Eskom

RESEARCH, TESTING AND DEVELOPMENT

SUSTAINABILITY DEPARTMENT

EZAMOKUHLE AIR QUALITY MONTHLY REPORT

DECEMBER 2016

EXECUTIVE SUMMARY

This monthly report covers the ambient air quality data as monitored at Ezamokuhle monitoring site in December 2016.

There were one hundred and fifty three (153) exceedances of O_3 8-hour moving average limit of 61ppb and no exceedances recorded for other parameters monitored (Table 3) at Ezamokuhle during the December 2016 monitoring period. There is already non-compliance with the daily PM_{10}, daily $PM_{2.5}$ and 8-hourly ozone ambient standards at this site for 2016.

SO_2 and PM_{10} ambient concentrations at Ezamokuhle monitoring site are predominantly influenced by tall stack emissions, and $PM_{2.5}$ ambient concentrations are influenced by low level sources while NO_2 ambient concentrations are also influenced by both low level and tall stack sources, as depicted in the diurnal variation graphs.

The dominant wind directions during the day time were east-north-east, east, west, west-north-west. During the night, the most frequent directions were north-east, east-north-east, east and west.

The overall percentage data recovered from the monitoring station was 97.2% and the overall station availability was 99.1%. The data losses for December were due to zero/span checks during routine site servicing and minor power outages.

DISCLAIMER

1. INTRODUCTION

The monitoring site was established as part of a greater air quality offset pilot 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 Ezamokuhle Township (Amersfoort) will represent baseline and post intervention implementation ambient air quality. Ambient monitoring results measured are presented in this report and are compared to the National Ambient Air Quality Standards.

The Ezamokuhle monitoring station is equipped to continuously monitor ambient concentrations of sulphur dioxide, oxides of nitrogen, ozone and fine particulate matter of particulate size <10µm and 2.5µm in diameter (PM_{10} and $PM_{2.5}$). In addition, meteorological parameters of wind velocity, wind direction, ambient temperature, humidity, rainfall and solar radiation are also recorded.

Standard Specifications, Equipment/Techniques used for the measurement of SO_2, O_3 and NOx conform to US-EPA equivalent method No EQSA-0486-060, EQOA-0880-047 and RFNA-1289-074 respectively.

2. SITE LOCATION

The Ezamokuhle monitoring site is located ±13.7km north-north-east of Majuba power station (Figure 1). It is situated centrally in Ezamokuhle Township, at Hlelimfundo High School at co-ordinates -26.997571, 29.850086. The monitoring site's main objective is to determine the background concentrations of pollutants measured at the site for Offsets intervention project.

Figure 1: Ezamokuhle air quality monitoring site (Amersfoort) in relation to Majuba power station

3. DATA RECOVERY

The South African National Accreditation System (SANAS) guideline figure of 90% data availability per parameter monitored is used as a standard for representative data capture. This describes the required completeness of data set for the reporting of averages and is based on standard arithmetic calculations. The completeness calculations for data sets exclude zero and span data and times where service and/or maintenance is being conducted on the instruments in question.

Availability is a management definition related to system reliability. The availability target is not set in terms of data quality criteria and has no associated quality objectives. A target of 100% availability has been set for performance evaluation. Availability is reported as a measure of the percentage of time that electrical power was available to the monitoring station.

Table 1 shows the percentage data recovered, for each parameter monitored, during the reporting period.

Table 1: Percentage data recovered per parameter for December 2016

NO_1	NO_2	NO_X	OZN	PRS	RAD	RFL	SGT	SO2	TMP	WDR	WSP	WVL	PM2.5	PM10	HUM	Data Rec	Station Avail
64.2	97.4	97.4	99.1	99.7	99.7	99.7	99.7	98.9	99.7	99.7	99.7	99.7	99.1	99.1	99.7	97.2	99.1

The overall percentage data recovered from the monitoring station during the period was 97.2% (Table 1) and the overall monitoring station availability was 99.1%.

4. SUMMARY OF RESULTS FOR REPORTED PERIOD

Table 3 is a summary report presenting highest mean concentrations and the number of exceedances above the respective National Ambient Air Quality Standards limits as presented in Table 2.

Note: PM_{10} and $PM_{2.5}$ are monitored, using Beta gauge (Beta-attenuation using a C-14 source).

Table 2: National Ambient Air Quality Standards.

Pollutant	Unit	Period	Limit	Number of annual exceedances allowed	Source
Carbon Monoxide	ppm	1hr	26	88	DEA
Carbon Monoxide	ppm	8hr	8.7	11	DEA
($PM\text{-}_{10}$) by Beta gauge	$\mu g/m^3$	24hr	75	4	DEA
($PM\text{-}_{10}$) by Beta gauge	$\mu g/m^3$	1year	40	0	DEA
($PM\text{-}_{2.5}$) by Beta gauge	$\mu g/m^3$	24hr	40	4	DEA
($PM\text{-}_{2.5}$) by Beta gauge	$\mu g/m^3$	1year	20	0	DEA
Nitrogen dioxide	ppb	1year	21	0	DEA
Nitrogen dioxide	ppb	1hr	106	88	DEA
Ozone	ppb	8hr	61	11.	DEA
Sulphur dioxide	ppb	1hr	134	88	DEA
Sulphur dioxide	ppb	10min	191	526	DEA
Sulphur dioxide	ppb	24hr	48	4	DEA
Sulphur dioxide	ppb	1year	19	0	DEA

Table 3: Summary report of parameters monitored at Ezamokuhle in December 2016

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
FPM (PM–2.5) by Beta gauge [ug/m^3]	128.1		18.4	0		135.9	
FPM (PM–10) by Beta gauge [ug/m^3]	83.4		10.	0		90.1	
Nitric oxide [ppb]	8.4		1.3			10.6	
Nitrogen dioxide [ppb]	14.5	0	5.4			19.3	
Nitrogen oxide [ppb]	24.5		7.9			32.5	
Ozone [ppb]	152.4		95.2		196	196.4	
Sigma theta [deg]	34.7		20.1			80.4	
Sulphur dioxide [ppb]	82.	0	14.7	0		132.3	0
Ambient temperature [deg C]	31.9		22.5			32.1	
Wind speed [m/s]	10.2		5.			10.9	
Wind velocity [m/s]	9.9		4.8			10.7	

There were one hundred and fifty three (153) exceedances of O_3 8-hour moving average limit of 61ppb and no exceedances recorded for other parameters monitored (Table 3) at Ezamokuhle during the December 2016 monitoring period

5. METEOROLOGICAL OBSERVATIONS

Figure 2 shows the daytime and night-time wind roses for the reporting period. The centre of the wind rose depicts the position of the air quality monitoring station. 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 wind directions during the day time were east-north-east, east, west, west-north-west. During the night, the most frequent directions were north-east, east-north-east, east and west.

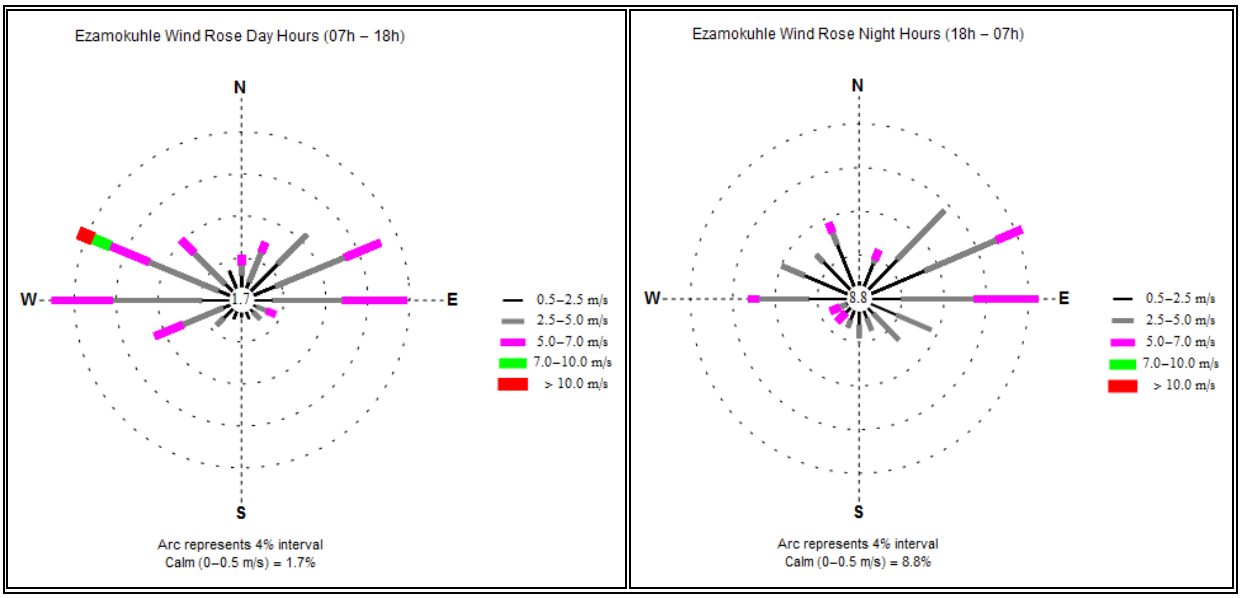

Figure 2: Day and night time wind roses at Ezamokuhle monitoring site

6. DISCUSSION OF POLLUTANTS

Emissions of primary pollutants such as PM_{10}, SO_2, and NO_X from typical low level sources such as domestic combustion and motor vehicles are expected to impact at ground level more significantly during the evening and morning hours as a result of temperature inversion. Emissions of such pollutants from tall stacks (power stations and other industries), are expected to have more significant impacts at ground level during the day, due to atmospheric turbulence influences. O_3 and other oxidants are formed in polluted atmospheres as a result of a wide variety of photochemical reactions as a result a gradual increase of O_3 throughout the day is expected, peaking at mid-afternoon and then decaying once more during the night.

6.1. Fine Particulate Matter (PM_{10}).

6.1.1. Source identification by PM_{10} diurnal variations.

Figure 3 shows the diurnal variation of PM_{10} concentrations. Hourly average PM_{10} concentrations show increase in concentration from 07:00 in the morning until maximum peak is reached at 17:00. The concentrations begin to decrease with minor peak at 20:00 and remain low for the rest of the evening. Concentration peaks observed at 10:00 in the morning and 20:00 in the evening are as a result from emissions from low level sources. High concentrations recorded during the day are as a result of emissions from tall stack emitters.

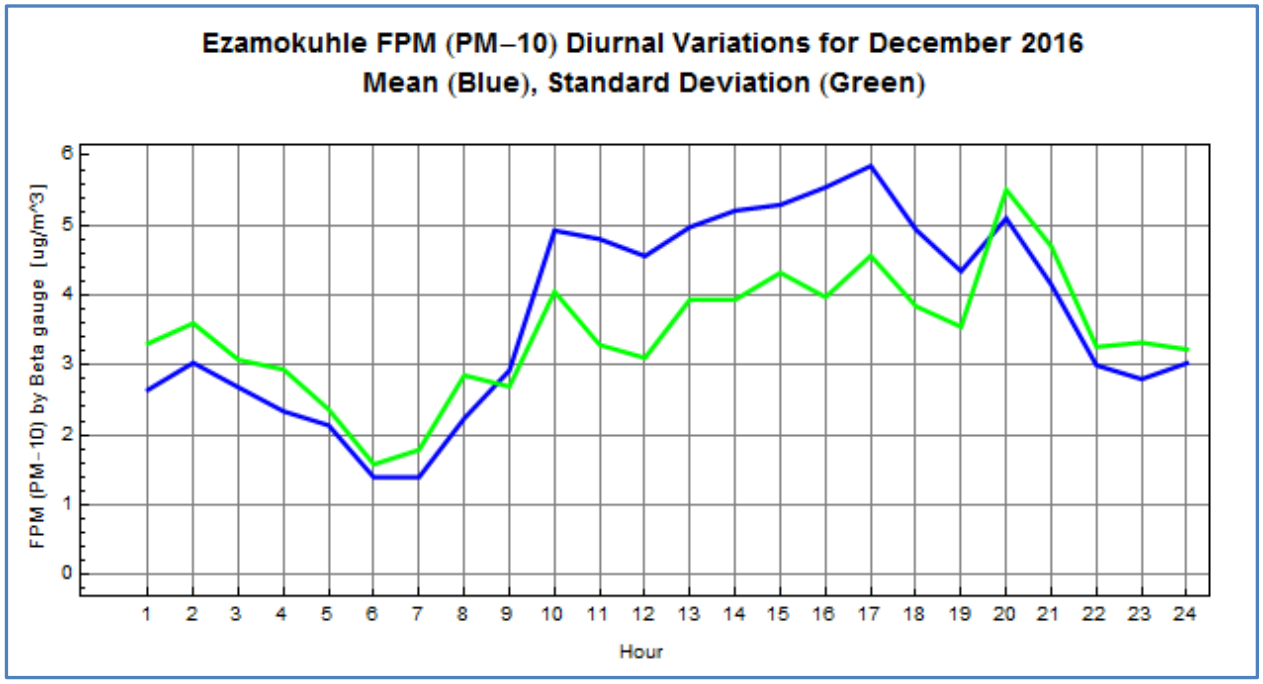

Figure 3: PM_{10} Diurnal variations (Mean concentrations = Blue line, Standard Deviation = Green line).

6.1.2. PM_{10} hourly mean event roses and tables.

Since there is no national hourly limit for PM_{10}; the hourly 98^{th} percentile daytime and night-time event roses are presented in Figure 4 to identify the wind sectors from which the highest concentrations are derived.

The most dominant hourly mean concentrations during daytime period were recorded from north-north-east, south, south-west, west-north-west and north-west sectors. The most dominant hourly mean concentrations during night time period were recorded from north-east, east, east-south-east, south-east, south-south-east, west-north-west and north-north-west

sectors. Major roads and other activities at Ezamokuhle Township around the monitoring site might be impacting the PM_{10} ambient concentrations.

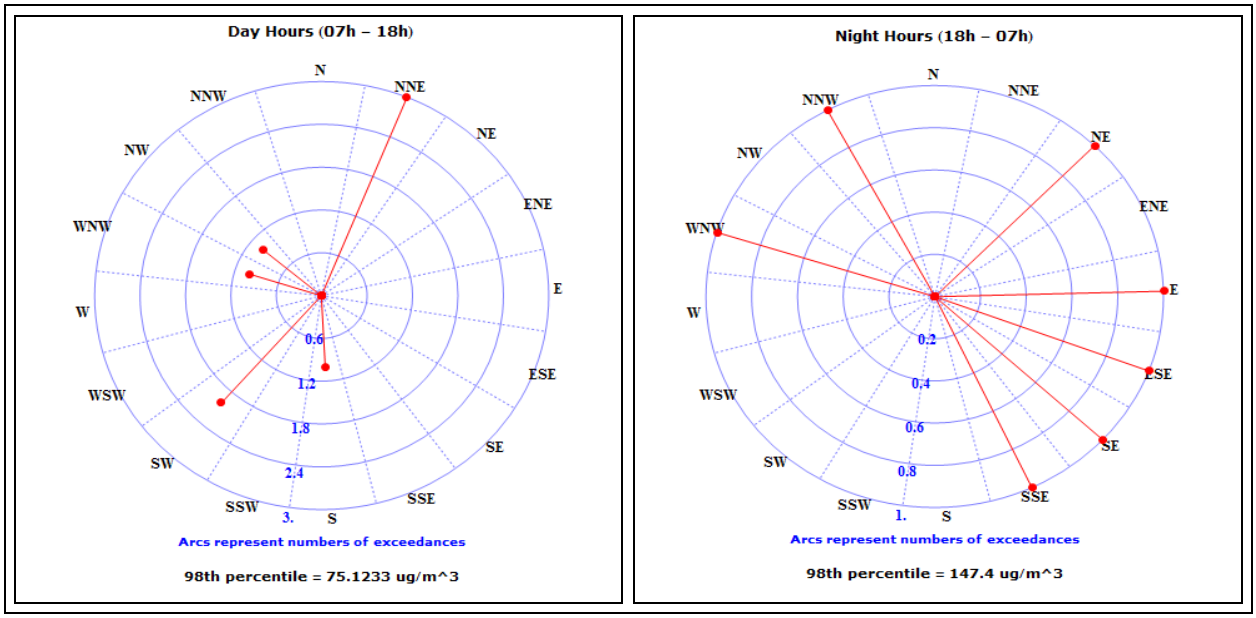

Figure 4: PM_{10} hourly mean 98th percentile event roses during day and night times

Table 5: PM_{10} daytime 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	3	0	0	0	0	0	0	1	0	2	0	0	1	1	0
%	0	37.5	0	0	0	0	0	0	12.5	0	25	0	0	12.5	12.5	0

Table 6: PM_{10} 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	1	0	1	1	1	1	0	0	0	0	0	1	0	1
%	0	0	14.29	0	14.29	14.29	14.29	14.29	0	0	0	0	0	14.29	0	14.29

6.2. Fine Particulate Matter ($PM_{2.5}$).

6.2.1. Source identification by $PM_{2.5}$ diurnal variations

Figure 5 shows the diurnal variation of $PM_{2.5}$ concentrations with elevated concentrations during the early hours of the morning and the evening hours. The concentrations show morning peak at 07:00 and evening peak at 20:00. Elevated concentrations in the mornings and evenings indicate typical contribution by low level sources.

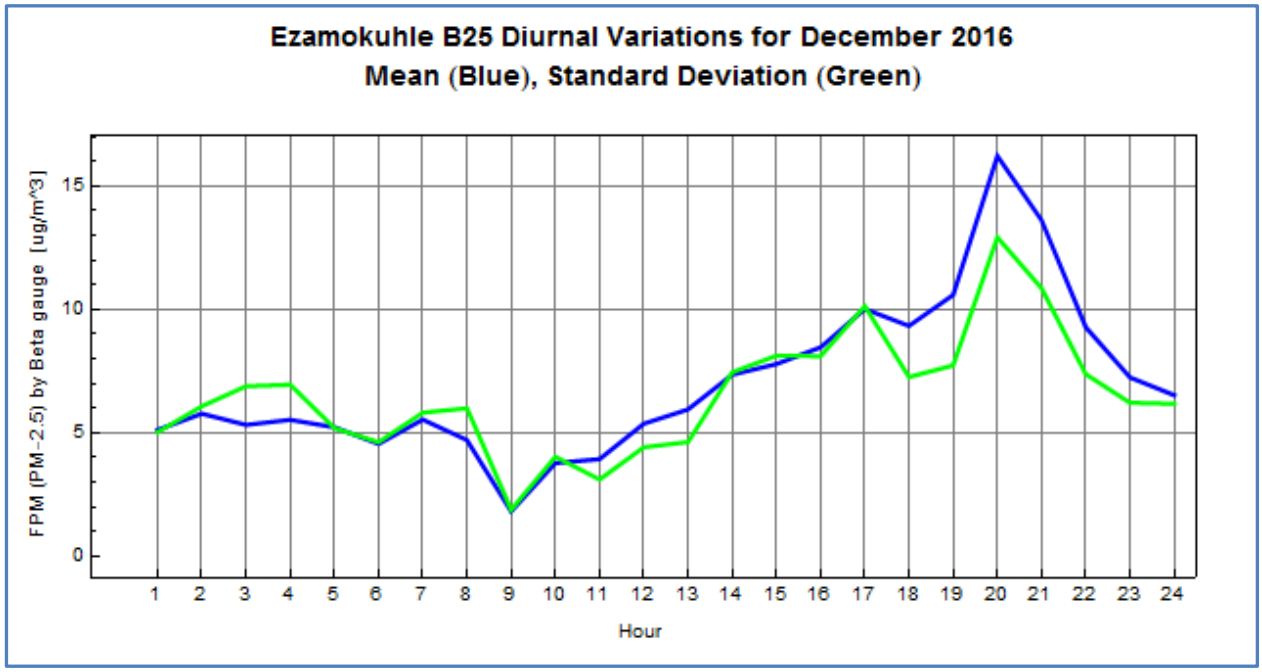

Figure 5: $PM_{2.5}$ Diurnal variations (Mean concentrations = Blue line, Standard Deviation = Green line).

6.2.2. $PM_{2.5}$ hourly mean event roses and tables.

Since there is no national hourly limit for $PM_{2.5}$; the hourly 98th percentile daytime and night-time event roses are presented in Figure 6 to identify the wind sectors from which the highest concentrations are derived.

The most dominant hourly mean concentrations during daytime period were recorded from north-north-east, south, south-south-west, south-west, west-north-west, north-west and north-north-west sectors. The most dominant hourly mean concentrations during night time period were north-north-east, east, east-south-east, south-south-east, south and north-north-west sectors.

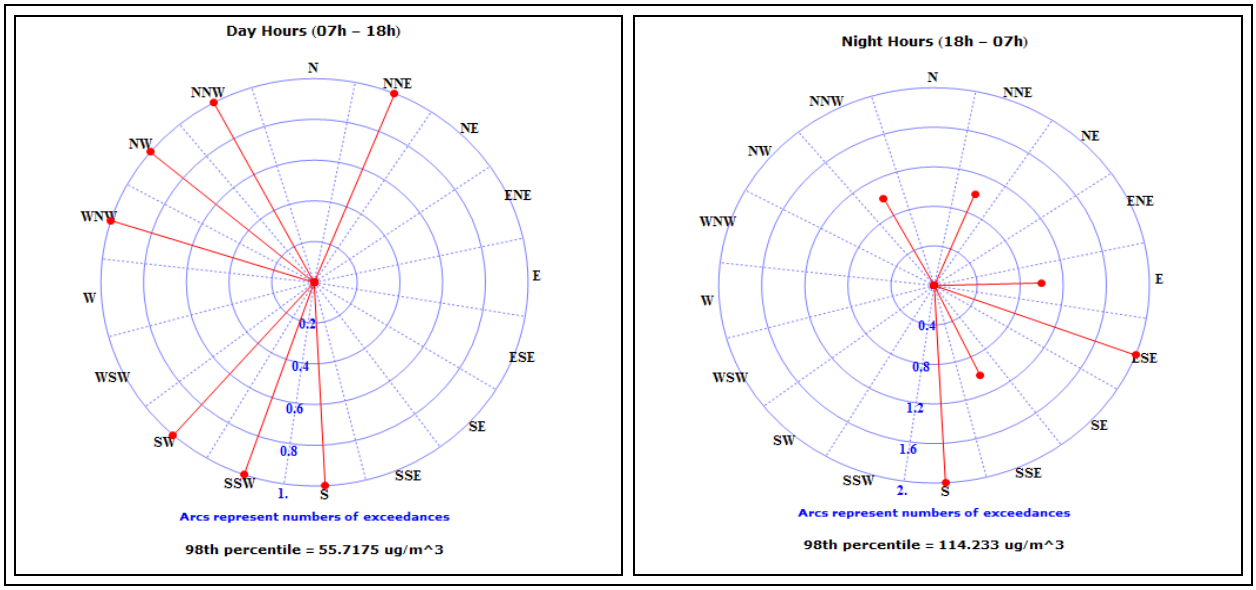

Figure 6: $PM_{2.5}$ hourly mean 98th percentile event roses during day and night times

Table 7: $PM_{2.5}$ daytime 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	1	0	0	0	0	0	0	1	1	1	0	0	1	1	1
%	0	14.29	0	0	0	0	0	0	14.29	14.29	14.29	0	0	14.29	14.29	14.29

Table 8: $PM_{2.5}$ 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	1	0	0	1	2	0	1	2	0	0	0	0	0	0	1
%	0	12.5	0	0	12.5	25	0	12.5	25	0	0	0	0	0	0	12.5

6.2. Sulphur Dioxide (SO_2)

6.2.1. Source identification by SO_2 diurnal variations.

The SO_2 hourly mean diurnal variation is presented in Figure 7. The diurnal variation shows an increase in SO_2 concentrations during the daytime hours with maximum peak observed at 14:00. This diurnal variation indicates emissions from tall stack sources that probably have influence on the ambient concentrations observed throughout the day.

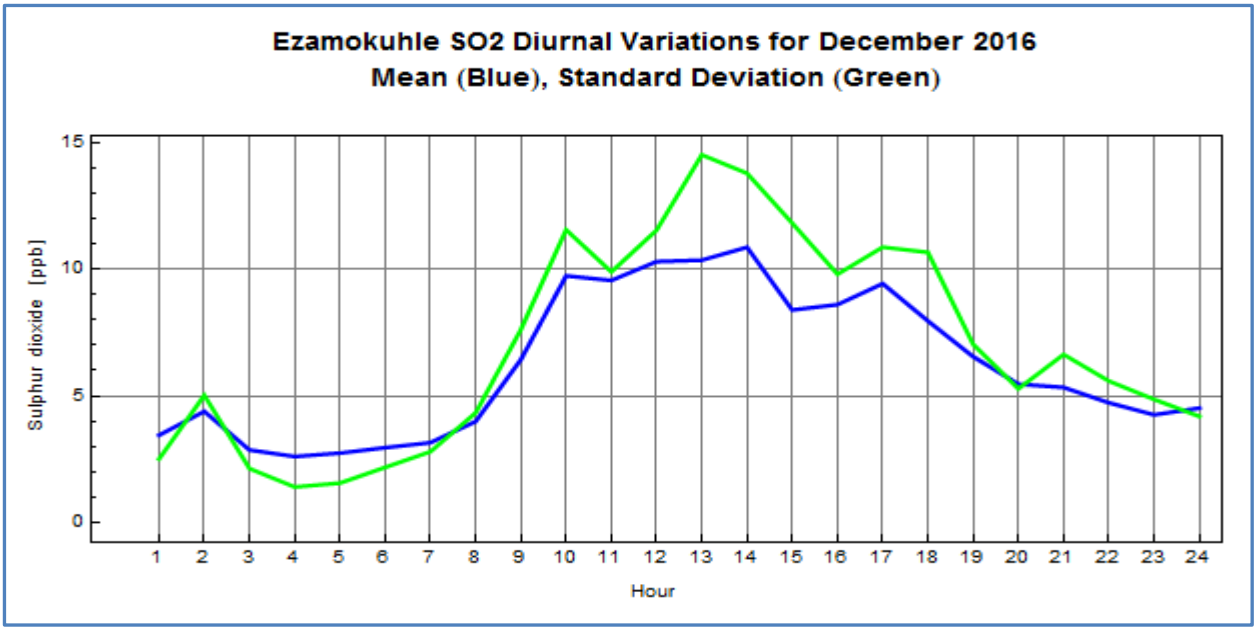

Figure 7: SO_2 diurnal variations (.Mean concentrations = Blue line, Standard Deviation = Green line).

6.2.2. SO_2 hourly mean event roses and tables.

Figure 8 presents the SO_2 98th percentile SO_2 event roses during the day and night-time. The most dominant hourly mean concentrations above 56.63ppb (98th percentile value) during the day time period were recorded from south-west, west, west-north-west and north-west sectors. Tutuka power station is located 55km north-west of the monitoring station. It is probable that this source could have an impact on the recorded SO_2 ambient concentrations. The most dominant hourly mean concentrations above 22.13ppb (98th percentile value) during night time period were recorded from north-north-east, north-east, south-south-east and south sectors.

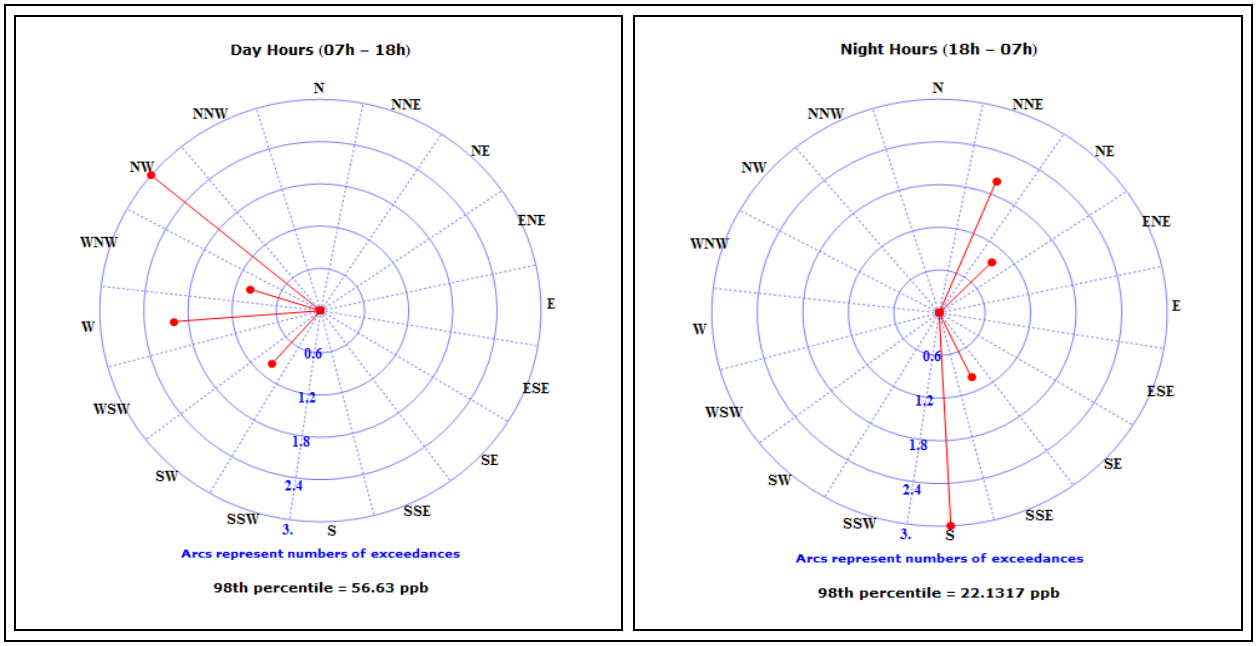

Figure 8: SO_2 exceedance rose for daytime and hourly mean 98th percentile night time event roses.

Table 9: SO_2 day-time hourly mean exceedance 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	0	0	0	0	1	0	2	1	3	0
%	0	0	0	0	0	0	0	0	0	0	14.29	0	28.57	14.29	42.86	0

Table 10: 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	2	1	0	0	0	0	1	3	0	0	0	0	0	0	0
%	0	28.57	14.29	0	0	0	0	14.29	42.86	0	0	0	0	0	0	0

6.3. Nitrogen Dioxide (NO_2)

6.3.1 Source identification by NO_2 variations

The NO_2 hourly mean diurnal variation show increasing NO_2 concentrations from early morning hours, with slightly elevated concentrations throughout the day. The concentrations show peaks at 17:00 in the afternoon peak and evening peak at 21:00. This indicates the influence of both tall stack emitters and low level sources on the ambient concentrations at site.

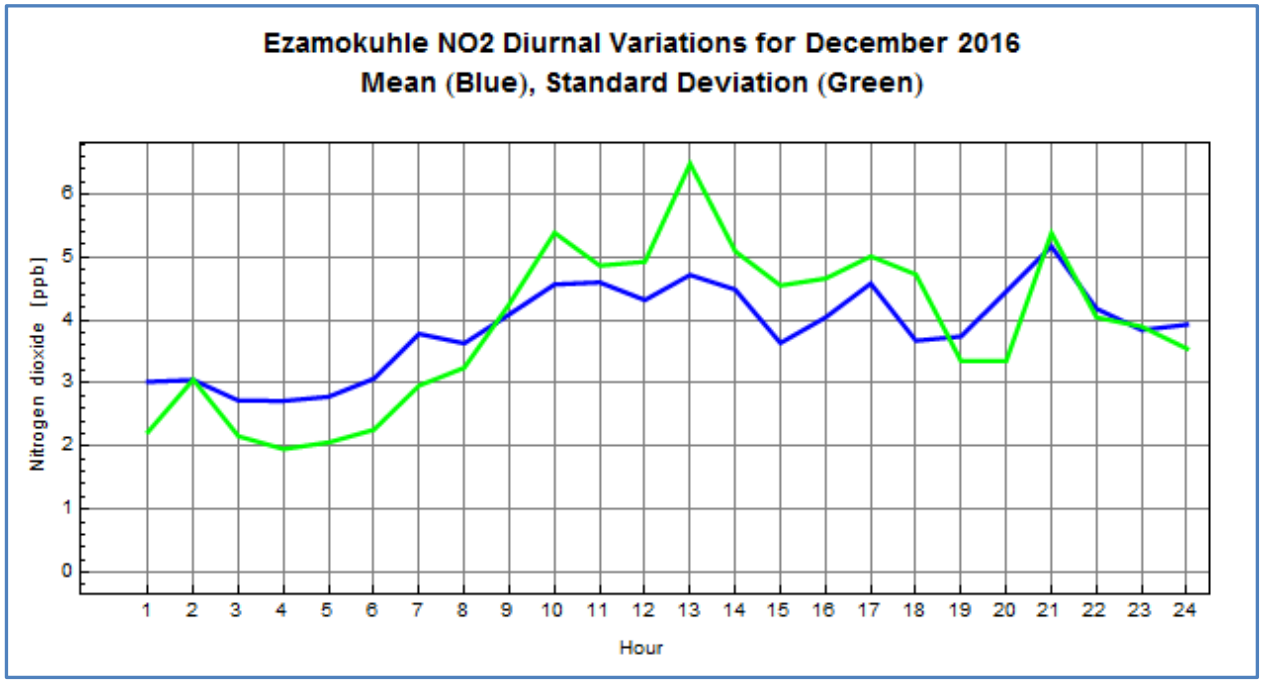

Figure 9: NO_2 diurnal variations (.Mean concentrations = Blue line, Standard Deviation = Green line)

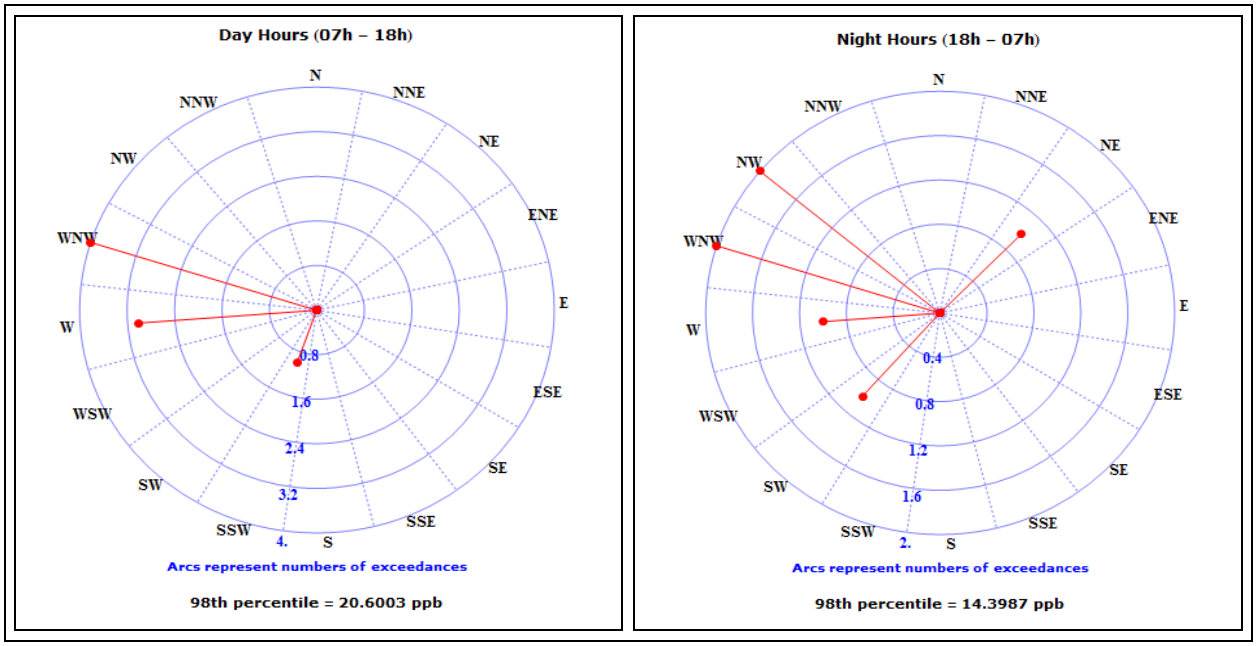

Figure 10: NO_2 hourly mean sector 98th percentile event roses

6.3.2 NO_2 hourly mean event roses and tables

The 98th percentile daytime and night-time event roses are presented in Figure 10 to identify the wind sectors from which the highest concentrations are derived.

The most dominant daytime concentrations above 20.60ppb (98th percentile value) were from south-south-west, west, west-north-west sectors (Table 11). The most dominant night-time concentrations above 14.39ppb (98th percentile value) were from the north-east, south-west, west, west-north-west and north-west sector (Table 12). The vehicles operating within Kriel properties and traffic department nearby monitoring station might have an impact on the NO_2 ambient concentrations.

Table 11: NO_2 day-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	0	0	0	1	0	0	3	4	0	0
%	0	0	0	0	0	0	0	0	0	12.5	0	0	37.5	50	0	0

Table 12: 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	1	0	0	0	0	0	0	0	1	0	1	2	2	0
%	0	0	14.29	0	0	0	0	0	0	0	14.29	0	14.29	28.57	28.57	0

6.4. OZONE (O_3)

Figure 11 shows the O_3 hourly mean diurnal variation with increase in ozone concentrations occurring from 07:00 and maximum peak recorded at 15:00 in the afternoon. The increase in concentrations in the morning can be associated with the formation of NO_2 and the photochemical reaction in the presence of sunlight during the day. Event roses shown in figure 12 indicate sectors from which O_3 hourly mean concentrations above 98th percentile value during day and night were coming from and Figure 13 shows the 8-hour moving average of ozone concentrations with 153 exceedances above 61ppb national limit recorded during the month.

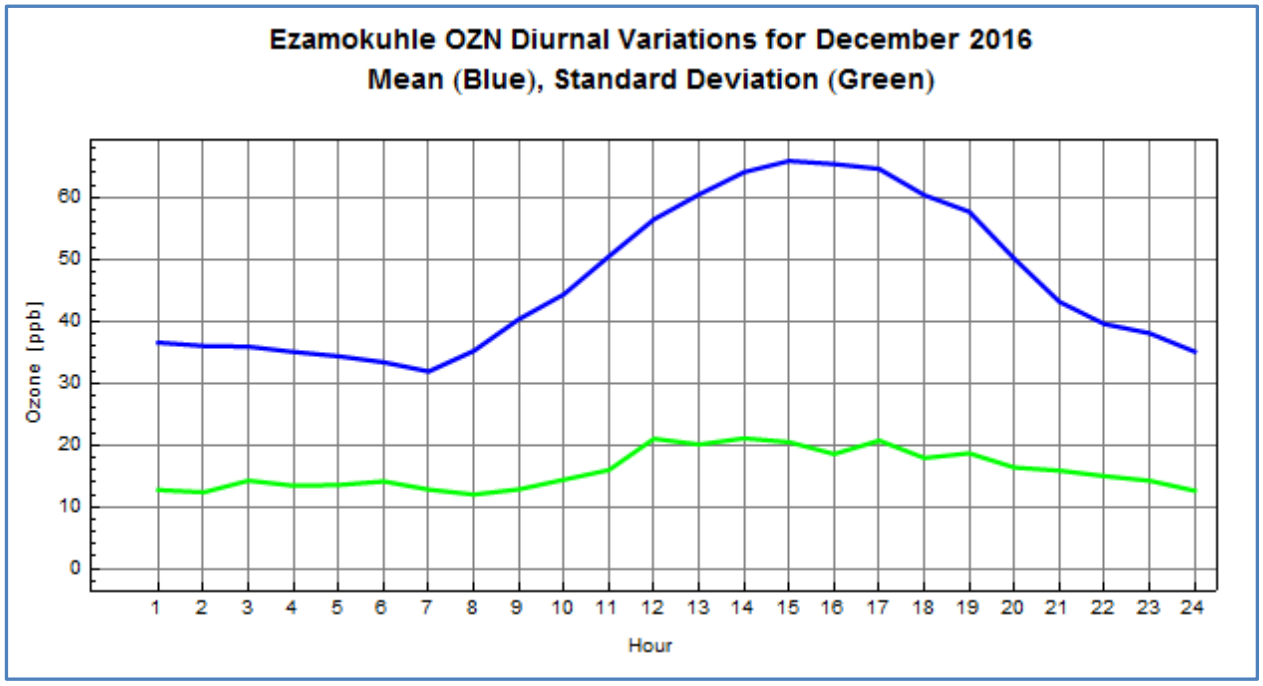

Figure 11: O_3 diurnal variations (.Mean concentrations = Blue line, Standard Deviation = Green line)

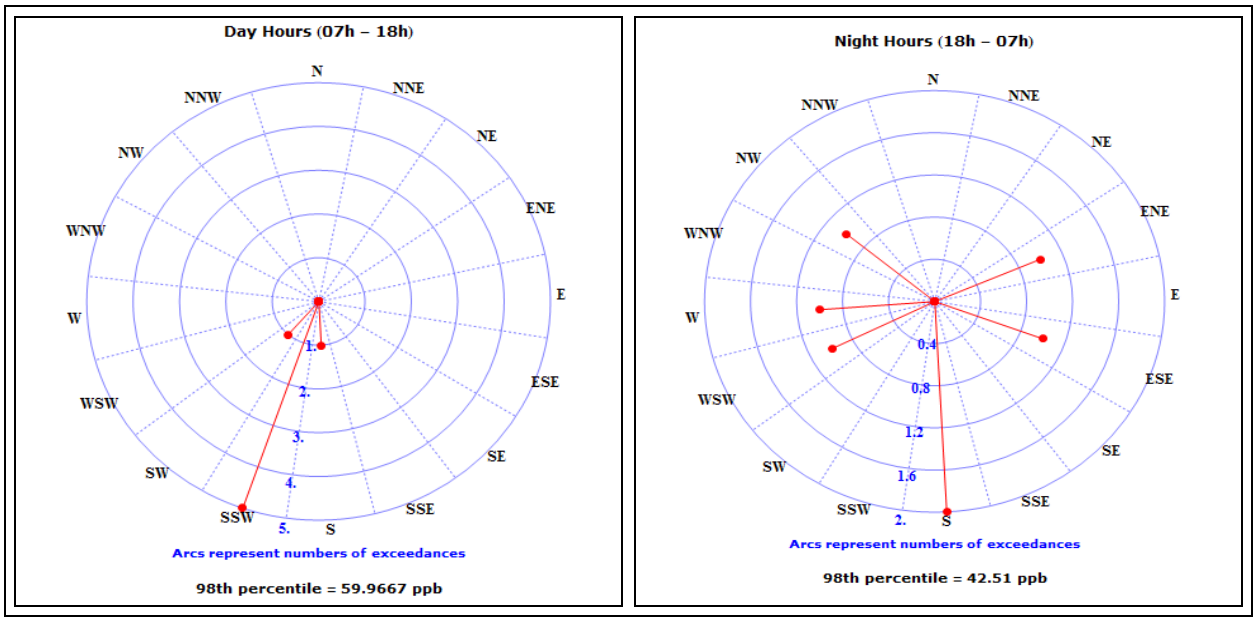

Figure 12: O_3 hourly mean sector 98th percentile event roses

Table 13: O_3 day-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	0	0	1	5	1	0	0	0	0	0
%	0	0	0	0	0	0	0	0	14.29	71.43	14.29	0	0	0	0	0

Table 14: O_3 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	1	0	0	2	0	0	1	1	0	1	0
%	0	0	0	14.29	0	14.29	0	0	28.57	0	0	14.29	14.29	0	14.29	0

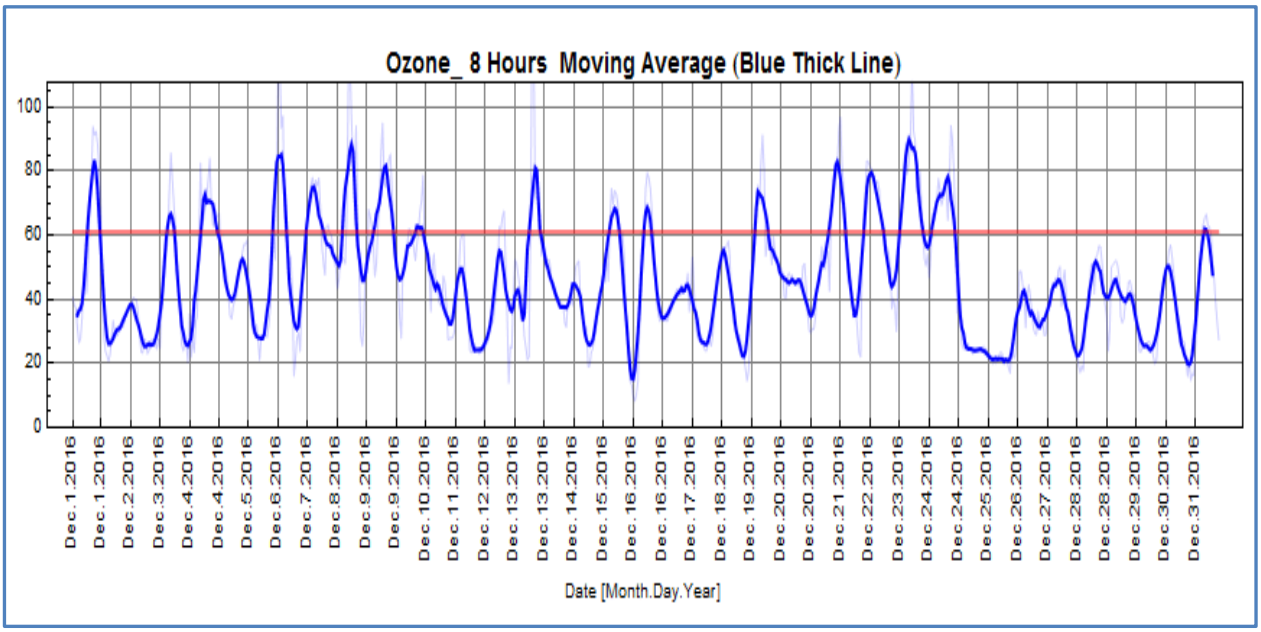

Figure 13: O_3 8 Hours Moving Average (Blue Thick Line)

7. HISTORICAL MONTHLY CONCENTRATIONS

7.1. MONTHLY MEANS FOR THE CURRENT CALENDER YEAR 2016

Table 13: Monthly means for all parameters measured for the current calendar year 2016

Parameter measured	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct	Nov	Dec
$PM_{2.5}$ ($\mu g/m^3$)							36.3	36	23.1	8.3	9.8	7
PM_{10} ($\mu g/m^3$)							61.6	57.5	13.2	8.8	6.2	3.7
NO_2 (ppb)							5.1	11.8	6.2	3.5	4.6	3.9
O_3 (ppb)							21.4	39.7	55.4	49	48.8	46.4
SO_2 (ppb)							8.4	8.9	6.4	5.1	6.5	5.4

Ezamokuhle station was commissioned in June 2016, therefore only data from July 2016 to December 2016 is available.

7.2 NUMBER OF EXCEEDANCES OF NATIONAL AIR QUALITY LIMITS

Table 14: Number of exceedances of the National Air Quality Limits

	SO_2 hourly	SO_2 daily	NO_2 hourly	PM_{10} daily	$PM_{2.5}$ daily	O_3 8- Hourly
Jul 2016	0	0	0	5	6	0
Aug 2016	0	0	0	11	11	87
Sep 2016	0	0	0	0	1	251
Oct 2016	0	0	0	0	0	190
Nov 2016	0	0	0	0	0	196
Dec 2016	0	0	0	0	0	153
Total	**0**	**0**	**0**	**16**	**18**	**877**
Allowed no of exceedances	88	4	88	4	4	11

The exceedances of PM_{10}, $PM_{2.5}$ daily and O_3 8-hourly moving average limits at Ezamokuhle between July and December 2016 have exceeded their respective allowed number of exceedances per year, and therefore in non-compliance with their national ambient standards. Monitoring at Ezamokuhle started in July 2016.

8. CONCLUSIONS

Good representative percentage data was recovered for most of the parameters monitored during the monitoring period under review at the site.

There were one hundred and fifty three (153) exceedances of O_3 8-hour moving average limit of 61ppb and no exceedances recorded for other parameters monitored (Table 3) at Ezamokuhle during the December 2016 monitoring period. There is non-compliance with the daily PM_{10}, daily $PM_{2.5}$ and 8-hourly ozone ambient standards at this site for 2016.

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Air Quality, Climate Change & Ecosystem Management
RT&D

Approved by: Kristy Langerman

Air Quality Centre of Excellence
Eskom Environmental Management

9. ABBREVIATIONS

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
NO1	Nitric oxide
NO2	Nitrogen dioxide
NOX	Oxides of nitrogen
NW	North-west
O_3	Ozone
PM_{10}	Particulate matter < 10 microns in diameter
$PM_{2.5}$	Particulate matter < 2.5 microns in diameter
ppb	Parts per billion
ppm	Parts per million
S	South
SANAS	South African National Accreditation System
SE	South-east
SGT	Sigma theta
SSE	South-south-east
SSW	South-south-west
SW	South-west
TMP	Ambient temperature
ug/m^3	Microgram per cubic meter
W	West
WDR	Wind direction from true North
WNW	West-north-west
WSP	Wind speed
WSW	West-south-west
WVL	Wind velocity

10. DISTRIBUTION LIST

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