Sustainability Task Force
Green Chemistry
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Mission Statement

This project will investigate current trends in the concept of green chemistry. Green Chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. Sustainability parameters that will be studied include:

- Tracking of incoming and outgoing sources of chemicals, specifically the hazardous chemical waste that will endanger the environment.
- Research the most inefficient procedures in research and teaching laboratories.
- Encourage "green" habits in laboratories to improve energy efficiency and reduce waste and carbon emissions.
- Provide accessible resources for people to investigate ways of creating their own "green" procedures.

The results will present valuable recommendations that the University can implement to develop and maintain a more sustainable environment in the future.

Chemical Management System

Indicator: There is little or no organization in the labs for use and recycling of chemicals today. If a researcher needs a chemical, they must order a new one. Also, there was a chemical storeroom for chemicals that were still good but used, however many people didn't use it because they could not find what they were looking for. Having a chemical inventory is rapidly becoming a necessity for campuses in the United States. Currently six out of the eleven Big Ten schools have a Chemical Inventory System (3). After conversations with other schools, ChemTracker seems to be favored among these schools and the only negative seems to be the long time to get the system up and running (3). Furthermore, all but one of the schools without Chemical Inventory Systems is interested in testing and finding a good working management system (3).

Baseline sustainability: With Indiana University producing over 100,000 pounds of hazardous waste a year, some of this waste comes from old and unused chemicals. These unused chemicals are found in labs throughout the campus and can be eliminated by allowing other labs on campus access to these chemicals. The system would allow for a campus wide chemical search database, where any scientist can find any chemical they need so that they will not need to purchase a new bottle. This will reduce incoming as well as outgoing chemicals and waste.

Cost: The cost for the Chemical Management System range from $22,000-150,000. Below are several systems and the various costs associated with each system. To lower the implementation cost, work-study students could be used.

System	Individual Costs	Total Cost
SciQuest-Chemical Manager	$48,000 Annual Fee, 734-1700 Barcode Software, $40,000-70,000 Professional Services	$119,700
ChemTracker	$20,000 Annual Fee, $2,000 campus site implementation	$22,000
"CISPro" Global Web for Oracle	$50,000 Annual Fee, $10,000 Tech Support, $8,000 Training/Implementation, $3,730 Barcode Hardware	$71,730
ChIM	$28,000 Annual Fee, $5,600 User license, $2,300 Barcode Hardware, $1,500 Training/Implementation	$37,400
EnvironMax	$28,000 Annual Fee, Hourly data migration, Hourly interfaces, $1,000 training, $5,600 maintenance	$34,600+

Plan: Finding the right system for IU. Whether it is using a developed system, such as Stanford's ChemTracker software or creating its own. Most of these systems work through a web browser and can be accessed over the internet

Long Term Goal: Have an operational Chemical Management System within two to three years. After the initial planning, there will need to be time and people to catalog and inventory all of the chemicals on campus.

Green Chemistry Labs

Indicator: Green chemistry is rapidly spreading throughout chemical industry. With the quick interest, it is necessary to provide students with as much information and experience as possible to help prepare them for industry. The University of Oregon has completely implemented Green Organic Chemistry Laboratories on their campus. The alteration of their chemical outlook has led to savings in many aspects, including waste, energy and money.

Baseline sustainability: This process will increase sustainability because it will reduce the hazardous waste, decrease the amount of energy needed to run fume hoods and ultimately decrease the amount of money needed to perform the chemical reactions in laboratories on campus. The alternative processes outlined in the Organic Teaching Laboratories used by the University of Oregon, reduces the amount of hazardous waste produced the by laboratories, thus reducing the amount of money and environmental impact of these laboratories. Since these methods use less harmful chemicals, many of the laboratory procedures can be performed on an open table top, as opposed to a chemical fume hood. Fume hoods are a major reason that laboratories use massive amounts of energy because the hoods constantly blow heated air out in the winter and cooled air out in the summer. Thus reducing the fume hood usage would reduce the amount of energy needed by each laboratory and minimize the carbon impact of the university as well as the amount of money spent on the electric bill.

Cost: There is an average of 21 fume hoods in each of the teaching organic laboratories. Estimating that each lab takes 5 hours a day, each fume hood costs $1,000 a year. For one lab, it cost $21,000 in fume hood operation. Working with green chemicals, the fume hoods do not need to be turned on, so this would save the university over $20,000 (12).

Plan: Beginning with existing Green Organic Chemistry Laboratory Manuals, Indiana can begin to impress the ideas of green chemistry in laboratories to complement the concepts presented in the classroom. If this chemistry begins to have a lasting effect, Indiana can develop a green chemistry course in order to attract the many environmentally conscious science students.

Long Term Goal: Implementation of a green chemistry curriculum at Indiana, where courses from undergraduate to graduate sections are taught in order to increase Indiana's range of world relevant learning.

Encouraging Development of Green Research Labs

Indicator: The Presidential Green Chemistry Challenge Awards are presented to Universities and corporations for making significant advances in Green Chemistry. In 2007, two universities (Texas and Oregon State) were awarded with this honor. Green Research has also become a political issue with many new grants and funds from government programs being created. In 2007, 125 million dollars over the next five years will be given to the University of Wisconsin by the Department of Energy in order to investigate alternate processes to creating biofuels. There is also The Green Chemistry Research & Development Act of 2007 being presented to the House of Representatives that would give $50 million worth of funding and grants out in 2008 (1).

Baseline Sustainability: Green Research laboratories will help open Indiana to a new group of environmentally conscious students and faculty. Providing research opportunities will lead to newly sustainable practices outside as well as inside the campus. Similar to Wisconsin (mentioned above), Indiana can provide important research into creating a more sustainable type of fuel, for example, because fossil fuels are coming rapidly scarce. Increasing these researchers on campus will also help to spread the word around campus about sustainability. Many people are not aware of their impact on the environment, but with new research opportunities becoming available, many more people will be able to see and help change the view of people on campus.

Plan/Goal: After the implementation of green teaching laboratories, finding a researcher willing to teach a course as well as do research on campus should not be far behind.

Encouragement of Green Ideas in Current Research Labs

Indicator: Harvard University did a survey on the usage of fume hoods on campus. They found that many of the fume hoods in the laboratories on campus were rarely closed and wasted much energy and money by the added air loss. Variable Air Velocity (VAV) fume hoods decrease the amount of air flow through the opening of the hood based on the height of the sash that is open. Most of the fume hoods on Harvard as well as Indiana campuses use the VAV system. Harvard started a competition around campus, where periodic checks of

fume hood levels in each lab were taken. The results were averaged and each laboratory was given a score. At the end of the year, the laboratory floor with the lowest average fume hood height was rewarded. Before the competition, the average fume hood height on the Harvard campus was 12 inches and after was only 2 inches (2). This change in the sash height saved Harvard an estimated $100,000 in energy and over 1 million pounds of greenhouse gas emissions (2).

Similar to the fume hoods on the Harvard campus, Indiana can do its part by increasing the awareness of its staff and students on their environmental impact. Whether it is posters hanging in the halls or an annual competition, encouraging less hazardous and smarter laboratory thinking will increase the sustainability of the Indiana campus.

Baseline sustainability: Encouraging the increased awareness of students/professors impact on the environment will likely cause Indiana to use less energy and decrease the amount of hazardous waste it produces. Decreasing energy means a decrease in amount of carbon used by the Indiana, lowering the carbon dioxide emitted into the air.

Plan: Taking Harvard's lead, Indiana can begin a campus wide competition for fume hood height. Hopefully IU can see the kind of encouraging results just as Harvard has. Also, placing posters about basic ideas of making any laboratory more sustainable, such as using less water, alternative lighting, or substitution of greener cleaning supplies will take information to the people, instead of making the people find the information.

Long Term Goal: Create semester long concepts/competitions that can be monitored in order to increase awareness of Green Practices in any laboratory. These competitions can start with something as easily monitored as fume hood height just to encourage the thinking of more sustainable practices in the laboratory. Other competition ideas can encourage the labs to come up with their own way of creating sustainability in the laboratory or inviting people to describe why their lab is the most sustainable on campus, with the most beneficial idea getting rewarded at the end of the semester. The ideas for laboratory sustainability are endless because there are constantly new ideas being formed about laboratory sustainability.

Green Cleaning By Institution

Indicator: Many cleaners and products used here at Indiana University have not been environmentally tested, even though they contain hazardous chemicals such as Phosphoric acid, Isobutane, 2-butoxyethanol, sodium xylene sulfide, and alcohol ethoxylates.

Common Cleaners Used at Indiana University Bloomington

Cleaner	Uses	Hazards
Crew	Tub and tile cleaner, Phosphoric acid cleaner for soap scum, mold, mildew, and hard water	Contains Phosphoric Acid (LD50 of 1530 mg/kg), Alcohol Ethoxylates
Glance	Multi-surface cleaner for mirrors, sinks, glass, and countertops	Contains Isobutane, 2-Butoxyethanol (LD50 470 mg/kg)
Emerel	Cream cleaner, removes stubborn spots and build up, scuffs, grease-porcelain ceramic, stainless steel and fiberglass	Quartz (LD50= 500 mg/kg), Dodecylbenzene sulfonic acid (LD50=500 mg/kg)
Forward DC	Disinfectant that deodorizes and kills germs	N-alkyl dimethyl Benzyl Ammonium Chloride (LD50=426 mg/kg), Sodium Hydroxide (140 mg/kg)
Stride	Neutral cleaner for floor cleaning	Sodium Xylene Sulfonate, Alcohol Ethoxylates
Good Sense	Air freshener	Alcohol Ethoxylates
Endbac	Disinfectant for mold and mildew, kills staph, strep, athletes foot fungus	N-alkyl dimethyl Benzyl Ammonium Chloride (LD50=426 mg/kg),
Snapback	Floor restorer	Dipropylene glycol methyl ether (LD50=5.4 ml/kg), diethylene glycol monoethyl ether (5.5 ml/kg)
Technique fortify	Floor cleaner	Diethylene glycol monoethyl ether (LD50=1920 mg/kg)
Bravo	Floor stripper	Sodium Hydroxide (LD50= 140 mg/kg), Monoehanolamine (LD50=1720 mg/kg)
Signature	Floor finishes	Dipropylene glycol methyl ether (LD50=5.4 ml/kg), diethylene glycol monoethyl ether (5.5 mL/kg)

* None of these cleaners had MSDS sheets that provided ecological information about environmental health hazards.

Environmental Hazards for Common Cleaning Chemicals

Chemical	Environmental Hazards
Phosphoric Acid	If released in the water, causes hazard to marine life
Alcohol Ethoxylates	Acute/chronic toxicity to aquatic organisms
Isobutane	No ecological effects
2-Butoxyethanol	Will leach into groundwater, toxic to aquatic life
Sodium Xylene Sulfonate	Hazard to aquatic life

Baseline sustainability: Changing these untested chemicals with ecologically friendly cleaners made that are made from natural sources so they are biodegradable.

Plan: Implement safer, less hazardous chemicals into cleaning of one building for a semester. This is to test out if the monetary sacrifice is worth the environmental benefit. After this semester, evaluating the cleanliness of the building as well as feedback from the custodial workers will tell if there are any unseen benefits to using green chemical cleaners. This semester will give a good indication on the future of green cleaners at IUB.

Long Term Goal: Switching most of the basic cleaners used on the IUB campus to eco-friendly cleaners. This will eliminate waste and fumes emitted from the hazardous cleaners.

References:

(1) Presidential Honors, Green Chemistry Challenge Awards, *Chemical and Engineering News,* 85(27), July 2, 2007, pp 6-21.

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(3) Summary of Chemical Inventory Systems, 9/14/06, Chris Kohler, personal communication.

(4) University of Illinois, Chemical Fact Sheets, http://www.ehs.uiuc.edu/factsheets/index.aspx

(5) Sustainability in the Organic Chemistry Lab Course; http://www.oc-praktikum.de/?lang=en

(6) Campus Pollution Prevention and Waste Minimization Guidelines; http://www.des.umd.edu/hw/min/guide.html#surplus

(7) Green Chemistry Network; http://www.chemsoc.org/networks/gcn/

(8) Green Chemistry Resource Exchange; http://www.greenchemex.org/about?PHPSESSID=7015c345d83f69f42e4bdac9999adbc0

(9) Greener Education Materials for Chemists; http://greenchem.uoregon.edu/gems.html

(10) Green Cleaner Buying Guide; http://www.greenerchoices.org/products.cfm?product=greencleaning&page=RightChoices

(11) "Greener" Alternative Wizard; http://web.mit.edu/environment/academic/wizard/greenChemWiz5.html

(12) Lab21 Fume Hood Calculator; http://hightech.lbl.gov/fh-calc.html

(13) Energystar Light bulb Calculator; http://www.getenergysmart.org/Files/Light%20Bulb%20Calculator.htm

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(15) Johnson Diversity Incorporated Material Safety Data Sheets; http://msds.johnsondiversey.com/viewer/wvnam.asp