FINAL REPORT

Effects of Road Pavement on PM_{10} Reduction in Nuevo Laredo, Tamaulipas, Mexico

BECC
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THE UNIVERSITY OF TEXAS AT EL PASO

Nuevo Laredo

January 20, 2011

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Effects of Road Pavement on PM_{10} Reduction in Nuevo Laredo, Tamaulipas, Mexico

prepared for:

The Border Environmental Cooperation Commission

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January 20, 2011

SUMMARY

A study to evaluate the effectiveness of roadway pavement on community exposures to the PM_{10} pollution was performed in Nuevo Laredo, Tamaulipas, Mexico. Ambient PM_{10} concentrations were measured at a selected location before and after paving a street in the community. Based on the concurrent meteorological and pollution observations at the selected location and the comparisons made between the two sets of pre-and post-pavement PM_{10} data, it appears that the average ambient PM_{10} concentrations were mostly affected by traffic traveling on the nearby unpaved street and that the daily PM_{10} trend followed the local traffic pattern. Ambient PM_{10} in the community elevated during the day and subsided at night. PM_{10} was observed to decrease by approximately 20 % during the weekdays after the street was paved. However, the improvement was not seen during the weekends. PM reduction was particularly significant during the day when traffic was high, suggesting that the reduction was caused by pavement of the street.

INTRODUCTION

Background and Objectives

Airborne particulate matter (PM) is a major health concern. The U.S. EPA (1996) has concluded from many community epidemiological studies that serious health effects (mortality, exacerbation of chronic disease, increased hospital admissions, etc) are associated with exposures to ambient levels of PM found in contemporary U.S. urban environments. PM pollution is particularly significant in many cities along the U.S.-Mexico border due to poor urban infrastructure, high percentage of unpaved roads, and poorly maintained and aged vehicle fleets. The condition is worsened by the region's arid weather, occasional high winds, frequent stagnations, shallow nighttime and morning mixing depths, and complex topography, which preclude simple explanations for excessive ambient PM levels. The elevated level of PM in the region poses potential health risks to the public, especially sensitive persons including the elderly and those with respiratory ailments (Dockery and Pope, 1994; Schwartz, 1994; Pope and Dockery, 1999). For instance, dust emissions from unpaved roads have been a major concern of PM pollution in the Paso del Norte (PdN) border region as well as many other border cities. Several characterization studies of the ambient PM concentrations and associated health effects in this region have been conducted since 1997 (Li et al, 2001, 2005; Arrieta et al 2004; Staniswalis et al 2005; Holguin et al 2007) and it was concluded that road dust and wind erosion are the major contributors of the PM pollution in the region. In a study conducted by TNRCC, DGEyPC, UACJ, and IMIP, they concluded that 80 % of the PM emissions are generated at unpaved streets, yet traffic activity in these roadways was estimated to be less than one-third of the total in the study area.

To mitigate the PM pollution problem in the region, many agencies including the U.S. EPA, BECC, PAHO, TCEQ, TxDOT, IMIP, and DGEyPC have begun roadway improvement projects in the border cities. However, the effects of roadway pavement on PM emissions and associated air quality impacts have not been quantified. In order to ensure the effectiveness of many roadway pavement projects along the U.S.-Mexico border, we propose to conduct a pilot PM measurement project in the border region before and after the implementation of pavement on a segment of road. The purposes of the study are to

- evaluate the effectiveness of roadway pavement on community exposures to the PM_{10} pollution; and
- quantify the PM_{10} emissions reduction due to roadway pavement.

<u>Selection of the Study Location</u>

Initially, the Air Quality Research Laboratory (AQRL) at the University of Texas at El Paso (UTEP) designed a study to be implemented in one of the sister cities in the PdN region: Cd. Juarez, El Paso, or Sunland Park. However, Nuevo Laredo was selected over Cd. Juarez at the request of the Border Environmental Cooperation Commission (BECC) and the following facts: 1) the drug related violence began to peak in 2009 in Cd. Juarez and our research staff was not allowed to conduct field work in Cd. Juarez due to a Texas statewide travel advisory whereas Nuevo Laredo had relatively low number of violence incidences and no travel advisory; and 2) a segment the Roma Street in Nuevo Laredo was scheduled to be paved in a month at that time. As a result, Nuevo Laredo was selected for the study although later on the same safety concern preventing our research staff to perform field work in Nuevo Laredo was enforced in Nuevo Laredo.

This report summarizes the results of the study for evaluating the impact of paving a section of Roma Street in Nuevo Laredo, Tamaulipas, Mexico on local ambient PM_{10} concentrations. The study consisted of monitoring ambient PM_{10} concentrations at the intersection of the Roma Street and Rio Loira Street at a public school (Secundaria Tecnica No. 78) before and after the paving of the Roma Street.

STUDY DESIGN AND METHODOLOGY

The intersection of Roma and Rio Loira was ideal because it is located at the only entrance into a new residential development and therefore traffic is highest at that point. The UTEP AQRL designed the study and was scheduled to perform the scope of work in its entirety. Unfortunately, the AQRL researchers were unable to conduct any field work in Nuevo Laredo shortly after the completion of the pre-paving air quality monitoring due to the increased safety risks associated with the drug-related violence in Mexico, as the State of Texas and the University of Texas System prohibit any official activity in Mexico. Therefore, a team of researchers led by Dr. Gerardo Mejia of the State Government of Nuevo Leon, Mexico was tasked by BECC to perform the PM_{10} monitoring after the Roma Street was paved. The Nuevo Leon team produced a report describing the results from their measurements and is as Appendix A in this report.

METHODOLOGY

PM_{10} monitoring was performed between July 28 and August 3, 2009 prior to the paving of the Roma Street. Post-pavement monitoring was conducted between October 7 and 16, 2010.

Instrumentation

During the pre-pavement monitoring campaign, ambient PM_{10} concentrations were measured with a Thermo Scientific Tapered Element Oscillating Microbalance (TEOM) model 1400a and wind direction and speed were measured with a Met One weather station. Additional weather data collected at the Laredo International Airport, Texas was also obtained for use in this study (Wunderground 2010). Posterior to the pavement activities PM_{10} concentrations were measured using a beta-gauge instrument. The TEOM and the beta-gauge instrument have both been found to accurately reproduce PM_{10} concentrations measured by a gravimetric method (Zhu et al 2007) and thus the results from both measurement campaigns are considered comparable. Further details on the instrumentation used by the AQRL are described elsewhere (Li et al 2003), and in Appendix A for that used by the Nuevo Leon team.

Experimental Setup for the Pre-Pavement Measurements

The Primary monitoring site was located at 27°30'56" N, 99°34'14" W inside a public school (Secundaria Tecnica No. 78) approximately 20 meters from the center of the intersection of Roma and Rio Loira. PM monitoring was conducted at two additional reference locations during the pre-pavement monitoring campaign: 1) the *Near* site across the intersection from the main site inside a church premise, and 2) the *Far* site within the school property located approximately 75 meters away from the unpaved road. The Near site was used to determine the impact of local traffic on the immediate ambient PM_{10} concentrations whereas the Far site was used to determine the air quality impact further away from the source (unpaved street) and thus provide an estimate of background levels. Figure 1 shows an aerial image of the three sites during the pre-pavement measurements. The MetOne station was located at the Primary monitoring site. All pre-pavement monitors were set at a height of approximately 7 ft above the ground.

Figure 1. Aerial view of monitoring site and instrumentation location. Source: Google Earth

Experimental Setup for Post-Pavement Measurements

During the post-pavement measurement campaign PM_{10} concentrations were measured only at the Primary monitoring site. The post-pavement measurements monitored meteorological variables such as wind speed and wind direction and pollutant concentrations including PM, CO, and NO2 (Appendix A). The precise PM sampling height during the post-pavements measurements was not reported, but it appears to be approximately 4 meters above the ground since the inlet head of the samplers was above the top of the mobile laboratory. Figure 2 shows the set-up during the pre- (left) and post- (right) pavement measurement activities.

Figure 2. Left) Picture of site during pre-pavement campaign. Right) Image of set up after pavement of Roma St.

RESULTS

Quality Assurance

Prior to initiating the pre-pavement PM_{10} monitoring activities the three TEOM units used were tested side by side at the Primary monitoring site for 24 hours. Time series plots of the duplicate PM_{10} measurements are shown in Figure 3. Figure 4 shows the scatter plots and R^2 values for the paired TEOMs. It is judged that all 3 TEOMs are compatible and their performances are acceptable, based on the extremely similar temporary variations and high R^2 values among the PM_{10} data collected by the 3 monitors.

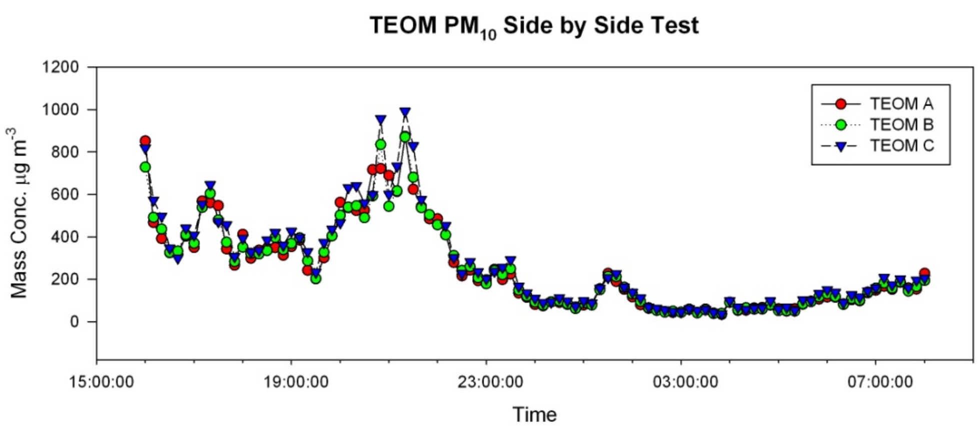

Figure 3. Time series of side-by-side TEOM measurements.

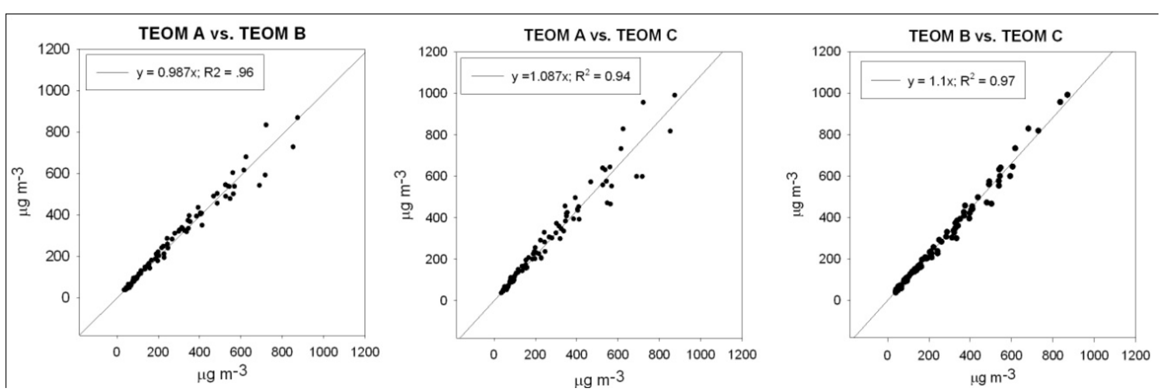

Figure 4. Scatter plots between all three TEOM units employed during the pre-pavement campaign.

Wind Conditions

Shown in Figures 5 and 6 are wind rose plots (joint frequency distributions of the wind speed and wind direction) produced with data collected during the pre-pavement monitoring campaign from the local site (at the school) and the regional site (Laredo International Airport), respectively.

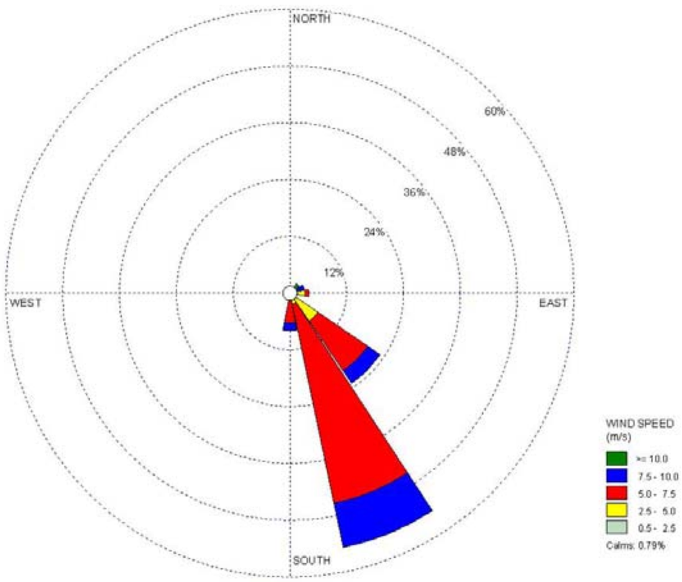

Figure 5. Wind rose plot at the primary monitoring site for the study period

The regional winds during the pre-pavement monitoring campaign were predominately blowing from the southeast, a direction indicating that the winds were coming from the Gulf of Mexico. During the course of the pre-pavement study, there was no precipitation observed although humidity remained high in the region.

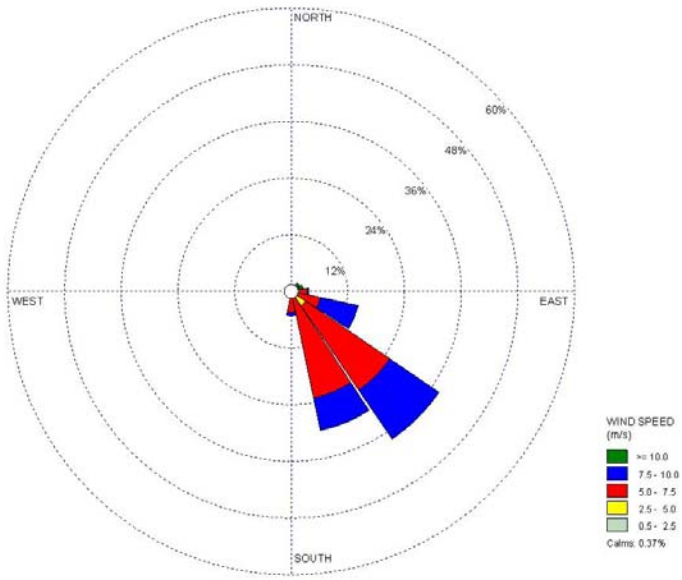

Figure 6. Wind rose plot produced with local data rose.

The wind pattern observed at the Primary monitoring site (Figure 6) was very similar to that observed at the Laredo International Airport (Figure 5). Southeasterly winds from the Gulf of Mexico were the predominant winds during the pre-pavement monitoring campaign. Wind conditions at the Primary monitoring site during the post-pavement monitoring campaign are shown in Figure 7. Easterly winds prevailed at the study site during the post pavement study period, as reported by the Nuevo Leon team in Appendix A. Regional wind data for the pos-pavement campaign was not available at the time this report was prepared. However, it is expected that wind conditions for the region and the study site will be very similar to each other, as judged from the regional topology and historical data recorded at the regional site.

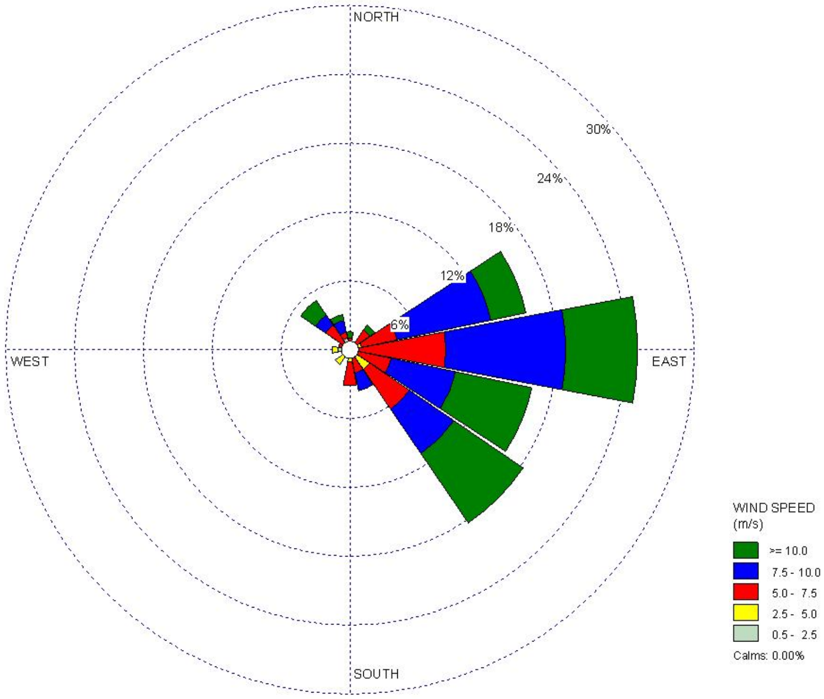

Figure 7. Wind rose plot produced with local data during the post-pavement campaign.

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Pre-Pavement PM_{10} Levels

Shown in Table 1 is a summary of the PM_{10} and local meteorological data collected during the pre-pavement PM_{10} monitoring campaign. During the pre-pavement campaign a high wind event occurred on July 28. Data recorded during the high wind event was not used in any analysis in this study.

The mean PM_{10} concentration observed throughout the pre-pavement campaign was 237 µg m^{-3} at the monitoring site, 200 µg m^{-3} at the Near site, and 116 µg m^{-3} at the far (background) site. The mean PM_{10} concentration observed at the background site was 51% lower than that observed at the Primary monitoring site. Figure 8 shows the average hourly PM_{10} concentrations for the entire study. The values shown in Figure 8 were obtained by averaging all the values observed for each hour of the day throughout the monitoring campaign.

Table 1. Statistical Summary by Day (Pre Pavement)

Date	Parameter	Site (School)	Near (Church)	Far (School)	Temp	Dew	Press	RH	Wind Speed (Regional)	Wind Speed (Local)
		μg/m³	μg/m³	μg/m³	F	F	in Hg	%	m/s	m/s
7/28/2009 (Tuesday)	Mean	333.62	173.62	150.40	96.44	67.44	29.82	38.83		6.68
	Std. Deviation	114.94	78.88	64.28	3.60	1.71	.02	6.33		.19
	Minimum	215.78	88.12	80.98	92.33	66.00	29.80	34.00		6.48
	Maximum	581.77	347.33	282.40	99.00	69.33	29.83	46.00	9.98	6.85
7/29/2009 (Wednesday)	Mean	196.13	124.40	101.76	91.40	71.84	29.77	55.96		5.93
	Std. Deviation	95.78	55.92	39.92	8.29	3.14	.04	17.81		1.17
	Minimum	67.55	56.80	57.25	82.00	66.00	29.71	30.00	4.59	2.24
	Maximum	439.40	224.88	193.35	103.60	75.00	29.88	76.40	9.86	7.15
7/30/2009 (Thursday)	Mean	268.61	426.11	170.03	92.62	71.46	29.81	52.62		6.45
	Std. Deviation	438.55	950.99	352.02	7.67	2.63	.04	15.23		2.75
	Minimum	57.13	36.40	41.30	84.00	66.00	29.75	27.20	1.92	.00
	Maximum	2113.57	4461.92	1711.90	108.00	75.00	29.93	74.00	9.43	14.30
7/31/2009 (Friday)	Mean	159.48	157.85	76.40	93.02	73.74	29.92	55.13		3.68
	Std. Deviation	142.05	144.92	61.77	5.23	2.38	.06	12.04		2.24
	Minimum	21.75	26.33	23.73	86.67	67.33	29.82	33.00	3.00	.00
	Maximum	659.98	467.92	312.83	102.00	77.00	30.03	71.33	8.91	9.39
8/1/2009 (Saturday)	Mean	298.34	161.87	124.45	94.99	64.91	29.90	43.77		7.35
	Std. Deviation	147.97	88.60	54.11	9.56	9.76	.06	23.42		.85
	Minimum	72.37	39.83	47.15	82.00	48.00	29.80	13.00	10.17	5.81
	Maximum	528.18	312.30	216.10	109.00	75.00	29.98	75.00	9.48	9.98
8/2/2009 (Sunday)	Mean	250.03	192.53	102.24	93.62	63.94	29.94	43.62		6.21
	Std. Deviation	145.77	114.19	37.50	9.05	9.24	.04	24.20		.95
	Minimum	75.35	54.97	59.72	82.00	52.00	29.87	15.80	6.04	4.32
	Maximum	737.47	464.37	204.62	106.67	75.00	29.99	78.00	9.37	7.60
8/3/2009 (Monday)	Mean	146.80	97.75	86.64	82.72	70.61	29.97	67.93		5.26
	Std. Deviation	50.57	38.44	17.01	3.47	3.37	.01	13.13		.97
	Minimum	82.23	65.28	65.70	79.00	62.67	29.96	41.00	5.38	3.91
	Maximum	233.17	184.73	115.78	89.33	73.00	29.99	83.00	8.66	7.15
Overall	Mean	236.76	200.27	116.01	92.38	69.14	29.88	51.23		5.88
	Std. Deviation	217.88	405.32	151.23	8.23	7.22	.08	19.67		2.06
	Minimum	21.75	26.33	23.73	79.00	48.00	29.71	13.00		.00
	Maximum	711.98	812.34	576.70	109.00	77.00	30.03	83.00	9.98	14.30

It was observed by the researchers that vehicle traffic at the Primary monitoring site picked up after 6:00 am and subsided after 9:00 pm. The graph shown in Figure 8 suggests that the local PM_{10} levels follow the daily traffic pattern.

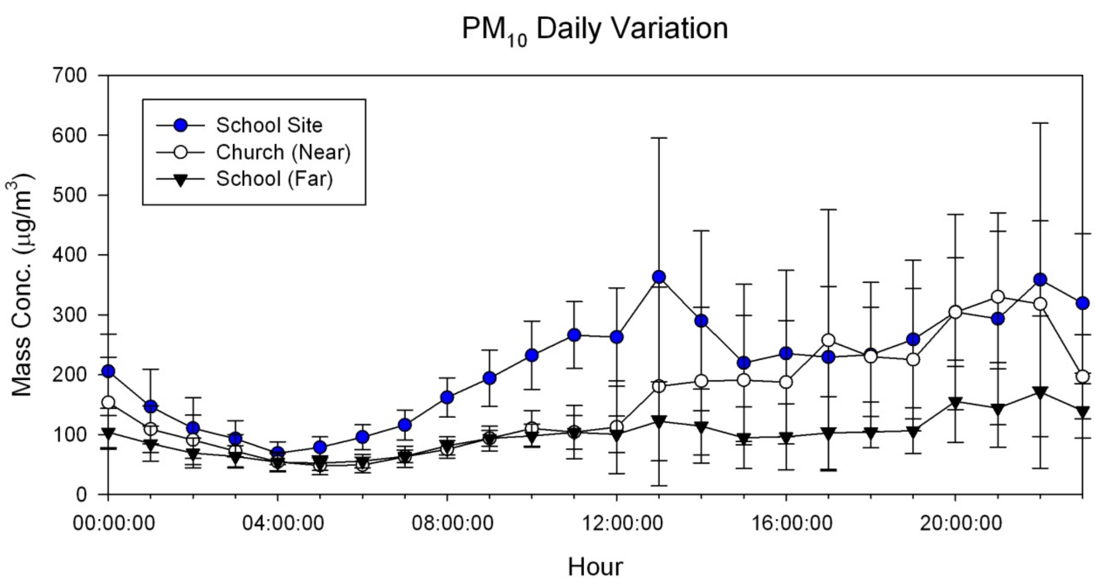

Figure 8. Hourly temporal average PM_{10} concentration variation throughout the pre-pavement campaign.

At the Near site, during the morning hours, ambient PM_{10} concentrations resembled those observed at the Far (background) site. The ambient PM_{10} level at the Near site gradually increased in the morning and was very similar to that observed at the Far site. However, the PM_{10} level at this site started to increase rapidly at noon and became similar to that observed at the Primary site in the afternoon. The diurnal pattern of PM_{10} at the background location can be seen visually in the figure that it was similar to that observed at the Primary site but at lower magnitudes. The Roma Street (see Figure 2) travels from east to west such that the north and south winds could have caused a direct impact on the PM_{10} concentrations at either the Primary site or the Near site due to the upwind- downwind geometry between the monitoring sites and the potential source of emissions. Figure 9 shows a set of graphs similar to that presented in Figure 8 but separated by wind direction. As expected, because the wind was blowing predominantly from the southeast during the monitoring campaign, the plots associated with wind blowing from the north (315°- 45°) and west (225°- 315°) lack meaningful data. The plots associated with wind blowing from the east (45°- 135°) and south (135°- 225°) have similar patterns, both showing elevated levels of PM_{10} over the daytime hours while traffic was present. The independence of the predominant daily PM_{10} variations to wind direction and the pattern showing an association with daytime traffic activities suggest that the major source of PM_{10} affecting the Primary and Near sites was the vehicle traffic traveling over the unpaved Roma street.

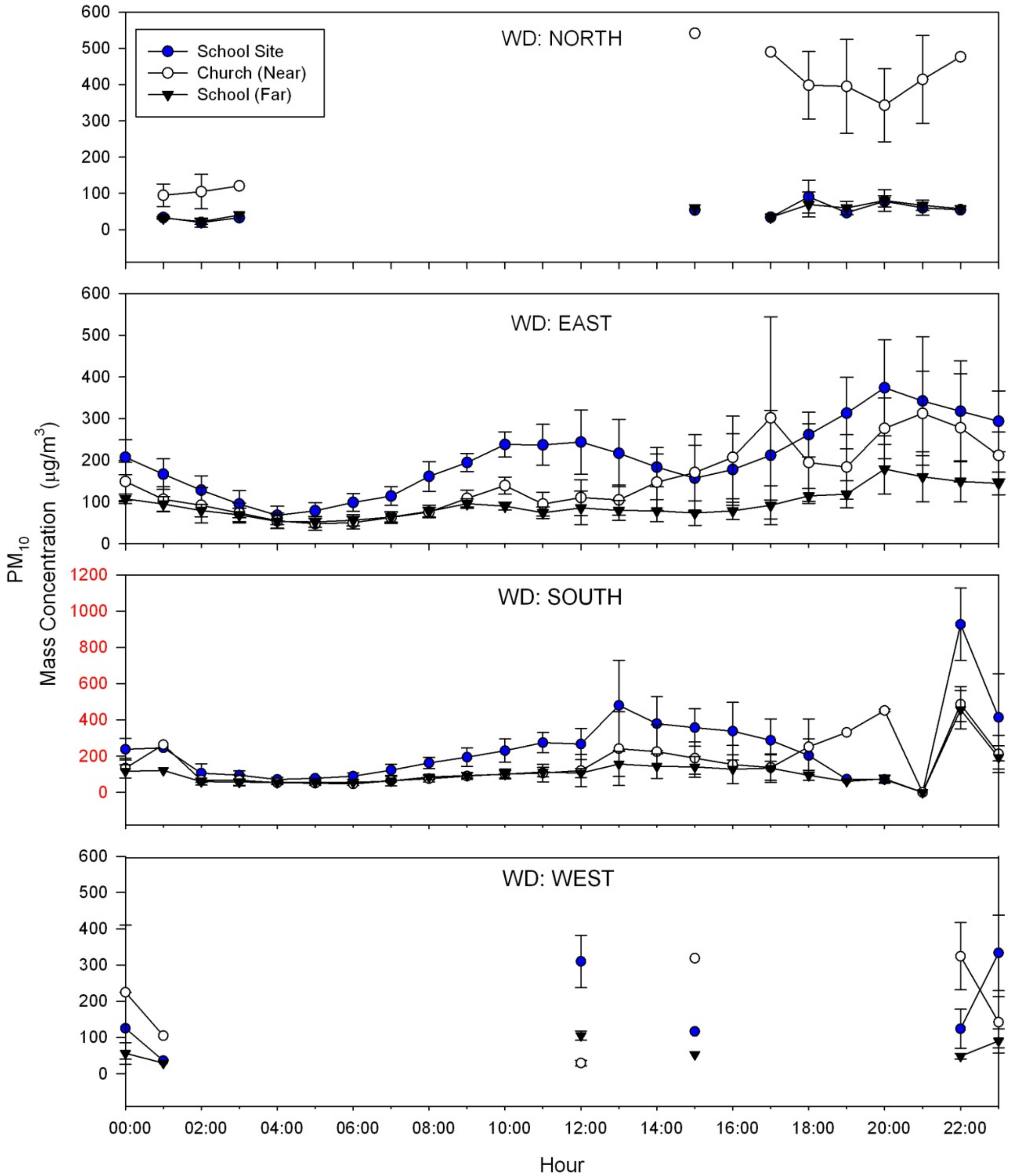

Figure 9. Hourly temporal average PM_{10} concentration variation throughout the pre- campaign by wind direction.

Post-Pavement PM_{10} Levels

Shown in Table 2 is a statistical summary of the relevant measurements performed during the post-pavement PM_{10} monitoring campaign. The Nuevo Leon research team reported the results from the post-pavement measurements on a separate document that is included as Appendix A.

Table 2. Statistical Summary by Day (Post Pavement)

Date	Parameter	Site	Temp	Press	RH	Wind Speed (Local)
		μg/m³	Temp	Press	%	m/s
10/7/2010 (Thursday)	Mean	44.00	26.84	753.76	39.25	8.90
	Std. Deviation	33.81	1.65	.79	7.92	.69
	Minimum	1.00	23.84	752.80	31.00	7.70
	Maximum	89.00	28.44	754.70	52.00	9.80
10/8/2010 (Friday)	Mean	115.95	23.01	753.16	53.27	5.70
	Std. Deviation	64.98	4.52	1.23	15.55	2.45
	Minimum	32.00	16.00	751.90	34.00	1.40
	Maximum	278.00	28.87	755.50	77.00	9.30
10/9/2010 (Saturday)	Mean	152.65	23.04	752.03	48.78	6.20
	Std. Deviation	158.47	4.40	1.29	18.30	2.32
	Minimum	49.00	16.84	750.60	24.00	1.70
	Maximum	742.00	29.13	754.50	74.00	9.70
10/10/2010 (Sunday)	Mean	214.50	22.85	750.05	51.59	6.43
	Std. Deviation	173.78	5.04	1.06	16.67	2.54
	Minimum	38.00	14.83	748.70	30.00	1.40
	Maximum	595.00	29.63	752.20	78.00	9.90
10/11/2010 (Monday)	Mean	135.46	23.00	747.82	56.46	7.25
	Std. Deviation	112.99	4.73	.85	18.95	1.85
	Minimum	41.00	18.04	746.80	29.00	4.20
	Maximum	381.00	30.38	749.80	77.00	9.70
10/12/2010 (Tuesday)	Mean	82.70	23.11	745.13	67.80	8.80
	Std. Deviation	63.42	3.69	1.15	19.97	.94
	Minimum	28.00	20.20	743.40	33.00	7.20
	Maximum	224.00	29.37	746.20	83.00	9.80
10/13/2010 (Wednesday)	Mean	130.57	27.88	743.77	51.71	7.71
	Std. Deviation	140.89	4.34	.77	15.69	1.31
	Minimum	23.00	20.60	742.70	34.00	5.00
	Maximum	449.00	32.61	745.20	79.00	9.40
10/14/2010 (Thursday)	Mean	61.43	22.32	745.47	78.71	6.77
	Std. Deviation	20.78	.50	.88	2.06	1.49
	Minimum	23.00	21.63	744.70	75.00	5.20
	Maximum	91.00	23.04	747.10	81.00	9.20
10/15/2010 (Friday)	Mean	129.25	26.20	752.50	35.38	6.00
	Std. Deviation	128.02	3.41	.59	9.23	1.92
	Minimum	39.00	21.15	751.80	22.00	4.00
	Maximum	429.00	31.06	753.30	51.00	9.10
10/16/2010 (Saturday)	Mean	81.70	18.97	753.76	56.90	4.99
	Std. Deviation	94.28	2.70	1.27	12.26	2.22
	Minimum	21.00	16.75	752.70	25.00	2.10
	Maximum	307.00	25.71	756.10	67.00	9.80
Overall	Mean	130.15	23.57	750.07	53.15	6.69
	Std. Deviation	128.32	4.57	3.59	17.86	2.27
	Minimum	1.00	14.83	742.70	22.00	1.40
	Maximum	742.00	32.61	756.10	83.00	9.90

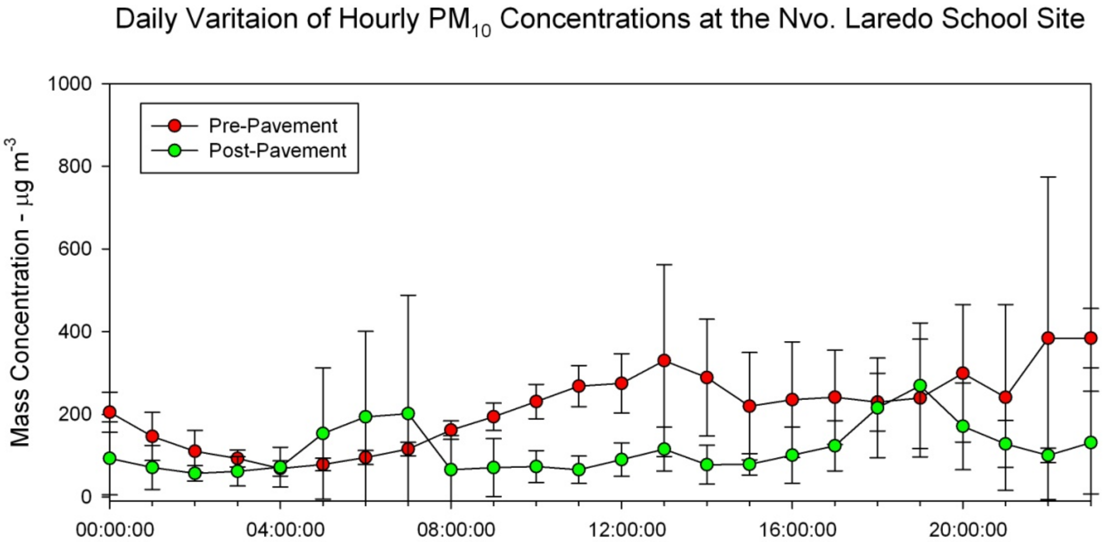

Figure 10. Temporal variation of average PM_{10} concentration by hour of day for both the pre-and post-pavement monitoring campaigns.

Impact of Pavement of Roma Street

A graph comparing the diurnal variation of PM_{10} concentrations before and after the paving of the Roma Street is shown in Figure 10. The variations appear distinct with the pre-pavement curve showing elevated values throughout the day and particularly in the evening hours and the post-pavement curve showing pronounced morning and evening peaks. The morning peak during the post-pavement campaign is well defined that starts after 4:00 am and ends before 8:00 am and the evening peak starts at around 4:00 pm and ends past 9:00 pm. Because the wind patterns were slightly different between pre-pavement and post-pavement monitoring campaigns data associated with wind blowing from the east was used to generate a daily variation graph as shown in Figure 11. In Figure 11, the morning peak during the post-pavement campaign is still evident and the evening peak appears similar on both pre and post-pavement curves. A plausible explanation for the morning peak could be a change in traffic patterns affected by the pavement of Roma Street with an increase in morning peak hour traffic caused by a preference of paved streets by drivers.

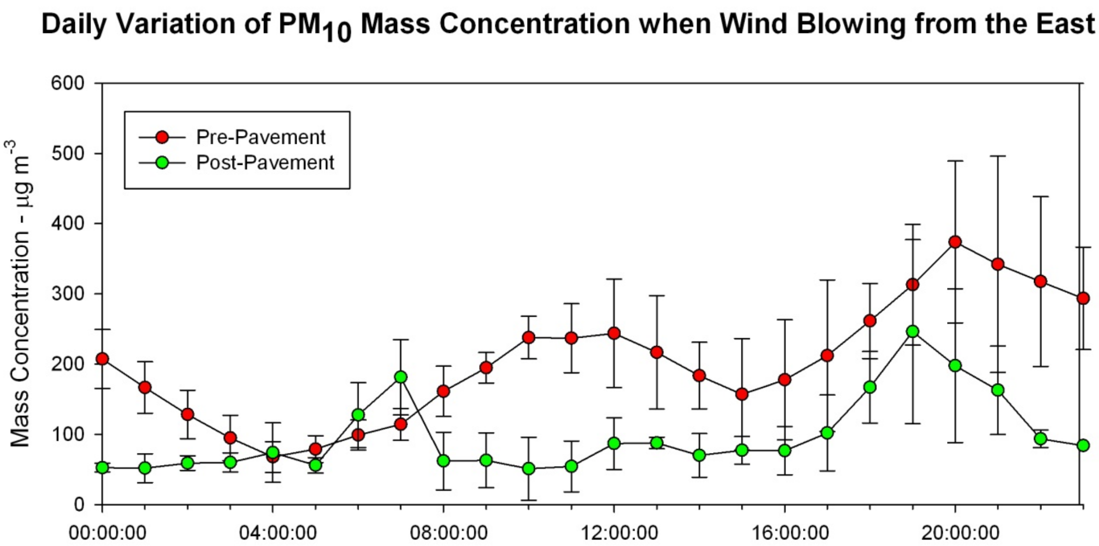

Figure 11. Temporal variation of average PM_{10} concentration by hour of day for both the pre-and post-pavement monitoring campaigns when wind was blowing from the east.

A significant change between monitoring periods, besides the pavement of Roma Street, was school activity. During the pre-pavement monitoring campaign school was out on vacation opposed to the post-pavement campaign that was perform during school activities. Therefore, it is plausible that school-associated traffic might have contributed to the morning peak. However school traffic does not completely explains the peak as it starts at 4:00 am, considerably before school activities begin.

Table 3. Student's *t* test for average PM_{10} concentration before and after pavement of Rio Loira St.

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	2.457	.118	3.166	329	.002	39.809	12.573	15.075	64.543
Equal variances not assumed			3.164	303.220	.002	39.809	12.580	15.053	64.564

As shown in Table 3, a student *t* test demonstrates that a significant reduction ($p = 0.002$) of average ambient PM_{10} concentration was observed between the pre- and the post-pavement monitoring campaign. The mean difference was of 39.8 $\mu g/m^3$, which represents a 16.8 % reduction. Because traffic is expected to be higher during weekdays than during weekends, additional pair of tests were conducted and are shown in Tables 4 and 5.

Table 4. Student's *t* test for average PM_{10} concentration before and after pavement of Rio Loira St. (Weekdays)

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	10.912	.001	3.629	220	.000	48.451	13.350	22.140	74.762
Equal variances not assumed			3.433	154.664	.001	48.451	14.115	20.568	76.334

A significant ($p = 0.000$) reduction of average PM_{10} concentrations is even more evident for weekdays as shown in Table 4. The mean PM_{10} concentration difference between pre and post-pavement weekday measurements was 48 $\mu g/m^3$, which represents a reduction of 20.5 %. A non-significant reduction was observed during weekends, as shown in Table 5.

Table 5. Student's *t* test for average PM_{10} concentration before and after pavement of Rio Loira St. (Weekend)

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	2.046	.156	.783	107	.435	20.269	25.883	-31.041	71.578
Equal variances not assumed			.821	104.174	.414	20.269	24.692	-28.696	69.234

Finally, a series of mean difference tests were performed for average hourly PM_{10} concentrations and the resulting P-values were plotted in Figure 12. Figure 12 shows that the most significant reduction of ambient PM_{10} concentration in the vicinity of the monitoring site was observed during daytime hours when traffic conditions are expected to be highest.

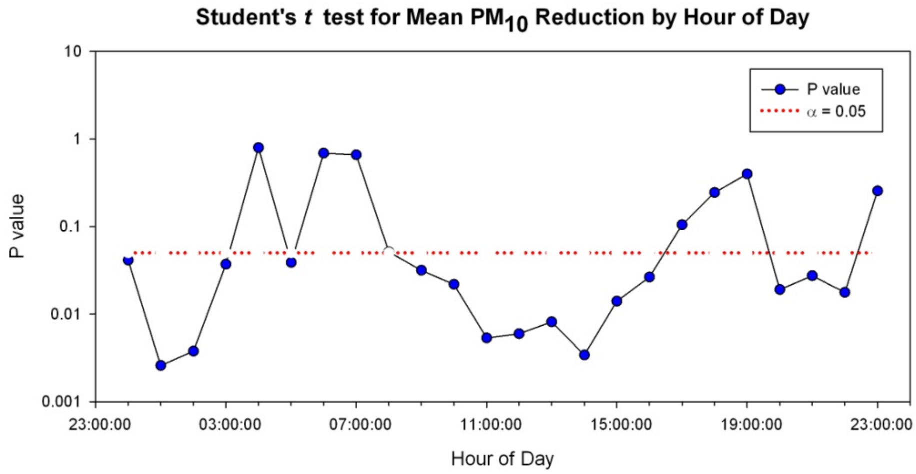

Figure 12. P values obtained from mean differences test performed for mean PM10 concentrations by hour of day.

CONCLUDING REMARKS

The results of this study suggest that the ambient PM_{10} concentrations near the intersection of the Roma Street and the Rio Loira Street were mostly affected by traffic traveling on the unpaved street of the Roma Street before the street was paved. During the pre-pavement monitoring campaign the southeasterly winds prevailed whereas the easterly winds prevailed during the post-pavement monitoring campaign. Nevertheless, the daily PM_{10} trend appeared to be independent of wind direction and appeared to follow the expected traffic pattern of heavier traffic during the day and lighter at night. During the post-pavement campaign a pronounced morning PM_{10} peak was observed. The source associated with the morning PM_{10} peak could be additional traffic caused by drivers' preference for paved streets and school in session, although the actual source remains undetermined. Overall, a significant reduction of 16.8 % in ambient PM_{10} levels was observed resulting from the pavement installation. The reduction was even more significant at 20.5 % during weekdays. The reduction was not significant during weekends. In particular, the reduction was most significant during the daytime hours when traffic is expected to be high, suggesting that the reduction was likely associated to the paving of Roma Street. All PM_{10} reductions were estimated at the Primary monitoring site, which is immediately adjacent to the Roma Street. Ambient PM_{10} levels at the "background" were only monitored during the pre-pavement campaign and some initially scheduled activities were not implemented due to the increased level of safety concerns for working and traveling in Mexico during our study periods. The average PM_{10} concentration at the background site during the pre-pavement monitoring campaign was observed to be 51% less than that observed at the Primary monitoring site. It is unclear if a reduction of PM_{10} concentrations proportional to that observed at the Primary monitoring site could have occurred at the background site after the pavement of Roma Street.

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APPENDIX A

Report Provided by The Nuevo Leon Research Team On the Results of the Post-Pavement Monitoring Campaign At the Roma and Rio Loira Intersection in Nuevo Laredo Tamaulipas

N. Laredo, Tam., Octubre 29 del 2010.

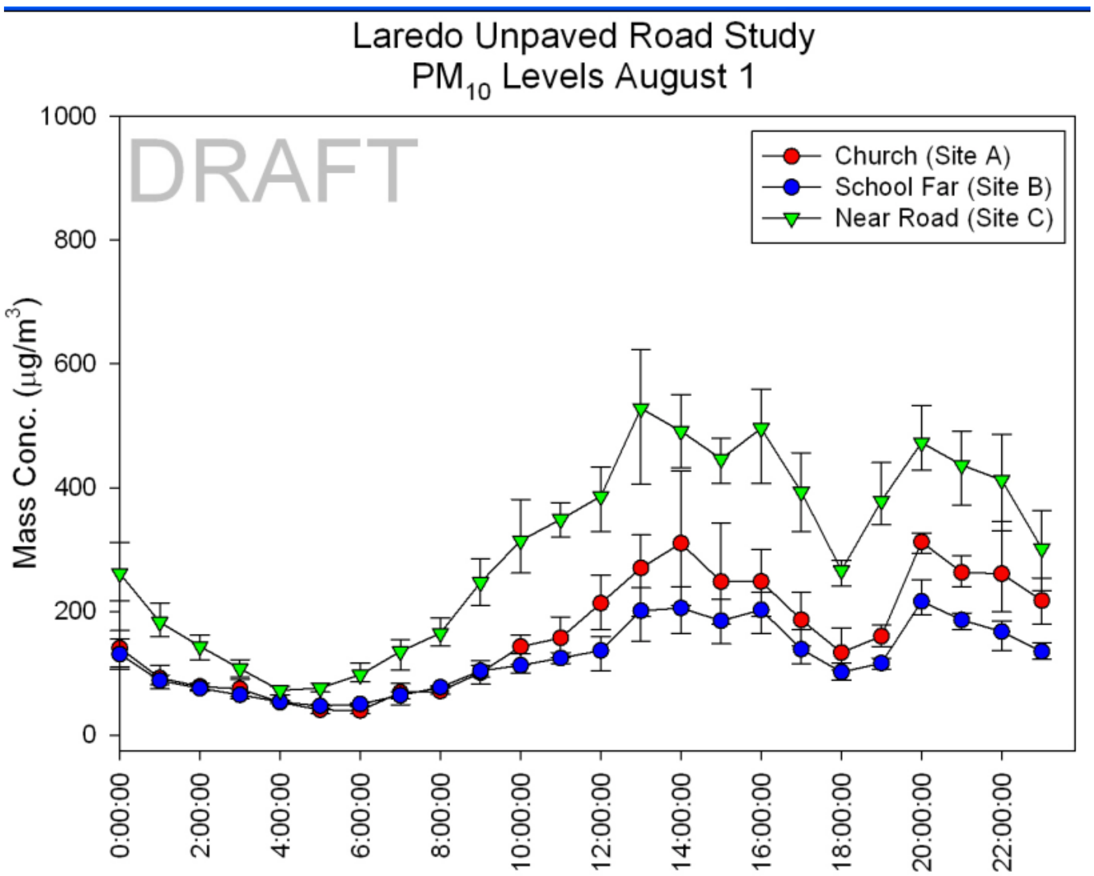
Monitoreo Atmosférico (Programa PASO)

El presente análisis muestra una comparación (opinión técnica) referenciada en la base de datos de los estudios (monitoreo atmosférico) en materia de calidad del aire de la vialidad de Río Loira y Roma en la Colonia Voluntad y Trabajo IV, antes y después de su urbanización (pavimentación) contemplado dentro del Programa PASO.

Nota: El análisis se desarrolla solamente del punto de muestreo de la intersección de Río Loira y Roma, dentro de la Secundaria Técnica No. 78.

Monitoreo Atmosférico 2009

(28 de Julio al 3 de Agosto)

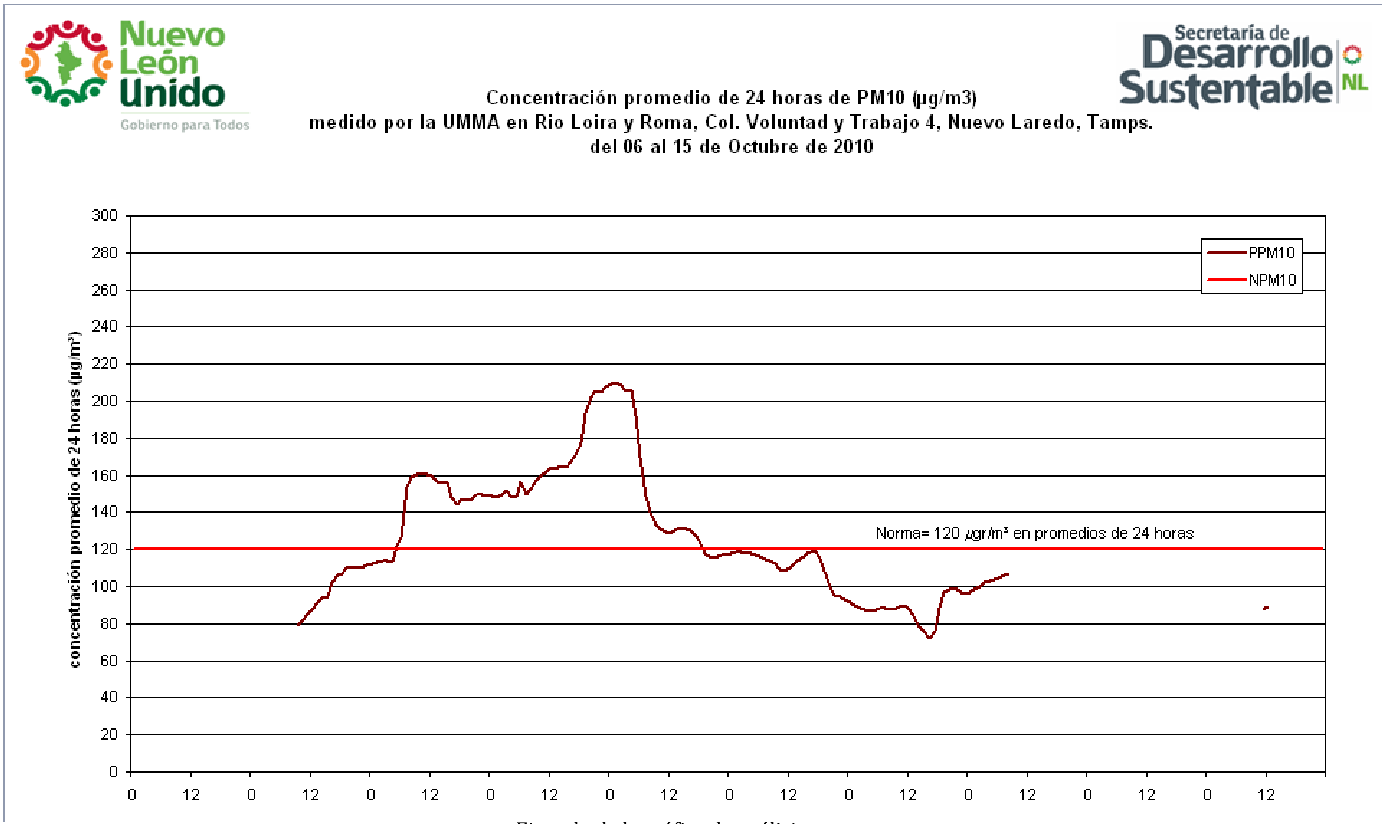


De acuerdo a las gráficas obtenidas en el análisis del resultado del monitoreo efectuado, se generan los siguientes comentarios:

- El aumento de la concentración del material particulado PM10 se observa después de las 8:00 hrs., sobre pasando el límite máximo permitido (lmp) de 120 ppm de acuerdo a la Norma Oficial Mexicana, y descendiendo hasta después de las 22:00 hrs. sin llegar por debajo del lmp.
- Este comportamiento se manifiesta en todos los días del monitoreo.

- La cresta (parámetro) más alto se determinó con un valor hasta de 750 ppm aprox. entre las 12:00 y 14:00 hrs.
- La cresta (parámetro) más bajo se determinó con un valor hasta de 35 ppm aprox. entre las 00:00 y 2:00 hrs.

Monitoreo Atmosférico 2010
(6 al 15 de Octubre)



Ejemplo de la gráfica de análisis

De acuerdo a las gráficas obtenidas en el análisis del resultado del monitoreo efectuado, se generan los siguientes comentarios:

- El aumento de la concentración del material particulado PM10 solo se observa después de las 6:00 hrs. del día 8 de Octubre hasta el día 10 a las 22:00 hrs. aprox., sobre pasando el límite máximo permitido (lmp) de 120 ppm de acuerdo a la Norma Oficial Mexicana.
- La cresta (parámetro) más alto se determinó con un valor hasta de 210 ppm aprox. entre las 5:00 y 6:00 hrs. del día 10 de Octubre.
- La cresta (parámetro) más bajo se determinó con un valor hasta de 72 ppm aprox. entre las 16:00 y 18:00 hrs.
- El resto de los días se mantuvo la concentración promedio por debajo de las 120 ppm, dentro de los parámetros permitidos por la Norma Oficial Mexicana.

Tabla Comparativa

Año	Concentración Máxima	Concentración Mínima	Días Monitoreados
2009	750 ppm	35 ppm	7
2010	210 ppm	72 ppm	10

Cabe destacar que las concentraciones promedio más altas en ambos monitoreos (2009 y 2010) fueron durante el fin de semana (de Viernes a Domingo).

A continuación se describe el análisis de otros parámetros del monitoreo atmosférico que van directamente relacionados con la calidad del aire del sitio materia del estudio, los cuales son importantes para contar con un criterio general de las condiciones particulares.

- Dirección del Viento

Se mantuvo un viento predominante del Este y Sureste la mayor parte del periodo de monitoreo

- Velocidad del viento

Se tuvo un promedio entre 6 y 12 millas por hora, velocidad máxima (15) y mínima (2.5)

- Presión Barométrica

Se mantuvo entre 740 y 755 milímetros de mercurio

- Humedad Relativa

Estuvo oscilando entre el 25% (mañana-tarde) y el 83% (tarde-noche)

- Radiación Solar

Oscilo entre 0 y 0.82 langs

- Temperatura

Se mantuvo entre 15 ºC (mañana) y 33 ºC (tarde)

Relación Puntos IMECA por contaminante
(Satisfactorio) menor a 100 puntos

- Ozono (O3)

Se mantuvo entre 3 y 55 puntos (**Satisfactorio**) promedio 29 puntos

- PM 10

Se mantuvo entre 60 y 145 puntos (**No Satisfactorio**) promedio 102.5 puntos; de los 10 días monitoreados, tres de ellos estuvimos por encima de los 100 puntos, lo cual se relaciona a la velocidad y dirección del viento, y la estructura de los predios colindantes.

- PM 2.5

Se mantuvo entre 8 y 52 puntos (**Satisfactorio**) promedio 30 puntos.
Este parámetro es muy relevante en materia de salud pública, ya que es uno de los principales contaminantes precursores de cáncer en vías respiratorias, el cual se relaciona con compuestos orgánicos volátiles como base de su emisión.

- Bióxido de Nitrógeno (NO2)

Se mantuvo entre 2 y 25 puntos (**Satisfactorio**) promedio 13.5 puntos

- Dióxido de Azufre (SO2)

Se mantuvo entre 2 (**Satisfactorio**)

- Monóxido de Carbono (CO)

Se mantuvo entre 5 y 13 puntos (**Satisfactorio**) promedio 9 puntos

Concentración promedio en 24 horas por contaminante

- PM 10

Se mantuvo entre 72 y 210 partes, el límite máximo permisible de acuerdo a la Norma Oficial Mexicana es de 120 partes; de los 10 días monitoreados, dos de ellos estuvimos por encima de la Norma.

- PM 2.5

Se mantuvo entre 2 y 36 partes, el límite máximo permisible de acuerdo a la Norma Oficial Mexicana es de 65 partes.

- Dióxido de Azufre (SO2)

Se mantuvo 2 partes, el límite máximo permisible de acuerdo a la Norma Oficial Mexicana es de 130 partes.

Concentración promedio en una hora por contaminante

- Ozono (O3)

Se mantuvo entre 3 y 60 partes, el límite máximo permisible de acuerdo a la Norma Oficial Mexicana es de 110 partes.

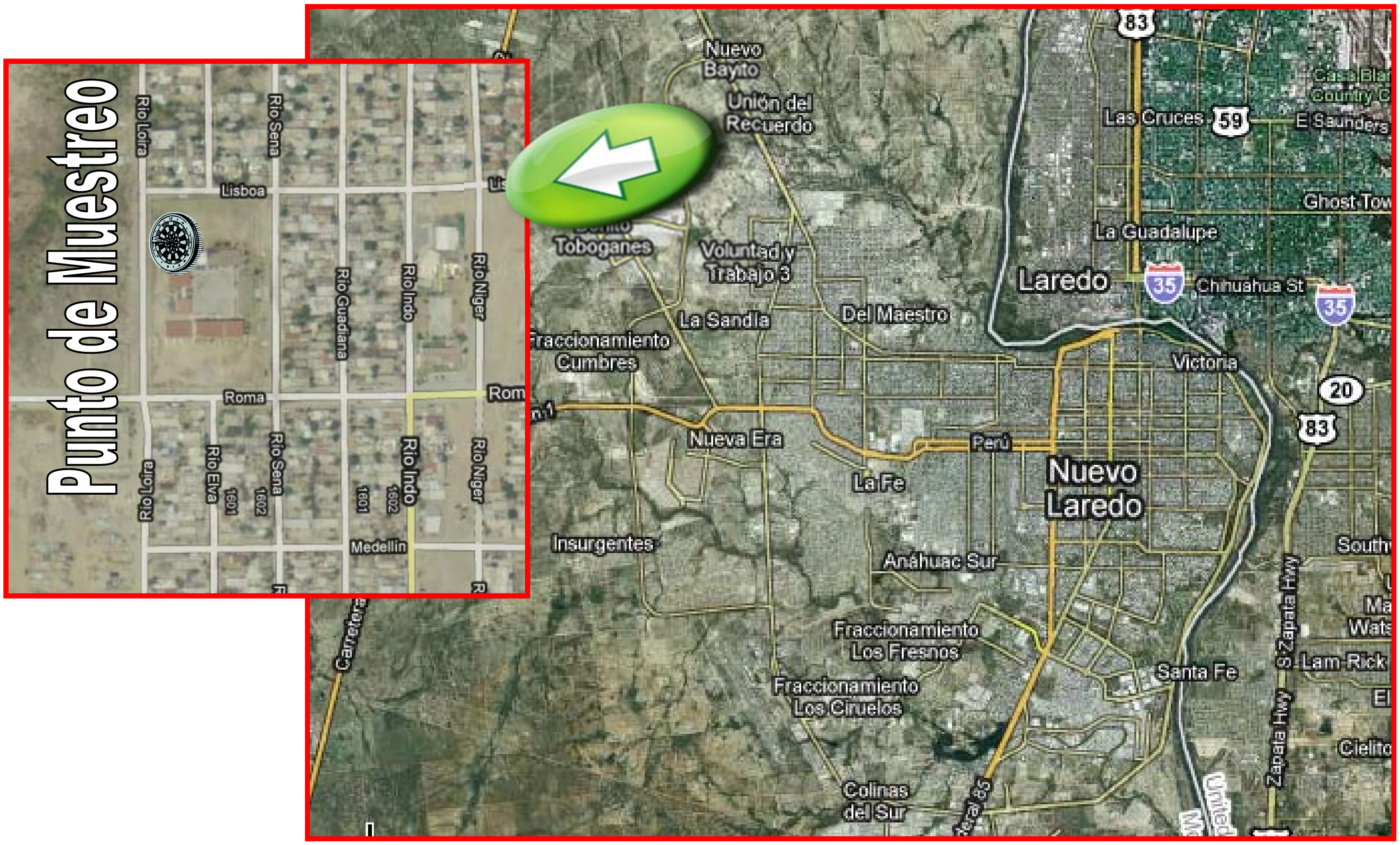
- Bióxido de Nitrógeno (NO2)

Se mantuvo entre 2 y 52 partes, el límite máximo permisible de acuerdo a la Norma Oficial Mexicana es de 210 partes.

Concentración promedio en ocho horas

- Monóxido de Carbono (CO)

Se mantuvo entre 0.5 y 1.3 partes, el límite máximo permisible de acuerdo a la Norma Oficial Mexicana es de 11 partes.
Comentario:
Cabe destacar que los contaminantes directamente relacionados con la circulación vehicular por este punto nos indica que las emisiones generadas por este punto están muy por debajo de los límites máximos permisibles de acuerdo a las Normas Oficiales Mexicanas, por lo que la Calidad del Aire es SATISFACTORIA para la comunidad de nuestra ciudad.


Punto de Muestreo
Rio Loira
Rio Sena
Lisboa
Rio Guadiana
Rio Indo
Rio Niger
Roma
Rio Elva
Medellin
Nuevo Bayito
Unión del Recuerdo
Toboganes
Voluntad y Trabajo 3
La Sandia
Del Maestro
Fraccionamiento Cumbres
Nueva Era
La Fe
Perú
Nuevo Laredo
Insurgentes
Anáhuac Sur
Fraccionamiento Los Fresnos
Fraccionamiento Los Ciruelos
Colinas del Sur
Santa Fe
Victoria
Laredo
Las Cruces
La Guadalupe
Chihuahua St
E Saunders
Ghost Tow
Zapata Hwy
Lam-Rick
Cielito
83
59
35
20