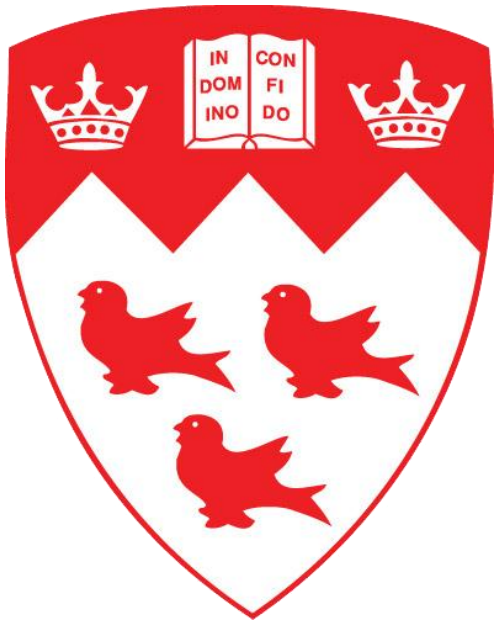


# Hazardous Waste Management

# The Challenge of Biomedical Waste Disposal and Sustainability at McGill University

## Final Report

Elizabeth Côté and Christian Bouchard, January 2014

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# 0 EXECUTIVE SUMMARY

The Hazardous Waste Management department (HWM) of McGill University is responsible for the collection of hazardous wastes coming from all research laboratories on campus. In order to improve the sustainability of our Biomedical waste (BMW) disposal practices, HWM hired a student to audit our procedures, consult with the research community and then make recommendations on what needs to be done to improve the efficiency of our BMW disposal services. At McGill, we have over 200 Principal Investigators (PI) that holds over 400 biohazard certificates. This calls for a very active biomedical research, and a large amount of BMW generated every week. In order to dispose of BMW, McGill's HWM collects the waste on a weekly basis from all the hazardous waste rooms across campus, then transports it back to their facility where all containers will be weighted, bar-coded and stored below 4ºC. All containers are single-use cardboard boxes. Once a week, a contractor (Stericycle) will transfer all the BMW to their warehouse, where it will ultimately be transported to their Moncton, NB incinerator for final disposal. In order to lower our carbon footprint related to BMW disposal, we need to look at ways to minimize generation of such wastes, as well as a more sustainable manner to dispose of it. To do so, we first used the year 2011 BMW volume statistics to determine which building was the highest volume generator (Life Science Complex and Lyman Duff generates 71% of BMW). Then we generated a checklist that would be used during laboratory visits of those targeted buildings to assess the present situation. Laboratories were contacted and asked if interested in participating. 17 laboratories accepted the invitation and were visited by Elizabeth Côté (student project lead). Then, all checklists were compiled in order to come up with recommendations for HWM. The observations we made as well as the feedback we got from the users was 1) the need for clearer instructions as to what type of waste goes where; 2) cross contamination between regular waste and BMW; 3) improper BMW sterilization procedures in lab. The following recommendations were made to the HWM: 1) implement a new BMW disposal framework that involves use of disposable containers for anatomical waste, reusable containers for non-anatomical waste and disposable/reusable containers for the autoclaved BMW; 2) Have a solid communication plan to successfully implement the new framework; 3) propose to higher administration the implementation of a central BMW sterilization system, operated by HWM. This would allow us to sterilize most of our non-anatomical BMW, which compose over 65% of our total volume of waste. Not only would this solution be more sustainable, but also make more sense economically.

# 1 INTRODUCTION

Hazardous waste management is an international concern and has been, for the past 20 years, a condition for sustainability. According to the United State Environmental Protection Agency (US EPA) hazardous wastes are dangerous and can be potentially harmful to our health or our surrounding if released in the environment (US EPA, 2011).

Therefore, hazardous wastes require special treatment before disposal in order to render them harmless or less dangerous for people and the environment. Without proper treatment, this type of waste can cause short and long-term damages to both terrestrial and aquatic ecosystem. An example of long term effects of hazardous waste on humans is exposure to heavy metals such as mercury, lead or cadmium that causes direct effect on the brain, kidneys, the nervous system, or on the fetal development (OECD, 2002).

Hazardous waste comes in various physical states such as liquid, solid, gas, or sludge and can be explosive, flammable, toxic, radioactive, corrosive, combustive or leachable. Production originates from many sectors, notably industrial (e.g. cleaning fluids from chemical industry), agricultural (pesticides), by-products of manufacturing processes, and many others. Examples of such wastes include acids, caustics, solvents, medical waste, resins, sludge and heavy metals.

On a national perspective, Canada's rank in terms of waste generation is far from good as we come, according to the Organisation for Economic Co-operation and Development (OECD), at the very last position out of 17 countries of the OECD in terms of municipal waste generation per capita (see figure 1). Indeed, the average Canadian produce 894 kg of municipal waste each year, more than twice the best performance of Japan and this number has been steadily increasing since the 1980s.

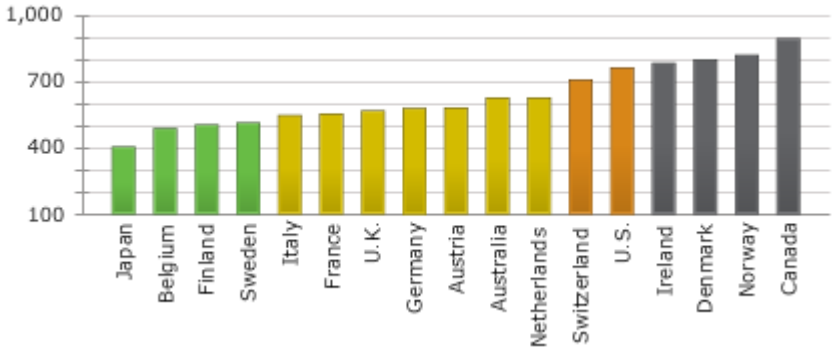


Figure 1 Municipal Waste Generation per capita in kilograms, (The Conference Board of Canada, 2011)

When it comes to our performance in terms of hazardous waste production, our performance does not seem to be very different from general municipal waste. Among the OECD nations, Canada is

one of the biggest producers as we came 24th out of 27 in hazardous waste generation per capita (see figure 2).

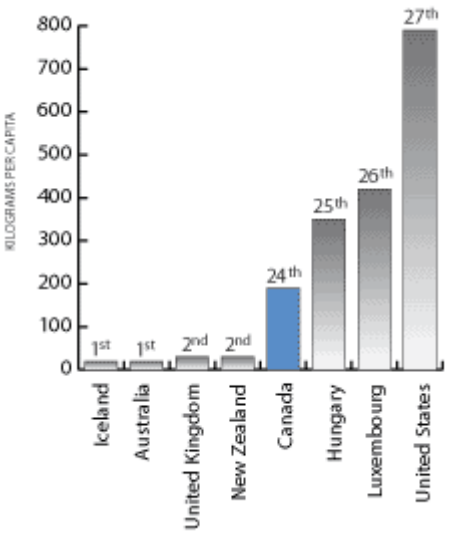


Figure 2 Kilograms of hazardous waste per capita (OECD Environmental data 1999), (Boyd, 2001)

According to the World Health Organization (WHO), high-income countries such as Canada can generate annually up to 6 kg of hazardous waste per person. Statistics Canada suggests that by 2004, there were 30 million tons of hazardous wastes produced (Schell, 2009).

Unfortunately, historical data for hazardous waste production are neither abundant nor steady as the latest statistics are dated of 2004. This is a concern that was brought up in the first report of the *Environmental Performance Reviews* programme of the OECD in 1995. This report was underlined the fact that designated Canadian authorities had difficulty with keeping track of hazardous waste; suggesting that approximately one-third of the waste sent of-site for disposal could not be traced back. Moreover, the OECD also recommended that Canadian laws regarding hazardous waste management should be strengthened in order to minimize the risk associated with the poor management of this type of waste.

In its latest *Environmental Performance Reviews* report published in 2004, the OECD revealed that good progress was made in terms of waste management, but still much needs to be done, again reinforcing that Canadian authorities should strengthen their compliance with international standards and embrace enforcement of environmental regulations at both federal and provincial levels (OECD, 2004). Due to the lack of available data, it is therefore difficult to derive comprehensive statistics in hazardous and biomedical waste generation. However, tonnage is believed to have increase nationally for the past years as a result of the aging “baby boomer” population requiring more medical support (Schell, 2009).

There is a clear need for re-assessing the way that we generate and handle hazardous wastes here in Canada. However, hazardous wastes are not only generated by industries, but also other sources such as Universities that contribute to those numbers.

In an educational context such as McGill University, radioactive, biomedical and chemical wastes are the three main categories of hazardous wastes that can be found on campus. The Hazardous Waste Management (HWM) has been McGill University's entity that is responsible for collection and disposal of hazardous waste for over 20 years. However, for the past decade, statistics revealed that the amount of hazardous waste generated on campus has been significantly increasing. This can partly be explained by the fact that new laboratory facilities were built (example: Life Science Complex) as well as a need to change McGill's culture on sustainability. As a high cost is associated to hazardous waste disposal, the HWM has been trying to find ways to proactively reduce generation of hazardous waste at the source and optimize segregation of the waste in order to reduce both cost and environmental impact associated with hazardous waste disposal.

This proactive change toward sustainable waste management was therefore translated into a three step initiative sponsored by the Sustainability Projects Fund (SPF). As all hazardous wastes are handled and disposed according to their different properties and respective regulations, the implementation of a sustainable management framework is a huge task. Therefore, in this report the focus will be on the third phase of the initiative mentioned above, the assessment of biomedical waste (BMW) management at McGill University. Note that the first and second phase are completed at this time and are respectively focusing on chemical waste minimization, as well as radioactive liquid scintillation cocktail disposal.

Currently at McGill University, no major incidents were reported regarding biomedical waste management. The current disposal stream is through biomedical cardboard boxes. Once generated in the laboratories, BMW is normally disposed in the designated boxes provided by the HWM, and is collected on a weekly basis. The boxes are brought back to a refrigerated storage space where they remain for a week until the final disposal company, Stericycle, collects all BMW boxes and transport them to their facility in Moncton, New Brunswick were they get incinerated.

Over the last 4 years, HWM noticed a major increase in BMW. The amount of boxes nearly quadrupled and the volumes went up by over 60%, which led them to question the sustainable aspect of incinerating all BMW. Disposing of BMW through a tierce party is approximately 300 times more expensive than disposing of regular waste and is much more energy intensive. Even though some biomedical waste needs to be incinerated (i.e. anatomical waste), shipping all of McGill's BMW to Moncton is costly, generates additional waste (cardboard boxes), and contributes to air pollution (transport and incineration).

BMW cardboard boxes were introduced by the HWM in the early 90s. Before that, most of BMW was treated onsite through alternative ways such as autoclaving (steam sterilization) or chemical sterilization. It was observed that since the cardboard boxes were introduced, it became more tempting for laboratories technician or researchers to use this alternative in order to save time and money. Indeed, some laboratories at McGill have access to autoclaves dedicated to BMW sterilization, but are currently not using them regardless of their state. When laboratories do use autoclaves to sterilize BMW, they are not always using the right procedures. For example, in order to monitor the performance of the autoclave, it is mandatory to use biological indicators on a regular basis. Those indicators, when used properly, will allow the researcher to ensure that the autoclave is working properly and confirm sterilization of the waste. We know for a fact that not all autoclaves are tested with indicators regularly, which means there is also a need to standardize autoclaving procedures at McGill.

Therefore, treating BMW locally is a logic economic and environmental choice. But establishing a framework that allows segregation of BMW through different disposal streams as well as ensuring the safety of all stakeholders is a challenge.

Considering that:

+ Service demand and waste volumes are increasing
+ Financial resources are limited
+ BMW disposal procedures are not optimized

There is an undeniable need for re-assessing the way that BMW is managed by the waste generators and HWM at McGill University.

In order to help HWM review the way BMW is generated, transported, stored and disposed at McGill as well as provide recommendations regarding sustainability principles, an overview of the literature that focuses on 1) the nature and different procedures by which harmful effects of biomedical wastes can be reduce or neutralized, 2) the federal and provincial legislations and regulation, and 3) McGill University's current approach will be explored, evaluated, and discussed. The intended outcome of this report is to provide recommendations that promote sustainability principles based on field observations and statistics.

# 2 LITERATURE REVIEW

## 2.1 Definition of Biomedical Waste

Environment Canada's (EC) definition is based on the 1992 Canadian Council of Ministers of the Environment's *Guidelines for the Management of Biomedical Waste in Canada*. According to EC, biomedical waste refers to "*waste that is generated by human or animal health-care facilities, medical or veterinary research and teaching establishments, health care teaching establishments, clinical testing or research laboratories, and facilities involved in the production or testing of vaccines*" (Environment Canada, 2012). EC classifies BMW accordingly to five types, notably:

1. ..**Human anatomical waste** : human tissues, organs and body parts, but does not include teeth, hair and nails;
2. ..**Animal anatomical waste**: all animal tissues, organs, body parts, carcasses, bedding, fluid blood and blood products, items saturated or dripping with blood, body fluids contaminated with blood, and body fluids removed for diagnosis or removed during surgery, treatment or autopsy, unless a trained person has certified that the waste does not contain the viruses and agents listed in Risk Group 4 of the Guidelines. This excludes teeth, hair, nails, hooves and feathers;
3. ..**Microbiology laboratory waste** : laboratory cultures, stocks or specimens of microorganisms, live or attenuated vaccines, human or animal cell cultures used in research, and laboratory material that has come into contact with any of these;
4. ..**Human blood and body fluid waste**: human fluid blood and blood products, items saturated or dripping with blood, body fluids contaminated with blood and body fluids removed for diagnosis during surgery, treatment or autopsy. This does not include urine or feces;
5. .. **Waste sharps**: waste sharps are clinical and laboratory materials consisting of needles, syringes, blades or laboratory glass capable of causing punctures or cuts.

Environment Canada does not include in this definition any microbiology laboratory waste, human blood and body fluid waste or waste sharps after these wastes have been disinfected or decontaminated. Moreover, waste from animal husbandry, household in origin, controlled in accordance with the *Health of Animals Act* (Canada) or generated in the food production is also discarded from this definition (Environment Canada, 2012).

## 2.2 Disposal Streams for Biomedical Waste

### 2.2.1 The Treatment Options

As suggested in the *Guidelines for the Management of Biomedical Waste* of the Canadian Council of Ministers of the Environment (CCME) published in February 1992, three methods of decontamination were considered for this report: autoclaving, chemical disinfection, and new technologies. The following table suggest the types of treatment that should be used depending on the nature of the waste (see Table 1).

Table 1 Types of treatment as a function of the nature of the BMW (CCME, 1992)

| WASTE TYPE | AUTOCLAVING | CHEMICAL DECONTAMINATION | NEW TECHNOLOGY |
|---|---|---|---|
| **Human**<br>**- Anatomical Waste** | No | No | Approval Required |
| **Animal Waste**<br>**- Anatomical**<br>**- Non-anatomical** | <br>No<br>Yes* | <br>No<br>No | Approval Required |
| **Microbiology Laboratory Waste** | Yes | Yes** | Approval Required |
| **Human Blood and Body Fluid Waste** | Yes | Yes** | Approval Required |
| **Waste Sharps** | Yes* | Yes* | Isolyser Sharps Management System |

* Only if followed by incineration under strict control. Chemical treatment alone does not render sharps safe for additional handling. This treatment option applies to filled sharps containers that may undergo further treatment after chemical decontamination, as part of a process, e.g., chemical decontamination coupled with mechanical shredding or incineration.
** Chemical decontamination solutions require pH buffering prior to discharge to holding tank or sanitary sewer. The discharge pH range is 6.5-10.5.

#### 2.2.1.1 *Autoclaving*

According to the CCME, autoclaving is an appropriate method for treating specific waste types, notably to render non-hazardous microbiology laboratory waste, human blood and body fluid waste, waste sharps, and non-anatomical animal wastes. However, autoclaving cannot be used for treating either human or animal anatomical waste. Moreover, wastes containing cytotoxic agents (e.g. chemotherapy drugs) and other chemical waste should also not be subjected to autoclaving. Finally, organic waste containing oxidizing agents (such as sodium hypochlorite) or solvents should not be autoclaved as one is a corrosive substance that could damage the autoclave, and the other could explode during the autoclaving process.

In its guidelines, the CCME suggests that the staff operating the autoclave must be thoroughly trained in the use of the equipment as proper operation of the autoclave is essential to its effectiveness. In fact, autoclaves can be dangerous and cause serious injuries or even death if not used properly.

The CCME also underline the need to monitor the effectiveness of the autoclaving cycle, using either chemical indicators or biological indicators. However, chemical indicators are not recommended as they only indicate the attainment of a temperature, not its duration. Biological indicators, which contain heat resistant spores (*Bacillus stearothermophilus)*, should therefore be used as they are found to be more reliable (CCME, 1992).

#### 2.2.1.2 *Chemical Decontamination*

Chemical decontamination must be done by trained personnel and is only appropriate to treat microbiology laboratory waste, human blood and body fluid waste. Chemical decontamination is mostly used for liquid waste before disposal.

Chemical decontamination can also be used for waste sharps. However, mechanical shredding should also be performed in order to eliminate any potential physical hazard. According to the CCME, the shredder should be use only if it is integral to an incinerator as this disposal method is the preferred one for disposal of waste sharps.

The following factors should be considered when using chemical decontamination: type of microorganism; degree of contamination; type of disinfectant used; concentration and quantity of disinfectant. Other factors such as temperature, pH, degree of mixing, and contact time with the disinfectant should also be considered (CCME, 1992).

#### 2.2.1.3 *New Technologies*

The CCME suggested in its guidelines that treatment of biomedical waste could also be achieved through innovative technologies. However, prior to the use of any new technologies, approval by the Department of Environment and Natural Resources (ENR) and municipal authority is required (CCME, 1992).

## 2.3 Perspectives and Legislations on Biomedical Waste Management

In Canada, the biomedical waste treatment and disposal market is expected to grow considerably within the next decades as a result of aging “baby boomers” and increase in demand for health care and services. Emphasis is currently put on procurement of cost effective medical waste treatment and disposal equipment that shall reduce environmental impacts and ensure safety (Schell, 2009). In order to define the ideal management framework, it is crucial to first evaluate what are the global perspectives on that matter, the federal and provincial standards as well as current practices in specific sectors such as Universities.

### 2.3.1 Global Perspectives

From a global standpoint, managing efficiently biomedical waste should be a priority. To support this statement, the World Health Organization (WHO) included in its core principles that were developed during the International Health Care Waste meeting (hosted by WHO in Geneva, 2007), that all authorities "*associated with financing or supporting health-care activities should provide for the costs of managing health-care waste*" (WHO, 2007). This is at the foundations of the duty of care. The WHO goes even further and suggests that even "*manufactures [...] share a responsibility to take waste management into account in the development and sale of their products and services*" (WHO, 2007).

The WHO proposes that it is the private sector that should take responsibility for the good management of waste associated with the products and services they provide, and that the design of products and packaging should be done accordingly. They also reinforce that all concerned institutions and organizations should promote sound medical waste management and try to develop innovative solutions to reduce the volume and toxicity of the waste they produce (WHO, 2007).

But things seem to get blurry when it comes to the definition of what is a *sound* management system for biomedical waste. In a recent report (2011) of the General Assembly of the United Nation on the adverse effects of the movement and dumping of toxic and dangerous products and wastes on the enjoyment of human rights, Calin Georgescu suggests that "*the use of medical waste incinerators appears to be expanding rapidly in developing countries at the same time as it is being phased out in many industrialized countries for health and environmental reasons. Given the deleterious health threats from emissions and ash, incineration cannot be regarded as the best method of disposal of hazardous medical waste, and should only be employed as an interim method in developing countries, if other options, such as non-burn technologies, are not available*" (Calin, 2011). According to the UN Special Rapporteur, what is defined as a sound management practice is a function of what kind of resources one has. He also suggest in his report that even in some developed countries, poor management and disposal techniques of BMW continue to be a significant threat to the enjoyment of several human rights, notably the right to life, the right to the highest attainable standard of physical and mental health, the right to safe and healthy working conditions and the right to an adequate standard of living.

#### 2.3.1.1 *The Current Normative Framework*

Despite the consequences that bad management of biomedical waste could have on the health and safety of workers and populations as well as the environment, the international community has not yet elaborated a formal comprehensive framework to regulate the sound handling, transport and disposal of hazardous waste generated by hospital or other related facilities. However, a number of international environmental treaties, which does not focus solely on medical waste, have

established guidelines in order to regulate specific aspects of the management and disposal procedure of this particular type of waste. Here is a list of a few of those treaties:

- **Basel Convention** : the first global instrument that aims to protect human health and the environment against the adverse effects resulting from the generation, management, transboundary movement and disposal of hazardous and other wastes. It entered into force on May 5th 1992 and was ratified by 176 States in June 2011;
- **Stockholm Convention** : which targets Persistent Organic Pollutants (POP);
- **World Health Organization (WHO):** has developed a number of technical guidance and policy documents, hand books as well as specific guidelines to ensure that biohazard waste is managed and disposed of in a safe and environmentally sound manner. These include notably :
    - *Safe management of wastes from health-care activities* (1999) - *Safe health-care waste management* (2004);
    - *Health-care waste management: guidance for the development and implementation of a national action plan, policy paper* (2005);
    - *Management of solid health-care waste at primary health-care centres: a decision-making guide* (2005);
    - *Management of waste from injection activities at district level: guidelines for district health managers* (2006);
    - *WHO core principles* (2007);
- **International Bill of Human Rights**: insure that basic human right are respected.

On a national level, the UN claims that only a limited number of countries have developed a national regulatory framework in respond of the challenges that may arise from biomedical waste management. Those initiatives are translated into the adoption of legislations that promotes a sound management for the benefice of human health and the environment (Calin, 2011).

As demonstrated previously, Canada is not a leader when it comes to biohazard waste or just general waste management, but progress is noticeable. In order to better understand the context in which the Hazardous Waste Management of McGill University is working in, an overview of the national and provincial standards and regulations is required.

### 2.3.2 National Perspectives

In Canada, there is no national regulatory framework for medical or biomedical waste disposal. BMW management is regulated by provincial policies, and regulations vary slightly among different provinces. This results from the fact that the proverbial Canadian jurisdiction is split on matters of

health. According to the Canadian Medical Association Journal (CMAJ), even if the provinces don't have a national framework regarding the handling and disposal of medical waste, most jurisdictions are said to be doing a "reasonable job" of disposal as we are not facing abuses that are witnessed in other countries (Walkinshaw, 2011).

Despite having a rigid regulatory framework, the Canadian Council of Ministers of the Environment (CCME) published, in February 1992, *Guidelines for the Management of Biomedical Waste in Canada* (CCME, 1992). In its guidelines, the CCME recommends that a written biomedical waste management program should be included in any facilities generating and handling BMW. Moreover, the CCME stresses that this program shall be regularly reviewed and updated by an appropriate review committee which includes designated waste handlers as member. Policies and procedures should include notably:

+ Strategies for minimizing the quantities of biomedical waste generated and disposed of;
+ Methods of segregating, packaging, labelling, moving, storing, treating, and transporting the various waste types;
+ Methods for keeping records of the quantities of biomedical waste generated, treated, and disposed of;
+ A list of all regulations and legislations concerning biomedical waste that are applicable in the facility's jurisdiction;
+ A list of those responsible for managing biomedical waste in the event on an accident or spill; and
+ Provision for regular, ongoing staff instruction about proper handling and potential hazards of biomedical waste.

In its guidelines, the CCME also suggest that the effectiveness of waste disposal policies and procedures should be assessed regularly. They recommend that focus should be put on reduction at the source, stating that this principle goes beyond biomedical waste and touch on all aspect of waste management at large. They also insist on the fact that designated authorities and BMW handlers should implement waste reduction strategies that lead to a source-reduction approach and to waste management where the creation of waste is avoided and, ideally, its by-products are recycled as much as possible. The CCME suggests that in order to operate efficiently, source separation and other innovations in waste handling may require designated and appropriately designed spaces and that this need should be considered when facilities are being designed or renovated.

The CCME reinforce that waste audits should be conducted regularly to identify sources and types of waste that facilities are generating (with a view to determine options for waste reduction). Waste

auditing should mainly target to : 1) define the sources, quantities, and types of waste generated; 2) highlight efficiencies and inefficiencies in waste management; 3) identify aspects of waste management requiring improvement or alteration; 4) help to set targets for waste reduction; 5) increase employee knowledge of waste management. Other factors that should be taken into consideration when undergoing an audit are the type of waste generator to be included in the audit, the service they provide, the type of medical supplies they used (including the amount of disposable products), the potential for source reduction and product substitution, as well as the waste treatment and disposal practices followed. Moreover the CCME insists in its report on the fact that waste reduction can be easily reached by replacing medical supply by reusable supplies, underlining the fact that preference should be given to products that are reusable, that contain recycled material, or that are themselves recyclable. Also, whenever possible, products purchase should be wearing the "EcoLogo" symbol; symbol of the *Environmental Choice Program* administered by Environment Canada that helps consumers to identify products that maximize energy efficiency and that use recycled or recyclable material.

A second concept that is valued by the CCME is segregation of waste. Indeed, the guidelines specify that all BMW should be segregated at the point of generation by type of waste, as explained in "section 2.1. Segregation at the source", between hazardous and non-hazardous waste, is a fundamental principle that should be reinforce in all institutions that generates BMW. Mixing them unnecessarily increase the volume of hazardous waste and costs associated with disposal.

The CCME also insist that waste packaging must be done carefully, using containers that must remain intact throughout handling, storage, transportation, and treatment. The CCME mentions a few factors that should be taken into consideration when selecting the packaging, notably the type of waste being contained, the appropriate colour-coding and labelling, the special transportation requirements, the method of disposal, and the local regulatory requirements. The guidelines also provide a description of the treatments options available but suggest that those may vary among provinces and territories and refer authorities and institutions to the local or provincial environmental regulatory authorities for better guidance on that matter (CCME, 1992).

### 2.3.3 Provincial Perspectives

In Canada, the province of Quebec seems to have a well-established biomedical waste-specific legislation as part of its *Environment Quality Act* (R.S.Q., c. Q-2, ss. 31, 46, 70, 109.1 and 124.1), notably the *Regulation respecting biomedical waste* (c. Q-2, r. 12) (Government of Quebec, 2012). Other provinces have general guidelines or targets but appear to aim at achieving only the minimum of the national standards as elaborated above for the handling of biomedical waste established by the *Canadian Council of Ministers of the Environment* in 1992.

The provincial legal framework suggests that all hazardous medical wastes should be sterilized prior to disposal at a landfill. The Government of Quebec also recognizes that sterilizing methods vary greatly, such as disposal through landfills, sanitary sewers, steam sterilization (autoclaving, hydroclaving), chemical decontamination, microwave processing and incineration. Environment Canada supports sterilizing techniques that reduce waste volume as well as emissions that could affect air quality. Therefore, hydroclaving and autoclaving are the recommended methods for sterilization by the provincial authority, with landfills and sanitary sewers as the final disposal method.

As mentioned previously, autoclaves comes in all sizes and shapes, and are essentially pressure vessels in which temperature and pressure are controlled to sterilize waste at high temperature and pressure.

Hydroclaves are similar to autoclaves, but differ in two points: they allow fragmentation of waste by internal paddle or cutters, and they allow the use of water within the waste load in order to help pressure build up. Once treated, waste is no longer considered as hazardous, but should still be segregated from domestic wasteland and be buried or disposed of separately as a general best management practice (Schell, 2009).

Note here that this last statement seems to be controversial as some individuals believes that sterilized BMW is not dangerous (as it is considered non-hazardous waste), and so could be buried with other domestic wastes, as long as it no longer looks like BMW (shredded for instance).

Note that an overview of Regulation respecting biomedical waste from the provincial *Environment Quality Act* is available to read for further details in appendix 1.

## 2.4 Advantages of reusable Bio-box

Reusable bio-boxes are far from being unsafe as some may think. Actually, using plastic reusable punch-proof containers appears to be much safer than actual cardboard disposable containers. Indeed, in terms of safety, cardboard boxes are much more dangerous than rigid containers as they are vulnerable to leakage and if poorly use, could allow sharps to puncture them, posing a threat during shipping and handling.

But also, one of the great advantages of using plastic punch-proof containers at McGill would lie in the fact that they have a smaller impact on the environment as they can be reused. As waste would undergo a different type of treatment (autoclaving), the container would not be destroy as it would in the case of cardboard boxes, reducing the amount of containers required for the treatment of an equivalent amount of waste. Moreover, as it is now at McGill, waste has to travel hundreds of kilometers to get incinerated. If the same waste would be segregated in different boxes for incineration (approximately 20 % of the waste) and for autoclaving (remaining amount), the greenhouse gases emissions associated with transportation of waste to be incinerate in New

Brunswick could be reduced, making this second option even more attractive and environmentally friendly.

One of the problems observed at the McGill University HWM facility is the storage of cardboard boxes. Boxes are normally delivered in large load, causing space management issues. Using plastic punch-proof reusable containers would reduce the amount of boxes needed for the turnover of BMW (going from 1000s boxes in stock to 100s), saving precious storage space. Plastic bins can be piled up nicely and don't need to be put up together with tape before usage.

The last, but not the least, advantage of using plastic punch-proof containers is that these types of containers are relatively cheaper than the cardboard boxes. For the past two years, McGill purchased an average of 8 700 boxes/year. Approximately 65 % of that amount were small boxes purchased at a price of 2,15$ and the balance were larger boxes at a price of 3,22$ per unit. This means that yearly, the HWM department spends approximately 2 200$ on cardboard boxes that disappear in smoke. Buying re-useable containers would be a significant initial investment, but on the long run, savings will be possible. However, a more into depth financial comparative analysis should be done by the HWM department, as well as precisions on the lifespan of this type of containers, the required amount, their cost, and other relevant information.

# 3 CURRENT APPROACH AT MCGILL

## 3.1 Stakeholders

### 3.1.1 Hazardous Waste Management

Every year, McGill University generate its fair share of hazardous wastes, and with over 850 laboratories, the Hazardous Waste Management (HWM) department has a lot on its hands when it comes to BMW management.

For the past three years, the HWM department has been working closely with McGill's Office of Sustainability (MOoS) on a project sponsored by the Sustainability Projects Fund (SPF) that aims to both reduce McGill's hazardous waste production and optimize its management framework. As part of phase three of this project, biomedical waste management is addressed.

Currently, the HWM spends on average over 100,000$ yearly for the disposal of BMW. The costs associated with external treatment of BMW can be as high as three hundred times more than for regular wastes, and this is why establishing a solid management framework to reduce production at the source is fundamental.

The implementation of such a framework requires knowledge of the provenance of the waste, the laboratories procedures, and the definition of optimal practices. But before drawing conclusions on practices, let's first explore the HWM approach to BMW management practices.

### 3.1.2 Current Biomedical Management Practices of the HWM

BMW disposal is provided at no charge to all generators at McGill University. Services offered by the HWM are essentially to provide supplies (cardboard boxes and plastic bags) as well as scheduled BMW pick-ups. All procedures used by HWM meet the Quebec biohazardous waste regulations described previously.

In the McGill's HWM disposal guidelines, it is recommended for BMW to be disposed of frequently to reduce risks associated with accumulation in work areas. Waste boxes should therefore be filled, closed with tape, and labelled as prescribed by the provincial regulations in the following manner:

+....Boxes are line with two biohazard plastic bags;

+....A biohazard warning sign with user identification sign is placed outside of the box;

+....Liquids should be placed in leak proof unbreakable containers;

+....Sharps items should be placed in a plastic puncture-proof container;

+....Boxes are stored in a cold environment, set below 4°C;

+….Different boxes should be used for each category of waste; human anatomical waste should not be mixed with animal anatomical or non-anatomical waste, and so on.

McGill's BMW management framework provides two types of container: the biohazard fibre drum used for large animals, and the biohazard cardboard boxes used mainly for non-anatomical solids and cell culture. Once a week, the containers are picked up by a HWM technician and are transported back to the HWM facility, where they will be stored a 4° C until the contractor, Stericycle, pick them up and ship them to their incinerator.

Those standards are respected and followed by all BMW production site at McGill. However two main problems remain unaddressed; first, as the HWM department promotes a high rotational rate for boxes disposal to prevent BMW accumulation, boxes that are picked up are sometimes barely filled, wasting cardboard as well as bags and increasing the treatment costs as more containers are being used to store an equivalent waste volume (disposal price being a function of waste weight).

Secondly, a lot of the boxes analyzed by the HWM contain additional wastes that do not correspond to BMW's definition, such as pipette wrapping of other laboratories tool that are usually considered to be non-hazardous.

In the eventuality where these non-hazardous items come in contact with BMW substances, their presence in the bin would be justifiable. However, occurrence of that exposure is in some cases questionable; indeed, in most cases non-hazardous waste might have been disposed of in the wrong container simply by ease or by mistake. At McGill University, BMW disposal containers are usually located close to a Biological Safety Cabinet (BSC) or a work bench, where regular waste bins are closer to the laboratory office space. Consequently, it may occur that people would unfortunately use those hazardous waste bins for regular waste stream.

Another factor contributing to high cost of BMW disposal at McGill would be the confusion surrounding waste handling once BMW has gone through the process of sterilization. Theoretically, wastes that have been sterilized are considered to be non-hazardous to human and environment health, but in practice, this perception is not uniform.

According to some McGill researchers, even disinfected BMW should be sent for incineration. Therefore, as a result of the lack of guidance on that matter, some BMW generators would still dispose of autoclaved waste in the BMW container, unnecessarily increasing the volume of BMW waste.

One of HWM' mission is to train laboratory workers on good hazardous waste management practices. This is mainly achieved through free training sessions for students and staff. During these training classes, biohazardous waste management and disposal procedures are addressed.

## 3.1.3 Research Facilities: Laboratories

### 3.1.3.1 *Role and responsibilities of the PI*

In McGill's laboratories, the PI or laboratory supervisor is in charge of what is going on in the lab and is responsible to ensure that safety procedures with regards to biomedical waste handling is conducted properly. The McGill Laboratory Safety Responsibilities are as follow:

Laboratory Directors are responsible to:

1. Ensure that activities conducted within their area of responsibility comply with University policies and relevant legal requirements;
2. Ensure that all personnel and students working within their unit are provided sufficient information, training and supervision to carry out their work safely;
3. Ensure that all lab personnel are equipped with the required personal protective equipment (PPE) and to ensure that such PPE are maintained properly and used correctly;
4. Ensure that safety devices and engineering controls are adequate, appropriate, and in good working order;
5. Ensure that all personnel receive appropriate and adequate information and training to be able to respond to emergency situations;

Laboratory personnel are responsible to:

1. Be familiar with the University and departmental safety instructions, whether written or oral, and to comply with these instructions when conducting laboratory work;
2. Wear the appropriate personal protective equipment when present in the lab and when conducting work with hazardous materials or operations;
3. Report all accidents, dangerous incidents or suspected occupational illnesses to their immediate supervisor without delay;
4. Refrain from manipulating any hazardous materials prior to undergoing appropriate safety training and receiving safety instructions;

Visitors, contractors and non-laboratory personnel are responsible to:

1. Obtain authorization from the lab director or designate prior to entering the lab;
2. Abide by the instructions of the lab director or designate regarding restricted access and the use of personal protective equipment.

Adopted by the University Laboratory Safety Committee, on November 18, 2004. Amended on June 28, 2006

### 3.1.3.2 *Handling and Collection of Biomedical Waste at McGill University*

Laboratory staffs are responsible for closing the boxes properly then transport them from their laboratory to the hazardous waste disposal area. Whenever possible, that waste room will be refrigerated.

Once a week, a HWM technician drives a refrigerated truck around campus to collect BMW generated from research activities. All containers are brought back to the HWM facility where they will be stored at 4° C, waiting for Stericycle to collect the waste and send it for incineration. Prior to final collection, all containers are weighted and recorded. Information such as the type of waste, the origin and the weight of the box is kept in a logbook.

In addition, a new procedure was recently implemented in selected buildings to collect autoclaved biomedical waste (ABW). Even if ABW is not considered as hazardous waste, we still have to treat it differently to meet the landfill requirements.

Figure 3 Current Autoclaved Waste Stream

The ABW is collected in yellow wheelie bins, which are stored with regular waste bins and recycling bins. Once a week, a HWM technician will empty those yellow bins in a dedicated 10 yards container. BFI will empty the 10 yard container every 2 weeks.

To summarize, BMW can be disposed of in 2 different ways:

+ Autoclaved biomedical wastes (yellow bins) are disposed through landfill by BFI;
+ Biomedical wastes (cardboard boxes) are disposed through incineration by Stericycle Canada.

#### 3.1.3.3 *Challenges Encountered with Biomedical Waste Management at McGill University*

Many challenges were encountered in the past couple of years regarding BMW management at McGill University. Standards and regulations are currently being followed; however, as the volumes of BMW generated increased considerably over the past few years, there is now a need for reviewing management practices.

The auditing of current practices must be done keeping in mind those four factors:

1. Safety;
2. Sustainability;
3. Compliance
4. Financial constraints.

In terms of safety, the current practices with BMW are quite safe. We have had the odd incidents involving sharps not disposed of in the proper puncture-proof container, but nothing major. Reinforcement of proper waste disposal procedures was made.

Even if safety is reinforced with current practices, we realized that there is room to improve the current framework when it comes to sustainability and financial constraints, as demonstrated previously.

But the main concern raised by this review process, which remains one of the greatest challenges for HWM, is the need to standardize waste disposal practices and make sure they are implemented properly in the laboratory. Indeed, with the reinforcement of a uniform BMW management framework, it would be much easier to promote good practices and identify the laboratories that would need more support.

In order to identify and implement such a framework, we needed to find out what were the current practices on the field, as explained in the next chapter.

# 4 FIELD OBSERVATIONS

## 4.1 Preliminary Observations

The first step was to do preliminary observations. In order to do so, Elizabeth Côté (student lead) went on the road with waste disposal assistant Steve Dufour to witness how he proceed with BMW collection, as well as visit some laboratories who generate BMW. M. Dufour guided her for two days during which he explained the precautions that needed to be taken while handling such type of waste. He also showed her the majority of the pickup points, as well as some of the labs where she met laboratory staff. Talking with M. Dufour proved to be a great introduction to what was really happening out there as he is on the frontline on a daily basis and gets to discuss directly with the users. Following is a list of observations from this preliminary visit to the labs:

+....It was observed and heard at many occasions that non-hazardous waste was found in bio-boxes. Regular waste was disposed of in biomedical bins intentionally or by mistake. The main explanation given by the users was the lack of regular waste and recycling bins, as well as not being aware of the proper disposal procedure. Plastic bottles, bed wrapping (see figure below), pipettes wrapping and other non-hazardous waste were seen at many occasions in the bio-boxes. It appeared obvious that non-hazardous waste is contributing to the increasing volume of BMW.

Figure 4 Example of the content of a BMW waste container

+....It was mentioned at several occasions that McGill's laboratories need a new and improved waste disposal framework, that would require different containers like recycling bins, regular waste bins, ABW bins and so on. However, this last argument is challenged by the space constrain that can be observed in many of the older laboratory facilities.

+....The current practice valorizes the concept of a box-in-a-box. This means that contaminated sharp such as pipettes should be, prior to be put in the cardboard bio-box, put in another

punch proof container. This double-wrapping concept contributes to the safety factor, but is a challenge for the environmental and financial consideration.

+....Some lab workers that have access to an autoclave are reluctant to use it for waste sterilization. Arguments were made regarding the good working condition of the autoclave as well as the smell that comes with it.

+....Users are lacking training to use the autoclave. Few of them were trained to use it and even less are using biological indicators to confirm proper waste sterilization.

+.... In general, laboratory staffs are open to new BMW management and disposal procedures, but it has to be reinforced by the PI as well as the administration.

Once these preliminary visits were done, it was now time to create a structured checklist that would allow reviewing a sample of around 25 laboratories (targeting the biggest generator).

## 4.2 Creating a Check List

A check list was designed in collaboration with the HWM manager, Christian Bouchard. The different elements of the checklist were selected in order to help understanding how much waste the labs are generating, the type of waste, the decontamination process if applicable, as well as the general impressions of the laboratory representatives regarding how biomedical waste is managed at McGill University.

The following table shows an example of what was found in the checklist.

Tableau 2 Biomedical Check List

| Biomedical Wastes Management Review | | |
|---|---|---|
| Investigator: | Laboratory name: | Building: |
| Laboratory manager: | Laboratory contact: | |

| General Observations |
|---|
| Estimated # of users in laboratory:<br>1-5 6-10 11-15 16-20 20-30 30+ |
| Type of biomedical waste produced:<br>Other: _____<br>Sharp (pipettes; pipette tips; micro pipettes; others) — Anatomical/Animal Waste — Biological Laboratory Waste: Solid (paper), Liquid (gels) — Blood & Bodily Fluids: Vial, Fluids, Saturated Items |
| Estimated weekly average waste production (# boxes):<br>0-5 6-10 11-15 16-20 20-30 30-40 40+ |

| Decontamination methods prior to disposal | |
|---|---|
| Do you have access to an autoclave? Yes No | |
| Autoclave method | State of the equipment:<br>Good Bad N/A |
| | Number of trained technicians:<br>0 1-3 4-7 8-10 10+ |
| | Percentage of waste treated:<br>10% 20-30% 30-40% 40-50% 50-60% 60-70% 70+% |
| | Type of infectious laboratory waste treated:<br>Sharp ; Anatomical/Animal ; Biological Laboratory ; Blood & Bodily Fluids |
| Chemical method | Type of chemical(s):<br>Bleach; Hydrogen peroxide; Lysol; Ammonia hydroxide; 70% isopropanol; other |
| No / other methods | Biomedical waste container; Others: _____ |
| Waste disposal stream post-sterilisation:<br>Biomedical Waste container ; yellow bin ; regular waste stream ; recycling ; other: _____ | |

**Animal Waste** - Animals carcasses, tissues and body parts, blood and bodily fluids and infectious bedding.
**Biological Laboratory Waste** - Cultures, stocks or specimens of microorganisms, live or attenuated vaccines, human or animal cell cultures and laboratory material that has come into contact with these (solid and liquid).
**Human Anatomical Waste** - any part of the human body, including tissues and organs but excluding extracted teeth, hair, and nail clippings.
**Human Blood and Body Fluid Waste** – Human fluid blood and blood products, items saturated or dripping blood, body fluids contaminated with blood and body fluids removed for diagnosis during surgery, treatment or autopsy. This does not include urine or feces. Material with minimal amounts of non-infectious blood (i.e. does not release blood if compressed) are not considered biomedical waste.
**Sharps** - Needles, syringes with needles, lancets, scalpels, razor blades, and precision knives. Contaminated broken glass, pipettes, test tubes, microscope slides, blood vials or any other material capable of causing punctures or cuts.

| General questions |
| --- |
| How could the HWM department help you to reduce or better segregate your wastes? |
| Has non biomedical waste such as pipettes wrapping ended up in the biomedical waste containers in the past? |
| Do you have general suggestions to help reduce biomedical waste load? |
| What good practice are you doing that others could benefit from? |
| Would you be open to use recyclable containers? |
| **Additional Comments** |
| Do you know where the waste is going once it has been collected?<br><br>Do you have any combined or complex hazardous waste? |

## 4.3 Laboratories Review

The selected approach used to review the current BMW framework was to first identify which laboratories were the largest BMW generators. The next step was to contact those laboratories in order to schedule a visit. We made sure to reinforce the fact that this project is not intended to judge or punish bad behaviour, but to focus on the understanding of how things are conducted in labs, and how the HWM department can help reduce BMW and manage it more efficiently. The next figure shows which McGill building generates the largest volumes of waste (%).

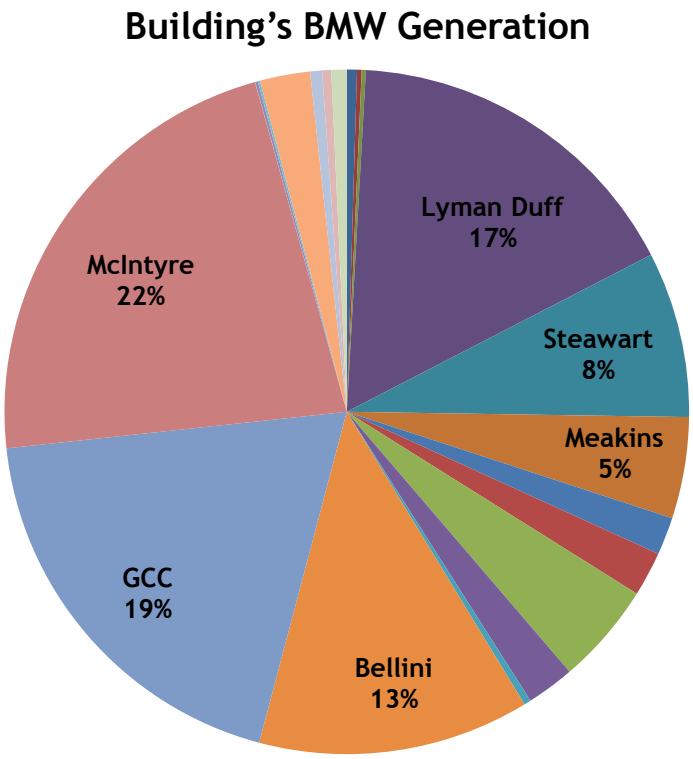


Figure 5 Biomedical waste generation proportions between main buildings on the campus

During spring 2012, an email was sent by Christian Bouchard (HWM manager) to all targeted labs, asking the PI if they would be willing to collaborate with the HWM department and schedule an appointment with the designated auditor, Elizabeth Côté. Our investigation was conducted one building at a time, starting by the Lyman Duff building. We then followed with the Life Science Complex, composed of the Goodman Cancer Research Centre, the McIntyre building and the Bellini building; Those 4 buildings are responsible for approximately 70 % of the total biomedical waste load, hence why they were selected. The response from the PI was great. As a result, 17 visits were scheduled and conducted at the time and date presented in the following table.

Tableau 3 Details of the sample of laboratories visited during this project

| | PERSON IN CHARGE | CONTACT | BUILDING AND ROOM | DATE | TIME |
|---|---|---|---|---|---|
| 1 | Serge Lemay | Erika Hooker | Lyman Duff, Room 225 | April 4th | 12h30 |
| 2 | Jay Louise Nadeau | Soon Hyang Park | Lyman Duff, Room 715/7 | March 26th | 10h30 |
| 3 | Benoit Cousineau | Caroline Monat | Lyman Duff, Room 617 | April 2nd | 10h30 |
| 4 | James Coulton | Wayne Mah, Mr | Lyman Duff, Room 402/3 | March 28th | 10h30 |
| 5 | Donald Sheppard | Josée Chabot | Lyman Duff, Room D24 | March 26th | 11h15 |
| 6 | Julie St-Pierre | Valérie Chénard | Goodman Cancer Research, Room 519/411 | April, 26th | 14h00 |
| 7 | Dr Teodoro | Isabelle Gamache | Goodman Cancer Research, Room 607 | May 1st | 14h00 |
| 8 | John White | Tian-Tian Wang | McIntyre, Room 1114 | May 1st | 9h00 |
| 9 | Nicole Beauchemin | N/A | McIntyre, Room 708 | April, 30th | 13h00 |
| 10 | Jerry Pelletier | Patrick Senechal | McIntyre, Room 810 | April, 30th | 9h00 |
| 11 | Philippe Gros | Normand Groulx | Bellini, Room 366 | April, 30th | 10h00 |
| 12 | Peter Siegel | Matthew G Annis | Goodman Cancer Research, Room 508 | May 1st | 15h00 |
| 13 | Anastasiya Nyzhnyk | N/A | Bellini, extension 5567 | May 3rd | 13h00 |
| 14 | Terry Hebert | Darlaine Pétrin | McIntyre, Room 1303 | May 1st | 10h00 |
| 15 | Albert M. Berghuis | Jonathan Blanchet | Bellini, Room 470 | April, 30th | 11h00 |
| 16 | Reza Sharif Naeini | Albena Davidova | Bellini, Room 173 | April, 30th | 14h00 |
| 17 | Luke M. McCaffrey | Jose-Bruno L'Abbee | Goodman Cancer Research, Room 503 | May 1st | 11h00 |

## 4.4 Laboratory Review Results

### 4.4.1 Biomedical Waste Box Flow

Figure 6 gives an overview of the BMW containers flow through the HWM facility over the year 2011. The data used to make this graphic is from the 2011 HWM logbook. As can be observed, the monthly generation of BMW is increasing over the course of the year and this trend is even more significant for sharps than for anatomical waste.

Figure 7 illustrates the BMW weight (Kg) generated throughout the year 2011by all buildings. We can see that some of the buildings contribution is marginal whereas others contribute considerably to the total amount of waste generated. Moreover, an interesting observation can be made from this figure: the peak generated between September and October 2011. This peak was caused by accumulation of waste during the MUNACA strike.

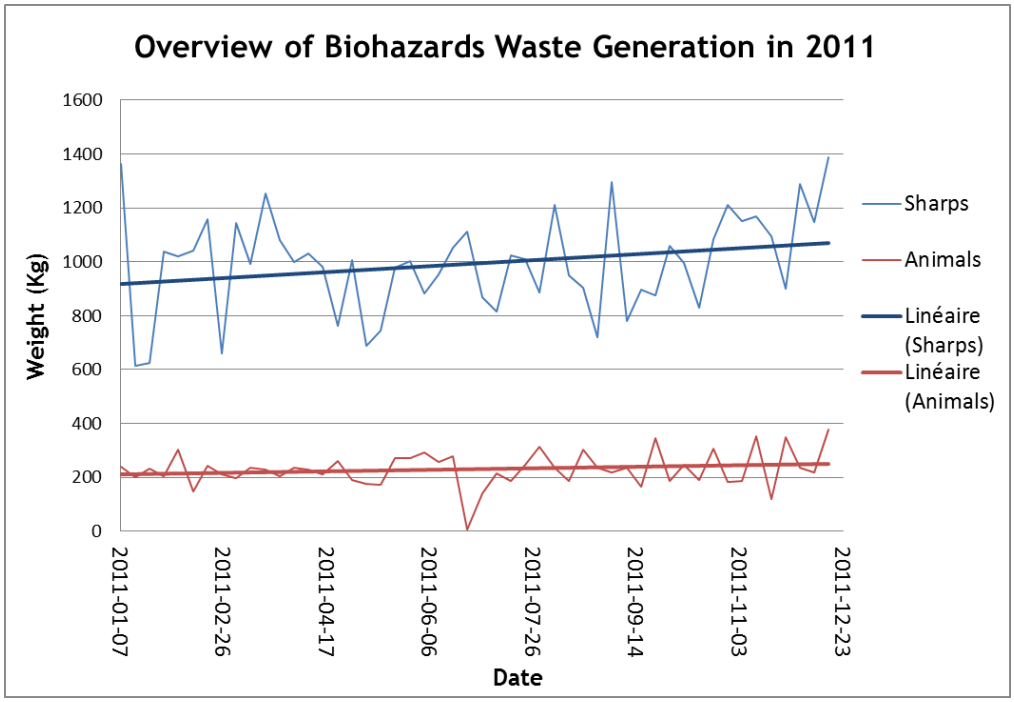


Figure 6 Annual 2011 waste generation illustrated through time

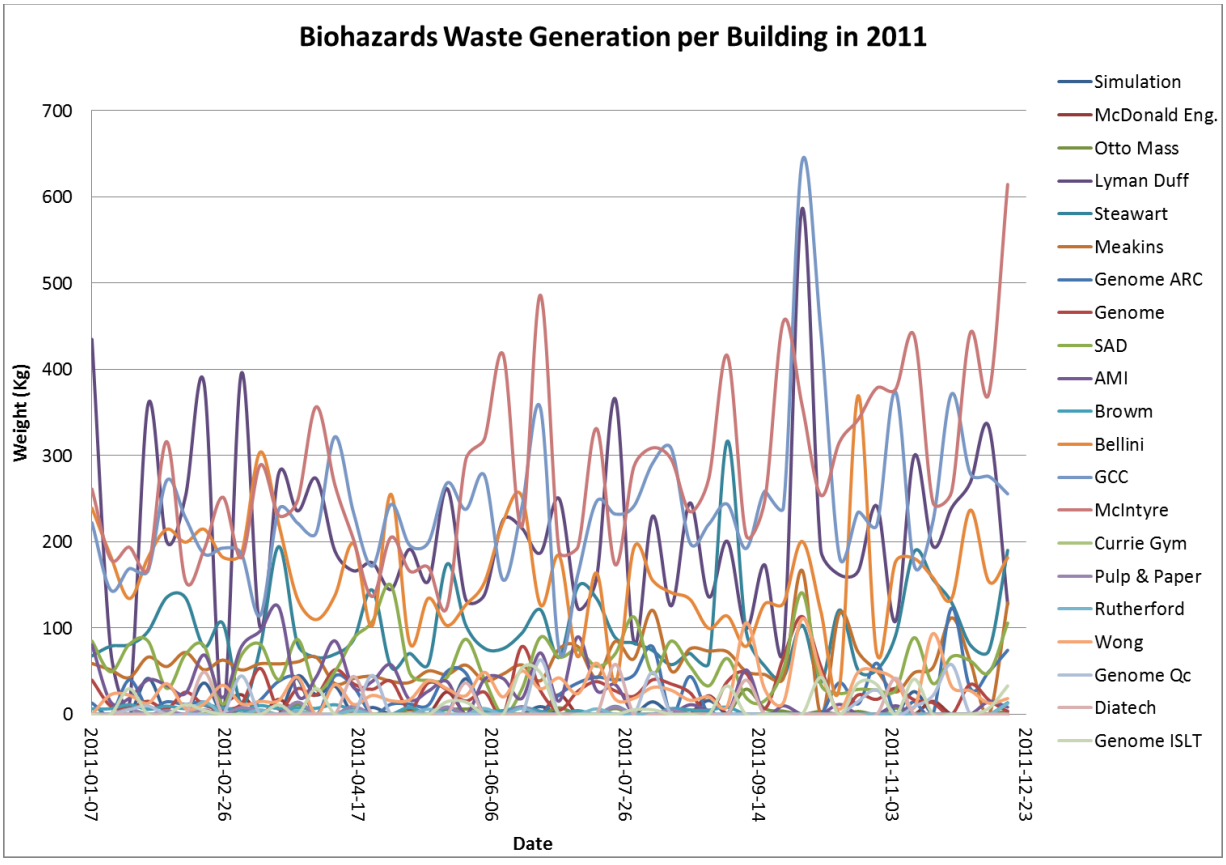


Figure 7 BMW weight generated through 2011 for all buildings

### 4.4.2 Laboratory Visit Review

Following the laboratory visits, we were able to use the information we got from the checklists and complement the data we had from the preliminary observations. That information was either observed by the auditor or laboratory staff. Following is a list of observations from the different exchanges and visits.

+....There was a consensus among most of the laboratory staffs regarding the need for a better laboratory waste disposal framework. They are willing to collaborate and participate, provided they have the right tools in place. For example, it was suggested for HWM to provide a list of what can be diverted from the bio-boxes.

+....Most clients are willing to use reusable plastic containers (grey bins from Stericycle) instead of cardboard boxes as long as the new container is smaller or remains approximately the same size as the previous one. Interviewed staff underlined the fact that older laboratories were not designed with waste management in mind and that space is already very limited. Having more containers or bigger ones might become a problem in some cases.

+....Most of the interviewed staffs were aware that BMW was disposed of by incineration. However, no one knew that the waste was travelling to New Brunswick in order to be treated. They suggested that HWM seek for a BMW treatment that would involve less travelling, therefore less greenhouse gas emissions and more sustainable.

+....I came across a few laboratories that had access to autoclaves designated for waste treatment. When those were in good condition, I've asked the staff if they were using them or not. In some cases, when the autoclaved was located within the lab, researchers told me that they preferred not to use it because of the smell generated by the process, bothering the laboratory staff. In other cases, researchers told me that they were using the autoclave to sterilize BMW. However, when I asked them if they were using biological indicators in order to see if the sterilization process was successful, some said that they were not. This raise a concern as there is no proof that the waste was rendered harmless. It is worth mentioning that biological indicators are not free and that it is the responsibility of the PI to purchase it. Moreover, the use of autoclaves must be restricted to trained staff. However, it appears that untrained personal are using them, which could potentially be dangerous. One should be aware of the potential danger that could be associated with poor autoclave usage. Autoclaves are not just a big dishwasher and it is not enough to simply follow the instructions written on it. Additional knowledge is required for proper usage, especially when treating BMW.

+....It was observed that very few labs treated BMW onsite. One of the main reasons given was the lack of time or the lack of resources available to them. Most of the waste was disposed of through biomedical boxes provided by the HWM department. However, when we asked users for

a ballpark figure of BMW volumes that could potentially be autoclaved, the answer was more or less 80%. Laboratory staffs are willing to go for a multi-stream disposal framework as long as the resources are put in place properly by McGill.

+....Using bio-boxes for non-hazardous waste disposal is a common practice. Some technicians tried to sensitize others about this bad practice but with no results. They claim that it is the PI's responsibility to reinforce the rules in the lab, not theirs. They proposed that training session should focus more on what should or should not go in the box, that the HWM conduct punctual visit to the labs to verify the content of the bio-boxes, and to implement a "punishment" system for those who don't behave.

+....A few PI's suggested for McGill to promote the use of reusable laboratory ware such as glass pipettes or glass tips instead of disposable plastic ones. According to them, glass pipettes could be chemically sterilized and reused. However, the enforcement of such practice might be challenging. Some researchers prefer to use disposable wares as there is, according to them, less factors that could jeopardize their results. It is not the role of McGill University to dictate how scientist should or should not conduct their experiments and what tools to use, but incentive to good or greener practices could be a way to trigger change.

+....The general consensus was for training sessions to focus a bit more on BMW disposal practices, as it appears that procedures changes from lab to lab. This is a bit surprising considering that it is mandatory for all laboratory workers to attend the HWM's "hazardous waste disposal" training.

+....It was proposed to have a designated trained technician to be in charge of the autoclave on each floor or in each building. This would reduce the biomedical waste volume that goes for incineration and would ensure that the actual autoclaving process is conducted properly.

# 5 RECOMMENDATIONS

## 5.1 Establishment of a BMW Management Framework

BMW management at McGill is done according to the federal and provincial regulations. However, with an increasing volume of biomedical waste to deal with, it is the responsibility of the hazardous waste management department to improve and optimize practices in order to implement a framework that promote safety, compliance, environmental protection as well as financial concern, four key indicators of sustainability.

There is a consensus among the visited laboratories that they are willing to change their practices as long as a clear and well defined framework is proposed. Following is a brief layout of how this framework could look like. It's definition and implementation should be supported by a committee where would sit together both scientists and managers with a common goal: trying to minimize BMW by autoclaving and diverting nonhazardous waste from the bio box to the proper waste stream.

Following is a description of the suggested framework that is divided in three categories: the single use cardboard bio-box for incineration, the reusable plastic bins used for waste to be autoclaved, as well as disposable bio-box for the autoclaved waste.

### 5.1.1 Suggested Framework: 3 Waste Streams System

#### 5.1.1.1 *Disposable Bio-box for Biomedical Waste*

As defined previously, some of the BMW generated must by law be incinerated. The use of cardboard containers is therefore mandatory. But instead of offering boxes to all labs, they could be distributed to laboratories that fulfill certain pre-established criteria decided by the expert committee. Laboratories that would require disposable cardboard bio-box would need to fill up a form and describe why they would need such type of containers and for how long. In 2011, approximately 20 % of McGill's biomedical waste that went for incineration was anatomical, meaning that non-anatomical waste is the remaining 80%. During laboratory visit, we were told by the users that around 80% of the non-anatomical waste could be autoclaved instead of incinerated. Bottom line, this means that approximately 65% of the total amount of BMW could be autoclaved and disposed in the regular garbage (80% of 80%). The remaining 35% would have to go in cardboard boxes for incineration.

#### 5.1.1.2 *Reusable Bio-box for Biomedical Waste*

Even if not presently used at McGill, there are plastic puncture-proof containers on the market specifically designed to hold and transport BMW. They are mainly used by the hospitals, like the McGill University Health Center (MUHC). Safety of McGill's laboratory staffs as well as HWM is the

main motivation behind the introduction of such container. In this context, reusable bio-boxes could be purchased (the amount still needs to be determined) and distributed from McGill's HWM to the laboratories in order to be filled, then back to the HWM to be weighted and tracked, and finally shipped to Stericycle for disposal. Stericycle would be responsible to decontaminate the containers as well as supply new ones for the following week.

The use of such container would reduce the risks of punctures and cuts associated with sharp objects and needles, as well as the amount of boxes required for BMW management, thus be an environmental benefit. However, some investigation must be done before implementing this new container. Information such as lifespan of containers, costs associated with waste treatment and plastic boxes, disposal method of those containers once they reached their end of life, and Stericycle's autoclaving plant location should be investigated before investing. If successful, the introduction this new waste stream would hypothetically divert 65 % of the biomedical waste that currently goes to incineration toward an alternative disposal procedure such as central autoclaving by Stericycle.

#### 5.1.1.3 *Disposable Bio-box for Autoclaved Waste*

A certain amount of McGill's BMW is currently being autoclaved on site by the researchers. However, it is recommended that autoclaving procedures be review as well as implementing a well-defined protocol that would dictate how to use the autoclaves. This should be reinforced by a strong training program as well as a certification process in order to prevent incidents that could potentially arise from improper use of autoclaves. As previously mentioned, one must use biological indicators on a weekly basis in order to verify if the treated waste was rendered harmless. This is actually not current practice at McGill, hence the need for reinforcement of the BMW disposal policy. Once the previous procedure is reviewed, an adequate disposal stream should be implemented.

Currently, autoclaved waste is being collected by custodial staff for disposal in the yellow bins that were described on page 30. One issue we have with these containers is that they do not have any locking system, meaning anybody can access their content. This pose a health and safety issue as well as the possibility of cross contamination with other bins used for recycling and regular waste. A solution to this would be to use color coded disposable "Autoclaved Biomedical Waste (ABW)" boxes. That way, autoclaved bags would not be visible and the container would be sealed with tape. The HWM department would be responsible for collecting those containers at the same time they do BMW bio-boxes. The boxes with autoclaved waste would then be disposed in a special container away from the other waste streams. Note that only few laboratories are autoclaving their waste, and therefore this special type of boxes would only be used by those labs.

## 5.2 Implementation of the new Framework

### 5.2.1 Communication Support

In order to implement this new framework, a well-defined communication plan shall be designed. For this purpose, media such as posters, website support, and training sessions should be planned. Posters with chart flow of where waste should go as a function of its nature could be put up in the laboratories. Training sessions on waste disposal as well as autoclaving procedures could be reviewed and redesigned. Stronger support and more information could be put up on the HWM website. The implementation of such framework will strongly depend on how the information is presented to stakeholders. One great thing about it is that people have already shown interest in this project and are willing to change their practices.

### 5.2.2 Expected Results

We are expecting the reinforcement of safety measures regarding the management of BMW at McGill University. Moreover, optimizing the different waste streams will reduce environmental impact of BMW disposal. Also, reducing the amount of waste disposed through incineration by maximizing on-site autoclaving as well as using reusable container would have a financial benefit. However, further analysis shall be conducted before implementing a new waste management framework. Ultimately, we are hoping that going through this process, laboratory staff will be aware that McGill is trying to go a step further toward sustainability and that it will inspire them to reduce biomedical waste generation.

### 5.2.3 Auditing Tools

Implementing such a framework is not a one off job. Indeed, it shall require a monitoring and auditing platform. Quantitative and qualitative objectives as well as targets should be defined. Also, auditing tools should be developed. However, this must be done without imposing a “surveillance” atmosphere on stakeholders. Indeed, it is not the role of the HWM department to police the laboratories. Keeping that in mind, no penalties should be imposed in case of non-compliance. This initiative will be successful only on a voluntary based function.

Therefore, the establishment of inspiring monitoring tools such as the introduction of a “greenlab” certification where benefice would be given as a reward to good behaviour could be an alternative. Auditing tools are an important component of the successful implementation of a new biomedical management framework and its design should be done with the collaboration of all stakeholders, notably with the laboratory staffs, the HWM employees, the EHS employees as well as any other concerned parties.

# 6 CONCLUSION

As demonstrated previously, hazardous waste management is a national, but also international challenge. However, Quebec is fortunate enough to be one of the first provinces to have well defined regulations regarding biomedical waste management. McGill University's current management approach of biomedical waste is in compliance with national and provincial standards, however, is just complying enough? Many different management practices exist in hospitals, health care centers, and other BMW generating facilities; some disposal procedures are better than others from a safety, environmental and financial point of view.

This project had the ambition to optimize our current laboratory waste disposal practices. What stood out from this project was the need to strengthen our autoclaving procedures, ensuring that staff that do use autoclaves on site also use biological indicators, as well as the need to implement a multi-stream framework for laboratory waste management that is adaptive to the need of all stakeholders, with the introduction of disposal and reusable containers. Not only should the waste coming out of laboratories be segregated properly, we also need to minimize waste generation at the source. One way to do so is to sterilize reusable glassware instead of using disposable one.

However, more investigations must be done in order to better define this biomedical waste management framework. Also, a communication as well as an auditing plan should be designed by a review committee in order to follow progress and adjust to need or demands. Having a "Greenlab" certification, reinforced training or visual tools and pictograms are only a few recommendations that could be implemented in support to this new management framework.

Ultimately, introducing a multi-streams framework would optimize safety conditions, would reduce environmental impacts of BMW disposal, and might be more financially viable for the HWM. This approach would defiantly be a step towards a sustainable way of managing biomedical waste at McGill University.

Ideally, in conjunction with a new BMW management framework, all waste that could potentially be sterilized should be autoclaved on-site. There are two possible scenarios: 1) the laboratories are responsible to autoclave their waste; 2) HWM is responsible to centrally autoclave all BMW. The first scenario would need a lot of effort from the researchers. Every lab/department would need to assign this task to a technician, train him, maintain the equipment on a regular basis, test the efficiency with biological indicators, and so on. Considering we have over 200 PI with at least one biohazard certificate, we would have a lot of duplicated effort, and it would be hard to certify that all the ABW generated by those labs was sterilized properly. We also have to consider the sustainability of having dozens of autoclaves running on a regular basis (water consumption, electricity, etc.) versus incineration. On the other hand, having a centralized service that would autoclave all of McGill's waste would make sense. With all operations under one department, the

sterilization procedure could be optimized and potential for errors would be minimized. But in order for this to be possible, HWM would need a major investment from the University to install and operate the central autoclave. In collaboration with Energy Management, Environmental Health and Safety and the Office of Sustainability, HWM should prepare a work study to assess the feasibility of such a project.

## 6.1 Challenges/victories of this SPF project

- We had a limited amount of time to do this project, so we had to focus on 17 out of 200 Principal Investigators. It is still a representative sample of the type of research we do at McGill (those 17 are part of the small group that generates over 70% of BMW), but it would have been nice to visit more labs.
- Elizabeth (student lead) started the project at the end of February. Her work was slowed down considerably by mid-term exams and finals. She also got a job in May, so her final report was never completed properly. Christian Bouchard (Manager HWM) had to finalize the report.
- In order to implement a new BMW disposal framework, we will need to impose a new procedure for laboratory waste disposal. From our previous experience, we can confirm that researchers don't like change. We think that the best way to implement this is to use our "champions" and do this gradually from one building to another. "Champions" are people from the research community that are sensible to health and safety, waste management and sustainability. They understand the importance of it and are often our go-to people from the research community of the University.
- We were pleasantly surprised at the positive response from the laboratories. We expected people to push us away a little, but they ended up being very welcoming and willing to help with our project. But that could be a very different story when we implement the new waste disposal framework.
- It was a good idea to go and visit the laboratories with the checklist instead of just sending it to a representative. We were able to fill up the checklist on site and discuss with the technicians, which helped us explain what we want to do and get proper feedback. Everyone felt they were part of the solution.
- Considering that hazardous waste is picked up by HWM and regular waste/recycling by building services, we will need to coordinate with them to make sure we have the proper bins in the laboratories. This might prove to be a challenge for our new waste disposal framework since we do not control regular waste/recycling disposal.
- When closed, it is impossible to know the content of a BMW container. Opening them would unnecessarily be exposing our technicians to a possible threat. So it is nearly impossible to do spot check to know if researchers are using the containers properly or not. That is one reason why having a central autoclave would make sense. Whether or not the content of a BMW box is 100% infectious, the autoclave would render it all non-hazardous and the waste could be disposed as regular waste instead of incinerated at 300 times the cost.

# APPENDIX 1 - ENVIRONMENT QUALITY ACT: OVERVIEW OF REGULATION RESPECTING BIOMEDICAL WASTE

In Quebec, the regulation respecting biomedical waste applies to waste that was previously defined in section 3.1. General Management practices of biomedical wastes require that anatomical biomedical waste shall be treated by incineration and that non-anatomical biomedical waste shall be treated by disinfection or incineration. Also, biomedical waste from outside Quebec shall be treated by incineration.

The legislation also requires that all equipment used to treat, store or transport biomedical waste should be kept in good working order and that the ash produced from the incineration process should be stored into rigid, sealed, airtight containers once cooled. It also states that BMW should not be mechanically compressed or discharged into a sewer system. It suggests that generation site should be closely audited, keeping a log book with all incoming BMW data (type, quantity, etc.).

Moreover, a record on the BMW treatment, disinfection, or incineration site should also provide information such as: type, address of origin, quantity, storage time, name of responsible, operating instructions, disinfection time and other operating irregularities. Similar register shall be kept by the operator of the transport system.

Yearly reports should be prepared by the operator of BMW generation, treatment, storage site accordingly to the Schedule I and II provide by the law. Register and report shall remain into archives for duration of at least three years. Storage, incineration and disinfection sites should be padlocked or bolted, and their access should be strictly limited to authorized persons. Finally, the operator of a facility that treats BMW by disinfection or incineration should report himself on the 15th day of each month to the Minister of Sustainable Development, Environment and Parks in order to provide them with a schedule and an itinerary of the disinfection or incineration operations planned for the following month.

The previous specifications give only a general overview the regulations respecting biomedical waste. Additional considerations should be taken into account when managing BMW, and those restrictions should be well considered as serious penalties could be imposed in cases of infractions.

Indeed, liability in case of natural person infraction range between 2,000$ to 25,000$, whereas for legal person, fines ranging from 5,000$ to 500,000$ are planned. Those penalties are doubled in case of redundancy (Government of Quebec, 2012).

Moreover, in Quebec's regulation respecting biomedical waste, no consideration is given on the environmental aspect of things. For instance, the law requires that biomedical waste destinated for shipment from its generation site shall be put into rigid, sealed, airtight containers, and that those

should be perforation resistant and stored at a temperature of 4ºC (Government of Quebec, 2012); no concern or emphasis, such as in the federal guidelines, is given to prioritise a type of container that is reusable or recyclable.

Regardless of the legislation, the current trend on the Canadian market is moving toward reusable containers and their sterilization techniques in order to reduce the amount of waste generated. Moreover, reusable containers are found to be less likely to be pierced and are said to provide better measures to be tracked (Schell, 2009).

Therefore, having a good idea of the current global, national and regional regulations on biomedical waste management practices is essential to establish a proper BMW management framework, but understanding of how these regulations are translated in current practices is the key to find where are the flaws and how could we optimize the BMW management system here at McGill.

# APPENDIX 2 - A STUDY CASE: YALE UNIVERSITY

The American legal framework guiding biomedical waste management was initiated in the late 1980s as a result of contamination problems observed in the East coast of the nation. In the 1990s, the University of Yale, faced with increasing regulations and public sensitivity associated with the BMW management of the institution as well as a constant increase of its waste volume - form 5% to 20% yearly due to growing research enterprise - decided to shift from its reliance on external disposal firm to an on-site disposal system composed of one large industrial autoclave and a shredder.

Indeed, in 2002 Yale University purchased, installed, and began operating an on-site biomedical waste treatment system at its School of Medicine campus consisting of a large autoclave and shredder. The system is currently operating, and has served the University well since its installation. The following figure illustrates the different streams biomedical waste can travel through for disposal. As can be observe, waste is segregated through various streams and is finally disposed of in three fashions: 1) metal collections carts, 2) box for off-site disposal, and 3) drain disposal. Once collected into the metal collection carts, waste undergo autoclaving and shredding. After shredding, as waste is considered to be unrecognizable, it can be disposed of along with other normal trash.

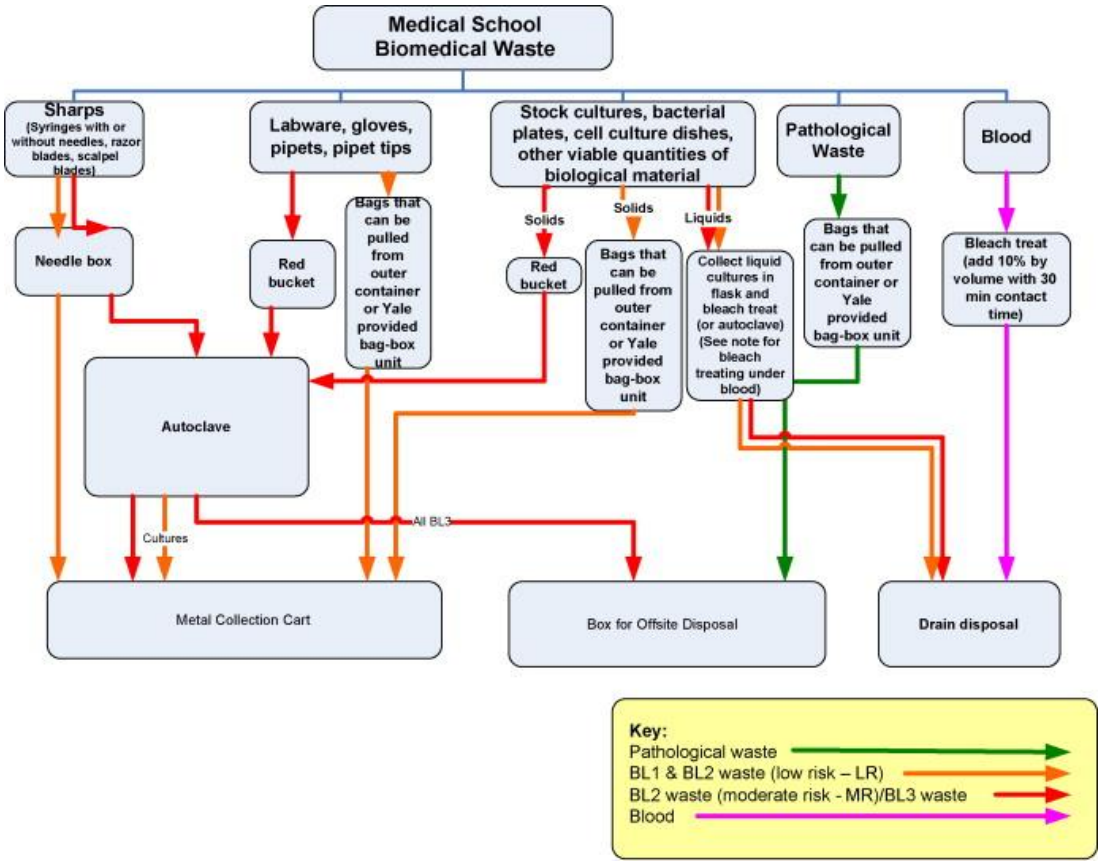


Figure 8 Yale University new biomedical waste disposal framework (Armstrong & Reinhardt, 2010)

By deciding to manage BMW on its own, Yale University has eliminated its dependence on a market where only little competition is met, meaning that the prices associated to biomedical waste disposal could be subject to changes at any times. Also, it allowed them to shift towards a different type of containers, going from disposable plastic containers to disposal cardboard containers, making their new approach greener and cheaper. Finally, this shift has also allowed reducing the pollution associated with transporting all that waste hundreds of kilometers away from the facility.

Yale took advantage of the opportunity of having a new laboratory building in planning to introduce its new waste management streams system and disposal technology. The shift required procedure changes and staff tanning. Also, many challenges were encountered in this process, notably the lack of space and high maintenance requirements. Moreover, as some types of BMW must be incinerated according to regulations, the University had to continue to dispose of a part of the waste it generates through a tierce party.

The overall conclusion of this shift is that the University has saved a lot on biomedical waste disposal cost since the introduction of the new system. Indeed, with a considerable increase in the price of the treatment of waste, with the savings done on maintenance cost of older waste disposal autoclave and the prevention from buying many other smalls autoclaves, the Direction board of Yale University  has concluded that the new establish framework has proven benefits in terms of economics, liability, and sustainability (Armstrong & Reinhardt, 2010).