Investigating Air Quality and Air-related Complaints in the City of Tshwane, South Africa

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Abstract

To determine the impact of implemented air quality interventions beyond ambient air pollution reductions, indicators need to be identified and appropriate health data need to be routinely collected to track air-related health. Presently, the only regulated environmental health performance indicator routinely collected as part of air quality management is the air-related complaint lodged by the public. Here, five years of air-related complaints (n = 875) made by residents in the City of Tshwane (Pretoria, Gauteng) were analysed and considered in relation to ambient SO_2 and PM_{10} concentrations monitored at permanent air quality monitoring stations. When considering exceedances of the National Ambient Air Quality Standards, there were 17 complaint days with either an SO_2 or PM_{10} daily average concentration exceedance. However, it was very difficult to make meaningful conclusions about the relation between ambient AQ and air-related complaints given social, economic and data challenges and constraints. There is a real need to have local, air-related health data, for example, upper and lower respiratory tract infections, asthma, etc, generated at clinics and hospitals delivered directly and on an on-going, continuously updated basis to those responsible for implementation of air quality management plans.

Keywords: Air-related complaints, air quality, human health, South Africa

Introduction

A growing number of studies show that the largest burden of air pollution-related diseases is on developing countries where air pollution levels are also among the highest in the world (Krzyzanowski, and Cohen, 2008). Air pollution may cause symptoms ranging from eye, nose and throat irritation (Pan et al., 2010), exacerbation of asthma (Koenig, 1999) and reduced lung function (WHO, 2005) to cardiovascular symptoms such as high blood pressure (Brook et al., 2010) and lung cancer (Cohen and Pope, 1995). There is also a statistically-significant association between air pollution and mortality from respiratory and cardiovascular illnesses (Krzyzanowski, and Cohen, 2008).

In South Africa, air quality management has gone through substantial changes in the past 6 years. In 2010, the National Environmental Management: Air Quality Act No 39 of 2004 (RSA, 2004) officially replaced the Atmospheric Pollution Prevention Act No 45 of 1965 (RSA, 1965). The new Act shifted the focus from centralisation of air pollution governance to the decentralisation of power, placing the responsibility of air quality management on local authorities.

The City of Tshwane (Pretoria) is one of three large metropolitan areas (the others being Johannesburg and Ekurhuleni) in the Gauteng Province. In 2006, the Air Quality Management Plan for the City of Tshwane, developed by the Environmental Management Division and Municipal Health Services of the City, was approved. The plan is being used as a management and performance-monitoring tool for air quality (AQ) and to provide a baseline assessment of AQ issues in the City. The Environmental Management Division maintains a network of five permanent and several semi-permanent (i.e. street boxes) ambient AQ and

meteorological monitoring stations around the City. These stations are strategically located to monitor ambient levels of priority pollutants, namely, particulate matter (PM), sulphur dioxide (SO_2), ozone (O_3), volatile organic compounds (VOCs), carbon monoxide (CO) and nitrogen oxides (NOx) from known and unknown sources in different areas of the City. An air Quality Officer monitors and assesses ambient AQ concentrations at these stations in accordance with the National Ambient Air Quality Standards that came into effect in 2009 (DEA, 2009).

Municipal Health Services of the City of Tshwane comprises Environmental Health Practitioners (EHPs) whose duties are defined by the National Health Act No 61 of 2003 (RSA, 2003). EHPs are responsible for the function of municipal environmental health services which include environmental pollution control. They are responsible for identifying air pollution agents and sources, and ensuring clean and safe air externally (ambient and from point sources) through emission inventory monitoring, modelling and toxicological reports (responsibilities shared with Environmental Management), reviews and complaints investigations (Government Gazette, 2009).

While activities to monitor ambient AQ and introduce appropriate interventions for air pollution reduction are underway, human health surveillance is presently not an integrated part of air quality management in the City, or South Africa, although National Ambient Air Quality Standards were derived from international epidemiological studies of personal exposure. To ascertain the impact of implemented interventions beyond ambient air pollution reductions, indicators need to be identified and appropriate health data need to be routinely collected and made available to AQOs and EHPs. Presently, the only routinely-collected indicator of the impact of air pollution on the public is air-related complaints lodged by residents of the City to Municipal Health Services. Previous studies have considered using air-related complaints as an indicator of air pollution emissions (Evendijk et al., 1980), environmental pollution (Dasgupta and Wheeler, 1996), and annoyance from traffic noise and air pollution (Klaeboe et al., 2000). To the best of our knowledge, air-related complaints have been considered to identify air pollution sources specific to a complaint (Cadman et al., 1997) but have not been considered in light of the publics' experience of AQ impacts in South Africa.

This paper reports on the analysis of 5 years of air-related complaints lodged by residents of the City of Tshwane. The nature and geographical location of these complaints were considered in relation to ambient AQ monitored at the AQ monitoring station nearest to the complainant's residential suburb. While the intention of this study was to explore the applicability and usefulness of using air-related complaints as an indicator of the public's experience of air pollution, several policy messages and suggestions for improvements to AQ and public health monitoring and reporting practices also became apparent and are mentioned.

Materials and Methods

Air-related complaints

Public complaints captured routinely by EHPs about odours, visible air pollution and symptoms perceived to be related to air pollution or air pollution incidents for 1 January 2005 to 31 December 2009 were obtained from Municipal Health Services of the City. For each complaint made, the date, region in the City, residential suburb and air-related complaint category were captured. The City comprises eight zones commonly collapsed into five regional administrative zones, known as North-West, North-East, Central-West, East and South. All residential suburbs were categorised by the EHPs into one of the five regional zones depending on their location. The air-related complaints' categories used in this study were identical to those applied to the raw, detailed complaints by the City.

Ambient AQ monitoring and wind direction

Permanent AQ and meteorological monitoring stations are located in four of the five regional administrative zones in the City. The stations are Booysens (Central-West), Pretoria West (Central-West), Rosslyn (North-West), Mamelodi (East), and Olievenhoutbosch (South) (Figure 1). The City of Tshwane is dissected with one large mountain range, Magaliesberg, and several smaller ranges which may affect air pollution dispersion under certain conditions and influenced the locating of monitoring stations. Of all the priority pollutants identified by the National Department of Environmental Affairs (RSA, 2009), SO_2 and PM_{10} were the two pollutants measured across all permanent sites; hence these pollution concentrations were used in this study. AQ data were provided by the Environmental Management Division of the City of Tshwane and the South African Air Quality Information System (SAAQIS). Data were available for 1 January 2009 to 31 December

2009. SO_2 concentrations were measured using API Model 100A and Thermo 43i instruments. PM_{10} concentrations were measured using Thermo FH 62 C14 Continuous Particulate Monitor and Tapered Element Oscillating Microbalance (TEOM) instruments. Annual average concentrations were used to compare SO_2 and PM_{10} across all sites. Daily average concentrations were applied to understand ambient AQ conditions, specifically, SO_2 and PM_{10} concentrations, on days when air-related complaints were lodged. Wind direction measured at the Eendracht meteorological monitoring station was used to understand whether ambient AQ measured at a particular station was a reasonable estimate of the ambient AQ experienced by the complainant in their residential suburb (data not shown).

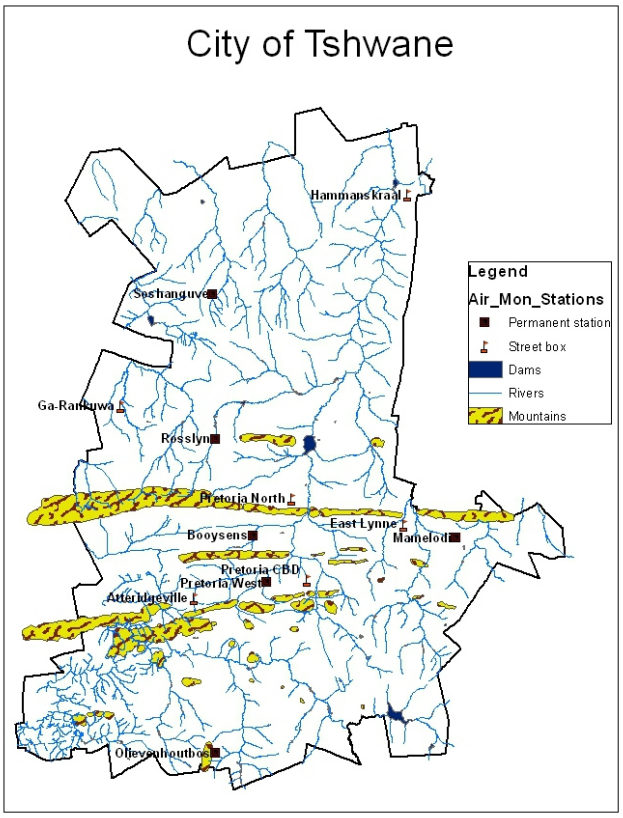

Figure 1. Physical map of the City of Tshwane showing the permanent AQ monitoring stations (square markers) used in this study.

Analyses

Air-related complaints were analysed by year, region and type of complaint. Ambient SO_2 and PM_{10} annual and daily average concentrations were analysed by AQ monitoring stations. Exceedances of the National Ambient Air Quality Standards were identified. Using Geographical Information Systems, the air-related complaints were mapped in relation to the permanent AQ monitoring stations. Air-related complaints were compared with ambient SO_2 and PM_{10} daily average concentrations recorded at the nearest permanent monitoring station for the day on which the complaint was made. Wind direction recorded at the AQ monitoring station was considered to provide insight into the applicability of using the nearest AQ monitoring station as a proxy for ambient AQ experienced by the complainant. For 2009, air-related complaints made on days when SO_2 and PM_{10} daily average concentrations were in exceedance of National Ambient Air Quality Standards were isolated and analysed separately. These results are discussed bearing in mind data shortages and limitations.

Results

Air-related complaints

From 1 January 2005 to 31 December 2009, a total of 875 air-related complaints were lodged by members of the public to the City of Tshwane Municipal Health Services. The number of complaints per year was 207 (in 2005), 198 (2006), 223 (2007), 155 (2008) and 92 (2009). Five years is insufficient time to consider long term trends. A linear trend line fit gave y = -27.3x + 54966 (R^2 = 0.6687) indicating a relatively poor fit, despite detecting a slight negative trend.

Figure 2 shows the type of air-related complaints as a percentage of the total complaints made between January 2005 and December 2009. The largest percentage of complaints were made about the presence of open fires (27.5%), followed by spray-painting fumes (20.4%) and dust (17.3%). Backyard fires (8.9%), fumes (unspecified source) (9.4%) and smoke (2.6%) were also reported.

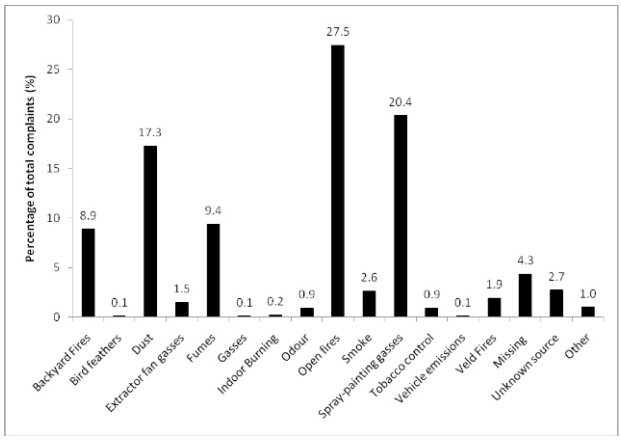

Figure 2. Type of air-related complaint as a percentage of the total complaints made from January 2005 to December 2009 (n = 875).

Air-related complaints were grouped by suburb into one of each of the five regional administrative zones and represented spatially in Figure 3 by ranking zones according to total number of complaints. The North-East and North-West zones had the least number of complaints over the past 5 years, with 55 and 98 complaints, respectively. The most number of complaints were lodged in the Central-West (n = 275) and East (n = 289) zones. The South had an average number of complaints (n = 158) compared to the other four zones. The type and number of complaints by regional administrative zone were analysed to understand where specific types of complaints were most frequently reported (Figure 4).

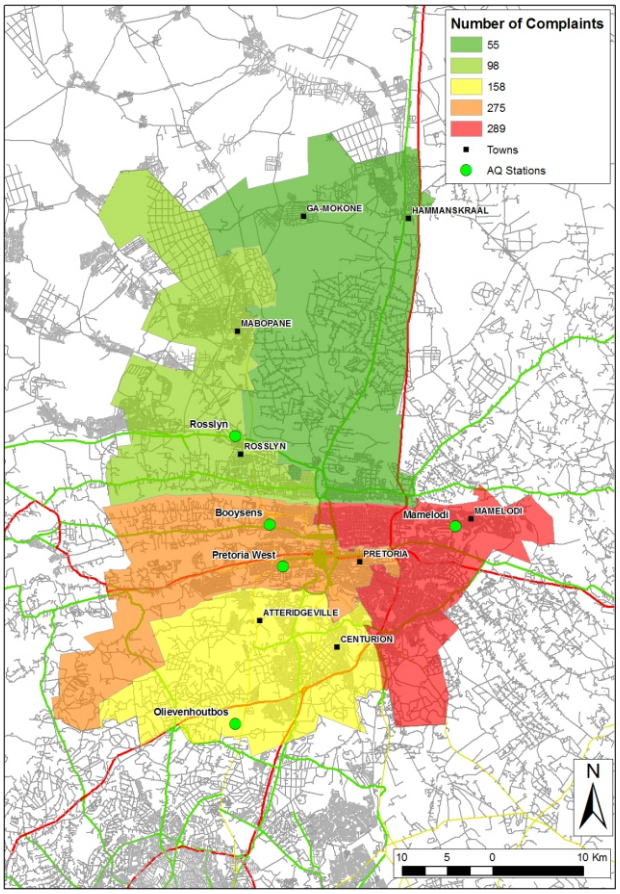

Figure 3. Total air-related complaints for 2005 – 2009 (n = 875) by City of Tshwane's five regional administrative zones: North-West, North-East, Central-West, East and South. Locations of permanent AQ monitoring stations are shown with green circles and black rings.

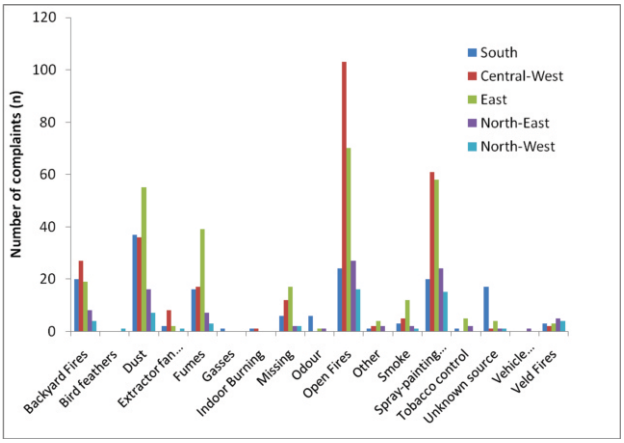

Figure 4. Type and number of air-related complaints for 2005 – 2009 by regional administrative zone in the City of Tshwane. ('Incomplete' category was combined with 'Missing' category.)

For the top-five most commonly reported air-related complaints, i.e. backyard fires, dust, fumes, open fires and spray-painting gasses, the Eastern zone consistently tended to have among the most number of complaints relative to all other zones. For backyard fires, several complaints were made in the Central-West and Southern zones too. Dust and fumes were also commonly reported in the Southern and Central-West zones. The largest proportion of complaints regarding open fires and spray-painting gasses was for the Central-West. A large number of complaints about open fires and spray-painting gases were also made in the North-East zone. Interestingly, the most number of 'unknown source' complaints and nearly three times that of any other zones were made by the public living in the South. The highest number of complaints by type in the North-West zone was for open fires and spray-painting gasses.

Ambient air quality at the permanent AQ monitoring stations

Air quality data for all five permanent AQ monitoring stations were available for 2009. Table 1 provides the annual average SO_2 and PM_{10} concentrations for each station and the National Ambient Air Quality Standards for each of these priority pollutants. There was no permanent AQ monitoring station in the North-East zone.

The highest annual average SO_2 and PM_{10} concentrations were found at the Pretoria West and Olievenhoutbosch AQ monitoring stations, respectively. The annual average SO_2 concentration for Pretoria West was also higher than the National Ambient Air Quality Standard of

19 ppb. For PM_{10}, annual average concentrations exceeded the National Ambient Air Quality Standard of 50 µg m^{-3} at all stations, except for Rosslyn, with the difference in concentration exceedances ranging from 1 µg m^{-3} to 42 µg m^{-3}.

Figure 5 and Figure 6 show the daily average SO_2 and PM_{10} concentrations for 2009 for the five permanent AQ monitoring stations, respectively. Daily average SO_2 exceedances (greater than 48 ppb) were recorded at Pretoria West (n = 38) and Rosslyn (n = 6). Daily average PM_{10} exceedances (greater than 120 µg m^{-3}) were recorded at Booysens (n = 85), Mamelodi (n = 70), Olievenhoutbosch (n = 84), Pretoria West (n = 43) and Rosslyn (n = 13). The National Ambient Air Quality Standards only allow for four exceedances of the 24-hour standard per annum. It is thus evident that, for SO_2, the Pretoria West and Rosslyn AQ monitoring stations did not comply. Most exceedances happened between April and August, the winter season, when domestic coal burning normally increases, coinciding with conditions highly conductive to the formation of inversions. These inversion layers have an influence on the dispersion potential of air pollution. The Pretoria West AQ monitoring station consistently showed the highest SO_2 levels compared to all of the monitoring stations in Tshwane (Figure 5). The exceedances at the Rosslyn AQ monitoring station occurred during mid-winter. Concentrations of PM_{10} exceeded the 24-hour guideline more than four times at all of the AQ monitoring stations (Figure 6). Roughly two peaks may be identified: one peak is evident at the beginning of the year (about January and February) and another from about April to August (wintertime). The Booysens AQ monitoring station recorded the most number of exceedances (85) for 2009. Most of the exceedances at Booysens happened during the first two months of 2009.

Table 1. Annual average SO_2 (ppb) and PM_{10} (µg m^{-3}) concentrations for the five permanent AQ monitoring stations in the City of Tshwane.

AQ monitoring station	Regional zone	SO_2 (ppb)	SO_2 National standard (ppb)	PM_{10} (µg m^{-3})	PM_{10} National standard (µg m^{-3})
Booysens	Central-West	3	19	51	50
Mamelodi	East	5		86	
Olievenhoutbosch	South	5		92	
Pretoria West	Central-West	24		67	
Rosslyn	North	16		35	

Note. Frequency of permissible exceedances per year: 0 for SO_2 and 0 for PM_{10}. Data included in this calculation span 1 January 2009 to 31 December 2009 and were provided by SAAQIS.

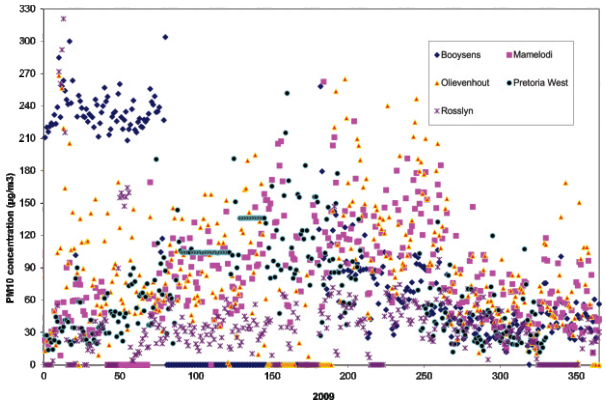

Figure 5. Daily average PM_{10} concentrations for all permanent AQ monitoring stations in Tshwane.

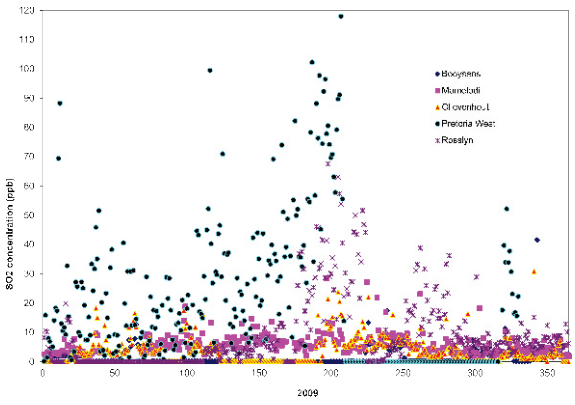

Figure 6. Daily average SO_2 concentrations for all permanent AQ monitoring stations in Tshwane.

Table 2. Type of air-related complaint by region and nearest permanent AQ monitoring station, with SO_2 and PM_{10} daily average concentrations for National Ambient Air Quality Standards exceedances only.

				Exceedance values (bold)	
Date in 2009	**Region**	**AQ Station**	**Complaint type**	**Measured SO_2 24-hour average concentration (ppb)**	**Measured PM_{10} 24-hour average concentration (µg m^{-3})**
2 March	Central-West	Booysens	Backyard fires	5.09	**215.61**
28 May	East	Mamelodi	Backyard fires	7.27	**144.62**
23 July	East	Mamelodi	Dust	6.72	**225.91**
13 August	East	Mamelodi	Dust	27.33	**161.98**
20 August	East	Mamelodi	Dust	22.00	**180.00**
18 February	South	Olievenhoutbosch	Backyard fires	2.50	**169.42**
1 September	South	Olievenhoutbosch	Dust	6.56	**224.99**
1 September	South	Olievenhoutbosch	Odour	6.56	**224.99**
28 January	Central-West	Pretoria West	Fumes	**159.94**	27.23
15 April	Central-West	Pretoria West	Undefined	7.20	**190.63**
8 July	Central-West	Pretoria West	Spray-painting gasses	33.29	**156.91**
20 July	Central-West	Pretoria West	Spray-painting gasses	**48.78**	**124.53**
22 July	Central-West	Pretoria West	Fumes	36.12	**184.79**
28 July	Central-West	Pretoria West	Dust	35.12	**155.67**
14 August	Central-West	Pretoria West	Backyard fires	**92.29**	91.27
23 February	North-West	Rosslyn	Odour	Missing	**155.48**
25 February	North-West	Rosslyn	Dust	Missing	**159.59**

Note. PM_{10} daily exceedance limit = 120 µg m^{-3}. SO_2 daily exceedance limit = 48 ppb (Immediate effect until 31 December 2014; from 1 January 2015, PM_{10} daily exceedance limit = 75 µg m^{-3}) (RSA, 2009).

Air-related complaints in relation to monitored ambient AQ concentrations

During 2009, there were a total of 86 air-related complaints for which AQ data from the nearest permanent AQ monitoring station were available. The greatest number of complaints were made during the winter months of June, July and August (n = 27: North, n = 8; Central-West, n = 10; East, n = 7; and South, n= 2). A similar number of complaints were made during summer (December, January and February), autumn (March, April and May) and spring (September, October and November), i.e. n = 20, n = 22 and n = 17, respectively. Of these, there were three days with air-related complaints when the 24-hour standard for SO_2 was exceeded and 15 days when the 24-hour standard for PM_{10} (Table 2) was exceeded.

The three SO_2 daily exceedances of 48.7 ppb (slight exceedance), 92.2 ppb (moderate exceedance) and 159.9 ppb (high exceedance) were all recorded in the Central-West regional zone. Of the 15 exceedances of the daily PM_{10} standard, 5 were recorded at the Pretoria West AQ monitoring station (Central-West zone) and 4 were recorded at the Mamelodi AQ monitoring station (East zone). Nine of these AQ exceedances for days when air-related complaints were lodged occurred during winter and early spring.

The daily average air pollutant concentrations on days when complaints were made by residents

in the two zones with the greatest number of air-related complaints during 2009, i.e. Central-West and East, are shown in Figures 7 and 8, respectively. There was no pattern or correlation between the two air pollutants' daily average concentrations on complaint days in the Central-West (R^2 = 0.026) and the East (R^2 = 0.3223) zones.

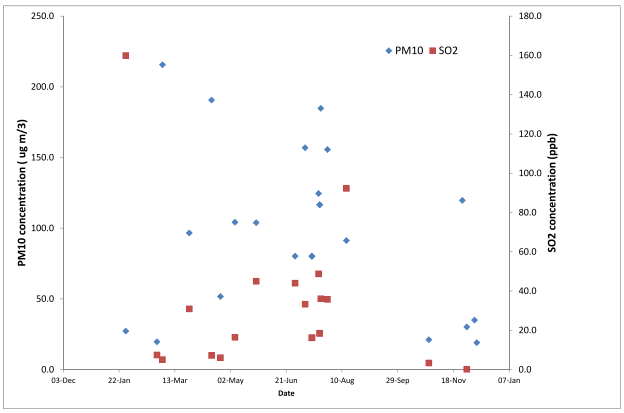

Figure 7. Daily average PM_{10} and SO_2 concentrations for those days when air-related complaints were made by the public for the Central West zone in Tshwane during 2009 (n = 23).

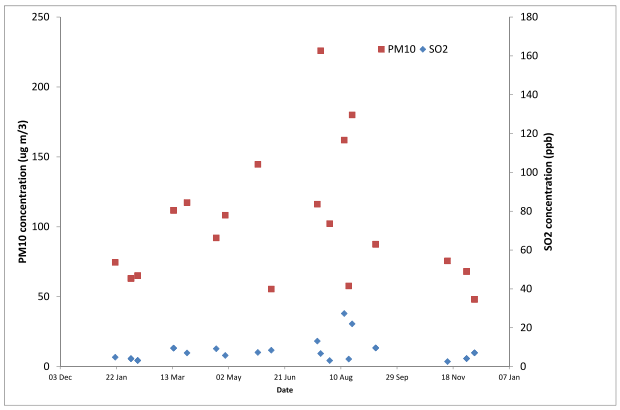

Figure 8. Daily average PM_{10} and SO_2 concentrations for those days when air-related complaints were made by the public for the East zone in Tshwane during 2009 (n = 25).

Discussion

Under new AQ legislation, South African local authorities are now responsible for AQ management. This trend of role decentralisation is common in several countries, including the United States (NRC, 2004), the United Kingdom and some European countries (Elsom, 1999). Most of these local authorities have developed and implemented air quality management plans which mention 'exposure assessment' in the suite of activities described in the plan. Efforts to intervene and improve AQ include, for example, continuous AQ monitoring and the introduction of Atmospheric Emission Licences (RSA, 2010) replacing the permits under APPA. However, no system for 'exposure assessment', either perceived experience or impact, or human health effects, such as air-related health surveillance, has been developed or implemented to consider whether the communities' experience of AQ may improve as air pollution is reduced. The only routinely-monitored 'quasi-indicator' of the impact of AQ on people is the 'air-related complaint'. Using 5 years of air-related complaints lodged by the public living in the City of Tshwane, this article explored the applicability and usefulness of using air-related complaints as an indicator of the public's experience of AQ on the public. It is well known that air pollution exposure is related to several adverse health effects, however, obtaining accurate, up-to-date and comprehensive health data for a specific location in a developing country to analyse trends is fraught with challenges and difficulties. Using the presently applied air-related complaints indicator as an example, it was seen that it is possible to routinely collect potentially useful information; however, this particular indicator is not optimized fully to elucidate a complete understanding of the public's experience of air pollution or suggest possible human health effects other than a nuisance effect that may impact on quality of life.

A total of 875 complaints were made during the 5-year period, i.e. 2005-2009. This is relatively few given that the population size of the metropolitan area estimated at 1 985 983 in 2001 (City of Tshwane, 2004). Access to a telephone, the correct telephone number for Municipal Health Services and willingness to lodge a complaint, are important factors influencing the likelihood of a complaint being made and successfully captured by the EHPs.

Over all, the most number of complaints were made about open fires. The Environmental Management Division recently initiated the 'Follow the Smoke' campaign. The aim of this programme is to attend to as many sighted smoke events as soon as possible. Particular emphasis is placed on cable and tyre burning, illegal open fires and veld fires. Complaints about spray-painting fumes were also common, most probably since the main air pollutants emitted are volatile organic compounds (VOCs) which have a strong odour. Dust was also frequently reported and most likely came from unsealed roads, open and non-vegetated plots and industrial and construction activities. Since the

City of Tshwane classification of complaint was retained during these analyses, it was not possible to define the difference between open fires and backyard fires; however, it was assumed that all backyard fires were contained within the boundaries of a property.

Spatially, the Central-West and East zones had the most number of complaints. These zones are densely populated, particularly when compared to the North-East zone, and this may have contributed to their total number of complaints. There was no specific type of complaint regularly made in a particular zone, most likely since the mix of type and number of industries and homes is similar across all regional zones, expect for the presence of a coal-fired power station and a cement factory in the in the Central-West Zone. In the East zone, there is a large settlement of formal and informal housing (Mamelodi) where residents burn solid fuel for heating during winter months. Further evidence of the impacts of these domestic and industrial influences across Tshwane was apparent from the AQ analyses.

The AQ monitoring station in Pretoria West consistently showed the highest SO_2 levels compared to all of the monitoring stations in Tshwane (Figure 5). Sources in the vicinity of this station that might have had an influence on the pollution levels are the coal-fired power station as well as informal communities. Given the prevailing wind direction (i.e. North-East) for the area, as measured at the Pretoria Eendracht meteorological station from 1993 to 2008, domestic coal burning in Mamelodi may have also contributed to these ambient AQ conditions. The exceedances at the Rosslyn AQ monitoring station occurred during mid-winter. Reasons for this phenomenon were most probably inversion layers and an increase in domestic coal burning. Although, as mentioned above, since the annual wind rose showed the prevailing wind to be from the North East, it is possible that the wind direction may have differed during the winter months. Should this be the case and the wind direction was more North and North West during winter, domestic fuel burning in two low income communities, namely, Ga-Rankuwa and Soshanguve, might also have had an influence on the SO_2 levels at the Rosslyn AQ monitoring station. Another possible source may include a cement factory in the area, depending on whether this industry makes use of coal burning, and a coal-fired power station in Rooiwal. It is known that these pollutants are emitted from the stacks at a high level, but depending on dispersion, climate and topography, these pollutants may deposit at the Rosslyn AQ station at the other side of the mountain that dissects the City of Tshwane in a West-East orientation.

For PM_{10}, the Booysens AQ monitoring station recorded the most number of exceedances (n = 85) for 2009. Most of the exceedances at Booysens happened during the first two months of 2009, thus not during winter when inversion layers and an increase in domestic fuel use are expected. Two possible explanations could be either upset conditions at a single source such as a start-up after the December holidays or the AQ monitoring station was malfunctioning, which could be the reason for not recording any PM_{10} concentrations directly following the peak. The latter explanation is difficult to ascertain given that levels recorded at the other stations also showed peaks during early 2009, however, this cannot be determined without further information and a better understanding of local conditions.

The objective of this study was not to pinpoint likely air pollution sources in relation to ambient AQ. Instead, it was to consider ambient AQ in the vicinity of the complainant as an indicator of the impact of AQ at the time when the complaint was made. When air-related complaints were considered in conjunction with ambient AQ, several challenges arose. There was not always a permanent AQ monitoring station near to the complainant's suburb of residence; hence the nearest AQ monitoring station was used as a proxy. The predominant wind direction for the day of the complaint was considered, qualitatively, to assess the validity of this approach, however, no data were disregarded because wind speed and topography also play a part in air pollution dispersal. In future, this could be considered using AQ modelling and with additional data sources as input to the models. The two air pollutants with consistent data streams at all permanent monitoring stations were SO_2 and PM_{10}. However, SO_2 and PM_{10} concentrations were not always representative of the types of air pollutants associated with air-related complaints. For example, spray-painting fumes are likely to comprise mainly VOCs (Donohue et al., 1996). Air pollution from open fires and backyard fires is likely to be particulates, SO_2 and VOCs when tyres are burnt (Murray and McGranahan, 2003). Dust and smoke are most likely particulate pollution (Murray and McGranahan, 2003). Future research should attempt to use the specific types of air pollutants, where monitored, and relevant to the complaint. For this study, SO_2 and PM_{10} concentrations were investigated. Furthermore, it was assumed that if the concentrations of these two most common air pollutants were high, then

the ambient AQ was possibly perceived by the public as being poor too due to the odour and impact on visibility of SO_2 and PM_{10}, respectively. This relates to a recent trend to manage AQ in a progressively 'multipollutant' manner by controlling as many air pollutants as possible in an integrative way for the greatest total reduction of adverse human health effects (Mauderly et al., 2010).

When considering exceedances of the National Ambient Air Quality Standards, there were 17 complaint days with either an SO_2 or PM_{10} daily average concentration exceedance. Of these, it is unlikely that complaint cases 'match' the monitored ambient SO_2 and PM_{10} daily average concentrations monitored, for reasons mentioned above. In some instances, there were exceedances of the PM_{10} standard at the nearest AQ monitored station on a day that a complaint about backyard or open fires was made, however, without additional data (not always available) and atmospheric modelling (expensive and time consuming), it is not possible to validate these findings. Since the purpose was to consider practical ways for local authorities to track the impact of AQ on the public, these options are consider nonviable.

It is evident from the monitoring data that air pollution in Tshwane, especially $PM_{10,}$ is a concern and the situation is worst during winter months. Presently, the only routinely-collected indicator of the possible impact of air pollution on the public is air-related complaints lodged by residents of the City to Municipal Health Services. It may be useful to record health symptoms experienced by the complainant with the air-related complaint. However, there is a real need to have local, air-related health data, for example, upper and lower respiratory tract infections, asthma, etc, generated at clinics and hospitals delivered directly and on an on-going, continuously updated basis to Municipal Health Services of the City of Tshwane. This would allow for long-term trend analyses as well as acting as an early warning system and way to identify air pollution hotspots.

Conclusions

It is very difficult to make meaningful conclusions about the relation between AQ and air-related complaints with the current number of AQ monitoring stations, air pollutants consistently measured, available AQ data and information captured when an air-related complaint is logged. However, the aim of this study was not to try and show an increase in the number of air-related complaints with increasing ambient air pollution. Several residents in the City of Tshwane may not be aware that they can lodge an air-related complaint or they may not know the correct Management Division with whom to lodge the complaint for official records and formal follow-up. Many residents may not have access to a telephone or the correct, up-to-date telephone 'hotline' number. Some residents may experience air pollution but apathy prevents them from lodging an official complaint. Given these social and economic constraints, as well as data and other challenges, it does not seem feasible to use air-related complaint as an indicator of the public's perceptions or experiences of ambient AQ. Instead, citizen complaints should be complimentarily when describing air quality impacts on the public, together with local, air-related health data, towards integrative public health surveillance in air quality management.

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