Breathing Harmful Air:
Considerations for Bicycle Route Selection and Design

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1. Introduction

Air quality has always been a concern in Hamilton, which is located about 70 km southwest of Toronto at the western corner of Lake Ontario (see Note 1). The City is a major steel and heavy industrial area with the accompanying pollution problems. Since the 1980's, industrial pollution has been slowly decreasing due to automation and stricter emission control measures.

In 1994, the City together with their partners in government, community, industry and academia carried out an assessment of the City's air quality situation. The study report concluded that significant health effects were associated with fine particles (PM10), ozone (O_3), nitrogen oxides (NO_x) and sulphur dioxide (SO_2). The report stated that these pollutants contribute to some 300 hospitalizations and at least 100 premature deaths annually in Hamilton. The victims are most often the elderly and people with heart and lung disorders.

Air pollution is of course not limited to Hamilton. Government agencies and the Ontario Medical Association (OMA) have expressed concerns about the increasing levels of fine particles and other pollutants. Some of these increases are due to emissions from autos and trucks. While emission control standards have become more stringent, increased vehicle usage per capita and a growing population will continue to degrade air quality.

Health studies have connected air quality, particularly PM10, O_3 and SO_2 with premature mortality and hospital admissions (see Note 2). The OMA reported that people with respiratory diseases are particularly at risk. People who carry out physical activities outdoors such as cyclists, joggers, walkers, outdoor workers and children may also be at risk.

As part of the City's Sustainable Community initiatives, cycling has been promoted for its health benefits and as an alternative mode of transport. However, a large proportion of cycling occurs on streets close to motor vehicle traffic. Not much research seems to have been undertaken on the health effects of air pollution on cyclists.

The purpose of this paper is to start a discussion on the effects of air quality on the selection and design of bicycle routes. The paper describes both the air quality and cycling activity in the City of Hamilton. This is followed by the results of some studies and observations which attempt to relate air quality, health and cycling. The paper concludes with some suggestions for bicycle route selection and other measures to reduce the adverse health effects of air pollution on cyclists.

2. Air Quality in Hamilton

The haze we experience on hot summer days, sometimes called smog, is comprised of fine particulate matter and other pollutants. It is a complex mixture formed in the air through heat and sunlight. Particulate matter is a generic term referring to small airborne particles including soil, dust and soot. Fine particles vary in size from 0.005 to 10 microns in diameter and are known to penetrate the respiratory tract. In comparison, a human hair is 70 microns in diameter.

In addition to tail pipe emissions, fine particles are created when dust on the roads is kicked up by traffic. Emissions from trucks, particularly those with diesel powered engines, are an important source of air pollution. Traffic congestion and stop and start situations produce increased tail pipe emissions.

Various government agencies have set standards above which smog alerts are being sent out. The air quality guideline of the World Health Organization (WHO) is 70 micrograms per cubic metre (µg/m3) as a 24-hour average. In Ontario, the Ministry of the Environment has set an Air Quality Index at 50 µg/m3.

Smog occurs mostly on hot sunny days. In recent years, there have been two or three occasions annually in Hamilton when the Air Quality Index has been above 50. These events have lasted two or three days, i.e. a total of five to six days a year.

Pollutants come from a variety of sources. Some are local, while others come from well beyond municipal boundaries. In Hamilton, 55 percent of the inhalable particles come from outside, 15 percent come from industry and 30 percent come from motor vehicles. The amount of fine particles (and other pollutants) produced by motor vehicle emissions is significant. It is predicted that emissions will grow significantly unless expected technological improvements take place and the growth in road traffic is reduced, especially the number of single occupancy vehicle trips.

3. Cycling Activity in Hamilton

Current and future cycling activity was determined through an analysis of demographic changes, lifestyle trends and travel data (see Note 3). The information was obtained from usage and attitudinal surveys in the urban area of Hamilton. It was found that:

- Forty percent of the adult (18 years and over) population cycles; half of them for both transportation and recreation, and the other half for recreation only.
- The total number of cycling trips relative to the number of trips by all modes of transport per day is small, approximately 2.5 percent during favourable weather conditions.
- Cycling is concentrated in certain residential areas which have higher housing densities.
- The distances traveled by cyclists are short: nearly 90 percent of all trips are 5 km or less, i.e. up to 15 to 20 minutes of cycling. But also a large number of auto trips are short: 50 percent are less than 5 km. Concerns about cycling are mostly related to inconvenience and traffic safety, and not to adverse health effects of air pollution.
- A significant increase in recreational and short trips may be expected in the next ten years as a result of a greater awareness of lifestyle issues, the trend to retire earlier and the high profile promotion of long trails such as the Trans Canada Trail.
- The growth potential for commuter trips is relatively small, as commuting by bicycle is no competition to motorized vehicle travel in terms of time and convenience.

Thus, the large majority of cycling trips are short. Some current auto trips could easily be converted into cycling trips, such as trips to the library, corner store, visiting friends, etc. These short trips would require bicycle-friendly neighbourhoods. Commuter and recreational trips tend to be somewhat longer; they are often made, entirely or in part, along major roads adjacent to motor vehicle traffic.

4. Air Quality, Health and Cycling

As part of their Sustainable Community initiatives, the City wants to encourage a shift in personal lifestyle and behaviour towards transportation choices that enhance personal health and fitness. The long-term result of this goal would be a healthier general public and reduced hospitalization costs and employment absences. One change people could make is to start cycling or cycle more often. Regular cycling improves physical activity levels and has environmental advantages such as cleaner air.

A large proportion of cycling occurs on our streets close to motor vehicle traffic. Cyclists may breathe harmful air as they can be within a few metres from the tail pipes of passing motor vehicles. In some parts of the world, cyclists are wearing masks on smog and other days.

It may be expected that long-term exposure to motor vehicle emissions is detrimental to the health of cyclists. Recent studies indicate that current levels of ambient air pollution, especially fine particles, may cause increased respiratory and/or cardiovascular illness. While it may be expected that cyclists with respiratory problems such as asthma, emphysema and chronic bronchitis are sensitive to these air pollutants, the effect on “healthy” cyclists is unknown. Not much research seems to have been undertaken on the health effects of air pollution on cyclists.

A study of some interest regarding this relationship was carried out in Hamilton as part of a proposal to construct a freeway and a parallel trail through the Red Hill Creek Valley (see Note 4). The projected daily traffic volumes on this freeway are in the range of 60,000 to 75,000 vehicles, of which 7.5 percent are large trucks. The trail is generally 100 m from the nearest freeway lane edge; one section of 300 m is within 50 m and several short sections are within 20 m of the road edge.

The concentrations of various pollutants at the adjacent trail were predicted using a computer simulation model with receptor locations. It was found that the levels of carbon monoxide (CO) and nitrogen dioxide (NO_2) were well below government standards. But the levels of fine particles (PM10) were exceeding the standards at some locations close to the roadway edge.

To determine the health risks to trail users, it was assumed that the trail was used during six months (May to October) by boys 13 to 17 years old and with a minimal mean body weight of 50 kg. They would spend 1 hour/day twice a week on the trail (i.e. “worst case approach”).

It was found that trail users on the worst days would receive about seven times the exposures of fine particles they would have received elsewhere in Hamilton. Scientists could not quantify the frequency and severity of the health effects of these exposures. They would only say that there is evidence of a relationship between air pollution and health impairments such as respiratory and cardiac illnesses, particular among the young and the elderly. These specific age groups should therefore be encouraged to limit their use of the trail.

It may be concluded that cyclists along streets with high volumes of motor vehicle traffic and on trails close to such roads are being exposed to fine particles with possible adverse health effects. Scientists seem currently unable to quantify these health risks. Cyclists suffering from cardiovascular and respiratory illnesses should limit their exposure, particularly on days with smog.

5. Bicycle Route Selection and Design

From a cycling perspective, the ideal street network would consist of all bicycle-friendly streets. This ideal is not affordable in Canadian cities in view of the small number of cycling trips and the lengths of the street networks. Unless there is a drastic change in personal mobility and behavioural attitudes this ideal will not be reached. North Americans are simply not willing to voluntarily reduce motor vehicle usage. The most cost efficient way to serve cyclists is therefore selecting and installing designated bicycle routes and improving bicycle-friendly neighbourhoods.

5.1 Bicycle Route Selection Criteria

In general, proposed route locations are evaluated and selected using three categories of criteria which a number of matters considered under each category:

- Continuity and Linkage – Items considered include the total length of the route, the number of stop signs and traffic signals encountered, important destinations on or near the route, direct connections to neighbourhoods and directness between origin and destination. This criterion should be used, for example, when the installation of wider curb lanes or bicycle lanes along major roads is being considered.
- Safety and Comfort – Items considered include the number and width of the traffic lanes along the route, the volume and speed of traffic, the percentage of trucks and buses encountered, the condition of the pavement and the sense of personal security. This criterion also guides the type of bikeway that should be selected. Table 1 is being used in Hamilton for this purpose.
- Ease of Implementation – Items considered include the presence of street parking, the need to adjust lane widths, impacts on traffic controls, cost and time required to implement.

24hr Volume per Lane	Average Motor Vehicle Operating Speed (km/h)			
	< 30	30 - 50	50 - 70	> 70
< 3,000	SL	WCL	WCL or BL	N/A
3,000 - 5,000	WCL	WCL or BL	BL	BL
> 5,000	N/A	WCL or BL	BL	BL or MP

SL = Shared Use Lane; WCL – Wide Curb Lane; BL = Bike Lane
MP = Multi-Use Path; N/A = Not Applicable

Table 1

The selection criteria do not include environmental factors. Air and noise pollution (and other factors) are, however, closely related to motor vehicle traffic. Multi-lane streets with high traffic volumes and speeds would require bicycle lanes or multi-use paths according to

Table 1. Bicycle lanes may not be advisable on some of these streets from a traffic safety viewpoint, but also because of the pollutants emitted, particularly if there is poor air dispersion. Building a multi-use paths farther away from the roadway or rerouting cyclists may be better solutions. Hence, a separate evaluation factor for air pollution may not be required as long as air dispersion is taken into account.

5.2 Mitigating Measures

The adverse health effects of air pollution on cyclists can be reduced through a variety of bikeway planning and design measures, improved public works practices and personal (cyclist) initiatives:

- Bikeway planning and design measures:
  - Install routes along existing streets with lower traffic volumes and connect them with cycling priority measures as, for example, in Vancouver. Such routes are sometimes called “bike boulevards”.
  - Designate urban trails provided that they are paved and without hazardous street crossings as, for example in Calgary.
  - Realign the route to create a larger separation between the roadway edge and the bikeway; this may be applicable to trails. For example, the Red Hill Valley trail was realigned as a result of the air quality and health effects investigations.
  - Install screens such as walls and plantings.
  - Install traffic calming measures instead of 4-way stop signs.
- Personal initiatives by cyclists in changing their riding routines:
  - Take a longer route along local streets with lower traffic volumes;
  - Refrain from cycling on “smog” days along streets with high traffic volumes, particularly cyclists with respiratory illnesses.
- Public works practices aimed at reducing the dispersion of fine particles:
  - Improve street cleaning such as wet roadway sweeping and flushing.
  - Pave the shoulders of roadways.
  - Pave trails.
  - Prevent soil erosion by planting vegetation.
  - Reduce the use of sand and salt in winter through improved snow plowing.

6. Conclusions

The following tentative conclusions can be reached:

- Motor vehicle traffic is a major source of air pollution, including fine particles.
- Research on health effects of air pollution is not conclusive except the growing evidence of the relationship between air pollution and increased respiratory illnesses such as bronchitis, asthma and pneumonia. This increase is becoming a major public health concern.
- No additional criteria for the evaluation and selection of possible routes are required provided the extent of air dispersion is accounted for.
- Concerns about air pollution should not affect the growing participation in cycling as a healthy way of transportation and recreation provided bicycle routes are carefully selected, designed and maintained and individual cyclists change their cycling routines on days with poor air conditions.

Notes

1 Currently, the Region of Hamilton-Wentworth consists of six local municipalities with a total population of approximately 475,000. The population of the urban area is approximately 300,000. On January 1, 2001, the Region and the local municipalities will be amalgamated into one new city: the New City of Hamilton. For easy reference, this paper has used the term City or City of Hamilton throughout.

2 Information on air quality was derived from the Hamilton-Wentworth Air Quality Initiative Summary Report (1997) and other reports (see Note 4).

3 Information on cycling activity was obtained from surveys conducted for the “Shifting Gears – A New Cycling Plan for Hamilton-Wentworth” study (1999).

4 Environmental impacts such as air pollution, noise, water quality, etc. were extensively explored during the preliminary design of the construction of a proposed freeway through the Red Hill Creek valley in Hamilton. The information was documented in a summary report and several background reports. Relevant reports on air quality and health are: “Air Quality Assessment, Red Hill Creek Expressway”, RWDI Inc. (1999), and “Possible Human Health Effects from Exposure to Predicted Increases in Respirable Particulate Matter due to the Red Hill Creek Expressway”, Cantox Environmental Inc. (1999).

5 The information in Table 1 was derived from “Selecting Roadway Design Treatments to Accommodate Bicycles”, Federal Highway Administration (US, 1994) and modified to account for local experience.