ASSESSING THE IMPACT OF THE HIGHWAY 25 EXPANSION PROJECT ON AIR QUALITY IN MONTREAL USING GIS

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ABSTRACT. ***Assessing the impact of the highway 25 expansion project on air quality in montreal using gis.*** *The aim of the paper is to assess local air pollution implications of the Highway 25 expansion project from Montreal. The basic concept of the roadway air dispersion model consists in calculating air pollutant levels in the vicinity of a highway by considering it as a line source. To fulfill this assessment, GIS software was used in order to determine pollutant distribution around the study area based on data collected by existing air monitoring stations located in the City of Montreal. GIS interpolation methods, notably Kriging and Inverse Distance Weighted (IDW), was used to generate maps of pollutant concentrations across the study area. From the results, recommendations will be made in regards to the project and appropriate mitigatory alternatives suggested.*

Key words: GIS for EIA, traffic pollution, air quality

1. Introduction

Within the transportation sector, many GIS applications have been used in order to improve the management of urban transport infrastructure mainly based on geotechnical and environmental considerations in highway layouts (Wang et al., 1996, Salah et al. 2000, Antunes et al., 2001). Air pollution from vehicular sources can also be assessed using GIS tools (Matejicek et al., 2006), modeling for the prediction of long-term average concentrations of traffic air pollutants still remains an important approach for the assessment of individual levels of exposure to traffic-related air pollutants (Hochadel et al. 2005, Litman 2005). Line source models simulate the dispersion of local pollutants, Gaussian based models being used in various dispersion models such as CALINE4, HWAY-2, GM model (Sivacoumar and Thanasekaran 1999). GIS provides several advantages for spatial analysis, however it still face limitations for assessing dynamic complex natural phenomena, such as air dispersion.

2. Study Area, Project Description and Context

The study area covers part of Northern Montreal and South-East Laval which is experiencing currently rapid development. Inaugurated in 1966, the Autoroute 25 serves as a link between areas in Northern Montreal, Laval and Lanaudiere and it is part of the TransCanada Road between the Metropilitan Boulevard (40) and the Autoroute 20. Currently, it misses part of the layout designed to cross Rivière des Prairies. On several occasions, the MTQ[1] had postponed the expansion of this section as a result of the strong opposition towards the project from several groups of citizen and associations. But starting to 2007 the Government has decided to proceed forward for the completion of the Project Autoroute 25. According to the Ministry of Transportation of Quebec (MTQ), the main objectives of this project are (i) to improve the traffic between North-East Montreal and Laval; (ii) to reduce the congestion of major roads such as highways 440, 40, 125, 19, 15; and (iii) to support the economic development of East Montreal and Laval. This project is also expected to help the provincial government comply with the Kyoto protocol agreement. However this project has been criticized since the first attempt[7] appeared to be inopportune and irrelevant due to its potential adverse impacts on the environment. An updated Environmental Impact Assessment (EIA) report (MTQ, 2001) had concluded to non-significant environmental impacts after mitigatory measures were applied.

This study area covers the whole linear trajectory of the proposed extension of highway 25 but as well a 5 km buffer on either side of the highway measuring approximately 200 sq. km. The extension of the study

[7] MTQ, (Ministère des Transports du Québec) EIA Report for Highway 25 Completion, published by the Ministry of Environment (MENV, 1992)

boundary of 5 km on either side of the highway was chosen due to the traveling abilities of air pollutants. The limit imposed by the study area does not mean that pollutants will not go beyond these boundaries but concentrations of pollutants will be highest within the boundary and therefore most significant within this area.

The Extension of Autoroute 25 will start from Boulevard Henri-Bourassa in Montreal to Highway 440 in Laval (fig.1). With a total length of 7.2 km and 90 m wide, the Autoroute 25 will have frontage roads on both sides including a bridge of 1.16 km crossing Rivière des Prairies. The Highway will have six lanes on two roadways separated with traffic interchanges and staging crossroads and railroads. In addition, the project will integrate a turnpike within Public-Private partnership and preferential regulations for the public transportation.

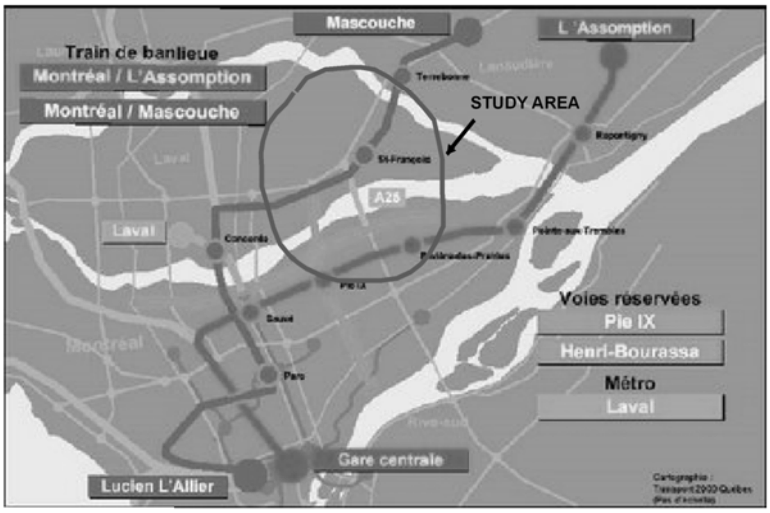

***Fig.1**. Montreal: main trafic system and study area*

Traffic is a major source of local air pollution in Quebec and as the Highway 25 expansion is a transport development project, this sector and its influence remains the primary context for our investigation into air pollution. Induced demand can inspire more vehicles utilizing the highway, as well as new urban and industrial development (Cervero, 2003).Various groups have noted the typical feedback mechanism, as eventually development and congestion rises and with it more local air pollution (Noland 1998, Sivacoumar et al.1998, Wang 2005). As reported by previous studies (Wang et al. 1996, Antunes et al. 2001, Henderson et al., 2005, Litman 2005, Hochadel 2006, Matejicek et al. 2006) public transport availability has an effect on transport choice and air pollution. Collectively, air pollution by public buses and other public transport modes is substantially less than private vehicles which are often single occupancy.

3. Data Collection

Collecting data for impact analysis and obtaining information has been very constraining and time consuming. First step has been to identify which data are needed for this specific study. In this case, most of the information collected comes from provincial agencies and local planning authorities.

For more than 30 years, RSQA[8] in conjunction with NAPS[9] is monitoring different types of pollutants that affect air quality around the City of Montreal. The Air Quality Index (AQI) is then used to control the Air pollution level. In Canada, this indicator measures mainly ground-level ozone and particles and provides information about population exposure to the tropospheric ozone, which is a key constituent of the smog. The monitoring network is made of 16 air monitoring stations distributed inside Montreal Island.

Among these stations, only three are located near the study area: Parc-Pilon (029/ Montreal North); Rivière des Prairies (055) and Anjou (006/ Chateauneuf). But, this last station measures only suspended particulates matters lower than 10 microns (PM_{10}) and lower than 2.5 microns ($PM_{2.5}$).

Baseline conditions refer to the current status of the Highway 25 study area. A strong understanding of baseline conditions is an important starting point for the prediction of impacts. In that case initial conditions to assess air quality are related to the SO2 concentrations, O3, NO2, CO and the suspended particles in the ambient air. However, for illustrative purpose and due to a better

[8] RSQA: Réseau de Surveillance de la Qualité de l'Air: http://www.rsqa.qc.ca/framville.asp?url=framrsqf.asp

[9] NAPS: National Air Pollution Surveillance http://www.etc-cte.ec.gc.ca/NAPS/index_e.html

representation, focus was made on Ozone which is monitored by ten stations within the City network. Data collected from air monitoring stations inside the buffer zone show according to ambient air quality norms that mean annual values are generally higher than annual mean standards (more than 40 with standard set to 30 μg/m^3 for the City of Montreal) (tabel 1).

Tabel 1. Ambient Air Quality Norms vs Canadian National Objectives

Ambient Air Quality Norms vs Canadian National Objectives (μg/m3)			
	Standards (Annual Mean)		(μg/m3)
Pollutants	Montreal Norms	National Standards	American Standards
Sulphur dioxide	52	60	80
Carbon Monoxide (1h)	35	35	40
Ozone	30	30	-
Nitrogen Dioxide (1h)	400	400	-
Nitrogen Monoxide (1h)	1300	-	-
Particulates	70	70	-
PM10 (24h)	50	60	150
PM2.5 (24h)	25	30	65

4. GIS Dataset and Scenario Analysis

Ozone data were extracted from RSQA database, and then exported to Excel where we have calculated the means for each station. The maximum values could be used; however these are not representative of the real situation along the whole year. For some reasons, the ozone ground level may reach high levels during one or two days. To overcome missing data issues from RSQA database, mean values have been generated accordingly to a database available for 2003.

Conducting a field sampling with more stations for monitoring the level of pollution of the ambient air in the study area around Autoroute 25 would be very useful to develop a sound GIS dataset for our analysis. For that reason, we created an arbitrary monitoring station exactly in the same location as the A25 Project and a mean value for the baseline condition was estimated from an initial interpolation of the closest ozone monitoring stations to the project site.

ArcGIS extended by geostatistical methods such as Inverse Distance Weighted (IDW) and Kriging with the Gaussian model were used to assess the impact of Project highway 25 on air quality. These interpolations methods provide predictions of ozone concentrations above the study area. However, the lack of monitoring stations in the Laval side does not allow to get a global sense of pollutant dispersion and ozone concentration in that area. Beside the geographic location of the stations and values of pollutant concentrations measured, the following data were also needed as inputs parameters for the GIS dataset: *meteorological conditions* (wind direction, speed and atmospheric stability), *traffic volume* (count of daily number of vehicles), *geometry of the road*, *distance between source and road.*

The equation used was integrated into a closed form solution using variations in geometry performed to include the full infinite line and to calculate three dimensional contours of resulting air pollutant concentrations:

$$\chi = \int_0^\infty \frac{q}{\pi\,(ucdx^2)\,(cos\alpha\;)} \left(\exp \frac{y^2}{2c^2x^2}\right) dx$$

where:
x is the distance from the observer to the roadway
y is the height of the observer
u is the mean wind speed
α is the angle of tilt of the line source relative to the reference frame
c and *d* are the standard deviation of horizontal and vertical wind directions (measured in radians).

To estimate the effect of project-A25 on Air quality, assumptions have been made based on the increase of the pollution levels as a result of traffic induced capacity (Litman, 2005) (fig.2).

Baseline Scenario: The Baseline scenario has been developed in the premise that future economic development will occur at the same pattern as it has been during the past trends (fig. 2).

Assumption made in the baseline scenario derives from both the ISQ census and Transport Quebec surveys on traffic analysis (MTQ, 2001) and according to information on traffic volume along A25, we could generate our dataset for the baseline using interpolations methods (Inverse Distance Weighted (IDW) and Kriging with the Gaussian model) (fig.3).

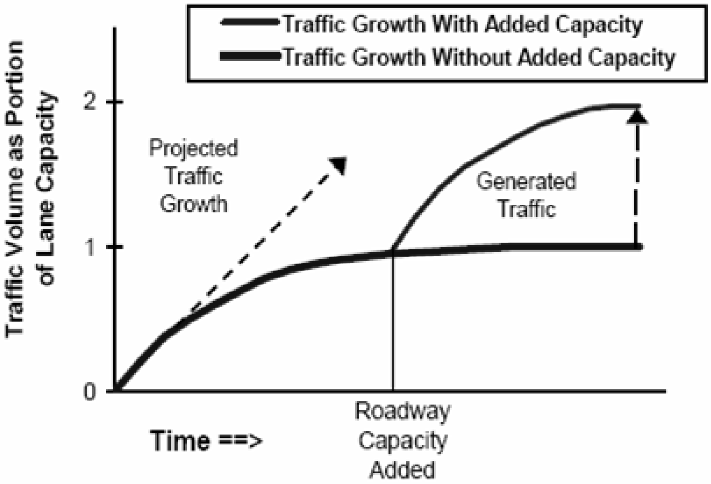

Fig.2 *Trends related to baseline and projected trafic scenario (Litman, 2005)*

*Project Scenario***:** This scenario involves the expansion of the Project A25 going ahead as planned, with development and population growth occurring on the North side of Rivière des Prairies. With the shift of vehicular traffic to the Highway 25 bridge site and increased traffic due to urban expansion and induced traffic (Litman, 2005), it is assumed that local ozone pollution levels will increase. This was built into the GIS application by increasing ozone levels at the new monitoring site "Hwy 25" by 20 per cent and other adjacent sites by 10 per cent, including air stations located at Rivière des Prairies and Parc-Pilon (fig.4).

Alternative Scenario: This one involves the absorption of much of the new and some of the existing commuter traffic through the aggressive use of less polluting public transport modes such as bus and subway. Similarly, car-pools and cleaner vehicle types could be promoted to mitigate atmospheric pollution production by increase of fuel efficiency. Therefore, to create the dataset used in this scenario, we assumed that ozone levels would decrease at the four adjacent sites by 10% in comparison with the baseline scenario. The ozone levels at the Hwy 25 site were lowered 20% to represent a best-case pollution mitigation scenario at the project site.

Air quality is very difficult to model and represents one of the most challenging aspects of GIS work for EIA (environmental impact assessment).The reliability of the interpolated predictions is compromised due to the lack of data across the study site. Given the ongoing interest in the project from multiple levels of government, the lack of air pollution monitoring sites in Laval or within the vicinity of the project is a surprise and remains a subsequent limitation of this analysis. In the EIA report released from the proponent (MTQ), analysis have been done using expert judgment based only on a few air stations monitoring located far from the study area. Ideally, a more robust number of sampling sites were needed to interpolate data and model air pollution.

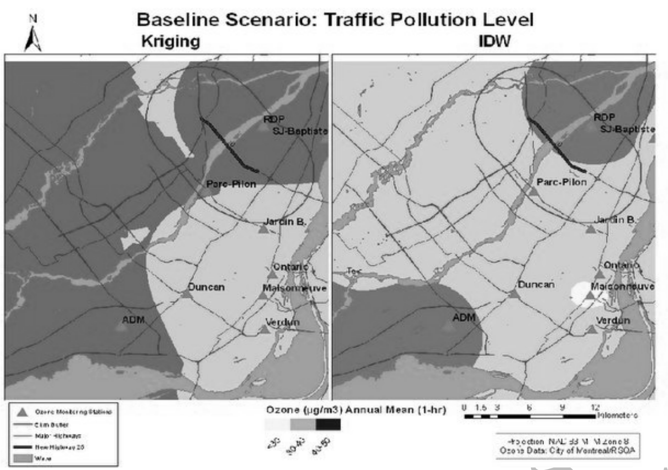

Fig.3: *The Baseline scenario*

5. Results and Discussion

After performing GIS analysis based on 2003 available data, three different scenario maps were created using two different methods of interpolation: Kriging with Gaussian model and IDW and trend analysis .
For IDW interpolation method we have used an optimized power factor and for Kriging, the angle direction was set to 200 degrees as South-West wind is dominant. The two methods provide interesting results however the Kriging/Gaussian model fit better for predicting and assessing air dispersion due to the fact that beyond the traffic volume, it also incorporates meteorological data such as wind direction, included in trend analysis which provide three-dimensional perspective of the data (fig. 5). Based on results, it appears that the proposed project will likely lead to an increased local air pollution within the study area.

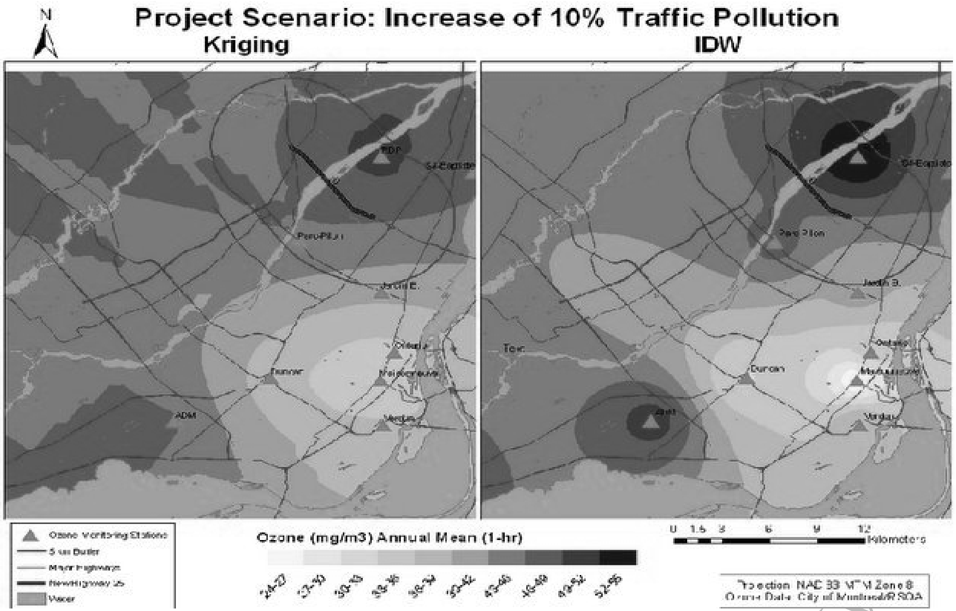

Fig. 4 *Project scenario*

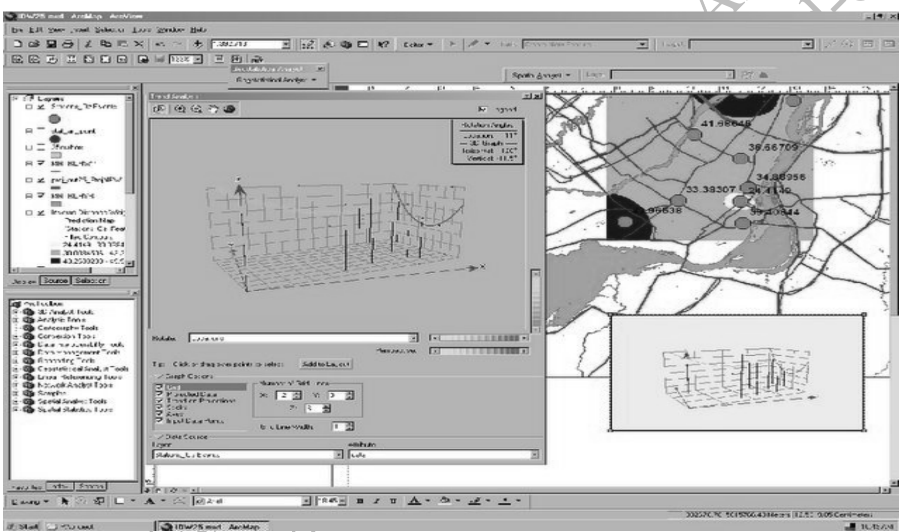

Fig.5 *Trend analysis*

Due to the complexity of atmospheric phenomena, an air dispersion model would have been more appropriate to simulate the dispersion of pollutants derived from line sources emissions, such as roadways and highways.

Results from this analysis indicate that the proposed project will negatively affect air pollution within the study area. Increased use of public transit, as represented by our alternative scenario, indicates that any future growth in the region and its impacts on air pollution could be mitigated in large part by shifting future transport requirements largely to alternative transport modes such as metro, buses and car-pools. As infrastructures are already in place this solution would be much more efficient in terms of congestion reduction and improvement of the air quality.

Acknowledge:
This paper is a result of the term project on GIS for EIA course held by Professor Sebastian Caquard at Concordia University, Montreal,Canada.

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