PROMOTING THE FIELD OF PUBLIC HEALTH TO THE NEXT GENERATION: A UNIVERSITY AND HIGH SCHOOL COLLABORATION TO ASSESS CHILDREN EXPOSURE TO DIESEL SCHOOL BUS EMISSIONS

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ABSTRACT

Children's exposure to school bus emissions is a national issue that is locally impacting Salt Lake area schools and communities. The significance of this topic is highlighted both by recent EPA initiatives and a National Public Radio broadcast focusing on the health impacts of exposure to diesel exhaust from idling school buses. A University of Utah industrial hygiene graduate student collaborated with an Advanced Placement Environmental Science class at a local Salt Lake City high school for the performance of research on this subject. An important aspect of this study was the participation made by high school students, which inherently promotes the discipline of industrial hygiene to individuals who will soon be choosing their fields of study at institutes of higher education. This collaboration successfully provided an opportunity for high school students to learn and apply principles of industrial hygiene/public health to assess an exposure concern and empower them to make recommendations for improvement of their school environment.

INTRODUCTION

This service-learning research project is based on the timely and relevant issue of environmental exposure to school bus emissions. The idea to perform a collaborative service-learning project between the University of Utah and a Salt Lake City high school was first initiated by a University of Utah professor after reflecting on an August 2002 National Public Radio (NPR) Morning Edition broadcast focusing on the public health concerns associated with idling school buses. This collaboration was formalized by a meeting between the University of Utah's Service-Learning Program, the University of Utah's Rocky Mountain Center for Occupational and Environmental Health, and a faculty member at Salt Lake City's Highland High School. Reinforcement of the validity of this project was realized by the fact that Highland High School administrators were currently debating the issue of how to address the environmental impacts of idling school buses at their school. The intent of this project was to address this issue through the performance of air pollution and health education community service activities.

High school students in an Advanced Placement (AP) Environmental Studies class collaborated with University of Utah entities to address this relevant local concern and contribute to a wider dialogue surrounding air pollution. During the development of the new curriculum for Highland

School's AP Environmental Studies class, a primary focus was to ensure that student learning outcomes would be well aligned with the air monitoring activities. While the high school students would be taught the mechanics of airborne sampling, the ultimate goal was to help them translate the numbers, understand the findings, and relate those findings in meaningful and responsible ways to various audiences. This project emphasized and addressed the need for public education on how air quality is monitored and what monitoring results mean in terms of public health. The policy development and promotion aspect of this project allowed students the opportunity to affect change and awareness concerning an issue that they are confronted with on a daily basis.

BACKGROUND ON DIESEL EXHAUST

Diesel exhaust contains very fine particulate matter and toxic gases. More than 40 individual diesel exhaust chemicals are known carcinogens and hazardous air pollutants.[1] The EPA has classified diesel exhaust as a probable human carcinogen. Many other agencies classify diesel exhaust as a known carcinogen. Diesel particulate matter (DPM) in exhaust is of great concern since 94% of it is almost totally respirable (<2.5 um in diameter) and 92% is less than 1.0 um in diameter and can penetrate deep within human lungs.[2] Exposure to DPM can exacerbate asthma and other respiratory problems and has been associated with decreased pulmonary function, increased airway inflammation and infection susceptibility, and increased cancer risk.[3] Children are especially susceptible to harmful effects of diesel exhaust since their airways are not fully developed and they breathe 50% more air per pound of body weight than adults.[4] Currently, no safe level of children exposure to DPM exhaust has been established.[2]

METHODS AND MATERIALS

Classroom

Prior to sampling in the field, multiple classes were taught to the high school AP Environmental Science class by the University of Utah graduate student. Students received a broad education on diesel emissions and potential effects of school bus idling. The components of diesel exhaust were discussed extensively, as were the potential associated environmental and health risks. A diesel sampling lecture familiarized students with specific monitoring instruments and techniques which would be used to sample for DPM in the field. Students coordinated with the Salt Lake City School Bus Transportation Department and each other to determine sampling dates and times that worked well for all involved.

Following sampling, class sessions were held to analyze monitoring data and results. This class session enabled students to interpret findings and compare results to similar studies. Students then developed a scientific paper and poster, with the assistance of the University of Utah student, to be entered in a regional science and engineering fair.

Questionnaire

Forty air quality questionnaires were developed and distributed to high school students, administration, and community members in order to assess the awareness of exposure to school bus emissions and Salt Lake Valley air quality.

Instrumentation

TSI DustTrak 8520 Aerosol Monitor. Dustrak 8520 real-time data loggers use light scattering from particles to measure and record airborne dust concentrations. Four of these (2 $PM_{1.0}$, 2 PM_{10}) were used to monitor for DPM and PM_{10} concentrations during typical bus routes and scenarios. These were programmed to log data at 1-second intervals, and record data as 10-second averages. Each monitor was calibrated to a nominal flow rate of 1.7 lpm.

TSI Q-Trak Plus 8554 IAQ Monitor. These real-time data loggers simultaneously measure concentrations of carbon monoxide, carbon dioxide, relative humidity, and temperature. Two of these were used and programmed to log data at 1-second intervals, and record data as 10-second averages. These were each placed with the Dustraks (1 in front of bus, 1 in back of bus).

Bus Route Sampling Protocol

For three consecutive days, comparison of DPM concentrations was performed between the front of the bus versus the back of the bus. Monitoring of DPM concentrations occurred during both morning and afternoon bus routes. Two DustTraks (1 $PM_{1.0}$ and 1 PM_{10}) were placed on the seat backs in both the front and back of the bus, thus simulating the approximate breathing zones of passengers. Instruments were operated having identical start times. Every two minutes corresponding location, bus activity, and # of people were logged to determine if large peaks / valleys in data were associated with certain bus activities. Each sampling session took approximately 3 hours.

Bus Idling Protocol

A characterization of a diesel school bus idling scenario was performed using 2 DustTrak data loggers (each monitored for $PM_{1.0}$) and 2 Q-trak data loggers monitoring for carbon monoxide levels. Five separate locations were sampled for 20 minutes each: tailpipe, inside bus with door open, 5 feet back from tailpipe, 5 feet toward front of bus from tailpipe (3 ft. out – approximate curbside location), and 10 feet toward front of bus from tailpipe (3 feet out - approximate curbside location). Each sample represented the approximate breathing zones of children.

High School Student Activities

The Advanced Placement (AP) Environmental Science Class at Highland High School consisted of ten students. Each student assisted in all aspects of the research project. Each student participated in delivering the questionnaire, acquiring at least one environmental data set, and working together to generate a final report and poster for entry into the Utah Regional Science

and Engineering Fair. Students also presented the results and recommendations of the study to school administrators.

RESULTS

Results of the questionnaire are presented in Table 1 below. The majority of respondents felt that they are directly affected by Salt Lake Valley air pollution and are concerned about the associated health implications. Over 75 % of respondents complained of increased sinus problems, bronchitis, and asthma that plague them throughout the Wasatch Front inversion season (November-February).

Question	% Respondents with Correct Answer
Overall air quality in Salt Lake Valley has *improved* in past 20 years:	13%
Motor vehicles are responsible for >65% all air pollution in Salt Lake Valley:	80%
Six Criteria Air Pollutants monitored by the EPA:	Pb - 7.5% PM_{10} - 40% SO_2 - 30% CO - 47.5% O_3 - 15% NO_2 - 13%
National cases of asthma have *increased* in past 20 years:	98%

Table 1. Questionnaire Correct Response Percentages

Table 2 below shows a comparison of average DPM levels in the front versus the back of the school bus.

Date	Time of Day	Front of Bus (mg/m3)	Back of Bus (mg/m3)
3-14-03	AM	**0.019**	**0.022**
	PM	*	0.017
3-17-03	AM	0.017	0.011
	PM	**0.013**	**0.029**
3-18-03	AM	0.016	0.012
	PM	**0.014**	**0.028**
Average for All	AM & PM	**0.0158**	**0.0198**

Table 2. DPM averages from front and back of bus during routine bus rides

The average from all days: front of bus 0.0158 mg/m^3 DPM, back of bus 0.0198mg/m^3

DPM. The difference in average DPM concentrations between the front and back of the bus was 0.004 mg/m3. Monitoring results in the morning versus the afternoon bus routes revealed very little differences in DPM concentrations. It was expected to see higher DPM levels in the afternoon assuming warmer weather conditions and particulate matter accumulation over the course of the day.

The result of this study indicates that the difference between DPM exposure in the front and the back of the bus is quite small. This result may very well have been due to the fact that the rainy atmospheric conditions were likely to have suppressed the particulate concentrations of the ambient air both within the bus and outside. It should also be noted that the sample size was small. Small sample sizes typically cannot be used to characterize the overall potential exposures that school children may encounter.

Figure 1 below reveals a comparison of DPM levels in the front versus the back of a school bus during one representative afternoon bus route.

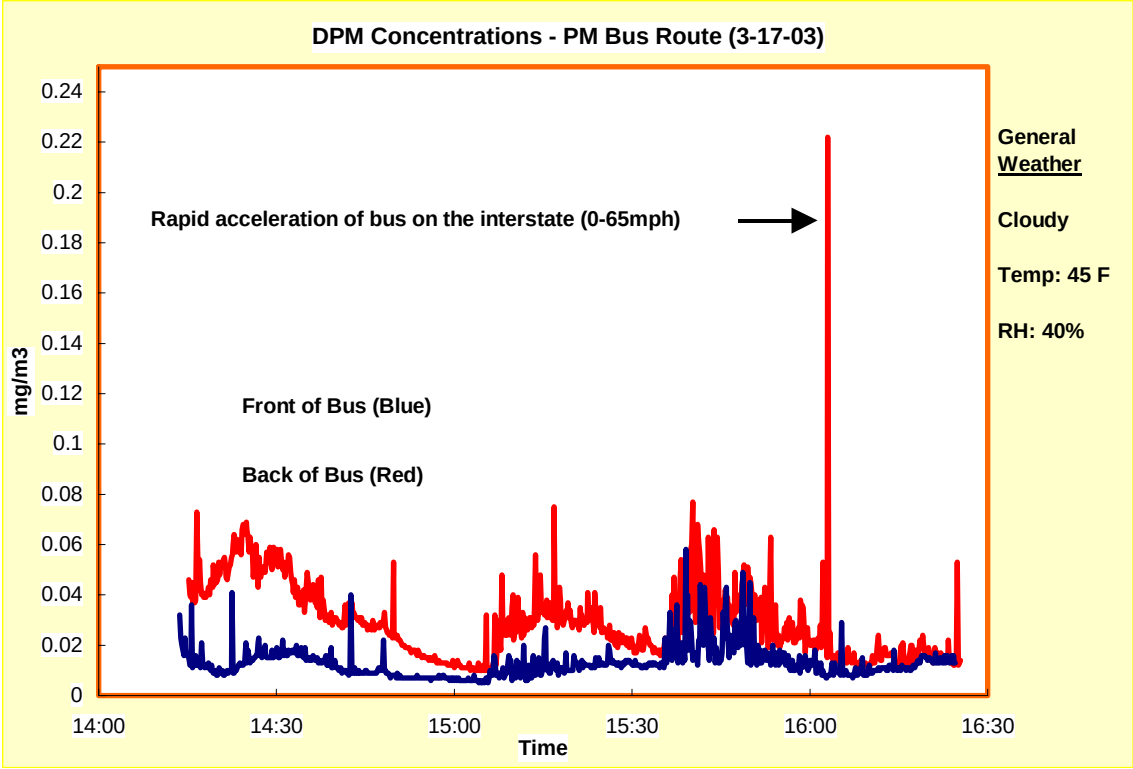

Figure 1. Comparison of DPM exposures from front versus back of bus

Table 3 provides DPM average levels during school bus idling. DPM concentrations are higher outside of the bus compared to the inside. Wind speed and direction played a large role in results obtained on the following page.

Sampling Location	Avg. CO (mg/m3)	CO min/max (mg/m3)	Avg. DPM (mg/m3)	DPM min/max (mg/m3)
tailpipe	14.2	0 / 59.4	0.256	0.006 / 1.619
inside bus – door open	0.000	0.000	0.009	0.007 / 0.015
5' back from tailpipe	0.8	0 / 6.4	0.02	0.007 / 0.436
5' toward front of bus - curb	0.7	0 / 2.3	0.037	0.007/ 0.150
10' toward front of bus - curb	1.4	0 / 3.1	0.023	0.008 / 0.066

Table 3. DPM concentrations during idling scenario – 5 sampling locations

CONCLUSION

The participation of high school students in this collaborative study appeared to be successful. Students had the opportunity to be informed about a relevant topic of interest that directly pertained to their lives. In a collaborative effort between a graduate Industrial Hygiene student and high school science students, school bus DPM emission data were collected and analyzed. Recommendations were then developed based on data interpretation and control options. Some of the recommendations that they made include: reducing the idling time in front of the school, loading/unloading buses away from school entrances and windows, and installing particle traps on older buses. One measurement of the success of this service learning study was receiving many awards in the Utah Regional Science and Engineering Fair. The students' team entry received third place overall.

This collaboration successfully provided an opportunity for high school students to learn and apply principles of industrial hygiene / public health to assess an exposure concern. It also empowered them to make scientific based recommendations for the improvement of their school environment. The significance of this type of community outreach cannot be understated, as there is little doubt that this activity promoted awareness and understanding of this important public health issue. Even more meaningful to the Department of Family and Preventive Medicine is the possibility that high school students will become interested in the field of public health.

ACKNOWLEDGEMENT

The authors of this publication were partially funded by the Department of Family and Preventive Medicine 's Health Studies Fund at the University of Utah and a training grant (#T42/CCT810426) from the Centers for Disease Control and Prevention/NIOSH. The contents are solely the responsibility of the authors and do not represent the official views of the University of Utah or NIOSH.

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