Characterizing Water Quality in Students' Own Community W

An Effective Campus Field Trip

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This experiment has been developed to help first-year college students who are preparing to become high school teachers to learn that science is interesting and has direct applications in their lives. We aim to achieve these five main goals when performing the surface water quality studies:

1. Train the students in analysis of water quality and instruct them to utilize chemistry equipment and test factors of pH, phosphates, nitrates, conductivity, dissolved oxygen and turbidity *(1–6)*.
2. Teach each student problem solving strategies. Students will learn with research that there is never one correct answer; all parameters must be analyzed.
3. Students will learn how to communicate their research findings to the classroom by providing a presentation of their experimental analysis.
4. Determine and examine effects of urbanization on water quality; allow students to address environmental issues *(7–8)*.
5. Assess student's content gain with pre- and post-tests given in the laboratory classroom.

The effects of urbanization on water quality present a complex and valid, relevant issue that calls for collaborative and thoughtful analysis by students. They decide the test location, sample size, and an appropriate testing schedule, as well as identifying the relevant aspects of, and making inferences about, their experimental data.

Water quality is intrinsically linked to the abundance and value of Ohio's resources, which in turn affects the health and prosperity of the local population. The ability to understand what clean water consists of and how to maintain that level of quality is critical for not only drinking water, but for the state's industries. Comprehending environmental effects on water quality also reveals the need to conserve and restore the integrity of water sources.

An innovative hands-on lab experience will challenge and actively engage students in learning about the natural world and their local environment. Characterizing the quality of the water in their own community will encourage students to internalize their lab experience, in comparison with abstracted cookbook laboratory experiments typically used in first-year chemistry courses. This effective, modified lab with

Table 1. Averaged Class Data for Water Sample Characteristics, Tipp City Urban Area, Great Miami River

Date Sample Obtained [a]	pH	Temperature/ °C	Conductivity/ μS cm^{-1}	Dissolved Oxygen (ppm)	Nitrates (ppm)	Phosphates (ppm)	Turbidity/ JTU [b]
26 Jan	8.32	2.9	77	13.3	6.2	0.36	11
09 Feb	8.23	4.3	81	12.0	7.7	0.26	12
26 Feb	8.04	5.2	76	11.0	8.7	0.31	11
23 Mar	7.98	9.0	922	7.58	9.4	0.00	8
06 Apr	8.17	7.1	598	10.9	34	0.050	3
14 Apr	8.21	15.6	1003	10.8	31	0.056	11
19 Apr	7.87	11.0	958	9.45	31	0.064	8
27 Apr	8.14	8.6	991	10.3	31	0.077	7
03 May	8.20	11.1	975	9.57	29	0.12	4
10 May	8.05	16.8	796	11.5	24	0.10	11
18 May	8.10	14.3	830	9.76	31	0.14	3
31 May	7.97	15.3	725	9.33	20	0.075	8
14 Jun	8.09	18.1	569	8.75	31	1.9	24
30 Jun	8.12	17.5	962	10.5	27	0.084	1

[a] Data were collected in 2005. [b] Jackson turbidity units.

a campus field trip for a first-year chemistry course increases student interest, independence, and critical thinking skills.

Lab Summary

Ten weeks are allotted for this environmental water quality analysis lab experiment. Students spend the first week learning how to use the test kit and selecting a focus area (e.g., one of the ten counties that drains into the Upper Great Miami River in Ohio). Students are required to pick a place where several sites may be investigated. These locations should be a region of recent urbanization, and an area removed from urbanization. Results for the example provided in this paper (and displayed in Table 1) are from sampling in the Great Miami River in Tipp City, an area of recent urbanization. The results from sampling in Wolf Creek in Clayton City—an area removed from urbanization—are illustrated in Table 2. We recommend that each lab class share data among all sections to compare sampling times and locations. In the last lab period of the course, students exhibit their water analysis results using presentation software (PowerPoint 2003; Microsoft Corp.), providing their conclusions and discussing any complications surrounding their area of experimentation.

Experimental Procedure

A low-cost, estuary and marine test kit is ideal for students to perform these water quality tests: we used test kits available from LaMotte Company *(9)*. The Chloride TesTab contains silver nitrate, the Nitrate #2 CTA TesTab contains zinc, the Phosphorus TesTab contains ammonium molybdate, and the Dissolved Oxygen TesTab contains 2,4 diamino-phenol dihydrochloride *(9)*. A thermometer is essential to correlate seasonal effects: an Enviro-Safe pocket thermometer available from Sigma-Aldrich is nonhazardous and affordable *(10)*. A Conductivity Pocket-Pal Tester was purchased from Hach (it measures from 10–1990 μS/cm) *(11)*.

Hazards

No chemicals or procedures used by students in this lab present any significant hazards; however, nothing should be ingested. Protective garments and gloves should be worn at all times. Students should wash their hands after sampling and they should be warned against drinking the water samples at *any* time before, during, or after collection and testing *(7)*.

Results

Table 3 shows evaluation criteria for rating and examining the results from the Tipp City area (Table 1). The responses to the effectiveness survey (Textbox 1) taken by students were very positive regarding the water quality experiment in the community around their university. The average ratings for each of questions 1–3 were 4.5 out of 5 points, which shows high effectiveness. A typical response to question 4 was "a field trip with the lab helped me to picture what we were learning and how the measurements relate to real-world issues

Table 2. Averaged Class Data for Water Sample Characteristics, Clayton City (Removed from Urbanization Area), North Branch of Wolf Creek, a Tributary of the Great Miami River

Date Sample Obtained [a]	pH	Temperature/ °C	Conductivity/ μS cm^{-1}	Dissolved Oxygen (ppm)	Nitrates (ppm)	Phosphates (ppm)	Turbidity/ JTU [b]
26 Jan	8.08	0.7	44	12.5	0.14	0.031	2
09 Feb	8.01	7.1	51	12.6	0.22	0.33	3
26 Feb	7.94	7.6	44	12.0	0.27	0.031	1
23 Mar	8.17	11.4	626	11.1	0.33	0.073	0
06 Apr	8.37	9.2	422	13.3	1.1	0.031	0
14 Apr	8.06	15.9	733	13.5	0.32	0.063	0
19 Apr	7.77	14.5	685	11.5	1.8	0.025	0
27 Apr	8.06	12.6	674	11.4	0.81	0.036	2
03 May	8.24	12.2	630	11.5	6.7	0.045	1
10 May	8.06	17.3	496	15.7	0.98	0.028	11
18 May	8.09	14.4	472	9.8	1.2	0.026	4
31 May	7.85	15.4	484	8.82	0	0.056	3
14 Jun	7.92	19.8	373	8.43	0	0.11	11
30 Jun	8.09	19.8	682	15.0	0	0.052	1

[a] Data were collected in 2005. [b] Jackson turbidity units.

of concern in the environment". Also, an overwhelming response to question 5 was "I enjoyed the water quality testing and field experiences in the chemistry course". Students' replies to question 6 show that the students prefer experiments to be in a problem-based setting instead of a standardized procedure for lab. An overall 90% approval rate indicates a positive reaction towards the water testing field experience.

Through analysis of the water quality, a real-world study of interest is carried out with the focus on how safe the water is in the surrounding area. Students should make a correlation between water quality and urban watershed. The students will enjoy learning through a hands-on application of concepts presented in their undergraduate first-year chemistry course.

In this lab students learn essential concepts, including how dissolved oxygen, turbidity, temperature, pH, and nitrate and phosphate levels affect water quality. Dissolved oxygen is one of the single most important factors affecting the quality of an aquatic ecosystem. Concentration of dissolved oxygen depends upon nitrate levels, turbidity, and temperature. Turbidity—clarity of water—has an effect on the production of oxygen in the water. Temperature not only affects the solubility of dissolved gases, such as oxygen, it also determines the photosynthetic rate of plants. The abundance of calcium, carbonate, phosphate, and nitrate ions in the water directly establishes the conductivity rating. An ecosystem's survival is dependent upon its maintaining a specific pH range *(6)*.

Table 1 and Table 2 illustrate the differences in the level of nitrates and phosphates in the rural area compared to the urban area. For this project the students' hypothesis was that the chemical levels would be lower in the undeveloped rural area (Clayton City) compared to the urban area (Tipp City). Table 1 shows an average nitrate level of 23 ppm and an average phosphate level of 0.26 ppm compared to the less urbanized area. Table 2 area with an average nitrate value of 0.99 ppm and an average phosphate level of 0.067 ppm. The

Table 3. Distribution of Parameters for Evaluating Experimental Data

Test Factor	Results	Rankings[a]	Score from Ranking[a,b]
Temp. Change / °C	0–2	4	4
	3–5	3	
	6–10	2	
	10	1	
pH	4–5	1	3
	6	3	
	7	4	
	8	3	
	9–10	1	
DOx[c] Saturation (%)	91–110	4	4
	71–90	3	
	51–70	2	
	< 50	1	
Nitrate / (mg/L)	5	2	1
	20	1	
	40	1	
Phosphate / (mg/L)	1	4	4
	2	3	
	4	2	
Turbidity / JTU[d]	0	4	2
	0–40	3	
	40–100	2	
	> 100	1	

[a]4 = Excellent, 3 = Good, 2 = Fair, 1 = Poor.
[b]4 = Excellent, 3 = Good, 2 = Fair, 1 = Poor; Ranking for area tested in Table 1 (Tipp City urban area on the Great Miami River).
[c]Dissolved oxygen.
[d]Jackson turbidity units.

Textbox 1. Effectiveness Survey

1. How effective was the field trip for the purpose of the chemistry course?
   5 = Very Effective
   4 = Effective
   3 = Somewhat Effective
   2 = Ineffective
   1 = Very Ineffective
2. How effectively did the field trip help integrate interdisciplinary teaching concepts of chemistry with biology and geology?
   5 = Very Effective
   4 = Effective
   3 = Somewhat Effective
   2 = Ineffective
   1 = Very Ineffective
3. To what extent did the chemistry course provide you with inquiry-based learning/problem-based structure?
   5 = Very Effective
   4 = Effective
   3 = Somewhat Effective
   2 = Ineffective
   1 = Very Ineffective
4. Overall, what is your preference to learning chemistry: a field trip with lab or only a lab with no field trip?
5. What did you like about the chemistry course?
6. What would you change in the chemistry course?

data collected support the students' hypothesis. As expected during warmer weather, nitrate and phosphate levels increased; increased concentration of nitrates and phosphates indicates more ions are in solution. The conductivity also increased, as exhibited in Table 1 and Table 2.

These water quality impact studies allow students to correlate geologic conditions and chemistry: for example, understanding the effects of a stream's water chemistry if the calcium carbonate streambed is dissolving into the water. First-year students have the chance to conduct field experiments and derive chemical concepts from exploring the natural environment *(4–6, 8)*. Students compile the data and then share it with each lab class as a whole using presentation software. Tables 1 and 2 report the averaged data and results. Finally, students take the overall effectiveness survey (Textbox 1). The pre- and post-test gave results of 0.75 content gain (pre-test 20/100 points versus post-test 80/100 points). This outcome has encouraged our faculty to consider further development of environmental problem-based labs for our chemistry and geology courses.

[W]Supplemental Material

Instructions for the students and notes for the instructor are available in this issue of *JCE Online*.

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