Waste Management 118 (2020) 62–67

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Current state and potential valorisation of ship-generated organic waste in Quebec, Canada

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ARTICLE INFO

Article history:
Received 27 April 2020
Revised 24 July 2020
Accepted 5 August 2020

Keywords:
Biomethanation
Composting
Maritime
Organics
Ship-generated waste
Valorisation

ABSTRACT

The Quebec residual materials management policy implies the banning of organic waste disposal or incineration from 2022 onwards. This policy also applies to domestic ship-generated organic waste. However, little is known about the current state of ship-generated organic waste management in the province of Quebec. This study aims to analyse the current situation and propose sustainable strategies for ship-generated organic waste valorisation in Quebec. Using the available data, it was attempted to estimate ship-generated waste quantities in Quebec, after which the current practices of domestic ship-generated organic waste management in Quebec and Europe were inventoried, along with international waste management practices. Five waste valorisation scenarios were then proposed and compared in terms of advantages and disadvantages, required equipment, and associated costs and revenues. It involves: 1) composting on board of the ship, 2) centralised composting, 3) composting at the port, 4) centralised biomethanation, and 5) biomethanation at the port. The current available data on ship-generated waste quantities in Quebec did, however, not allow selecting an optimal scenario. The information provided in this short communication can serve as a valuable basis to guide future research efforts and decision-making in this regard. Furthermore, the current management of international waste was found to be complex and costly, although biomethanation of such waste could offer a suitable and more sustainable solution. Finally, it was concluded that a good cooperation between ships and ports is crucial to the implementation of any sustainable waste valorisation strategy.

1. Introduction

The Quebec residual materials management policy implemented in 2011 imposes the banning of organic waste disposal or incineration by 2022 (LégisQuébec, 2020). This policy also concerns the maritime sector. Organic waste produced on board of ships mainly concerns food waste which has an average calorific value of 17,000 kJ/kg dry matter (DM) (Menikpura et al., 2007; Trabold and Babbitt, 2018), an average dry weight and organic carbon content in the range of 22–38% and 46–60%, respectively (Wilewska-Bien et al., 2016), and contains valuable macronutrients such as nitrogen (8.4–43 g/kg DM) and phosphorus (4.2–8 g/kg DM) (Wilewska-Bien et al., 2016). Additional data on the quality of ship-generated organic waste is currently lacking in literature, but the detailed food waste characterisation study provided by WRAP (2015) can provide additional guidance with the following average values: 26% total solids (TS), 23% volatile solids (VS), 48% carbohydrates on TS, 21% lipids on TS, 23% proteins on TS, 3.3% nitrogen on TS, 0.33% phosphorus on TS, 0.53% sulfur on TS, 48% organic carbon on TS, 6% hydrogen on TS and 36% oxygen on TS. Hence, organic food waste is generally considered a suitable source for valorisation through, for example, biomethanation or composting (Paritosh et al., 2017; Trabold and Babbitt, 2018). The average biogas production potential is in the range of 400 to 500 m^3 of methane per ton of volatile solids (WRAP, 2015).

Nevertheless, managing ship-generated food waste is complicated by several factors. First, the prolonged presence of untreated organic waste on board of ships can lead to odor, health and hygiene problems (Granhag et al., 2018). Next, there is a lack of space available for storage or processing of organic waste on board (Granhag et al., 2018). Further, the quality and the quantity of residual materials produced on board is very variable according to the ship type, the sorting strategy, the navigation duration and the geographical path (Strazza et al., 2015; Vaneeckhaute and Fazli, 2020). Finally, organic waste management requires a good coordination between ships and collection services offered at ports (Vaneeckhaute and Fazli, 2020; Wilewska-Bien et al., 2018).

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https://doi.org/10.1016/j.wasman.2020.08.009
0956-053X/

This study aims to perform a preliminary analysis of the current state and the potential for collection and valorisation of ship-generated organic waste in Quebec, Canada. This research has been executed upon request from Technopole maritime du Québec and the members of MeRLIN (industrial network dedicated to innovation in the shipping and port sectors in Quebec) with the goal of optimising sustainability in the field. No alternative comprehensive research study on the potential valorisation of ship-generated organic waste is currently available for Quebec. First, it is attempted to estimate ship-generated waste quantities based on the available data for Quebec obtained from the members of MeRLIN. Next, the current practices of domestic ship-generated organic waste management in Quebec and Europe are inventoried, along with international waste management practices, based on a literature review and communications with the members of MeRLIN. Scenarios for valorisation of ship-generated organic waste in Quebec are then proposed and compared in terms of advantages/disadvantages, required equipment and associated costs and revenues. Finally, recommendations for further research are provided in order to obtain the required data to further deepen the present study and guide decision-making regarding ship-generated organic waste valorisation.

2. Quantities of ship-generated organic waste in Quebec

In order to be able to propose and compare different valorisation scenarios, it is important to know how much total organic waste is generated on board of ships and arrives at ports in Quebec in the course of a year. However, this was found to be a complex task. In fact, the quantity of organic waste produced on board of ships is often expressed as the amount produced per person per day. Hence, a detailed analysis of each trip is necessary since the number of people on board and the duration of travel are not always the same. As such, based on an inventory and analysis of the current available data, it was not possible to precisely estimate the total amount of ship-generated organic waste arriving at ports in Quebec. However, one Quebec shipping company had all required data available for some of their domestic ships for five subsequent years (2013–2017). Using these data, an average value of 0.0035 (based on 6 ships), 0.0071 (based on 5 ships), 0.0051 (based on 7 ships), 0.0052 (based on 7 ships) and 0.0096 (based on 9 ships) m^3 of organics (food waste) produced per person per operational day was found for 2013, 2014, 2015, 2016 and 2017, respectively. The difference throughout the years is likely related to the different number of ships that measured their waste quantities as indicated above. These values for Quebec align with the limited information available in literature. For example, CE Delft (2017) have reported average values in the range of 0.001–0.003 m^3 per person per day based on audits on 12 ships in Europe, including cruise ships, oil tankers, gas carriers, bulk carriers, container vessels, ro-ro cargo vessels, ferries, recreational crafts and fishing vessels. The wide variability is related, for example, to whether the organics are grinded or collected in bins for delivery to port reception facilities, the former significantly reducing the volume. In parallel, Vaneeckhaute and Fazli (2020) have reported values ranging from 0.21 to 3.5 kg per person per operational day depending on ship types in their recent review on ship-generated organic waste, where cruise ships show the highest values. Considering an average density of 500 kg per m^3 for food waste (WRAP, 2015), the weight-to-volume conversion results in values ranging from 0.00042 to 0.0070 m^3 per person per operational day, depending on the ship type. According to CE Delft (2017), a general problem in quantifying ship-generated waste exists in the fact that often waste discharged at sea is not registered or included in the calculations, which may also explain the wide variation found in the provided quantitative values. Overall, in order to better quantify ship-generated organic waste, shipping companies and ports should closely work together in order to develop a detailed portfolio of organic waste produced on board and delivered to the ports in the course of a year.

3. Current state of domestic ship-generated organic waste management in Quebec and Europe

The information in the following section is based on interrogations executed among the members of the industrial network dedicated to innovation in the shipping and port sectors in Quebec (MeRLIN). In Quebec, several companies have undertaken strategies to collect organic waste on board of their ships. As such, one of the biggest shipping companies has installed numerous brown containers inside the dining rooms and kitchens to collect organic waste. The organic waste is then transferred into 0.24 m^3 brown bins on board of the ship. The company operates around twenty vessels, most of which are now recycling the waste produced on board. The company has targeted 30% recovery of its waste (organics and other recyclable materials) in 2018 for all of its ships. Some of the ships are now already recovering more than 70% of their organic and recyclable waste. Once arrived at the port, the collection and treatment of organic waste is done by external firms.

For another big shipping company, the separation of organic waste from other waste on board is common practice since 2011. However, the size and shape of the organic waste collection bins used on board of the company's vessels is currently not compatible with the machines used by the firms responsible for collection of the waste at Quebec ports. The collected organic waste at the ports thus represents less than 5% of the ship-generated organic waste from this company. The challenge in this case is the non-standard size of the containers available on board which makes handling difficult or even logistically impossible for companies responsible for collecting organic waste from ships at the port. This emphasizes the importance of a good coordination between shipping companies and ports.

The collection service proposed by external firms at the ports in Quebec generally includes: 1) Exchange of 0.24 m^3 containers filled with organic waste for empty containers; 2) Emptying he full bins into a 1.5 m^3 container which is collected by a company that takes care of disposal or valorisation; 3) Spraying the bins with disinfectants once emptied and returning them to the ships during the next exchange.

In Europe, the situation is similar to Quebec. In the document "The Management of Ship-Generated Waste On-board Ships" (CE Delft, 2017), one can find the different practices carried out by ships in Europe. Grinding and discharging of organic waste at sea is still common practice, although some ships sort the organic waste on board to unload it in the facilities of the host port. When there is waste sorting on board, the organic material is usually dried to reduce its volume and the risk of putrefaction or simply stored in a cold room to prevent odor emissions and the development of diseases. The aforementioned European study also presents, for different audited vessels, figures such as the quantities of organic waste generated and the quantity discharged at sea, as well as the quantity collected by port reception facilities. These numerous audits show that there is no consensus on a method of managing organic waste by ships. There are, however, the European directives 2009/16/EC and 2010/65/EU on port State control and reporting formalities for ships arriving in and/or departing from the port, repealing Directive 2000/59/EC on port reception facilities for ship-generated wastes, which describe the European law on the treatment and delivery of ship waste in European ports. These directives state that: 1) Member States must ensure that port reception facilities for waste are sufficient to meet the needs of ships; 2) Each port must set up and manage a collection and treatment system for all the waste from the ships that it welcomes. It is important to note that these directives concern all types of waste, not just organic waste.

Overall, based on the above identified current waste management challenges, Sections 5 and 6 below provide general guidance and recommendations for improved decision-making regarding the implementation of ship-generated waste valorisation strategies.

4. International waste

International waste is any waste that is part of the Canadian Food Inspection Agency's (CFIA) international waste policy (CFIA, 2012). This waste includes waste from international ships, aircraft garbage, animal waste (manure, urine, etc.), as well as confiscated material.

Canadian law does not prohibit the treatment of this international waste, but regulates it very strictly. International waste must meet various criteria in order to be accepted, otherwise it must be disposed of. The process states that the Canadian Border Service and the CFIA must first authorize the unloading of an international waste source if it does not pose a risk to the animal and plant health of the country. Then, the waste source in question must be collected by an approved international waste transporter and immediately transported to an approved treatment site for the treatment of international waste. Upon arrival at the treatment site, the waste must be disposed of under the supervision of a Canadian inspector to ensure that it does not cause any risk of introducing or spreading diseases or toxic substances in the country. Elimination of international waste must be done quickly by one of the following methods (CFIA, 2007): 1) Incineration; 2) Heat treatment at a temperature of at least 100 °C and a period of at least 30 min; 3) Burial in an embankment of at least 1.8 m deep. Once transport is completed, the truck transporting international waste must be cleaned and disinfected before it can be reused as required by paragraph 105 of the Health of Animals Regulations (Government of Canada, 2020).

Hence, the treatment of an international waste source is complex. Moreover, the processing of international organic waste generates high disposal and monitoring costs while generating no or low revenues. The majority of international organic waste is thus still directly discharged into the sea as permitted by Annex 5 to the Convention between MARPOL and the International Maritime Organization (MARPOL, 1988). In Annex 5 of the Convention, it is, for example, listed that it is possible to discharge any type of food waste at sea under the following conditions (MARPOL, 1988): 1) To be more than 12 nautical miles from the nearest land; 2) Having passed this organic waste through a grinder.

The interest of treating international organic waste would be much greater if valorisation is permitted, for example, through composting or anaerobic digestion. These options will be further discussed in Sections 5 and 6.

5. Potential valorisation scenarios for ship-generated organic waste

Two methods of valorising ship-generated organic waste are proposed in this study: composting and biomethanation. These processes are brought forward because they are prioritized by the Quebec government in the framework of the Quebec policy on organic waste management (LégisQuébec, 2020).

Composting consists of degrading organic waste in the presence of oxygen (O_2) and moisture. This process produces a fertilizer rich in nutrients and organic matter, i.e. compost, as the final product. Biomethanation also consists of organic waste degradation, but in the absence of O_2. Such fermentation produces two final products: biogas and digestate. Biogas consists mainly of methane (CH_4) and carbon dioxide (CO_2) and can, after purification, be injected into energy supply networks or used to produce heat, electricity or fuel for vehicles. The remaining digestate can be used as a fertilizer product after further upgrading.

For each of these technologies, different ship-generated waste management scenarios are possible. Following discussion with the MeRLIN consortium, five scenarios were conceptualised for Quebec as presented in Fig. 1 and briefly described below.

A. Composting on board of the ship (Fig. 1A): In this case, the organic waste is treated in composting bins on board of the ship. The compost is collected in collection bins on board, transferred into trucks upon arrival at the port, and then transported for further treatment or marketing.

B. Centralised composting (Fig. 1B): In this case, the organic waste is collected in bins on board of the ship, transferred into trucks at the port, and then transported to a centralised composting site.

C. Composting at the port (Fig. 1C): In this case, the organic waste is collected in bins on board of the ship and then transported to a composting site at the port.

D. Centralised biomethanation (Fig. 1D): In this case, the organic waste is collected in bins on board of the ship, transferred into trucks at the port, and then transported to a centralised biomethanation site.

E. Biomethanation at the port (Fig. 1E): In this case, the organic waste is collected in bins on board of the ship and then transported to a biomethanation site at the port.

6. Preliminary comparison of the selected scenarios

6.1. Advantages and disadvantages

Table 1 presents the advantages and disadvantages of the different scenarios under study. Biomethanation at the port has a particular advantage, i.e. the possibility to treat international waste. If one decides to install a biogas plant at the port, a second unit could be used for international waste only. In this way, it would be possible to valorise the biogas produced from this waste. The remaining digestate could then be disposed of as prescribed by international waste regulations (Section 4), if valorisation is not allowed.

6.2. Required and proposed infrastructure

Each of the proposed scenarios requires the installation of infrastructure in order to deal with the organic waste. These facilities are necessary and will influence the capital cost for commissioning the treatment system. Table 2 therefore presents the equipment required for each of the scenarios proposed in this study. For composting on board of the ship, a wide range of suitable composting units is already available on the market, including, for example, Actium Resources LTD, Brome Composters, Joracan, EMISPEC, Vertal, etc. (RECYC-Québec, 2018). Multiple of these technologies allow a fast and efficient process. The Joracan, for example, provides a ready-to-use Grade A compost (CCME, 2005) in only four weeks time.

6.3. Costs and revenues

One of the important factors in choosing a scenario for treating organic waste is the cash flow. Cash inflows and outflows must be estimated to evaluate the economic feasibility of a project. Table 3

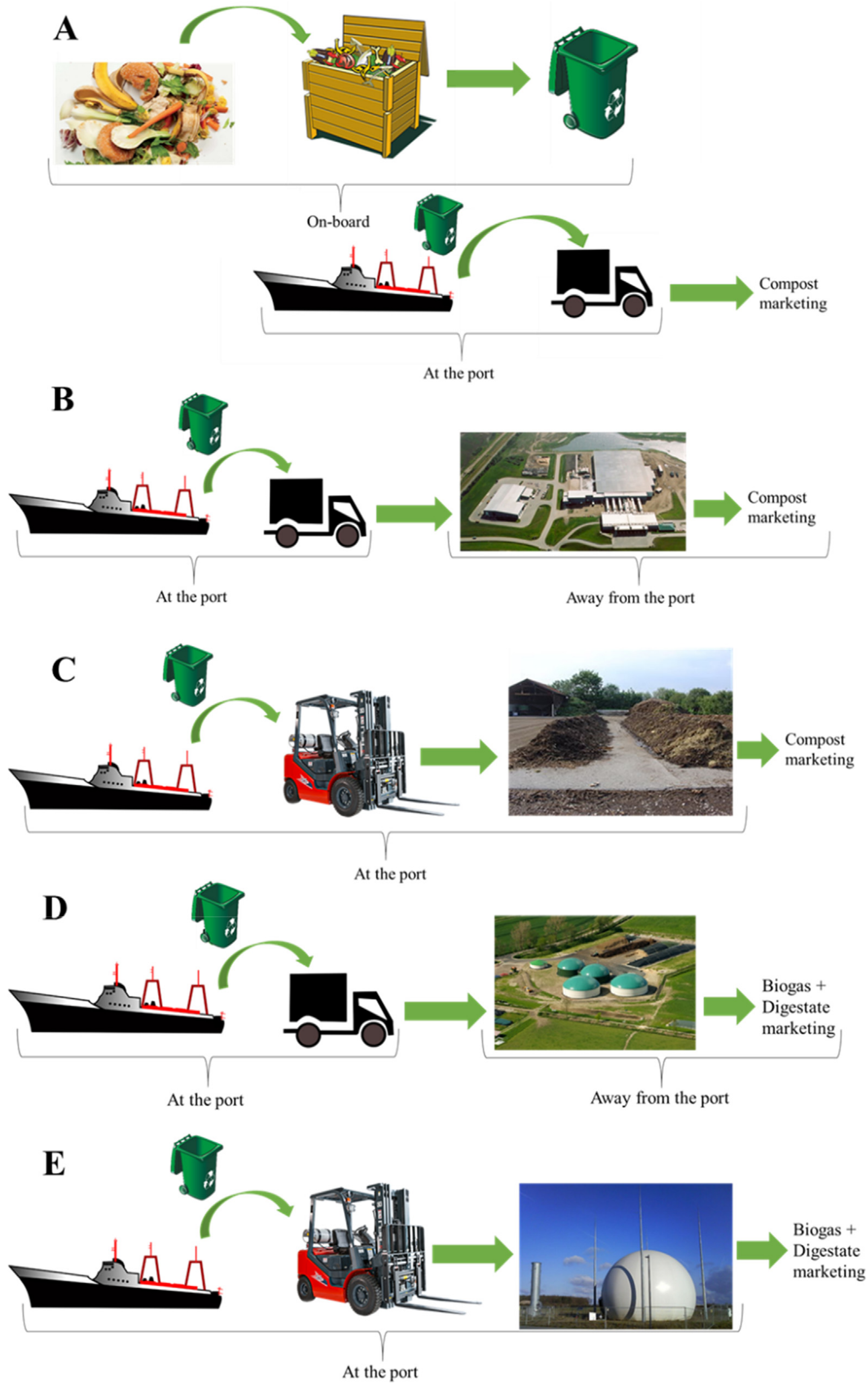

Fig. 1. Schematic representation of five potential waste valorisation scenarios: A) Composting on board of the ship, B) Centralised composting, C) Composting at the port, D) Centralised biomethanation, E) Biomethanation at the port.

presents the cost items associated with each scenario, as well as the expected income following the processing of the organic waste. Note that, due to lack of specific data for Quebec, it has been assumed that the value of dry digestate is equal to the value of compost, which is expected to be in the range of 20–30 $/ton depending on the quality (Recyc-Québec, 2006; Ahmed, 2013).

Table 1
Advantages and disadvantages of the proposed scenarios.

SCENARIO	ADVANTAGES	DISADVANTAGES
Composting on board of the ship	- Compost can be produced when it arrives at the port (depending on the equipment used and the duration of travel) - Revenues from compost marketing	- Odor risks - Space requirements on board of the ship - Training on the equipment required - The time required for composting can be an issue depending on the equipment used and the duration of travel (Section 6.2)
Centralised composting	- Composting at large scale by an external company - No need to invest in equipment for composting - No need for supervision by port operators - More controlled process	- Need for transport to the composting site or need for take-off at the port - No revenues for the port - Need for a composting site in the nearby area
Composting at the port	- Revenues from compost marketing	- Need for an operator - Need for a market for the compost - Need for structuring materials - Space requirements at the port
Centralised biomethanation	- Co-digestion with other waste sources potentially leading to a more stable process - Methane capture so less greenhouse gas emissions as compared to composting - Production and valorisation of biogas and digestate	- Need for transport to the biomethanation site - Need for a biomethanation plant in the nearby area - No revenues for the port
Biomethanation at the port	- Potential use of biogas in the port - Revenues from digestate and biogas sales - Potentially of interest for international waste treatment - Methane capture so less greenhouse gas emissions as compared to composting	- Need for a specialised operator - Relatively high investment costs - Need for a market for the digestate - Space requirements at the port

Table 2
Required equipment for each of the proposed scenarios.

SCENARIO	REQUIRED EQUIPMENT
Composting on board of the ship	- Composting bin - Collection bin with standard dimensions
Centralised composting	- Collection bin with standard dimensions
Composting at the port	- Collection bin with standard dimensions - Composting equipment
Centralised biomethanation	- Collection bin with standard dimensions
Biomethanation at the port	- Collection bin with standard dimensions - Biomethanation unit - Optional: Second biomethanation unit for international waste - Digestate treatment process - Biogas purification (depending on the application)

6.4. Recommendations and research needs

Based on the above inventory, Table 4 presents the recommendations and the research needs for each of the five proposed scenarios for valorisation of ship-generated organic waste in Quebec.

Following these recommendations, it should be remarked that a decision-support software tool for optimal selection of organic waste management strategies in Quebec is under development by the first author's research team (www.optim-o.com) in close collaboration with experts in geomatics and Quebec industry. The tool comprises information on the location of centralised digestion and composting facilities, agricultural lands, economic and environmental factors, and allows to calculate and optimize transport distances between facilities or to select the optimal location of a new treatment plant, among other features. In future research, when accurate data on the total yearly available quantity

Table 3
Costs and revenues for the proposed scenarios.

SCENARIO	RESPONSIBLE FOR PRODUCT MARKETING	COSTS FOR THE PORT	REVENUES FOR THE PORT
Composting on board of the ship	In charge of the port or an external firm	- Composting unit: estimated at 500–2,000 $ depending on the provider and the volumetric capacity of the bins (Hénault-Ethier et al., 2017; contact with technology providers) - Transport of compost: 1.55 $/ton/km (Hénault-Ethier et al., 2017)	Compost: 20–30 $/ton (Ahmed, 2013)
Centralised composting	In charge of an external firm or the city	Transport of organic waste: 1.55 $/ton/km (Hénault-Ethier et al., 2017)	None
Composting at the port	In charge of the port or an external firm	- Investment (Hénault-Ethier et al., 2017): 200 $/ton (open), 500 $/ton (closed) - Operation and Maintenance (Hénault-Ethier et al., 2017): 40 $/ton (open), 85 $/ton (closed) - Transport of compost: 1.55 $/ton/km (Hénault-Ethier et al., 2017)	Compost: 20–30 $/ton (Ahmed, 2013)
Centralised biomethanation	In charge of an external firm or the city	Transport of organic waste: 1.55 $/ton/km (Hénault-Ethier et al., 2017)	None
Biomethanation at the port	In charge of the port or an external firm	- Investment (Hénault-Ethier et al., 2017): 700 $/ton - Operation and maintenance (Hénault-Ethier et al., 2017): 120 $/ton - Transport of dry digestate: 1.55 $/ton/km (Hénault-Ethier et al., 2017) - Digestate upgrading and biogas purification can result in additional costs depending on the required quality	- Dry digestate: 20–30 $/ton - Possibility of recovering nutrients from liquid effluents = additional revenues (Vaneeckhaute et al., 2017) - Biogas: 105 m^3 CH_4/ton of waste at 2.96 $/GJ and 1 m^3 = 0.03789 GJ (Énergir, 2020)

Table 4
Recommendations and research needs for the proposed scenarios.

SCENARIO	RECOMMENDATIONS AND RESEARCH NEEDS
Composting on board of the ship	- Study on the most appropriate equipment for composting on board of ships - Study on the location of agricultural land around the port (compost market) or identification of potential users for the compost produced - Study on the potential value of the compost
Centralised composting	- Study on the location of composting sites around the port and their capacity
Composting at the port	- Study on the location of agricultural land around the port (compost market) or identification of potential users for the compost produced - Study on the potential value of the compost
Centralised biomethanation	- Study on the location of biomethanation sites around the port and their capacity
Biomethanation at the port	- Study on the location of agricultural land around the port (digestate market) or identification of potential users for the product - Study on the potential value of the digestate - Study on the potential applications of biogas in the port (fuel, natural gas, etc.) - Study on the potential valorisation of international waste

of ship-generated organic waste in Quebec is available, this tool can be used for optimal decision-making regarding which ship-generated waste valorisation strategies to be implemented. Finally, it should be remarked that an in-depth characterisation (elemental, proximate and heating value analyses) of ship-generated organic waste in Quebec as function of ship type and travel time is also recommended to further refine the decision-making process.

7. Conclusions

This study attempted to perform a preliminary analysis of the current situation and the potential valorisation of ship-generated organic waste in Quebec. At first, it was found that the currently available data did not allow to precisely estimate the total quantity of ship-generated organic waste in Quebec. Shipping companies and ports are therefore recommended to closely work together in order to develop a detailed portfolio of organic waste produced on board and delivered to the ports. Next, current ship-generated organic waste management practices in Quebec and Europe were inventoried, along with international waste management practices. The current management of international waste was found to be complex and costly, although biomethanation of such waste could offer a suitable and more sustainable solution. Next, five waste valorisation scenarios were proposed and compared in terms of advantages and disadvantages, required equipment, and associated costs and revenues. Future research will target a more precise quantification of ship-generated organic waste in Quebec along with qualitative analyses, which will allow for optimal decision-making regarding which waste valorisation strategies to be implemented. The information provided in this short communication can serve as a valuable basis to guide future research efforts and decision-making in this regard.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank Technopole maritime du Québec and the members of MeRLIN (industrial network dedicated to innovation in the shipping and port sectors in Quebec) for their financial and in-kind contributions to this study. Céline Vaneeckhaute is funded by the Natural Science and Engineering Research Council of Canada through the award of an NSERC Discovery Grant (RGPIN-2017-04838). Céline Vaneeckhaute also holds the Canada Research Chair in Resource Recovery and Bioproducts Engineering.

References

Ahmed, J., 2013. Composting: A sustainable solution for the University of Regina's food waste disposal. Report, University of Regina, SK, CA.
CCME (2005). Guidelines for compost quality. Canadian Council of Ministers of the Environment, Winnipeg, Manitoba, Canada.
CE Delft (2017). The management of Ship-Generated Waste On-board Ships. CE Delft for European Maritime Safety Agency, Delft, the Netherlands.
CFIA (2007). Déchets internationaux sur les navires, Canadian Food Inspection Agency.
CFIA (2012). International Waste Directive, TAHD-DSAT-IE-2002-17-6, Canadian Food Inspection Agency.
EC (2000). Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues.
Government of Canada (2020). Health of Animals Regulations (C.R.C., c. 296), Minister of Justice, Canada.
Granhag, L., Wilewska-Bien, M., Andersson, K., 2018. Rapporten Kartläggning av näringstillförsel från sjöfart till Östersjön är finansierad av Stiftelserna Thurséus Forskarhem och BalticSea2020. Chalmers tekniska högskola, Göteborg, Sweden.
Hénault-Ethier, L., Martin, J.P., Housset, J., 2017. A dynamic model for organic waste management in Quebec (D-MOWIQ) as a tool to review environmental, societal and economic perspectives of a waste management policy. Waste Manage. 66, 196–209.
LégisQuébec (2020). Québec residual materials management policy. Environmental Quality Act, Chapter Q-2, s 53.4.
MARPOL (1988). Annex V: Regulations for the prevention of pollution by garbage from ships. Available from: http://www.marpoltraining.com/MMSKOREAN/MARPOL/Annex_V/r9.htm.
Menikpura, S.N.M., Basnayake, B.F.A., Boyagoda, P.B., Kularathne, I.W., 2007. Estimations and mathematical model predictions of energy contents of municipal solid waste (MSW) in Kandy. Tropical Agricultural Research 19, 389–400.
Paritosh, K., Kushwate, S.K., Yadav, M., Chawade, A., Vivekanand, V. (2017). Food waste to energy: An overview of sustainable approaches for food waste management and nutrient recycling. BioMed Research International 2017, ID 2370927, 19p.
RECYC-Québec (2018). Compostez vos matières organiques sur place. Available from: https://www.recyc-quebec.gouv.qc.ca/entreprises-organismes/matieres-organiques/scenarios-gestion-entreprise/compostage-sur-place.
RECYC-Québec (2006). Guide sur la collecte et le compostage des matières organiques du secteur municipal, QC, Canada.
Strazza, C., Del Borghi, A., Gallo, M., Manariti, R., Missanelli, E., 2015. Investigation of green practices for paper use reduction onboard a cruise ship—a life cycle approach. Int. J. Life Cycle Assess. 20 (7), 982–993.
Trabold, T., Babbitt, C.W., 2018. Sustainable Food Waste-to-Energy Systems. Academic Press, p. 292p.
Vaneeckhaute, C., Fazli, A., 2020. Management of ship-generated food waste and sewage on the Baltic Sea: A review. Waste Manage. 102, 12–20.
Vaneeckhaute, C., Lebuf, V., Michels, E., Belia, E., Tack, F.M.G., Vanrolleghem, P.A., Meers, E., 2017. Nutrient recovery from bio-digestion waste: Systematic technology review and product classification. Waste Biomass Valor. 8 (1), 21–40.
Wilewska-Bien, M., Granhag, L., Andersson, K., 2016. The nutrient load from food waste generated onboard ships in the Baltic Sea. Mar. Pollut. Bull. 105 (1), 359–366.
Wilewska-Bien, M., Granhag, L., Andersson, K. (2018). Pathways to reduction and efficient handling of food waste on passenger ships: from Baltic Sea perspective. Environ., Develop. Sustain. 1–14.
WRAP, 2015. Household food waste collections guide, The Waste and Resources Action Programme (WRAP). Oxon, UK.