Project Final Report

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Project Title: Ambient and Personal Exposure Levels of Fine Particulate Matter ($PM_{2.5}$) Throughout the Prince George Airshed.

Project Team Leader: Peter L. Jackson, 3333 University Way, Prince George, BC V2N 4Z9, peterj@unbc.ca, (250) 960-5985

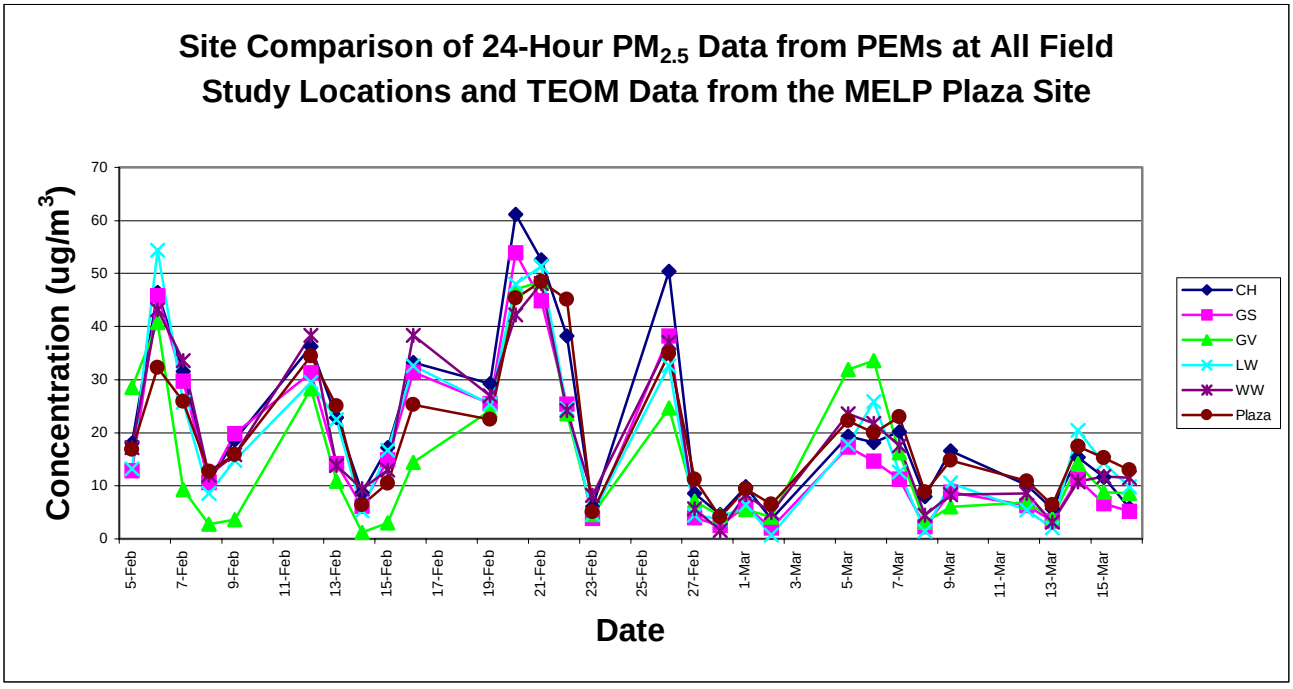
Final Report:
This research study has been completed. All fieldwork, lab work and data analysis were successfully concluded in April 2002. It is only the publication of research findings and writing of Melanie Noullett's thesis that is still underway. The following research abstract was submitted for the joint conference of the International Society of Exposure Analysis (ISEA) and the International Society for Environmental Epidemiology (ISEE). Melanie will be attending this conference in August and presenting a poster of her work. This abstract will be published in the July issue of *Epidemiology*. A more detailed data summary and discussion of research conclusions follows the abstract and highlights the main findings of the study.

Research Abstract:
The goal of this study was to develop a preliminary understanding of the relationship between ambient concentrations and children's personal exposure to $PM_{2.5}$ and to characterize the spatial variation of ambient $PM_{2.5}$ within the airshed of Prince George, British Columbia. Air pollution is a serious concern in the city of Prince George because of the topography of the area and the amount and location of industrial development. The core of Prince George (population 80,000) is situated in a valley where two rivers converge. Three pulp and paper mills, an oil refinery and several sawmills are also located in this valley. Under certain meteorological conditions, air pollutants frequently become trapped in the valley resulting in air pollution episodes. 24-hour average ambient and personal samples of $PM_{2.5}$ were collected each weekday during a six-week field study in February and March 2001. Elementary school children, aged 10 to 12, carried the personal $PM_{2.5}$ monitors and ambient monitoring was conducted on school roofs in five different neigbourhoods throughout the city. 9 to 10 personal samples were collected from each subject on a non-random rotating schedule enabling better representation of individual exposure over the 6-week period. 30 ambient samples were collected at each outdoor location. Harvard Personal Environmental Monitors were used for both the personal and ambient sampling. Samples were analyzed for mass, sulphate and elemental carbon to assess the contribution of regional and local outdoor sources on 24-hour personal exposures. Sulphate was determined by ion chromatography and elemental carbon was assessed indirectly by measuring absorbance using a simple reflectance method. This reflectance method was calibrated to actual elemental carbon levels determined by thermal optical reflectance on samples from a pilot study. Analysis of variance performed on the outdoor data indicated some spatial variation in $PM_{2.5}$ within the airshed. The results suggest that the addition of another permanent $PM_{2.5}$ monitor would enable better characterization of $PM_{2.5}$ levels in the city. The following table summarizes the correlations between personal exposure and ambient concentration for each individual:

	Mean	Median	Minimum	Maximum
$PM_{2.5}$	0.44	0.49	-0.34	0.82
SO_4	0.97	0.98	0.94	0.99
EC	0.71	0.72	0.19	0.99

These data suggest that for total $PM_{2.5}$ ambient concentration is not an adequate surrogate measure for personal exposure. Both sulphate and elemental carbon may be more useful indicators of exposure to particles of ambient origin. An average personal – ambient sulphate ratio of 0.6 (range 0.5-0.7) was calculated from the data. A slightly higher personal –ambient ratio of 0.7 (range 0.5-1.0) was found for elemental carbon at 4 of the 5 monitoring locations. High elemental carbon ratios (mean 1.8) at the Glenview site suggest that there may be an important personal $PM_{2.5}$ source in this neighbourhood that was not well characterized by the neighbourhood ambient monitor. One possible explanation for this finding is residential wood smoke.

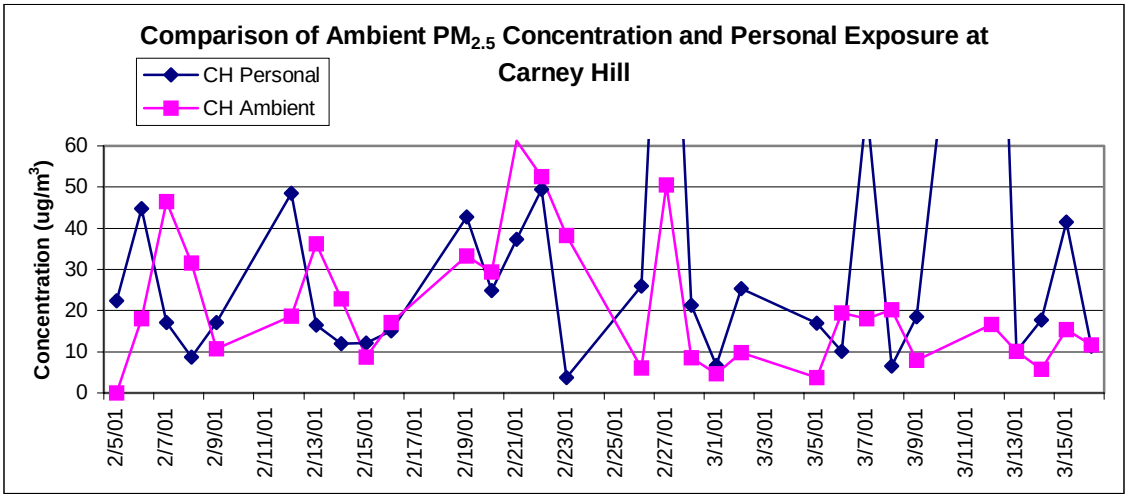
Final Data Summary and Conclusions:
The Canada-Wide Standard for 24-hour $PM_{2.5}$ exposure is 30ug/m^3. This standard was exceeded in 21% of the ambient samples and 14% of the personal samples collected during the 6-week field study. These statistics show that during wintertime inversion conditions, levels of $PM_{2.5}$ are a serious concern in the city of Prince George. The high PM2.5 levels observed during the study impacted all 5 of the ambient monitoring locations. The following graph shows the 24-hour average $PM_{2.5}$ levels at each ambient monitoring site including the existing continuous monitor operated by the BC Ministry of Water, Land and Air Protection (Plaza).

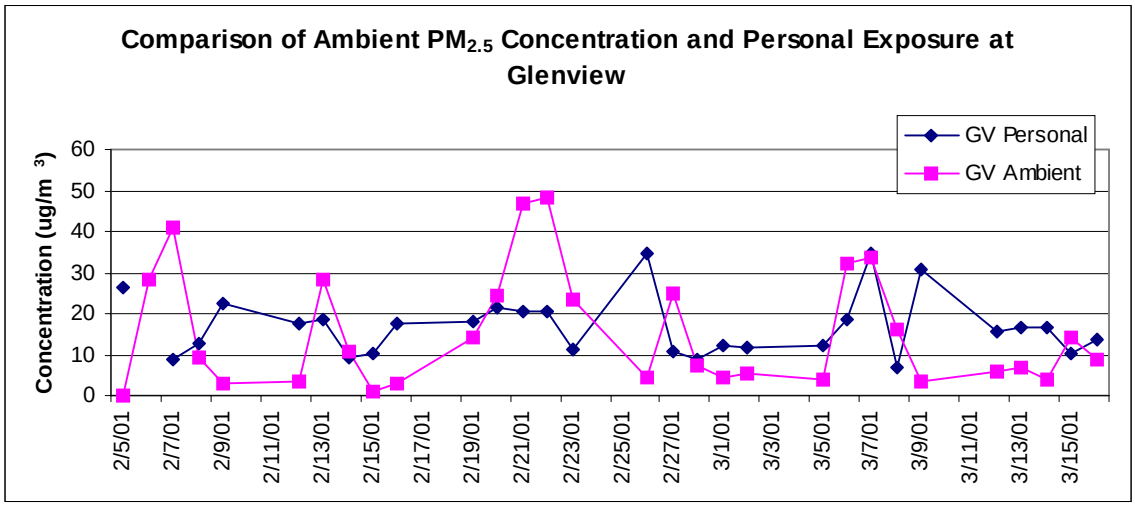


The average Pearson correlation for $PM_{2.5}$ levels at all the ambient monitoring sites was 0.9. This suggests that $PM_{2.5}$ levels correlate well throughout the city. When levels rose significantly they went up at all the monitoring sites. But there were some differences between sites that became apparent when an analysis of variance of the data was performed. There was a significant difference between Carney Hill School and Glenview and Gladstone when both time

and location were considered as factors in the analysis. Carney Hill is located closest to downtown Prince George. Gladstone is in the west end of the city and Glenview is in the north end of the city – both of these schools are at a higher elevation than the other three.

By looking at the actual $PM_{2.5}$ concentrations determined for all personal samples collected at two of the elementary schools, one can better understand the complication in using ambient concentrations as a surrogate for personal exposure. The following time series graphs show the pooled data collected at two schools.

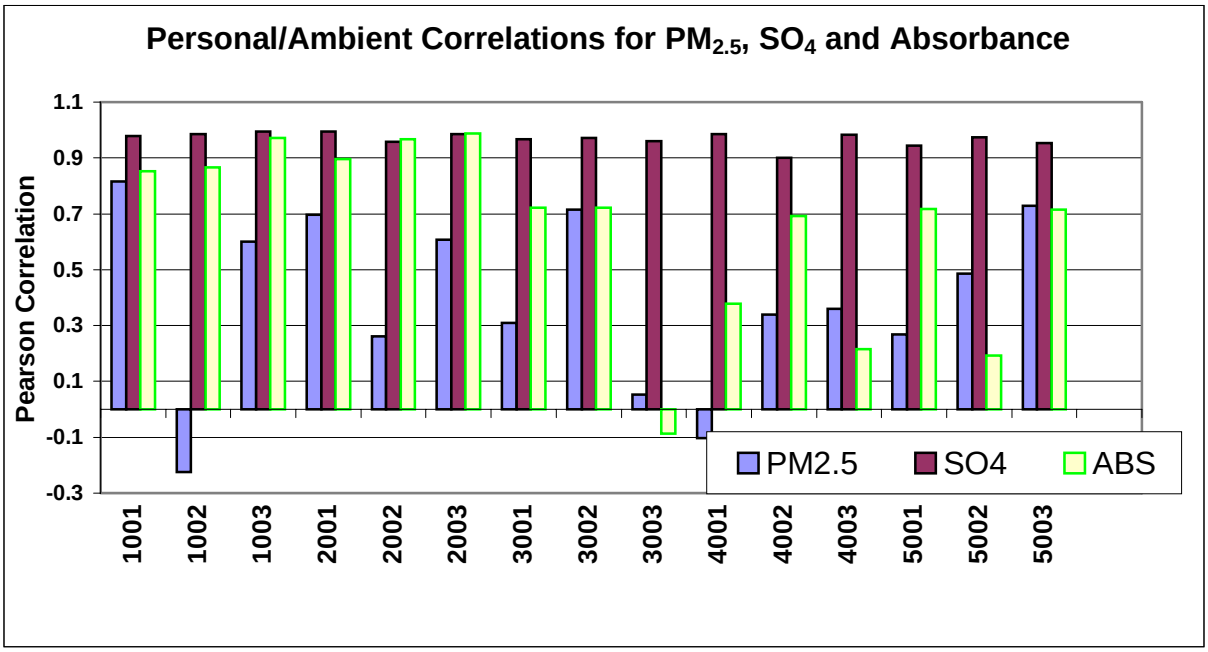




These graphs show the ambient concentrations in pink and the personal exposure in blue. It is very clear that sometimes the personal exposure is higher and at other times the ambient concentration is higher. For most individuals in the study there was no consistent pattern apparent. The actually correlations calculated for ambient $PM_{2.5}$ levels and personal exposure verify that the relationship is inconsistent. The average correlation across all individuals was 0.44 with a range of –0.34 to 0.82. This data confirms the hypothesis that ambient $PM_{2.5}$ concentration would be a poor surrogate for personal exposure.

The data for sulphate and elemental carbon show a different pattern. Both of these components of the $PM_{2.5}$ sample were suspected to be mainly from outdoor sources. Therefore a better correlation should result when ambient and personal data were compared. The following graph shows the correlations between ambient concentration and personal exposure for each individual

and for all three variables – total $PM_{2.5}$ concentration, sulphate concentration and elemental carbon concentration.



The blue bars show the extensive variation in total $PM_{2.5}$ correlations discussed previously. The brown bars are consistently close to 0.9 demonstrating the excellent correlation found between ambient and personal sulphate levels. The green bars represent ambient and personal elemental carbon correlations. These correlations appear to be fairly high and consistent for the first 2 schools (schools 1 and 2) but then the relationship changes. As there are 5 out of 9 individuals at schools 3, 4 and 5 that still show a relatively high correlation, approximately 0.7, the difference at these schools may be insignificant and only apparent due to the small sample size. But this difference may also be due to an important source of elemental carbon that only impacted some of the personal samples. One possible explanation may be residential wood smoke.

The high correlation between ambient sulphate concentration and personal exposure to sulphate suggests that ambient sulphate levels may be a useful indicator of personal exposure to ambient sources of $PM_{2.5}$. The average ratio of personal to ambient sulphate observed during the study could be used to represent the proportion of outdoor $PM_{2.5}$ that individuals are exposed to in Prince George even when they are indoors the majority of the time. The average sulphate ratio observed was 0.59 with a range of 0.50 to 0.66.

Although the average correlation across all ambient monitoring locations was good, there were some differences in $PM_{2.5}$ concentration when both time and location are considered. The addition of a second permanent $PM_{2.5}$ monitor to the existing network would provide a more complete representation of $PM_{2.5}$ levels throughout the city. It is also clear from these results that more personal monitoring would be necessary if a health study examining the impacts of $PM_{2.5}$ was undertaken. However, the average sulphate ratio of 0.59 is a valuable constant that could be utilized when assessing $PM_{2.5}$ exposure from outdoor sources only.