than 660,000 dry tonnes of stabilized biosolids are generated annually (CCME, 2012a) and in the United States WWTPs produced 7.18 million tonnes of dry biosolids in 2004 (NEBRA, 2007). In the EU, approximately 5.2 million dry tonnes of substance were produced in 2014 (Eureostat, 2017) while sludge production China has grown at a rate of 13% since 2007 with a total production of dry biosoilds of 6.25 million tonnes in 2013 (Yang et al., 2015). It has been estimated that approximately 50% of the operating cost of wastewater treatment is associated with sludge processing and biosolids management (CCME, 2012b).

Historically, a substantial inventory of sludge processing technologies and operating practices have been developed to manage sludges and produce products that meet disposition requirements in developed countries (Eureostat, 2017; MEP, 2016). This inventory represents a considerable capital investment and when considered on a system-wide (i.e. province or state) basis incurs considerable operating costs (Englande and Reimers, 2001). The composition of the sludge processing inventory that is present in a region will depend upon a number of factors such as the historical evolution of regulatory requirements, availability of disposition pathways, and the chronology of community development. It can be expected that the make-up of the inventory will influence the quality of biosolids produced in a region and also the environmental impacts of the sludge processing. For example, system-wide generation of greenhouse gases and the consumption of energy and chemicals will be influenced by the inventory composition and operating strategies (Davis, 1996).

Access to system-wide information on sludge processing technologies and disposition practices will be of interest to a variety of wastewater industry stakeholders. Owners and operators of WWTPs would find information of this nature to be useful for benchmarking their own operations. Technology developers and vendors can employ system information to identify opportunities for implementation of new technologies that may increase the cost effectiveness and sustainability of sludge processing at plant. Consulting engineers could employ such information to improve the guidance that they provide to clients when

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making decisions about acquisition of technologies. Regulators of WWTPs could employ this information for improved policy making related to biosolids disposition (Mininni et al., 2015). As examples, the EU and China have each developed centralized databases that document the historical inventory of sludge production quantitatively and quality (Yang et al., 2015; Eureostat, 2017).

System-wide surveys of wastewater treatment technologies or quality-related data have been gathered and evaluated in various countries and regions. Yang et al., (2015) reviewed the sludge management practices in China with a focus on sludge quantity, regulations and the technologies implemented for biosolids treatment. Zhang et al. (2016), Lue-Hing et al. (1996), Kelessidis and Stasinakis (2012) have evaluated biosolids disposition practices in China, North America, East Asia and EU countries, respectively and discussed current and future trends/challenges associated with biosolids disposition. Jensen and Jepsen (2005) documented the quality and quantity of sludges produced in Denmark and discussed the impacts of control strategies on biosolids management. Jiménez et al. (2004) focused on the economic and regulatory perspectives of sludge handling in developing countries and identified health risks associated with pathogens and parasites in produced biosolids. When viewed collectively, it can be seen that access to system-wide information describing the quantity and quality of biosolids and implemented sludge processing technologies in a region can inform decision-making by various stakeholders as they address potential challenges/drivers (Rulkens, 2004; Campbell, 2000; Bertanza et al., 2014, 2015).

Currently, there is little system-wide information available on the types of sludge processing technologies that are employed at wastewater treatment plants in Ontario. In the present work, the sludge handling technologies employed and the quantity and quality of biosolids generated in Ontario between 2014–2016 were characterized. The use of sludge handling technologies was categorized by functionality and subsequently WWTP design hydraulic capacity as it was anticipated that technology adoption would be scale dependent. The quantities of biosolids generated by WWTPs were profiled to identify the distribution of generation in the province. Data on important biosolids properties (i.e. solids content, pathogen indicators, metals, nitrogen and phosphate) were collected, analyzed and sorted by relevant indicators such as WWTP DHC and related regulations. Subsequently, drivers that are expected to impact biosolids handling practices in Ontario in the future are proposed and discussed.

2. Data collection

In the province of Ontario, WWTPs are primarily owned by municipalities while operations and maintenance are carried out by either the municipalities themselves, the Ontario Clean Water Agency (OCWA, a crown agency of the Ontario government) or privately contracted operators. Hence, there is no organization responsible for maintaining a central database on infrastructure and operating data. The Ontario Ministry of Environment and Climate Change (OMOECC) is responsible for permitting WWTPs however, its operations are decentralized and consolidated data on biosolids properties and disposition have not been regularly compiled.

In Ontario, wastewaters reflect a large range of mixtures of sanitary, stormwater, commercial and industrial inputs that are specific to the individual municipalities. In particular the contribution of stormwater inputs to the overall flow in sanitary sewers varies between municipalities depending upon the age of the sewer system. Thus, a variety of treatment technologies have been implemented at WWTPs, including conventional activated sludge (82), extended aeration (129), sequencing batch reactors (23), rotating biological contactors (13), contact stabilization (6), biofilters (4), membrane bioreactors (3) and lagoons (154). All WWTPS are required to provide secondary or equivalent level treatment (CCME, 2014) to meet minimum performance requirements including cBOD of 25 mg/L, Total Suspended Solids of 25 mg/L and Total Residual Chlorine of 0.02 mg/L. Often site-specific effluent discharge requirements are more rigorous (especially for nitrogen and phosphorous) and are based upon the nature of the receiving environment.

In the current study, information on the sludge treatment technologies present, as well as the quantity and quality (i.e. solids content, pathogen indicators, metal and nutrient concentrations) of biosolids generated at municipal WWTPs in the province of Ontario was assembled into a database. In addition, a database of Design Hydraulic Capacities (DHC) was employed for the purpose of evaluating scale-dependent responses. The data available did not provide insight into the inhabitant equivalents contributing sewage to the facilities. However, the WWTP Design Guidelines for Ontario (OMOECC, 2016a, b, c) require WWTPs to provide a capacity of 225 L/day-capita and hence this value might be employed to extend the DHC values to estimate community size. The DHC was used as an approximate indicator of the scale of wastewater treatment facilities generating biosolids. In the subsequent discussion plants are generally categorized as either small, medium or large. While, there is no consistent definition of the term small and medium for WWTPs, in the Ontario context, this typically refers to plants whose DHC are less than 10,000 m^3/day while plants with DHC larger than this are referred as “large”.

Further, information on biosolids disposition practices was summarized. The data were provided by the OMECC, the OCWA and through direct approaches to individual municipalities. The databases that this study built upon had been developed through self-reporting by the owners/operators and there were some inconsistencies in terminology used to describe the technologies and biosolids disposition practices.

A total of 486 WWTPs were identified in the province and they are operated by the local municipalities (253), OCWA (183) or private companies (50), respectively. Quantitative data on sludge handling during the period 2014–2016 was obtained for 199 of the 360 WWTPs operated by the OCWA, municipalities or private operators with a hydraulic capacity greater than 1000 m^3/day. Most of the WWTPs (163) that were not reported on employ lagoons to treat the wastewater and do not generate biosolids on a regular basis. Viewed collectively, operating data was obtained for a majority of the WWTPs that generate biosolids on an ongoing basis. The operating data that was gathered was provided in a variety of formats that included spreadsheets of regular operational data, annual reports, raw data reports from certified labs and regional master plans. Often, single values that reflected the averaging of a number of samples were provided without an indication of the number of tested samples or the variability of the results. The averaging period in the various reports was inconsistent as some sources provided monthly/bi-weekly values whereas others provided yearly average values. Thus, statistical analysis of the sludge quality data was not conducted in this study.

3. Quantities of biosolids

In this section, the annual generation of biosolids (liquid and dewatered) that were generated in the surveyed WWTPs in the period 2014–2016 is described. Fig. 1 presents the generation of biosolids in terms of the number of plants that had biosolids production within specified ranges to demonstrate the distribution of the magnitude of biosolids generating facilities in the province. For liquid biosolids production (Fig. 1a), the largest number of WWTPs (~40%) produced between 1000–5000 m^3/year of liquid biosolids and this was followed by those (22%) that produced less than 1000 m^3/year and those (17%) producing between 10,000–100,000 m^3/year. Over the reporting period there was an increase in the number of plants producing less than 1000 m^3/year whereas a decrease in the number of plants that produced between 1000 to 5000 m^3/year of liquid biosolid was observed. Only a few WWTPs produced more than 100,000 m^3/year of liquid biosolids. There were no significant trends in liquid biosolids