**Table S4.** **Justification of factors selected affecting composting of organic waste (city and urban agriculture (UA))**

| **Factorsa** | **Importance of factor to urban P recycling** | **Specific Montreal situation** |
| --- | --- | --- |
| **City level** |  |  |
| Quebec law on organic waste management | Motivation for local compost production and thus increases availability of recycled P fertilizer. | 60% of organic material recycled by 2015 and zero organic waste (food, green, and sewage) sent to landfills by 2020 (thus 100% recycling and/or reduction in waste). |
| 1st world view of waste management | Do not view waste as a resource (rather something we must get rid of because it is dangerous) thus limits P recycling. | Currently some reticence to the reuse compost made by the City, and concerns over odor, and pests associated with compost collection and processing |
| *Ageing infrastructure* | *Can mean leaky sewage system thus loss of P, but also that there are other pressing priorities for money in the city and not necessarily P, although there are opportunities if we are rebuilding to change infrastructure. In addition, built infrastructure creates a legacy for current P cycling.* | *Most major built infrastructure projects date from the 60’s and 70’s and need considerable repair (e.g., Champlain Bridge, Turcot Interchange, Olympic stadium). Currently Montreal has underspent in updating sewage and water infrastructure (and subject to overspending through corruption), and a large part of the budget is now dedicated to this sector.* |
| *Central, mixed, and no-recycle sewage system* | *Affect fate of P in sewage waste.* | *We have a legacy of centralized sewage (some pipes are over 100 years old), primary wastewater treatment plant started construction in the 1970’s but only completed in the 1990’s. The city itself and most of the East island is mixed but the west-island does have separate wastewater and rainwater systems. Currently the pant complies with P discharge laws but there is still a significant amount of P discharged.* |
| Landfilling of most organic waste (w/small composting projects) | Means little P is recycled, and most accumulates in landfill sites. | Have implemented a few pilot projects for organic waste collection but currently garbage collection is mixed (organic and non-organic) and sent to landfill (including all biosolids from the wastewater treatment plant). Only 11% of Montreal’s solid waste is composted or diverted from landfills. |
| "NIMBYism" about large scale composting | Delay the implementation of composting programs and make it difficult to find sites to process organic waste, and thus P recycling. | City has had political, business, and citizen opposition to two (Saint-Michel and Dorval Airport) of the four proposed processing sites necessary to implement 100% composting program. Also some reticence from boroughs to start separate organic waste collection.  |
| *Waterway characteristics (no eutrophication around Mtl)* | *Possibly less motivation to be particularly efficient and careful about P management.* | *There are high P concentrations in the St-Lawrence downstream of Montreal but don’t see effects directly around the city (Environment Canada, 2013b).* |
| *Diet* | *Affects amount of P in food imported, produced, and P in human solid and liquid waste streams.* |  |
| Understanding of proper collection and composting | A lack of knowledge can decrease adoption of composting and thus P recycling, and/or the creation of useable compost and thus P recycling. | There seems to be a lack of knowledge in many parts of the population. |
| Compost Market | Determines if P is actually recycled toward food (or other) production. | Currently have limited markets for the planned compost produced by the City. At smaller scales compost producers are the compost users, creating a “closed” market. |
| Density | Population influences amount of food consumed and wasted, and thus quantities of P imported and wasted, area determines the amount of space available for composting. | 4,517.6 people per km2 in 2011 (Statistics Canada, 2013), leaving limited space for home composting in the downtown core, and also limited spaces for large scale compost facilities. |
| Perception of actors roles and responsibilities | If stakeholders have different opinions and understandings of who should be responsible for certain aspects of P recycling or some actors not trust that an actor fulfill their roles, this can be a road-block towards increasing P recycling through compost production. | The central City (agglomeration) is responsible for organic waste treatment through the waste management plan, boroughs are responsible for waste collection for residences with less than 8 units and small businesses, but large condos, institutions, and businesses must use private contractors. There are different opinions about who and how compost should be produced (small scale vs large scale). There is also some mistrust with regards to government management because of a history of corruption (Radio-Canada, 2014; Vérificateur général de la Ville de Montréal, 2013). |
| **Urban agriculture level** |  |  |
| Amount of urban agricultural and urban food system initiatives | Amount of UA affects the amount of P that is applied and can be recycled and the # of actors involved in urban food system initiatives can affect the amount of UA but also support policies and practices to increase UA and/or composting. | (Metson and Bennett, 2015) surveyed 163 actors, the agriculturemontreal website identified 410 gardens, and OCPM got 1500 participants and 103 “memoires”, which resulted in the creation of a permanent committee on UA, GTAU got 29000 signatures to get the public consultation, there are also new overarching organizations like Food Justice Montreal (JAM), and the adoption of The Montreal Food System Plan (SAM 2025). |
| Understanding of larger environmental and social problems in the food and/or waste system | Can act as a motivator toward composting and the selection of specific fertilization and waste management practices, thus affecting P application and reuse, and affect the type of infrastructure put in place to compost. |  |
| Desire for education and outreach | Influences which type of P inputs gardeners and farmers will choose, the type of substrate, and waste management techniques they may choose. | Health and safety guidelines in schools, and general concern for food safety when education is a priority in UA projects often means organizers want certified inputs, and may not be able to compost on site. |
| Desire for "organic" | Influences which type of P inputs gardeners and farmers will choose, the type of substrate, and waste management techniques they may choose. | Access to fresh and local foods, and environmental concerns (including wanting organic) were two of the top three functions of UA community and private gardeners identified as key to their participation in Montreal (Duchemin, 2013). |
| Access to capital for food | This affects food choices and thus P consumption and imports to the city, but also possible participation in UA to supplement food. | -Food insecurity is present in 16.2% of population (Ville de Montréal, 2013)- 18% of community garden respondents indicated that food security was a motivation for UA (Duchemin, 2013) |
| *Concern about soil quality* | *Impacts where UA and composting can be done on soil and where soil remediation is necessary or container gardening becomes necessary (although some studies have shown limited health risk (McBride et al., 1997).* | *There are UA sites with some heavy metal contamination (some remediation has been done, or containers provided) and study shows that not a large health risk, although people do perceive it as a large problem (Beausoleil and Price, 2010; Direction de la santé publique de Montréal, 2008; Wegmuller and Duchemin, 2010).* |
| *Substrate use* | *Inputs used and management can be a bit different between different types of substrate (e.g. some container garden systems have specific soil mixtures proposed, and roof gardens must use light substrate because of weight).*  | *Currently more UA is on soil, where on soil is favored on the West Island, container gardens are more common in the city-center, and there are a few roof-top gardens and farms. High density means there is a maximum area to increase UA upon, especially on soil. Large rooftop gardens, like Lufa Farms, may be one option to further expand UA but may not be able to reuse City compost because of its weight.* |
| *Quebec laws on Environmental quality and agriculture &**Quebec law on water quality* | *Determines fertilizer and waste management practices on large farms, wastewater and sewage treatment techniques to meet standards* | *-Must have P balance on farm based on soil test if you have a large enough farm with animals (so must export extra manure if your soil is saturated)**-Phosphorus in water bodies can not exceed 0.03 mg P\*l-1* |
| Choice of inputs and amounts (including fertilizer purchase, and availability of inputs) | Affects the amount of P applied to soil and the choices also affect the source of the P applied (recycled on or imported to the island) | Many gardeners chose to use some on-island compost, but not necessarily in large quantities and most of them supplement with purchased sources of P that come from outside the island. |
| *Rules in community gardens and UA* | *Affects the types of crops grown and thus how much P is applied and harvested. The fact that few animals are allowed means that there is less P flowing in and out of UA, perhaps limiting P losses, but can also limit recycling potential. Laws on compost location also limit recycling of P.* | *-No farm animals (expect west-island ag zoning)**-Plant diversity in community gardens (min 5 plants not covering more than 25% of space each)**-Cleanliness laws (can’t have anything that doesn’t look “orderly”)* |
| Knowledge of proper composting (often limited) | Lack of knowledge can translate to lack of participation in composting activities, or compost not being usable when produced on-site because of contamination or not decomposing rapidly enough, implicit in the big NIMBYism about compost. | UA practitioners seem more knowledgeable that non-practitioner citizens, but even in those UA practitioners that do compost, some times contamination, incomplete decomposition, or poor management of input material ratios make compost unusable. |
| Access to capital for UA projects (often limited) | Affects the amount of UA on the island as well as the number of trained people who can help ensure continued composting and knowledge transfer. | There is limited access to long-term and stable financial and human resources for UA. For example, there are less and less horticultural councilors in community gardens and full-time employees on NGO UA projects. |
| *Impervious surface cover* | *Affects P runoff rates from gardens and lawns. Also can affect substrate use because to cultivate on soil need access to it, so if impervious surface is high may use alternative substrate or not cultivate.* | *Areas with more impervious surface are responsible for more P losses. There is more impervious surface downtown, where there is thus less access to easy land for UA or compost sites.* |
| *Land ownership/tenure* | *Can influence what you can and are willing to do with the property and also the longevity of projects and return on investment (Brown and Carter, 2003; Lynch et al., 2001), some argue that insecure land tenure is problematic, while others argue that UA can take advantage of under-utilized spaces without long-term tenure (Smit and Nasr, 1992).* | *Less than 50% own in the city of Montreal, while over 80% of households in the West island are owned by an occupant of the household (Statistiques Canada, 2013).*  |
| *Amount of different types of land use* | *Relevant as it determines which actors have access to space for UA and composting. Amount of residential land use is particularly important as it determines space for private citizens which produce the most about of organic waste and highest demand for food.* | *-Residential land use is 37% on the island (including high, medium, and high density).**-Green space is 12% (including cemeteries, gold, urban and regional parks, nature reserves, and rural land uses)**- Vacant land is 14.57%**(Communauté Urbaine de Montréal, 1996)* |
| *Access to fresh water (unlimited)* | *In other cities, high cost of urban water can limit UA projects (also when fresh water access is limited the use of wastewater (high in nutrients) can more easily be proposed in UA (Smit and Nasr, 1992).* | *Montreal does not meter household water use although the city does have rules regulating outdoor use in the city itself.* |
| *Crop choice* | *Link between P applied and how much is P harvested as different crops require different amount of P.* |  |
| *Sunlight hours* | *Affects crop choice and number of rotations possible and thus amount of inputs used and waste produced.* | *2015.2 sunlight hours, Canada is in Plant Hardiness Zone 5a (which is enough to grow corn and most other crops) (Agriculture and Agri-Food Canada, 2013; Environment Canada, 2013a)* |
| *"Short" growing season* | *Affects crop choice and number of rotations possible and thus amount of inputs used and waste produced.* | *156 days, (143 days or 20 weeks) Average based on survey (2013)(environ Canada 1950-1980) and survey* |
| *High temperature and precipitation variability and average low temperature* | *Affects crop choice and number of rotations possible and thus amount of inputs used and waste produced.* | *-Average temperature (C°, 2012) and average growing season temp (May-Oct): 8.5 (18.26)**-Minimum temperature (C°, 2012): -24.1**-Maximum temperature (C°, 2012): 33.3**-Total precipitation (mm, 2012): 927.4* *-725.8 mm rain and 192.4cm snow**(Environment Canada, 2013c)* |
| **Needs to overcome barriers towards more P recycling in City and UA** |  |  |
| Knowledgeable citizens | Affects capacity to compost and thus recycle P properly in large quantities at individual and collective scales. |  |
| Valued compost product | Can motivate compost collection, processing, and use of recycle P if it is viewed as a valuable resource. |  |
| Ease of practice through infrastructure | Affects capacity of individuals and groups to actually recycle waste. |  |
| Monitoring | Necessary to see if implementation of any plan to increase compost and/or UA is effective, and also necessary to ensure high quality compost and trust between actors. |  |
| High compost quality (shared definition) | Need “high quality” compost to ensure P is actually reused, and need shared definition of what quality means. |  |

a For each factor (column 1), we explain its general importance to urban P cycling (column 2), as well as the situation in Montreal (column 3). Factors in normal font are key factors used in the Results and Discussion section of the article while the factors in italic were deemed to be secondary.