Eskom

RESEARCH, TESTING AND DEVELOPMENT

SUSTAINABILITY

KWAZAMOKUHLE AIR QUALITY REPORT

MARCH 2016

EXECUTIVE SUMMARY

This monthly report covers the ambient air quality data as monitored at KwaZamokuhle monitoring site for March 2016.

There were three (3) exceedances of the national ambient air quality for PM_{10} daily mean limit of 75µg/m³ and two (2) for the $PM_{2.5}$ daily limit of 40µg/m³ recorded. There were no exceedances of the national ambient air quality limits for SO_2 10 minutes, SO_2 hourly, NO_2 hourly and Ozone 8-hourly average recorded during the monitoring period under review**.**

Both SO_2 and NO_2 ambient concentrations at KwaZamokuhle monitoring site are influenced by the combination of low-level sources and tall stack emitters and ambient fine particulate matter concentrations indicate the influence of low-level source emissions at KwaZamokuhle. Motor vehicle emissions and major roads in the township and Hendrina town might contribute to PM_{10} and $PM_{2.5}$ ambient concentrations.

The national ambient air quality limits for, SO_2 hourly, SO_2 daily, NO_2 hourly and Ozone 8-hourly average monitored during the period under review are well below their national air quality annual limits, with the exception of PM_{10} and $PM_{2.5}$. Both the PM_{10} and $PM_{2.5}$ have reached the limit and therefore a risk of non-compliance is perceived in the monitoring station.

The dominant winds during the day were from east -north-east, east, east-south-east and north-north-west. The dominant winds during the night were from east-north-east, east, east-south-east and south-south-east sectors.

The overall percentage data recovered from the monitoring station during the reporting period was 80.3% and station availability was 77.9%. Some of the parameters monitored at site did not meet the SANAS requirement of 90% data recovery per parameter due to incoming power interruptions and respective faults on the analysers. Data on NOx analyser was affected by faulty outputting channels, which resulted in high negative values and the following analysers: O_3, SO_2, PM_{10} and $PM_{2.5}$ data recovery was affected by tripping of circuit breaker that had blown-out.

1. INTRODUCTION

The KwaZamokuhle monitoring station is equipped to continuously monitor ambient concentrations of sulphur dioxide (SO_2), nitrogen oxides (NO, NO_2 and NO_x), ozone (O_3), fine particulate matter (FPM) of particulate size <10µm in diameter (PM_{10}) and fine particulate matter (FPM) of particulate size <2.5µm in diameter ($PM_{2.5}$). In addition, meteorological parameters of wind speed (WSP), wind direction (WDR), solar radiation (RAD), relative humidity (HUM), rainfall (RFL), pressure (PRS) and ambient temperature (TMP) are also recorded.

The monitoring site was established as part of a greater air quality offset pilot research study. The objective of the pilot study is to test the effectiveness of the most promising household emission offset interventions identified during Eskom's pre-feasibility study. This includes identifying the possible improvement in ambient air quality resulting from emission reductions at a household level. Data measured at KwaZamokuhle will represent baseline- and post intervention implementation ambient air quality**.**

2. SITE LOCATION

The KwaZamokuhle monitoring site is located in Hendrina about 22.5 km south-south-west of Arnot power station, about 27.3 km east-south-east of Komati power station and about 18.3 km south-east of Hendrina power station. (Co-ordinates: -26.138252, 29.738953)

Figure 1: KwaZamokuhle air quality monitoring station in relation to Komati, Hendrina and Arnot Power Stations

3. DATA RECOVERY

Data was analysed for completeness against a required SANAS guideline of 90% per parameter monitored and is represented in Table 1 for KwaZamokuhle monitoring site.

Table1. Percentage data recovered per parameter for March 2016

NO	NO_2	NO_x	O_3	PRS	RAD	RFL	SO_2	TMP	WDR	WSP	WVL	$PM_{2.5}$	PM_{10}	HUM	Data Recovery	Station Availability
29.7	29.7	29.7	78.8	100	99.9	99.9	75	100	99.9	100	99.9	73.1	72.4	99.9	80.3	77.9

The overall percentage data recovered from the monitoring station during the reporting period was 80.3% and station availability was 77.9%. Some of the parameters monitored at site did not meet the SANAS requirement of 90% data recovery per parameter due to incoming power interruptions and respective faults on the analysers. Data on the NOx analyser was affected by faulty outputting channels, which resulted in high negative values and consequently O_3, SO_2, PM_{10} and $PM_{2.5}$ data recovery was affected by the tripping of the circuit breaker that had blown-out.

4. SUMMARY OF RESULTS FOR REPORTED PERIOD

The National Department of Environmental Affairs (DEA) has set the South African Ambient Air Quality Standards for the criteria pollutants as illustrated in Table 2

Table 2: South African National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration	Allowed Frequency of Exceedances
NO_2	1 hour 1 year	106 ppb 21 ppb	88 0
SO_2	10 minute average 1 hour 24 hours 1 year	191 ppb 134 ppb 48 ppb 19 ppb	526 88 4 0
O_3	8 hours (running ave)	61 ppb	11
PM_{10}	24 hours	75 µg/m^3	4
	1 year	40 µg/m^3	0
$PM_{2.5}$	24 hours	40 µg/m^3 $^{(1)}$25 µg/m^3	0 0
	1 year	20 µg/m^3 $^{(1)}$15 µg/m^3	0 0

$^{(1)}$Compliance required by 1 January 2030

Table 3 is a summary report presenting highest mean concentrations and the number of exceedances of the respective National Ambient Air Quality Standards as monitored at KwaZamokuhle during the February 2016 monitoring period.

Table 3: Summary report

Pollutant	Highest Hourly Mean	No of Hourly National Limit Exceedances	Highest Daily Mean	No of Daily National Limit Exceedances	No of 8hr Moving Average Limit	Highest 10min Mean	No of 10min National Limit Exceedances
$PM_{2.5}$ (µg/m^3)	202.4		62.2	2		420	
PM_{10} (µg/m^3)	324.2		8601	3		420.9	
NO (ppb)	50.6		11.9			79.2	
NO_2 (ppb)	44.5	0	14.4			51.1	
NOx (ppb)	66		22.6			98.1	
OZN (ppb)	80.6		38.3		0	90.9	
SO_2 (ppb)	94.4	0	32.3	0		184.1	0
TMP (°C)	31.3		23.2			32.9	
WSP (m/s)	6.2		5			7.2	
WVL (m/s)	6		4.8			7	

There were three (3) exceedances of the national ambient air quality for PM_{10} daily mean limit of 75µg/m³ and two (2) for the $PM_{2.5}$ daily limit of 40µg/m³ recorded. There were no exceedances of the national ambient air quality limits for SO_2 10 minutes, SO_2 hourly, NO_2 hourly and Ozone 8-hourly average recorded during the monitoring period under review**.**

Table 4: Exceedances for the National Ambient Air Quality Standards.

Pollutant	75µg/m³ Limit	Year	Month	Day	Conc.
PM_{10}	75	2016	03	07	86.1
PM_{10}	75	2016	03	08	78.2
PM_{10}	75	2016	03	27	75.8

Pollutant	40 µg/m³ Limit	Year	Month	Day	Conc.
$PM_{2.5}$	40	2016	03	19	46
$PM_{2.5}$	40	2016	03	31	62.2

5. METEOROLOGICAL OBSERVATIONS

The distributions of wind direction and wind speed for daytime and night-time hours for the reporting period are summarised on polar diagrams. The centre of the wind rose depicts the position of the air quality-monitoring site. The positions of the spokes in the polar diagram represent directions from which the wind was blowing. The length of the segment indicates the percentage of the time the wind blew from that direction and the speed in the various categories are denoted by colours and width.

The dominant winds during the day were from east—north-east, east, east-south-east and north-north-west. The dominant winds during the night were from east-north-east, east, east-south-east and south-south-east sectors.

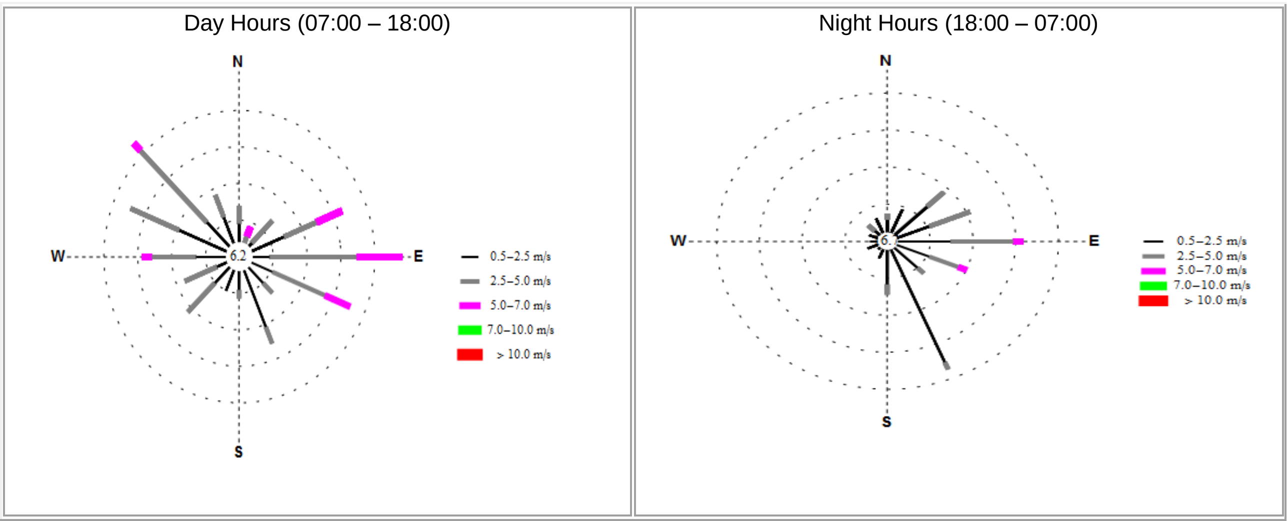

Figure 2: Wind profile at KwaZamokuhle monitoring site

6. DISCUSSION OF POLLUTANTS

Emissions of primary pollutants such as PM_{10}, SO_2, and NO_X from low level sources such as domestic combustion and motor vehicles are expected to impact at ground level more significantly during the evening and early morning hours as a result of temperature inversion. Emissions of such pollutants from tall stacks (power stations and other industries), are expected to have a more significant impact at ground level during the day between 09:00 and 16:00, due to atmospheric turbulence influences.

6.1. Sulphur Dioxide (SO_2).

6.1.1. Source identification by SO_2 hourly diurnal variations.

Figure 3 shows SO_2 concentrations increasing from the morning, recording a series of peaks at 11:00 and 17:00 in the afternoon, indicating the impacts of emissions from high level sources. A concentration peak was again recorded at 20:00 in the evening, indicative of influence from low level source emissions.

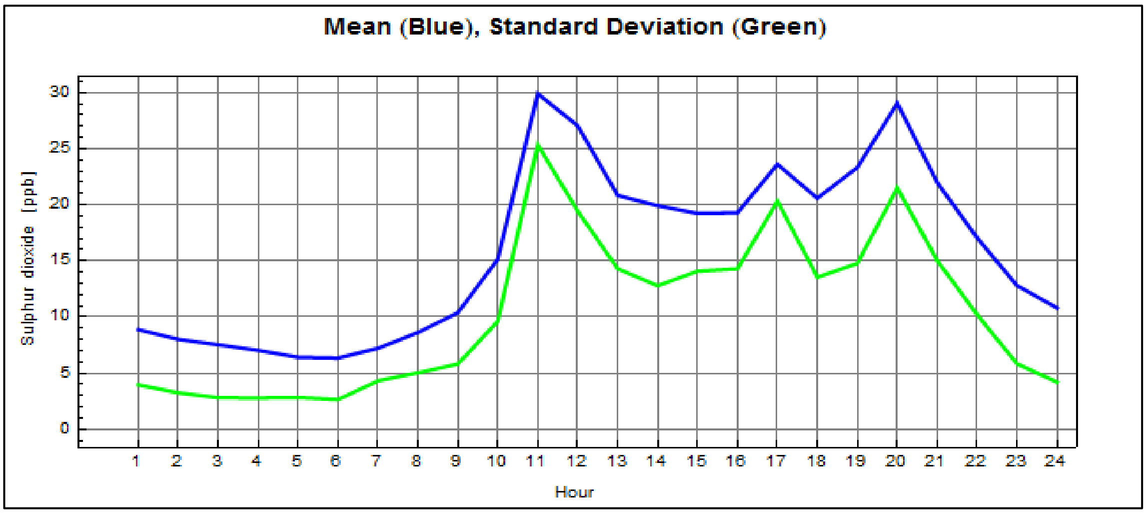

Figure 3: Diurnal variation of SO_2 hourly at KwaZamokuhle for March 2016

6.1.2 Sulphur dioxide hourly event roses

Since there were no exceedances of the SO_2 hourly limit of 134 ppb, 98^{th} percentile event roses were drawn to indicate the sectors where highest hourly concentrations were coming from during the day and night as indicated by Figure 4.

During the daytime the highest hourly mean concentrations above 64.34 (98^{th} percentile value) (Table 5) were recorded in the west-north-west and north-west sectors. Komati power station is about 27.3 km west-north-west and Hendrina power station about 18.3 km north-west of the monitoring site. The highest hourly mean concentrations above 56.35 ppb (98^{th} percentile value) (Table 6) during the night-time were recorded in the east-north-east, south-west, west and west-north-west sectors.

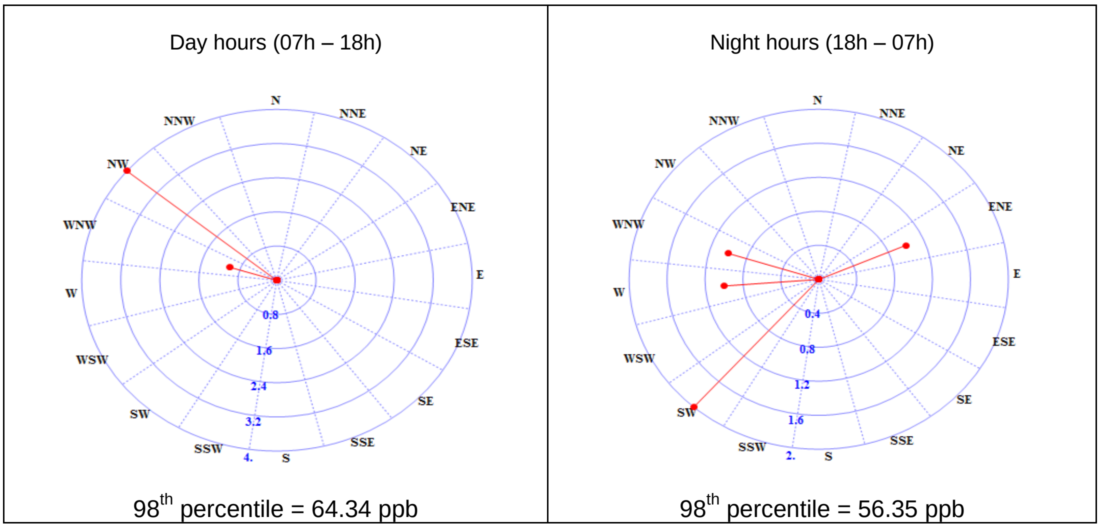

Figure 4: SO_2 hourly mean 98th percentile event roses during day and night times

Table 5: SO_2 day time hourly mean 98th percentile event table

Dir.	N	NNE	NE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0
%	0	0	0	0	0	0	0	0	0	0	0	0	20	80	0

Table 6: SO_2 night-time hourly mean 98th percentile event table

Dir.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	0	0	1	0	0	0	0	0	0	2	0	1	1	0	0
%	0	0	0	20	0	0	0	0	0	0	40	0	20	20	0	0

6.2. Nitrogen Dioxide (NO_2)

6.2.1. Source identification by NO_2 diurnal variations

The NO_2 diurnal variation shows NO_2 concentrations reaching peaks at 08:00 in the morning, 12:00, and 15:00 in the afternoon and 20:00 in the evening as indicated by Figure 5 below. The concentration peaks observed in the afternoon may be associated with influence from high-level sources, those recorded in the morning and evening may be associated with influence from low-level sources. Care should be taken when reporting using low data recovery (29.7%) since definite conclusions cannot be reached.

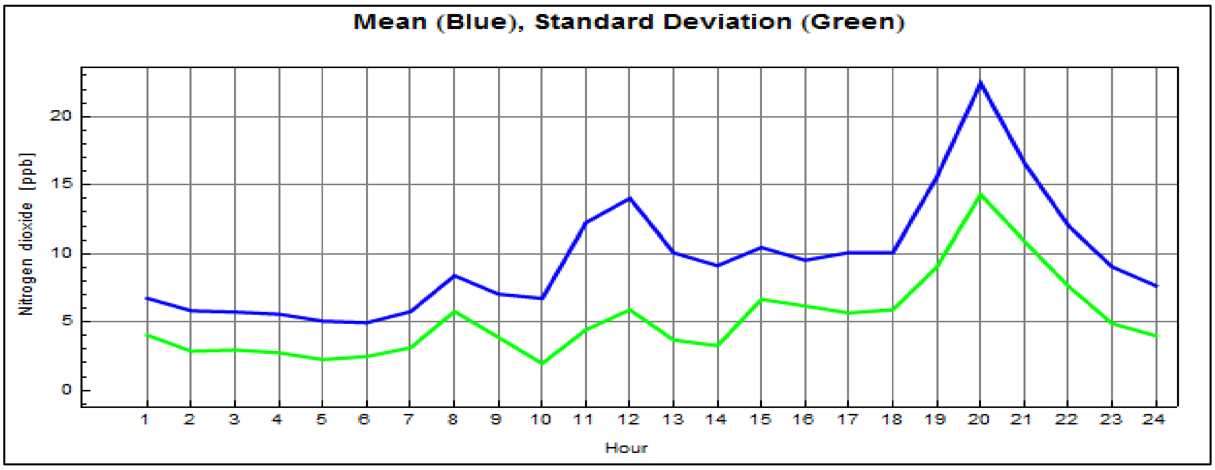

Figure 5: Diurnal variation of NO_2 hourly at KwaZamokuhle for March 2016

6.2.2 Nitrogen dioxide hourly event roses

Since there were no exceedances of the NO_2 hourly limit of 106 ppb, 98th percentile event roses were drawn to indicate the sectors where highest hourly concentrations were coming from during the day and night as indicated by Figure 6. During the daytime the hourly mean concentrations above 22.81 ppb (98th percentile value) (Table 7) were recorded in the north-west sector and Hendrina power station about 18.3 km north-west of the monitoring site. It should be noted that low percentage data (29.7%) was recovered for NO_2 during March 2016 which is not representative of the area and therefore care should be taken when using this data. The hourly mean concentrations above 31.74 ppb (98th percentile value) (Table 8) during the night-time were recorded in the west-south-west, west and west-north-west sectors and Komati power station is about 27.3 km west-north-west of the monitoring station.

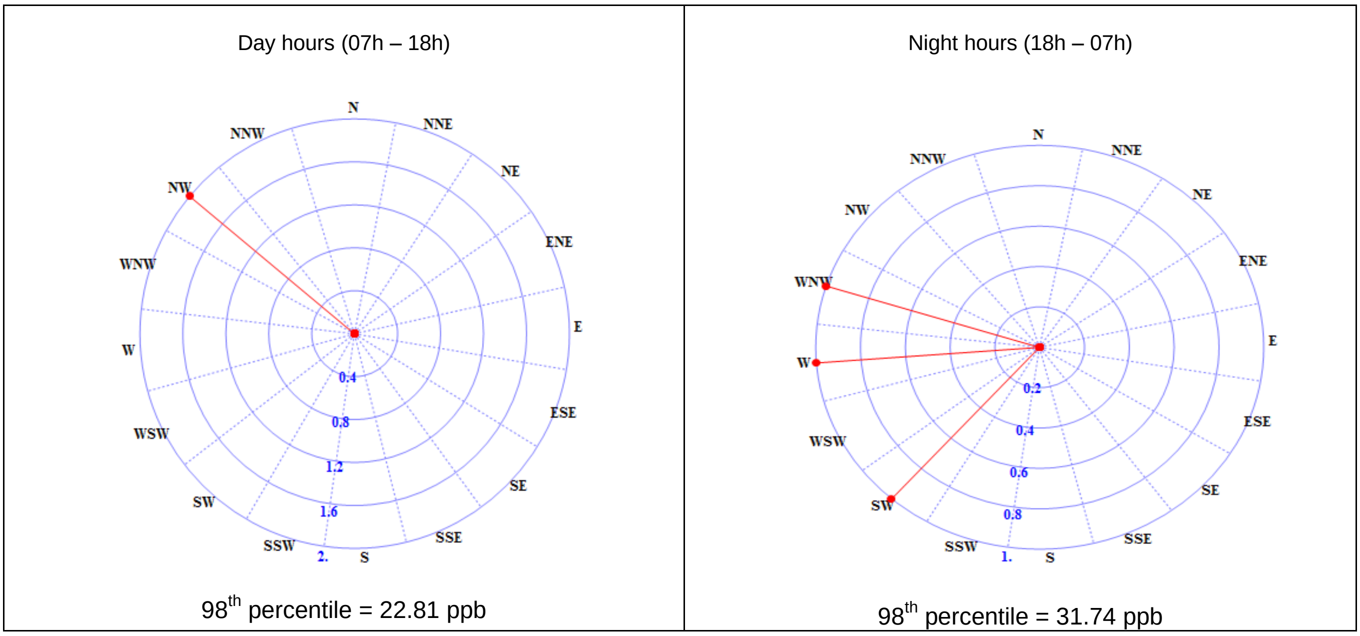

Figure 6: NO_2 hourly mean 98th percentile event roses during day and night times

Table 7: NO_2 day time hourly mean 98th percentile event table

Dir.	N	NNE	NE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
%	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0

Table 8: NO_2 night-time hourly mean 98th percentile event table

Dir	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0
%	0	0	0	0	0	0	33.33	0	0	0	0	0	33.33	33.33	0	0

6.3. Fine Particulate Matter (PM_{10} and $PM_{2.5}$).

6.3.1. Source identification by PM_{10} and $PM_{2.5}$ diurnal variations.

The $PM_{2.5}$ and PM_{10} diurnal variations (Figures 7 and 8) display a similar pattern that is an indicative of low-level emission source influence, with low concentrations in the morning. The concentrations increase from 06:00 and peak at 09:00 in the morning. They then decrease until 10:00 and continue to be low throughout the afternoon. They increase again from 16:00, reaching a maximum peak at 20:00 and decrease throughout the evening. These peaks observed in the morning and evening could be associated with emissions from low-level sources.

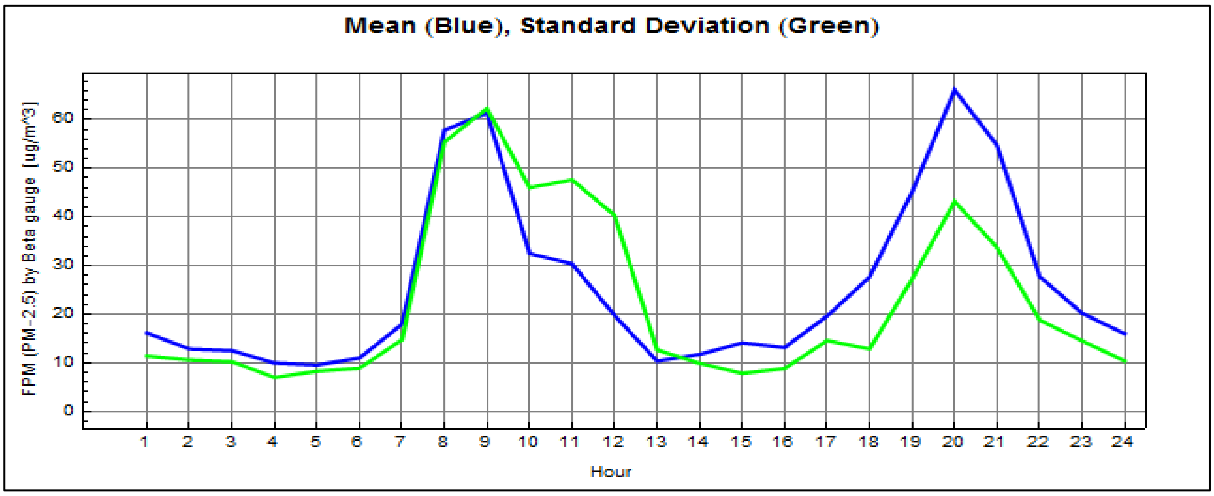

Figure 7: Diurnal variation of $PM_{2.5}$ concentrations at KwaZamokuhle for March 2016

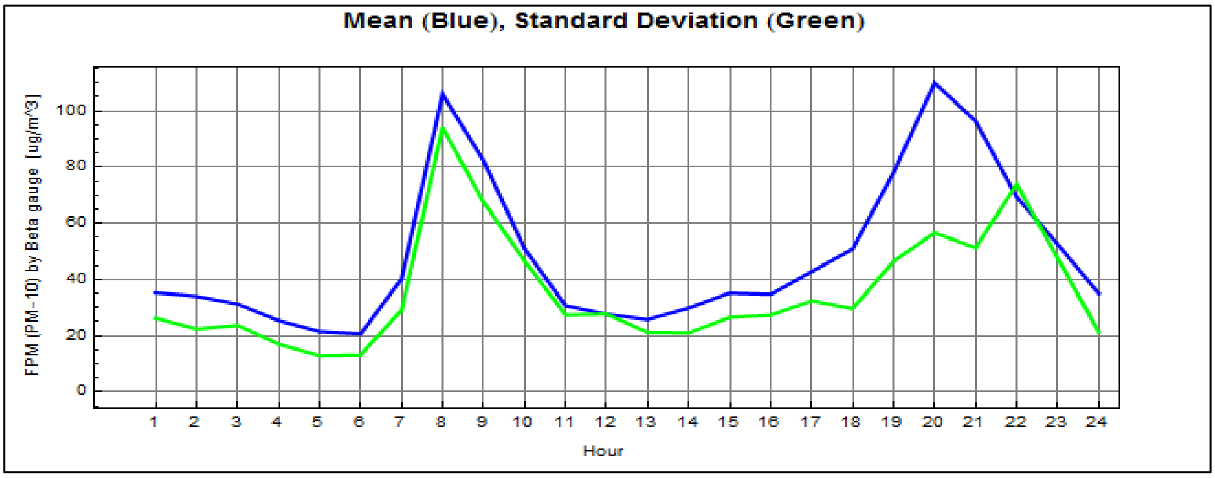

Figure 8: Diurnal variation of PM_{10} concentrations at KwaZamokuhle for March 2016

6.3.2 Particulate fine matter hourly 98th percentile event roses

Since there are no national hourly PM standards, the hourly mean 98th percentile daytime and night-time event roses are presented to identify the wind sectors from which the highest hourly concentrations were derived during the monitoring period.

Figure 9 shows the $PM_{2.5}$ hourly mean 98th percentile event roses during day and night times. During the daytime the $PM_{2.5}$ hourly mean sector concentrations above 161.13 µg/m^3 (98th percentile value) (Table 9) were recorded in the south-south-east, west-north-west, north-west and north-north-west sectors. The hourly mean sector concentrations above 105.33 µg/m^3 (98th percentile value) (Table 10) during the night-time were recorded in the north-north-east, east-north-east, south, south-west and west sectors.

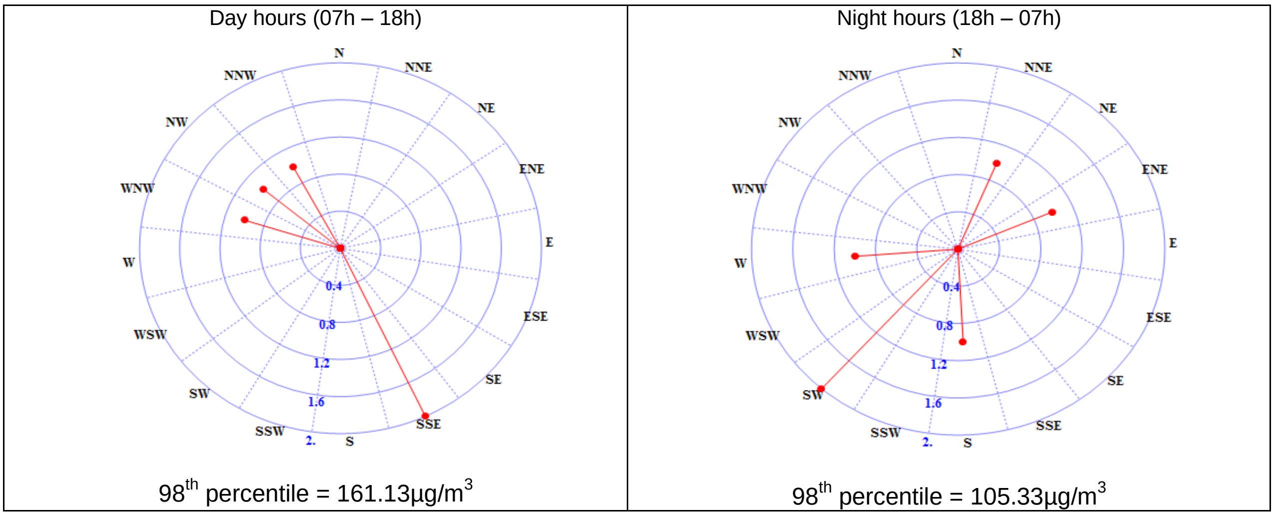

Figure 9: $PM_{2.5}$ hourly mean 98th percentile event roses during day and night times

Table 9: $PM_{2.5}$ daytime hourly mean 98th percentile event table

Dir	N	NNE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	0	0	0	0	0	2	0	0	0	0	0	1	1	1
%	0	0	0	0	0	0	40	0	0	0	0	0	20	20	20

Table 10: $PM_{2.5}$ night time hourly mean 98th percentile event table

Dir	N	NNE	NE	E	ENE	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	1	0	0	1	0	0	0	1	0	2	0	1	0	0	0
%	0	16.67	0	0	16.67	0	0	0	16.67	0	33.33	0	16.67	0	0	0

Figure 10 shows the PM_{10} hourly mean 98th percentile event roses during day and night times. PM_{10} hourly mean sector concentrations above 203.38 µg/m^3 (98th percentile value) (Table 11) were recorded in the east-south-east, south-east and south-south-east sectors during the daytime. During the night, the hourly mean concentrations above 185.72 µg/m^3 (98th percentile value) (Table 12) were recorded in the north-north-east, east-north-east, south-east, south-south-east and west sectors. PM_{10} ambient concentrations might be contributed to by motor vehicle emissions and major roads in the township and Hendrina town.

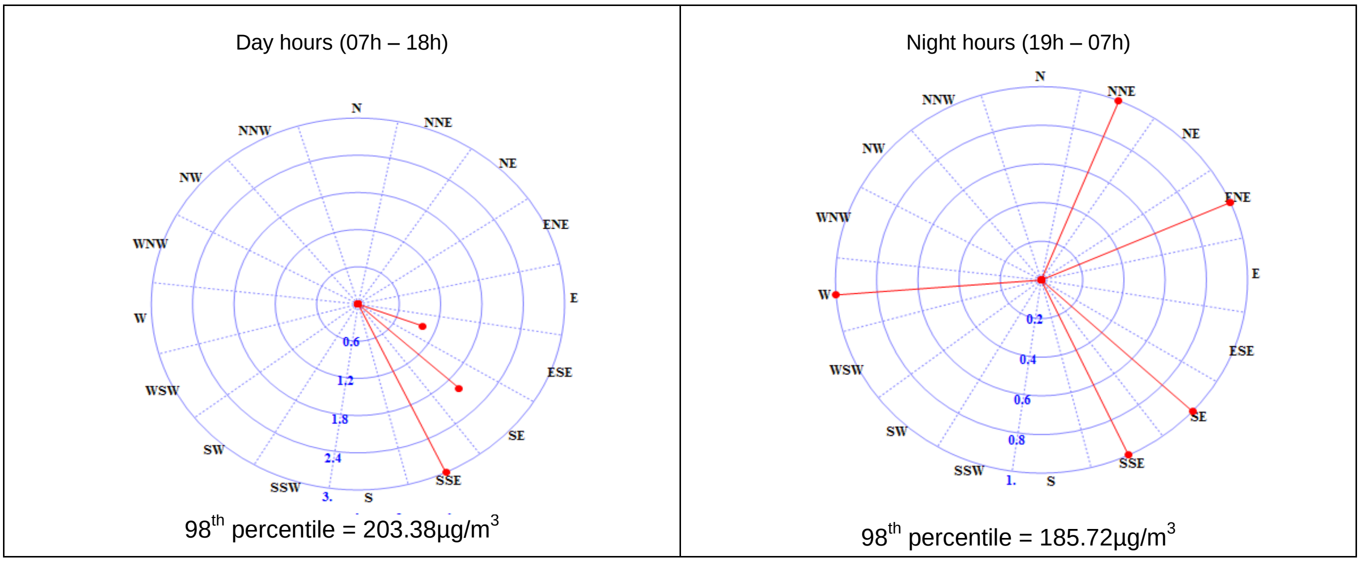

Figure 10: PM_{10} hourly mean 98th percentile event roses during day and night times

Table 11: PM_{10} daytime hourly mean 98th percentile event table

Dir	N	NNE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	0	0	0	1	2	3	0	0	0	0	0	0	0	0
%	0	0	0	0	16.67	33.33	50	0	0	0	0	0	0	0	0

Table 12: PM_{10} night time hourly mean 98th percentile event table

Dir	N	NNE	NE	E	ENE	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	1	0	0	1	0	1	1	0	0	0	0	1	0	0	0
%	0	20	0	0	20	0	20	20	0	0	0	0	20	0	0	0

6.4. OZONE (O_3)

6.4.1. Source identification by O_3 diurnal variations

The O_3 hourly mean diurnal variations show low concentrations in the morning with an increase from 07:00 in the morning due to the break of the inversion layer when the sun goes up. The concentrations increase throughout the day as a result of photochemical reactions, peaking at 15:00 before decaying rapidly due to the lack of sunlight during the night-time period shown in Figure 11.

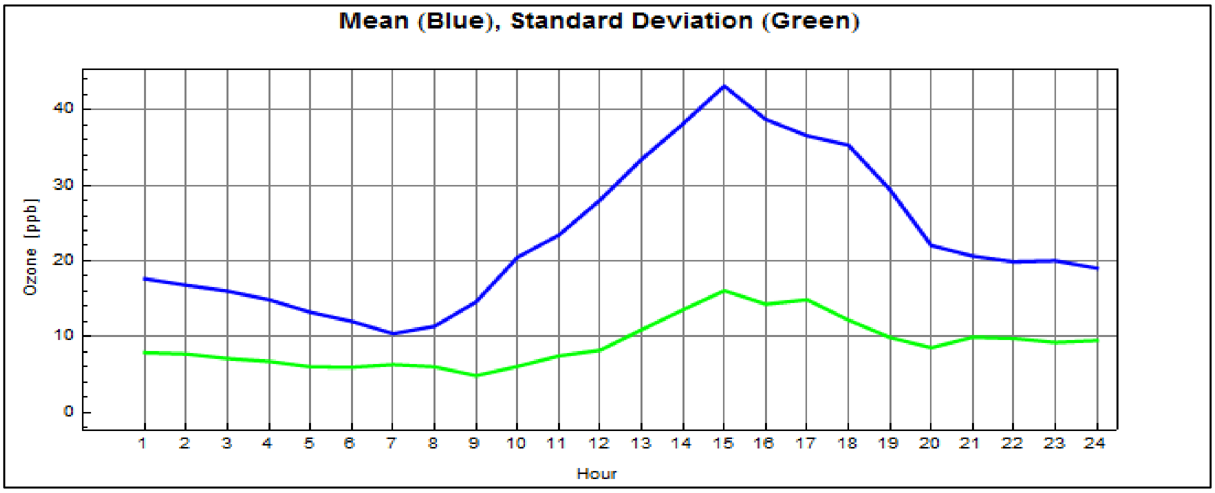

Figure 11: Diurnal variation of Ozone concentrations at KwaZamokuhle for March 2016

7. MONTHLY MEANS FOR THE CURRENT CALENDER YEAR

7.1. HISTORICAL TRENDS

Time series graphs for each pollutant with respect to the national ambient limits are represented from the beginning of each month for the reporting period or since inception of the monitors. The resultant period may vary for each analyser, depending on when it was installed.

Figures 12 - 16 show seasonal trends where high concentrations were recorded from May to August 2015 (winter season) and low concentrations are also recorded from January – March 2016 (summer season) for all the parameters monitored at the site. Gaps in the data are as a result of the analysers being out of service due to faults experienced on them, as well as leakage trips and power interruptions. There is no distinct trend observed on the O_3 8hourly moving average monthly concentrations during the 2015 monitoring period (Figure 17).

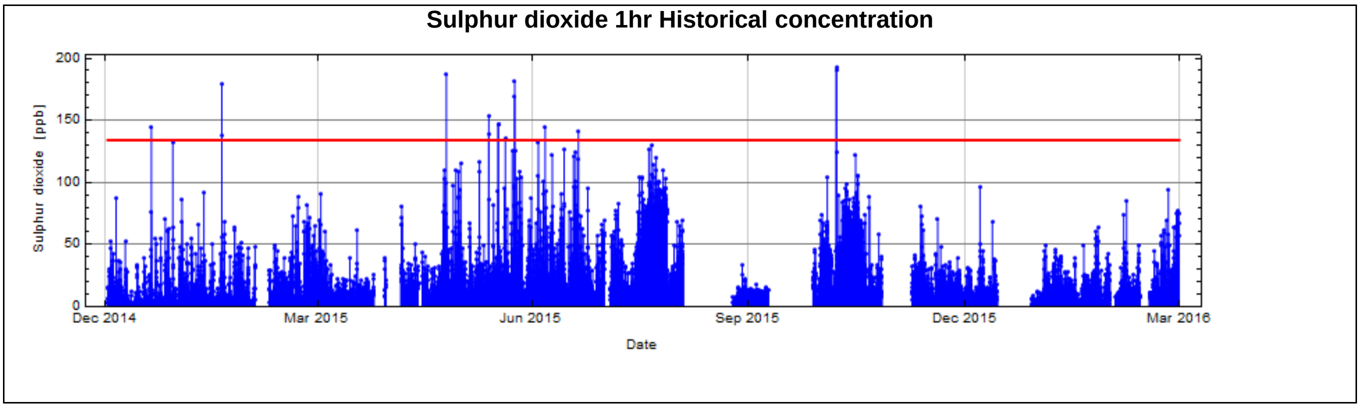

Figure 12: SO_2 1hr mean concentration

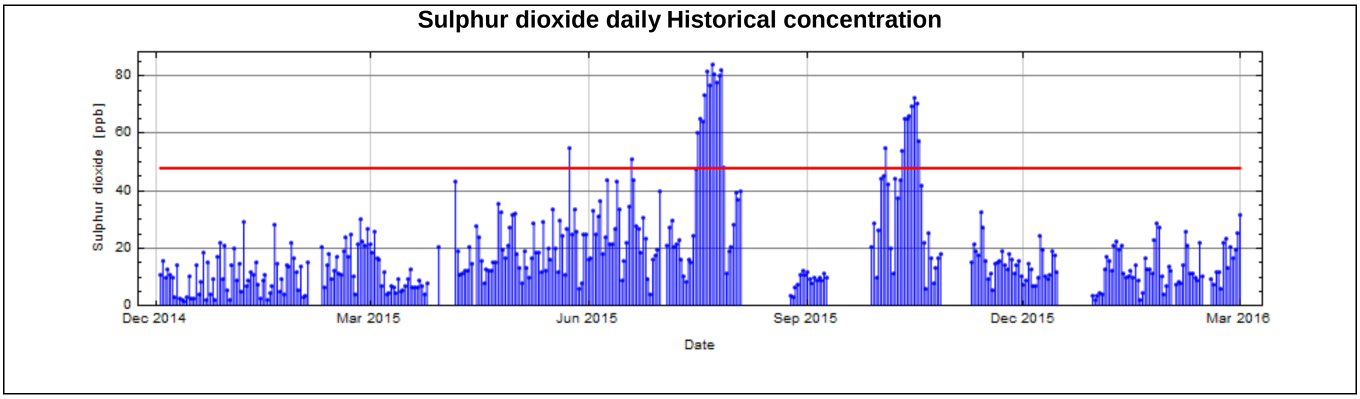

Figure 13: SO_2 daily monthly concentrations

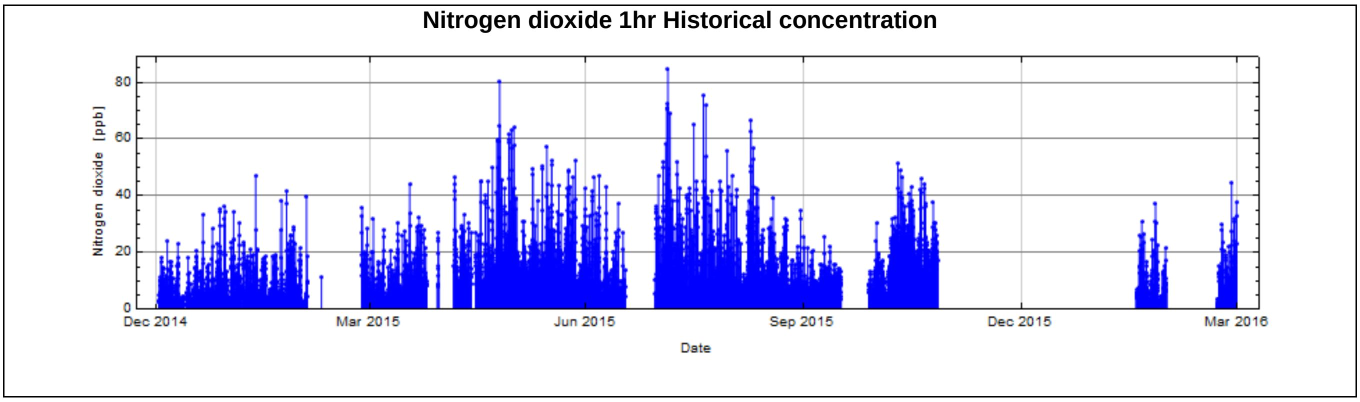

Figure 14: NO_2 1hr monthly concentration

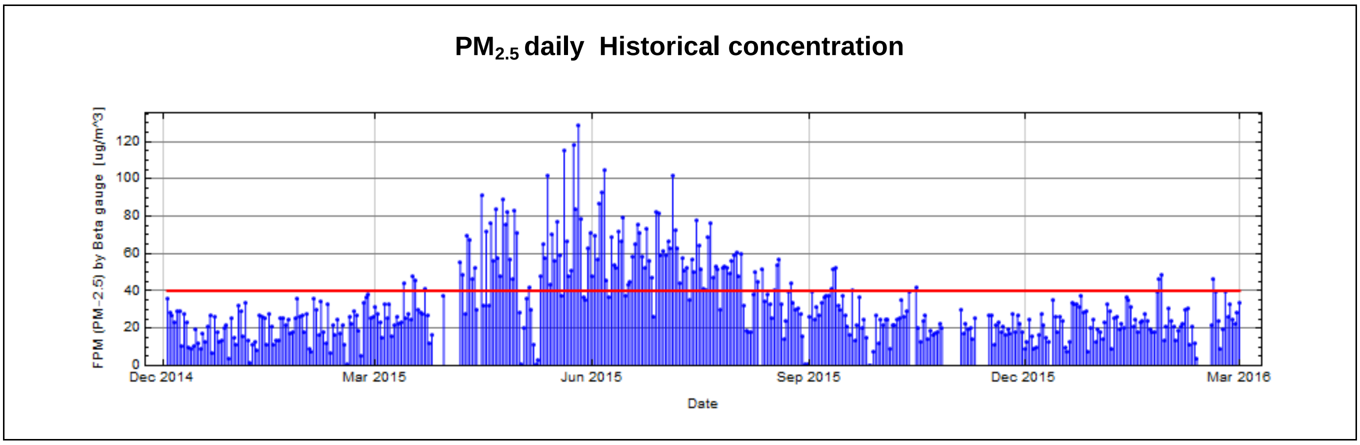

Figure 15: $PM_{2.5}$ daily monthly concentration

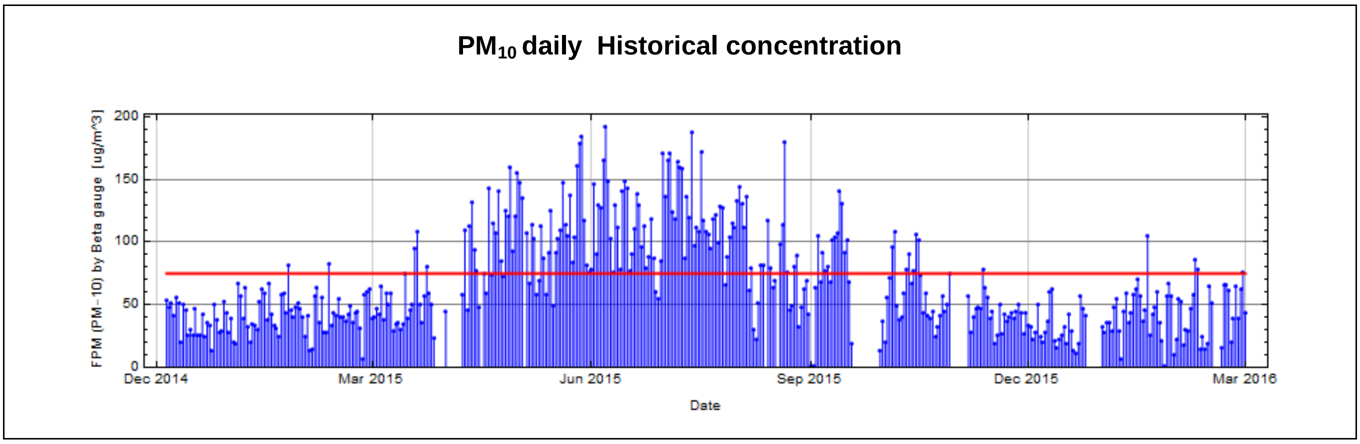

Figure 16: $PM_{2.5}$ daily monthly concentrations

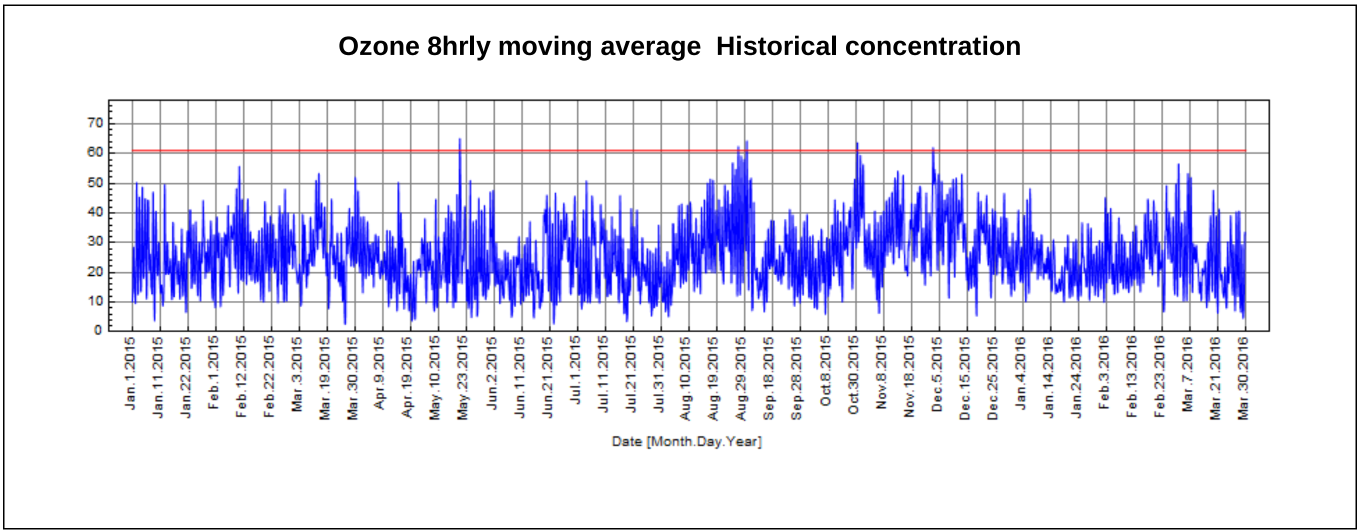

Figure 17: O_3 8hrs moving average

Table 13: Monthly means for the calendar year 2016

Parameter measured	January	February	March
$PM_{2.5}$ (µg/m³)	21	25.2	25.5
PM_{10} (µg/m³)	32.5	44.1	47.9
NO_2 (ppb)	NA	8.2	9.7
O_3 (ppb)	22.4	25.5	23.5
SO_2 (ppb)	10.9	13.7	16

Table 14: Number of exceedances of the National Ambient Air Quality Limits in 2016

	SO_2 hourly	SO_2 daily	NO_2 hourly	PM_{10} daily	$PM_{2.5}$ daily	O_3 8-Hourly
Jan 2016	0	0	NA	0	0	0
Feb 2016	0	0	0	1	2	0
Mar 2016	0	0	0	3	2	0
Total	**0**	**0**	**0**	**4**	**4**	**0**
Allowed no of exceedances	88	4	88	4	4	11

The number of exceedances for both PM_{10} and $PM_{2.5}$ recorded from January to March 2016 have already reached their allowed number of exceedances per year and therefore in the risk of non-compliance with their national air quality standards.

8. CONCLUSION

There were three (3) exceedances of the national ambient air quality for PM_{10} daily mean limit of 75µg/m³ and two (2) for the $PM_{2.5}$ daily limit of 40µg/m³ recorded. There were no exceedances of the national ambient air quality limits for SO_2 10 minutes, SO_2 hourly, NO_2 hourly and Ozone 8-hourly average recorded during the monitoring period under review**.**

Both SO_2 and NO_2 ambient concentrations at KwaZamokuhle monitoring site are influenced by the combination of low-level sources and tall stack emitters and ambient fine particulate matter concentrations indicate the influence of low-level source emissions at KwaZamokuhle. Motor vehicle emissions and major roads in the township and Hendrina town might contribute to PM_{10} and $PM_{2.5}$ ambient concentrations.

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Approved by:

Air Quality Centre of Excellence
Eskom Environmental Management

9. DISTRIBUTION LIST

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Project File Project Leader Attention: Trinity Ngomane	RT&D

ABBREVIATIONS

µg/m³	Microgram per cubic meter
DEA	Department of Environmental Affairs
deg	Degree
deg C	Degree Celsius
E	East
ENE	East-north-east
ESE	East-south-east
FPM	Fine particulate matter
HUM	Humidity
m/s	Meters per second
MWP	Megawatt Park
N	North
NE	North-east
NNE	North-north-east
NNW	North-north-west
NO_1	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
NW	North-west
Ozn/O_3	Ozone
$PM\text{-}_{10}$	Particulate matter < 10 microns in diameter
$PM\text{-}_{2.5}$	Particulate matter < 2.5 microns in diameter
ppb	Parts per billion
ppm	Parts per million
PRS	Pressure
RAD	Solar Radiation
RFL	Rain Fall
RT&D	Research, Testing and Development
S	South
SANAS	South African National Accreditation System
SE	South-east
SGT	Sigma theta
SO_2	Sulphur Dioxide
SSE	South-south-east
SSW	South-south-west
SW	South-west
TMP	Ambient temperature
W	West
WDR	Wind direction from true North
WNW	West-north-west
WSP	Wind speed

WSW	West-south-west
WVL	Wind velocity