Greening UW-Madison Laboratories:

Sustainable Supply Recommendations for Campus Labs

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Introduction

This report details the results of a semester-long project focused on providing more sustainable alternatives to some of UW-Madison's top laboratory purchases. The university campus is home to approximately eight hundred laboratories in a variety of fields, ranging from stem cell research and microbiology to bacteriology and general chemistry. Due to the diversity of chemicals, equipment, and supplies used, our research and resulting recommendations target items that are used by multiple departments. Often, the technical nature of lab supplies limit their ability to be replaced, but we found that sustainable options do exist for a number of general-use items. Moreover, in many cases certain items could be used more efficiently if sustainable lab practices were adopted. In this report, we provide recommendations for product replacements as well as techniques to improve resource efficiency in university laboratories. All cost analyses are based on a query of the Materials Distribution Service's list of the top 100 lab purchases from Thermo Fisher Scientific and VWR, for the 2011 fiscal year (July 1, 2010 to June 30, 2011). The provided data represent campus-wide purchases, meaning that cost analyses could not be customized to individual departments and calculated totals do not include lesser-purchased items. Step-by-step documentation of the calculations used to provide totals and recommendations is in the attached appendix.

Pipettes, Polystyrene, & Glassware

Pipettes compose a significant portion of the top 100 purchases from VWR and Fisher. UW-Madison labs bought approximately 1.78 million disposable pipettes, resulting in an annual cost of $211,050. All of the currently purchased pipettes are disposable, and the majority of these pipettes are made of polystyrene, an extremely common form of petroleum-based plastic used to make everything from plastic bottles to Styrofoam™ cups. Styrene, the building block of polystyrene, is classified as a possible human carcinogen by the Environmental Protection Agency (EPA), and has been linked to multiple health risks associated with acute and chronic exposure to the substance, such as skin, eye, and respiratory tract irritation, and depression, headache, and fatigue. In 1992, the US Department of Labor and Occupational Safety and Health Administration tried unsuccessfully to limit the amount of worker exposure to styrene [1]. In addition to health-related concerns, polystyrene is rarely recycled, making it a significant contributor to the large amount of solid waste accumulating in US landfills. In 1986, the EPA reported that polystyrene manufacturing was the fifth largest creator of solid hazardous waste in the nation [1]. While the technology exists to recycle polystyrene, manufacturing new plastic is still more cost effective than recycling. Even if the market favored recycling, there are currently no locations in the Madison area that recycle the polystyrene used in pipettes.

After speaking with various laboratory technicians [11, 14], we determined that in some cases, disposable pipettes can, and should be, replaced with reusable glassware. The undesirable properties of polystyrene make borosilicate or soda lime glass pipettes a more sustainable alternative. Borosilicate glass is almost identical to what consumers know as PYREX®, lending itself well to lab use because of its clarity as well as its chemical and heat resistant properties. While negative environmental impacts in glass manufacturing exist—such as intensive energy use in the heating process and production of particulate matter—glass can be reused many times, making it a more sustainable long-term option compared to petroleum-based plastic [2]. No single material, however, is environmentally neutral. One significant drawback to borosilicate glass is its inability to be recycled with other types of glass, due to the presence of boron.

While not all pipettes can be replaced with reusable versions because of the potential for contamination in medical labs or other reasons determined by the researcher, some plastic pipettes should be substituted with glassware that can be sterilized using autoclave equipment, already in place in many campus labs. The intended use of each pipette will largely determine which type is purchased, but we recommend that reusable options be considered whenever sterilization is feasible. An example of a situation in which glassware should be substituted for plastic, is the use of ten milliliter polystyrene pipettes. The cost of a reusable 10mL glass pipette ($7.35) is significantly higher than the cost of disposable versions (average $0.15/pipette), and for this reason, replacement of the entire category is inadvisable. However, substitution is recommended when pipettes are used for educational purposes. Teaching students how to appropriately use pipettes is done with innocuous liquids that do not compromise the viability of the pipette. We recommend that plastic demonstration pipettes be replaced with borosilicate glass versions. There are 6,000 students in general chemistry each year, and we estimate that 1,000 reusable glass pipettes would cover the number of demonstration pipettes used, since lab equipment is reused in subsequent labs [12]. The initial cost of replacement would be $6,462, undoubtedly a large investment, but $888 dollars would be saved annually by not buying 6,000 disposable pipettes every year, resulting in a payback period of 8.3 years.

Pasteur pipettes make up 43% of the total pipette use, and 17% of the total pipette cost. The versions that UW labs currently purchase are made of borosilicate glass and soda lime glass. Despite the fact that both materials can be repeatedly sterilized without damage to the pipettes, UW labs typically dispose of these items after a single use. During a conversation with Laura Kalvestran, Senior Sales Representative at Fisher Scientific, we discovered that this practice has been adopted out of habit and convenience [11]. Most UW labs are well-financed and need not consider reuse potential. However, when labs see a reduction in funding (as occurred in campus lab that will go un-named) technicians and researchers are forced to clean and sterilize glassware instead of purchasing disposable items [11]. This example shows that reuse of certain items is not only possible, but currently practiced in some UW labs. For this reason, we suggest that the decision not be made simply based on financial ability.

Opportunities to reuse glassware do exist, especially in educational labs. In our discussions with senior chemistry lab technician Jeff Burkett, we learned that during many student lab sessions, each student uses a “disposable” glass pipette to dispense a required chemical. Instead of needlessly disposing of these pipettes, we recommend that a single pipette be designated to each chemical, thereby reducing the number of pipettes used in a single lab session. If one in ten pipettes were reused in this fashion, the result would be an annual cost savings of $1,130. Specific labs will know best how many pipettes can be reused, but any amount of reuse will ultimately lead to a reduction in annual costs. We also recommend that when purchasing pipettes, the researcher choose the “paper-paper” packaging option, as opposed to the “paper-plastic” option that is most commonly chosen. Opting to use the former eliminates the unnecessary use of petroleum-based plastic [11] with a simple click of a button.

Culture Tubes

UW labs purchase approximately 630,000 culture tubes annually, with an associated cost of $33,800. Although they are made of borosilicate glass, they are disposed of after each use. Borosilicate glass is designed to withstand repeated sterilization, so instead of disposing of every culture tube after a single use, when possible, culture tubes should be reused. During our interview with Laura Kalvestran, we discovered that most manufacturers label glass culture tubes as disposable so that they are not liable for any cross contamination that may occur. This does not mean, however, that culture *must* be disposed of after a single use [11]. While many uses of culture tubes may produce hard solids that would be difficult and water-intensive to clean, other uses are only utilizing liquid solutions. These tubes could be rinsed out and autoclaved repeatedly until the researcher deems the tube unusable. If only one in ten culture tubes—about 126,000—were reused, university labs would save $5,040 each year.

Petri Dishes

University labs purchase 1.26 million polystyrene petri dishes annually, totaling $149,300. The higher cost of glass petri dishes ($1.73 per glass dish compared to an average of $0.12 for disposable versions) is a major obstacle to replacement. Long payback periods make replacement of plastic petri dishes with glass alternatives inadvisable. Instead, we recommend that a portion of petri dishes be replaced by a compartmentalized version. In some cases, the volume of an entire petri dish is not required for a single culture. A compartmentalized petri dish allows for four cultures to be placed within a single dish. Meeting the experimental needs currently met by 10% of the petri dish purchases with compartmental versions (4 compartments per dish) would reduce the quantity of dishes purchased from 125,780 to 31,445. Due to their similar costs, this replacement would result in an annual savings of $11,163.

Acetone

UW labs purchase roughly 1,543 gallons of pure acetone each year, totaling $18,000 annually. Dr. Cathy Middlecamp, Director of the Chemistry Learning Center and Distinguished Faculty Associate, informed us that the majority of this acetone is used for quickly drying glassware [12]. Acetone is a volatile organic compound (VOC), which means that it is unstable at room temperature, and although acetone is a useful chemical in the laboratory, it is not environmentally friendly. As a VOC, it evaporates at room temperature, coming into contact with people through touch and inhalation. Effects of moderate to high acetone exposure in humans include skin and eye irritation, nausea, headaches, dizziness, and a shorter menstrual cycle for women. The effects of long term acetone exposure in humans include kidney, liver and nerve damage, increased birth defects, and lowered ability to reproduce in males [7, 8]. Clearly the health impacts of UW-Madison laboratories on students and faculty could be reduced by decreasing the use of acetone.

One way to decrease the use of acetone is by using acetone recyclers. These machines use a process called fractional distillation to capture used acetone. In the case of glassware drying, the used acetone is captured in a container and loaded into a recycler. At least 95% of the acetone can be recovered by this process [13]. CBG Biotech is well known for their acetone recycling machines, and they supply them to chemistry labs at universities such as Harvard, Yale, and Colombia. We spoke with a company representative who helped us understand the technology, and cost savings associated with it. A conservative estimate for the disposal cost of the volume of acetone that UW labs purchase is $5,400 each year [13]. Added to the cost of purchasing acetone, the result is a total cost of $23,400 each year. If the university purchases acetone recycling equipment for all of its labs, the annual savings associated with purchasing and disposing of acetone would be $22,230 since 95% of the acetone can be recovered and used over and over again.

CBG Biotech sells acetone recycling equipment in various sizes. According to the CBG Biotech representative, a large chemistry lab can recycle all of the acetone it uses with a 2.5

gallon recycler. The price for a manual 2.5 gallon bench recycler is $16,800. A large chemistry lab would run the 2.5 gallon recycler approximately two times each day during the school year [13]. Estimating that 50% of the chemical solution loaded into the equipment is acetone and 95% of the acetone can be recovered, this would result in the recycling of approximately 380 gallons of acetone each year with this machine alone. The resulting annual savings associated with purchasing and disposal of acetone are $4,414 and $1,326 respectively, resulting in an annual savings of $5,740. Therefore, the payback period for this machine would be 2.9 years.

Weigh dishes

UW laboratories purchase 49,000 polystyrene weigh dishes annually for a cost of $4,630. The disadvantages of polystyrene could be avoided by purchasing aluminum weigh dishes. Aluminum is a commonly recycled material; in fact, it takes "95% less energy to recycle aluminum than it does to make it from raw materials", and the recycling process is more efficient than the recycling of plastic, newspaper, glass, and steel [4]. In addition to being more recyclable, the aluminum weigh dishes also cost less ($0.02 on average). Replacing plastic weigh dishes with aluminum versions would result in an annual savings of $960. In addition, if lab practices could be changed in a way that would use fewer weigh dishes, such as sharing them between lab partners or groups, this would produce additional cost savings.

Latex Gloves

Latex gloves are another top purchase by the university. We recommend that latex gloves be replaced with nitrile gloves for a number of reasons. Latex poses a health threat to users because of its allergenic properties. Since latex gloves account for 446,000 (80%) of the 560,000 gloves purchased every year, UW laboratories are increasing the risk to students with latex allergies. Estimates of latex sensitivity in the general population range from 1% to 6%, but due to repeated exposure to latex, this percentage is increasing, and it is estimated that 8 to 12% of health care workers are latex-sensitive because of repeated exposure [5, 6]. Nitrile is a synthetic material that is comparable to latex in its fit and feel, as well as its barrier properties [5]. Purchasing all nitrile gloves would not only reduce students' risk of developing latex sensitivities and reduce the potential for allergic reactions, it would also save money. If all purchases of latex gloves were switched to nitrile, the university would save $3,200 dollars annually.

Cuvettes

UW labs purchase 95,000 cuvettes each year, for a total cost of $8,000. Since cuvette use involves observing the behavior of light passing through a solution, it is important that the cuvettes are transparent and blemish-free. This makes it difficult to purchase glass cuvettes for multiple uses, since they are prone to scratching [12]. The currently purchased cuvettes are made of polystyrene, but methacrylate—another form of disposable plastic—versions are also available. According to Professor Tim Osswald, Co-Director of the Polymer Engineering Center at UW-Madison, methacrylate is a more environmentally friendly option [15]. Unlike polystyrene, which loses many of its properties during the recycling process and produces hazardous particulates, methacrylate maintains its integrity during and after the recycling process and if burned, produces fewer toxins. If all of the cuvette purchases were changed to the methacrylate alternative, it would cost UW an additional $351.50 each year, an increase of just 4.4% over current costs.

Plastic Bags

Although plastic bags were not a top purchase on the list, in conversations with Jeff Burkett we learned that plastic bags are unnecessarily used in general chemistry labs [14]. Small plastic bags are used to dispense individual portions of an unknown chemical mixture to students, who are then assigned to determine what the unknown chemical mixture is composed of. Rather than giving each student their own plastic bag with the chemical mixture, we suggest that the teaching assistant dispense the unknown substance to each student directly into their test tube from a bulk container. This is a simple change in practice that would save 6,000 bags from landfills each year.

Detergent

UW labs predominantly use disposable plastic lab supplies which reduces the need to purchase cleaning detergents. Our recommendations include switching select plastic lab supplies to reusable glassware that requires cleaning and sterilization. Currently, university labs purchase approximately 200 lbs of Alconox powder detergent, at a total cost of $945.50 annually. Although biodegradable, this concentrated detergent is composed of sodium alkylaryl sulfonate, alcohol sulfate, phosphates, and carbonates. Phosphates are known water pollutants that facilitate the growth of blue-green algae, which depletes aqueous oxygen and leads to the degradation of aquatic ecosystems. The university's proximity to Madison's lakes makes this a particularly important point. To ensure that UW labs do not contribute to the growth of algae blooms, we recommend that university labs purchase a Decon Detergent that is both biodegradable and phosphate-free. This concentrated powder detergent has comparable cleaning power and can be used manually or in dishwashers. Replacement poses an additional cost of $55 annually, but this is a minuscule amount compared to the environmental benefits that result.

Conclusion

Some of our recommendations undoubtedly require significant initial investments (e.g. pipettes), but the benefits of substitution and reuse are worth more than their monetary value. Teaching students the value of reusing materials helps ingrain an ethic of sustainability by creating awareness of production processes, resource use, and disposal. These practices will encourage students to become more conscious of the materials and chemicals they are using, as well as produce habits of more efficient resource use.

To summarize, we recommend that university laboratories replace disposable plastic supplies with reusable glassware when possible and reuse at least a portion of the glass items that are currently purchased. We also recommend introducing new ways to use lab resources more efficiently. Researchers that lack funding to purchase new materials have been known to come up with innovative ways to reuse lab materials, while labs with ample financing choose to dispose of materials and purchase new ones [11]. If every lab were to place an imaginary budgetary constraint on itself, we are certain innovation in resource conservation would follow. To spur a sustainable initiative without financial constraint, the aforementioned recommendations redirect the 'disposable' dollars that UW laboratories throw away each year to a long-term investment in a sustainable future.

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