Research article

The quality of the first and second Vaal Triangle Airshed Priority Area Air Quality Management Plans

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Abstract

In response to deteriorating air quality, South Africa implemented national programmes that aim to manage and regulate ambient air quality and air pollution. Air Quality Management Plans (AQMPs) are clear outlines of measures and resources needed to achieve air quality objectives in a given geographical area and require support from government, business, industry, non-governmental organisations (NGOs) and the public. The success of the AQMPs depends primarily on the support of all stakeholders and the quality of the management plan. The Vaal Triangle Airshed Priority Area (VTAPA) was declared in 2006 as an area where ambient air quality standards are exceeded or may cause adverse air quality impacts. This research study focused on the VTAPA to evaluate the quality of the first and second-generation AQMPs for the VTAPA. Quality evaluation includes an analysis of procedures, processes, methods and documents. Effectiveness refers to the results of individual activities; therefore, the extent to which the AQMP met the expected outcomes of the review package defined the quality of the AQMP report. Both the first and draft second-generation AQMPs were considered to be of good quality. The first-generation AQMP was found to be of better quality than that of the draft second-generation AQMP. Funding mechanisms need to be investigated to assist in implementing intervention strategies in the AQMP as both the first and draft second-generation AQMPs were found to lack the potential to secure funds. Though the draft second-generation AQMP was found to be of lesser quality, the source apportionment study for identification of all sources as well as a better-outlined air quality management system was found to be good improvements to the AQMP.

Keywords

air quality management, quality, priority areas, airshed, Vaal Triangle

Introduction

Research studies worldwide have reliably recorded the devastating effect of ambient air pollution on human health. It has been estimated that annually at least seven million deaths worldwide are due to the impact of air pollution (Mannucci & Franchini, 2017). According to Altieri and Keen (2016); McCarthy (2020); Robinson (2019), the economic burden associated with air pollution equated to 3.3% of the world's gross domestic product (GDP) in 2018, 3.8% of China's GDP in 2007, 5% of GDP in the U.S in 2014 and 6.0% of South Africa's GDP in 2012, accounting for 7.4% of deaths associated with exposure to $PM_{2.5}$.

Effects of exposure to poor ambient air on human health varies from mild upper respiratory irritation to severe chronic respiratory and cardiac diseases (Katoto et al., 2019). According to Stats S.A. (2018), cardiovascular disease, respiratory disease, and HIV/AIDS constitute three of the five leading causes of death in South Africa. An estimated 14,356 premature deaths in 2012 were caused by Acute Lower Respiratory Infection (ALRI), Chronic Obstructive Pulmonary Disease (COPD), lung cancer, Ischemic Heart Disease (IHD), and stroke from all causes (Langerman & Pauw, 2018).

Many countries, including South Africa, have implemented national programmes to manage and regulate ambient air quality and air pollution (Garland et al., 2017). Air Quality Management Plans (AQMPs) are clear outlines of measures and resources needed to execute a strategy or strategies for achieving a particular objective on air quality (DEA, 2018a). The AQMPs set out a course of action to achieve air quality objectives in a given geographical area. To reduce the effects of poor air quality in South Africa, the National Environmental Management Air Quality Act 39 of 2004 (NEM: AQA) requires that all spheres of government and emitters develop AQMPs and emissions reduction management plans (Tshehla & Wright, 2019). The NEM:AQA permitted the establishment of priority areas for

interventions in air quality management to ensure compliance with national air quality management standards and to monitor possible adverse impacts on human health (Wright et al., 2011).

Three national priority areas have been declared to date, with Vaal Triangle Airshed declared in 2006, Highveld declared in 2007 and Waterberg-Bojanala in 2015. Efforts have been put in place to enhance and sustain good air quality in those areas (DEA, 2018a). The Vaal Triangle Airshed Priority Area (VTAPA) faces complex and persistent air pollution challenges due to its extensive commercial, agricultural, residential, industrial, and mining activities close to each other (Scorgie et al., 2003). After years of implementation of the VTAPA AQMP since its publication in March 2009, a second-generation AQMP was developed in June 2020 to define the baseline and assess any improvements to air quality since the initial air quality management plan was initiated (DEFF, 2020). The second-generation AQMP aimed to develop new approaches and action plans, focused on a deeper understanding of the relationships between cause and effect to ensure further progress and eventual compliance (DEA, 2018c).

This study is aimed to evaluate the quality of the AQMP for the VTAPA. The evaluation focused on both the first- and second-generation draft AQMPs. Evaluation of the quality of the second-generation AQMP for the VTAPA will enable the stakeholders of the VTAPA to identify and eliminate any shortcomings of the AQMP should there be any. Lee and Colley (1992) indicate that the success of an Environmental Impact Assessment (EIA) process depends on the quality of environmental statements; therefore, it is fair to assume that the success of any management plans execution depends on the quality of the plan itself. The assessment of the quality of the document used to improve ambient air quality could contribute to the uncovering of the deficiencies not only of the first generation AQMP but also of the second-generation plan (DEA, 2019b). It is only through systematic assessment that we can recognise their particular strengths and weaknesses and determine if their overall output is good enough to provide a framework for ensuring that they meet the desired standard or outcome (Berke & Godschalk, 2009). Efforts to assess their quality are necessary in order to make gradual changes in future versions through the AQMP review process (Hossu et al., 2020).

Sadler (1998) identified four aspects of EIA effectiveness as: 1) The quality of the reports, 2) The effect on decision making, 3) The effectiveness of prediction and management of the impacts, 4) monitoring and post-auditing. Based on Sadler 1996's analysis, it is clear that effectiveness evaluations encompasses more aspects than quality and therefor this study is only limited to quality of AQMP in VTAPA and not effectiveness thereof. The Lee and Colley package has been adopted and adapted to define quality evaluation criteria for the VTAPA AQMP. This criteria was informed by Manual for Air Quality Management Planning (the manual) (DEAT, 2008), secondly, The National Framework for Air Quality Management in South Africa (the framework); and lastly the National Environmental Management: Air Quality Act 39 of 2004 requirements with respect to aspects of an AQMP.

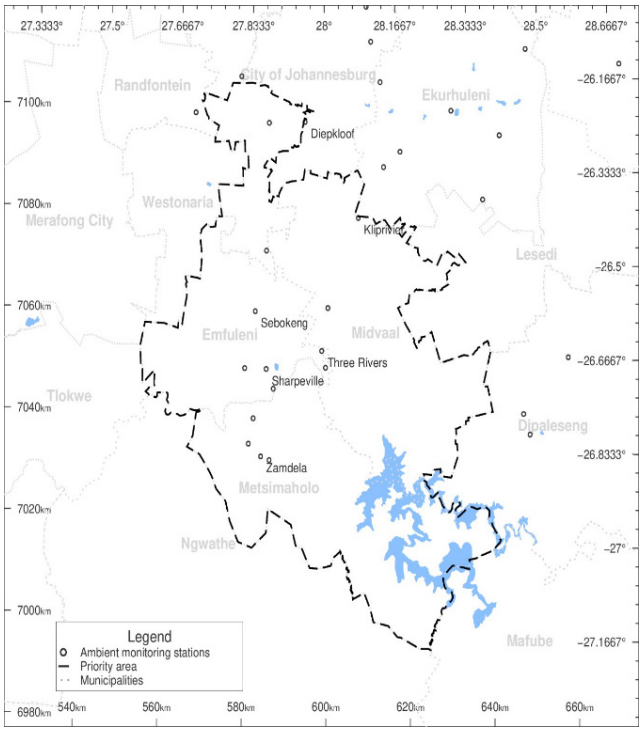

Figure 1: *The VTAPA and ambient monitoring sites*

Air quality management

According to Gulia et al. (2015) and Sivertsen and Bartonova (2012), developing countries cannot effectively implement AQMPs due to the lack of stakeholder commitment, weak policies, standards and regulations and the absence of air quality data and emission inventories. Further research into understanding all sources of emissions and the identification of unknowns, including eliminating uncertainties, is needed to address all sources of pollution (Kim & Lee, 2018).

The National Environmental Management: Air Quality Act requires the development of a framework for air quality management by the minister. The National Framework for Air Quality Management was first developed in 2007, with a review done in 2012 and 2017 (DEA, 2018a). The framework's successes include establishing the National Ambient Air Quality Standards (NAAQS), three air quality priority areas, and the South African Air Quality Information System (SAAQIS). Priority area management relies on the collaborative effort from all government spheres, industry, and the broader community, and SAAQIS significantly improves the availability of information to establish AQMPs going forward (Scorgie, 2012).

Vaal Triangle Airshed Priority Area

The VTAPA was declared in 2006 and comprised a portion of the City of Johannesburg Municipality, Emfuleni, Midvaal, and Metsimaholo Local Municipalities (Figure 1) (DEA & NWU, 2018; DEA, 2018c; DEAT, 2006). The VTAPA has high emissions from various industrial sources, including a coal-fired power plant, collieries, and quarries. This area is heavily populated with large high-density informal residential settlements, where coal

and wood-burning are typical and have exceeded the health and NAAQS (Annegarn & Scorgie, 1997; DEA & NWU, 2018; DEAT, 2009; Feig et al., 2014; Lindeque, 2018; Mathee & von Schirnding, 2003; Mundackal et al., 2014).

Ambient air quality trend analysis

The South African Air Quality Information System (SAAQIS) holds a live database of ambient air quality across the monitoring stations in the country. It is available for all stakeholders to view (DEA, 2018a). Six ambient monitoring stations (Figure 1) have been set up in the Vaal Triangle locations of Diepkloof, Kliprivier, Sebokeng, Sharpeville, Three Rivers and Zamdela (Sasolburg) (DEA, 2018c; Feig et al., 2014).

Figure 2 is a representation of the particulate matter (PM_{10} and $PM_{2.5}$) annual average data from 2007 to 2018 as presented in the "State of Air Report and National Air Quality Indicator" of 2018 (DEA, 2019a). These graphs illustrate the state of compliance of the different areas within the VTAPA with the NAAQS over the past ten (10) years which indicates that almost all are in noncompliance. Fugitive dust, fires, mining, transportation, electricity generation, industrial activities, domestic fuel burning, and traffic are PM sources (Altieri & Keen, 2019; de Lange et al., 2019; Kim et al., 2000). Conclusions made by the State of Air report indicated that PM is the most significant concern due to the numerous pollution sources, even though climatic conditions are an essential factor (DEA, 2019a). Therefore, increased action from national, provincial, and local levels of government would be required to decrease particulate matter concentrations to meet the standards.

It should be noted that a reduction in pollutants cannot solely be a factor of good intervention implementation because, from the air quality perspective, climatic conditions also play a significant role (Lewis et al., 2020). Furthermore, major policy shifts in the energy, mining and transport sectors would be critical to achieving clean air goals, in addition to the continuous and successful implementation of emission reduction strategies (DEA, 2019a).

Methodology

The Lee and Colley Review Package was adopted and modified in this study to review the quality of the VTAPA AQMP (Lee & Colley, 1992). There has not been a study that evaluates or assesses air quality management plans in South Africa. Research available internationally focuses on the improvement of air quality through different models to compare the ambient air quality before and after management interventions have been put in place (Berhane et al., 2016; Cheng et al., 2019; D'Elia et al., 2009; Ghodousi et al., 2017; Kim & Lee, 2018; Mardones & Cornejo, 2020; Pisoni et al., 2019; Thunis et al., 2017; Wang et al., 2016; Wang & Hao, 2012). This method has been successfully and widely used in the review of the quality of environmental impact assessments and modified for strategic environmental assessment reports, environmental management programmes as well as health impact assessments similar to this study (Anifowose et al., 2016; Bonde & Cherp, 2000; Chang et al., 2013; Cilliers et al., 2015; Fischer, 2010; Fredsgaard et al., 2009; Hallatt et al., 2015; Sandham & Pretorius, 2008; Sandham et al., 2013b; Swanepoel et al., 2019). The LCRP, though seemingly complex, is relatively simple, easy to learn, and easily adaptable with minor changes to suit the application (Lee et al., 1999). The LCRP is robust in that it can be amended to satisfy the legislative requirements of different countries while staying mainly in its original form (Lee & Colley, 1992). In addition, the

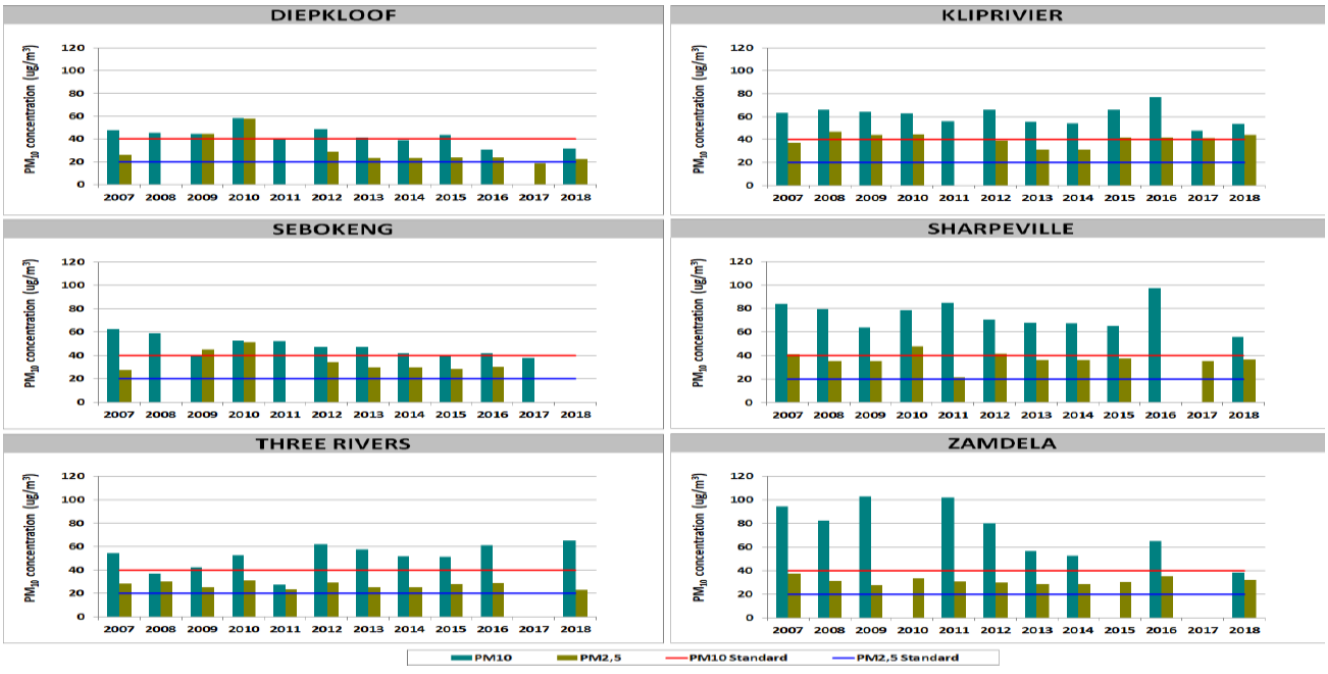

Figure 2: *PM_{10} and $PM_{2.5}$ yearly average data from 2007 to 2018 comparing the Vaal Triangle's compliance with the NAAQS (DEA, 2019a)*

LCRP provides the framework and methodology for quality evaluation for any subject. Three documents were used as guidelines in the development of the review package: firstly, the Manual for Air Quality Management Planning (the manual) (DEAT, 2008); secondly, the National Framework for Air Quality Management in South Africa (the framework); and lastly the National Environmental Management: Air Quality Act 39 of 2004.

In this study, a qualitative research method was adopted using a single case study, specifically reviewing the quality of the first-generation and the second-generation draft AQMP for the VTAPA. The VTAPA AQMP was chosen as a case study because among the priority area AQMPs, it was the first AQMP to be developed and the only one with a second-generation plan. Therefore it was essential to assess the quality of the second-generation version of the plan since the air quality in the area could not be sufficiently improved since the development of the first generation AQMP (Tshehla & Wright, 2019).

The LCRP has been successfully and widely used in the review of the quality of environmental impact assessments and has also been widely or adapted or modified for strategic environmental assessment reports, environmental management programmes as well as health impact assessments (Anifowose et al., 2016; Bonde & Cherp, 2000; Chang et al., 2013; Cilliers et al., 2015; Fischer, 2010; Fredsgaard et al., 2009; Hallatt et al., 2015; Sandham & Pretorius, 2008; Sandham et al., 2013b; Swanepoel et al., 2019).

The LCRP requires at least two reviewers to independently do the assessment (Lee et al., 1999). The reviewers later discuss or compare the differences of the assessment outcomes and re-evaluate to resolve the differences in those assessments to decide the terms of the scoring (Põder & Lukki, 2011). However, similar to used only one reviewer due to similarities in the reviews and very little variance in the two reviewers' assessments, a single reviewer was used for this research.

The methodological principles of the LCRP, as the hierarchical approach and the use of letters for rating, were used in the design of the AQMP review package (Cilliers, 2016; Põder & Lukki, 2011; Retief, 2007).

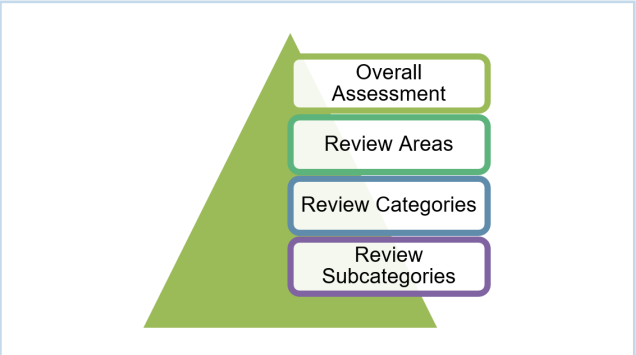

Figure 4: *Pyramid structure of Lee and Colley review method (Sandham & Pretorius, 2008)*

A review starts at the base of the pyramid with subcategories which are given a score of A-F based on the success of a task, and then the score is combined to provide an overall rating for each category as shown in figure 3 (Sandham et al., 2013a). Subcategories refer to actions/activities that must be done to ensure that the activities listed in the category are performed well (Lee et al., 1999).

Review categories are the activities that need to be undertaken within review areas. Review areas are the main activities of the AQMP (i.e. baseline air quality assessment) (Lee et al., 1999). The A-F sliding score indicates the level of quality, with scores of A-C reflecting the good quality and rating of D-F relatively poor quality (Bonde & Cherp, 2000). As part of the modification LCRP in this study, the categories and subcategories of the review package were developed using the three documents, i.e. the manual, the National Framework, and the Air Quality Act. This study has developed nine (9) review areas for the AQMP review package.

Table 1: *A-F assessment score table with explanations (Lee & Colley, 1992)*

Symbol	Explanation
A	Relevant tasks well performed; no important tasks left incomplete.
B	Generally satisfactory and complete; only minor omissions and inadequacies.
C	It can be considered just satisfactory despite omissions and/or inadequacies.
D	Parts are well attempted but must, as a whole, be considered just unsatisfactory because of omissions or inadequacies.
E	Not satisfactory, significant omissions or inadequacies.
F	Very unsatisfactory, important tasks(s) poorly done or not attempted.
N/A	Not applicable. The Review topic is not relevant, or it is irrelevant in the context of this statement.

Methodological limitations

The second-generation AQMP for the VTAPA was assessed in its draft format as the plan's development was ongoing at the time of this study. Although there is an inherent risk in analysing a document out for public review, the quality checks done by the Project Steering Committee and the expert panel includes members of academia, regulators, industry experts and NGO's, as well as the National air quality officer, means that the draft document is essentially scientifically correct and has gone through a vigorous vetting process (DEFF, 2020).

Data analysis, results and discussion

Review packages and checklists for quality assessment in environmental impact reports have been the main tools used internationally and locally and consist of set criteria of rating

evaluation tasks against the Environmental Impact Report (Lee et al., 1999; Sandham et al., 2013a). Quality reviews are undertaken to systematically evaluate the strength and weaknesses of plans to judge the overall quality and that they are of a good standard (Berke & Godschalk, 2009). Refer to appendix A for a comprehensive comparison of the review scores per review area. The second-generation draft AQMP was not analysed in Review Areas 8 and 9, these were not analysed because, at the time of the analysis, the second-generation AQMP was still in its draft format and was undergoing its public comment phase of the AQMP development.

Overview of the AQMP – Review Area 1

This study shows that AQMPs for both the first and second generation did well to identify overall and specific goals in line with air quality problem areas of the region. Section 1.4 of the National Framework requires that goals and objectives be "SMART" (specific, measurable, achievable, realistic, and timeous) and informed by section 2 principles of the NEMA. However, the overall goals set out in Section 5.3 of the first-generation AQMP do not have timeframes, thereby not fulfilling the SMART principle. Compliance with the minimum emissions standards and fugitive dust, veld fires, and awareness in the second-generation AQMP were also not SMART because these goals did not outline the timeframe with which the goal would be met although the different objectives may have included timeframes.

Both AQMPs fail to adequately describe the different land uses, topography, landscape, and natural resources, including the socio-economic status of the region. Section 2 of the manual requires that the socio-economic impacts be addressed in all interventions. Therefore, it was pertinent that the socio-economic status should be known. According to the summary of the health study provided for in the second-generation draft AQMP, the socio-economic status of an area and its fuel use make people vulnerable to air pollution (DEFF, 2020). This category scored a C for both AQMPs, indicating that it can be considered satisfactory despite omissions and/or inadequacies.

Implementation of Chapter 3 NEM: AQA – Review Area 2

Despite a health study being conducted, people living in areas where fossil fuels are used for household purposes remains unknown in the VTAPA. A health impact study in the study area determined poor health related to energy use in the household coupled with poor hygiene practices, overcrowding, and lifestyle choices (DEFF, 2020).

Industrial air pollution sources were only identified in the hotspot area in the first-generation AQMP. Dust-generating sources identified in the VTAPA include mining operations, Eskom's ash dump, the petrochemical sector, and iron and steel sectors, which were identified in Section 2.4.2. Section 2.4.2.1 of the first generation AQMP provides no distinction between Section 21 (listed air quality activities) and Section 23 (Controlled Emitters) industries as per Section 16 of the NEM: AQA, which requires a quantification of Section 21 and Section 23 facilities however it is to be noted that Section 21 and 23 requirements were not published at the time of publication of the first generation AQMP. No obligations with respect to international agreements were referenced. However, best practice guidelines and strategies for local and international examples were used, including the progress and shortfalls of best practices. Furthermore, the roles and responsibilities for all the spheres of government were well laid out.

Section 3.3 of the second-generation draft AQMP report mentions the total number of point sources within the region including the number of Section 21 (listed air quality activities) and Section 23 (controlled emitters). Other pollution sources are well-represented in terms of source profiling. International agreements, best practice principles and plans for improved air quality as required by the Act have not been identified. Although the second-generation draft AQMP mentions that best practice guidelines will be used throughout the document, it does not stipulate which and where this learning is coming. In some instances, further study is needed in terms of best practices. Such an omission does not inspire confidence that adequate research was done on the best practice of air quality. The use of best practice guidelines assists in using methods, techniques, and technologies that are already tried and tested and have proven success or failure (DEAT, 2009).

The lack of capacity within the government may have led to the poor implementation of the identified interventions (DEFF, 2020). This led to the conclusion that the local government option, as a lead for implementation, is inadequate to effectively tackle and comply with air pollution challenges (Gollata & Newig, 2017).

Therefore, both the first and second-generation draft AQMPs were given a score of C.

Air quality goal setting – Review Area 3

Overall, the primary pollutant impacting health identified in the plans is PM_{10}, as outlined in Section 5.2.1 in the first generation and Section 2.2 in the second-generation draft AQMP.

The first-generation AQMP has assessed the regional impacts and greenhouse gases were considered in Section 2.3, 3.1.1, and 4.9 of the report. No evidence could be found that the second-generation draft AQMP had documented environmental and climate change-related impacts as required by subcategories 3.1.2 and 3.1.3 of the review package. Furthermore, regional and transboundary issues are also poorly expressed. Similarly, greenhouse gases and indoor exposure risks are also poorly represented in the second-generation draft AQMP.

The provision of training, institutional building, and information management has been well laid out and maintained from the first-generation to the draft second-generation of the AQMPs. The referencing of legislation throughout both texts is excellent, with obligations to create specific laws achieved.

The first-generation AQMP fared better than the second-generation draft AQMP. The first generation scored overall a B which is satisfactory and complete with only minor omissions and inadequacies. On the other hand, the second-generation draft AQMP was considered just satisfactory, despite omissions and/or inadequacies, scoring a C.

Baseline air quality assessment – Review Area 4

Both AQMPs described the boundaries of the AQMPs well. They included the regions that fall within the VTAPA as well as the affected municipalities. However, the AQMPs did not provide information on the urban populated extensions and the boundaries of the most populated areas.

The climate and climatic conditions such as wind, temperature and precipitation data are well-presented in both AQMPs. The climate and meteorology data are crucial as it indicates the dispersion conditions within the area. The dispersion potential is attributed mainly to climatic conditions, particularly the wind field (DEA, 2018c). Thus, having this information for the baseline assists greatly in modelling the pollution potential of emissions within the area and predicting their movements when analysing wind data. An explanation of the air stability and temperature inversions and impacts thereof were well explained within the first-generation AQMP in Section 4.1 of the baseline report.

Nevertheless, this was not investigated thoroughly in the second-generation draft AQMP. An inversion layer in the atmosphere traps pollutants within that layer. This results in the pollutants being easily transported by the wind. There is a high dispersion potential in the case of strong winds, and the inverse is true for slight breezes (Thomas, 2008). Therefore, this is an essential omission that the second-generation draft AQMP suffers as it describes the behaviour of the pollutants as a direct result of the climatic conditions. Both AQMPs score a B in this review area.

Air quality management system – Review Area 5

A well-placed monitoring network, working optimally under the recommended standards and guidelines, is critical to monitor the pollution trends of the area (DEAT, 2009; DEFF, DEFF Department of Environment Forestry and Fisheries, 2020). Modelling plays a part both in the planning stage of initiatives and in providing insight into the efficacy of intervention after it has been implemented (Lewis et al., 2020). Having confidence in the air quality management systems gives assurance in any analysis done in line with the data provided (DEAT, 2008). A large data set improves the statistical power of research, particularly over a more extended period, accounting for meteorological factors (Lewis et al., 2020).

The air quality monitoring systems reflected for the second-generation draft AQMP report had more than enough information available to ensure that the monitoring network was well-established and covered the entire study area. Going forward, additional monitoring points have also been identified for the VTAPA to expand the monitoring network (DEFF, 2020).

Regarding the ambient monitoring network for the first-generation AQMP, there were no set standards to measure against as the National Ambient Air Quality Standards had not yet been promulgated when the plan was published. The DEA monitoring stations were only operational for a short time before the development of the AQMP and did not fulfil the three years required for data availability (DEAT, 2009).

The identification of sources was grouped in sectors (industry, commercial, mines and ash dumps, vehicles and domestic fuel burning) and not in terms of point, line and area as required by the manual. The first-generation AQMP scored a B in this review area, while the second-generation AQMP scored an A overall.

Gap analysis and challenges – Review Area 6

Section 3.6 of the manual requires that a gap analysis is conducted. In the first-generation AQMP, the gap analysis was carried out in a problem analysis and objectives setting, whereby a fault tree analysis was conducted in Section 4 of the AQMP for each of the problem complexes identified. In this study, eleven (11) problem complexes were identified and were further divided into emission and non-emission problem complexes. The manual requires that gaps be identified in many ways, including, but not limited to, the inadequacies of monitoring data, emissions inventory, stakeholder consultation, complaints, capacity, and funding constraints, to name a few (DEAT, 2008). Complaints data (complaints lodged) was overlooked entirely in terms of adequately trending the complaints received in the VTAPA, and these could have provided invaluable information for problem areas (DEAT, 2008).

The draft second-generation AQMP complaints data was not considered when evaluating weaknesses and challenges for the plans. However, stakeholder participation was evident in the second-generation draft AQMP, where the voice or opinions of stakeholders were noted as concerns in the implementation of the AQMP for the VTAPA. The first- and second-generation AQMPs score a C and B, respectively, indicating good performance.

Intervention strategies – Review Area 7

The implementation of intervention strategies is proposed to be directly linked to improved ambient air quality (DEAT, 2009). Improved ambient air quality was used as a marker for effective intervention implementation; Section 5 of the second-generation draft AQMP models the emissions performance after successfully implementing all intervention strategies (DEFF, 2020).

Section 5 of the first-generation AQMP highlighted all the intervention strategies implemented in terms of policy and legislative changes, as required by Section 3.9 of the manual.

Several standards, manuals, and publications were planned for in the first generation AQMP as intervention strategies relating to governance. These standards, manuals and publications included the National Ambient Air Quality Standards, National Framework for air quality management, Listed Activities and National Emission Standards, and declaration of small industries as controlled emitters, to name a few significant governance interventions that have since been established.

The first-generation AQMP identified interventions for each air pollution source and specific facilities, including Sasol, Eskom, and Samancor. Furthermore, all the intervention strategies identified indicated the time frames (short-, medium- and long-term) for implementation. Yet, they did not tackle the technical or socio-economic impacts of the intervention as required by the manual in Section 3.8.2.1. Dispersion modelling for potential reduction in pollution after implementing the reduction strategy was not included as required by the manual in Section 3.28.2. The estimated cost for the projects proposed was included for each of the strategies in most cases. However, the benefits associated therewith were not included as required by Section 3.8.2.1 of the manual. Measures to reduce emissions from different sources were well-documented, along with responsibilities to implement the reduction strategies for each problem complex.

The second-generation draft AQMP does not supply the intervention strategies that each facility would implement for emissions reduction however the requirement to comply with the MES provides guidance in terms of the expectation from government in terms of compliance. Each emission source needs to provide information on existing emission reduction strategies (DEAT, 2008). General strategies have been identified, and time frames for execution have been specified from short to long-term. The budget implication for each strategy was also included as required in Section 3.8.2.1 of the manual. The dispersion model predictions showed an observed reduction in emissions (PM_{10}, $PM_{2.5}$, NO_2, O_3 and SO_2) if all intervention strategies were implemented within the committed timeframes (DEFF, 2020). Measures to reduce emissions from point, line and area sources were well documented, along with responsibilities to implement the reduction strategies. However, in some cases, the responsibility might need to be clarified when the roles are split with different entities (government, NGOs, CBOs) as indicated in the Implementation plans for domestic waste burning and biomass emissions.

The collaboration of Non-Governmental Organisations (NGOs) and/or Community-Based Organisations (CBO) in assisting the municipalities with conducting awareness and educational campaigns are prevalent in both AQMPs. Despite this, it is unclear if there were Public-Private Partnerships (PPPs) to facilitate these agreements. Section 5.9.2.3 of the framework identifies PPPs as one of the strategies that can be used to improve capacity through awareness. The first-generation AQMP indicated collaboration between Eskom, Sasol and the government in implementing the Basa Njengo Magogo top-down fire making method. However, the second-generation draft AQMP does not have such promises or commitments.

Where the interventions are to be conducted by government organisations, the municipal fund has been identified in the first-generation AQMP. In the second-generation AQMP, there has been no mention of where the funds will be coming from. Section 4.2.5 of the national framework identifies the national and provincial governments as the principal responsibility for these funds. For some projects, it has been recognised as an enabling factor for intervention funds raised from offset projects and social responsibility initiatives projects. These statements do not assure that funds are available, and there is no legal requirement that forces industries to provide funding for projects identified by the department. Industries had already identified viable projects that they will implement as part of the postponement applications when Atmospheric Emissions Licenses (AEL) were issued (SRK consulting, 2019). This concern over the lack of adequate budgetary allocations is identified as a risk that would result in an inability to achieve the goals in the second-generation draft AQMP.

The overall goals, targets and objectives for the VTAPA have been well-summarised for each of the problem complexes in the first- and second-generation draft AQMPs. In terms of goal one (1), specifically of the second-generation draft AQMP, it stipulates that industries need to comply with the Minimum Emissions Standards (MES) by 2025 as an objective. Some industries, however, have received postponements on their MES limits, allowing for postponements of the 2020 MES limits. (DEA, 2018c). Therefore, the industry's expectation will comply with MES by 2025 does not conform to the current situation. Perhaps the timeframe for compliance with this requirement should have been extended up to 2030. Overall, for this Review Area, the first-generation AQMP scored a B, which is generally satisfactory, and the second-generation draft AQMP scored a C which is just satisfactory.

Communication and stakeholder participation – Review Area 8

According to the framework, successful development and implementation of the AQMP relies on the participation of multiple stakeholders (DEA, 2018a). According to the manual, stakeholder participation should take place early at goal setting phase through consultation. It was clear that stakeholder participation has taken place as per the requirements of the manual. This is further supported by the provision of concerns highlighted by stakeholders within the AQMP, which resulted from various stakeholder interventions allowing them to voice their concerns (DEAT, 2009). The AQMP has indicated awareness campaigns and communication channels that ought to be used for communication and stakeholder participation. The MSRG and workshops were the platforms used for the AQMP development (DEAT, 2009). The first-generation AQMP scored a B overall in this review area, which is generally satisfactory and complete.

Reporting, monitoring and review – Review Area 9

According to Section 3.11.2 of the manual, the annual performance of the AQMP should be provided. The content should include: firstly, the extent to which the AQMP was implemented; secondly, air quality management initiatives; thirdly, compliance of the AQMP to the applicable standards; fourthly, how the priority area performed in achieving the targets; and lastly, any amendments to the plan (DEAT, 2008). The AQMP at the time stipulated that this function was a multi-stakeholder function and, therefore, the MSRG would be the platform through which this annual performance would be undertaken. A framework was to be developed as part of the AQMP process.

The provision of funding has been identified as a requirement in Section 3.1.2 of the manual, including explaining any budget constraints in Section 3.6. The second-generation draft AQMP refers to various potential funding mechanisms, although it is unclear whether these mechanisms have been finalised. For both plans, there is a barrier to implementing the AQMP because, without funds, most of the mechanisms identified, especially from the regulator's point of view, cannot be implemented.

According to the planning arrangements in the first-generation AQMP, the plan was to be revised after five (5) years unless stipulated otherwise. Eleven years after it was published, a second-generation draft report was published. Among other things, it was delayed by the need to adequately identify the sources of pollution in the area to create interventions that cater to the primary pollution sources (DEFF, 2020). Therefore, the review process of the AQMP failed to meet its commitment of a 5-yearly review. A score of B was determined for the first-generation AQMP.

Conclusion

The main aim of this study was to determine the quality of the VTAPA AQMPs. The quality of the AQMP was determined using the requirements as stated in the manual, the framework and the NEM: AQA, effectiveness evaluation was not undertaken as a part of this paper. Evaluating the quality of the first-generation AQMP could assist in unearthing shortcomings of the first-generation AQMP and those of the second-generation draft AQMP and indicating why the initial plans were not effective.

In general, the first-generation AQMP was of better quality than that of the second-generation draft AQMP. The first-generation AQMP scored a B overall for its quality assessment which is generally satisfactory and complete with only minor omissions and inadequacies. In contrast, the second-generation draft AQMP scored a C, which is just satisfactory despite minor omissions. These documents included goals, fact bases, policies, public participation, and plan provisions for implementation and monitoring as required for plans to be considered of good quality (Lyles & Stevens, 2014).

Several shortfalls were identified which affected both plans, these shortfalls were identified in the following areas: (1) the description of the socio-economic status; (2) the identification of international agreements; (3) the assessment of regional and greenhouse impacts; (4) description of urban population extension and urban agglomeration boundary; (5) complaints data; (6) and lastly, funding. The failure of planners to predict demographic and economic change inevitably restricted the reach of planning at the outset (Talen, 1997). Funding for intervention plans as a primary driver for development was a shortfall identified in this review for both AQMPs. According to (Talen, 1997) (1) political complexity and lack of consensus in society, (2) vagueness and lack of data, and (3) the lack of funding and level of community support are some of the factors that may lead to poor implementation of plans.

Implementing task teams and further awareness and training in different platforms have also been well-outlined. Some intervention strategies were implemented by government departments, which do not form part of the VTAPA Multi Stakeholder Reference Group (MSRG). To curb waste and tyre burning, the public needs to be made aware of its impacts. Therefore, awareness campaigns need to have a far wider reach than what is allotted in the draft plan.

The intervention strategies identified for the second-generation draft AQMP are more projects-orientated instead of investigation, research and policy-driven, as with the first-generation AQMP. Lewis et al. (2020) note that a reduction in pollutants cannot solely be a factor of good intervention implementation because the atmospheric conditions such as temperature, wind and precipitation also play a significant role from an air quality perspective in terms of pollution dispersion potential.

The lack of capacity within the government may have led to the poor implementation of the identified interventions (DEFF, 2020). This led to the conclusion that the local government option for implementation may be inadequate in effectively tackling and complying with air pollution challenges at a regional scale (Gollata & Newig, 2017). Local authorities have stronger administrative powers; however, they lack sufficient compliance capabilities such as legal and financial backing and are reluctant to enact higher levels of regulation (Gollata & Newig, 2017).

The first-generation AQMP quality assessment reveals that it is of good quality because it met the review package's requirements better than the second-generation draft AQMP. However, the first-generation AQMP still failed to meet the overall objectives set, which includes improving the ambient air quality of the region.

Consequently, the conclusion is that the second-generation draft AQMP requires more input to perform better since it has performed poorly compared to the first-generation AQMP in general. Some of the information that may improve the AQMP quality other than funding includes, but are not limited to: (1)

the description of socio-economic impacts; (2) the identification of areas that use fossil fuels; (3) a reference to international agreements; (4) best practice examples both nationally and internationally; and (5) lastly, using complaints data to outline emission excursion trends. However, there were many improvements that the second-generation draft AQMP provided: the health and the source apportionment studies as well as a better-outlined air quality management system.

Despite being of good quality, the first-generation's implementation did not result in the desired outcomes due to external factors beyond the plan. Therefore, the quality of a plan does not necessarily mean it will be implemented well so long as the external factors impacting upon the plan are not addressed, and therefore high implement ability does not translate to a good plan (Talen, 1997; Tian & Shen, 2011). As discussed by (Talen, 1997), these include but are not limited to political complexities, lack of information, lack of funding and an inability to link cause and effect. The energy, mining and transportation sectors need major policy shifts if the country is to successfully move towards a path of pollution reduction (DEA, 2019a). Interventions created for any management plan need to be effective and yield sustainability in their implementation (Wright & Oosthuizen, 2009).

Recommendations and areas of future research

To improve the quality of the AQMP, funding mechanisms need to be investigated to assist in implementing intervention strategies. The industries that cause any air pollution could be used to generate revenue in the form of environmental pollution taxes/levies for the implementation of AQMP intervention strategies, this can be achieved by having regulations in line with the NEMA polluter-pays principle. This can be achieved by having a regulation in line with the NEMA polluter-pays principle like the implementation of the Carbon Tax Act.

Future research in this field should include evaluating and comparing the quality and effectiveness of AQMPs in the different air quality Priority Areas; the AQMP review package can be used in further studies evaluating the quality of other AQMPs, and a should be developed to assess effectiveness.

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Appendix A Summary tables of review areas 1-9

RA, Category, subcategory	First-generation	Draft Second generation
1. Overview of the AQMP	C	C
1.1 The AQMP clearly sets the goals and objectives of the VTAPA AQMP	A	A
1.1.1 The overall goals of the AQMP have been identified	A	A
1.1.2 The specific goals of the AQMP have been identified	A	A
1.1.3 The goals and objectives are linked to the specific air quality problems of the area	A	A
1.1.4 Objectives are SMART (Specific, Measurable, Realistic and Timeous)	C	B
1.2 Geographical area within which the AQMP will be implemented are described	C	C
1.2.1 The geographical area is mapped out	A	A
1.2.2 Description of the area, land use, topography, landscape and natural resources are described	D	D
1.3 The description of socio-economic status is provided for	F	F
1.3.1 The description of demographics is addressed	F	F
1.3.2 Socio-economic status is outlined	F	F

	First-generation AQMP	Draft second-generation AQMP
2. Implementation of Chapter 3 of Air Quality Act – Section 16 and 17	C	C
2.1 Identification of the main air pollution sources	A	A
2.2 Identification of areas where fossil fuel are used for domestic use	D	F
2.2.1 List of areas that use fossil fuel for domestic use	C	C
2.2.2 Health status of persons living in areas of high fossil fuel use for domestic use	F	D
2.3 Identification of all industrial air pollution sources	D	D
2.3.1 Inventory of Section 21 industries	D	C
2.3.2 Inventory of Section 23 industries	F	C
2.3.3 Inventory of industries generating dust	D	B
2.3.4 Inventory of industries that may cause air pollution but are not listed	C	F
2.4 International Agreements	F	F
2.5 Best practice guidelines identified for air quality management and listed	A	F
2.6 Roles and responsibilities	B	B

	First-generation AQMP	Draft second-generation AQMP
3. Air Quality goal setting	B	C
3.1 Identification of primary and secondary pollutants of concern	B	C
3.1.1 Pollutants impacting health	B	B
3.1.2 Environmental impact-related	B	F
3.1.3 Climate change-related	D	F
3.2 Assessment of impact of industrial activities	A	A
3.3 Assessment of regional issues	D	D
3.4 Assessment of greenhouse gases	C	D
3.5 Assessment of indoor exposure	D	D
3.6 Provision made for training, institutional building and information management	A	A
3.7 Reference made to compliance with legislative requirements	A	A

	First-generation	Draft Second generation
4. Baseline air quality assessment	B	B
4.1 Area description and definition		C
4.1.1 Description of administrative boundaries	A	A
4.1.2 Description of region or municipality	A	A
4.1.3 Description of Priority Area definition	B	A
4.1.4 Description of urban populated extension	F	F
4.1.5 Description of urban agglomeration boundary	F	F
4.2 Meteorology and climate description	A	B
4.2.1 Description of the climate of the area	A	A
4.2.2 Presentation of wind, temperature and precipitation data	A	A
4.2.3 Description of air stability and temperature inversions	A	C
4.3 Information about the population distribution and population density presented	B	B
4.4 Evaluation of baseline air quality data	B	B
4.4.1 Description of air quality monitoring programmes	B	B
4.4.2 Description of quality assurance and quality control (QA/QC) programme	B	C
4.4.3 Description of current air quality	B	B
4.4.4 Identification of sources and emissions	A	A
4.4.5 National and Provincial requirements	F	B
4.4.6 Adequacy of AQM structures	C	B
4.4.7 Inventory of current procedures and methods	A	A

	First-generation	Draft Second generation
5. Air Quality Management system	B	A
5.1 Air quality monitoring	B	A
5.1.1 Ambient air quality monitoring network	C	A
5.1.2 Location of monitoring stations	B	B
5.1.3 Source monitoring	A	A
5.1.4 Continuous meteorological monitoring	C	A
5.2 Emissions inventory	B	A
5.2.1 Identification of types of sources – point, line, area	C	A
5.3 Atmospheric dispersion modelling conducted for the area	B	A

	First-generation	Draft Second generation
6. Gap Analysis and challenges	C	B
6.1 A gap analysis conducted	C	B
6.2 Description of pressures and challenges	C	B
6.3 Problems associated with enforcement and compliance	C	A
6.4 Stakeholder consultation	B	B
6.5 Complaints data	F	F
6.6 Description of problems associated with enforcement and compliance	B	B

	First-generation	Draft Second generation
7. Intervention strategies	B	C
7.1 General intervention strategies available	A	C
7.1.1 Intervention strategies on policy implementation and legislative changes	A	B
7.1.2 Intervention strategies on the use of international best practice	A	D
7.2 Intervention strategies relating to air quality	C	B
7.2.1 Air pollution source has identified existing emission reduction initiatives and their effectiveness	B	C
7.2.2 Potential reduction strategies – short-, medium- and long-term	A	A
7.2.3 A description of each strategy	C	C
7.2.4 Dispersion modelling	F	A
7.2.5 Estimation of expected costs and benefits	B	B
7.2.6 Roles to implement the reduction strategy	A	C
7.2.7 Measures to reduce emissions from mobile sources identified	B	B
7.2.8 Measures to reduce emissions from area sources	A	A
7.3 Implementation of intervention strategies	B	C
7.3.1 Implementation task teams	A	A
7.3.2 Short-, medium- and long-term actions	A	A
7.3.3 Conducting awareness and educational campaigns	A	A
7.3.4 Public-Private Partnership	C	F
7.3.5 By-Laws developed	D	F
7.3.6 Funding	D	F
7.3.7 A summary of the entire AQMP is provided	C	C

	First-generation	Second-generation draft
8. COMMUNICATION AND STAKEHOLDER PARTICIPATION	B	
8.1 Stakeholder participation	A	
8.2 Awareness campaign and communication	C	
8.2.1 Engaging with the stakeholders	C	
8.2.2 Stakeholders to participate in the AQM planning process	B	
8.2.3 Workshops with interested and affected parties	A	
8.2.4 Awareness raising and building capacity	D	
8.3 Examples of successful implementation	B	
8.4 Benchmarking	B	

	First-generation AQMP	Second-generation draft AQMP
9. REPORTING, MONITORING AND REVIEW	B	
9.1 Reporting	A	
9.2 Monitoring	B	
9.2.1 Strategic issues	B	
9.2.2 Communication and public participation	B	
9.2.3 Financial plan	F	
9.2.4 Air quality management implementation programme	D	
9.2.5 Review of AQMPs	C	