Eskom

RESEARCH, TESTING AND DEVELOPMENT

SUSTAINABILITY

KWAZAMOKUHLE AIR QUALITY REPORT

MAY 2017

EXECUTIVE SUMMARY

This monthly report covers the ambient air quality data for May 2017 as monitored at KwaZamokuhle monitoring site.

There were fifteen (15) exceedances of the national ambient air quality for PM_{10} daily limit of 75µg/m³, twenty (20) exceedances of the national ambient air quality for $PM_{2.5}$ daily limit of 40µg/m³ and there were three (3) exceedances of the national ambient air quality limit for SO_2 hourly, nine (9) exceedances of the national ambient air quality limit for SO_2 10-minutes and there were no exceedances of the other national ambient air quality limits 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. Ambient fine particulate matter concentrations indicate the influence of low-level source emissions at KwaZamokuhle, probably domestic burning.

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

The overall percentage data recovered from the monitoring site during the reporting period was 90.7% and station availability was 98.1%. NOx analyser and radiation sensor did not meet SANAS requirement of 90% data recovery per parameter. NOx analyser was affected by high temperature at site and the radiation sensor went faulty and was replaced.

DISCLAIMER

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 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, 27.3 km east-south-east of Komati Power Station and 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 and KwaZamokuhle Township

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 the KwaZamokuhle monitoring site. All parameters met the SANAS guideline

Table1. Percentage data recovered per parameter for May 2017

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 Avail
74.6	74.6	74.6	97.5	100	30.8	100	97.4	100	100	100	99.9	97.2	96.8	99.8	90.7	98.1

The overall percentage data recovered from the monitoring site during the reporting period was 90.7% and station availability was 98.1%. NOx analyser and Radiation sensor did not meet SANAS required due to being affected by high temperature at site, which then resulted to invalid data and other monitored parameters met the SANAS requirement of 90% data recovery per parameter.

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 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)	385.3		75.9	20		499	
PM_{10} (µg/m^3)	467.2		126.3	15		543.2	
NO (ppb)	74.4		15.1			114.7	
NO_2 (ppb)	51.8	0	16.6			102.6	
NOx (ppb)	110		27.1			156.1	
OZN (ppb)	53		26.5		0	56.3	
SO_2 (ppb)	186.5	3	45.6	0		241	9
TMP (°C)	24.1		15.5			24.5	
WSP (m/s)	7.9		4.8			10.1	
WVL (m/s)	7.7		4.7			9.9	

There were fifteen (15) exceedances of the national ambient air quality for PM_{10} daily limit of 75µg/m³, twenty (20) exceedances of the national ambient air quality for $PM_{2.5}$ daily limit of 40µg/m³ and there were three (3) exceedances of the national ambient air quality limit for SO_2 hourly, nine (9) exceedances of the national ambient air quality limit for SO_2 10-minutes and there were no exceedances of the other national ambient air quality limits recorded during the monitoring period under review**.**

Table 4: Exceedances above national ambient air quality standards

SO_2 hourly exceedances								
Pollutant	**Limit**	**Year**	**Month**	**Day**	**Time**	**Conc.**	**WDR**	**WVL**
SO_2	134	2017	May	20	20:00	144.63	SSE	0.287
SO_2	134	2017	May	23	18:00	183.3	W	1.796
SO_2	134	2017	May	23	19:00	186.48	WNW	0.874
SO_2 10 minutes exceedances								
Pollutant	**Limit**	**Year**	**Month**	**Day**	**Time**	**Conc.**		
SO_2	191	2017	May	23	06:50	208.9		
SO_2	191	2017	May	23	06:20	194.5		
SO_2	191	2017	May	23	06:40	193.7		
SO_2	191	2017	May	23	05:30	194.7		
SO_2	191	2017	May	23	05:50	197.4		
SO_2	191	2017	May	23	05:40	205		
SO_2	191	2017	May	22	05:50	192.2		
SO_2	191	2017	May	04	07:20	191.2		
SO_2	191	2017	May	04	07:30	241		

PM_{10} daily exceedances					
Pollutant	**Limit**	**Year**	**Month**	**Day**	**Conc.**
PM_{10}	75	2017	May	03	92.1
PM_{10}	75	2017	May	04	114.2
PM_{10}	75	2017	May	05	106.7
PM_{10}	75	2017	May	06	106.3
PM_{10}	75	2017	May	07	109.6
PM_{10}	75	2017	May	08	88.1
PM_{10}	75	2017	May	09	75.1
PM_{10}	75	2017	May	10	78.1
PM_{10}	75	2017	May	11	91.9
PM_{10}	75	2017	May	23	110.2
PM_{10}	75	2017	May	24	126.3
PM_{10}	75	2017	May	26	97.3
PM_{10}	75	2017	May	27	97.2
PM_{10}	75	2017	May	30	81.9
PM_{10}	75	2017	May	31	116
$PM_{2.5}$ exceedances					
Pollutant	**Limit**	**Year**	**Month**	**Day**	**Conc.**
$PM_{2.5}$	40	2017	May	03	67.5
$PM_{2.5}$	40	2017	May	04	70.6
$PM_{2.5}$	40	2017	May	05	54
$PM_{2.5}$	40	2017	May	06	52.7
$PM_{2.5}$	40	2017	May	07	64.4
$PM_{2.5}$	40	2017	May	08	53.6
$PM_{2.5}$	40	2017	May	09	45
$PM_{2.5}$	40	2017	May	10	44.2
$PM_{2.5}$	40	2017	May	11	49.3
$PM_{2.5}$	40	2017	May	17	43.8
$PM_{2.5}$	40	2017	May	19	43
$PM_{2.5}$	40	2017	May	22	54.6
$PM_{2.5}$	40	2017	May	23	66.3
$PM_{2.5}$	40	2017	May	24	73.9
$PM_{2.5}$	40	2017	May	25	47.6
$PM_{2.5}$	40	2017	May	26	53

$PM_{2.5}$	40	2017	May	27	54.2
$PM_{2.5}$	40	2017	May	29	49.2
$PM_{2.5}$	40	2017	May	30	53.2
$PM_{2.5}$	40	2017	May	31	75.9

5. METEOROLOGICAL OBSERVATIONS

The distribution of wind direction and wind speed for daytime and night-time hours for the reporting period are summarised on polar diagrams in Figure 2. 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 south-west, west-south-west, south-south-east and east. The dominant winds during the night were from south-south-east, south and east-south-east.

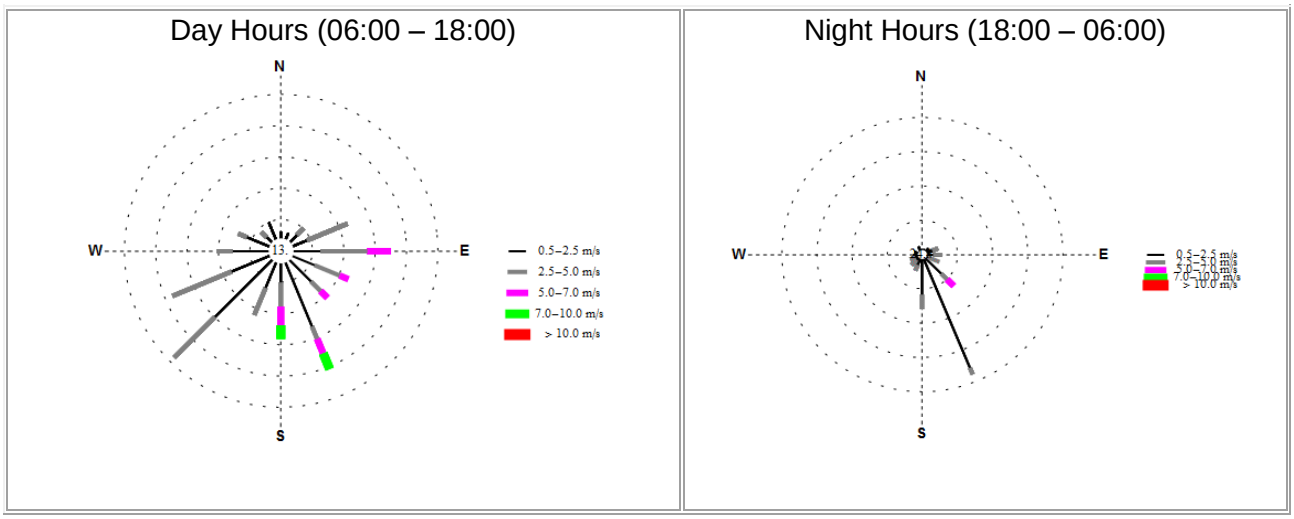


Figure 2: Wind profile at KwaZamokuhle monitoring site

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 08:00 in the morning. The concentrations continue to rise throughout the afternoon with a peak between 12:00 and 13:00 and indicative of influence from tall stack emitters on the ambient SO_2 concentrations in the area. The concentrations increase from 17:00 and reach a maximum peak at 20:00 in the evening, indicative of influence from low-level sources, probably domestic coal burning and motor vehicle emissions.

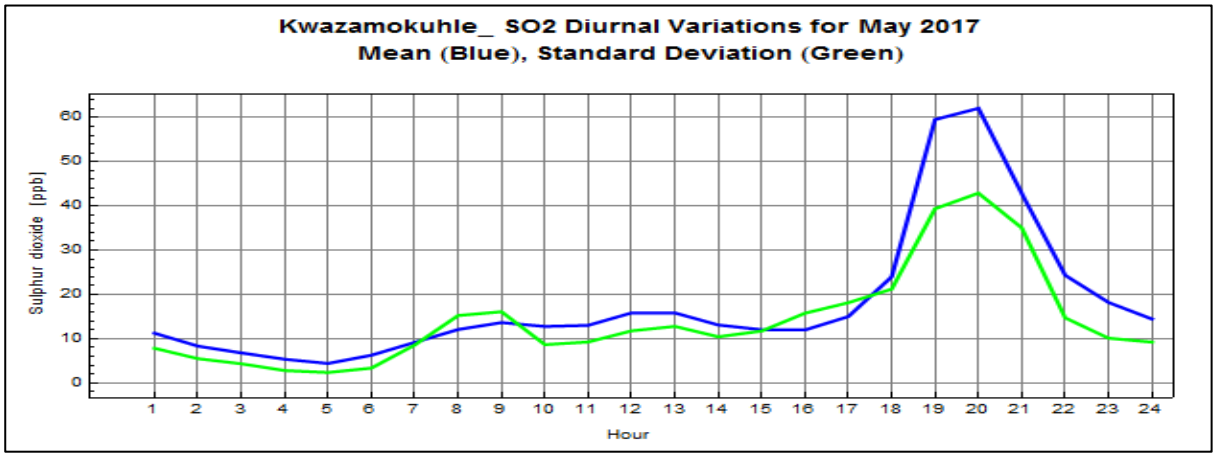


Figure 3: Diurnal variation of SO_2 hourly at KwaZamokuhle for May 2017

6.1.2 Sulphur Dioxide Hourly Event Roses

There were three (3) exceedances of the national ambient air quality limit for SO_2 hourly, nine (9) exceedances of the national ambient air quality limit for SO_2 10-minutes. Figure 4 shows the SO_2 hourly limit exceedance roses during day and hourly limit exceedance roses during night times.

During the daytime, one exceedance of the SO_2 hourly limit of 134 ppb was recorded in the west sector; Komati Power Station is located 27.6 km west to west-north-west of the monitoring site. The hourly limit exceedances of 134 ppb during the night-time were recorded in the south-south-east and west-north-west sectors.

KwaZamokuhle Township is located from north to south and Hendrina power station is located in the north-west sectors of the monitoring site and this could have shown impact on the SO_2 ambient concentrations around the monitoring site.

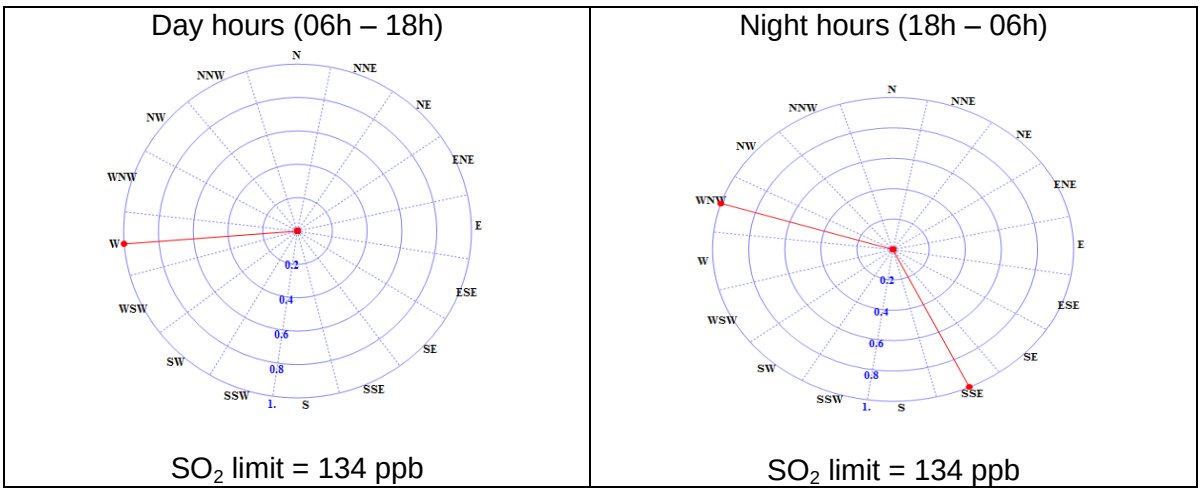


Figure 4: SO_2 highest hourly concentrations for event roses during day and night

Table 5: SO_2 day-time hourly limit for exceedance table

Dir.	N	NNE	NE	ENE	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Exe	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	100	0	0	0

Table 6: SO_2 night-time hourly limit for 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	1	0	0	0	0	0	1	0	0
%	0	0	0	0	0	0	0	50	0	0	0	0	0	50	0	0

6.2. Nitrogen Dioxide (NO_2)

6.2.1. Source identification by NO_2 diurnal variations

The diurnal variation indicates NO_2 concentrations reaching minor peaks between 08:00 and 09:00 in the morning and a maximum peak between 19:00 and 20:00 in the evening as indicated by Figure 5. The peaks observed could be associated with influence from low-level sources like domestic burning and vehicles

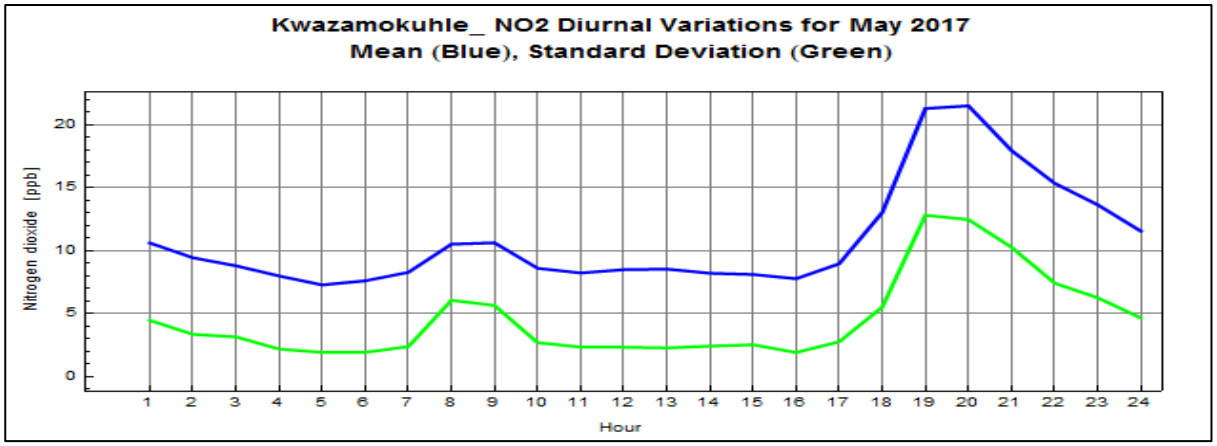


Figure 5: Diurnal variation of NO_2 hourly at KwaZamokuhle for May 2017

6.2.2 Nitrogen dioxide hourly event roses (98th percentile)

There were no exceedances of the NO_2 hourly limit of 106 ppb. Figure 6 shows the 98th percentile event roses indicating the sectors where highest hourly concentrations were coming from during the day and night. During the daytime the highest hourly mean concentrations above 28.63 ppb were recorded in south-east, west-north-west and west sectors. The hourly mean concentrations above 37.57 ppb during the night-time were recorded in the north, south-south-east, south, west-south-west and north-west sectors.

KwaZamokuhle Township is located from north to south sectors of the monitoring site and this could have shown impact on the NO_2 ambient concentrations around the monitoring site.

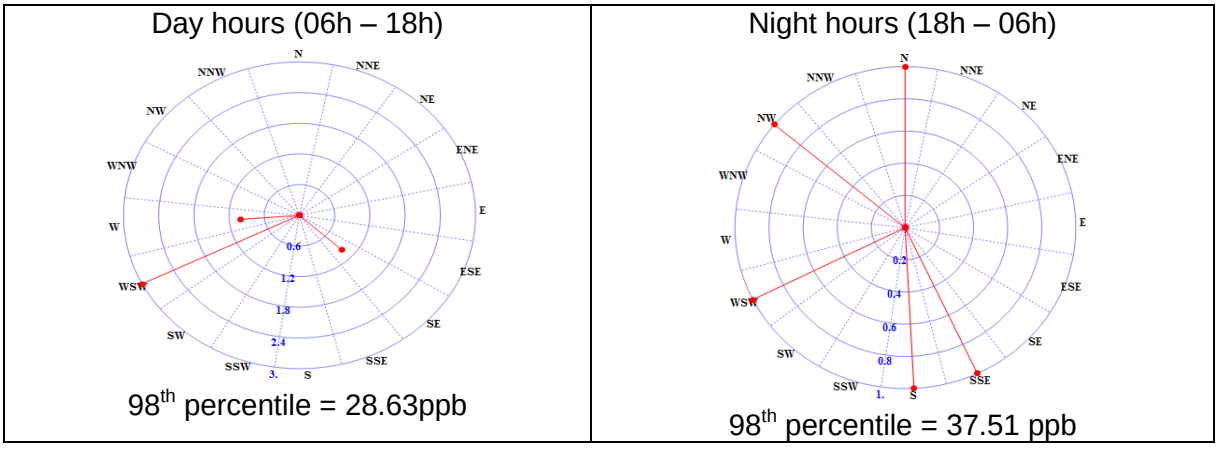


Figure 6: NO_2 hourly mean 98th percentile event roses during day and night times

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	1	0	0	0	0	0	0	0	0	0
%	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0

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

Dir.	N	NNE	NE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0
%	20	0	0	0	0	0	20	0	0	0	20	0	0	20	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 showing impact of low-level source emissions on the particulate matter ambient concentrations. Two distinct peaks are evident at 10:00 in the morning and 20:00 in the evening and concentrations remained low throughout the day. These peaks are typical of emissions from low-level sources, probably domestic fuel combustion in KwaZamokuhle.

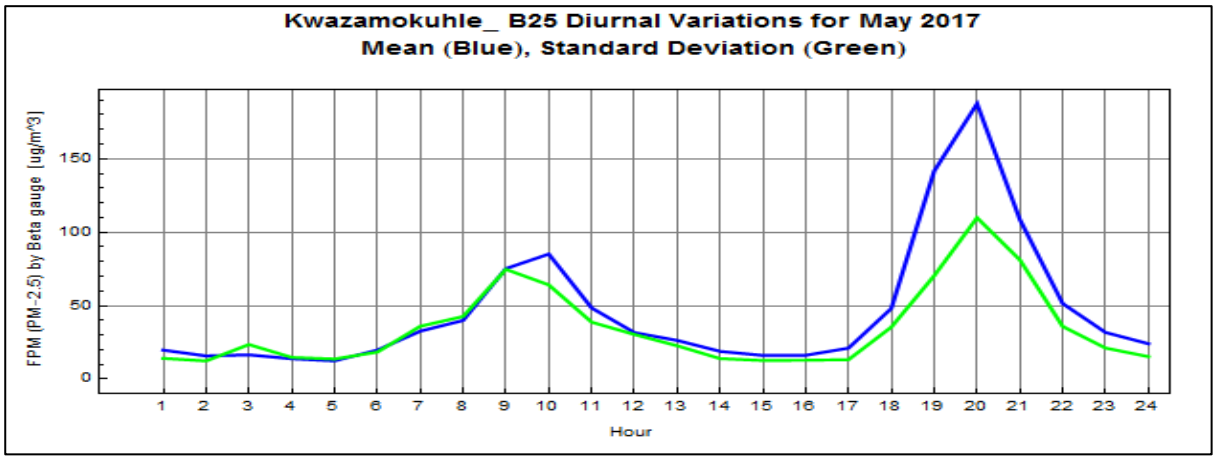


Figure 7: Diurnal variation of $PM_{2.5}$ concentrations at KwaZamokuhle for May 2017

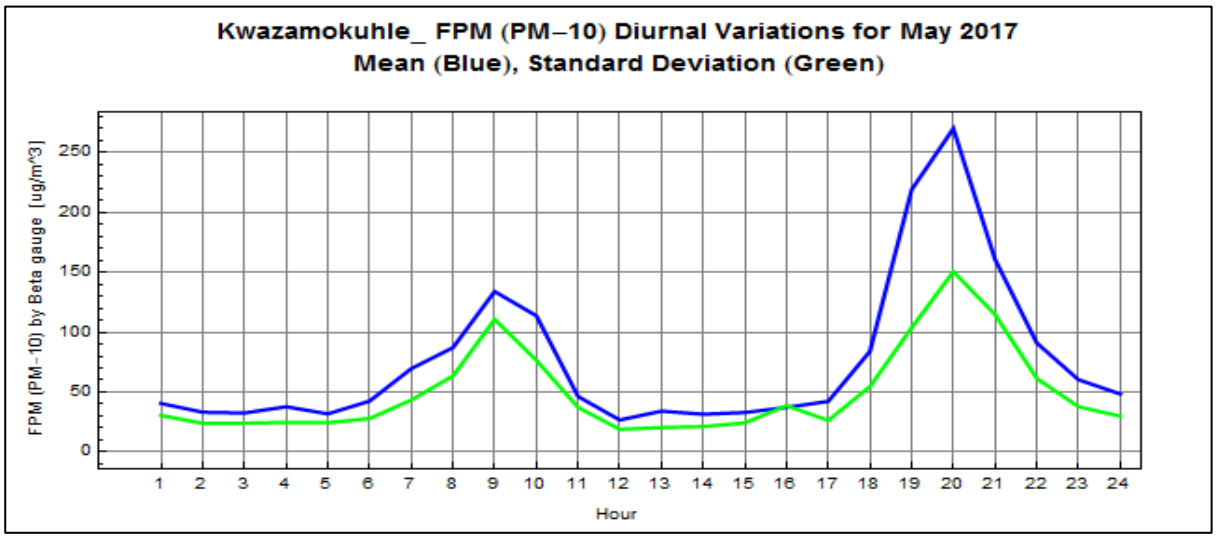


Figure 8: Diurnal variation of PM_{10} concentrations at KwaZamokuhle for May 2017

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 from 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 concentrations above 212.58µg/m^3 were recorded in the south-east, south-south-east, west-south-west and west sectors. The hourly mean sector concentrations above 282.72µg/m^3 during the night-time were recorded in north, south-south-east, south-west, west and west-north-west sectors.

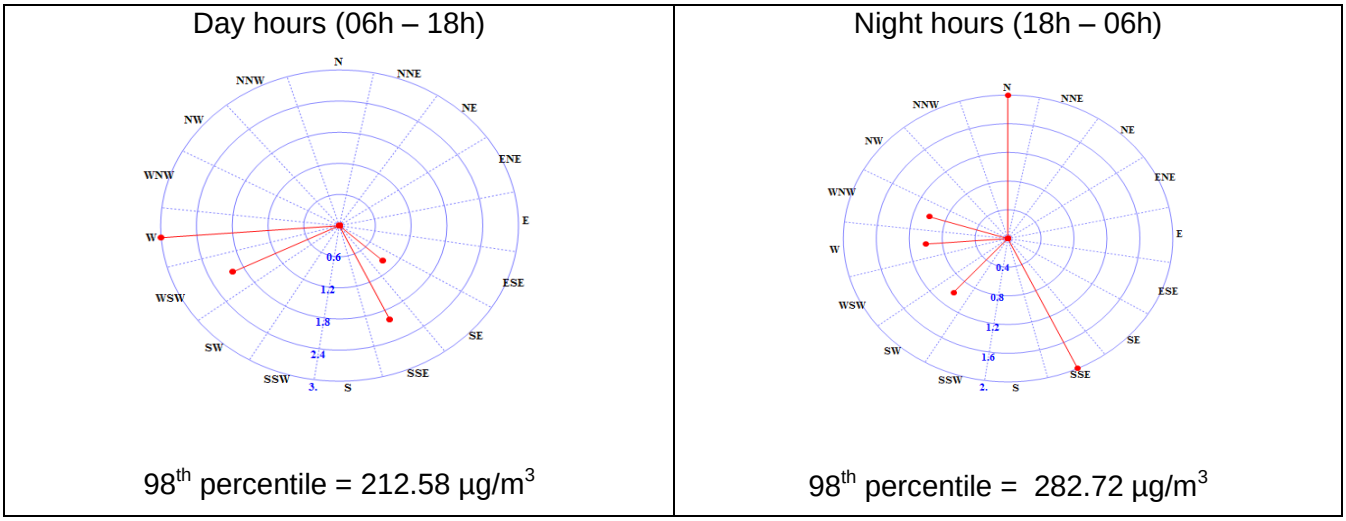


Figure 9: $PM_{2.5}$ hourly mean 98th percentile event roses during day and night times

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

Dir	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	0	0	0	0	0	1	2	0	0	01	2	3	0	0	0
%	0	0	0	0	0	0	12.5	25	0	0	0	25	37.5	0	0	0

Table 10: $PM_{2.5}$ 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	2	0	0	0	0	0	0	2	0	0	1	1	0	0	0	0
%	28.57	0	0	0	0	0	0	28.57	0	0	14.29	14.29	0	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 3335.42µg/m^3 were recorded in the north-north-east, north-east, south-south-east, west-south-west, and west and north-north-west sectors. During the night, the hourly mean concentrations above 413.63µg/m^3 were recorded in the north, south-south-east, south, south-south-west, south-west and west-north-west sectors. Domestic burning in KwaZamokuhle is probably the largest source of PM_{10}.

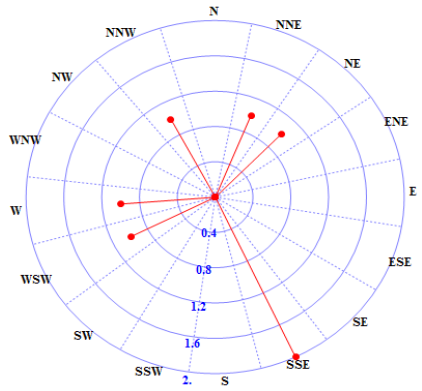
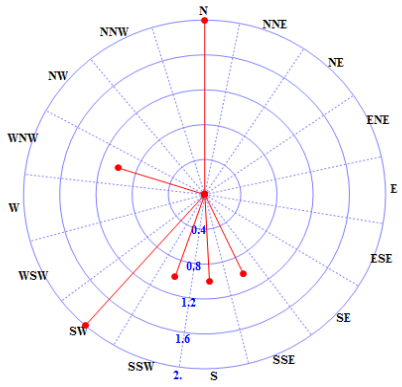
Day hours (06h – 18h)	Night hours (18h – 06h)
	
98th percentile = 335.42 µg/m3	98th percentile = 413.63 µg/m3

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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Eve	0	1	1	0	0	0	0	2	0	0	0	1	1	0	0	1
%	0	14.29	14.29	0	0	0	0	28.57	0	0	0	14.29	14.29	0	0	14.29

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	2	0	0	0	0	0	0	1	1	1	2	0	0	1	0	0
%	25	0	0	0	0	0	0	12.5	12.5	12.5	25	0	0	12.5	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 09:00 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 reaction, peaking at 15:00 before decaying rapidly due to the lack of sunlight during the night-time period shown in Figure 11. The ozone 8-hourly average limit was exceeded twenty eight times.

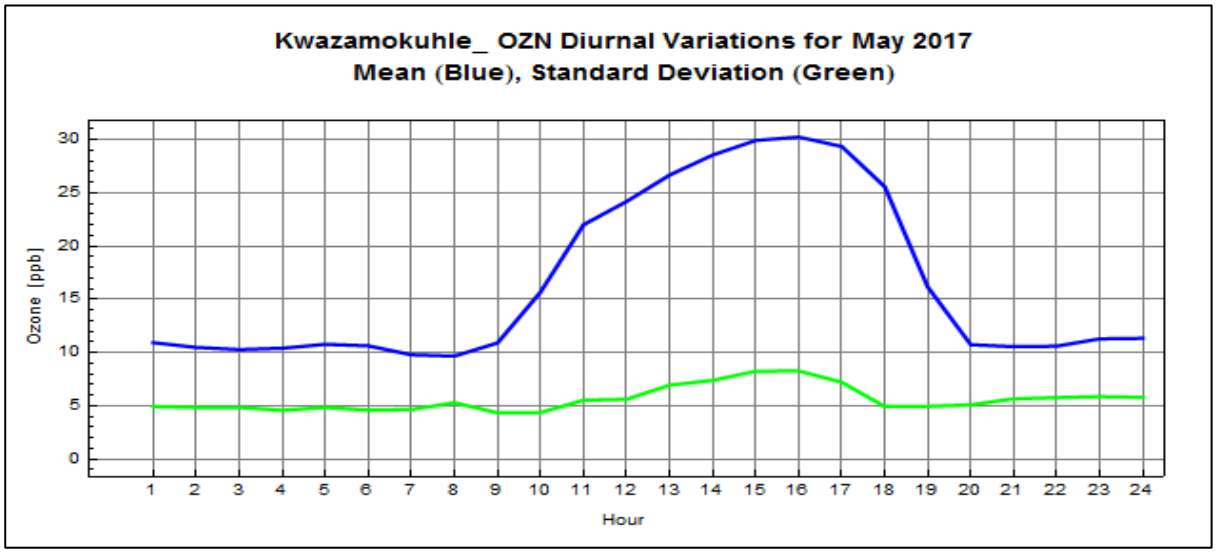


Figure 11: Diurnal variation of Ozone concentrations at KwaZamokuhle for May 2017

7. MONTHLY MEANS FOR THE CURRENT CALENDAR YEAR

7.1. TRENDS OVER THE REPORTING PERIOD

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 2016 (winter season) and low concentrations are also recorded from January 2016 – April 2016 and October 2016 - May 2017 (summer season) and concentrations are becoming high since winter season has approached for 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, tripping of circuit breakers and incoming power interruptions. There is no distinct trend observed on the O_3 8hourly moving average monthly concentrations during the 2016 monitoring period,however there has been an increase on the O_3 concentrations levels from July 2016 – January 2017, in February – May 2017 concentrations were low (Figure 17).

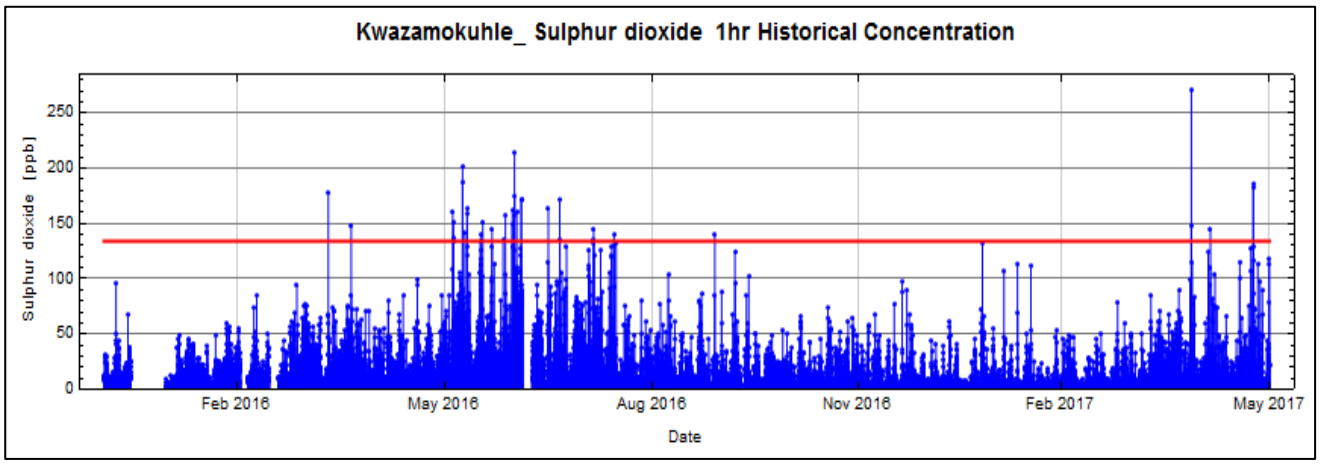


Figure 12: SO_2 1hr mean concentration

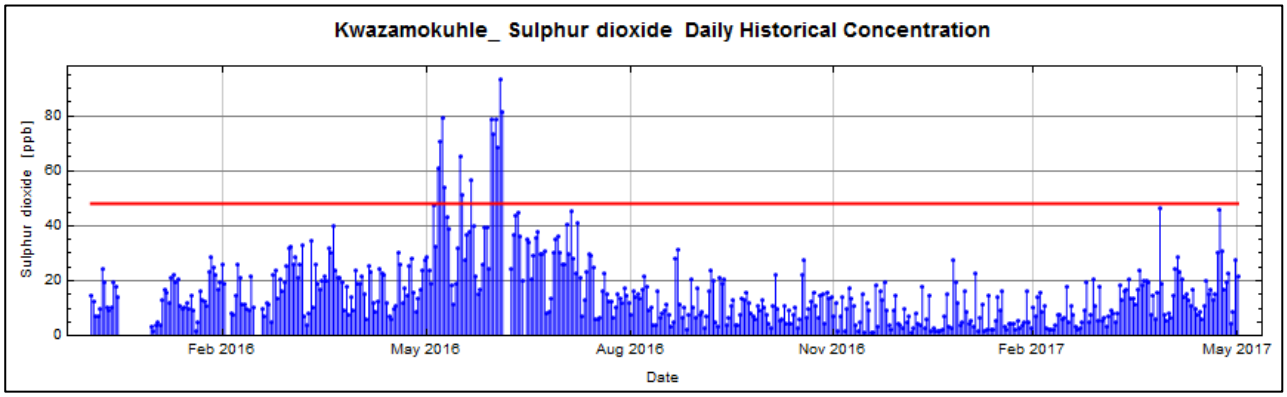


Figure 13: SO_2 daily monthly concentrations

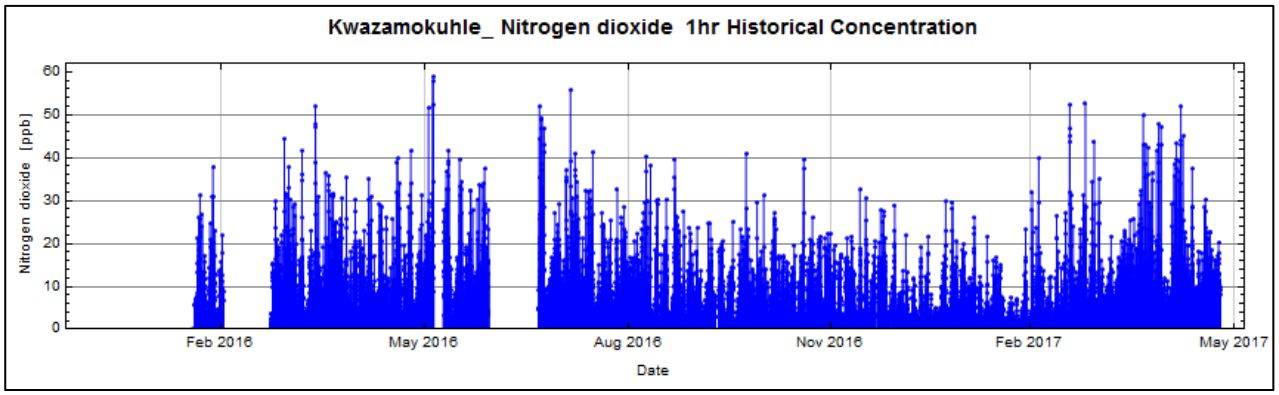


Figure 14: NO_2 1hr monthly concentration

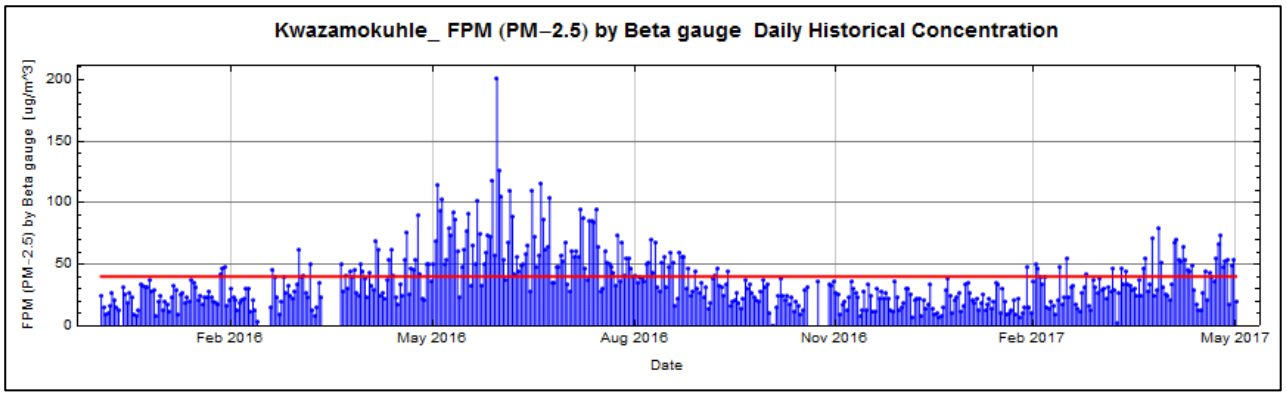


Figure 15: $PM_{2.5}$ daily monthly concentration

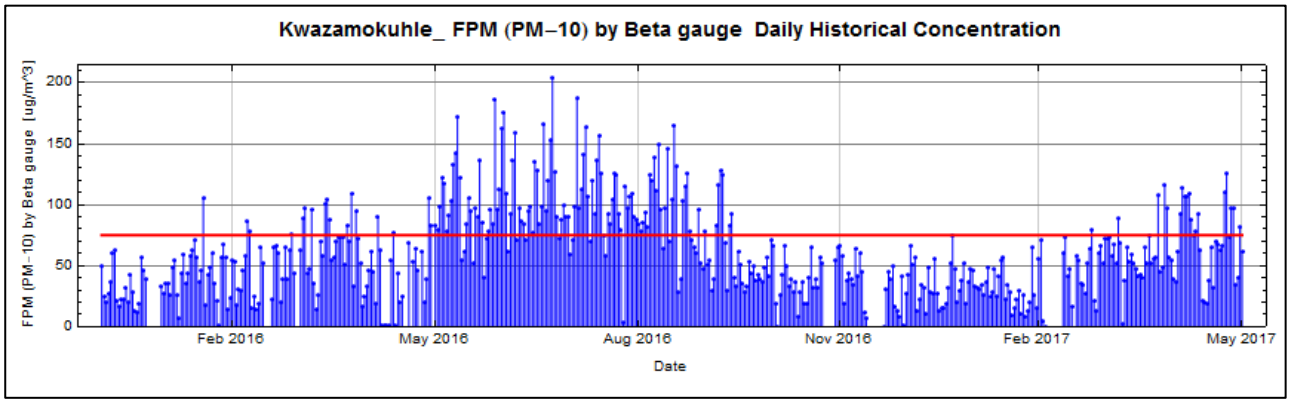


Figure 16: PM_{10} daily monthly concentrations

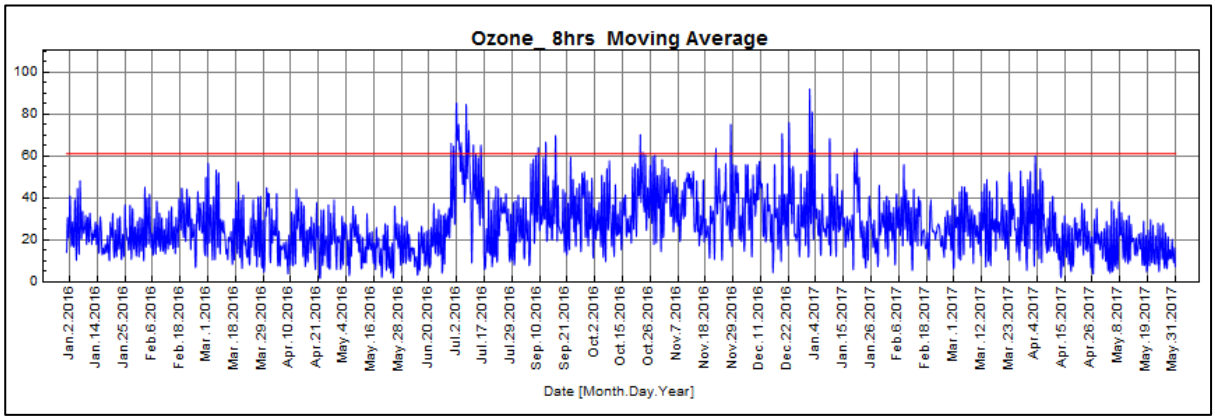


Figure 17: O_3 8hrs moving average

Table 13: Monthly means for the calendar year 2017

Parameter measured	**Jan**	**Feb**	**Mar**	**Apr**	**May**
$PM_{2.5}$ (µg/m³)	21	19.3	28.3	35.1	45.2
PM_{10} (µg/m³)	33	30.7	50	59.2	73.7
NO_2 (ppb)	5.3	3.9	7.9	9.4	10.9
O_3 (ppb)	22	25.8	27.1	22.4	16.4
SO_2 (ppb)	11	6.6	8.2	14.1	17.8

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

Period	SO_2 hourly	SO_2 10-nimutes	SO_2 daily	NO_2 hourly	PM_{10} daily	$PM_{2.5}$ daily	O_3 8-Hourly
Jan	0	0	0	0	0	0	28
Feb	0	1	0	0	0	1	0
Mar	0	0	0	0	1	6	0
Apr	2	7	0	0	4	8	0
May	3	9	0	0	15	20	0
Total	**5**	**17**	**0**	**0**	**20**	**35**	**28**
Allowed no of exceedances	88	526	4	88	4	4	11

There is non-compliance with the ambient O_3 8-hourly moving average standard. Exceedances of PM_{10} and $PM_{2.5}$ daily limits are already above their allowed number of exceedances per year, and all other monitored parameters are within their respective allowed number of exceedances per year at KwaZamokuhle**.**

8. CONCLUSION

There were fifteen (15) exceedances of the national ambient air quality for PM_{10} daily limit of 75µg/m³, twenty (20) exceedances of the national ambient air quality for $PM_{2.5}$ daily limit of 40µg/m³ and there were three (3) exceedances of the national ambient air quality limit for SO_2 hourly, nine (9) exceedances of the national ambient air quality limit for SO_2 10-minutes and there were no exceedances of the other national ambient air quality limits 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. Ambient fine particulate matter

concentrations indicate the influence of low-level source emissions at KwaZamokuhle, probably domestic burning.

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

The overall percentage data recovered from the monitoring site during the reporting period was 90.7% and station availability was 98.1%. NOx analyser and Radiation sensor did not meet SANAS requirement of 90% data recovery per parameter. The NOx analyser was affected by high temperature at site and the radiation sensor was faulty and replaced.

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9. DISTRIBUTION LIST

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10. 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-$_{10}$	Particulate matter < 10 microns in diameter
PM-$_{2.5}$	Particulate matter < 2.5 microns in diameter
ppb	Parts per billion
ppm	Parts per million
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