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Utilizing Service Learning in the Analytical Chemistry Classroom

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Abstract

Service learning has been incorporated into the Analytical Chemistry Laboratory to give students a real world sampling experience including both soil and water, alongside professionals in their fields. Analysis of the soil and water includes metals, suspended solids, phosphorus and nitrogen containing compounds requiring knowledge of several different instrumental and wet chemical techniques. Most educational experiences do not afford students the chance to see the real world applications of their classroom knowledge, but with the service learning aspects this deficiency has been resolved. In the soil experience, students provide homeowners from the Highland Park and South Wedge neighbors with lead analysis of their soil as well as written reports of those levels and information on removing or working with lead contaminated soil. For the water project, students are providing baseline analysis of nutrients and metals found in Buckland Creek for the Department of Environmental Services, Division of Pure Waters, which studies the effects of industrial expansion and human activity on water quality in Rochester. The analytical chemistry students further their experience in an advanced analytical chemistry course the following year by performing further analysis on the soil and water, but on a more independent level. They use their previous learned skills to gather water after rainfall and perform analysis back in the laboratory with no structured guidance. The class is also expanding to include a plant biology section, where students will test the affects on growth and safety of plants grown in leaded soil. This experiment will allow students to provide proof to homeowners as to which plants are healthy to eat and which can be used for phytoremediation. In addition to feeling like active contributors to the community, the students and homeowners have been interviewed and photographed for an article detailing lead contamination issues.

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ABSTRACT

Service learning has been incorporated into the Analytical Chemistry Laboratory to give students a real world sampling experience including both soil and water, alongside professionals in their fields. Analysis of the soil and water includes metals, suspended solids, phosphorus and nitrogen containing compounds requiring knowledge of several different instrumental and wet chemical techniques. Most educational experiences do not afford students the chance to see the real world applications of their classroom knowledge, but with the service learning aspects this deficiency has been resolved. In the soil experience, students provide homeowners from the Highland Park and South Wedge neighbors with lead analysis of their soil as well as written reports of those levels and information on removing or working with lead contaminated soil. For the water project, students are providing baseline analysis of nutrients and metals found in Buckland Creek for the Department of Environmental Services, Division of Pure Waters, which studies the effects of industrial expansion and human activity on water quality in Rochester. The analytical chemistry students further their experience in an advanced analytical chemistry course the following year by performing further analysis on the soil and water, but on a more independent level. They use their previous learned skills to gather water after rainfall and perform analysis back in the laboratory with no structured guidance. The class is also expanding to include a plant biology section, where students will test the affects on growth and safety of plants grown in leaded soil. This experiment will allow students to provide proof to homeowners as to which plants are healthy to eat and which can be used for phytoremediation. In addition to feeling like active contributors to the community, the students and homeowners have been interviewed and photographed for an article detailing lead contamination issues.

INTRODUCTION

Service learning in the classroom involves students interacting with and aiding the community as part of their educational experience. Three analytical chemistry classes (36 students total) have been involved in two service learning projects during the 2008-09 and 2009-10 academic years. Students had the option of participating in the service learning portions of class with alternative options available to anyone not comfortable with the premise. However, none of the students chose to opt out of the experiments.

Lead poisoning is a serious health issue caused by exposure to excessive amounts of lead. Young children are highly susceptible to lead poisoning because they are prone to hand to mouth behavior. Their bodies are also more prone to harm by lead because they absorb lead more readily and their systems are undergoing development. Affected children display lower IQ's, behavior issues and slow development, while adults display conditions such as sterility and elevated blood pressure. Soil surrounding older homes, especially homes in Rochester, NY, tends to be saturated with lead from peeling house paint and leaded gasoline use. Inner city and poorer neighborhoods have higher incidences of lead contamination because of lack of up keep on homes and the use of cheap leaded paint available in the 1970's.

The soil project was carried out in three phases.
Part 1: sample collection from client homes and analysis of lead extracted from the collected soil. (Students made contact with homeowners and collected soil from bare soil and garden areas)
Part 2: Vegetable planting in lead containing soil. The resulting plants were subjected to the same extraction procedures as the soil analysis. This part of the project was carried out with aid from the St. John Fisher biology department.
Part 3: Growth of plants in homeowners lead contaminated soil. Students at this step will collect sufficient soil for planting, care for the plants through their development and perform extraction of lead from both the soil and resulting plants. Upon project completion, students prepare formal reports to inform homeowners of their findings.

Growth and Development has led to pollution of waterways in industrial locations around Rochester. Nitrogen containing compounds and metal contaminants can harm plants and animals residing in these waterways as well as finding their way into drinking water. The Department of Environmental Services, Pure Waters Division in Rochester was established to gauge baseline water contaminant levels surrounding areas with new construction. The water project was completed in two parts. Part 1 involved sampling training for the students and collection of water from creek sources. Collection occurred prior to and just after (about an hour) rain events. Part 2 involved analysis and reporting of results to the Department of Environmental Services. Students compared instrumental and wet chemical techniques for time, financial considerations and accuracy. In some cases experiments had to be completed within the hour of collection or treated immediately for storage. Thus the project required a lot of out of class time from the students, but all agreed the experience was worth the effort.

RESULTS & DISCUSSION

Soil Analysis

Samples were taken from bare soil in four different locations surrounding each house. Plastic shovels were used to avoid any metal contamination and samples were stored in Ziploc plastic bags. Lead extraction was completed using EPA method 3050B, which is an acid digestion with reflux condensation. Detection of lead was completed utilizing a Buck Scientific Atomic Absorption Spectrometer.

Neighborhood/House #	Front- near Lead conc. (ppm)	Front - far Lead conc. (ppm)	Back - near Lead conc. (ppm)	Back - far Lead conc. (ppm)
Clara Barton 1[a]	8.3×10^3	6.3×10^2	2.2×10^3	1.7×10^3
Clara Barton 4[b]	4.2×10^3	8.4×10^2	7.6×10^2	9.1×10^2
Clara Barton 5[b]	4.4×10^3	5.5×10^2	1.3×10^3	1.1×10^3
Clara Barton 7[b]	6.3×10^2	4.2×10^2	1.9×10^3	6.2×10^2
Highland Park 1[a]	7.6×10^3	2.2×10^2	2.5×10^3	1.8×10^3
Highland Park 1[b]	8.5×10^3	4.0×10^2	2.9×10^3	2.7×10^3
Highland Park 2[b]	7.6×10^2	2.3×10^2	1.9×10^4*	Not detected
Highland Park 3[b]	3.8×10^3	1.1×10^3	1.4×10^3	3.9×10^3
Highland Park 6[b]	2.2×10^3	1.5×10^2	4.8×10^3	4.1×10^2
Highland Park 4[b]	Front-far	Front-near	Back-near	Garden
	8.7×10^2	3.2×10^3	1.4×10^3	3.6×10^3
Highland Park 5[b]	Front-near	Side of House-near	Back-near	Back-far
	7.0×10^2	4.4×10^3	4.2×10^2	6.0×10^2
Highland Park 7[b]	Front-garden	Back-garden	Back-near	Back-far
	8.3×10^2	1.9×10^2	1.2×10^3	3.7×10^2

[a]beaker reflux; [b]condenser reflux; *-average value

Selected soil results from two neighborhoods completed by two analytical chemistry laboratory sections.

Results show that 23 locations had lead levels higher than the EPA accepted limit of 1200 ppm for soil and 42 exceeded the children's play area limit of 400 ppm. Students reported soil levels to individual homeowners along with suggestions on removal of lead from their yards. Suggestions for removing lead involved lowering soil pH

Plant Analysis

To further aid homeowners and student learning, phytoremediation studies were completed. In the spring of 2009, students planted mustards, collards, peppers, tomatoes, beans, and cucumbers and watered with either 1000 ppm lead nitrate or plain tap water. Upon fruiting, samples were taken and subjected to extraction and analysis using EPA method 3050B.

Date	Sample	Concentration Bean Spiked	Concentration Soil Spiked	Concentration Bean Control	Concentration Soil Control	R^2
7/27/09	Bush Blue Lake Beans	2×10^3 ppm	------	Not detected	-----	0.987
8/17/09	Bush Blue Lake Beans	Not detected	6×10^3 ppm	Not detected	Not detected	0.9882
10/9/09	California Wonder PS Peppers	Not Detected*	1.166×10^4 ppm* (1.320×10^4, 1.012×10^4)	Not Detected*	Not Detected*	0.982
10/23/09	Southern Giant Curled Mustard	Not Detected*	9.487×10^3 ppm* (1.247×10^4, 6.505×10^3)	Not Detected*	Not Detected*	0.982
11/1/09	Scarlet Nantes Carrots	Not Detected*	8.173×10^3 ppm* (5.295×10^3, 1.105×10^4)	------	------	0.982
11/1/09	Danvers Carrots	------	------	Not Detected*	Not Detected*	0.982

Selected plant results subjected to watering with 1000 ppm lead nitrate or plain tap water. The edible portion of each plant was sampled.

Plants grown in the presence of lead demonstrated no difference in appearance or growth rate. The edible portions of the plants selected showed little accumulation of lead and thus are safe to consume when properly washed. However, the plants chosen were meant to hyper accumulate lead thus future studies must be performed. At this time, the entire plant is being sliced and extracted to determine if and where the lead may be accumulating in the plant. If lead is accumulating in the stems and leaves, but not the fruits phytoremediation may serve to provide both a food source and a lead removal technique.

Water Analysis

Students collected water from four sites along Buckland Creek in Brighton, NY before and after rainfall events. Water was collected several times from each location over the course of the fall semester. Each student was responsible for one analysis including phosphorus, nitrogen/nitrate content, lead, zinc and copper.
Students found no detectable levels of metals in the four creek locations before or after rain events. Both phosphorus and nitrogen/nitrate content were at detectable levels but far below EPA limits. Studies demonstrated higher levels of phosphorus and nitrogen containing compounds after rainfall events, which supported run-off contamination hypotheses. Studies after snow events are currently being completed to determine winters affect on water quality.

CONCLUSIONS

Written reports given to homeowners outlined any lead soil issues for the four different areas around their homes. St. John Fisher College has received many more requests from different neighborhoods that want to take part in future studies after learning of the success of the first trial. One such neighborhood has already signed on for studies during the spring and fall of 2010. Two classes will be involved in the study, which will allow for duplicate analyses of each location.
Phytoremediation studies will be continued in the analytical chemistry class starting in fall 2010. Students will plant beans, collards, mustards and peppers (the best growers) in soil from home locations with high lead values determined in the spring 2010 class. By utilizing soil directly from the homeowners the students will be able to give more definitive feedback on the phytoremediation process.
The facilitators of the water project utilized the students data in their water reports on Buckland Creek. They have expressed an interest in continuing the service learning project with different areas of the creek being studied along with the addition of new waterways.
The student feedback on the project was incredibly positive with the students expressing a desire to add projects along this line. Comments included that they finally felt like their time in the laboratory was meaningful beyond academics. Secondly, the students were excited by the career prospects that they did not know existed. Feedback from the Department of Environmental Services and individual homeowners was also excellent and both remarked on the professionalism of the students and their reports.
Service learning has proven to be an effective tool for engaging students in chemistry laboratory classes. Analytical chemistry is well suited for this integration and we will continue to research projects that offer similar experiences.

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