

CLIMATE, AIR QUALITY, AND THERMAL COMFORT IN THE URBAN ENVIRONMENT

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ABSTRACT

To ensure health and well-being for the increasing fraction of the populace exposed to the urban atmospheric environment, it is important to study urban climate and its impacts on people. This thesis consists of two main parts. The first part investigates the existence and character of thermally induced wind systems in and around the city of Göteborg and their significance for urban ventilation and air pollutant transport. The second part investigates the influence of the urban atmospheric environment on people, in terms of personal exposure and thermal comfort.

The field surveys were conducted in Göteborg (57°42'N, 11°58'E), a city of approximately 500,000 inhabitants, situated on the west coast of Sweden. Five urban environments—one open area, two built-up areas, one park, and one plaza within the city centre—were studied more thoroughly. The methods included an array of meteorological, air quality, and behavioural measurements.

Results showed that a 10-hectare open area surrounded by dense street canyons develops a weak intra-urban thermal breeze (IUTB) when the canopy layer atmosphere is separated from wind flow aloft. Both measurements and model simulations showed that, under certain conditions, intra-urban air temperature differences of 2–3 °C are enough to develop an IUTB. Like other local- and mesoscale thermal winds, the IUTB cannot be assumed to be a good pollution ventilator because of its low wind speed and closed system.

Further, results showed that the land breeze has a significant influence on the air pollutant transport during clear and calm weather conditions. The land breeze transports rural air masses with high ozone concentration into the city, resulting in high night-time concentrations.

Extensive monitoring campaigns performed within three central urban environments showed that there is large spatial variability in urban benzene concentrations and in levels of personal exposure. Although the benzene levels have fallen in most Swedish cities including Göteborg during recent decades, the recommended low-risk value for benzene was frequently exceeded in several places. Given the large spatial heterogeneity within cities, careful considerations must be given to how representative single street point measurements actually are when used for estimating urban concentrations and exposure levels.

Meteorological and behavioural studies, performed in one central park and one plaza, showed that the thermal environment is an important factor in the usage of these places. It was found that people adapt to the ambient thermal conditions by modifying clothing and activity pattern, choosing the most supportive thermal opportunities available within the place. Besides physiological adaptation, psychological parameters such as thermal history, expectations, experience and environmental stimulations were shown to have great influence on people's thermal sensation. Although different seasons and places require different approaches, the use of places would increase by creating a variety of different sub-spaces within them.

The presented results can be used to provide a better guidance in urban planning. In an attempt to provide a comprehensive tool for urban planners and decision makers, a method for creating local-scale bioclimatic maps with the aid of a geographical information system was developed. The method links meteorological data with geographical information in order to generate spatial distributions of the thermal component.

Keywords thermal wind systems, air quality, personal exposure, human behaviour, thermal comfort, bioclimatic maps, Göteborg