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INSTRUCTIONAL USE OF A PHYSICAL MODEL TO EXPLAIN QUANTITIATIVE AIR DISPERSION MODELING

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1. INTRODUCTION

Learning the concepts of atmospheric dispersion modeling for the first time can be quite a challenge. Even if the qualitative portions of the topic are not difficult to grasp, the quantitative, formulaic parts can be rather intimidating to students. Use of pedagogic tools, such as physical models, can reap terrific benefits in the form of accelerated student learning. Furthermore, instruction that combines physical models and computer models with basic theory can help students gain a deep and lasting understanding of complicated real world phenomena such as air pollution dispersion.

2. THE PHYSICAL MODELS

The construction of simple life-size and bench-scale artificial smokestacks has contributed to student learning of the fundamentals of atmospheric dispersion modeling. Specifically, two pieces of demonstration equipment were constructed. The first device, designed for outdoor use, is a 13-foot tall representative life-size stack with a 4-inch inner diameter. A small sampling port is positioned part way up the stack. A perforated cup at the base of the stack stores "contaminants" that travel up the stack via air supplied by a two-speed blower.

The second piece of equipment is a table-top unit that performs all the same simulation as its taller counterpart, except the miniature version has additional features for successful indoor use, including a stack-top fan to mimic the wind.

See Figures 1 through 3.

3. EQUIPMENT OPERATION

To simulate air contaminants, both models are stocked with "particulate matter" in the form of standard paper hole punches. Hundreds of these particles are loaded into the base of the stack where the blower ejects them through to the ambient air. The wind disperses the particles that eventually settle in high concentrations not far from the stack base. A cubic-meter framework is then used to identify the area on the ground where the highest concentrations of particles are found. From this activity, the concept of mass per unit volume (e.g., grams per cubic meter) can be readily demonstrated

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4. CLASSROOM APPLICATION

Classroom use of the stacks has engaged students in active learning of the basic concepts of atmospheric dispersion modeling. The instructor helps students examine the coupling of these physical models with the fundamental equations of air-dispersion modeling and computer models to assist student comprehension of dispersion theory.

The demonstration of the physical models are linked to their simulation of real world air pollution dispersion and the corresponding basic relational formula: **C = Q S / U**. C represents concentration (g/m^3), Q is emission rate (g/s), S is stability (m^{-2}), and U is wind speed (m/s).

Discussion then advances to the link of the physical models to the Gaussian plume equation: $\mathbf{X = (q\ /\ (\pi\ u\ \sigma_y\ \sigma_z))\ exp\ (-0.5\ H^2/\sigma_z^2)}$, where X represents concentration (g/m^3), q is emission rate (g/s), π equals 3.1416, u is wind speed (m/s), σ_y is the lateral plume spread (m), σ_z is the vertical plume spread (m), and H is the effective stack height (m).

5. ADDITIONAL INFORMATION

For additional photographs and a more complete explanation of the instructional stacks, see *Pollution Engineering* articles: "Emitting Education" (Jan. 2009) (http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=3&sid=678969d1-ca07-415b-bb33-58324ba4a9a1%40sessionmgr4002&hid=4206) and "Mini-Modeling Measurements" (Oct. 2010) (http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=4&sid=678969d1-ca07-415b-bb33-58324ba4a9a1%40sessionmgr4002&hid=4206).

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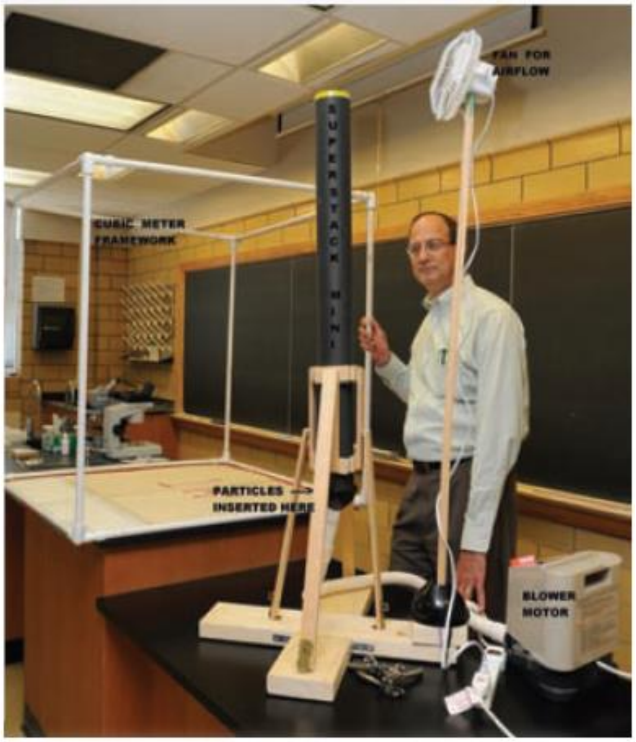

Figure 1: Assembled SuperStack Mini with the cubic meter framework in the Geneva College laboratory.

Figure 2: The SuperStack (~ 13 feet tall, 4 inches inside diameter).

Figure 3: The SuperStack with optional wind sensor near stack top and square-meter board.

Figure 1 from *Pollution Engineering* article titled "Mini-Modeling Measurements" (October 2010).

These figures show the author's own design and construction of his *SuperStack Mini* and *The SuperStack* models for instructional use.

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