The application of a new air pollution management program (PROAIR) in Mexicali 2011-2020, Baja California, México

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Abstract

The *Program to Improve the Air quality of Mexicali 2011-2020* (PROAIR) was released in the year 2011 if applied as planned it will help to reduce the emissions of the different contaminants that exceed the normal values of air quality. The first Mexicali PROAIR 2000-2005 was released in 2000 and it followed a national policy to evaluate what at the time were considered the more polluted cities in Mexico, such as Mexico City; Guadalajara, Jalisco; Ciudad Juárez, Chihuahua; Tijuana, Baja California amongst others. In spite of the Mexicali PROAIR, Mexicali City is considered the most polluted in the world according to the World Health Organization (2011) at least in relation to particulate matter pollution PM_{10} and $PM_{2.5}$. This paper analyses the actual situation of Mexicali PROAIR 2011-2020, describes the air quality tendencies of the criteria pollutants (SO_2, CO, NO_2, O_3, PM_{10} and $PM_{2.5}$) and makes recommendations on how to reduce the air pollution. It is imperative that actions described in the program should be carried out in a common effort shared by all the participants to reduce the environmental impact of the air pollution at the US-Mexico border.
Keywords: air pollution management program, Mexicali, Baja California, Mexico, pollutants.

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1 Introduction

The city of Mexicali, Baja California, is located in a strategic place at the border of Mexico with U.S.A. It emerged as an agricultural area at the start of the twentieth century (Fig. 1). The Valley is characterized by very hot weather during the summer months and an air pollution problem caused primarily by suspended particles arising from the desert environment, a large agricultural sector, the vehicular fleet as a whole, and an abundance of unpaved streets in Mexicali. The location of the Valley of Mexicali and its neighbor Imperial Valley, CA, USA, where the cities of Calexico, El Centro and Brawley are found, is regarded as a unique international atmospheric airshed. Air quality has deteriorated over several years. Actually, Imperial Valley does not comply with the North American air quality standards for PM10 and Mexicali exceeds the Mexican official norms for PM10, carbon monoxide and ozone [1].

Figure 1: The city of Mexicali is located in the northwest of Mexico.

In 1987 The US Environmental Protection Agency (EPA) designated Imperial valley as a non-attainment zone for PM10, based on its failure to attain targets set in the State Implementation Plan (SIP) in 1990. Efforts to abate pollution are part of a strategic plan of local and federal authorities, through the Air Quality USA-Mexican Binational Task Forces.

The Program to Improve the Air Quality of Mexicali 2000-2005 [2] represents a joint effort of society, the local economic sector and three levels of government.

Due to its great urban dynamism, demographic, manufacturing and commercial activities, Mexicali, plays a significant role in the national economy. The growth of the city brings social and economic improvement, but also problems related with the urban development, in particular the deterioration of the air quality.

The proliferation of a great number of industrial, commercial and services activities, as much as an accelerated motorization, has caused a degradation of

the air quality of Mexicali, especially due to the bad state of public transport and private automobiles, and in particular due to the importation of second hand cars that generally did not pass the smog check in USA. Additionally, the situation is exhacerbated by emissions of particles and dust from the urban clandestine burns, agricultural burns [3], and emissions from paved and unpaved streets [4]. The existence in the Mexicali-Imperial valley region of Mexican and North American authorities with different responsibilities and jurisdictional structures; urban agglomerations with different levels of development; the diversity of agricultural, commercial and services activities; makes the solution to the air pollution problem the need for integred and complex approaches [5].

2 Tendencies of criteria air pollutants in Mexicali (1997-2008)

The air quality monitoring stations net in the city of Mexicali is integrated by: UABC station, ITM station, COBACH station, CBTIS station, PROGRESO station at the Health Center (Centro de Salud) and the CONALEP station at Ejido Puebla (Figure 2). The latter stations measure only PM10 on a weekly basis. The CBTIS station started operations in February 1997 and ended in 2002 for logistic reasons. It was replaced by CAMPESTRE monitoring station in 2005.

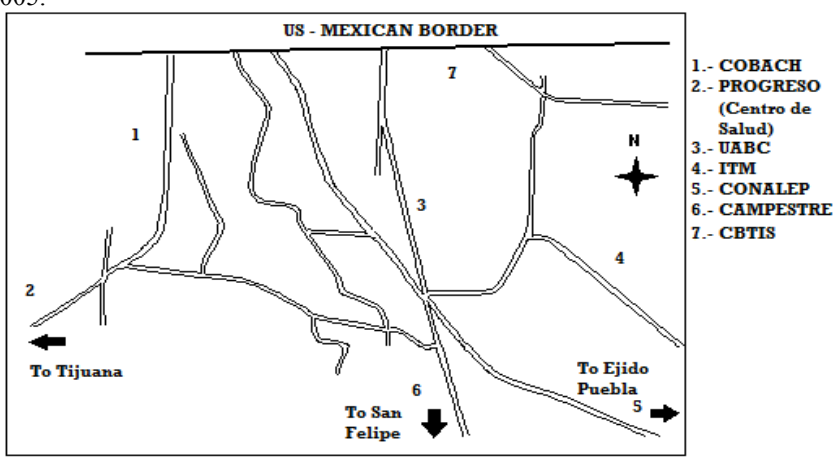

Figure 2: Distribution of the air quality monitoring stations in the city of Mexicali.

3 Criteria pollutants and national ambient air quality standards

Of the myriad of air substances known to be harmful to human health and welfare, some have been identified as being sufficiently hazardous and present in the air in sufficient quantities to merit enforceable standards. Mexico has developed and adopted the Mexican Official Norms (Normas Oficiales

Mexicanas–NOMs). Mexico has set standards for six categories of pollutants: ozone, carbon monoxide, total suspended particulates (more recently labeled particulate matter), sulfur dioxide, lead, and nitrogen oxide and established its own ambient air quality standards (the NOM), which are very similar to the National Ambient Air Quality Standards (NAAQS) from U.S. (Table 2)

Table 2: Comparison of ambient air quality standards (AAQS) in the United States and NOMs in Mexico, as of February 2010.

Pollutant	Averaging Time	U.S. NAAQS	Mexico NOM
Carbon monoxide (CO)	8-hour	9 ppm (10 mg/m^3)	11 ppm (12.6 mg/m^3)
	1-hour	35 ppm (40 mg/m^3)	
Lead	3-Month Average	0.15 μg/m^3 (October 15, 2008)	1.5 μg/-m^3
	Quarterly Average	1.5 μg/m^3	
Nitrogen dioxide (NO_2)	Annual (Arithmetic Mean)	0.053 ppm (100 μg/m^3)	
	1-hour	0.100 ppm	0.21 ppm (395 μg/m3)
Particulate Matter (PM_{10})	24-hour	150 μg/m^3	120 μg/m^3
	Annual	50 μg/m^3	50 μg/m^3
Particulate Matter ($PM_{2.5}$)	Annual (Arithmetic Mean)	15.0 μg/m^3	15.0 μg/m^3
	24-hour	35 μg/m^3	65 μg/m^3
Total suspended particulates (TSP)	24-hour		210 μg/m^3
Ozone (O_3)	8-hour	0.075 ppm (2008 std)	0.08 ppm (1993 std)
		0.08 ppm (1997 std)	
	1-hour	0.12 ppm	0.11 ppm
Sulfur dioxide (SO_2)	Annual (Arithmetic Mean)	0.03 ppm	0.03 ppm (79 μg/m^3)
	24-hour	0.14 ppm	0.13 ppm (341 μg/m^3)

Sources: EPA, SEMARNAT, and Mexico's Ministry of Health, 2010.

3.1 Nitrogen dioxide (NO_2)

In 2005 the potential emissions of NO_2 were in the order of 28,785 tons [6], out of which 44.6% came from the utility sector, 45.4% from the transportation sector and 10% from commerce, services, burning of agricultural residues, soil and other industries. An important change in relation to the contribution of NO_2 to the air, since PROAIR 2000-2005 is the vehicular fleet. Due to the

construction of a couple of combined cycle thermoelectric power plants to the west of Mexicali, the vehicular fleet became second in terms of the NO_2 pollutant, according to the Emissions Inventory [6]. The highest values were obtained at CBTIS in 1999 and at COBACH in 2007**.** Four exceedences of NO_2 were detected in 2001 and 2004 in violation of the norm at ITM. From 2005 to 2008 exceedences were not registered [7].

3.2 Ozono (O_3)

The highest values were obtained at COBACH in 2001 and at CAMPESTRE in 2007. Exceedence of ozone concentrations (1 hr) in all monitoring stations were detected. The highest values (16) were registered in 1997 at UABC monitoring station. The exceedence diminished to 2 in 2008 for the same monitor.

The study of the tendencies of concentration of ozone every 8 hours started in 2002 when this new norm was considered. There was only one peak in 2005 at the COBACH station and a decline at CAMPESTRE station. The highest value was registered in 2003. In 2008 a reduction of ozone at ITM and UABC was noted [7].

3.3 Carbon monoxide (CO)

The emissions of carbon monoxide (CO) estimated in the emissions inventory were 85,996 tons corresponding to the vehicular fleet, out of which 63,026 tons belong to the transportation sector, 4116 tons to the industrial sector and 18,854 tons to the commercial and service sectors. Figure 3 shows the annual average concentration of CO per monitoring stations at Mexicali. Highest values were obtained at COBACH in 1999.

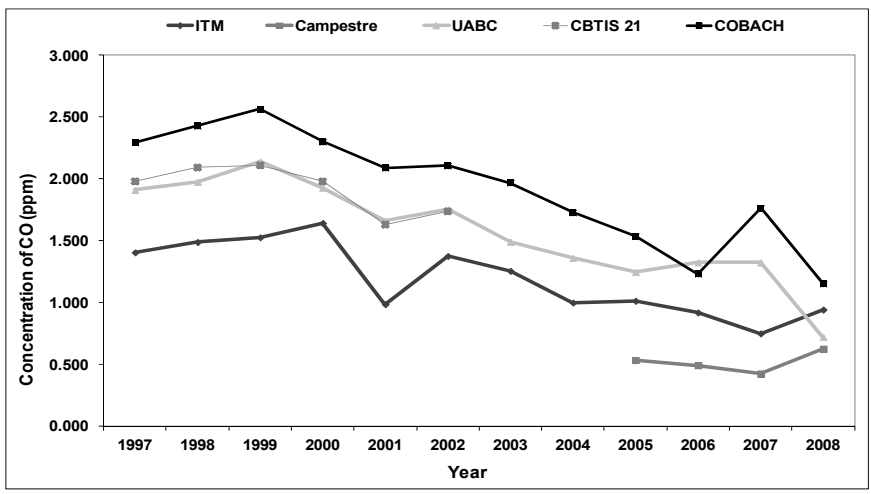

Figure 3: Annual averaged concentrations of CO at the air quality monitoring stations in Mexicali, 1997-2008.

The year with the highest number of exceedences (58) to the CO standard was 1998 at COBACH monitoring station. The number of violations detected reduced to 6 in 2006 [7].

3.4 Sulphur dioxide (SO_2)

Sulphur dioxide has not been an important pollutant in Mexicali, since there are not industries that utilize fuels with high sulphur content. No exceedences were detected which was the reason to continue the SO_2 pollutant readings just at the UABC monitoring station and abandon the other three [7].

3.5 Particulate matter (PM_{10})

The most important air pollutant in Mexicali is PM. It is considered the most polluted border city and third nationwide according to the Third Almanaque by the National Institute of Ecology [8]. The last emissions inventory [6] reported 53,818.11 tons/year of PM_{10}, out of which 87.2% originate from eolic resuspension from paved and unpaved roads and the rest, 12.8%, from industrial, road and non road mobiles. The averaged annual concentrations of PM10 per monitoring station in Mexicali from 1997 to 2008 are shown at Figure 4. Highest values were obtained at PROGRESO station in 2000. Tendency shows that values of PM_{10} concentrations are diminishing for 2008 in general.

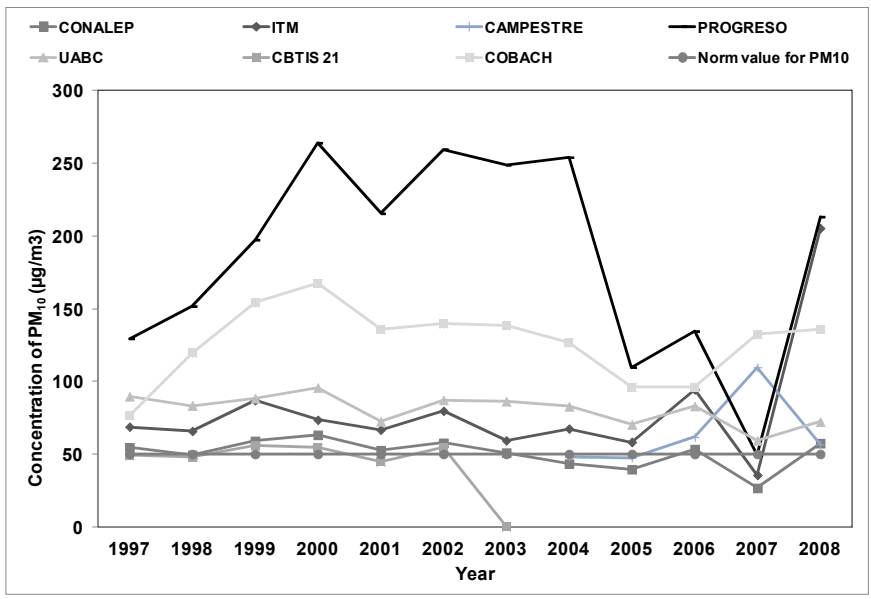

Figure 4: Averaged annual concentrations of PM_{10} at the air quality monitoring stations in Mexicali, 1997-2008.

The year 2000 registered the highest value at the PROGRESO station for the years under analysis. In the vicinity of the site where the monitor is located there is an unpaved road and the sampling equipment has not the right height. It is recommended to review the objective of the sampling at the PROGRESO monitoring station and decide whether it is better to relocate it [7].

3.6 Particulate matter ($PM_{2.5}$)

In Figure 5 are shown the annual concentrations of $PM_{2.5}$ since the monitoring was established at UABC station in 2003 using the technique of Beta Attenuation Monitor (BAM). It is the only station where this pollutant is sampled. Discontinuous values were obtained during the years, and 2004 was the most complete.

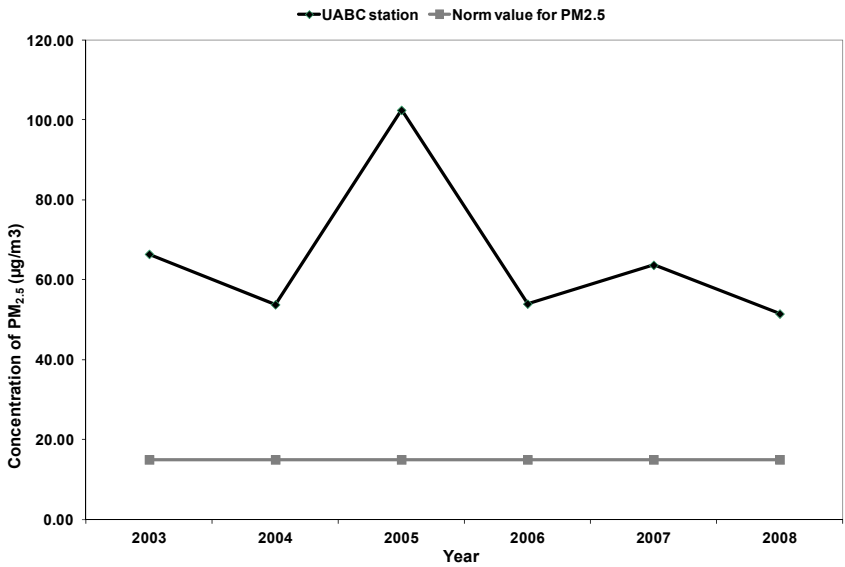

Figure 5: $PM_{2.5}$ concentrations for the UABC monitoring station using the BAM technique.

In the case of PM2.5, the year 2008 registered the largest number of exceedences (78) [7].

4 Strategies and measures for the PROAIR Mexicali 2011-2020

The "PROAIR" has as a general objective the health of the population, reducing the concentration of pollutants in the atmosphere, by the application of coordinated actions aimed at the control of emissions from industry, commerce, services, transport and soil.

The PROAIR Mexicali 2011-2020 [7] proposes 5 concrete strategies and 40 measures to be implemented that will allow in the midterm reduction in the pollution of the city until eventually the normativity for air quality is reached. The environmental authorities from the municipality, the state and the feds, members of the academic community and non gubernamental organizations participated in developing the program. The program is a guide not only for the benefit of Mexicali, but the whole binational airshed, which includes the neighboring county of Imperial Valley, CA, USA. The strategies and the most important measures are described next.

4.1 Strategy I. reductions of emissions from fixed sources

Eight measures were established, out of which two are critical: strengthen the inspection and vigilance in industries within federal and state jurisdiction and the design and application of a program to reduce the emissions in a coordinated manner with the electricity utilities.

4.2 Strategy II. reductions of emissions from area sources

Of eleven measures the following are directly relevant: design of a program to reduce the burning of agricultural residual and the application of actions to reduce the emissions of particulate matter from paved and unpaved roads.

4.3 Strategy III. reductions of emissions from movil sources

Relevant measures are: establishment and supervision of a compulsory smog and check program and the creation of an initiative to reduce the emissions by automobiles and pickup trucks at the border crossings.

4.4 Strategy IV. protection and prevention of community health

Of the five measures the relevant ones are the development of a system of epidemiological vigilance and the development and application of a program of atmospheric contingencies.

4.5 Strategy V. development of institutional capacities, education and international cooperation

Eight measures were designed and the most relevant in terms of its effectiveness was the establishment of the Core Committee which will be in charge of implementing, following up and evaluating the PROAIR.

5 Conclusions

It is important to mention that this analysis was done with 12 years of data, since the beginning of the operation of the air quality monitoring stations (using data base of AQS from USEPA and from The Secretary of Environmental Protection

of the State of Baja California),. Some conclusions may be drawn on the actual status of the air quality of Mexicali:

- Ozone (1hr), the exceedences for O_3 (1 hr) have been diminishing since 1997.
- Ozone (8 hr), since its evaluation began in 2002 has diminution with time.
- Nitrogen dioxide, with 2 or 3 exceedences from 1998 to 2004, respectively, shows no violations from 2005 to 2008.
- CO, shows a low trend in all stations. It registers the biggest number of violations to the norm during the period under study and with a high contrast: 144 exceedences in 1999 and zero in 2008. Levels of CO were higher at winter time due to atmospheric stability in those months.
- SO_2, no exceedences were detected at all times. Sampling of SO_2 was left only to UABC station
- PM_{10}, exceeded the norm mainly at winter time, during unrainy months. PROGRESO station registered the highest averaged annual values, runner up being COBACH station. It is recommended to relocate PROGRESO station due to it actual location in a semi-rural zone and the height of the sampler. It explains why Mexicali stands as the most polluted city in the world in relation to particulate matter [9].
- $PM_{2.5}$, has exceeded the norm since the sampling started at only the UABC station using the BAM system. In 2008 80 violations to the norm were registered.
- Zone pollution. The trends of pollutants by zone, in Mexicali normally the norms for O_3 and CO are exceeded in the west (COBACH). Violations by NO_2 are found in the east (UABC). Concerning PM the west zone shows 50% of the sampling out of norms.
- Is convenient to make clear that although some trends show decreasing pollutants it does not imply that the air quality is becoming optimal, as there still some episodes close or exceeding the maximum permissible limits of the Mexican normativity (NOMs).
- The solution to the problem of atmospheric pollution in this Mexicali-Imperial valley airshed would be possible if it is given the involvement of the people that live and work in the region and the adequate coordination of the authorities in the application of the necessary measures in order to reduce the environmental impact of the area. The permanent follow up of the advancement in the development of the PROAIR will allow to evaluate its efficiency and to orient its course in a dynamic way.

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