

Liz Fitzgerald
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Chemical Use and Hazardous Waste

Introduction

Many types of hazardous waste are produced annually at Macalester College. The chemistry, biology, geology, physics, art, and theatre departments, as well as the facilities management office, are the main generators of hazardous waste on campus. Hazardous waste includes everything from used motor oil and oil filters from campus vehicles, chemicals from science laboratories, paints and other art supplies, as well as chemical fertilizers and pesticides. These materials are classified as hazardous because they can be dangerous to human, as well as environmental, health if they are not disposed of properly. Because these materials can be harmful if not properly taken care of, Macalester has developed hazardous waste disposal plans to take care of all hazardous waste generated on campus. The current strategy employed by the college when it comes to hazardous waste management is a “front end” approach. This approach involves predicting the amount of hazardous waste that will be generated by the college, and then attempting to reduce the amount of waste before it is actually produced.

Data – Hazardous Waste Management at Macalester

Hazardous waste disposal is regulated at both the state and federal level. Because these regulations exist, Macalester has always been in the practice of employing techniques to reduce chemical use and manage its hazardous waste. In the past, Macalester’s chemical usage and hazardous waste management were not the model of efficiency, but over the past 10 to 15 years,

faculty and staff at Macalester have made some serious changes that have greatly reduced our chemical use and decreased the amount of hazardous waste produced.

Before the remodel of Olin-Rice, the chemical stockroom was in the basement of the building. Because of the inconvenient location of the stockroom, chemicals were ordered somewhat haphazardly; professors would order whatever chemicals they wanted whenever they wanted. Duplicate orders were common and chemicals were often ordered in large quantities because they were cheaper per unit volume, leaving large amounts of chemical excess. Moreover, laboratory exercises were often run on gram scales, consuming large amounts of chemicals and creating large amounts of waste. Mercury was also used in general chemistry teaching labs.

In general, much of the waste from chemistry laboratory exercises is water-soluble and can be poured down the drain, or treated and then poured down the drain. However, waste containing certain metal ions like manganese, cadmium, lead, and cobalt as well as most organic compounds cannot be poured down the drain. Additionally, most of the solid waste generated in the chemistry department cannot be thrown out. Special procedures must be followed in order to dispose of this waste. Organic waste and waste containing certain hazardous compounds is collected in the labs in designated waste jugs. When the jugs are full, they are collected and moved to the on-site storage facility located on the first floor of Olin-Rice. The waste is stored in there until a hazardous waste disposal company comes to remove it. Macalester puts out bids to several hazardous waste companies at the end of the year, and then chooses a disposal company based on several factors, including price and reputation. Regardless of the disposal company, most of the hazardous waste generated at Macalester is fuel blended and incinerated by the waste disposal company. Because Macalester produces very little hazardous waste, the

college is classified as a “very small” producer of waste, and its waste need not be collected more than once a year. If Macalester were to produce enough hazardous waste to reach “small” status in terms of waste production, its waste would need to be collected three times a year.

Hazardous waste is generated not only in the chemistry department, but also in the other science departments, art and theatre, and by the facilities management office. The hazardous waste produced by the other sciences is mostly liquid chemical waste, which is included with the waste from chemistry when it is removed. Hazardous waste from the art department includes used darkroom chemicals, which contain silver ions, and paint thinner. These are also disposed of with the chemistry waste. The waste from facilities management includes things like used oil and oil filters, fluorescent light bulb tubes, and lead-acid batteries. Most of these things can be recycled. The hazardous waste removed from the college for each of four years is shown in the table below. In 2003, the college spent \$3,524.66. Data was not available for other years.

Hazardous Waste Disposal at Macalester

	1996	1997	1998	2003	Disposed Of	Recycled
	Amount	Amount	Amount	Amount		
Corrosives	1103 pounds	60 gallons	750 pounds	96 gallons	✓	
Oxidizer	350 pounds	20 pounds	30 pounds	10 gallons	✓	
Flammable	1289 gallons	330 gallons	1000 pounds	813 pounds	✓	
Poisonous Materials	716 pounds	155 gallons	100 pounds	845 pounds	✓	
Combustibles	NA	NA	NA	8 pounds	✓	
Flammable Solids	41 pounds	none	NA	10 pounds	✓	
Miscellaneous	240 pounds	165 gallons	500 pounds	239 pounds	✓	
Peroxides	5 pounds	none	NA	10 pounds	✓	
Photo Fixer	NA	8 gallons	17 gallons	NA		
Fluorescent Light Bulb Tubes	NA	2272 pounds	3300 pounds	2572 bulbs		✓
Light Ballasts	NA	4375 pounds	NA	900 pounds		✓
Lead-Acid Batteries	NA	180 pounds	274 pounds	240 pounds		✓
Oil	128 gallons	703 gallons	37 gallons	27 gallons		✓
Oil Filters	NA	21 pounds	30 pounds	24 pounds		✓

*NA indicates that this information was not available.

Based on this table, it is hard to make comments about any trends in the amount of hazardous waste generated; first, because some of the data is missing, and second, some of the data is recorded in pounds and some in gallons, making comparisons difficult. Also, the amount of waste generated by facilities management can change greatly if a major project is underway. For example, in 1997 an underground oil drum was dug up and emptied, resulting in much more oil waste than normal, and in 1998 a building was redone and new light fixtures were installed, resulting in a higher than normal amount of fluorescent light bulb waste. Even with all these data gaps, it is possible to say that in certain areas, there is a distinct difference between hazardous waste in 1996 and 1997. This corresponds to the remodeling of the Olin-Rice Science Building.

Beginning around 20 years ago, the facilities management office, then called physical plant, and the chemistry department began looking at ways to reduce the amount of hazardous waste generated in the chemistry labs. By the time the science building was remodeled in 1996, efforts had been made to reduce laboratory waste by redesigning labs or running labs on smaller scales. With the remodel of the building, it was necessary to empty out the old chemical stockroom, and then move all the chemicals to the new stockroom. This seemed the perfect opportunity to begin making more drastic changes in chemical usage and hazardous waste management policies. Chemicals in the stockroom that were no longer in use were disposed of. This accounts for of the very large amount of waste removed in 1996. Additionally, the new stockroom had an updated chemical inventory and all chemical orders now go through the stockroom. Furthermore, chemicals are generally ordered in small quantities that will be consumed within a semester or a year, reducing greatly the number of chemicals that sit unused in the stockroom.

In addition to creating a more efficient and effective way to keep track of and order chemicals, many of the chemistry professors have made a concerted effort to reduce the amount of hazardous waste produced in their laboratories. In the past few years, students in teaching labs have begun to work in pairs. The professors believe that this provides a better learning experience for the students, but it also cuts the chemical usage and the amount of waste from each lab in half. Mercury, a very toxic metal that is expensive to dispose of, has been phased out of usage in laboratory exercises and mercury thermometers are only used in exceptional cases. Many labs have been redesigned to be run on smaller scales, using fewer chemicals and generating less waste, and some labs have been redesigned to create waste that is less toxic. Also, the chemistry faculty and facilities management staff meet biannually to discuss ways in which to change laboratory exercises to generate less waste, or less harmful waste.

Chemistry faculty have also made an effort to reduce waste in their research labs. Professor Thomas Varberg uses dyes dissolved in methanol, a common organic solvent, to perform his physical chemistry research. Professor Varberg used to throw away the used methanol and use new methanol for each new experiment. Now, he has set up a still to recycle his used methanol so that it can be used more than once.

Professors Ron Brisbois and Becky Hoye have also made efforts to reduce the waste generated in their organic research labs. This past summer, all of the rotary evaporators or rotovaps (devices used to remove organic solvents from dissolved solids) were refitted with new recirculating aspirators. Previously, the rotovaps had run on water aspirators, and some of the organic solvents would always be washed down the drain with the used water. By using recirculating aspirators, all the solvent is collected and disposed of properly. Additionally, each

rotovap is equipped with a vacuum pump connected to the fume hood so solvent vapors are sucked into the hood instead of being released into the air.

A large source of solid waste in organic chemistry research is silica gel, which is used to perform column chromatography. Tubular glassware, called columns, are filled with silica gel, which acts as a filter, and is used to purify organic compounds. When performing flash column chromatography, the most common type of column chromatography, silica gel is used once and then must be disposed of. However, several medium pressure liquid chromatography (MPLC) machines have recently been set up in the organic research labs. The MPLC machines use a reusable column. An MPLC column requires three to four times the amount of silica gel as a flash column, but the MPLC column can be reused 30 or 40 times, thus reducing the total amount of silica gel waste. Also, the organic research labs have instituted new policies to cut down on the use of acetone. Acetone is a relatively harmless organic solvent used to dry glassware. Previously, all glassware used in the organic research labs was washed and dried with acetone. Now, only reaction glassware (around half of all glassware) is dried with acetone. This greatly reduced the amount of acetone used in the organic research labs.

Other departments have also made efforts to reduce the amount of hazardous waste they generate. The art department has switched to water-miscible oil paint which can be poured down the drain. This also reduces the need for paint thinner which needs to be disposed of by a hazardous waste disposer. When paint thinner is needed, it is filtered and reused. Latex paint waste is allowed to dry out, and then thrown away. The art department has also switched from a petrol-based clay to a food-safe variety that is easier to dispose of.

The facilities management office has reduced the number of times that it treats the grounds with pesticides and fertilizers. Five years ago, the number of annual pesticide

treatments was reduced from four to one. Fertilizer application takes place a few times a year, and specific weed and fungal problems are treated on a case-by-case basis, instead of using blanket spraying. Pesticides and fertilizers are only purchased in amounts that will be used within the year, so there is rarely any excess at the end of the year to be disposed of. If there is an excess of pesticides or fertilizers, it is usually small enough that it can be disposed of through the Ramsey Country Hazardous Waste Home Program

The Computing and Information Technology office is also doing its part to reduce hazardous waste. Some metal parts in computers are considered hazardous waste, so in order to avoid the cost of disposing of computers, CIT donates many old computers to non-profit organizations, and recycles all other computers.

Recommendations

Overall, Macalester has done a very good job in its hazardous waste management practices, and there are only minor areas where improvements could be made. One problem that has recently developed at Macalester is that, while waste from teaching laboratories has gone down, waste from research laboratories has gone up, due mostly to the increasing number of students choosing to participate in student-faculty research. In the organic research labs, one of the largest waste-producing procedures is column chromatography. In addition to using large amounts of silica gel, as mentioned above, column chromatography also uses large amounts of organic solvents, and unfortunately, MPLC columns use even more solvents than flash columns. Up until this point, chromatography waste had been put into the waste stream. However, there is the possibility of recycling these solvents, as Professor Varberg does in his laser lab. Equipment is available to set up solvent stills, and doing so would greatly reduce the amount of organic waste produced in research.

Furthermore, several members of the chemistry faculty would like to see waste management practices used as a teaching tool. They feel that by discussing waste and waste disposal practices in labs, students will not only learn more about chemistry, but will become more aware of the environmental impacts of certain chemical compounds.

Although strict procedures are in place regarding the handling of hazardous waste until it is removed by the waste disposal company, these procedures are not always strictly enforced. Waste jugs in labs are sometimes overfilled or not stored in secondary containers, and several waste jugs are often stored in one fume hood. Fortunately, mislabeling of waste jugs and cross-contamination are not a problem. Thus, problems associated with the enforcement of hazardous waste handling procedures are mainly safety concern; however, overfilled waste jugs and waste jugs not in secondary containers do pose the threat of a chemical spill which could have environmental repercussions. Though the enforcement of waste handling procedures is sometimes lax in the laboratory, when the waste jugs are removed to the on-site storage facility overfilled jugs are emptied into other jugs and all waste jugs are stored in secondary containers. To date, the less than strict enforcement of the hazardous waste handling procedures has not caused any problems, but the threat of a chemical spill is still there, and could be reduced by more stringent enforcement.

Best Practices

Many colleges around the country have also taken the initiative to reduce the amount of hazardous waste released annually. Several members of the chemistry faculty at Bowdoin College started the “Microscale Revolution” in the 1970s. They published a book entitled *Microscale Organic Laboratory* that included commonly practiced organic chemistry laboratories, modified to be run on smaller scales. Now, running teaching labs on smaller scales

is common practice at most colleges and universities. Macalester currently runs most of its laboratory exercises on milligram scales which, while not as small as microgram, is a significant improvement over running reactions on gram scales.

The University of Washington developed a database for keeping track of all chemicals and associated waste. They try to purchase recycled chemicals whenever possible, substitute less toxic chemicals in their laboratory exercises, and resell their recycled chemicals to industries. Macalester has a comprehensive inventory of all its chemicals in the chemical stockroom. The college also tries to give some of its unused chemicals to facilities around that Twin Cities that may be in need of them. This is done either through the waste disposal company or the waste exchange program in the Twin Cities.

How Does Macalester Rate?

Macalester College receives an A for its chemical use and hazardous waste management practices. Strict procedures are in place regarding the disposal of hazardous waste, and on the whole, they are followed. Furthermore, over the past 15 years, faculty and staff have made many changes in order to reduce the amount of hazardous waste being produced on campus, and they are continually looking for ways to reduce this amount even further. Macalester has not pioneered any breakthroughs in the reduction of hazardous waste, but the college has adopted the best practices from other schools; Macalester is certainly among the frontrunners when it comes to chemical use and hazardous waste management. It is for Macalester's successes in reducing chemical use and hazardous waste, and also its continuing efforts to make further reductions, that Macalester College receives a top rating for its chemical use and hazardous waste management practices.

Sources

Campus Ecology

Ecodemia

Dr. Ron Brisbois, Chemistry

Terry Gorman, Facilities Management

Mark Holte, Art

Darlane Kroening, Chemistry

Dr. Keith Kuwata, Chemistry

Christian Nelson, CIT

David Sisk, CIT

Dr. Tom Varberg, Chemistry

Dr. Wayne Wolsey, Chemistry