Lab Waste Disposal at Queen's: The potential for significantly reducing materials that are unnecessarily going to landfill and hazardous waste by diverting them to the recycling stream

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Summary

At present, most waste produced from Queen's University lab research groups is directed to either the regular landfill or hazardous waste streams. To determine the potential for redirecting some significant proportion of that lab waste into the recycling stream, we surveyed 22 labs across Queen's within the Departments of Biology, Biomedical and Molecular Sciences, Environmental Studies, Geography, and Civil Engineering.

The most frequently reported lab waste items that are potentially recyclable (i.e. items that have not been contaminated with hazardous chemical or biological residues) were plastic sample tubes, plastic pipette tips, lab gloves, and pipette tip holder boxes. The vast majority (60-100%) of these lab waste items had not come in contact with hazardous substances, and therefore seem to be totally appropriate for recycling. Furthermore, on the basis of a tentative extrapolation of these 'snapshot' data across the entire university, our analysis suggests that doing so would divert ~74000 plastic sample tubes, ~37000 pipette tips, ~28 boxes of lab gloves, and ~234 pipette tip holder boxes per week from the Queen's landfill plus hazardous waste streams. Finally, the survey data indicate that although ~75% of all lab supply packaging materials such as cardboard, Styrofoam and plastic wrapping were currently being recycled, the remaining 25% is being disposed of in the regular landfill waste stream even though it should be totally appropriate for recycling.

Overall, the primary sustainability goal is obviously to reduce as much as possible the use of lab supply materials that give rise to waste, and secondarily, to re-use materials where possible. However, a lot of science research activity necessarily requires the one-time use of large amounts of expendable supplies, and so at the very least, attempting to recycle as much as possible is a sustainability imperative. Together, our results here strongly suggest that very significant waste diversions of both lab supplies and their associated packaging materials from landfill and hazardous waste to the recycling stream are possible at Queen's. To move forward on this, an appropriate waste haulier will need to be identified, an appropriate and effective campus-wide collection system will need to designed and implemented, and protocols will need to be established so that participating lab groups take full responsibility for ensuring that such diverted materials are not contaminated with hazardous chemical or biological residues.

Full report

University lab research groups produce a wide variety of potentially recyclable waste products such as plastics, glass, metals, paper, etc. (see Appendix 1) that are generally directed to either the regular landfill or hazardous waste streams. This project was conducted by members of the SustainabilityAction committee at Queen's University with the hope of improving future lab waste diversion practices and protocols throughout campus. A short voluntary survey (Appendix 2) was distributed to a wide variety of research lab groups on campus in late Fall 2019 to get a 'snap-shot' of common laboratory non-hazardous waste product materials.

Completed surveys were received from 22 research lab groups (Appendix 3) across Queen's within the Departments of Biology (13), Biomedical and Molecular Sciences (7), Environmental Studies (3 cross-appointees), Geography (1), and Civil Engineering (1), and a total of 51 different waste items were reported (Appendix 4). Of those items, various types and sizes of plastic sample tubes were reported 40 times in total across all surveys, followed by various sizes of pipette tips (27 times), lab gloves (22 times), cardboard (18 times), Styrofoam (14 times), plastic wrap (13 times), plastic petri dishes (10 times) and pipette tip holder boxes (9 times) (see Figure 1).

The survey data clearly indicate that almost all of the lab supply packaging materials such as cardboard, Styrofoam and plastic wrapping had no contact with hazardous materials (as defined by *Queen's Health and Safety Protocols*). However, only approximately ¾ of these materials were being recycled each week, while the remaining ~¼ of each is currently being disposed of in the regular landfill waste stream (Appendix 4). This latter portion clearly represents a very significant and easily implementable component of Queen's lab waste that could be diverted to potential recycling.

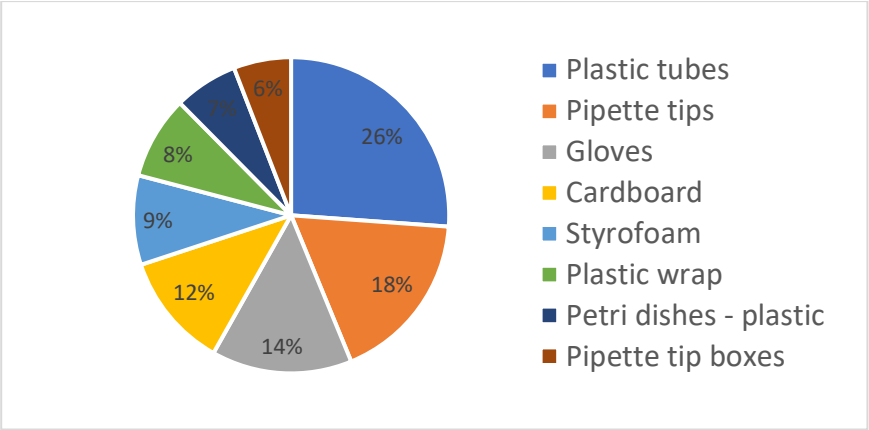

Fig. 1. The most frequently reported waste items in the surveys. Note that the top three categories include multiple entries within individual surveys associated with different types of plastic sample tube, pipette tip and lab glove.

For the four most-commonly listed non-packaging waste items (i.e. plastic sample tubes, pipette tips, gloves and pipette tip box holders), we calculated the total number of each produced per week that had no contact with hazardous materials (as defined by *Queen's Health and Safety Protocols*) AND that were not being recycled (i.e. uncontaminated items that could potentially be recycled but that are currently being disposed in landfill or hazardous waste streams) (Table 1). The vast majority (60-100%) of each of these waste items were reported as uncontaminated with either chemical or biological hazardous residues, and therefore seem to be totally appropriate for recycling.

Furthermore, we attempted to extrapolate the total amounts of each of these items produced each week at Queen's that could be diverted from the landfill and hazardous waste streams to recycling. Queen's has 385 lab rooms containing potentially hazardous chemicals, and 140 lab groups that do research requiring specific biohazard safety protocols (Tom Martinek, pers. comm.). For the purposes of our extrapolation, we have conservatively assumed that there is a total of 140 Queen's labs that produce these particular waste items, and that the proportions of these waste items that could be recycled is represented by our survey data. Note that our assumption of 140 total labs is more likely an underestimate rather than an overestimate because: 1) some lab groups (such as in Chemistry and Ecology) may do research that produces hazardous chemical waste, but that does not require biohazard safety protocols; 2) since D.B.M.S. alone has 120 faculty listed on its website, we expect that there are probably >140 science labs in total on campus at Queen's doing research that requires the particular lab supplies focussed on in this report.

This tentative extrapolation of the survey data across the entire university suggests that ~74000 plastic sample tubes, ~37000 pipette tips, ~28 boxes of lab gloves, and ~234 pipette tip holder boxes per week could be diverted from the Queen's landfill plus hazardous waste streams to the recycling stream (Table 1).

Waste item	**Measurement unit**	**Total number of units produced by all survey respondents each week**	**Total number of units with no hazardous residue contact produced by all survey respondents each week**	**Proportion (%) of total units with no hazardous residue contact that is currently being disposed of in landfill or hazardous waste streams**	**Extrapolated total number of units produced at Queen's that could be diverted for recycling each week**
Plastic sample tubes	~500 tubes	196	23	99	148 (i.e. ~74000 tubes)
Pipette tips	96 tips	133	58	100	385 (i.e. ~37000 tips)
Nitrile lab gloves	Box of ~200 gloves	9.2	4.2	100	~28 boxes
Pipette tip holder boxes	1 box (96 slot)	59	58	60	~234 boxes

Table 1. A breakdown of the four most frequent non-packaging waste items used in lab analyses that could potentially be recycled, and an extrapolation of total amounts across Queen's that could be diverted each week.

Overall, the primary sustainability goal in this context is obviously to reduce as much as possible the use of lab supply materials that give rise to waste, and secondarily, to re-use materials where possible. However, a lot of science research activity necessarily requires the one-time use of large amounts of expendable supplies, and so at the very least, attempting to recycle as much of it as possible is a sustainability imperative. In that context, these survey results strongly suggest that very significant amounts of lab packaging materials and plastic sample tubes, pipette tips, gloves, and pipette tip boxes could be diverted from landfill and hazardous waste to the recycling stream at Queen's. The most important criterion to enable this diversion is that the lab groups producing such wastes take great care to ensure that only materials that are not contaminated with chemical or biologically hazardous residues are directed into the recycling stream. Secondly, Queen's would need to identify a waste haulier willing to take on such materials, and thirdly, an appropriate and effective campus-wide collection system would need to be implemented. The final outcome would be an important contribution to making a "greener" campus, while also helping science as a whole become more environmentally friendly.

Discussion points:

1. The survey data indicated that although ~75% of lab supply packaging materials are currently being disposed of in the recycling stream, ~25% are placed in the regular landfill waste stream. This latter portion clearly represents a very significant and easily implementable component of Queen's lab waste that could be diverted to potential recycling. Further research is required to determine why any of these materials are currently being placed in the landfill stream, and what education and/or infrastructure would be necessary to encourage the responsible lab personnel to switch to recycling.

2. For a science research lab waste recycling program to work, the material for diversion must be entirely free from hazardous chemical (e.g. radioactive elements, mercury etc.) or biological (e.g. genetically engineered or non-native organisms) residues since the health and safety of the custodians as well as of the transport hauliers and the recycling material processors would otherwise be at risk. One suggestion to ensure compliance by the producers of such lab waste is for each lab to collect their materials in a clear distinctively colored (i.e. not the normal completely clear or off-white color) plastic bag and attach a tag labelled with the lab Principal Investigator's name before depositing it in a dedicated, distinctive, and clearly labelled lab waste recycling container bin that would be maintained in each lab building.

3. For any waste recycling program to work, the materials diverted into the recycling stream must be reasonably clean of residues (e.g. for household domestic recycling). The packaging materials itemised above (and perhaps the pipette tip holder containers) are not normally actually used in research and therefore can generally be assumed to be free of any hazardous or non-hazardous contamination, and hence should be readily recyclable.
   What about the other materials highlighted above such as plastic sample tubes, pipette tips, and gloves that are used in non-hazardous research and therefore are in theory recyclable, but that are not absolutely clean (e.g. that have been used for non-hazardous chemical analyses, or have been in contact with non-hazardous organisms?). Are residual traces of such substances

acceptable (as they are in household waste)? If the residues are substantial (i.e. clearly visible), would a quick rinse in detergent and/or tap water be sufficient to make such materials acceptable for recycling? Further discussion and investigation with potential waste haulier companies is required to clarify the required cleanliness of such material. An alternative but much less desirable option from a sustainability perspective would be for the materials to be passed into an incineration waste energy production stream.

4. Several lab glove recycling programs may warrant further investigation. For example, see the current Kimberly Clark 'RightCycle' glove recycling program which has recently undergone some changes so that materials are transported to their plant in Huntsville Ontario, rather than Michigan as in the past. Dr. Yat-Tse (Department of Biological and Medical Sciences) is currently using and satisfied with this program for some of his lab's glove waste. Also see a useful discussion of nitrile glove recycling and other 'green' lab issues (courtesy of Madelen Fellows of the Queen's Sustainability office) at: https://groups.google.com/forum/?utm_medium=email&utm_source=footer#!forum/green-labs-planning.

5. Lab waste materials that have been in contact with biohazardous residues could be autoclaved (sterilised) to ensure that they are safe for diversion into the recycling stream. The potential for this approach warrants further consideration.

6. Several labs buy pipette tips in bulk plastic bags and then autoclave groups of them in saved pipette tip holder boxes.

7. Overall, the primary sustainability goal should be to reduce the use of lab materials that give rise to waste in the first place. For example, at least one surveyed lab have returned to the use of (readily washable) glass pipettes wherever possible to completely avoid producing the waste associated with one-time use of plastic pipette tips.

8. Our survey data is a single snapshot for one week in late Fall and so types, amounts and proportions contaminated of individual waste items may vary substantially through the academic year.

9. We received the vast majority of the surveys from biologically-focussed departments on campus, and therefore our analysis is probably somewhat biased because it does not include information on waste production in other types of research labs such as in Departments of Chemistry, Physics, Geology, and Mining.

10. As described above, the extrapolation of total weekly amounts of waste that are potentially divertible to recycling is a preliminary tentative estimation dependent particularly on the assumed number of active labs producing such waste items, and on the proportion contaminated.

11. Plastic sample tubes were the most frequent survey entry but our analysis did not discriminate between types and sizes of tubes used in the various lab applications, suggesting that further research should be done to better characterise the plastic tube waste in active labs across campus.

12. An initiative to divert significant amounts of appropriate lab waste from landfill and hazardous waste to recycling would promote Queen's University as a leader in environmental issues and place it among other high-end institutes that have begun similar initiatives. For example, schools such as the University of Alberta, University of British Columbia, University of British Columbia Okanagan, McGill University, and University of Toronto have substantial lab waste recycling programs in place.

13. For more information specifically on lab waste issues, as well as more generic information on reducing the ecological footprint of doing lab-based science, the following resources are strongly recommended:

    - https://sustain.ok.ubc.ca/initiatives/labplastics/
    - https://www.i2sl.org/working/labwaste.html
    - https://sustainability.ucsb.edu/labrats-best-practices/
    - Eizagirre, S. Science has a garbage problem. Why aren't recycling schemes more popular? https://massivesci.com/articles/research-labs-generate-plastic-waste-recycling-sustainability-gloves/
    - https://www.colorado.edu/ecenter/greenlabs
    - https://www.mygreenlab.org
    - https://www.freezerchallenge.org
    - https://www.labconscious.com/
    - https://zerowasteboxes.terracycle.ca/collections/ppe/products/safety-equipment-and-protective-gear-zero-waste-boxes

Appendix 1. Typical lab waste items currently being disposed in the regular landfill and hazardous waste streams that could be diverted to recycling provided they are not contaminated with hazardous chemical or biological residues (photo courtesy of Dr. Yat Tse).

Appendix 2. Survey form used to assess lab waste products, the extent of hazardous contamination, and disposal practice.

Waste Product	**Material-type** (Add plastic recycling identification # if known)	**Waste Origin**	**Has it come into contact with hazardous materials** (as defined by *Queens Health and Safety*) Yes/No	**Where do you currently dispose of it?** - Hazardous waste stream - Regular waste stream - Recycling stream	**Amount produced per week by your entire lab** (rough estimate is fine)	**Department**

To help you complete the table, here's a list of possibly relevant lab waste products but please also add extras that are specific to your lab:
Pipette tip boxes
Petri dishes and multiwell assay plates
Centrifuge tubes 1.5ml etc
Conical test-tubes
Water sample bottles (20ml)
Latex lab gloves
Styrofoam
Glass items
Cardboard packaging
Paper packaging
Plastic packaging

Appendix 3. Lab group survey participants, contact details, and associated Departments.

Principal Investigator /Team leader	Lab manager /assistant /contact	E-mail contacts	Department
George DiCenzo		george.dicenzo@queensu.ca	BIOL
Anna Rooke	(BIOL 212 program associate)	a.rooke@queensu.ca	BIOL
Ian Chin-Sang	Jeff Boudreau	jeff.boudreau@queensu.ca chinsang@queensu.ca	BIOL
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Paul Grogan		groganp@queensu.ca	BIOL
Fran Bonier	Ivy Schoepf	ivana.schoepf@queensu.ca bonierf@queensu.ca	BIOL
Paschale Champagne	Nathan Mullins	nathan.mullins@queensu.ca pascale.champagne@queensu.ca	Civil Engineering (Beaty Water Research Centre)
Brian Cumming	Kate Laird	lairdk@queensu.ca cummingb@queensu.ca	BIOL
Melissa Lafreniere		melissa.lafreniere@queensu.ca	GEOG
Jackie Monaghan	Katy Dunning	k.dunning@queensu.ca jm355@queensu.ca	BIOL
Louise Winn	Peter Lu	peter.lu@queensu.ca winnl@queensu.ca	DBMS/ENVS
Richard Oko	Wei Xu	ro3@queensu.ca wx@queensu.ca	DBMS
Steve Pang	Yat Tse	yat.tse@queensu.ca pangsc@queensu.ca	DBMS
Virginia Walker	Kristy Moniz	kristymoniz@gmail.com walkervk@queensu.ca	BIOL
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Chris Mueller		muellerc@queensu.ca	DBMS
Leda Raptis		raptisl@queensu.ca	DBMS
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Vicki Friesen	Emma Lachance-Linklater	13emll@queensu.ca vlf@queensu.ca	BIOL/ENVS
Bill Plaxton		plaxton@queensu.ca	BIOL

Appendix 4. Composite data from all surveys. Items in the red and yellow highlighted rows were the most frequently reported and voluminous material reported, and therefore were chosen as the focus of the analyses in the study. Units for each of the major items (red rows) are specifically defined in Table 1. Units for the other items generally refer to the smallest box or package size in which the material is typically priced.

Waste item	# survey mentions	Plastic recycling-type identifier # (only reported in some surveys)	Average # units used	Maximum # units used	Total # units used	Hazardous waste stream (# units disposed)	Landfill waste stream (# units disposed)	Recycling or Compost waste streams (# units disposed)	Was the item in contact with hazardous contaminants (as defined by E.H.&S.)?
Agarose Gels	1		0.004	0.004	0.004		0.004		Yes
Aluminium foil	1		0.026	0.026	0.026		0.026		No
Blades	1		1.000	1.000	1.000	1.000			Yes
Blister pack	1		10.000	10.000	10.000		10.000		No
Bubble wrap	1		Not indicated					*	No
Cardboard	18		2.588	5	44		12	32	No
Chemical bottles	1		0.250	0.250	0.250	0.25			Yes
Container	1		1.000	1.000	1.000			1	No
Culture Plates	2		17.500	30	35	5	30		Yes
Cuvettes	2		0.030	0.04	0.06		0.06		Yes or No
ddPCR Cartridge	1		12.000	12.000	12.000	12			No
Filter paper	1		0.310	0.310	0.310			0.31	No
Foam ice pack	1		10.000	10.000	10.000		10		No
Gel ice pack	1		20.000	20.000	20.000		20		No
Glass	8		0.861	2	6.89	3	1.89	2	Yes or No
Gloves	22		0.416	2	9.16	0.675	8.485		Yes or No
Kim Wipes	5		0.206	0.5	1.03	0.33	0.7		Yes or No
Media bottles	1		5.000	5.000	5.000		5		Yes
Paper incl. packaging	6		1.520	5	9.12	4.12	5		No
Paper Towel	8		0.713	3	5.7	0.25	5.2	0.25	Most no
Parafilm	2		0.013	0.02	0.026		0.026		Yes or No
PCR Strips	1		0.004	0.004	0.004		0.004		Yes
Petri dishes	10		0.108	0.6	1.084	0.754	0.33		Yes or No
Pipette tip holder boxes	9	5	6.567	20	59.103		36.083	23.02	Most no
Pipette tips	27	5	4.926	20.8	133.01	45.85	87.16		Yes or No
Pipetting Reservoirs	2		0.260	0.5	0.52	0.52			Yes or No
Plant pots	1		50.000	50.000	50.000			50.000	Yes
Plastic bags	3		13.333	20	40		30	10	No
Plastic Wrap	13		2.208	10	26.5		7	19.5	No
Plates	6		0.045	0.15	0.27	0.09	0.18		Yes or No
Rubber Gasket	1		12.000	12.000	12.000	12			No
Sample tubes (plastic)	40	1 or 5	4.908	150	196.32	22.004	173.816		Yes or No
Styrofoam	14		1.742	5	22.64	0.12	6	16.52	Most no
Syringe tips	1		0.010	0.010	0.010	0.01			Yes
Tags	2		8.000	10	16		16		No
Vials	6		0.150	0.3	0.9	0.1	0.7	0.1	Yes or No
Weigh Paper	1		0.010	0.010	0.010	0.01			No
Weight Boats	3		0.009	0.02	0.024	0.004	0.024		Yes or No
X-Ray film	1		0.100	0.100	0.100		0.1		No