EXPOSURE TO TRAFFIC RELATED AIR POLLUTION IN NORTHERN IRELAND

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June 9 – 10, Pernik

Education Science Innovations

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EXPOSURE TO TRAFFIC RELATED AIR POLLUTION IN NORTHERN IRELAND

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Abstract. *Clean Air is a basic requirement for human health and wellbeing. There is an extensive body of knowledge that associates a number of health conditions with exposure to air pollution. Within the United Kingdom transport is considered the main contributor to exceedances of the air quality objectives set in European legislation. Current literature focuses on outdoor exposure to traffic related air pollution, however for the majority of the public, greater time is spent indoors. Within this study nitrogen dioxide was measured in 30 homes. The indoor and outdoor levels were measured using passive diffusion tubes. Factors such as temperature, seasonal variation and distance from the road were considered when analysing the results. The findings indicate that as the level of outdoor nitrogen dioxide increased, the indoor level also increased. As the distance from the road increased, the level of nitrogen dioxide decreased.*

Keywords: *Traffic Related Air Pollution; Nitrogen Dioxide Levels; Air Quality Management*

1. Introduction

In Europe, 80 % of people living in urban areas are exposed to air pollution levels greater than recommended within the World Health Organisation Guidelines [1]. Recent research has questioned if the guidelines are protective of health as exposure levels lower than the standards set have led to health effects [2]. For effective action to be taken to reduce human exposure, consideration needs to be given to the source, exposure location and the public's awareness and concern.

1.1. Traffic Related Air Pollution

In the United Kingdom the main source of urban air pollution is traffic [3]. The pollutants emitted from petrol and diesel vehicles include particulate matter, nitrogen oxides, carbon monoxide and hydrocarbons [4]. Within the United Kingdom there has been an increase in the uptake of diesel vehicles. The government reduced Vehicle Exercise Duty (VED) and had company car incentives for vehicles emitting less carbon dioxide. The majority of vehicles with low carbon dioxide

emissions are diesel [3]. This policy was introduced to meet climate change targets but has negatively impacted on the levels of other pollutants. Diesel vehicles can emit up to 22 times more particulate matter and 4 times more nitrogen dioxide than the petrol equivalent [5]. The increase of air pollution from vehicles has also been attributed to the failure of the Euro Standards in reducing vehicle emissions [6]. The International Council for Clean Transportation [6] found that real world emissions for nitrogen dioxide were up to seven times higher than those in laboratory testing. These factors together with an increase in the number of registered vehicles and miles travelled by car worldwide has led to an increase in traffic related air pollution. The increase in air pollution levels has increased human exposure to pollutants which are harmful to human health.

1.2. Health Impact

Each year it is estimated that 40,000 deaths are attributable to outdoor air pollution [2]. The largest body of evidence in relation to air pollution and health focuses on exposure and its impact on asthma. A recent review of the current literature on asthma and traffic related air pollution concluded that there is extensive evidence that short term exposure to air pollution can lead to the exasperation of asthma symptoms. It also found increasing amounts of research linking long term exposure to new onset asthma [7]. Further evidence has linked air pollution to the following health conditions: Chronic obstructive pulmonary disease (COPD) rrespiratory illnesses, cardiovascular illnesses and diabetes [2,8,9,10]. Particulate matter and nitrogen dioxide from vehicle emissions has been found to impact on respiratory health at levels below those stated within European legislation [2].

1.3. Northern Ireland Context

In Northern Ireland, if any area exceeds or is likely to exceed an air quality objective, it must be declared as an Air Quality Management Area (AQMA) [11]. Currently there are twenty six AQMAs in Northern Ireland. Twenty one of these are declared due high levels of nitrogen dioxide from traffic. For an AQMA to be declared, it must also be demonstrated that there is human exposure to the air pollution levels. This indicates that there are currently 21 areas where residents are being exposed to levels of air pollution that could impact upon their health and wellbeing. There is a lack of research into the impact of air pollution in Northern Ireland and the awareness of residents of their personal exposure.

1.4. Human Exposure

It is estimated that people in the United Kingdom spent 90 % of their time indoors [12]. The majority of research completed on traffic related air pollution

focuses on outdoor levels of air pollution, with the level of exposure in the home unknown. Challoner et al [13] found a correlation between increased traffic levels in the morning and evening and an increase of nitrogen dioxide inside a city centre office building. Residential exposure to nitrogen dioxide needs to be considered.

1.5. Research Gaps

There is currently a large amount of research into the health impact of air pollution. The majority of research focuses outdoor levels of air pollution. In Northern Ireland, a large proportion of the populations time is spent indoors therefore the impact of outdoor air pollution on indoor levels should be considered. In addition, research on air pollution often uses techniques such as modelling or central monitoring stations to estimate the level of human exposure to pollutants. Measurements at the façade of properties would give a greater understanding of exposure levels. It is evident that further research on traffic related air pollution is required.

2. Research method

Taking into consideration the current gaps in literature, a study was designed to measure exposure to traffic related air pollution in areas with a high traffic volume.

2.1. Study Locations

For suitable study locations to be identified, an inclusion and exclusion criteria was devised. For a location to be included it must meet the following criteria;

- It must be declared as an Air Quality Management Area (AQMA) due to pollution from traffic
- It must have an Automatic Monitoring Station which records the levels of nitrogen dioxide
- It must have residential accommodation for the impact of exposure to be identified

In total there were seven locations which meet all of the above criteria.

This study is part of a wider research project which used questionnaires to identify the public's awareness, concern and knowledge of air pollution in their area. In total 339 questionnaires were collected. The overall response rate was 20 %.

2.2. Study Participants

The participants in this study were identified by having completed the preceding study which involved the use of questionnaires. All participants who completed the questionnaire and met the criteria outlined below were asked participate.

To partake in this study the participants had to live in a smoke free property and live within 200 metres of the automatic monitoring station. A total of 30 properties agreed to participate in the research.

2.3. Indoor and Outdoor Measurements

Diffusion tubes were chosen as the most appropriate method of monitoring nitrogen dioxide levels. There were several reasons for this decision. Diffusion tubes are unobtrusive and do not require any electricity or internet connection therefore causing little disturbance to the occupiers. In addition, they are inexpensive therefore a greater number of homes could be included. This method also allowed for homes to be monitored simultaneously therefore reducing the impact of influencing factors such as temperature difference. The diffusion tubes were supplied by Environmental Services Limited. This company was chosen as they are a UKAS accredited laboratory and follow the diffusion tube guidance issued by Department for Environment Food & Rural Affairs (DEFRA) Northern Ireland.

Each property had 2 diffusion tubes. One was placed on the front façade of the property. All outdoor tubes were placed at a height of 5 metres to avoid vandalism. The second diffusion tube was placed inside the property. The room chosen in each property was facing the road and if possible was upstairs to reduce the impact of pollutants from cooking appliances and boilers. Each diffusion tube was left for 30 days before collection. The monitoring was conducted for 1 winter month (February) and 1 summer month (June). This allowed for an investigation into seasonal impact.

The distance of the road from the front façade of each of the properties was measured using a Leica DISTO A3 laser distance meter. The temperature for each day was recorded from the Met Office Northern Ireland readings. Other influencing factors such as the presence of traffic lights, hedges and number of windows were all recorded.

To give a deeper insight into exposure to nitrogen dioxide, personal exposure was investigated. Three (3) of the participants agreed to wear a personal monitor for 1 week. A passive rapid air monitor was chosen as the most appropriate method. The monitor is small and can be easily attached to an item of clothing.

2.4. Data Analysis

The results were analysed using Statistical Package for Social Scientists (SPSS). For all tests conducted, statistical significance was considered at least 95 % confidence level ($p < 0.005$). The monitoring results from this study were combined with the questionnaire results from the previous study.

3. Findings

To increase the reliability of the diffusion tube results, the measurements were compared with those obtained from the automatic monitoring station in each location. A positive correlation was found for both the winter ($p<0.002$) and summer ($p<0.001$) results indicating the similarity in the results.

A correlation was also found between the winter and summer levels of nitrogen dioxide. As the winter levels increased so did the summer levels ($p<0.001$). In 6 of the 7 locations the winter level of outdoor nitrogen dioxide was higher than the summer level. The average level of nitrogen dioxide measured for indoor and outdoor are illustrated in Figure 1. The highest indoor and outdoor levels were found in Newry. This location is a street canyon with 3 storey buildings on each side of the street hindering the dispersion of pollutants. This indicates the impact which built environment features can have on the level of air pollution.

A strong, negative correlation was found between the level of outdoor Nitrogen Dioxide and the distance of the property from the road. In winter ($r=-0.695$, $n=29$, $p<0.001$) and in summer ($r=-0.771$, $n=29$, $p<0.001$) the results indicate that as the distance from the road increases, the level of nitrogen dioxide decreases.

As the level of outdoor nitrogen dioxide increased, the indoor level also increased. The result was significant for both the winter($r=0.394$, $n=77$, $p<0.001$) and summer monitoring($r=0.556$, $n=77$, $p<0.001$). In five of the locations the average indoor level of nitrogen dioxide was higher in summer than the winter level. In the summer, a greater number of the residents opened their windows for longer periods of time.

A positive correlation was found ($p<0.005$) between the measured level of nitrogen dioxide and daily average number of vehicles. The greater the number of vehicles on the road each day, the higher the level of nitrogen dioxide.

The monitoring results were combined with the questionnaire responses from the previous study. The questionnaire asked residents to rate the level of air pollution on a five point Likert scale. The results from this were compared with the measured level of nitrogen dioxide. A correlation ($p<0.005$) indicated that as the measured level of nitrogen dioxide increased, the participants were more likely to describe the air quality in their area as 'good' or 'very good'. This indicates the low level of awareness the participants have about the air pollution which they are exposed to.

The personal monitoring was also completed on 3 of the research participants. In all three cases the personal level of nitrogen dioxide was higher than the measured indoor level. However in all three it was lower than the measured outdoor level.

4. Discussion

In winter, colder temperatures can lead to a temperature inversion. This creates a barrier causing pollutants to become trapped therefore hindering dispersion. Increased levels of air pollution in winter were found within this research. Current literature agrees that during the cooler months of the year, air pollution levels can peak [14 – 17].

The façade of all properties included in the research were within 25 metres from the edge of the kerb. The research found that those who lived further from the road were exposed to a lower level of nitrogen dioxide. All properties within 2 metres of the roadside had higher levels of nitrogen dioxide than recommended within the World Health Organisation Guidelines. Due to the amount of influencing factors, such as built environment factors, it is difficult to determine a distance in which the levels decrease to within the recommended level. All properties except for one were within the recommended level if situated above 20 metres from the roadside. A similar research project also found monitors placed less than 30 metres from the source had significantly higher levels of nitrogen dioxide. It noted that distance is not the only factor which affects air pollution levels and therefore should not be considered in isolation [18].

As the level of nitrogen dioxide increased outdoors, the level of nitrogen dioxide within a property also increased. This indicates that outdoor levels impact upon the indoor levels and therefore should be considered when monitoring. In summer the indoor levels were higher in all areas. The residents were more likely to open their windows for longer periods of time in the summer which impacted on the indoor levels. Advice should be given to residents to avoid opening windows during peak traffic in the morning and evening.

All locations included within the research had a daily average of at least ten thousand vehicles per day. As the daily number of vehicles increased the level of nitrogen dioxide increased. Average number of vehicles is often used in other research to relate health impact and traffic. This result indicates that it can be considered as an indicator of nitrogen dioxide levels.

There was a lack of awareness among the residents about the air pollution in their area. In areas where the measured level of nitrogen dioxide was the highest the residents considered the air quality to be 'good'. For the public air pollution levels are difficult to determine as they cannot be detected by any of the senses. Increasing public awareness of air pollution levels could aid in reducing exposure to harmful levels. The greater the publics concerns for environmental issues, the greater the government's priority to tackle the issue [19].

5. Conclusions

This article makes a contribution to our understanding of the impact of road vehicle emissions of nitrogen dioxide on air quality. It is innovative in the manner in which it examines both indoor and outdoor air quality and incorporates a spatial and locational aspect within the investigation. The findings indicate nitrogen dioxide from traffic can impact on the level of nitrogen dioxide inside a property. The findings demonstrate that greater consideration should be given to indoor exposure to air pollution. Another important feature of the research is the assessment of the awareness of air quality issues in neighbourhoods already designated as experiencing poor air quality. The results suggest that alternative approaches need to be developed to raise awareness among the public about the air pollution levels to which they are exposed. While current Northern Ireland Executive Programme for Government consultation document contains a commitment to "*improve air quality and increase sustainable transport*" [20] consideration needs to be given to a range of initiatives to address the current impacts of transport emissions on the levels of air pollution.

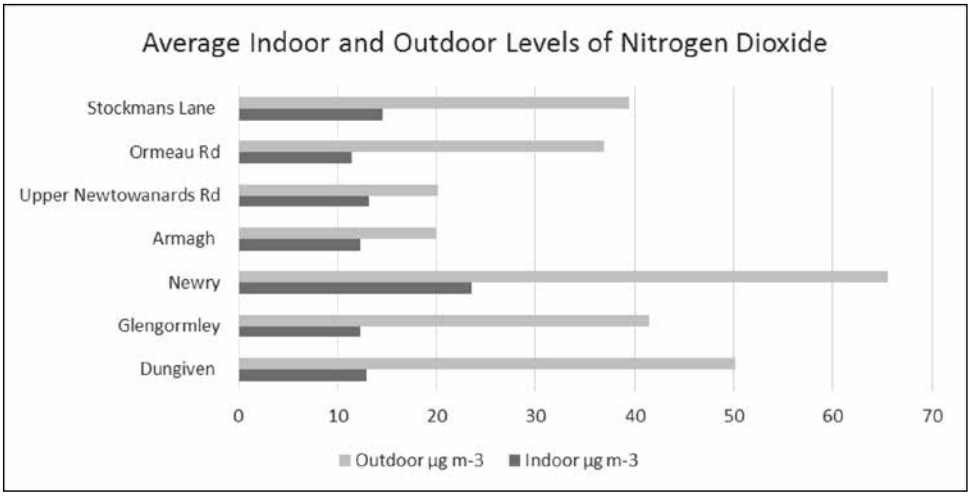

Figure 1: Measured Level of Nitrogen Dioxide

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