Eskom

RESEARCH, TESTING AND DEVELOPMENT

SUSTAINABILITY DEPARTMENT

EZAMOKUHLE AIR QUALITY MONTHLY REPORT

JUNE 2017

EXECUTIVE SUMMARY

This monthly report covers the ambient air quality data as monitored at Ezamokuhle monitoring site in June 2017.

There were three exceedance of SO_2 10-min average limit of 191ppb, three exceedances of SO_2 hourly limit of 134ppb, seven exceedances of $PM_{2.5}$ daily limit of 40 µg/m^3, three exceedances of O_3 8-hourly limit of 61ppb and no exceedances of other national ambient air quality limits recorded for other parameters monitored at Ezamokuhle during the June 2017 monitoring period. There is already non-compliance with the $PM_{2.5}$ and 8-hourly ozone ambient standard at this site for 2017.

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

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

The overall percentage data recovered from the monitoring station was 67.3% and the overall station availability was 69.7%. The data losses for June were due to a major power interruption due to incoming power, faulty NOx analyser which was not responding to the span gas and 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 June 2017

NO_1	NO_2	NO_X	O_3	PRS	RAD	RFL	SGT	SO_2	TMP	WDR	WSP	WVL	$PM_{2.5}$	PM_{10}	HUM	Data Rec	Station Avail
55.3	55.3	55.3	69.3	70.1	70.1	70.1	70.1	69.2	70.1	70.1	70.1	70.1	69.4	69.4	70.1	67.3	69.7

The overall percentage data recovered from the monitoring station during the period was 67.3% and the overall monitoring station availability was 69.7%.

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	µg/m^3	24hr	75	4	DEA
($PM\text{-}_{10}$) by Beta gauge	µg/m^3	1year	40	0	DEA
($PM\text{-}_{2.5}$) by Beta gauge	µg/m^3	24hr	40	4	DEA
($PM\text{-}_{2.5}$) by Beta gauge	µg/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 June 2017

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]	276.		55.9	7		381.9	
FPM (PM−10) by Beta gauge [ug/m^3]	151.7		37.4	0		218.7	
Nitric oxide [ppb]	9.2		3.5			9.4	
Nitrogen dioxide [ppb]	39.4	0	18.8			39.9	
Nitrogen oxide [ppb]	41.4		20.1			42.	
Ozone [ppb]	151.		37.4		3	226.3	
Sigma theta [deg]	42.9		19.2			75.5	
Sulphur dioxide [ppb]	160.1	3	44.2	0		226.3	3
Ambient temperature [deg C]	23.5		12.6			23.9	
Wind speed [m/s]	9.7		5.4			10.6	
Wind velocity [m/s]	9.4		5.3			10.4	

There were three exceedance of SO_2 10-min average limit of 191ppb, three exceedances of SO_2 hourly limit of 134ppb, seven exceedances of $PM_{2.5}$ daily limit of 40 µg/m^3, three exceedances of O_3 8-hourly limit of 61ppb and no exceedances of other national ambient air quality limits recorded for other parameters monitored (Table 3) at Ezamokuhle during the June 2017 monitoring period.

Table 4: Exceedances above the national ambient air quality limits

$PM_{2.5}$ daily exceedances					
Pollutant	**Limit**	**Year**	**Month**	**Day**	**Conc. (µg/m^3)**
$PM_{2.5}$	75	2017	06	01	42.5
$PM_{2.5}$	75	2017	06	02	55.9
$PM_{2.5}$	75	2017	06	03	45.5
$PM_{2.5}$	75	2017	06	07	53.1
$PM_{2.5}$	75	2017	06	13	54.2
$PM_{2.5}$	75	2017	06	14	44.8
$PM_{2.5}$	75	2017	06	20	45.2

SO_2 hourly exceedances								
Pollutant	**Limit**	**Year**	**Month**	**Day**	**Time**	**Wind Direction**	**Wind Velocity**	**Conc. (ppb)**
SO_2	134	2017	06	03	17:00	WNW	1.960	157.27
SO_2	134	2017	06	03	18:00	WNW	2.581	160.09
SO_2	134	2017	06	30	19:00	WSW	1.758	143.35

SO_2 10 minute exceedances						
Pollutant	**Limit**	**Year**	**Month**	**Day**	**Time**	**Conc. (ppb)**
SO_2	191	2017	06	30	18:20	226.30
SO_2	191	2017	06	30	18:30	200.60
SO_2	191	2017	06	04	11:40	212.74

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 west-south-west, west and west-north-west. During the night, the most frequent directions were west-south-west, west and west-north-west.

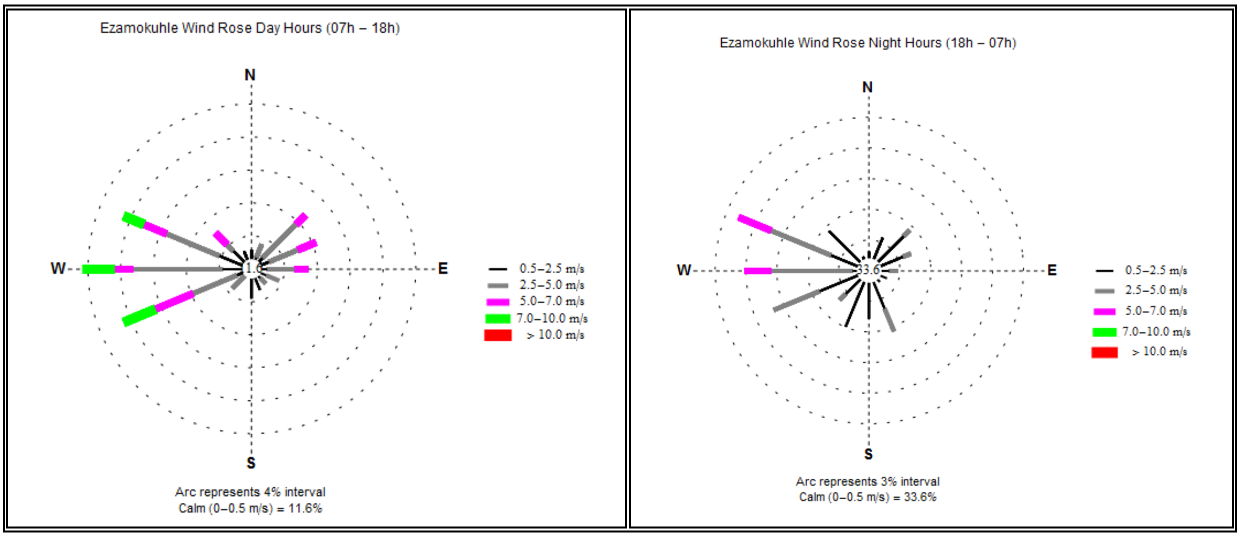

Figure 2: Day and night time wind roses at Ezamokuhle monitoring site

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 peaks are reached at 10:00 and 14:00 during the day. The concentrations begin to decrease and remain low for the rest of the afternoon with a major peak observed at 20:00 in the evening. Concentration peaks observed at 09:00 in the morning and 20:00 in the evening are as a result of emissions from low level sources. Concentrations peak recorded at 14:00 during the day could be as a result of emissions from tall stack emitters.

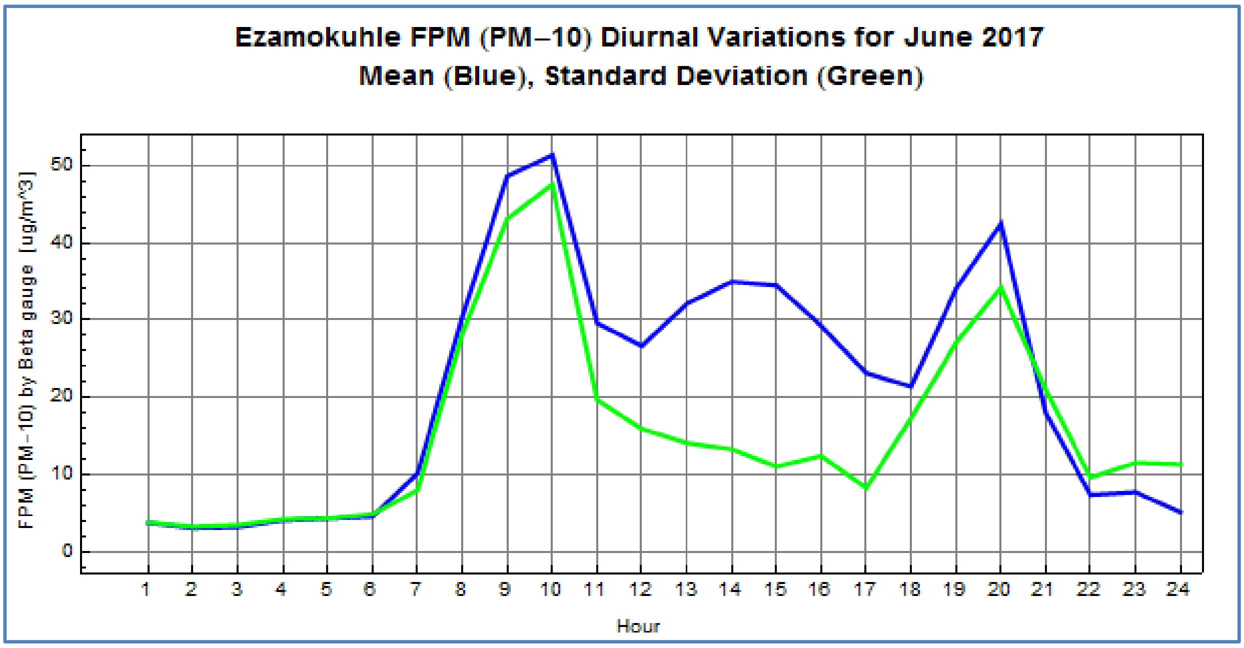

Figure 3: PM_{10} Diurnal variations (Mean concentrations = Blue line, Standard Deviation = Green line).

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

Since there is no national hourly limit for PM_{10}; the hourly 98th 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 east-north-east, east, east, south-east, south, west-north-west and north-west sectors. Majuba Power Station is located about 13.8 km from south-west to west-south-west of the monitoring site. The most dominant hourly mean concentrations during night time period were recorded from east-north-east, west-south-west and west-north-west sectors. Major roads and other activities at Ezamokuhle Township around the monitoring site might be impacting on the PM_{10} ambient concentrations.

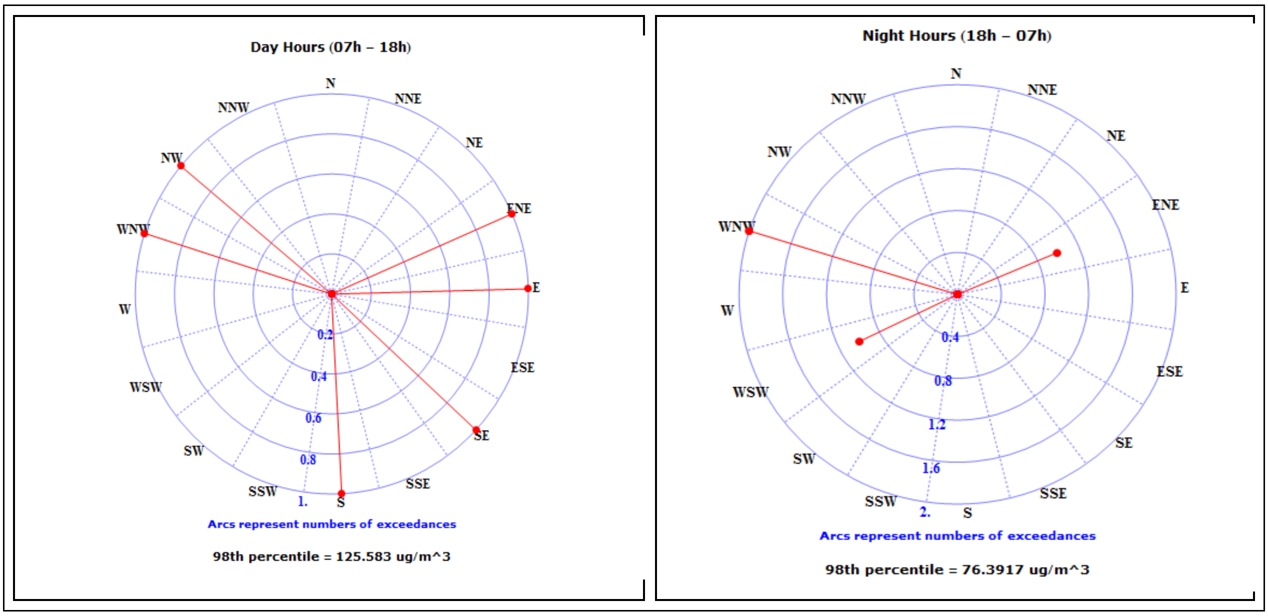

Figure 4: PM_{10} hourly mean 98th percentile event roses during day and night times

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	0	0	1	1	0	1	0	1	0	0	0	0	1	1	0
%	0	0	0	16.67	16.67	0	16.67	0	16.67	0	0	0	0	16.67	16.67	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	0	1	0	0	0	0	0	0	0	1	0	2	0	0
%	0	0	0	25	0	0	0	0	0	0	0	25	0	50	0	0

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 a morning peak at 09:00 and a dominant evening peak at 20:00. Elevated concentrations in the mornings and evenings indicate typical contribution by low level sources.

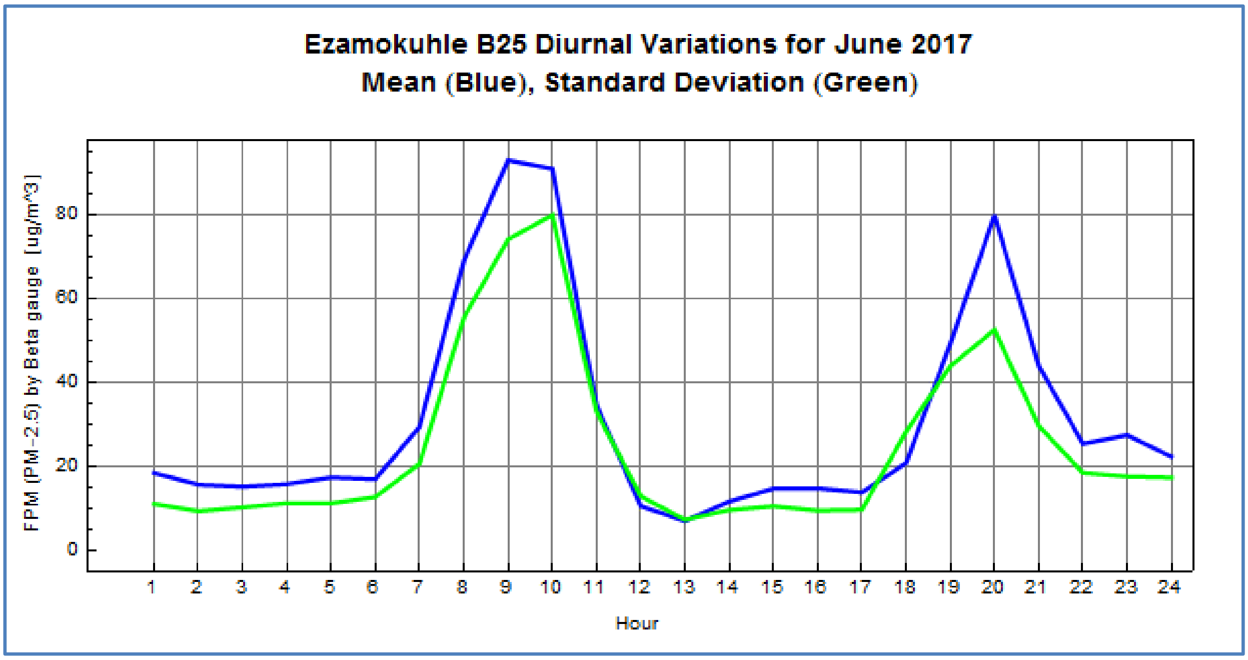

Figure 5: $PM_{2.5}$ Diurnal variations (Mean concentrations = Blue line, Standard Deviation = Green line).

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

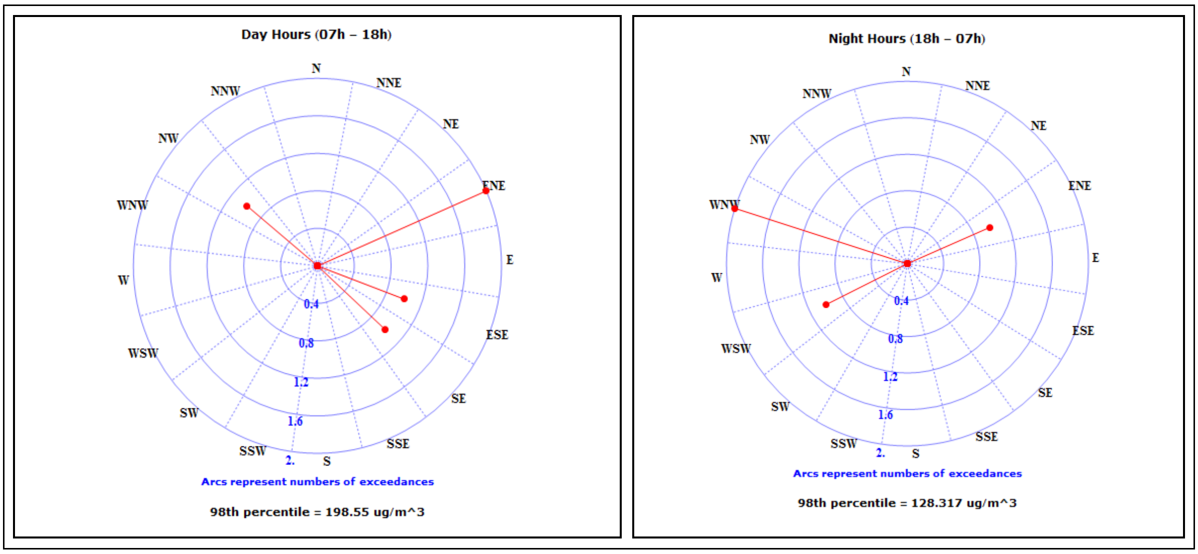

Figure 6: $PM_{2.5}$ hourly mean 98th percentile event roses during day and night times

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	0	0	2	0	1	1	0	0	0	0	0	0	0	1	0
%	0	0	0	40	0	20	20	0	0	0	0	0	0	0	20	0

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	0	0	1	0	0	0	0	0	0	0	1	0	2	0	0
%	0	0	0	25	0	0	0	0	0	0	0	25	0	50	0	0

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 peak observed at 14:00 and maximum peak at 20:00. This diurnal variation indicates emissions from tall stack sources that probably have influence on the ambient concentrations observed throughout the day.

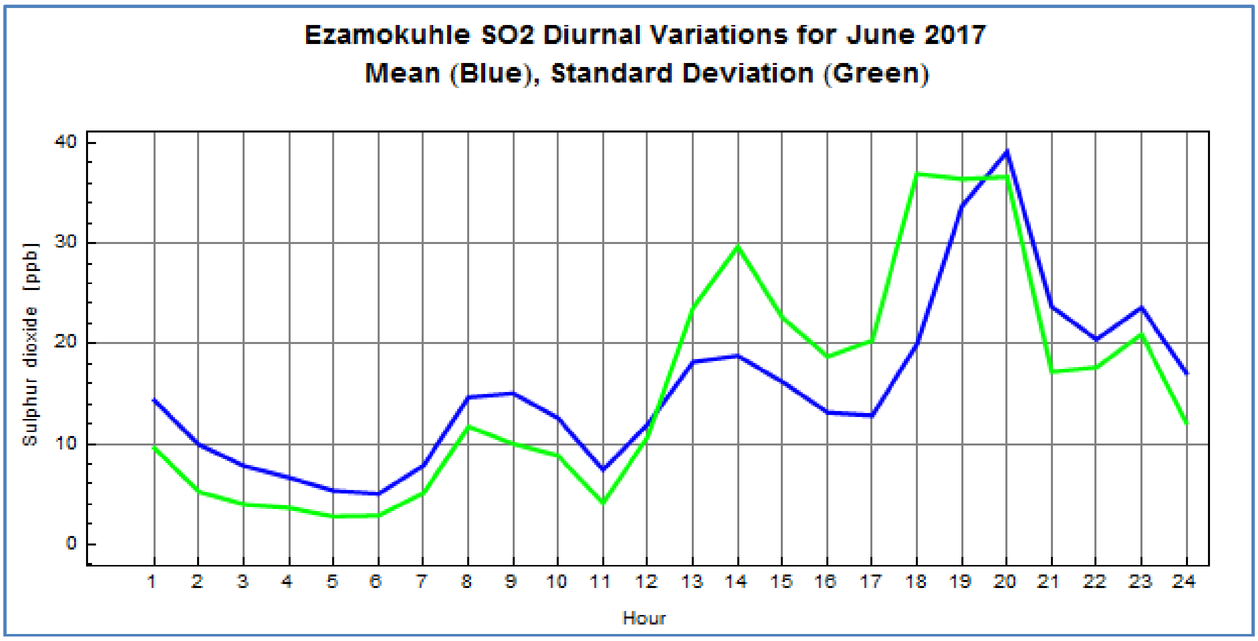

Figure 7: SO_2 diurnal variations (.Mean concentrations = Blue line, Standard Deviation = Green line).

6.2.2. SO_2 hourly mean event roses and tables.

Figure 8 presents the SO_2 exceedances rose during daytime and night-time. The SO_2 exceedances above hourly national limit during daytime and night-time exceedance roses are presented in Figure 8 to identify the wind sectors from which the highest concentrations are derived. There were two exceedances recorded from west-north-west sector during the day and one exceedance recorded during the night from west-south-west sector. These exceedances are probably from local sources due to burning of wood and coal during the winter season.

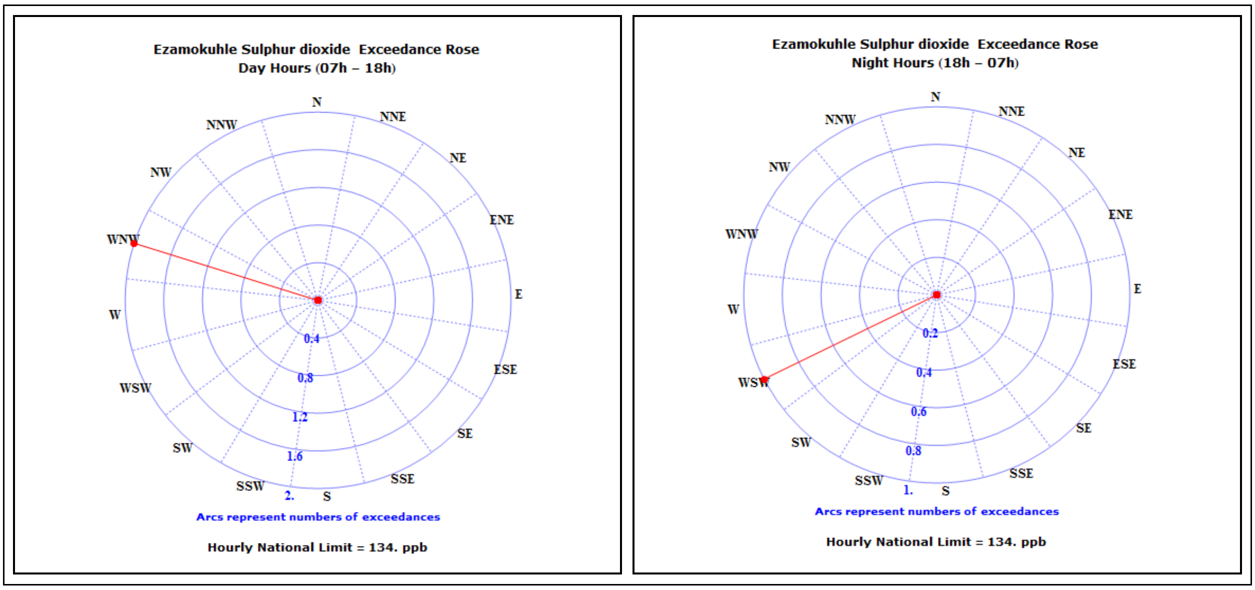

Figure 8: SO_2 exceedance roses for daytime and night time.

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	0	0	0	2	0	0
%	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	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	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
%	0	0	0	0	0	0	0	0	0	0	0	100	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 the morning hours, with slightly elevated concentrations during the day. The concentrations show elevated concentration during the day 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.

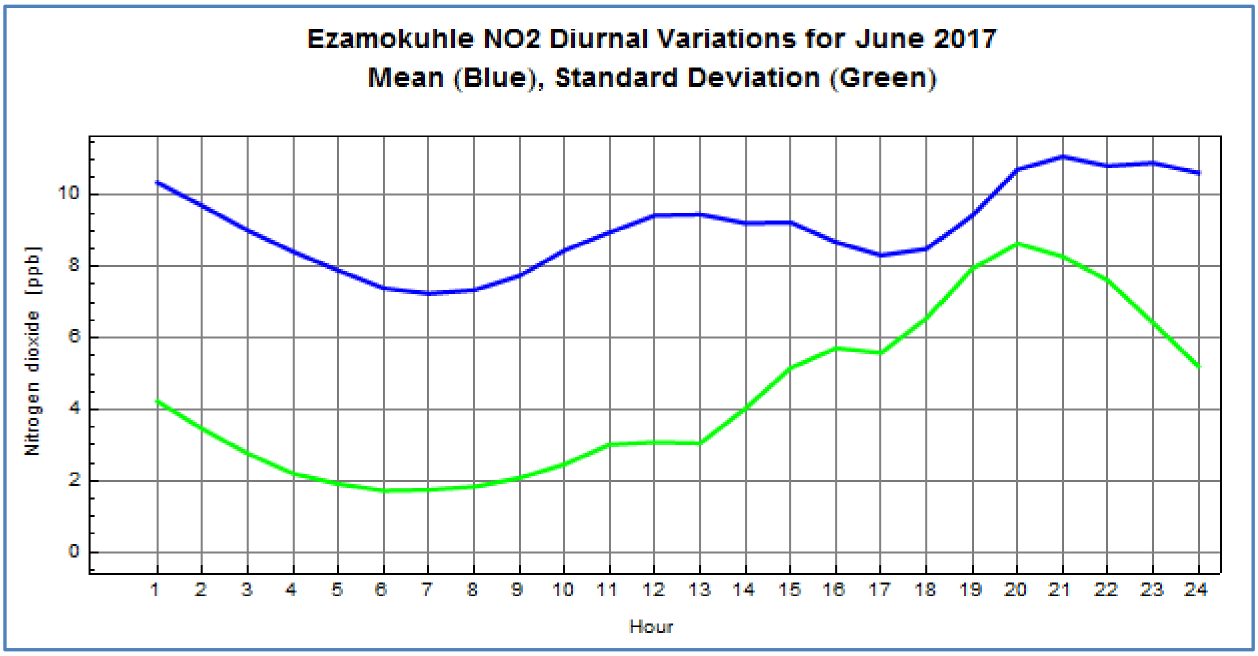

Figure 9: NO_2 diurnal variations (.Mean concentrations = Blue line, Standard Deviation = Green line)

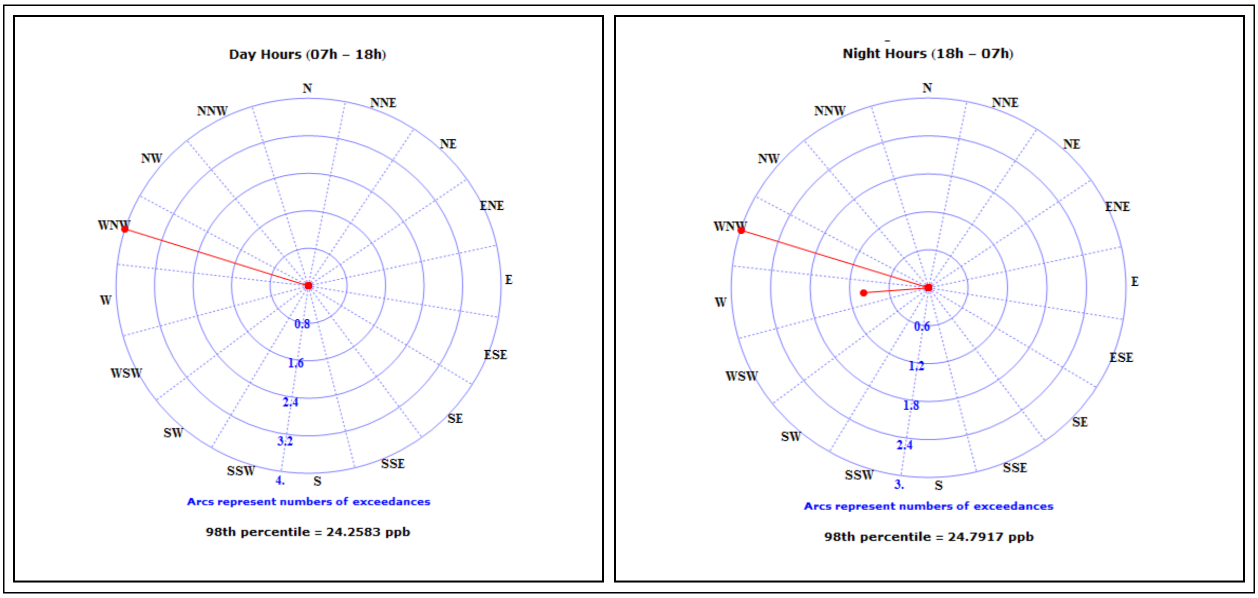

Figure 10: NO_2 hourly mean sector 98th percentile event roses

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 24.25ppb (98th percentile value) were from west-north-west sectors (Table 11). The most dominant night-time concentrations above 24.79ppb (98th percentile value) were from west and west-north-west sectors (Table 12). The vehicles operating within the school 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	0	0	0	0	4	0	0
%	0	0	0	0	0	0	0	0	0	0	0	0	0	400	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	0	0	0	0	0	0	0	0	0	0	1	3	0	0
%	0	0	0	0	0	0	0	0	0	0	0	0	25	75	0	0

6.4. OZONE (O_3)

Figure 11 shows the O_3 hourly mean diurnal variation with increase in ozone concentrations occurring from 08:00 and maximum peak recorded at 17:00 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 recorded during the month.

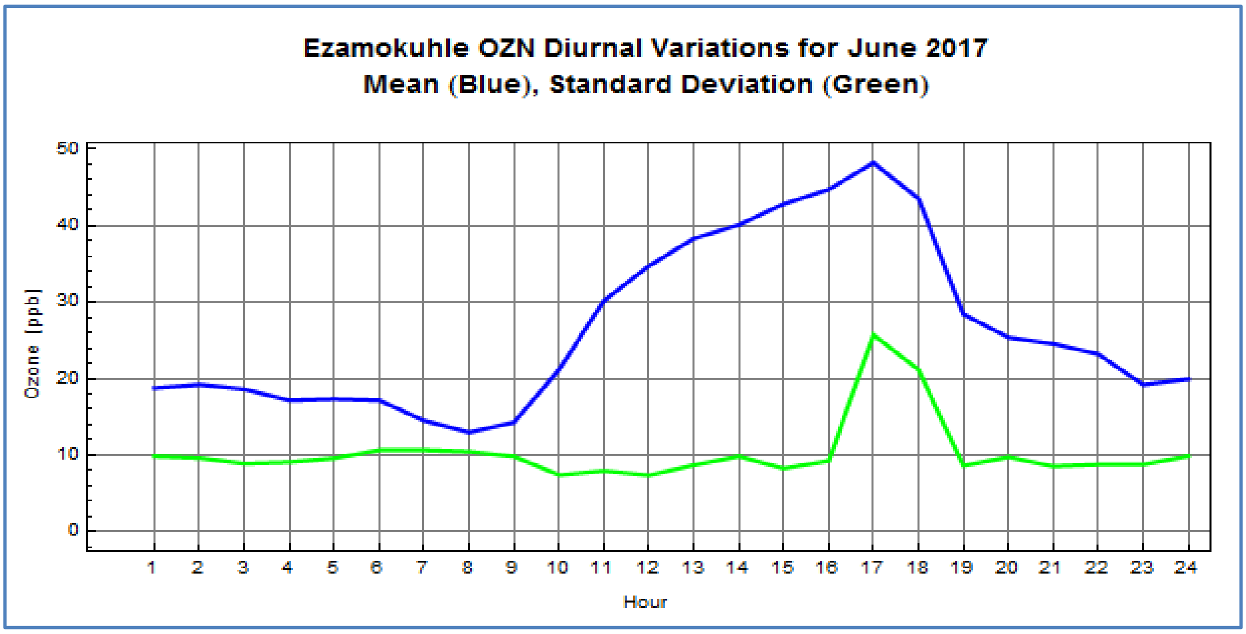

Figure 11: O_3 diurnal variations (.Mean concentrations = Blue line, Standard Deviation = Green line)

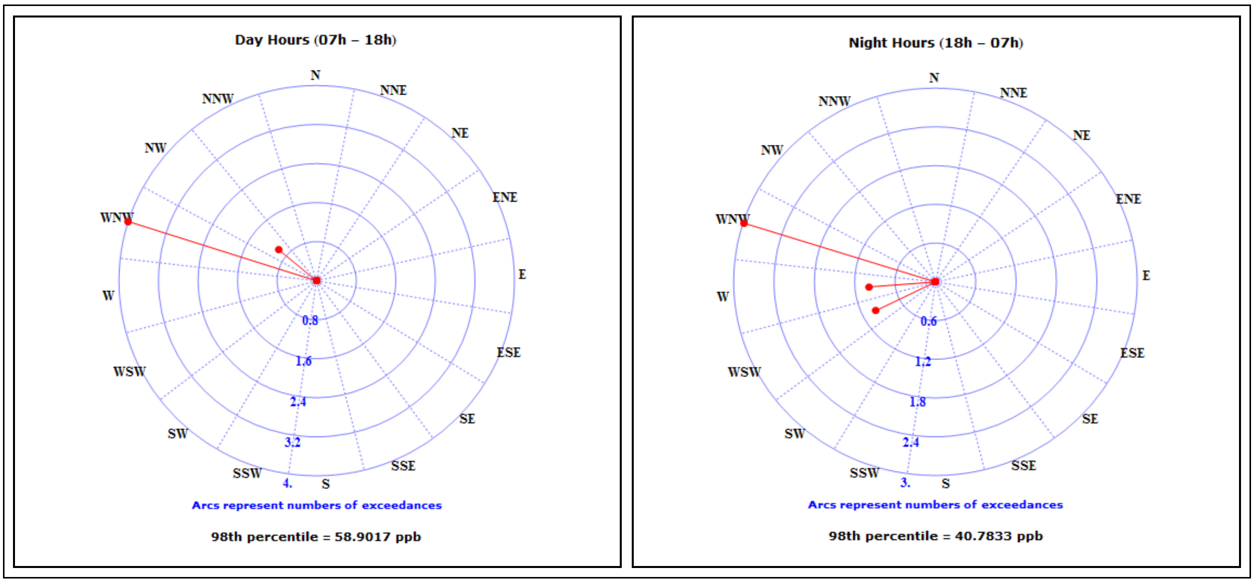

Figure 12: O_3 hourly mean sector 98th percentile event roses

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	0	0	0	0	0	4	1	0
%	0	0	0	0	0	0	0	0	0	0	0	0	0	80	20	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	0	0	0	0	0	0	0	0	1	1	3	0	0
%	0	0	0	0	0	0	0	0	0	0	0	20	20	60	0	0

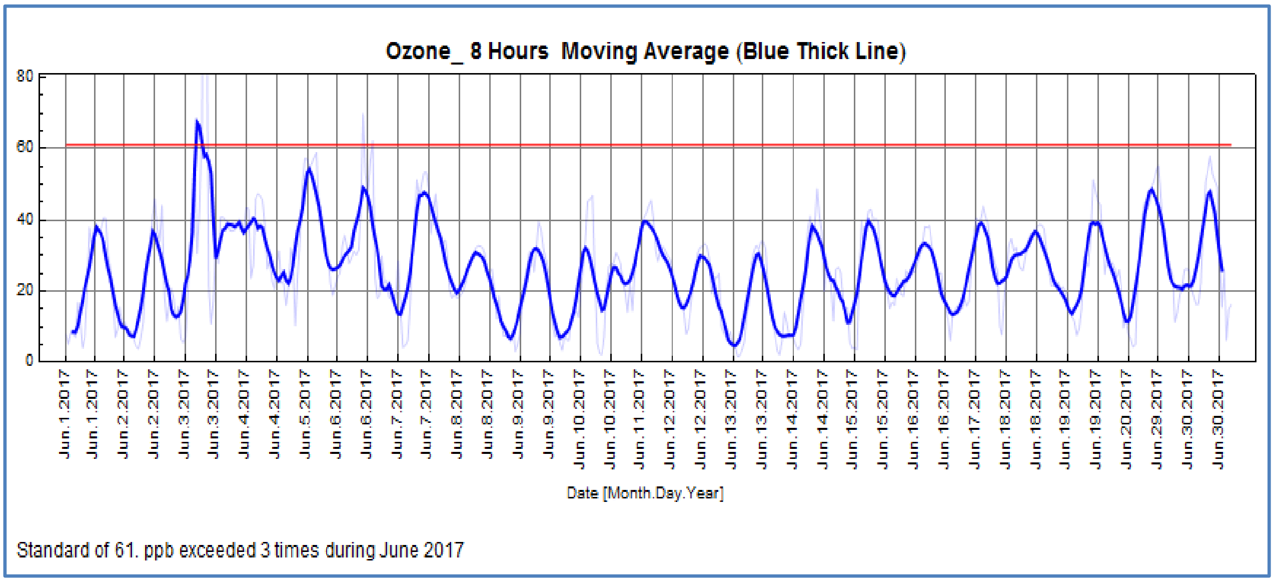

Figure 13: O_3 8 Hours Moving Average (Blue Thick Line)

7. HISTORICAL MONTHLY CONCENTRATIONS

7.1. RECENT TRENDS

Time series graphs for each pollutant with respect to the National Ambient Air Quality Standards are represented from the beginning of the previous year until the end of the current reporting period or since inception of the monitors.

Ozone concentrations show increase levels during spring period and lower levels during winter. The SO_2 concentrations indicate lower concentrations at Ezamokuhle since inception and PM_{10} and $PM_{2.5}$ show increased levels and exceedances during winter periods (July) and lower concentrations during summer and spring. The NO_2 concentrations did not exceed the national ambient standard since July 2016, but they do show elevated concentrations during the winter period over the past six months.

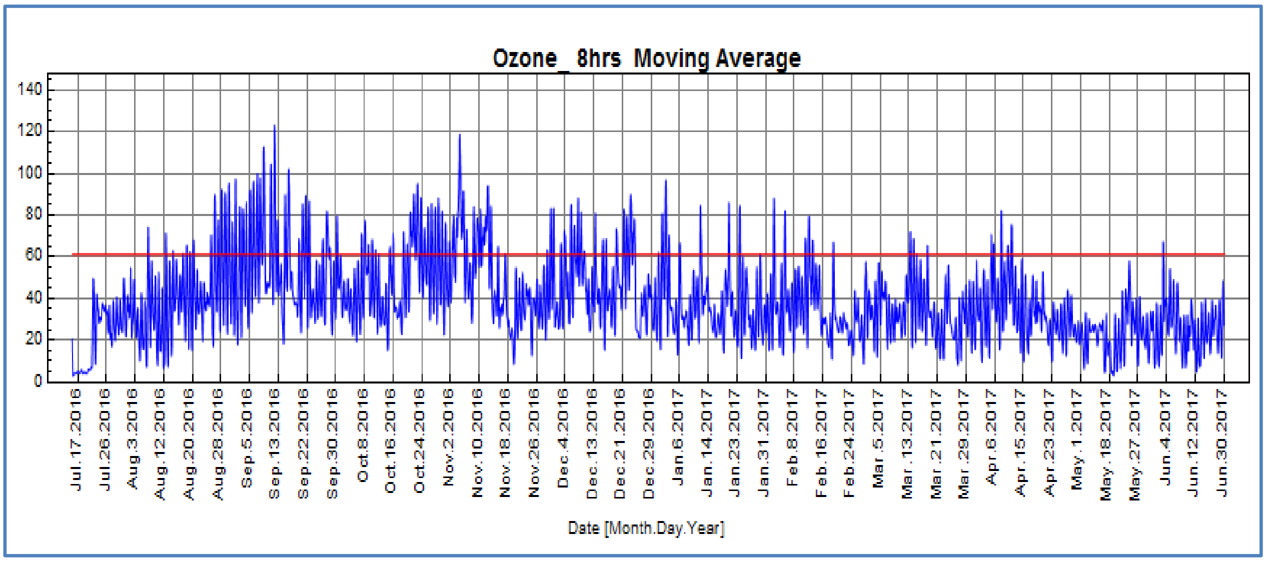

Figure 14: Historical ozone 8 hours moving average from July 2016 to June 2017

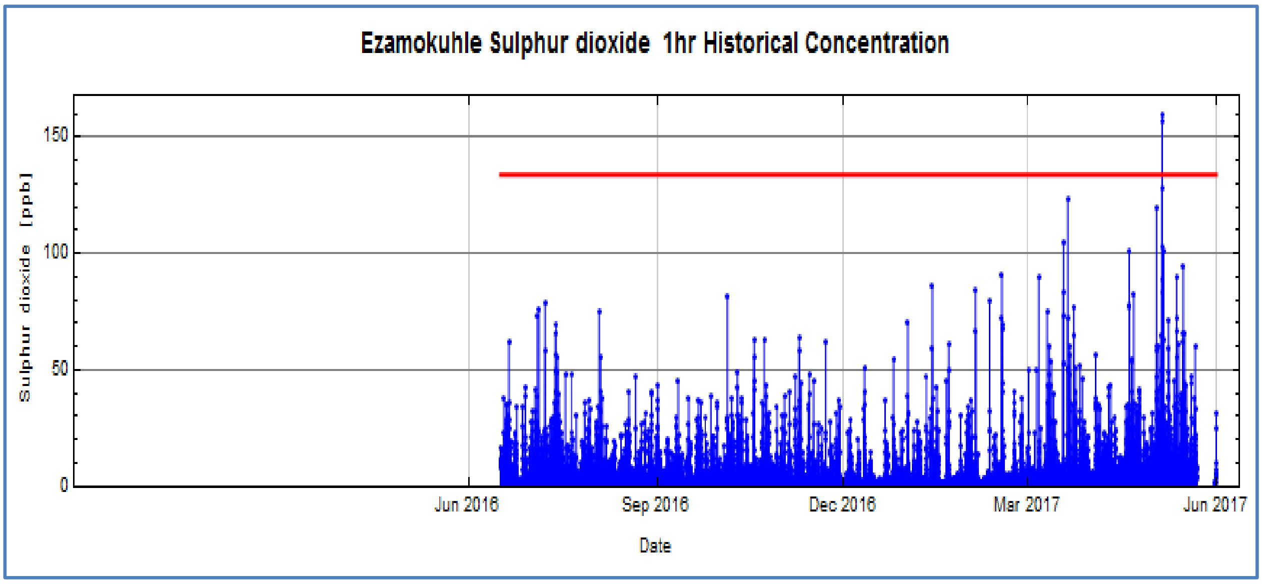

Figure 15: Time series graph for SO_2 hourly data from July 2016 to June 2017

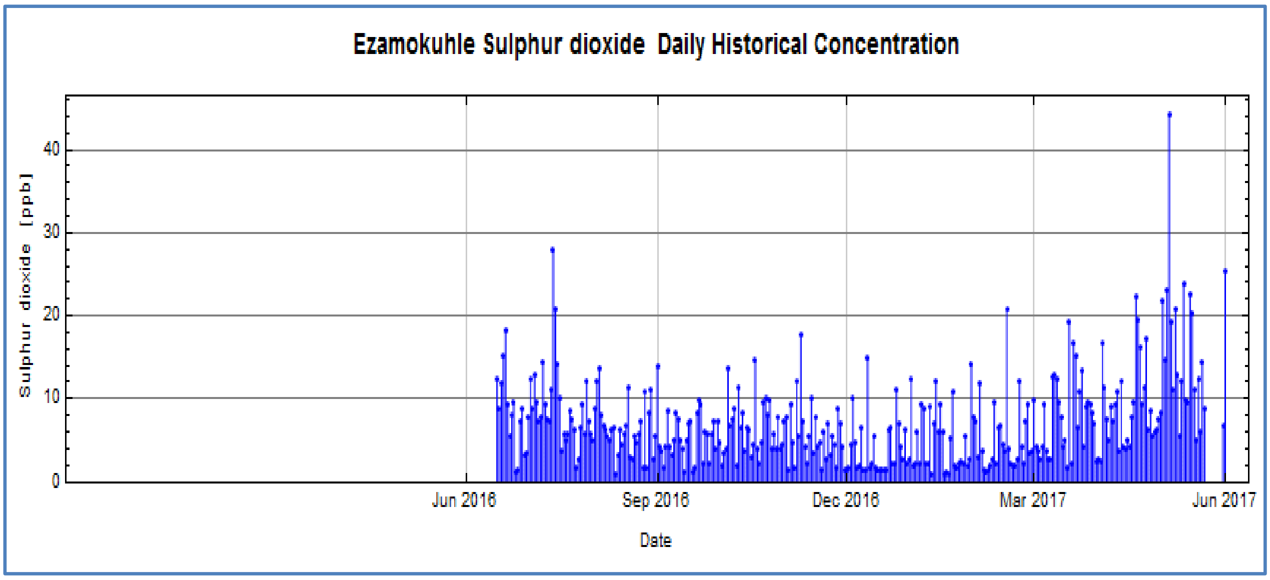

Figure 16: Time series graph for SO_2 daily data from July 2016 to June 2017

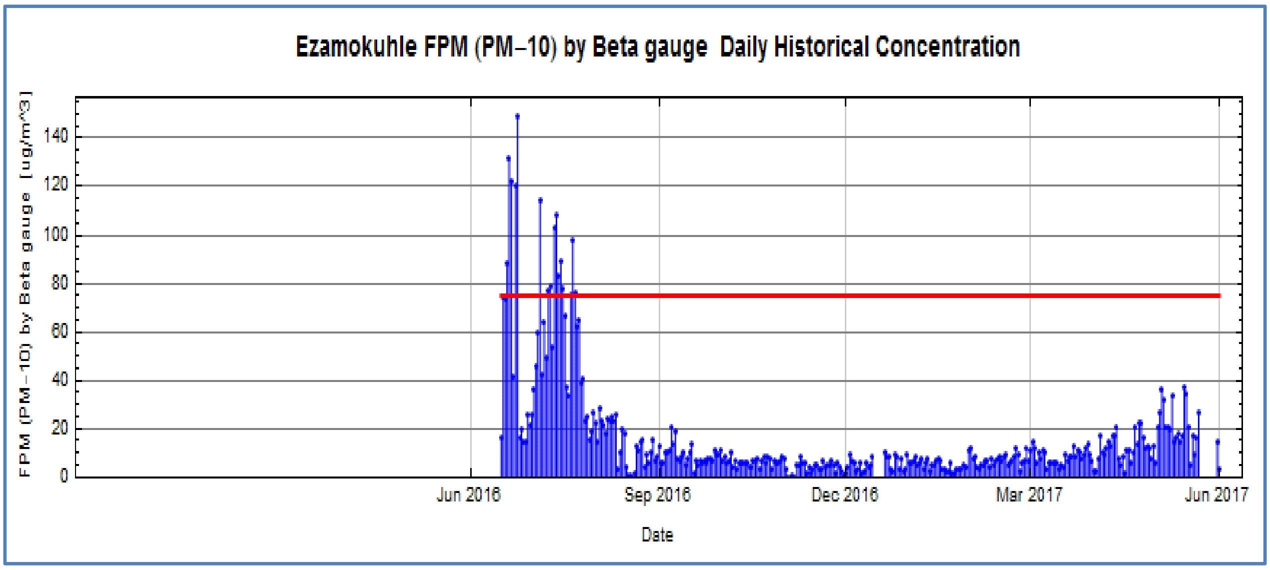

Figure 17: Time series graph for PM_{10} daily data from July 2016 to June 2017

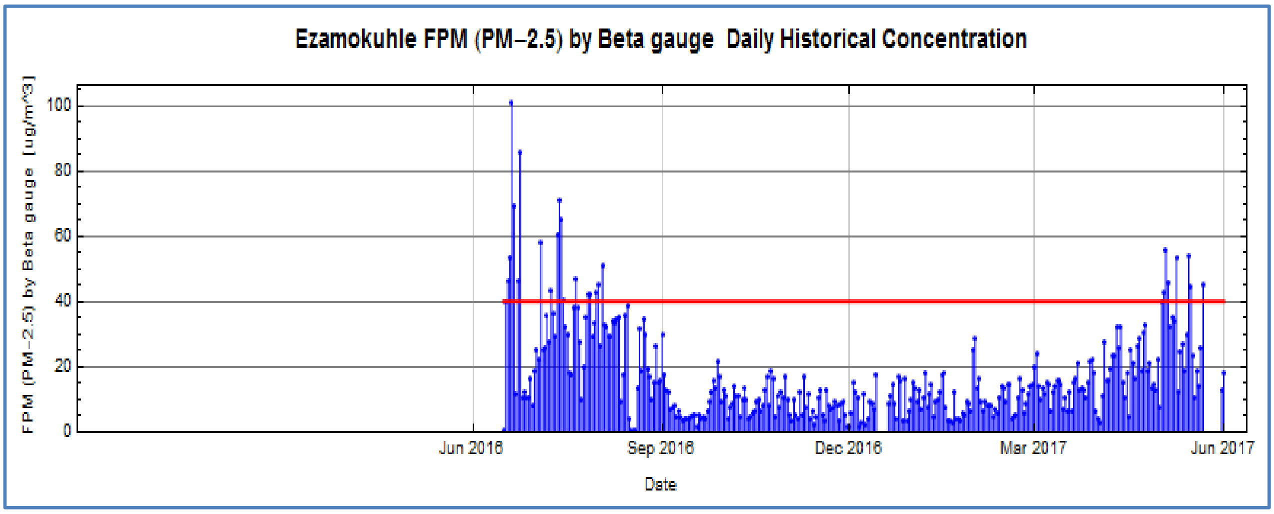

Figure 18: Time series graph for $PM_{2.5}$ daily data from July 2016 to June 2017

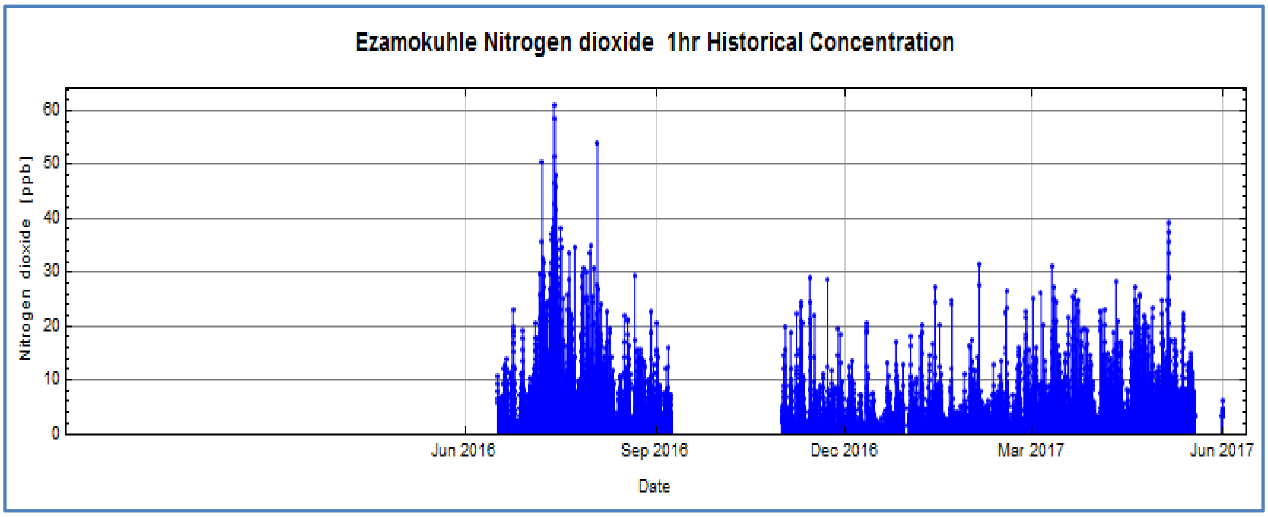

Figure 19: Time series graph for NO_2 hourly data from July 2016 to June 2017

7.2. MONTHLY MEANS FOR THE CURRENT CALENDER YEAR 2017

Table 13: Monthly means for all parameters measured for the current calendar year 2017

Parameter measured	**Jan.**	**Feb.**	**Mar**	**Apr**	**May**	**Jun**
$PM_{2.5}$ (µg/m^3)	9.6	9.4	11.3	12.9	20.2	31.6
PM_{10} (µg/m^3)	5.5	4.8	7.4	7.9	12.3	21.3
NO_2 (ppb)	3.1	3.6	4.2	6.2	7.2	9.1
O_3 (ppb)	37.1	34.9	33.2	34	23.1	26.4
SO_2 (ppb)	4.3	4.9	5.3	7.7	9.4	15.6

7.3 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	SO_2 10 Min	NO_2 hourly	PM_{10} daily	$PM_{2.5}$ daily	O_3 8- Hourly
Jan 2017	0	0	0	0	0	0	61
Feb 2017	0	0	0	0	0	0	41
Mar 2017	0	0	0	0	0	0	15
Apr 2017	0	0	1	0	0	0	32
May 2017	0	0	1	0	0	0	0
June 2017	3	0	3	0	0	7	3
Total	**3**	**0**	**5**	**0**	**0**	**7**	**152**
Allowed no of exceedances	88	4	526	88	4	4	11

Ozone and $PM_{2.5}$ have already exceeded its annual national standard.

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 three exceedance of SO_2 10-min average limit of 191ppb, three exceedances of SO_2 hourly limit of 134ppb, seven exceedances of $PM_{2.5}$ daily limit of 40 µg/m^3, three exceedances of O_3 8-hourly limit of 61ppb and no exceedances of other national ambient air quality limits recorded for other parameters monitored at Ezamokuhle during the June 2017 monitoring period. There is already non-compliance with the $PM_{2.5}$ and 8-hourly ozone ambient standard at this site for 2017.

Report compiled by: Kgancho Komane
RT&D

Reviewed by: Bontle Monametsi

Air Quality, Climate Change & Ecosystem Management
RT&D

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

Air Quality Centre of Excellence MWP
Eskom Environmental Management
Attention: K Langerman
Attention: O Makhalemele
Projects file RT&D
K. Komane