Comparative Analysis of Dog Waste Processing Methods for Metro Vancouver

Prepared by: Kaitlin Lovering, UBC Sustainability Scholar, 2018
Prepared for: Seann Greenwood, Park Operations Technician, Regional Parks, West Area Parks, Planning and Environment, Metro Vancouver

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Contents

List of Figures and Tables

Executive Summary

An average dog can produce 124 kilograms of waste per year—the equivalent of 0.34 kilograms a day. An estimated 2.5 million dogs visit Metro Vancouver's regional parks annually. Metro Vancouver Parks has established a procedure to collect and treat the dog waste. In the current program, park users place bagged dog waste in designated dog waste receptacles. The dog waste is collected by a private contractor, who separates the waste from the bags. The dog waste is then taken for treatment at Iona Island Waste Water Treatment Plant (WWTP). In 2017, a total of 110.71 tonnes of dog waste were diverted from the land fill using this program. This method reduces the volume of waste that enters the landfill and also provides an opportunity to produce value-added products from the dog waste, including biofuels and soil additives.

Due to the success of the program, the City of Vancouver, the City of North Vancouver, the District of North Vancouver, the District of West Vancouver, the Township of Langley, the City of Port Moody, and the City of Port Coquitlam, have started their own programs using the Metro Vancouver model. As all of these programs expand to include more parks, and as the regional dog population grows, it is important to ensure that the treatment of the dog waste is effective and sustainable. Dog waste has a high pathogen content and treatment methods must ensure that the potential to adversely impact human or environmental health is eliminated. Additionally, the sustainability of the program needs to be ensured by assessing the potential environmental, economic and social impacts as well as the logistical and regulatory considerations. In this study, the current management method is evaluated alongside other treatment options.

A survey of treatment options indicates that there are currently three ways to treat dog waste: (1) anaerobic digestion (AD), (2) composting, and (3) AD followed by composting. In AD, bacteria decompose organic matter in the absence of oxygen. This anaerobic process produces methane and biosolids. The methane is a biofuel and used to generate electricity. The biosolids, like compost, can be used as a soil additive. The bacteria used in AD thrive at either 30-42 °C or 43-50 °C, referred to mesophilic or thermophilic digestion, respectively. Composting is an aerobic method of decomposing organic matter. The process occurs at elevated temperatures and produces a nutrient rich soil additive. Though the temperature of composting depends on the volume of the organic matter and the system that is used, a minimum of 55 °C for three days is required for the product to be sold commercially as a fertilizer. Using a combination of the two methods allows the production of biogas and also produces a smaller volume of soil additive without reducing the nutrient content.

Composting dog waste is historically the most common treatment method, however, all three of these methods are currently used in the Pacific Northwest. Green Pet Compost in the U.S.A. compost dog waste. Metro Vancouver uses mesophilic AD to treat dog waste at Iona Island WWTP. Whistler Resort Municipality uses AD followed by composting. These and past experiences of dog waste treatment were used to help evaluate the options in Metro Vancouver.

The treatment options were evaluated based on economic, environmental, and regulatory criteria. Available regional infrastructure and ease of public participation were also key considerations. A literature review indicates that all treatment options will eliminate pathogens, however, not all treatment options are currently available to the region. While Metro Vancouver has facilities for mesophilic and thermophilic digestion, industrial-scale composting, and AD followed by composting, not every facility is willing to process dog waste. Based on the evaluation criteria, AD is the best option for dog waste treatment in the region.

It is safe and sustainable to continue to use the TWL stream at Iona Island WWTP to manage the region's dog waste. Direct discharge to the sewer and ultimately to Annacis Island WWTP is feasible and would reduce reduce greenhouse gas emissions caused by transport of the waste to the TLW facility. Permitting requirements for direct discharge may be cost restrictive but should nevertheless be further assessed. Additionally, as the regional infrastructure for sustainable organic waste treatment expands, it may be possible to further improve sustainability and minimize environmental impacts of waste. Also, as biodegradable plastics and technologies to effectively process them are developed, the region can pursue opportunities to incorporate plastic reduction into the dog waste treatment program.

Introduction

Metro Vancouver is committed to reducing waste throughout the region. Residents are encouraged to sort their recycling and compost at home and public areas are provided with separate waste receptacles for food scraps, recyclable containers, etc. Human waste is also dealt with sustainably at waste water treatment plants (WWTPs) where waste is used to generate biogas that powers the plant and produce biosolids that can be used as soil additives. Though the region and its residents are committed to waste reduction, pet waste is easily overlooked. An estimated 2.5 million dogs visit Metro Vancouver's regional parks annually, and the Regional Parks Department has effectively spearheaded an effort to include dog waste in the waste reduction efforts.

Red labelled waste receptacles, designated for dog waste, are found in all regional parks. This waste is collected, debagged, and taken to a WWTP. Due to the success of the program, the region's municipalities are adopting the program and installing dog waste receptacles in public areas. As these programs expand, the volume of collected dog waste is expected to double in the next two to three years. It is necessary to ensure that the collected waste is being effectively managed. Three treatment options are identified: anaerobic digestion (AD), composting, and AD + composting. These are compared in this report on the basis of elimination of environmental risks and sustainability.

Dog waste, especially the waste of stray dogs or of dogs consuming raw meat, can have very high pathogen concentrations. Additionally, dogs are the definitive host of a species of roundworm and a species of hookworm. As the pathogens in dog waste can infect marine, riverine, and human animals, it is important that, after collecting the dog waste, the environmental and human health risks are eliminated. A literature review indicates that all treatment options can eliminate the pathogenic risks of dog waste.

The identified treatment options are all used in the Pacific North West area and a questionnaire was used to understand the practical application of each method. This information, along with information provided by Metro Vancouver employees, was used to assess the sustainability of each treatment option. Sustainability was assessed by considering infrastructural and financial feasibility as well as conversion of waste into useable products.

Summary of Treatment Options

Livestock produce large volumes of waste in a relatively small area. As a consequence, livestock waste can be harnessed as a resource and cow manure in particular is regularly used to produce

biogas and soil additive.[1] While dogs are also domesticated animals, their waste is less commonly targeted for resource extraction, because (1) they are carnivores and consequently their waste has more pathogens[2] and (2) their population is more dispersed. In places like Fairbanks, Alaska, however, dogs are used for transportation and live in more concentrated populations. In the mid-1990s some dog kennel owners began to collect and compost the dog waste. This program successfully produced composted dog waste deemed safe for use in landscaping (though not for gardens).[3] Dogs also congregate in dog parks and the City of Montreal introduced a composter in an active dog run and enlisted dog owners to help maintain the compost.[4] The City provided shovels, detailed instructions, and training. Park users were enthusiastic but the composting process did not reach the necessary conditions to render a safe end product. Neither of these programs proved to be sustainable and are no longer in use.

There are, however, active programs in the Pacific Northwest including treatment programs operated by Metro Vancouver, Resort Municipality of Whistler, and Green Pet Compost, a composting company serving the I5 corridor between Seattle and Portland, USA.

Green Pet Compost

Green Pet Compost[5] is a for-profit company that collects and composts dog waste from subscribers. They operate in Western Washington and Northern Oregon. Subscribers fill 20 gallon totes with dog waste. The totes have a compostable plastic liner, the waste is in compostable plastic bags, and the tote is air tight. This prevents any issues of odour. The totes are regularly collected from the pet owners and are stored offsite. 100-120 totes are collected at a time and driven to the composting facility.

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[1] Keleti, P. D. (1993). Inactivation of Giardia by Anaerobic Digestion of Sludge. *Water Sci Technol* , 111-114.

[2] Jenkins, E., Castrodale, L., Rosemond, S. d., Dixon, B., Elmore, S., Gesy, K., . . . Thompson, R. (2013). Tradition and transition: parasitic zoonoses of people and animals in Alaska, northern Canada, and Greenland. *Adv Parasitol*, 33-204.

[3] USDA Natural Resources Conservation Service. (2005). *Composting Dog Waste.* United States Department of Agriculture.

[4] Nemiroff, L., & Patterson, J. (2013). Design, testing and implementation of a large-scale urban dog waste composting program. *Compost Sci & Util*, 237-242.

[5] Information from questionnaire and telephone conversation. The completed questionnaire can be found in Appendix A.

The contents of the totes are emptied into a mixer along with wood chips and shavings. The compostable bags are easily torn and the bags and waste are then composted together. Green Pet uses in-vessel composting that can handle approximately 250 totes at a time (250 x 20 gallon = 5,000 gallons or approximately 18927.06 L). In addition to wood chips, food scraps are occasionally added. Nitrogen rich materials, such as green grass, green leaves, and fish are also included as needed. The compost process lasts 90 to 120 days in total. The compost spends 10 days in-vessel during which temperatures can reach 60 – 63 °C. Over the remaining 80 to 110 days the compost is cured and temperature is allowed to drop in windrows. In the winter time, excess water can adversely affect the composting process. Metro Vancouver similarly experiences heavy rainfall in the winter months and the compost of dog waste could be effected.

After the composting process, large rocks and non-compostable plastics are removed by screening. Visual inspection ensures the compostable bags are fully degraded. Green Pet Compost includes some of the composted material in a second iteration of the in-vessel composting process. The second cycle does not affect the nutrient composition, but it does reduce the overall volume of the compost.

Green Pet Compost checks for pathogens and heavy metals 3 times a year and the health department checks once per year. Their compost system, reaches temperatures in excess of the legal requirement, which is 55 °C for 3 days.

Green Pet Compost owners use the compost for landscaping and gardening on their personal property, however, only distribute the compost for use in landscaping. They donate the majority of the compost.

Resort Municipality of Whistler

The Resort Municipality of Whistler (RMW)[6] collects dog waste from two parks in red 120 litre bins. Compostable bags are provided in all park and village dispensers. They rely on park signs, print media and word-of-mouth to encourage dog owners to place dog waste in the red receptacles. Odour from the park receptacles can be an issue.

The dog waste is first treated at the municipal Waste Water Treatment plant using anaerobic digestion. The biosolids are then composted in-vessel at a commercial facility with other

[6] Information from questionnaire and email correspondence. The completed questionnaire can be found in Appendix B.

compostable materials, including food scraps and wood shavings. The compost reaches ≥55 °C for three days with an average temperature is 60 °C. The system produces Class A compost, which is sold in bulk to the public.

The compost is tested in accordance with RMW guidelines and meets provincial requirements for Class A compost.

Metro Vancouver

Metro Vancouver explored four dog waste treatment option pilots before settling on the current practice.[7] These options were as follows:

(1) A septic tank was installed below grade with two access points where they would be accessible to pumping trucks: one in the large-dog leash-optional area and one in the small-dog leash-optional area. Painted shovels were stored nearby in wooden holders. The aim was to have dog owners pick up dog waste with the shovels provided and deposit it into the tank. This project was somewhat successful and had the additional benefit of reducing plastic bag use. Nevertheless, some dog waste was still placed in the trash, especially if defecation occurred at a distance from the septic tank.

(2) A sandbox was installed for dog defecation with the aim to divert dog waste from the landfill and also reduce the use of plastic bags. These doggie litter boxes were unsuccessful. Dog owners were unsure of what to do and very little waste was diverted from the landfill.

(3) Dog waste collected in parks was taken off-site and vermicomposting of dog waste was attempted. While the dog waste composted adequately, the decomposition of the compostable bags took significantly longer. The success of this project is indeterminate and more experiments would need to be done to fully assess the applicability of vermicomposting.

(4) Red waste receptacles were placed near other waste receptacles with clear signage indicating that the red bins were for dog waste only, similarly to the methods described in RMW. This project diverts dog waste from the landfill but does not reduce the usage of plastic bags. Nevertheless, in terms of dog waste diverted from the landfill and user participation, it was the most successful pilot program and has been expanded.

[7] Metro Vancouver. (2012). *Dog Waste Pilot Summary.*

Current Practice in Metro Vancouver

Currently, pet owners can use any type of bag to pick up their dog's waste and then place the bagged waste in a red labelled recycling bin. These bins are usually found alongside other waste bins (figure 1). Metro Vancouver has engaged residents to sort their waste for many years and, especially because dog waste receptacles are next to other waste receptacles, there is a low barrier to participation for pet owners.

Figure 1. A pet owner puts his pet's waste in a designated bin.

Although for dog owners, the ability to use any type of plastic to collect the dog waste is ideal, the dog waste and plastic must be separated from the dog waste before treatment. The separation is done manually by Scooby's Dog Removal Service. Scooby's is also contracted to pick up the dog waste collected in the receptacles and take the dog waste to be treated. The plastic bags go to the incinerator while the dog waste is taken to the Iona Island Waste Water Treatment Plant (WWTP) where it enters the plant via the trucked liquid waste (TLW) stream.

In addition to gaseous methane, AD produces a liquid suspension (sludge). After leaving the digesters, the suspension is placed in retention ponds, where it is left to settle 2-3 years. After settling, the solids are moved to a stockpile where the liquids are further drained to produce biosolids that can be used and distributed as class B biosolids.

Regional Infrastructure

WWTPs

Wastewater that enters the headworks of a plant has solids screened and removed before treatment. During primary treatment the solid organic phases sink and oil/grease phases float, allowing mechanical separation. The liquid is then discharged and the solids go on to be anaerobically digested. Some plants have additional treatment of the wastewater, called secondary treatment. In secondary treatment, the liquid is further treated with microorganisms to help remove and settle out additional suspended or dissolved organic matter. Waste can also enter a WWTP via the Trucked Liquid Waste (TLW) stream. TLW goes directly to the anaerobic digester.

There are five WWTPs in Metro Vancouver, two of which are relevant in the discussion of dog waste treatment: Iona Island and Annacis Island. Iona and Annacis have several differences. Iona Island WWTP was built in 1961 and has only primary treatment. Provincial regulations require that all WWTPs be upgraded to include secondary treatment and Iona Island will be upgraded by 2030. Annacis Island WWTP already uses both primary and secondary treatment.

The digesters at Iona Island operate at mesophilic conditions (30-42 °C). The digesters at Annacis Island operate at thermophilic conditions (43-50 °C). Iona Island WWTP accepts non-domestic TLW and the TLW stream at Iona Island is screened before it enters the digester. Annacis Island accepts primarily domestic TLW, though it does accept some screened high-strength TLW.

After AD, the digester tanks contain a slurry. Iona Island currently uses holding ponds (lagoons) that allows the solids to settle out of the liquid over the course of 2-3 years. At Annacis Island the separation is facilitated by centrifugal forces and occurs much more quickly to produce a biosolid cake that can be used directly as soil amendment.

While there is concern that dog waste would have an adverse impact on the microbial communities in the AD tanks at a WWTP, the dog waste entering Iona Island WWTP AD tanks does not have a noticeable effect on the methane production at the plant. Figure 2 shows the amount of dog waste discharged per day via the TLW stream at Iona Island between 1 January, 2018 and 25 July, 2018 in orange and the total methane produced at Iona Island during the same time frame in blue. There is a 2-3 day delay before the dog waste can be expected to produce methane. The amount of dog waste currently discharged at Iona WWTP is very small when compared to the total amount of waste water treated by the plant. Additionally, 7 months may be insufficient to identify trends.

Nevertheless, figure 2 suggests that expansion of the current dog waste treatment plan is possible and not likely to cause disruption to the plant.

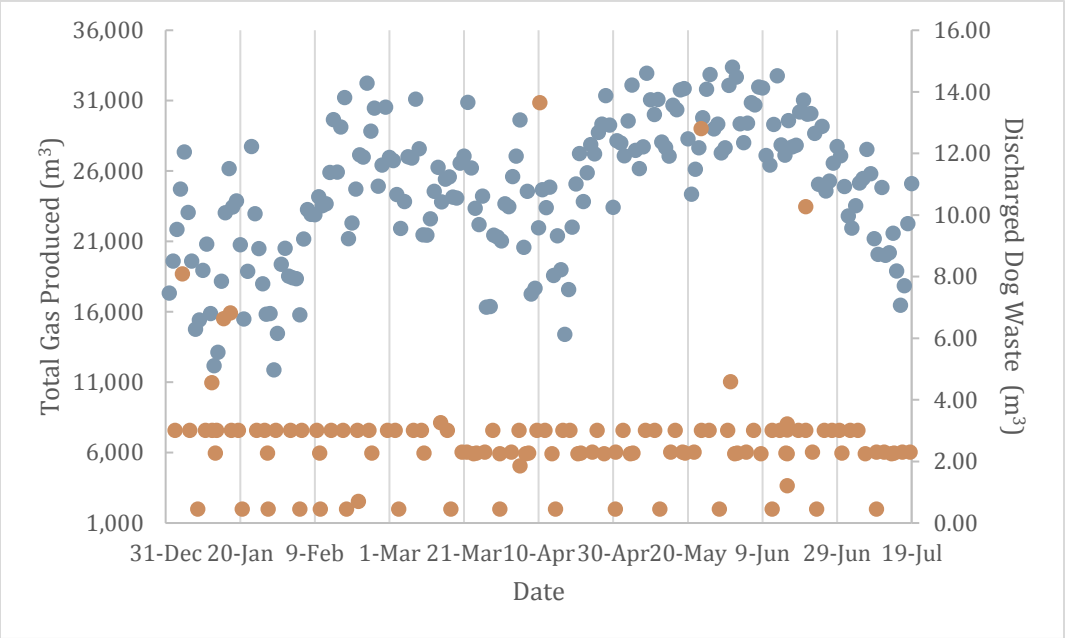

Figure 2. The volume of dog waste discharged and the volume of methane produced at Iona Island WWTP between 1 January, 2018 and 25 July, 2018. Discharged dog waste is shown in orange and methane produced in blue.

Composting

There are three composting facilities in the region. These facilities process domestic compost and do not currently accept dog waste.[8] The facility in Richmond and the facility in Delta are often the target of odour complaints.[9]

AD + Composting

The facility in Metro Vancouver that combines AD and composting is Surrey Biofuels.[10] They process domestic organic waste and do not currently accept dog waste. In their process, the waste is first shredded to increase surface areas and break open any plastics. The solids are then piled in 3-4 m stacks and sealed in oxygen free chambers. The facility currently uses mesophilic digestion but is considering switching to thermophilic digestion. The AD stage lasts around 28 days. The

[8] Harvest Power. (2018). Retrieved from http://www.harvestpower.com/locations/bc_richmond/

[9] Metro Vancouver. (2018). *Harvest Power's Richmond Compost Facility > Complaints*. Retrieved from http://www.metrovancouver.org/services/Permits-regulations-enforcement/harvest-power-richmond/complaints/Pages/default.aspx

[10] Information from in-person tour

digestate is then mixed with fresh materials and previously composted materials and allowed to compost for 14 days at > 40 °C, with three of those days at ≥ 55 °C. After composting, the material is screened into three size distributions. The smallest are sold as compost, the medium are sent to composting again, and the largest, which are generally plastics, are taken to a landfill. Only ~ 0.8-1.4% of the material needs to be taken to the landfill.

Environmental concerns

There are three main categories of concern related to dog waste: pathogen content, plastic bag use, and greenhouse gas impact. Each of these aspects are discussed in the following subsections. Pathogens can affect human, marine, and riverine health and the ability of dog waste to affect these different groups is considered.

Pathogens

Dog waste is host to many pathogens that can pose a risk to human and environmental health. Table 1 lists the most common zoonotic pathogens in dog waste. These pathogens are T*oxocara canis*, *Echniococcus granulosus*, *Giardia duodenalis*, *Cryptosporidium* spp., and *Campylobacter* spp.[11] Fecal coliform are also present in dog waste in concentrations higher than those is human waste.[12] The concentration of these pathogens varies and depends on diet and veterinary care. For example, though dogs are carnivores, pets do not often eat raw meat; commercial dry diets lower the concentration of campylobacter.[13] Though some pet owners prefer to feed their dog meat for health reasons, it is likely that the dogs eat meat suitable for human consumption, which also reduces the likelihood of infection.

Pathogen concentration in dog waste will vary. Consider, for example, giardia. Studies in Northern Canada found that more than half of tested samples of dog waste contain giardia[14] but a

[11] Himsworth, C. G., Skinner, S., Chaban, B., Jenkins, E., Wagner, B. A., Harms, N. J., . . . Hill, J. E. (2010). Multiple Zoonotic Pathogens Identified in Canine Feces Collected from a Remote Canadian Indigenous Community. *Am J Trop Med Hyg*, 338–341.

[12] Pacific Shellfish Institute. (2010). *Pet Waste: What's the Problem?*

[13] Procter, T., Pearl, D., Finley, R., Leonard, E., Janecko, N., Reid-Smith, R., . . . Sargeant, J. (2014). A cross-sectional study examining Campylobacter and other zoonotic enteric pathogens in dogs that frequent dog parks in three cities in south-western Ontario and risk factors for shedding of Campylobacter spp. *Zoonoses Public Health*, 208-218.

[14] Himsworth (2010)

meta-analysis of giardia prevalence studies found an overall prevalence rate of 15.2%.[15] Additionally, being a pet reduces infection rates. Dogs that are pets are also likely to receive anti-helminth medication and treatment for gastro-intestinal problems.[16]

Though the majority of collected waste from Metro Vancouver parks will likely be from pets, the variation in pathogen concentration requires that all pathogens be considered as risks. For example, pets in parks often consume untreated water; regional assessments find giardia in the watershed.[17] Each pathogen is considered separately below.

Helminths

Two of the pathogens are helminths, or parasitic worms. These are *toxocara canis* (roundworm) and *echniococcus granulosus* (hookworm). Dogs are the definitive host of these worms and both live in the intestine of dogs and the eggs are excreted in feces. The eggs can remain infective for up to one year in soil without a host, depending on conditions.[18] Both prefer moist conditions at moderate temperatures; hookworm 4-15 °C and roundworm 10-30 °C.[19] Hookworm eggs can additionally survive freezing.[20]

Due to their survival in soil, humans in close contact with soil can easily ingest the eggs and become infected. Children are particularly vulnerable. Infection can lead to visceral larva migrans with high morbidity and mortality. Fish can also become infected by consuming eggs or by consuming already infected animals.

Toxacara canis eggs are inactivated at temperatures > 34 °C[21] but other species of roundworms, specifically *Ascaris suum*, found in pigs, requires higher temperatures. Ascaris eggs are inactivated at T>55 °C within 1-3 h but require up to 10 days at 37 °C.[22] Additionally, Ascaris eggs are more

[15] Bouzid, M., Halai, K., Jeffreys, D., & Hunter, P. (2015). The prevalence of Giardia infection in dogs and cats, a systematic review and meta-analysis of prevalence studies from stool samples. *Vet Parasitol.*, 181-202.
[16] Jenkins (2013)
[17] Metro Vancouver. (2016). *Greater Vancouver Water District 2016 Quality Control Annual Report.*
[18] World Health Organization. (2001). *Chapter 4: Geographic Distribution and Prevalence - Manual on Echinococcosis in humans and animals.* Paris: World Organisation for Animal Health.
[19] WHO (2001), Jenkins (2013)
[20] WHO (2001)
[21] Jenkins (2013)
[22] Johansen, A., Nielsen, B., Hansen, M. C., Andreasen, C., Carlsgart, J., Hauggard-Nielsen, H., & Roepstorff, A. (2013). Survival of weed seeds and animal parasites as affected by anaerobic digestion at meso- and thermophilic

quickly destroyed in anaerobic environments than aerobic environments.[23] *E granulosus* eggs die within five minutes at temperatures between 60 and 80 °C and will also quickly be killed in low humidity environments.[24]

Protozoa

Two of the pathogens in dog waste are protozoa: giardia and cryptosporidium.[25] Outside of a host, protozoa exist as cysts, which are able to survive without hosts and in harsh conditions. Giardia cysts can survive low salinity environments (such as estuaries) while cryptosporidium can survive in sea water for long periods of time.[26]

The cysts enter a new host by ingestion and then become infective. Infection causes abdominal cramps, bloating, nausea and bouts of watery diarrhea. Humans, many other land mammals, marine bivalves, marine mammals, and riverine animals, can all be hosts for giardia and cryptosporidium.[27] Marine bivalves are able to inactivate giardia, but cryptosporidium remains infective.

Giardia is a common pathogen at WWTPs and is mostly removed from the liquid phase during clarification.[28] Giardia that remains in the solid phases can then be removed during AD.[29] AD at

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conditions. *Waste Management*, 807-812.; Saunders, O., Harrison, J., Fortuna, A. M., Whitefield, E., & Bary, A. (2012). Effect of Anaerobic Digestion and Application Method on the Presence and Survivability of E. coli and Fecal Coliforms in Dairy Waste Applied to Soil. *Water, Air, & Soil Pollution*, 1055–1063.

[23] Saunders (2012)

[24] WHO (2001)

[25] Cats are additionally the host of toxoplasma gondii, which is particularly difficult to eliminate. Cat waste cannot be treated the same as dog waste.

[26] Fayer, R., Dubey, J. P., & Lindsay, D. S. (2004). Zoonotic protozoa: from land to sea. *Trends Parasitol*, 531-536.

[27] Robertson, L. (2007). The potential for marine bivalve shellfish to act as transmission vehicles for outbreaks of protozoan infections in humans: a review. *Int J Food Microbiol*, 201-2016.; Fayer (2004)

[28] Berglund, B., Dienus, O., Sokolova, E., Berglind, E., Matussek, A., Pettersson, T., & Lindgren, P. (2017). Occurrence and removal efficiency of parasitic protozoa in Swedish wastewater treatment plants. *Sci Total Environ*, 821-827.; Casson, L., Sorber, C., Sykora, J., Gavaghan, P., Shapiro, M., & Jakubowski, W. (1990). Giardia in wastewater- Effect of Treatment. *Res J Water Poll Control Fed*, 670-675.

[29] Casson (1990)

37 °C deactivates giardia cysts within 18 hours.[30] Cryptosporidium cysts are deactivated in two days at 55 °C, four days at 47 °C and in ten days at 37 °C. AD at 37 °C deactivates the cysts in one day.[31]

Bacteria

The remaining two common pathogens are bacteria. Fecal coliform are not necessarily dangerous but high concentrations are considered indicative of pathogenic risk. Dog waste has higher concentrations of fecal coliform than human waste. Campylobacter are also common in dog waste; a survey of parks in in southwest Ontario found that 43% of fecal samples contained campylobacter.

Bacteria enter the body via ingestion and cause gastro-intestinal problems in humans. Infections in humans are usually self-limiting. Bacteria in waterways can, like protozoa, become concentrated in marine bivalves and progress up the food chain.

Fecal coliform bacteria are able to respire aerobically and anaerobically. Campylobacter respire aerobically. Though dog waste can have higher concentrations of bacteria than other animal waste, studies of anaerobically digested cow manure consistently show a reduction in bacteria content.[32] Nevertheless, a feasibility study on using AD to treat dog waste noted that WWTPs are designed to treat human waste, not dog waste.[33] Though dog and human waste are obviously different, the specific concern is not noted. It seems the largest difference for bacterial pathogens is concentration rather than type.

Pathogens and composting

As there is considerably more experience with composting dog waste than the other treatment methods, there are more reports of the effective treatment temperatures. One website states that

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[30] Keleti (1993)

[31] Jakubowskii, K., Stadterman, A., Sninsky, J., & Sykora, W. (1995). Removal and inactivation of cryptosporidium oocysts by activated sludge treatment and anaerobic digestion. *Water Sci Technol*, 97-104.

[32] Saunders (2012); Saunders, O., & Harrison, J. (2013). *Pathogen Reduction in Anaerobic Digestion of Manure.* eXtension.; Borchardt, M., Spencer, S., Borchardt, S., Larson, R., & Alkan-Ozkaynak, A. (2013). *Inactivation of Dairy Manure-Borne Pathogens by Anaerobic Digestion.* Madison: USDA.

[33] Christy, A. (2013). *Anaerobic Digestion and Other Alternatives for Dog Waste Management and Education in Thurston County.* Olympia: Pacific Shellfish Institute.

73 °C is the necessary temperature,[34] while the USDA report states 60 °C.[35] Regulations specify 55 °C for three days as the minimum conditions for safe, effective compost.[36] Large scale composting facilities, such as those located in municipalities and those used by Green Pet Compost, regularly exceed the regulatory minimum and are deemed safe. Backyard composting, however, does not effectively reduce pathogens and the Pacific Shellfish Institute, Thurston County Animal Services, and the owner of Green Pet Compost, all recommend against this treatment option.[37] This recommendation is highlighted by the experience of composting dog waste in a Montreal park.[38]

Pathogens and AD

Despite growing interest in AD treatment of dog waste, this method is not frequently used.[39] As a consequence, there is less in-situ evidence that AD creates safe biosolids from dog waste. In-situ evidence from cow waste as well as experimental evidence, all indicate that AD is capable of rendering safe biosolids. In Metro Vancouver, the dog waste can be processed in mesophilic or thermophilic conditions. Both will eliminate the pathogens, but thermophilic will be faster and more effective.

The waste will undergo AD if it is taken to a WWTP. If the waste enters the digester directly, as occurs when it enters via the TLW stream, then all pathogens will necessarily enter the digester. If the dog waste enters at the headworks of the WWTP, as occurs via direct disposal into sewer systems, then it is possible that some of the pathogens will remain in the liquid phase after settling. For example, one study found that 83.4% of cryptosporidium settled in the sludge phase during primary treatment. Secondary sedimentation extracted 90.7%.[40] Similarly, the majority, but not all, of giardia is removed during sedimentation.[41]

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[34] Grant, B. L. (2018). *Dog Waste In Compost: Why You Should Avoid Composting Dog Waste*. Retrieved from https://www.gardeningknowhow.com/composting/manures/dog-waste-in-compost.htm

[35] USDA Natural Resources Conservation Service. (2005). *Composting Dog Waste.* United States Department of Agriculture

[36] Organic Matter Recycling Regulation Schedule 1, section 4b

[37] Thurston County Animal Services. (2018). *The Connection Between Pet Waste and Water Quality*. Retrieved from http://www.co.thurston.wa.us/planning/natural-res/shellfish-pet-waste.htm

[38] Nemiroff, L., & Patterson, J. (2013). Design, testing and implementation of a large-scale urban dog waste composting program. *Compost Sci & Util*, 237-242.

[39] Christy (2013)

[40] Jakubowskii (1995)

[41] Berglund (2017)

Pathogens- Summary

In summary, all methods are able to reduce risks posed by pathogens in dog waste. Composting has been the most common method of treating dog waste. The safety of the treated product can therefore be ensured from in-situ evidence. In their report on the feasibility of AD treatment of dog waste, the Pacific Shellfish Institute note that the Ecology department is concerned that, because WWTPs are designed to treat human waste, dog waste will not be effectively treated. Experimental evidence shows that helminths and protozoa are effectively removed by AD while in-situ evidence from AD of cow manure shows the bacteria are removed. Table 1 summarizes the results. The combination of AD and composting is not explicitly considered because it can be assumed, based on the results for composting and AD individually, that the combination eliminates pathogenic risks.

		Removal	
Pathogen	Type	Compost	AD
Toxocara canis = roundworm	Helminth	T > 55 °C, 1-3 hours T=47 °C, 10 days, 75%	T>55 °C, 1-3 hours T=47 °C, 2 days
Echonococcus granulosus = tapeworm	Helminth	T>60 °C, 5 min	T>60 °C, 5 min
Giardia	Protozoa	T > 55 °C, 3 days	T=37 °C, 18 hrs
Cryptosporidium	Protozoa	T=55 °C, 2 days T=47 °C, 4 days T=37 °C, 10 days	T=55 °C, 2 days T=47 °C, 4 days T=37 °C, 10 days T=37 °C, 1 day
Campylobacter	bacteria	Yes	Yes (Thermophilic > Mesophilic)
Fecal Coliform	bacteria	Yes	Yes (Thermophilic > Mesophilic)

Table 1. The ability of treatment methods to remove pathogens.

Greenhouse gases

Scooby's Pet Removal collects dog waste from the regional parks, debags the waste at a separate facility, and trucks the waste to Iona Island for discharge into trucked liquid waste. While it is not

possible to eliminate the necessity of pick-up from parks, it is possible to reduce the amount of driving if the dog waste is directly discharged into the sewer and enters a WWTP at the headworks.

WWTPs in Metro Vancouver provide themselves energy by burning the methane that is produced during AD. Dog waste is high in carbon and if the waste enters at the head works it will go to primary and secondary treatment. In secondary treatment, oxygen is bubbled into the liquid in accordance with the biological oxygen demand (BOD). Dog waste has a high BOD and will require more bubbling, which requires energy. The relatively low volumes of dog waste may mean that the energy demand increase is negligible. Nevertheless, it is still possible that more energy, in the form of methane, will be obtained if dog waste directly enters the digester via the TLW stream.

Both composting and AD produce a nutrient rich solid. These solids can be used in landscaping and gardening in accordance with regulations to be discussed later. Though these products are useful, large volumes are produced and transport of the solids can be costly. In fact, the biosolids produced at WWTPs do not generate revenue. In order to minimize costs and GHG due to transport, it is possible to reduce the amount of solid produced by combining AD and composting. This two-step process reduces volume without effecting nutrients.

Plastic Bags

As pet owners will understandably use plastic in order to pick up dog waste, plastics seem unavoidable. A possible exception is in special circumstances when dogs are likely to defecate in a confined area and the pet owners are provided with shovels for immediate waste disposal, as observed in the pilot study of in-park AD.

Green Pet Compost and RMW provide compostable bags that, based on visual inspection, successfully degrade. There are four issues to consider for Metro Vancouver to adopt a similar practice.

(1) Green Pet Compost is a private company and subscribers sign-up for the service, indicating that they are personally motivated to sustainably manage their pet's waste. They still report some issues with subscribers using traditional plastics. RMW also reports issues with traditional plastic bags, though they provide bags and only collect from two sites.
(2) Metro Vancouver has observed that when bag that say 'biodegradable' or 'compostable' are provided, pet owners are more likely to leave bagged pet waste on the ground in public areas, apparently under the impression that the bag and waste will both safely degrade.
(3) At the moment, Metro Vancouver has asked residents to not place so-called compostable straws, cups and other containers in the green bin. The local facilities are unable to

successfully process these plastics because they often require specific conditions and/or microorganisms that are not achievable. Biodegradable plastics used for plastic bags may be more easily degraded, however, regional facilities may be unwilling to accept them. The Compost Council of Canada notes that not all plastics marketed as compostable are certified to be compostable.

(4) Composting facilities in Metro Vancouver do not currently accept dog waste

Use of compostable bags does not seem like a viable option at the moment. In the current system, the plastic bags that have been separated from the dog waste are sent to the Burnaby incinerator, where they are burned for electricity. As biodegradable and compostable plastics become more common, Metro Vancouver can re-evaluate the problem of plastic bags and dog waste.

Regulations of Untreated Waste

Regulations constraining the transport and use of the raw waste and treated waste, at a provincial and regional level, are important considerations. Dog waste can arrive at a WWTP via the trucked liquid waste stream or via direct discharge into the sewer. Additionally, the raw waste needs to be handled in a way that does not lead to odour complaints.

WWTPs

Trucked liquid waste (TLW) is defined as 'any Non-Domestic Waste that is collected and transported off the site on which it originated by means other than discharge to a Sewer, including but not limited to Oil and Grease from interceptors and other sludges of organic origin. WWTPs must approve the dumping of non-domestic waste.

Iona Island has approved Scooby's and has a screen as part of the TLW intake. Annacis Island does not typically accept non-domestic waste, though it does take some screened high strength waste on a case by case basis through the co-digestion facility at the discretion of management. Screening of dog waste may be particularly important as it can contain significant amounts of grit.

In order to enter the TLW stream at Annacis Island, Scooby's will need to obtain a permit. If off-site grit screening is required as part of the permit, the odour production potential of the system should be considered. This additional step may increase the cost of the operation.

An alternative to the TLW stream is direct discharge into the sewer system. Direct discharge of the dog waste would require a discharge permit issued by a sewer control manager.[42] The bylaw for sewer use is being reviewed with respect to definitions and permitting. The current bylaw does not specifically cover dog waste. If Scooby's applies for a discharge permit the approval process will consider flow of the waste, type of pipe the waste is discharged into, and capacity of the WWTP to process the waste.[43] The cost of permitting and dumping is unknown.[44]

Compost

According to provincial regulations, animal excreta from pets is suitable for composting.[45] This does not mean that the facilities in Metro Vancouver will be willing or able to accept dog waste. One of the facilities, Harvest Power in Richmond, expressly states that pet excreta are not accepted. Moreover, Harvest Power and Enviro-Smart both experience odour complaints. Green Pet Compost reports that odour is not an issue because their methods ensure that the dog waste is in airtight containers until it is placed in the mixer. In the mixer the bags are broken open and mixed with wood chips. The wood chips quickly neutralize the odour. Green Pet Compost then uses in-vessel composting. RMW reports that odour is only an issue when the dog waste is in the collection bins and not during composting. The dog waste, however, is not directly composted but rather the digestate from a WWTP.

Regulations of treated waste

The treated waste is a value-added product and is used as a soil additive or fertilizer. Compost and anaerobic digestate, called biosolids, are defined and controlled provincially by the Organic Matter Recycling Regulation (OMRR). Both compost and biosolids are defined as either Class A or Class B depending on the temperature and duration of the treatment. The class of the material determines how the material can be used.

Biosolids

Class A biosolids are the result of thermophilic anaerobic digestion at a temperature of not less than 50 °C for at least 10 consecutive days. Class B biosolids are formed by mesophilic anaerobic digestion between 15 days at 35 °C to 55 °C and 60 days at 20 °C. Class A biosolids can be sold to

[42] Section 5.3 of sewer use bylaw
[43] Conversation with Linda Parkinson
[44] Scooby's has reported that the current estimate is very expensive
[45] Organic Matter Recycling Regulation Schedule 12

the general public in of volume ≤ 5 m^3 per vehicle per day, unless in a sealed bag. Class A biosolids can be distributed to composting facilities or biosolids growing facilities in unlimited quantities. Class B can also be distributed in unlimited quantities to composting facilities. Land use applications, however, are restricted. Class B biosolids must be applied on sites with restricted public access or use, at least 30 m from potable water sources, 20 m from major roadways, and 10 m from minor roadways. Additionally, it cannot be applied on land where the water table is within one meter of the surface. If it is applied, domestic animal grazing will be restricted for 60 days, above ground crops for 18 months, and below ground crops for 38 months.

In Metro Vancouver, Lulu and Annacis Island WWTPs produce Class A biosolids, while Iona Island, Lion's Gate, and NW Langley WWTPs produce Class B. Metro Vancouver tends to manage all of their biosolids according to stricter Class B requirements and refers to biosolids as Nutrifor.[46] Nutrifor is used to re-introduce vegetation to mine sites and gravel pits, fertilize rangeland, hayfields and forests, and topsoil for landscaping, among other applications. Around 25-30% of Class A biosolids from Annacis Island WWTP are taken to South Richmond where a private company mixes it with appropriate amounts of sand to produce Nutrigrow which is sold for profit. While there is a profit sharing program with the contractor, Metro Vancouver does not have a net profit on biosolids management.

Compost

Class A compost must reach 55 °C for 30 minutes or longer. Industry standard is three days. Class B compost is produced by conditions between 40 days at 20 °C and 60 days at 15 °C or by air-drying in shallow sand bends for several months. Class A compost can be distributed without restriction. The compost facilities in Metro Vancouver produce Class A compost that is sold in the region. Though Green Pet Compost also produces Class A compost, in personal conversation, they stated that they are unwilling to sell it for use in gardens, though the owner uses it in his personal garden. He stated that, though he does not think his compost would cause a problem, he is unwilling to risk being blamed if there is a problem. As a consequence, he sells and donates Green Pet Compost exclusively for landscaping.

[46] Conversation with Dave Keeney

Summary

Dog waste treatment presents environmental, operational, financial, and regulatory concerns. These concerns have been discussed in detail in the preceding sections. Table 2 provides a condensed comparison between the treatment methods. AD treatment is subdivided into trucked liquid waste (TLW) and direct discharge (DD) streams. Though AD can also be subdivided into mesophilic and thermophilic digestion, this division is not necessary because these options differ only in temperature of treatment and both treatments provide a safe end product. TLW and DD streams, however, have significant differences in GHG emissions, operational concerns at the WWTP, potential tax burden, and are subject to different regulations and permitting processes. Table 2 is designed as a quick reference to understand the barriers to implementation of each method. It attempts to summarize the most significant concerns without reducing complexity.

		Environmental Concerns			Operational Concerns	Financial Concerns		Regulatory Concerns	
		Pathogens	Plastic	GHG		Tax Burden	Value-added products	Permission	Bylaw
AD	TLW	Pathogen are removed by mesophilic and thermophilic temperatures. Thermophilic is preferred	Does not eliminate plastic usage	GHG from transport of untreated waste unchanged GHG from transport of treated waste unchanged	Increase in dog waste might cause changes to microbial ecosystem Grit needs to be screened from waste before digester	No change expected	Biogas (CH4) produced; Biosolid produced. (MV calls biosolid Nutrifor.) Prefer Class A from thermophilic to Class B from mesophilic. (Class A is sold commercially as Nutrigrow.)	Permission to discharge is given by each plant. Dog waste, charged as domestic waste, goes to Iona, which has a screen for TLW.	Dumping permit is required. Dog waste collected from parks is non-domestic waste.
	DD	Pathogens that enter digester will be eliminated, however, must ensure they are in the solid phase. Secondary treatment is necessary	Does not eliminate plastic usage	GHG from transport of untreated waste reduced GHG from transport of treated waste unchanged	Increase in dog waste might cause changes to microbial ecosystem Biological Oxygen Demand could increase	Change unknown, pending cost of permit and warehouse		Permit required	Dog waste is not specified in current sewer use bylaws.
Compost		Pathogens will be eliminated in commercial/industrial facilities	Opportunity to use compostable bags	GHG from transport of untreated waste unchanged GHG from transport of treated waste unchanged	Though others do not report odour issues with dog waste, given existent odour complaints, this will be a concern. use of conventional plastics	Buying compostable bags will increase cost of program	Class A compost is produced. Though all pathogens are eliminated, there may be lingering concern on the use of the compost because the dogs are carnivores	Regional facilities do not accept dog waste	Dog waste is allowed in compost (Organic Matter Recycling Regulation)
AD +Compost		Pathogens will be eliminated in commercial/industrial facilities	Does not eliminate plastic usage	GHG from transport of untreated waste unchanged; GHG from transport of treated waste reduced	Odour is not an issue at Surrey biofuels but may be an issue with dog waste	Should occur at the same facility or location to be feasible	Biogas produced. Class A compost is produced. This method reduces the volume of the waste without reducing the nutrient content. The volume reduction is beneficial	Regional facilities do not accept dog waste	There is no limit to the amount of biosolid that can be accepted by a composting facility.

Table 2. Significant concerns of treatment methods.

Table 3 is less detailed to allow direct comparison. Operational concerns are not included in the table but need to be addressed if that method is chosen. The attributes listed on the left are all positive; a check mark indicates a method has the positive attribute and an 'x' mark indicates that the method does not have the attribute. Lack of an attribute does not mean the method cannot be used, but it does suggest the method is less desirable. The 'Reduce Tax Burden' category is difficult to determine, particularly in the case of direct discharge because the cost of permitting is unknown. The AD-DD box consequently has an open box.

Counting the check marks indicates that if the DD has the most positive attributes. If the permit is not cost prohibitive, it is a desirable treatment option. It is important to note, however, that if DD is used, the dog waste must go to a WWTP with secondary treatment.

AD-TLW is also a good option for dog waste treatment and is the current method of treatment. At Iona Island, where the dog waste is accepted into the TLW stream, the waste is subject to mesophilic conditions producing Class B biosolids. At a plant such as Annacis Island, the TLW is subject to thermophilic conditions producing Class A biosolids. While thermophilic treatment is preferable, Annacis Island is the busiest plant in the region and may not approve the additional discharge. Moreover, the dog waste likely would need to be screened before reaching the facility. Iona Island has a built-in screen for TLW.

AD-TLW and AD+Compost have the same number of positive attributes, though the categories differ. AD+Compost has the potential to reduce GHG emissions because the dual treatment reduces the volume of treated material. The lower volume reduces transportation requirements. If the AD and composting facilities are not located in the same location, any benefit due to minimization of transport is lost. Surrey Biofuels, which does combine the two treatments in one location, does not currently accept dog waste.

Composting, though it has the fewest positive attributes, has a unique advantage over the other treatment options: the ability to reduce plastic use. The potential to reduce plastic waste is however limited by the availability of compostable plastics and the inability of regional facilities to accept these plastics. Additionally, though experience and research shows that composting eliminates pathogens in dog waste, there is a significant bias against using composted dog waste as Class A compost. Composting is not a recommended treatment option unless a separate and designated composter that allows the region to keep this treated waste stream separate.

	AD			
To Consider	TLW	DD	Compost	AD+Compost
Removes Pathogens	✓ Thermophilic conditions preferred.	✓ Secondary treatment required.	✓	✓
Reduce Plastic	×	×	✓ Depends on users	×
Reduce GHG	×	✓ Reduce transport of untreated waste.	×	✓ Reduce volume of treated waste
Reduce Tax Burden	×	☐ Cost of permit unknown.	× Possible increase due to cost of bags	×
Biogas produced	✓	✓	×	✓
Biosolid produced	✓ Thermophilic → Class A Mesophilic → Class B	✓ Thermophilic → Class A Mesophilic → Class B	✓ Class A	✓
Permits Available	✓	✓	×	×
Regulatory Acceptable	✓	✓	✓	✓

Table 3. Comparison of treatment options.

Recommendations

It is safe to continue to use the TWL stream at Iona Island WWTP. The following steps should additionally be taken.

- Assess cost of permit for direct discharge to a plant with secondary treatment.
- As the volume of dog waste increases, compare the volume to the biogas production and pathogen reduction in biosolids to ensure that it is safe to treat dog waste at WWTPs. This information will be valuable to Metro Vancouver and other regions.
- Do not pursue AD + Composting unless AD and composting are done in the same facility.
- Do not pursue composting unless a designated dog waste composter is used.

In addition, as regional infrastructure develops and as alternatives to traditional plastics are developed, opportunities to improve the dog waste treatment program can be incorporated.

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Appendix A: Green Pet Compost Questionnaire

Options for dog waste treatment

1) Are you aware of any methods other than composting to process dog waste for resource recovery?
   - ○ Yes Anaerobic Digestion
   - ○ No

2) Why did you choose composting?
   methane but they would still have to compost to meet regulationsthinking about it in the future to develop AD in future composting 50 miles from where you pick up

Participation in the program

3) How do you encourage pet owners to participate (check all that apply)?
   - ○ Brochures
   - ○ Signs in parks
   - ○ Print media
   - ○ Social media
   - ○ Word of mouth
   - ○ Billboards
   - ○ Community events
   - ○ Other Free Pick up from the humane society

4) Do you have any issues with pet owners using non-compostable bags?
   - ○ Yes Yes if they use biodegradable or regular – harder to get out of bag – mixer rips everything up (mix with wood chips and saw dust). Screen at the end to get rocks and wood chips – end up getting out bags
   - ○ No

5) What brand or type of compostable bags do you prefer pet owners use?
   provide bucket w/ compostable liner. 100% compostable out kygopoly out of canada

The system

6) What type of composting system do you use?
   - ○ In-vessel Composting

- ○ Aerated Static Pile Composting
- ○ Aerated (Turned) Windrow Composting
- ○ Vermicomposting
- ○ Other (please specify)

7) What was the initial cost of implementing the system?
~ 80K- includes mixer that he developed and also skidster
8) What are the annual operational costs of maintaining the compost system?
~ 30 K (plus labor)
9) Are there any additional system components specifically required to handle dog poop?
   a. For transport
      - ○ Yes trucks
      - ○ No
   b. For storage
      - ○ Yes 20 gallon tubs with compostable liner
      - ○ No
   c. For debagging
      - ○ Yes Mixer
      - ○ No
   d. Other

20 gallown totes with compostable liner – onto trucks – seal full tubs into storage 100-120 into storage. Can Hand 250 tubs at a time

10) What volume of dog poop can you compost concurrently?

15,000 lbs a month

11) Do you ever need to store excess dog poop?

- ○ Yes
- ○ No

12) If yes to question 12, what is the capacity for storage?
   a. Volume?
   b. Number of days?

13) What are the operating conditions of the system?

a. Temperature? gets to 140-145 after ~3 days- it is always mixing- a thru process
b. Residence time? 10 days
   2 bins afte vessel into aerated bins for 45 to 60 days until temp drops
   90 to 120 days total processing time – then screening ¾ screen – take that pile with more sawdust and more waste and back through composter – this reduces amount of compost produced (does b/c not selling all of it)

14) Do you have any issues maintaining appropriate compost conditions in winter months?

- ○ Yes It is too wet. Cannot get enough dry carbon
- ○ No

15) Do you compost other materials with the dog poop (check all that apply)?

- ○ Wood shavings or other carbon rich material
- ○ Other animal feces
- ○ Food scraps occasionally
- ○ Other green grass, green leaves, and fish, all of which are good sources of N
- ○ No

16) Are there any operational challenges that may be attributed to dog poop?

<u>Environmental & Human Health Impact</u>

17) Is odour from the pre-treated dog waste a problem?

- ○ Yes
- ○ No

18) Is odour from the composting dog waste a problem?

- ○ Yes
- ○ No

19) If yes to either question 18 or question 19, what methods are used to mitigate odour?
goes into sealed containers and once it is mixed with wood chips smell goes away in vessle there is kinda a sweet odor (not very strong)

20) Dog poop has a high number of pathogens, what standards must be met to ensure safety of the compost? (check all the apply)

- ○ Compost is known to reach specific conditions
- ○ Compost is tested for pathogens have it tested (3 batches/year) and work with health and ecology departments. test for ecoli, samonello, bacterial
- ○ Other (please specify)

21) From question 20, if compost reaches specific conditions, how are the appropriate conditions determined? (check all that apply)

- ○ Scientific studies indicate appropriate conditions
- ○ Government regulations
- ○ Other (please specify)

22) From question 20, if the compost is tested for pathogens, how frequently is the compost tested?
health department- once a year, send in reports of anaylsis by local lab. heavy metals as well

23) From question 20, if the compost is tested for pathogens, what pathogens do you test for?

state of WA WAC regulations is the 131 for 3 days and that is industry standard

24) What methods do you use to ensure the compostable bags are broken down?

- ○ Visual inspection
- ○ Other (please specify)

25) Are you aware of any other risks associated with composting dog waste?

- ○ Yes (please specify)
- ○ No pacific shell fish discourages back yard composting

26) What procedures are used to ensure worker safety when handling dog poop? (check all that apply)

- ○ Provide gloves
- ○ Provide safety glasses
- ○ Provide nose masks

- ○ Provide additional training
- ○ Other (please specify)

27) Do workers express concerns with handling dog waste?

- ○ Yes
- ○ No

The resource

28) What do you do with the composted dog waste?

- ○ Personal landscaping would not sell to people because liability risk. Sell for yards and ornamentals. Gives to local churches to give to landscaping Things that eat meat have more pathogens. House dogs now eat mostly grains
- ○ Municipal landscaping
- ○ Return to pet owners
- ○ Sell to pet owners
- ○ Sell to general public
- ○ Other

  most is given away. good to even out lawn. 60:30 with soil very good for plants

29) If you sell the compost, do you package the compost or sell the compost in bulk?

- ○ Packaged
- ○ Bulk
- ○ Both

30) If you sell the compost, what instructions do you provide to the customers?

31) Do you know other resources that can be recovered from dog waste?

Appendix B: Whistler Resort Municipality Questionnaire

Options for dog waste treatment

1) Are you aware of any methods other than composting to process dog waste for resource recovery?
   - ○ Yes --Dog waste into electricity 'Park Spark Project'
   - ○ No

2) Why did you choose composting?
   After consultation with Metro Vancouver and Metro Toronto it was determined that the composting was the best option at the time

Participation in the program

3) How do you encourage pet owners to participate (check all that apply)?
   - ○ Brochures
   - ○ Signs in parks
   - ○ Print media
   - ○ Social media
   - ○ Word of mouth
   - ○ Billboards
   - ○ Community events
   - ○ Other (please specify)

4) Do you have any issues with pet owners using non-compostable bags?
   - ○ Yes
   - ○ No

5) What brand or type of compostable bags do you prefer pet owners use?
   Biobag – supplied in all parks and village poo bag dispensers

The system

6) What type of composting system do you use?
   - ○ In-vessel Composting

- ○ Aerated Static Pile Composting
- ○ Aerated (Turned) Windrow Composting
- ○ Vermicomposting
- ○ Other (please specify)

7) What was the initial cost of implementing the system?
Commercial facility treat the biosolids. The cost per kilo of dog waste is minimal

8) What are the annual operational costs of maintaining the compost system?

9) Are there any additional system components specifically required to handle dog poop?
   a. For transport
      - ○ Yes
      - ○ No
   b. For storage
      - ○ Yes
      - ○ No
   c. For debagging
      - ○ Yes
      - ○ No
   d. Other

10) What volume of dog poop can you compost concurrently?
1 MT

11) Do you ever need to store excess dog poop?
   - ○ Yes
   - ○ No

12) If yes to question 12, what is the capacity for storage?
   a. Volume?
   b. Number of days?

13) What are the operating conditions of the system?

a. Temperature? Above 55 °C, Average 60 °C
b. Residence time? 3 days

14) Do you have any issues maintaining appropriate compost conditions in winter months?

- ○ Yes
- ○ No

15) Do you compost other materials with the dog poop (check all that apply)?

- ○ Wood shavings or other carbon rich material
- ○ Other animal feces
- ○ Food scraps
- ○ Other (Biosolids)
- ○ No

16) Are there any operational challenges that may be attributed to dog poop?

No. It is first sent to the WWTP then sent along with other biosolids to our commercial composter, producing a Class A compost.

Environmental & Human Health Impact

17) Is odour from the pre-treated dog waste a problem?

- ○ Yes
- ○ No

18) Is odour from the composting dog waste a problem?

- ○ Yes
- ○ No

19) If yes to either question 18 or question 19, what methods are used to mitigate odour?

Use of a red ecotainer120 L, with lid.

20) Dog poop has a high number of pathogens, what standards must be met to ensure safety of the compost? (check all the apply)

- ○ Compost is known to reach specific conditions
- ○ Compost is tested for pathogens

- ○ Other (please specify)

21) From question 20, if compost reaches specific conditions, how are the appropriate conditions determined? (check all that apply)

- ○ Scientific studies indicate appropriate conditions
- ○ Government regulations
- ○ Other (please specify)

22) From question 20, if the compost is tested for pathogens, how frequently is the compost tested?
Tested as per Organic Matter Recycling Regulations

23) From question 20, if the compost is tested for pathogens, what pathogens do you test for?

24) What methods do you use to ensure the compostable bags are broken down?

- ○ Visual inspection
- ○ Other (please specify)

25) Are you aware of any other risks associated with composting dog waste?

- ○ Yes (please specify)
- ○ No

26) What procedures are used to ensure worker safety when handling dog poop? (check all that apply)

- ○ Provide gloves
- ○ Provide safety glasses
- ○ Provide nose masks
- ○ Provide additional training
- ○ Other (please specify)

27) Do workers express concerns with handling dog waste?

- ○ Yes

- ○ No

The resource

28) What do you do with the composted dog waste?

- ○ Personal landscaping
- ○ Municipal landscaping
- ○ Return to pet owners
- ○ Sell to pet owners
- ○ Sell to general public
- ○ Other

29) If you sell the compost, do you package the compost or sell the compost in bulk?

- ○ Packaged
- ○ Bulk
- ○ Both

30) If you sell the compost, what instructions do you provide to the customers?

Class A Compost

31) Do you know other resources that can be recovered from dog waste?

No