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BAQMAP Air Quality Monitoring and Surveillance Program for Botswana

Mission 2 Report
27 January - 18 February 1997

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Contents

Summary

Mission 2 was undertaken as part of the annual meeting between NORAD (Norwegian Agency for Development Co-operation) and Department of Mines (DoM) 4 February 1997.

Status meetings were held between Norwegian Institute for Air Research (NILU) and DoM. Status reports for:

- instrumentation (monitoring and calibration);
- data retrieval, processing and modelling;
- collection and processing of data from continuous gas analysers,

were submitted to NILU's project co-ordinator. The status reports are given in Appendix B – Appendix E.

Discussions and decision on the proposed new national air quality monitoring program was undertaken by the NILU representative and DoM representatives after the annual meeting. Also, site visits of the new site in Mosopa (background station for Gaborone) and the new residential site close to Broadhurst Mall (Gaborone) was undertaken.

Passive samplers were installed in Selebi-Phikwe (SO_2) and Francistown (NO_2) at respectively 20 and 6 locations. The passive samplers were installed to monitor the concentration distribution of air pollutants as a result of emissions from the BCL copper smelter in Selebi-Phikwe and the traffic in Francistown.

The passive samplers were exposed for a 2 week period before they were brought back to NILU for analysis. The analysis results showed that the SO_2 concentrations in the residential areas of Selebi-Phikwe ranged from 5.7 $\mu g/m^3$ to 18.7 $\mu g/m^3$ with an average value of 12.1 $\mu g/m^3$.

2 samplers were installed at the railway track and the railway station to measure the inflluence in the main wind direction from the 150 m BCL stack. The analysis result for these two stations show much higher concentrations than the passive sampling in the Selebi-Phikwe residential area, with two week average concentrations of 378.9 $\mu g/m^3$ and 91.3 $\mu g/m^3$, respectively. The one hour average concentration at the railway track could be in excess of 1000 $\mu g/m^3$, based on a two week average of 378.9 $\mu g/m^3$, assuming that the BCL stack is the main source of pollution. The maximum one hour SO_2 concentration is by WHO (World Health Organization) given as 350 $\mu g/m^3$.

The NO_2 concentrations in Francistown ranged from 3.6 $\mu g/m^3$ to 10.0 $\mu g/m^3$, with an average two week value of 41.2 $\mu g/m^3$.

BAQMAP Air Quality Monitoring and Surveillance Program for Botswana

Mission 2 Report

27 January - 18 February 1997

1. Introduction

Mission 2 was carried out as part of the annual meeting between NORAD (Norwegian Agency for Development Co-operation) and Department of Mines (DoM) 4 February 1997. Discussions and decision on the proposed new national air quality monitoring program was performed by the NILU representative and DoM representatives.

Screening study of SO_2 and NO_2

As part of the design of the new national air quality monitoring program for Botswana, a screening study of SO_2 and NO_2 concentrations in Selebi-Phikwe and Francistown was carried out using passive samplers. SO_2 and NO_2 samplers were installed in field to measure ground level concentrations as a result of emissions from the BCL smelter in Selebi-Phikwe (20 SO_2 samplers) and emission from traffic in Francistown (6 NO_2 samplers). The sampling period was from 30 January to 14 February 1997. The passive SO_2 and NO_2 samplers were brought to NILU for analysis. The results from the screening study is prestended in chapter 3.3.

New national air quality monitoring program for Botswana

The proposed new national air quality monitoring program was agreed upon with a few alterations. In Maun (background station), it was proposed to install continuous monitors for measurement of all components (SO_2, NO_2, O_3 and PM_{10}) since Maun is too far away from Gaborone and Selebi-Phikwe to have personnel go there once a week. Passive sampling will be performed to check the concentration levels of SO_2 and NO_2 compared with the detection limits of the sensors.

A possible site location for the background station in Maun was found close to the airport. DoM will proceed with the necessary preparations for installation of an air quality monitoring station on DCA properties. There are two other possible locations in the central Maun area, and still another location at the properties of Okavango Research Centre outside central Maun (with telephone-lines and power).

A background station for the Gaborone area was agreed upon after visiting different small villages 30-50 km from Gaborone. The Diratsame Community Junior Secondary School in the village of Mosopa, approximately 67 km WSW of Gaborone, was selected as the Gaborone background station. Parameters to be measured will be SO_2, NO_2, CO, O_3, PM_{10} and meteorology.

Meteorological tower

NILU has proposed to install a 36 m meteorological tower at DoM laboratory in Selebi-Phikwe. A 36 m meteorological tower will give DoM vertical profiles of wind, turbulence and temperature which are important inputs for modelling of transport and dilution of air pollution from tall stacks. A 36 m tower was not included in the original project proposal. Because of the expenses of a 36 m tower, the project cannot fund the purchasing of the tower and the necessary instruments. However, NILU will assist with necessary training in installation, QA/QC on site and at laboratory, and communication devices. This part of the project (estimated to first quarter of 1998), will only be realized if DoM finance the purchase of the meteorological tower and necessary equipment.

AirQUIS software (Air Quality Information System)

AirQUIS (Air Quality Information System) is part of the ENSIS system (Environmental Surveillance and Information System) specifically constructed for air quality surveillance and planning. The AirQUIS system is a flexible surveillance and planning tool, composed of separate modules, which can easily be customized to meet any special requirements specified for the installation site.

During the one week visit at NILU in September 1996, the first version of the AirQUIS system developed at NILU was presented to Choma J. Matale (DoM).

NILU is at present developing the next version of AirQUIS. The construction and database structure of the new version is fundamentally improved compared to the first version. The user interface is also radically changed, with a more user-friendly functionality. The new interface has the GIS functionality as a closely integrated component, giving it immediate access to the underlying data directly from the map.

The new version of AirQUIS will be available in English during autumn 1997.

The implementation of AirQUIS as a national system or at selected sites in Botswana is not included in this NORAD project.

For more information on the technical specifications of the AirQUIS system, please read Appendix F.

2. New national monitoring program for Botswana

This chapter presents the new national air quality (AQ) monitoring program for Botswana. The monitoring program was presented by NILU to DoM in January 1997, and was with minor changes accepted by DoM in February 1997.

The first part of the chapter is a detailed description for each monitoring area (Gaborone, Selebi-Phikwe, etc.), followed by a summary of the total national AQ monitoring program.

Chapter 3 gives a brief presentation on how to perform passive sampling of SO_2 and NO_2, followed by a short summary of the passive sampling performed in Selebi-Phikwe (SO_2 – residential area) and Francistown (NO_2 – main street) during week 5 and 6 February 1997. Chapter 3 also presents the sampling results.

2.1 The new national AQ monitoring program for each monitoring area

Gaborone

It has been suggested by NILU that the measuring program for Gaborone consists of a total of 5 monitoring stations. Of these, a minimum of 4 should have continuously monitoring equipment.

In addition to the existing kerb-side station at Civic Centre, and the urban area (public transport) station at Gaborone Fire Brigade, the monitoring program should consist of one urban, one residential and one background station for the Gaborone area. The urban station could be located at the new DoM offices. The air intake should be approximately 3 m above ground, and the monitors inside the office building. The station should monitor SO_2, NO_x and PM_{10}. At the residential station 24 h average SO_2 and NO_2 samplers could be used instead of continuous monitors. Gaborone Secondary School, close to Broadhurst Mall, was suggested for the residential station (high density area). The background station for Gaborone should be located away from local sources approximately 30-40 km from Gaborone. The station should not be influenced by traffic or surrounding vegetation. The Diratsame Community Junior Secondary School in the small village of Mosopa could be suitable as a background station. The background station should monitor SO_2, NO_x, PM_{10} and O_3.

Table 1 presents a summary of the total monitoring program for Gaborone.

Table 1: New monitoring program for Gaborone as part of the new national air quality (AQ) monitoring program for Botswana.

Gaborone		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.
Kerb-side	Civic Centre	0	0	x	x		0	0	x		
Urban	DoM	x	x		x				x		
Residential	Broadhurst	x*	x*		x*				x		
Urban area	Fire Brigade	x	0	0	x			0			x
Background	Mosopa	x	x		x		x				x

0 = Already existing equiment – Continuous monitors
x = Additional equipment to be procured – Continuous monitors
x* = 24 h average samplers

Selebi-Phikwe

At present there is no continuous monitoring of air pollutants in the Selebi-Phikwe area. There are some sites measuring 24 h average SO_2 concentrations with bubblers and a few sites with additional PM_{10} measurements.

4 automatic monitoring stations should be installed in the Selebi-Phikwe area, in addition to one residential site WSW of the smelter measuring 24 h average SO_2

concentrations using impregnated filters. Continuous monitors measuring SO_2, NO_x, CO and PM_{10} should be installed at the DoM laboratory (residential area). In addition, a 36 m meteorological tower measuring wind speed (2 levels), wind direction (2 levels), temperature (2 to 3 levels), relative humidity, radiation, and turbulence (σ_v and σ_w) should be installed at the laboratory. Diffuse emissions from the lower BCL stack should be registered using a continuous monitoring station at the Water Utilities.

One of the continuous monitoring stations should be a background station. The site, preferably upwind of the BCL stack, is by DoM suggested in the small village of Tobane to the east of the BCL smelter. In addition, Mmadinare will be a background station when the wind is from NE, and hence, will produce additional information to the data from Tobane.

The detailed monitoring program for Selebi-Phikwe is given in Table 2.

Table 2: New monitoring program for Selebi-Phikwe as part of the new national AQ monitoring program for Botswana.

Selebi-Phikwe		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.	Precip.
Max. stack	Railway track	x			x				x	(x)$^{(2)}$		x
Diffuse	Water Utilities	x			x							
Residential	DoM	x	x	(x)	x				x	(x)$^{(2)}$	x	
Residential		x*	x*		x*							
Background	Tobane	x*	x*		x*							(x)

0 = Already existing equiment – Continuous monitors
x = Additional equipment to be procured – Continuous monitors
x* = 24 h average samplers
(x)$^{(2)}$ = No monitoring. Special analysis of biota and/or meat.

Mmadinare

DoM already has continuous monitors up and running at Makobe Hill Junior Secondary School in Mmadinare. The station is located to continuously monitor the longer range pollution from the tall BCL stack in Selebi-Phikwe.

The station will, in the new monitoring program, still be located at Makobe Hill Junior Secondary School, and will include an ozone monitor. The carbon monoxide monitor should, however, be moved to DoM Laboratory in Selebi-Phikwe. Also, the 24 h average PM_{10} sampler should be replaced with a continuous monitor for PM_{10}. See Table 3 for summary.

Table 3: New monitoring program for Mmadinare as part of the new national AQ monitoring program for Botswana.

Mmadinare		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.	Precip.
Max. stack	Sec. School	0	0	0**	0*		x				0	(x)

0 = Already existing equiment – Continuous monitors
x = Additional equipment to be procured – Continuous monitors
0* = 24 h average samplers
0** = Should be moved to DoM laboratory in Selebi-Phikwe.

Palapye

The PM_{10} sampler at Palapye Primary Hospital has been installed to register the concentrations of particles from the Botswana Corporation Power Plant near Morupule. The station should also be equipped with 24 h average SO_2 impregnated filters.

Table 4: New monitoring program for Palapye as part of the new national AQ monitoring program for Botswana.

Palapye		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.
Max. stack	Primary Hospital	x			0						

0 = Already existing equiment – Continuous monitors
x = Additional equipment to be procured – Continuous monitors

Tonota

The station at Tonota is installed to monitor long range transport of pollutants from the BCL smelter. It contains one SO_2 monitor in addition to meteorological recordings. The station has only been in operation since 1995.

This station should also be equipped with a PM_{10} monitor. The measured SO_2 concentrations should be combined with meteorological data to identify the source for the air pollutants measured at the Tonota monitoring station. If the recordings are well below the air quality guidelines, the monitoring station may be relocated.

Table 5: New monitoring program for Tonota as part of the new national AQ monitoring program for Botswana.

Tonota		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.
Max. stack	T. Coll. of Educ.	0			x						0

0 = Already existing equiment – Continuous monitors
x = Additional equipment to be procured – Continuous monitors

Serowe

The existing monitoring station in Serowe has already continuous monitors for SO_2, NO_x and CO, in addition to meteorological recordings (wind speed, wind direction, temperature and humidity).

The station has been installed to monitor SO_2 concentrations from the Botswana Corporation Power Plant in Morupule.

The ground level concentrations from the Power Plant should be calculated and combined with meteorological data to decide whether to relocate the station.

Table 6: New monitoring program for Serowe as part of the new national AQ monitoring program for Botswana.

Serowe		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.
Industrial	T.Tr.College	0	0	0**			x		x	(x)[(2)]	0

0 = Already existing equiment – Continuous monitors
0** = Should be moved to Civic Centre in Gaborone
x = Additional equipment to be procured – Continuous monitors
(x)(2) = No monitoring. Special analysis of biota and/or meat.

Moropule/Power Plant

The major source of air pollution in the Moropule/Palapye area is the Botswana Power Corporation power plant. Annual average SO_2 concentrations of 20 µg/m^3 have been recorded at Palapye government hospital for 1995. This was well within the government guidelines of 80 µg/m^3.

However, dispersion model estimates of hourly average ground level concentrations gave SO_2 concentrations of approximately 620 µg/m^3 8 to 10 km from the power plant during light stable atmospheric conditions and low wind speeds. This is well above the Air Quality Guideline for SO_2 given by WHO (350 µg/m^3 as an 1 h average). During unstable and neutral conditions the calculated 1 hour concentrations are approximately 450–650 µg/m^3 1–3 km from the Power Plant.

A screening study will be performed based on the critical distances from the stack (given by the calculations) and prevailing wind directions (meteorology). This will be performed by DoM during February 1997.

Table 7: New monitoring program for Morupule/Power Plant as part of the new national AQ monitoring program for Botswana.

Power Plant		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.
Industrial	Screening	(x)	(x)		(x)						

(x) = Instruments to be procured if screening indicates high SO_2 and/or NO_2 values.

Francistown

The main industrial sources in Francistown are the Sorghum Beer Brewery (Botswana Breweries) and the Botswana Meat Commission. In addition, traffic along the main street (Blue Jacket Street) in Francistown is believed to give high NO_2 concentrations during rush hours, especially the evening rush hour when the atmosphere stabilizes.

Screening of NO_2 concentrations along Blue Jacket Street was performed during the first two weeks of February 1997. If the NO_2 concentrations from the screening are close to or in excess of the WHO (World Health Organization) air quality guidelines, a kerb-side station will be installed along the Blue Jacket street to continuously monitor the concentrations along the street.

The monthly and annual average SO_2 concentrations in Francistown are found to be well within the government guidelines for 1995, according to DoM annual report for 1995.

Measurements of 24 h average SO_2 concentrations in the residential areas of Francistown could be performed with impregnated filters put up in the main wind direction from any of the polluting sources. If, after a period of recordings the measured concentrations are well below the air quality guidelines, the station could/should be relocated.

HC could be measured with steel bottles and analyzed in the laboratory with Gas Chromatograph (GC).

Table 8 shows selected parameters/components to be measured at the kerb-side and the residential site in Francistown.

Table 8: New monitoring program for Francistown as part of the new national AQ monitoring program for Botswana.

Francistown		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.
Kerb-side	Screening	(x)	(x)		(x)			(x)(1)			
Industrial	Screening	(x)			0*						

0* = already existing euipment 24 h average sampler
(x) = Instruments to be procured if screening indicates high SO_2 and/or NO_2 values
(x)(1) = HC measurements with steel bottle. GC analysis.

Sua Pan

The major source of air pollution in the Sua Pan region is the Soda Ash plant. The main air contaminants are sulphur dioxide, hydrogen sulphide and dust. According to DoM Air Pollution Control Division's Annual Report for 1995, the average SO_2 concentrations were within the government objectives in 1995.

However, based on emission data and stack dimensions for the Soda Ash plant, preliminary calculations show that maximum one hour averaged ground level SO_2 concentrations of approximately 800 $\mu g/m^3$ may occur 5 to 6 km from the Soda Ash plant during light stable atmospheric conditions and low wind speeds (typical night time conditions). During unstable or neutral atmospheric conditions the maximum ground level concentrations may be up to 650 $\mu g/m^3$ at a distance of 1-2 km.

The estimated concentrations are above the Air Quality Guidelines given by WHO (World Health Organization) by a factor 2.3. Hence, a screening study of SO_2 concentrations in the area around the Soda Ash plant by using passive samplers will be performed by DoM within February 1997, and analyzed at the NILU laboratory.

Table 9: New monitoring program for Sua Pan as part of the new national AQ monitoring program for Botswana.

Sua Pan		SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.
Industrial	Screening	(x)	(x)			(x)					

(x) = Instruments to be procured if screening indicates high SO_2 and/or NO_2 values.

Lobatse

At present, instruments measuring 24 hour average sampling of SO_2 (bubblers) and TSP (HiVol) are performed close to the bus terminal in Lobatse. These recordings show, according to the Annual Report from DoM Air Pollution Control Division (1995), that both monthly and annual average SO_2 concentrations were well within the government guidelines for 1995. The governmental guidelines for SO_2 are respectively 160 µg/m³ and 80 µg/m³ for monthly and annual average concentrations.

The main sources of industrial pollution in Lobatse are Botswana Meat Commission's coal fired boilers and standby diesel generators, the Lobatse Clay Works and the Lobatse Tannery.

Based on the reported concentrations, installation of 24 hour average samplers for SO_2, NO_2 and PM_{10} is suggested in one of the industrial areas of Lobatse. The samplers should be installed down-wind of the main sources. HC could be measured with steel bottles and analyzed in the laboratory with Gas Chromatograph (GC). Table 10 gives a summary.

Table 10: New monitoring program for Lobatse as part of the new national AQ monitoring program for Botswana.

Lobatse	SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Met.
Residential	x*	x*		x*	0*		$(x)^{(1)}$			

x* = Additional equipment to be procured – 24 h average samplers
$(x)^{(1)}$ = HC measurements with steel bottle. GC analysis
0* = Existing equipment – 24 h average samplers.

Maun

There has so far not been any monitoring/measurements of air pollutants in the Maun region. The reason for this is no large local industrial sources in Maun.

However, Maun is suggested for monitoring background concentrations of the main air components in addition to precipitation.

24 h average sampling (or 2+2+3 days average sampling) of SO_2, NO_x and an O_3 monitor is recommended for the Maun background station. The recordings from the Maun background station will give an overall picture of the longer range transport of air pollution on a regional scale.

In addition, measurements of precipitation for analysis on heavy metals; Ca, K, Mg, Cl, sum ammonia (NH_3+NH_4^+), sum nitrate (HNO_3+NO_3^-), pH, cations/ anions and conductivity should be performed at the background station. The elements to analyze for should be compared with the South Africa/SACD Acid Rain Program.

The station should be located away from local ammonia sources and preferably on a grass lawn to avoid dust whirling into the rainfall collector.

Table 11: New monitoring program for Maun as part of the new national AQ monitoring program for Botswana.

Maun	SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	Precip
Background	x	x		x		x	(x)(1)			x

x = Additional equipment to be procured – continuous monitors
(x)(1) = HC measurements with steel bottle. GC analysis.

2.2 Total air quality monitoring program for Botswana

Table 12 presents the total national AQ monitoring program for Botswana. The program has been discussed by DoM and NILU. The most important air pollution sources are located in Selebi-Phikwe and Gaborone. It is of most importance that these complete monitoring stations be up and running within the next year (for training purposes). Training in QA/QC both at the monitoring sites and at the laboratory will be performed when the instruments are procured and installed in field. The training will be performed by NILU experts.

The necessary monitoring equipment presented in Table 12 will be purchased by DoM. Training in QA/QC at the site and at the laboratory will enable DoM personnel to be sustainable to perform the needed QA/QC of future stations.

Table 12: New national air quality monitoring program for Botswana.

			SO_2	NO_x	CO	PM_{10}	TSP	O_3	HC	PAH	Dioxins	(Spec. meas.) Met.	Precip.
Gaborone	Kerb-side	Civic Centre	0	0	x	x		0	0	x			
	Urban	DoM	x	x		x				x			
	Residential	Broadhurst	x	x		x				x			
	Urban	Fire Brigade	x	0	0	x			0			x	
	Background	Mosopa	x	x		x		x				x	
Selebi-Phikwe	Max. stack	Railway track	x			x				x	$(x)^{(2)}$		x
	Diffuse	Water Utility	x			x							
	Residential	DoM	x	x	(x)	x				x	$(x)^{(2)}$	x	
	Residential		x*	x*		x*							
	Background	Tobane	x*	x*		x*							(x)
Mmadinare	Industrial	Makobe Hill Sch.	0	0	0**	0*		x				0	(x)
Palapye	Industrial	Primary hospital	x			0							
Tonota	Industrial	T. Coll. of Educ.	0			x						0	
Serowe	Industrial	Teach. Train Coll.	0	0	0**			x		x	$(x)^{(2)}$	0	
Power Plant	Industrial	Screening											
Francistown	Kerb-side	Screening	(x)	(x)		(x)			$(x)^{(1)}$				
	Industrial	Screening	(x)			0*							
Sua Pan	Industrial	Screening	(x)	(x)		(x)							
Lobatse	Residential		x	x		x	0*		$(x)^{(1)}$				
Maun	Background		x	x				x	$(x)^{(1)}$				x

0 = Existing equipment – Continuous monitors
0* = Existing equipment – 24 h average samplers
0** = Existing equipment – Should be moved to DoM laboratory in S-P
x = Additional equipment to be procured – Continuous monitors
x* = Additional equipment to be procured – 24 h average samplers
$(x)^{(1)}$ = HC measurements with steel bottle. GC analysis.
$(x)^{(2)}$ = No monitoring. Special analysis of biota and/or meat.

3. Passive sampling

3.1 Passive samplers for SO_2 and NO_2

A sensitive diffusion sampler for sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) in ambient air has been used in several investigations to undertake a screening of the spatial concentrations distribution of the parameters.

The sampler was developed by the Swedish Environmental Research Institute (IVL) and has been used in several studies by NILU. The sampler includes an impregnated filter inside a small plastic tube. To avoid turbulent diffusion inside the sampler, the inlet is covered by a thin porous membrane filter. Gases are transported and collected by molecular diffusion. The uptake rate is dependent upon the diffusion rate of the gas.

After exposure the samplers are returned to NILU where concentrations of SO_2 are determined as sulphate by ion chromatography. NO_2 and NH_3 is determined by spectrophotometry. For more information on the passive samplers, read "Information. No. 2, 1995" (NILU, 1995).

3.2 Passive sampling performed at selected sites in Selebi-Phikwe and Francistown, February 1997

Passive sampling was performed at selected sites in Selebi-Phikwe and Francistown during the period 30 January–14 February 1997. Approximately 20 SO_2 passive samplers were installed in Selebi-Phikwe 30 January, and 6 NO_2 passive samplers were installed in Francistown 31 January. The passive samplers installed in Francistown, were installed along the Blue Jacket Street, which is the most busy street in Francistown.

Selebi-Phikwe

The passive sampling in Selebi-Phikwe was performed to get a better picture of the spatial differences of ground level air pollution concentrations (mainly SO_2) as a result of emissions from the BCL smelter. The samplers were positioned at equal distance from the smelter, forming an arch. The samplers were located under the softening of residential buildings facing the BCL smelter. In addition, two samplers were located at the railway station and the railway track, respectively. The SO_2 samplers were exposed from 30 January to 13 February 1997.

All the passive samplers, except for three, were retrieved after the 2 week sampling period. We presume that curiosity is the reason for the loss of the three samplers in Selebi-Phikwe.

Francistown

In Francistown, passive sampling was carried out to get an indication of the level of traffic pollution along the most busy street of Francistown. According to DoM this is the Blue Jacket Street. The Blue Jacket Street experience high density of vehicles during the three rush hour periods of a daily cycle (morning, lunch and evening). Six buildings were identified for location of the NO_2 passive samplers along Blue Jacket Street. Permission was asked for from the manager of each building before positioning the passive samplers on the building facade. The NO_2 samplers were exposed from 31 January to 14 February 1997. All the NO_2 samplers were recovered.

All the samplers (SO_2 and NO_2) were brought back to NILU for analysis, after the sampling period. The results of the analysis are given in the next chapter.

3.3 Analysis results from the passive sampling of SO_2 and NO_2 performed at selected sites in Selebi-Phikwe and Francistown, February 1997

The analysis results from the passive sampling performed in Selebi-Phikwe (SO_2) and Francistown (NO_2) during the 2 week period of February 1997 is presented in Appendix H.

The results are given in two Tables; one for the measurements performed in Selebi-Phikwe, and one for the measurements in Francistown. The Table presents sampler identification, the sampling period (date and number of days) and the concentrations of SO_4-S (µg/ml), SO_4-S (µg/m^3) and SO_2 (µg/m^3). The Table only presents the samplers that were recovered after the sampling period.

The air quality guidelines for SO_2 and NO_2 from the Norwegian Pollution Control Authority (SFT, 1992) and World Health Organization (WHO) are given below:

		24 hour average	
Component	Effect	SFT	WHO
SO_2	Health Vegetation	90 µg/m^3 50 "	125 µg/m^3
NO_2	Health	75 "	150 "

Selebi-Phikwe

The results from the sampling in Selebi-Phikwe show that the SO_2 concentrations decrease with distance from the stack, as expected. Also, the concentrations decrease following the arch from north-west to south-east (Figure 1, Appendix H). This is in accordance with the wind roses presented by the Meteorological Office and the wind observations from the BCL Smelter. The main wind direction in the Selebi-Phikwe area is from the east and south-east, and hence, the south-eastern part of the arch should have the lowest average concentrations. Most of the samplers in the arch were installed in the major residential area of Selebi-Phikwe, two samplers were installed at the railway track, and one at the railway station.

The analysis results showed that the SO_2 concentrations in the residential area of Selebi-Phikwe ranged from 5.7 µg/m^3 to 18.7 µg/m^3 with an average value of 12.1 µg/m^3. 2 samplers were installed at the railway track and the railway station to measure the inflluence in the main wind direction from the tall BCL stack.

The analysis result for these two stations show much higher concentrations than the passive sampling in the Selebi-Phikwe residential area, with two week average concentrations of 378.9 µg/m^3 and 91.3 µg/m^3, respectively.

The one hour average concentration at the railway track could be in excess of 1000 µg/m³, based on a two week average of 378.9 µg/m³, assuming that the BCL stack is the main source of pollution.

Francistown

The analysis results in Appendix H for Francistown show that the measured concentrations for the Blue jacket Street in Francistown is low compared to the guideline values. The NO_2 concentration ranged from 3.6 µg/m³ to 10.0 µg/m³, with an average two week value of 7.0 µg/m³. Compared to the air quality guidelines given by SFT, these values are well below the guidelines. Hence, although the traffic during rush hour in the main street of Francistown (Blue Jacket Street) is assumed to be very high, the measured concentrations are much lower than the air quality guidelines, and hence, no continuous measurements of air pollution from traffic along this street seem to be necessary.

4. Minutes to discuss the technical assistance by NORAD (NORAD, DoM and NILU) 4 February 1997

– Minutes written by DoM –

Present were R.C. Gabonowe – DoM (Chairman), C.J. Matale – DoM, L.N. Cephas – MFDP, J. Thema – MRWA, O. Oskarson – NORAD, S. Haukland – NORAD, T. Bekkestad – NILU, B. Kjølaas – NORAD, K. Lenyatso – DoM, T. Tshukudu – DoM.

The chairman opened the meeting by saying that according to the Agreement between the two parties (the Government of the Republic of Botswana and the Government of the Kingdom of Norway), there should be a consultative meeting only if certain documents were present. He indicated that he was not sure what kind of documents were required, but requested the NORAD representative if they would explain to the meeting what kind of documents were required.

The Ambassador of Norway to Botswana replied by first introducing his colleagues. He then tanked the chairman to have invited them to the meeting. He then explained that for a consultative meeting to suffice certain documents were to be put forward as per the Agreement between the Norwegian and Botswana Government of 23rd July 1996, and the Agreement specifies the form of documents to be prepared.

1. The consultative meeting should discuss what is planned for the next year. The ambassador emphasised the point that the meeting should be more of a legal meeting where a draft of the minutes is to be produced. He said that there were some documents missing from the papers that were presented to them, but needed to be discussed in the meeting. It was made clear that it was very important to comply with the requirements of the Agreement. Therefore, the meeting can be a consultative meeting only if the requirements of such a meeting are adhered to.

The Chairman asked Mr. Matale to comment on the documentation. In his comment Mr. Matale said that it was their first experience to be involved in a project of this nature and they were not able to meet the requirements of the Agreement. They could not submit the report because of the time constraints but the document will, however, be prepared as required by the Agreement.

It was then concluded that the two parties were not ready for a consultative meeting. This meeting was then considered as a preparatory meeting for the consultative meeting. The meeting then proceeded with the agenda for the preparatory meeting and Mr. Matale was asked to report on the progress of the project to-date.

1. Mr. Matale started by mentioning the visit to NILU by the project co-ordinator, and that there is a report that gives a brief summary of the visit. This visit was intended for the project co-ordinator to see what was available at NILU and prepare for the kick-off seminar.

2. There was a seminar held in Gaborone on 4–8 November 1996 to introduce the Department of Mines staff to modern air pollution surveillance methods. Various aspects in chemical analysis, modelling and instrumentation were covered during the seminar and were further discussed in workshops. The seminar and workshops gave the NILU experts an idea of what sort of structure the Department of Mines Air Pollution Control Division would require to meet international standards.

3. It was found that among other things there is need to build a national environmental laboratory. However, Department of Mines is awaiting the beginning of the financial year and also the NDP8, hence implementation of the laboratory project is expected to start in June, 1997. NILU has identified equipment needs both for the new laboratory and the field stations. However, the Department of Mines has started purchasing some equipment for the project with the help of NILU experts.

Ms. Bekkestad reported on the seminar and the workshops and informed the meeting that laboratory and modelling workshops had been successfully concluded. She indicated that there was not enough time to prepare the project in accordance with the Agreement. However, the NILU representatives promised that they will fulfil the requirements of the Agreement in their next reports.

1. There were some corrections made on the draft work-plan that was submitted by NILU. It was indicated that item 17 of the draft work-plan does not need to involve NILU, i.e. the suppliers of the equipment will have to take the responsibility of supplying, installing, and commissioning of the equipment. This was to make sure that the equipment is supplied in good working condition. It was suggested that some items be condensed in order to reduce the time required for the project. Items D1–D3 can be combined with E1 to form one component and be reduced to an intensive training program.

2. NORAD representatives commented that a work-plan should include the time when each component of the project will be done. A draft plan that included all the activities and their time schedule was produced by NILU. The plan indicated all the work that will be done from now to 1998 and when the Agreement will terminate. Both NILU and Department of Mines were requested to jointly prepare a report in the required format for consideration by the consultative meetings.

3. A NORAD representative (Semund Haukland) asked if condensing the items in the work-plan was a compromise for the time spent for the educational training part in Norway, or was it to reduce the financial pressure on the Botswana Government. In reply the Department of Mines representative said that it was very important for the Botswana Counterparts to visit NILU and familiarise themselves with the modern air quality monitoring programme through attachments, and this can be achieved only if they condense the training by NILU experts in Botswana because a lot of work has already been done by Department of Mines after the seminar and workshops.

4. The budget was based on the draft work-plan. It showed only the budget to the NILU consultations and did not show the expenses of their Botswana counterparts. It was then suggested that the Botswana Government budget and the NILU budget have to be merged to give the whole picture. Both Department of Mines and NILU were reminded that it was very important for them to give the whole estimated budget for 1997 and estimates for the remaining years of the agreement so as not to exceed the agreed total amount for the project.

5. It was suggested that the budget should show DoM personnel selected to undergo training, staff should be allocated to the training. Department of Mines responded by saying that people have been identified for training and NILU has considered seeking extra funding from outside the project fund to enhance training. NORAD representatives emphasised that training was the most important factor in making the project sustainable and that they were concerned that if training is not included in the budget there might be a problem in making the project sustainable. It was emphasised that any additional activities should not affect the terms of the Agreement.

6. NILU indicated that the project cannot afford training enough people. According to the draft plan they had prepared, the training budget was not enough to meet the expense of two people in one year, therefore other financial sources need to be considered if more people are to be trained. The Department of Mines indicated that the draft plan did not adequately address all the training requirements. The period that has been stipulated in the proposal is in terms of weeks, but the interaction between NILU has shown that more time for training was necessary.

7. NORAD commented that other activities can be scaled down in order to fit more training. Department of Mines and NILU were advised that in whatever

they do, they should reflect the overall goal of the project. All their decisions should be based on sustaining the project beyond the expiry of the Agreement.

8. NILU asked if there was a possibility of an E-Mail connection in the Department of Mines, because fax and telephone are more expensive. In response it was indicated that E-Mail will be considered in due course but Department of Mines is not sure when it will be connected.

Finally NILU and Department of Mines were asked to prepare the document that is required in terms of the agreement to have a consultative meeting and submit it to both parties on or before the 27 February 1997.

Date of next meeting: 13 March 1997.
Time: 9:00
Venue: Department of Mines, Director's office.

Appendix A

Note from NILU to DoM:
36 meter meteorological tower in Selebi-Phikwe

Norsk institutt for luftforskning
Norwegian Institute for Air Research

NOTE

To : Department of Mines - Air Pollution Control Division /Choma J. Matale
Copy :
From : NILU /Tone Bekkestad
Date : Gaborone, 13 March 1997
Ref. : TOB/O-96082/metmast

SUBJECT: 36 meter meteorological tower in Selebi-Phikwe

Based on previous discussion between NILU and Department of Mines (DoM) of the contents of the new national air quality monitoring program for Botswana, NILU hereby recommend in written, that a 36 meter meteorological tower be installed at Department of Mines' laboratory in Selebi-Phikwe.

A 36 meter meteorological mast produces more information on the meteorological conditions of the lower atmospheric layer. In a 36 meter tower the following components should be measured:
- wind speed at two levels
- wind direction at two levels
- temperature at two levels
- relative humidity
- radiation
- turbulence

Two different meteorological towers are available:
- Fixed 36 meter tower. A company has to be hired both for installation and maintenance of the instruments. Maintenance is performed at 36 m above the ground.
- Telescopic 36 meter mast. DoM procure the instruments and the telescopic mast, and NILU installs and performs QA/QC of the instruments together with DoM personnel. The telescopic mast is easier to handle because maintenance of the instruments is performed at 10 m above the ground.

NILU will highly recommend that a 36 meter telescopic mast be installed at DoM laboratory in Selebi-Phikwe. NILU will do the installation of the instruments and QA/QC of the instruments together with DoM personnel. DoM personnel will thereafter be able to performed necessary maintenance themselves (which is cost and time effective).

Vennligst adresser post til NILU, ikke til enkeltpersoner/Please reply to the institute.

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Foretaksnr./Enterprise No. 941705561

NILU OR 13/97

A 36 meter meteorological tower is more expensive that a 10 meter mast. This expense has not been included in the project proposal, and the 36 m mast should therefore be procured by DoM. NILU will perform necessary training of DoM personnel.

The estimated work for installation of a 36 meter meteorological tower and meteorological equipment, QA/QC of instruments in field and at the laboratory, installation of communications devices, and performance and training in sensor maintenance, amounts to a total of approximately 126 days for an engineer. (See Table below). This is equivalent to 512 000 NOK.

	(Days of work)	
	RD	HW
I7 Met tower		
Installation	14	14
Training	4	4
Draw tower adapter		2
I8 QA/QC in field	20	10
Monitor/met.sensor procedures		
Report procedures	8	4
I9 QA/QC at DoM		
Draft procedures	5	2.5
Perform procedures	10	5
I10 Communication		
Site selection	5	5
Connection and test	3	
Connection and test	3	
I11 Sensor maintenance		5
I12 Administration	1	1
	73	52.5
Total days of work		125.5
Total cost (NOK)		**512040**

More specifically this work consist of:

- MET TOWERS: Installation and securing of 10 m meteorological towers are estimated to two days per tower. A 36 m tower is estimated to eight days. The work plan given above is for installation of one 36 m tower and three 10 m towers. Emphasis is put on procedures/training in security, maintenance, guying, and correct installation of sensors.
- COMMUNICATION: Two days are estimated at each site for installation, tuning and control of radio modems. One day per site is estimated where ordinary telephone lines are available. This includes set-up procedures.
- METEOROLOGICAL EQUIPMENT: Instruction on maintenance procedures will be given for the different type of sensors. This includes; How much can be performed in field?, What can be performed at the laboratory? And When to ship the unit back to the manufacturer?
- QA/QC IN FIELD: Extensive checklists will be made for each site. Each site is unique, but the lists will be based on a common template.
- QA/QC AT DoM: instruction in data acquisition and control procedures will be performed. Invalid data and calibration values shall be identified and removed prior to further processing. Visual control of the data will be performed based on graphically displayed raw data, to detect trends and errors.

Appendix B

Chemical laboratory - status report

MEMO

TO: Principal Air Quality Inspector

FROM: Assistant Chemist

DATE: 13/02/97

K.K. Mogami

REF. NO. : M228.A10I

BAQMAP : LABORATORY ACTIVITIES STATUS REPORT

Please find attached, the Status Report of the Laboratory Activities up to the period ending 31st January 1997.

LABORATORY ACTIVITIES (Status Report) January '97

Communication

Communication Link : Botswana(DoM) - Norway(NILU)

All the telephone lines are linked to a switchboard. So it is not possible to link up our computer fax to a telephone line so as to be on-line for direct communication with NILU.

It is anticipated that we will have moved to a new building by the end of June 1997. So obtaining a *direct telephone line* for NILU-DoM communication installation is likely to be delayed until after we have moved to the new building

Safety in the Laboratory

First Aid Box

Status

A price quote for complete standard First Aid kit has been obtained.

Next Step

An order is to be made before 14/02/97. It is hoped that this will have arrived by the end of February, 1997)

Safety Equipment (eye wash bottles, fire alarms/ blankets/shower)

Status

A price quote for *eye wash bottles* has been requested from suppliers. We are still awaiting their response.

It is anticipated that we will have moved to a new building by the end of June 1997. So obtaining a *fire alarms/ blanket/ shower* for installation at the laboratory should wait until after we have moved to the new building.

Next Step

An order for the *eye wash bottle(s)* will be placed with as soon as we receive a price quote.

Learn How to use Safety Equipment

Status

Nothing Has been done so far. The reason for this is that we are still awaiting the purchase of the first aid kit, eye wash bottle, etc.

Next Step

As soon as the equipment arrives, the learning will commence.

Safety Data Sheets

Status

Information about these has been requested from Chemical & Reagents suppliers. We are still awaiting response from the suppliers.

Next Step

To explore the means of acquiring the same.

Direct Telephone Line For the Laboratory, Emergency Numbers

Status

It is anticipated that we will have moved to a new building by the end of June 1997. So obtaining a *direct telephone line* for installation in the laboratory should wait until after we have moved to the new building.

Gas Leakages

Status

We are thinking of obtaining a digital gas detector meter. We have been looking at a Helium and/or Hydrogen gas detector in catalogues and will be requesting a price quote from the suppliers. We are still trying to find an electronic acetylene and/or nitrous oxide gas detector.

Next Step

We will be placing an order for a Helium/ Hydrogen gas detector before 21-02-97. As soon as we find a quote for an electronic acetylene and/or nitrous oxide gas detector this also will be purchased. In the mean time, a soap bubble meter which we intend purchasing, would do just as well.

Gravimetric and Volumetric Equipment

Balance Control Weights

Status

We are still awaiting price quotations for the control weights for the balance.

Next Step

They will be ordered as soon as they are available.

Check Volumetric Equipment By Gravimetry

Status

No Work Done Yet. The balance still to be calibrated using control weights.

Next Step

These will be checked as soon the balance has been calibrated with control weights.

Quality Assurance/Quality Control System

Sample Handling Procedures

Status

The documentation of procedures for the handling of water/effluent samples intended to be analysed for dissolved metal content has been completed.

Next Step

To teach other personnel the importance of following the steps outlined in the procedures all the time. This is expected to be done before 28-02-97.

Method Descriptions

Operation and Maintenance of Instruments

Status

Currently putting together a document of how to operate an Atomic Absorption Instrument.

Nothing Has been done yet on the maintenance of the instrument.

Next Step

To put together a document of how to operate a UV/Visible Spectrometer(end of February '97).

Use of Volumetric Equipment

Status

The documentation of procedures still in progress. It is expected that these will be completed by the end of February '97.

Next Step

To teach other personnel the importance of using volumetric equipment the right way.

Chemical Handling and Storage

Status

The documentation of steps to follow still in progress. It is expected that these will be completed by the end of February '97.

Next Step

To teach other personnel the importance of handling chemicals the right way.

Cleaning of glassware/ Laboratory equipment

Status

Procedures for cleaning of Glassware and sample containers for the avoidance of sample contamination of metal samples have been completed.

Next Step

Teach other personnel the importance of cleaning equipment correctly.

Cleaning of laboratory

Status

No work done yet in this area.

Next Step

To document all that needs to be done as regards the cleaning of benches, sinks, windows/window sills, etc.

Sample Forms

Status

Sample Form Sheets have been completed.

Next Step

Their use will be introduced during the month of February '97.

Field Blanks

Status

The use of Field Blanks was introduced during the month of January '97.

Next Step

To continue using Field Blanks for every sample batch.

Control Samples

Status

No work has been done on this.

Next Step

To prepare a control sample during the month of February.

Control Charts

Status

These are dependent on the use of control samples. No work has been done in this line.

Next Step

To make a control chart as soon as two data points from control samples are obtained.

Stickers on Chemical Containers

Status

We are still awaiting quotations for the sticker labels from stationary suppliers.

Next Step

To order the stickers as soon as the quotes have been received.

Chemical Waste Handling

Status

Still working on the steps to follow as regards the handling of chemical waste from the laboratory.

Next Step

Feedback is expected by the end of February.

Data Flow and Treatment in the Laboratory

Status

It is now possible to collect data from the Atomic Absorption Spectrometer straight into a computer. From the computer, the data can then be read into a Microsoft Excel Calibration Spreadsheet using a simple macro. We are working on another macro to process the data and produce a summary of all the results for the month.

Next Step

To document the steps for retrieving and analyzing data on an Excel spreadsheet. To teach the other personnel how to use this system: from obtaining data in a diskette from the AAS machine to processing the results and producing a summary of results. These should be done by end of February '97.

To set-up a system of transferring data to a data base. It is expected that this will be completed by the end of February '97.

To create a file for storing all the data (raw and processed data alike) in a hard copy format by end of February.

Method Development

AAS Method Development

Status

A procedure for the analysis of dissolved metals from effluents has been documented. Steps are already underway to teach other personnel all that which is involved.

Next Step

To ensure that other personnel can perform analysis competently with minimum supervision.

UV/Vis Method Development

Status

The procedures for the determination of Sulphate, Nitrate, Ammonia and Chloride in water have been compiled (ref. :EMEP MANUAL). We are currently awaiting suppliers to provide us with price quotes for the chemicals and apparatus required to carry out the analyses.

Next Step

As soon as we receive the price quotes we will place orders for the chemicals, reagents and apparatus as required.

APPENDIX

LARGE METAL FIRST AID KIT (COMPLETE & LOCKABLE)

Large Metal Box
Cotton wool ✔
Triangular bandage ✔
Crepe bandage ✔
Conforming bandage ✔
Gauze bandage ✔
First aid dressing- size 4 or 5 ✔
First aid dressing-size 2 or 3 ✔
First aid dressing- size 1 ✔
Sterile gauze swabs ✔
Assorted plasters ✔
Micropore tape ✔
Eye drops; eye pad; eye cup; eye patch.
Burn kit (burnshield dressing, burn hydrogel, burn blots adhesive dressing) ✔
Antiseptic ointment ✔
Gentian Violet ✔
Mercurochrome
Savlon or dettol liquid ✔
rubbing stuff ✔
Paracetamol 500 mg (headache + pain) ✔
First aid scissors ✔
Safety pins ✔
Eno or freshen salts (stomach)
Wooden splints (muscle and bone)
Cervical collar (neck)
Jelonet paraffin dressing (burns)
Throat lozenges
Cough mixture
Rubber gloves
Fabric dressing strip
cold and flu medicine
Rennies sweets (heartburn, indigestion, etc.)
Gesic spray (muscle pain)
Deep heat ✔
Oral thermometer ✔

SAMPLE FORM

CHEMICAL LABORATORY * AIR POLLUTION DIVISION
DEPARTMENT OF MINES

SAMPLING

Sample Site:

Sample Date:

Sampled by:

Observations/Notes:

SAMPLE PREPARATION

Date:

Signature:

Method:

Notes:

ANALYSIS:

Date:
Signature:
Method(s):

AAS: ☐Cu ☐Ni ☐Fe ☐Mn ☐Pb ☐Al ☐Cd ☐Co ☐Zn ☐Mg

UV-Vis : ☐ SO_4^{2-} ☐ NO_3^- ☐ NH_4^+ ☐ Cl^-

GC/MS : ☐VOC

Notes :

DATA STORING

Date:
Location:
Signature:
Notes:

DETERMINATION OF DISSOLVED METAL CONCENTRATION IN WATER

[Copper (Cu), Nickel (Ni), Iron (Fe), Lead(Pb), Cadmium (Cd), Manganese (Mn), Cobalt(Co), Aluminium (Al), Zinc (Zn), Magnesium (Mg)]

Principle

The sample is filtered through a 0,45 µm membrane filter. (By definition, dissolved metals are those which pass through a 0,45 µm filter). Reagents are added to suppress ionization, and to release the sought elements from refractory compounds. The ions in the sample solution are transformed to neutral atoms in an air/acetylene flame. Light from a hollow cathode (HCL) or an electrodeless discharge (EDL) lamp is passed through the flame. The light absorbed by the atoms in the flame, which is proportional to the ion concentration in the sample, is measured by a detector following a monochromator set at the appropriate wavelength. Thereafter, the concentration of each element is determined with reference to calibration standards of matched matrix.

Interference

Both ionization and chemical interference are likely to occur. These interferences are caused by other ions in the sample, and result in reduction of the number of neutral atoms in the flame.

Cesium chloride is added to suppress ionization interference. Alkali metals tend to be ionized in the flame with subsequent loss of absorbace. Introduction of an element of lower of an easily ionized element (i.e. with lower ionization potential) such as cesium to the samples and calibration solutions increases the population of free electrons, minimizing and stabilizing the degree of ionization. *The ionization effect is more pronounced in the hotter nitrous oxide /acetylene flame.*

Lanthanum chloride is added as a “releasing agent”. Refractory compounds formed in the flame tend to prevent the formation of the essential atomic vapour. Lanthanum combines with preferentially with the interfering ions, thus releasing the sought elements for atomization. *Refractory compounds form less readily in the nitrous oxide/acetylene flame.*

A Field Blank is used as a control of the sample handling procedures. This is a solution of distilled water obtained from the laboratory when the water samples are to be collected. It is then treated in the same manner as the normal samples.

Apparatus

- Atomic absorption spectrometer
- Micro-filtration apparatus: fitted with a 0,45 µm filter membrane
- Compressed air: Oil and water-free , at a pressure of 400 kPa
- Nitrous oxide
- Acetylene
- Pipettes

- Volumetric flasks
- 1-L Polyethylene plastic bottles for sample collection

Reagents and Chemicals

- Nitric acid; suprapur quality
- Hydrochloric acid; suprapur quality
- Lanthanum chloride (for AAS)
- Cesium chloride (for AAS)
- Standard stock solutions of copper, nickel, iron, cadmium, manganese, cobalt, zinc, chromium, lead, calcium, magnesium, aluminium : each element, 1 000 μg/cm^3. Standard solutions are available from reliable commercial sources.
- Interference suppresser solution

  Dissolve 10g of lanthanum chloride and 12.67g of cesium chloride in water. Add 25 cm^3 of suprapur nitric acid, and stir to effect solution. Dilute with water to 100 cm^3 and mix thoroughly.

Cleaning of Apparatus and Sample Bottles

- Fill the vessel with 20%v/v hydrochloric acid and leave for two days. Include the plastic lids in the leaching and cleaning process.
- Discard the acid solution, and fill the vessel with 20%v/v nitric acid and leave for a further 2 days. Again, include the plastic lid in this leaching and cleaning process.
- Discard the nitric acid, and rinse the vessel thoroughly with distilled water.
- Air dry the vessels and store until required. Ensure that airborne particles cannot fall into the vessel prior to use by covering.

Samples Collection & Preparation

- Collect a portion of the water sample in the “sample bottle” and rinse.
- Collect the water sample in the 1-Litre polyethylene bottle.
- Filter 200 ml of sample through a 0.45 μm cellulose nitrate membrane filter paper.
- Rinse the collection flask with the final portion of the filtrate (about 10-20 ml).
- Collect the rest of the filtrate in a collection flask.
- Add 6 ml of Nitric acid to the sample solution.
- Add 2 ml of the Cs-La solution and mix.
- Rinse the filtration apparatus with distilled water followed by ultra high quality pure water, between the filtering of the samples

Field Blank

Collect distilled water from the laboratory each time the samples are collected, and treat in the same manner as the samples.

Composite Working Standard Solution

Pipette 5 ml of each of the 1000 mg/l stock solutions Cu, Mn, Cd, Co, Al, Pb, Zn; 10 ml of the Fe stock solution; 50 ml of the Ni stock solution; and 200 ml of the Mg stock solution, to a 1000 ml volumetric flask. Dilute to the mark with de-ionised water. Store the solution in a polyethylene bottle.

- The concentrations in the solution will be:
    - 5 µg/ml for Cu, Mn, Cd, Co, Al, Pb, Zn;
    - 10 µg/ml for Fe;
    - 50 µg/ml for Ni; and
    - 200 µg/ml for Mg respectively.

The solution should be made fresh each time the calibration solutions are prepared.

Calibration Solutions

- Pipette 10, 20, 30, 40, and 50 ml, from the working standard solution, into five volumetric flasks. Add 1 ml of the Cs-La-solution and dilute to the mark with ultra high purity water. The concentrations in the solutions will be:
    - 0.5, 1, 1.5, 2, and 2.5 µg/ml for Cu, Mn, Cd, Co, Al, Pb, Zn;
    - 1, 2, 3, 4, and 5 µg/ml for Fe;
    - 5, 10, 15, 20, and 25 µg/ml for Ni; and
    - 20, 40, 60, 80, and 100 µg/ml for Mg respectively.

  A solution with 1 ml Cs-La-solution diluted to 100 ml is used as a blank.

- The calibration solutions and the blank should be prepared the day of the analysis and then stored in polyethylene bottles.

Instrument Calibration

After a ***10 minutes*** warm-up time of the instrument and the lamp, set the wavelength for the element to be analyzed, the slit width, and the air/acetylene or *nitrous oxide/acetylene* ratio as given in table 1 below.

Table 1 : ***Recommended Instrumental Parameters for the Analyses***

Element	Wave length (nm)	Slit Width (nm)	Fuel	Support	Flame Stoichiometry
Cu	324.7	0.5	acetylene	air	oxidizing: slightly fuel rich
Ni	352.4	0.5	acetylene	air	oxidizing: slightly fuel rich
Fe	248.3	0.2	acetylene	air	oxidizing: slightly fuel rich
Pb	217.0	1.0	acetylene	air	oxidizing: slightly fuel rich
Cd	228.8	0.5	acetylene	air	oxidizing: slightly fuel rich
Mn	279.5	0.2	acetylene	air	oxidizing: slightly fuel rich
Co	240.7	0.2	acetylene	air	oxidizing: slightly fuel rich
Al	309.3	0.5	acetylene	nitrous oxide	reducing; red cone 10-20 mm high
Zn	213.9	1.0	acetylene	air	oxidizing: slightly fuel rich
Cr	357.9	0.2	acetylene	nitrous oxide	reducing: red cone 10-20 mm high
Mg	202.6	1.0	acetylene	nitrous oxide	oxidizing: slightly fuel rich
Ca	422.7	0.5	acetylene	nitrous oxide	reducing; red cone 10-15 mm high

N.B.: Flame stoichiometry is a critical parameter, and should be optimized by adjusting fuel and support flow rates.

Background correction must be applied to the measurement of lead, cadmium, cobalt and nickel absorbents.

Ignite the flame and allow ***5 minutes*** for it to stabilize. Adjust the reading of the instrument to zero by spraying the blank into the flame. Run the calibration solutions and use their absorption signals to plot a calibration graph.

Without further adjusting the controls, determine the absorbents of the sample solution (use appropriately diluted samples).

The instrument should be re-calibrated after 20 - 30 samples.

Data Treatment

From the calibration plot, determine the concentration of metal in the sample solutions as given below:

Step 1

$$\text{Concentration} = \frac{(\text{Absorbance} - \text{Intercept})}{\text{Slope}} \text{ x Dilution Factor}$$

Step 2

Actual Concentration = Concentration (Step 1) – Concentration (field blank from Step 1)
of Sample

DETERMINATION OF AIRBORNE LEAD

Principle

Lead is collected on the same filters that are used to collect Total Suspended Particulate dust samples. The samples are prepared by digesting in nitric and hydrochloric acids to bring the lead into solution. The solution is filtered through a 0.45 µm membrane filter to remove suspended materials, and then analysed by an atomic absorption spectrometer. Results are reported as mass of lead per volume of air sampled (µg/m^3).

Samples Collection

Air is drawn with a high volume sampler through a fibreglass filter at the rate of 1.5 - 2.0 m^3/min.

Samples Preparation

1. Place the fibreglass filter in a flask containing 100 ml of 50% v/v nitric acid solution.
2. Heat the contents of the flask and maintain just below the boiling point for 45 minutes.
3. Filter the extract through a prewashed Whatman 540 filter paper and repeat steps 1 & 2.
4. Combine the filtrate and washings and boil down to moist salts.
5. Re-dissolved in nitric acid and dilute to 50 ml with distilled water.

Working Standard Solution

Same as for water samples.

Calibration Solutions

Same as for water samples.

Instrument Calibration

Same as for the water samples. Run the calibration solutions and use their absorption signals to plot a calibration graph.

Without further adjusting the controls, determine the absorbents of the sample solution.

Data Treatment

a) From the calibration plot, determine the concentration of metal in the sample solutions as given below:

Step 1

$$\text{Concentration} = \frac{(\text{Absorbance} - \text{Intercept})}{\text{Slope}} \text{ x Dilution Factor}$$

Step 2

Actual Concentration = Concentration (Step 1) – Concentration(field blank) from Step 1 **of Sample**

b) Multiply the concentration by 50 ml to get the mass of metal in the sample as given below:

Total Mass of Metal in the dust sample = Concentration x 50 ml

c) Divide by the total air volume from which the dust was collected to obtain results in micrograms of metal per cubic meters of air as given below:

$$\text{Concentration of Metal in the Air} = \frac{\text{Total Mass of Metal in Dust Sample}}{\text{Volume of Air Drawn}}$$

SPECTROPHOTOMETRIC ANALYSIS FOR THE DETERMINATION OF SULPHATE, NITRATE, AMMONIUM, AND CHLORIDE IN WATER/ EFFLUENTS

DETERMINATION OF SULPHATE IN WATER

by the barium perchlorate-Thorin method

Field of application

This method is applicable to the determination of sulphate in water within the range 0.15 mg SO_4/L to 12 mg SO_4/L. Samples containing higher concentrations must be diluted prior to analysis.

Principle

$Ba(C10_4)_2$ is added in excess to precipitate the sulphate as barium sulphate in an organic solvent. The organic solvent will minimise the solubility product of barium sulphate. The excess concentration of barium (II) ions in the solution is determined spectrophotometrically at 520 nm through the reaction with Thorin (the sodium salt of 4-(ortho-arsenophenyl-azo)-3-hydroxy-2,7-naphthalene-disulphonic acid).

Several organic solvents may be used. The most favourable calibration curve is obtained with dioxane.

Interferences

Phosphate will interfere with this method.

Instrumentation

♦ Spectrophotometer for measuring absorbent at	520 nm
♦ Optical glass spectrophotometer cells;	20 nm
♦ Micro pipette:	250 µl
♦ Bulb pipettes:	1,2,3,4,5,6,7,8,9 and 10 ml
♦ Burette:	50 ml
♦ Ion exchange columns:	15 cm length, 1 cm diameter
♦ Test tubes:	30 ml
♦ Volumetric flasks:	50, 100 and 1000 ml

All glassware should be of borosilicate and should be thoroughly rinsed in distilled water before use.

Chemicals

All chemicals, except Thorin, must be of a recognised analytical grade. The water used for dilution and rinsing must be double distilled or de-ionized.

- Sulphuric acid (H_2SO_4) 0.05 M
- Perchloric acid, ($HClO_4$) 72%
- Barium perchlorate ($Ba(ClO_4)_2$), anhydrous
- Dioxane or isopropanol
- Thorin (disodium salt)
- Cation exchange resin, strongly acidic (e.g. Dowex 50 W x 8, 50-100 mesh).

Reagents

1. 0.1 M perchloric acid ($HClO_4$).
2. 0.01 M perchloric acid ($HClO_4$).
3. Barium perchlorate reagent solution
   100 mg anhydrous barium perchlorate, ($Ba(ClO_4)_2$, is dissolved in 0.1 M $HClO_4$ to a volume of 100 ml in a volumetric flask.

4. Barium perchlorate reagent solution
   10 ml of solution (3) is diluted to 1000 ml with dioxane

5. Thorin reagent solution
   5 mg of the disodium salt is dissolved in 5 ml 0.01 M $HClO_4$ and diluted to 50 ml in a volumetric flask. A fresh solution should be prepared each day.

6. Primary Sulphate standard solution
   31.25 ml of 0.05 M H_2SO_4 is diluted to 1000 ml in a volumetric flask. The concentration is equal to 150 mg SO_4/L.

Calibration

Prepare a series of standard solutions containing 0, 1.5, 3.0, 4.5 ... 12 mg SO_4/L by diluting 0, 1, 2, 3, ... 8 ml of the sulphate standard solution in Section 4.2.1.5(6) to 100 ml with water in volumetric flasks. Transfer 4 ml of each of these standard solutions to a test tube. Add 10 ml barium perchlorate reagent solution and 250 µl Thorin solution. Use a micro pipette for the Thorin solution. Mix thoroughly (do not use rubber stoppers!)

Transfer the solutions to optical cells. The spectrophotometer wavelength is set at 520 nm, and 0% transmission is adjusted according to the procedure in the manual of the photometer. Then gain and/or slit width is adjusted to give a reading of 0.80 absorbent units with the blank (0 mg SO_4/L) in the sample compartment. Measure the absorbent of the solutions within 10 minutes after addition of the Thorin solution. This is especially important for low concentrations of sulphate and for the blank because the barium-Thorin compound may precipitate from the solution.

A calibration graph is constructed from the absorbent readings obtained from the standard solutions. The calibration curve is not linear below 1.5 mg SO_4/L. This is suppressed by adding sulphate in a quantity corresponding to 1.5 mg SO_4/L to all samples and blanks. The detection limit is then 0.15 mg S/1.

Analytical procedure

Cations are removed by treating the sample with a strongly acidic cation exchange resin.

Transfer 4 ml of the pre-treated sample to a test tube and add 10 ml barium perchlorate reagent solution and 250 µl Thorin solution. Use a micro pipette for the Thorin solution. Mix thoroughly (do not use rubber stoppers!). Transfer the solutions to optical cells and measure the absorbent of the solutions within 10 minutes after addition of the Thorin solution. This is especially important for low concentrations of sulphate and for the blank because the barium-Thorin compound may precipitate from the solution.

Determine the sulphur concentration of the sample from the absorbent reading by means of the calibration curve.

DETERMINATION OF NITRATE IN WATER

by the Griess method

Introduction

This method is applicable to the determination of the nitrate content in water within the range 0.02-0.23 mg NO_3-N/1 (0.1-1.0 mg NO_3/1).

Principle

Nitrate is reduced to nitrite using cadmium treated with copper sulphate as a reducing agent, in presence of ammonium chloride. Thus, by this method the sum of nitrate and nitrate is determined.

Nitrite and sulphanilamide form a diazo compound which couples with N-(1-naphthyl)-ethylenediamine-dihydrochloride to form a red azo dye. The concentration in the solution is determined spectrophotometrically at 520 nm.

Instrumentation

- Spectrophotometer
- Optical glass cell, 20 mm. If more than one cell is used, the cells should be matched
- photometrically
- Shaking machine
- Erlenmeyer flasks: 25 ml with stoppers
- Volumetric flasks: 100 and 1000 ml
- Test tubes
- Pipettes: 1.0, 2.0, 4.0, 6.0, 8.0, 12.0 and a 20.0 ml graduated
- Micro pipettes: 100, 250, 500 µl
- pH-meter
- Beaker 200 ml

Chemicals

During analysis, use only chemicals of recognised analytical grade. The water used for dilution and rinsing must be double-distilled or distilled and deionized.

- Ammonium chloride (NH_4C1)
- Sulphanilamide
- (1-naphthyl)-ethylenediamine dihydrochloride
- Cadmium, 40-60 mesh
- Copper sulphate ($CuSO_45H_2O$)
- Hydrochloric acid (HCl)
- Potassium nitrate (KNO_3)
- Ammonia (NH_3)

Reagents

1. 5% ammonium chloride solution
   Dissolve 5 g ammonium chloride in water in a 100 ml volumetric flask. Adjust the pH of the solution to 8.6 using diluted ammonia. Dilute with water to the mark.

2. 1.2 M hydrochloric acid:
   Dilute 10 ml concentrated hydrochloric acid to 100 ml with water in a volumetric flask.

3. 2 M hydrochloric acid:
   Dilute 16.7 ml concentrated hydrochloric acid to 100 ml with water in a volumetric flask.

4. 1% sulphanimide solution:
   Dissolve 1.0 g of sulphanilamide in some 1.2 M hydrochloric acid (2) in a 100 ml volumetric flask. Dilute with 1.2 M hydrochloric acid (2) to the mark.

5. 0.1% N-(1-naphthyl)ethylenediamine dihydrochloride solution:
   Dissolve 0.1 g N-(1-naphthyl)-ethylenediamine dihydrochloride in some water, in a 100 ml volumetric flask. When all is dissolved, dilute to the mark.

6. 2% copper sulphate solution:
   Dissolve 2.0 g copper sulphate in water in a 100 ml volumetric flask, and dilute to the mark.

7. Reducing agent for nitrate:
   Transfer 10 g of cadmium to a beaker, add 2 M hydrochloric acid (3) to cover the cadmium and stir. Rinse well with water. Add immediately 100 ml of the 2% copper sulphate solution (6), and mix well. Pour off excess of solution. Rinse with water until there is no more precipitated copper in the washing water. The reducing agent must not be exposed to the air.

8. Standard nitrate solution I, 1000 mg NO_3/1:
   Dissolve exactly 1.6305 g potassium nitrate in water in a 1000 ml volumetric flask. Dilute to the mark.

9. Standard nitrate solution II, 100 mg NO_3/1
   Dilute 10 ml of standard nitrate solution I with water to 100 ml in a volumetric flask.

Calibration

Preparation of the calibration curve:

1. Transfer to 100 ml volumetric flasks 0, 100, 250, 500 and 1000 µl of standard nitrate solution II. Dilute with water to the mark and mix well. The concentration of nitrate in the five flasks are 0.0, 0.1, 0.25, 0.50 and 1.00 mg NO_3/1.

2. By means of a pipette, transfer 4.0 ml of each of these standard solutions to a 25 ml Erlenmeyer flask. Add 6.0 ml 5% ammonium chloride solution using a pipette, and approximately 0.5 g of the nitrate reducing agent to the Erlenmeyer flask. Shake vigorously for 10 minutes. Transfer 8.0 ml of this solution by means of a pipette to a test tube. Add 2.0 ml 1% sulphanilamide solution and 2.0 ml of 0.1% N-(1-naphthyl)-ethulenediamide dihydrochloride solution using pipettes. Mix well, and leave for 10 minutes for the colour to develop. Transfer this solution to a 20 mm cell. Measure the absorbent of the solution at 520 mn.

3. Prepare a calibration curve by plotting the absorbent of each of the standard solutions against its concentration of nitrate.

Analytical procedure

Transfer 4.0 ml of the water sample to a 25 ml Erlenmeyer flask, using a pipette. Add 6.0 ml 5% ammonium chloride solution using a pipette, and approximately 0.5 g of the nitrate reducing agent to the Erlenmeyer flask. Shake vigorously for 10 minutes. Transfer 8.0 ml of this solution by means of a pipette to a test tube. Add 2.0 ml 1% sulphanilamide solution and 2.0 ml of 0.1% N-(1-naphthyl)-ethylenediamide dihydrochloride solution using pipettes. Mix well, and leave for 10 minutes for the colour to develop. Transfer this solution to a 20 mm cell. Measure the absorbent of the solution at 520 mn. Proceed according to Section 4.3.1.6(2).

Convert the absorbent of the sample to mg NO_3/1 by means of the calibration curve. The concentration may be expressed as mg N/1 by multiplying with 0.226.

Samples containing more than 1 mg NO_3/1 must be diluted before the analysis.

DETERMINATION OF AMMONIUM IN WATER

by the indophenol blue method

Introduction

This method is applicable to the determination of the ammonium content in precipitation within the range 0.04 to 2.0 mg NH_4/l.

Principle

In an alkaline solution (pH 10.4-11.5) ammonium ions react with hypochlorite to form monochloramine. In the presence of phenol and an excess of hypochlorite, the monochloramine will form a blue coloured compound, indophenol, when nitroprusside is used as catalyst. The concentration of ammonium is determined spectrophotometrically at 630 nm.

Interferences

Iron (III) may interfere if the concentration is more than 2 mg/l. This concentration of iron (III) does not occur very often in precipitation samples.

If the pH-value of the sample is lower than 3, the sample should be neutralised.

If the sample is turbid, both the sample and the blank should be filtered through a white band filter.

Instrumentation

- Spectrophotometer
- Optical cell, 10 nm. If more than one cell is used, the cells should be matched photometrically.
- Water bath with thermostat, 50°C
- Test tubes: 30 ml
- Volumetric flasks: 10, 500 and 1000 ml
- Pipettes: 1.0, 2.0, 4.0, 5.0, 10.0, 20.0, 25.0, 50.0 ml.
- Micropipette: 250 µl

Chemicals

During analysis, use only chemicals of recognised analytical grade. The water used for dilution and rinsing should be double-distilled or de-ionised and distilled.

- Phenol (C_6H_5OH)
- Sodium nitroprusside ($Na_2Fe(NO)(CN)_5(2H_2O)$)
- Sodium hydroxide (NaOH)
- Sodium hypochlorite solution (NaOCl) 1M:
- Make a solution containing approx. 3.5% active chlorine (35 g/l) in 0.1 M
- NaOH (e.g. British Drug House no. 23039)

- Ammonium chloride (NH_4Cl)
- Sodium thiosulphate ($Na_2S_2O_3$)

Reagents

1. Reagent A:
   Dissolve 3.5 g phenol and 0.040 g sodium nitroprusside in 100 ml water. Store the solution refrigerated in the dark. If the colour of the solution turns greenish, it must be discarded, and a fresh solution prepared.

2. Reagent B:
   Dissolve 1.8 g sodium hydroxide in some water in a 100 ml volumetric flask. Add 4.0 ml 1 M sodium hypochlorite solution, and dilute with water to the mark. Store the solution refrigerated in the dark. If the solution is stored for weeks, the concentration should be checked by titration with a sodium thiosulphate solution.

3. Standard ammonium solution I, 100 mg NH_4/l:
   Ammonium chloride must be dried for one hour at 100°C. Dissolve 0.2965 g of the dried salt in water in a 1000 ml volumetric flask. Dilute to the mark with water. The solution is stable for six months when stored in a refrigerator.

4. Standard ammonium solution II, 4 mg NH_4/1:
   By means of a pipette, transfer 20.0 ml of standard ammonium solution I to a 500 ml volumetric flask. Dilute with water to the mark. This standard ammonium solution, and the ammonium solution made for preparing the calibration curve, must be freshly made.

Calibration

Preparation of calibration curve.

1. Transfer to 100 ml volumetric flask 0.0, 1.0, 2.0, 5.0, 10.0, 25.0, and 50.0 ml of standard ammonium solution II. Dilute to the mark with water. The concentrations of these solutions are 0.00, 0.04, 0.08, 0.2, 0.4, 1.0 and 2.0 mg NH_4/l. Transfer 5.0 ml of each of these standard solutions and 5.0 ml of water to a 30 ml test tube.

2. Add to the test tube 250 µl reagent A using a micro pipette, and mix well. Add then 250 µl reagent B using a micro-pipette and mix well. Cover the opening of the tube with some inert material. Place the tube in the water bath at 50°C for two hours.

3. Cool the solution to room temperature, and transfer it to a 10 mm cell. Measure the absorbent at 630 nm.

4. Prepare a calibration curve by plotting the absorbent of each of the standard solutions against its concentration of ammonium. Prepare a new calibration curve for each series of samples.

5. In order to check for ammonium in the reagents, take a photometric reading of the blank (0.00 mg NH_4/l) against water. The absorbent should not exceed 0.020.

Analytical procedure

Transfer 5.0 ml of the sample and 5.0 ml of water to a 30 ml test tube. Add to the test tube 250 µl reagent A using a micro pipette, and mix well. Add then 250 µl reagent B using a micro-pipette and mix well. Cover the opening of the tube with some inert material. Place the tube in the water bath at 50°C for two hours. Cool the solution to room temperature, and transfer it to a 10 mm cell. Measure the absorbent at 630 nm.

Convert the spectrophotometric readings of the sample to mg NH_4/l by means of the calibrations curve. The concentration may be expressed as mg N/l by multiplying with 0.778. Samples containing more than 2.0 mg NH_4/l must be diluted.

DETERMINATION OF CHLORIDE

by the mercury thiocyanate-iron method

Introduction

The method can be used for direct determination of the chloride ion content in precipitation samples within the range 0.04 to 5 mg/1.

Principle

Chloride ions will substitute the thiocyanate ions in undissociated mercury thiocyanate. The released thiocyanate ions react with ferric ions forming a dark red iron-thicyanate complex.

The absorbent is measured at 460 nm.

$$
\begin{aligned}
2\,Cl^- + Hg(SCN)_2 &\longrightarrow HgCl_2 + 2SCN^- \\
SCN^- + Fe^{3+} &\longrightarrow Fe(SCN)^{2+}
\end{aligned}
$$

Instrumentation & Apparatus

- Spectrophotometer, equipped with 50 mm optical cells
- Pipettes
- Volumetric flasks
- Erlenmeyer flasks

Chemicals

During the analysis, use only chemicals of recognised analytical grade and only double-distilled or deionized and distilled water.

- Perchloric acid ($HClO_4$) 72%
- Mercury (II) (thiocyanate ($Hg(SCN)_2$)
- Ion (III) nitrate nanahydrate ($Fe(NO_3)_3 9H_2O$)
- Sodium chloride (NaCl)
- Ethanol (C_2H_5OH)

Reagents

1. Perchloric acid, 1:1
   Mix 1 volume 72% perchloric acid with 1 volume of water.

2. Mercury (II) thioccyanate solution, saturated:
   Shake 1 g Hg(SCN)2 with 1000 ml ethanol. Filter the solution after 24 hours. The solution may be stored in a glass bottle at room temperature.

3. Iron (III) nitrate solution, 6%:
   Dissolve 6 g $Fe(NO_3)_3 \cdot 9H_2O$ *in 100 ml 1:1 perchloric acid. Filter the solution after 24 hours.*

4. Standard chloride solution I, 1000 mg/1:
   Dissolve 412.5 mg NaCl dried at 140-200°C, in water and fill it up to 250 ml with water.

5. Standard chloride solution II, 10 mg/1:
   Dilute 10.0 ml standard chloride solution I to 100 ml water.

Calibration

Preparation of the calibration curve.

1. Transfer 2.5, 5.0, 7.5, 10, 15, 20 and 25 ml of standard chloride solution II to 50 ml volumetric flasks, and fill up to the mark with water. These solutions contain 0.5, 1.0, 1.5, 2.0, 3.0, 4.0 and 5.0 mg C1/1.

2. Transfer 25 ml of the calibration solutions to 100 ml Erlenmeyer flasks to each flask. Add with pipettes 5 ml mercury (II) thiocyanate solution and 2 ml iron (III) nitrate solution. Mix well between and after the additions. After 20 minutes, measure the absorbent in 50 mm cells at 460 nm.

   As reference, use 25 ml water mixed well with 5 ml of reagent (2) and 2 ml of reagent(3)

3. Plot the readings against the concentrations and draw the calibration curve.

Analytical procedure

Transfer 25 ml of the water sample to a 100 ml Erlenmeyer flask. Transfer 25 ml of the calibration solutions to 100 ml Erlenmeyer flasks to each flask, add with pipettes 5 ml mercury (II) thiocyanate solution and 2 ml iron (III) nitrate solution. Mix well between and after the additions. After 20 minutes, measure the absorbent in 50 mm cells at 460 nm. Read the chloride content of the sample from the calibration curve.

Appendix C

Instrumentation (monitoring and calibration) – status report

MEMO

FROM: Senior Technical Officer M.D. Mmolawa

TO: Principal Air Quality Inspector

REF. NO: M228.A10 II(7)

DATE: 17/02/97

BAQMAP STATUS REPORT JANUARY 1997
INSTRUMENTATION (MONITORING & CALIBRATION)

AT SITE:

◊ Calibration gases and regulators for VOC analysers.

We have been able to procure the following:

- 60-90 ppm methane in med air
- 60-90 ppm propane in med air

and a regulator for each cylinder.

◊ Regulators and calibration gases for other analysers.

Orders for the following material and calibration gases were placed on 05/02/97

- 100 ppm NO_2 in nitrogen as balance.
- 100 ppm CO in nitrogen as balance.
- 100 ppm SO_2 in nitrogen as balance.
- Zero air in nitrogen as balance and a Stainless Steel diaphragm regulator for each cylinder.

◊ Zero point generator (dryer, ozonator, activated charcoal).

Orders for the activated charcoal and dryer were placed on 5\02\97. We are working on sourcing the ozonator and the zero gas generator.

◊ T-pieces tubings and small flow meter.

Request for quotations for the polyflo tubings as recommended by Mr. Rolf Drein to substitute the expensive teflon tubings have placed. Orders will be placed as soon as possible. A small flow meter is already available and T-pieces will be sourced from local suppliers.

AT LABORATORY:

We currently have no room to use as a calibration laboratory. However we intend to acquire a zero gas generator and calibration gases that we will keep at one of our stations in Gaborone in the mean time.

Appendix D

Data retrieval, processing and modelling – status report

MEMO

FROM: AGME T. Tshukudu

TO: PAQI

REF. NO.: M228.A10 II(8) 18TH February, 1997

BAQMAP STATUS REPORT, FEBRUARY 1997

Monthly Data

1. Made a Preliminary data processing folder for each station and prepared Macros for importing data from Envaid into the folder
2. Recorded Macros for making monthly plots
3. Made a Final data storing folder for each station where data is saved as flat files without plots.

Collected data from all the stations with continuous gas analysers and stored it in the Gaborone base station.

Daily Data

1. Made a Preliminary data processing folder for Gaborone stations and prepared Macros for importing data from Envaid into the folder
2. Recorded Macros for making daily plots

Prepared a document outlining the collection of data from the field, processing the data in Envaid, importing it into data processing folder and running macros to make daily plots.

Appendix E

Collection and Processing of Data from Continuous Gas Analysers – Dept. of Mines

Collection and Processing of Data from Continuous Gas Analysers

Note: You do not have to use the file CC-10-96 that is used as an example in this procedure.

1. **Monitoring Shelter**

   - Need to bring a diskette that is used to collect data for that particular station.
   - You will find the data acquisition system in a logging mode
   - Press **F10** to exit the logging mode returning to the **Main Menu**
   - Press **D** for shutdown returning to **C:\LOGGER>**
   - Copy the file from the hard drive to the diskette

     This really depend on the station you are at e.g. for Civic Centre you type
     COPY REP_D210.DAT A: Where:
     D = Station Letter
     10 = Tenth month of the year
     For the Station Letters
     A = Mmadinare
     B = Tonota
     C = Serowe
     D = Civic Centre
     E = Fire Brigade
   - Type **LOGGER** to Return to the Main Menu
   - Press **L** to enter the **logging mode**

2. **Base Station**

   Envaid

   - From **C:**type **CD ENVAID**
   - From **C:\ENVAID>** type **CD RAW_DATA**
   - Copy the raw data file from the diskette to the hard drive e.g. **COPY A:REP_D210.DAT**
   - To convert the raw data file from a DAT to ASC file you type **HERS44A** at **C:\ENVAID\RAW_DATA>**
   - At **Enter the Source File Name:** you enter the file the file you have just copied e.g. **REP_D210.DAT**
   - At **Enter the Report averaging Time in Minutes**: you enter either 60 for hourly averages or 1440 for daily averages
   - At **What Type of Data:** you type **RPT1** for hourly averages and **RPT2** for daily averages
   - At **Select Channels to be Selected:** enter **Y**(Yes) or **N**(No) depending on if you want the data for that parameter
   - At **Are There Any Channels that Require Manual Data Input?** you enter **Y** (Yes) or **N**(No) but in our case you enter **N**
   - **Enter the Year of the Data File:** 1996

- **Enter the Station Name:** e.g. Civic-Center
- **Enter the Town or State**: e.g. Gaborone
- **Enter the Target File Name:** e.g. **CC-10-96.ASC**

Where:
CC - the station initial
10 - Month
96 - Year

- At **C:\ENVAID\RAW_DATA>** type **CD..**

- At **C:\ENVAID>** type **ENVAID**
- At **SELECT DESIRED PROCEDURE** select **DATA LOADING AND EDITING** by pressing **[X]** then **F1**
- **Name of the Data File:** type **CC-10-96.ASC.** Place an **[X]** to select **ASCII Raw Data** then **F1**
- At **Binary File to Contain the Edited Data**: you type **CC-10-96.BIN**
- Press **F1** until you get to the **Select Data for Raw Data** Menu. Select **Return to the Main Menu**

- At **Select Desired Procedure** select **Analyse Edited Data**
- At **Enter Edited File** enter **?** then **F1**, move the cursor to the desired file press enter to select the file then **F1**
- At **Select Analysis Desired** select **Special Report**
- At **Select Desired Format** select **Lotus 1-2-3 Import File** and **Direct Output to D** for Disk.
- At **Name of the Disk output file** enter **CC-10-96.PRN** this really depends on the file and station for which you are processing the data
- At **Select New Analysis** select **Return to the Main Menu**
- At **Select Desired Procedure** select **Exit Envaid**

- At **C:\ENVAID>** type **CD REPORTS**
- At **C:\ENVAID\REPORTS>** type **Edit**
- Press **Alt F**
- Press **O** for Open
- Press **Alt F** to get to the list of files
- Move cursor to the desired file and press **Enter**
- Delete the top of the file until you get to the measured parameters
- Press **Alt F** and **X** to exit the edit mode and **Save** the changes

Microsoft Excel

There are files with the name of each station already created. You need to open the file you want to add the new worksheet to. In this file there is a sheet called **Inputfileetc**. This sheet must be opened for file importation

- You first have to input the **Directory** to import from e.g. **C:\Envaid\Reports>**

- Then you input the **Filename** e.g. **CC-10-96.PRN**
- Click on the **Start Here!** Cell
- Open the sheet you have just imported
- Click on **Tools** of the Main Menu
- Click on **Macro**
- Run the Personal Micro called **Monthlyplots**

You can now adjust the plots to suit your needs.

Appendix F

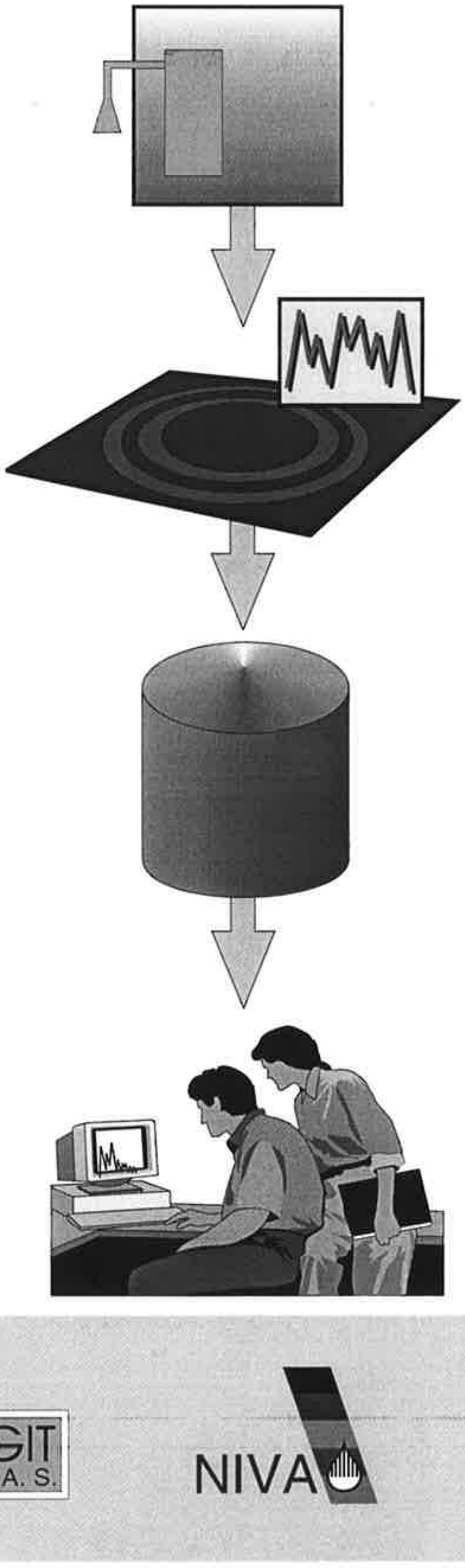
AirQUIS
Technical Specifications

ENSIS

An Environmental Surveillance and Information System

AirQUIS

Version 2.0
Technical specifications



The ENSIS system is an Environmental Surveillance and Information System developed in Norway. The AirQUIS part of ENSIS is specifically constructed for air quality surveillance and planning and includes

- data acquisition system,
- measurement database,
- emission inventory database,
- emission models,
- dispersion models,
- effect models,
- statistical tools and graphical presentation procedures,
- manual data entering application,
- automatic data transfer system,
- a user interface with an integrated geographical information system (GIS) functionality.

The AirQUIS system is a flexible surveillance and planning tool. It is composed of separate modules, and can easily be customized to meet any special requirements as specified for the installation site.

The ENSIS-group:

NILU

NORGIT SENTERET A. S.

NIVA

AirQUIS

Technical specifications

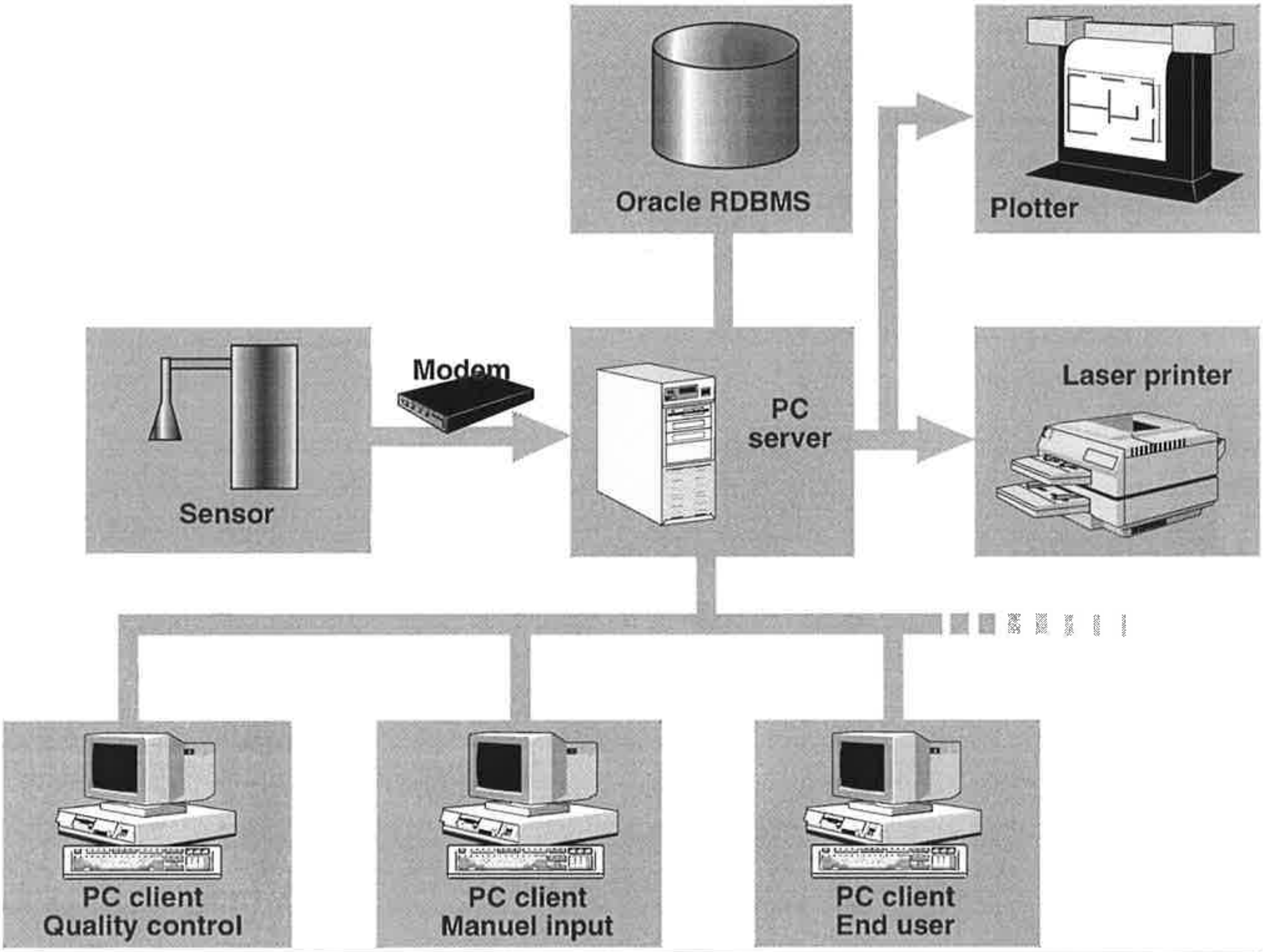
The technical platform includes:

- IBM compatible PC with Pentium Processor,
- 32 Mbytes RAM,
- VGA or VGA compatible monitors,
- video card with at least 1 Mbyte internal memory,
- minimum 50 Mbytes disk for programmes and data bases dependent upon specific needs (size of area and amount of data),
- for each user a minimum of 20 Mbytes swap disk or local disk,
- Windows NT or Windows '95 and Windows NT.

The data base system most commonly used is Oracle, but AirQUIS can also be based on other relational data base systems. The geographical information system is based on Map Objects from ESRI, and is an integrated part of the user interface.

Installation and Training

The system has to be installed for a specific purpose in a well defined area. Establishment includes system configuration, site acceptance testing and model adaptations. Introduction (seminar) and training will be undertaken by ENSIS experts.



For further information on AirQUIS, contact:

Norwegian Institute for Air Research (NILU)
Instituttveien 18, P.O.Box 100, N-2007 Kjeller, Norway
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NORGIT Senteret A/S
Bryggeriveien 2, P.O.Box 229, N-1601 Fredrikstad, Norway
Telephone: +47 69 39 48 00 • Telefax: +47 69 39 49 10

Appendix G

New selected sites for the national air quality monitoring program for Botswana

New sites selected for the national air quality monitoring program for Botswana

Site Name: **Diratsame Community Junior Secondary School**

Type of area: Background.

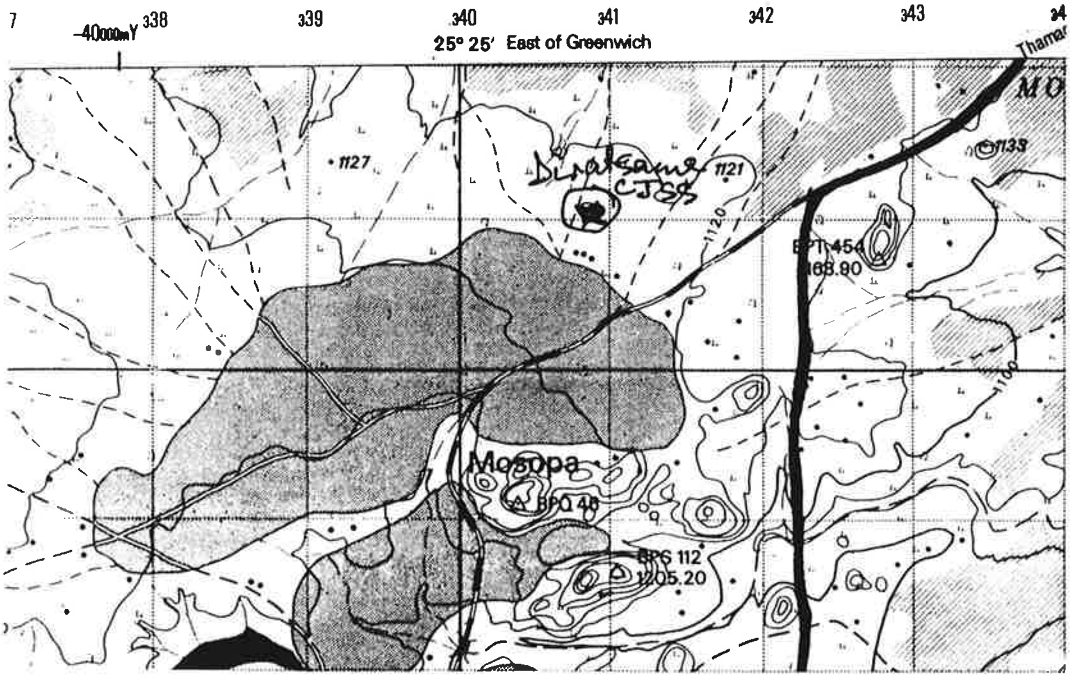
Area description: School property. Sandy ground. No residential area or any industry in the up-wind direction. The monitoring station could/should be placed in the fenced corner close to the teachers residences.

Objectives: Background station for Gaborone. Continuous monitors will be used.

Parameters: SO_2, NO_2, PM_{10}, O_3 and meteorology.

Air intake: 3.5 m above ground on monitoring shelter roof.

Comments: Choma J. Matale (DoM) will send a formal proposal to Deputy Head of Diratsame CJSS, Mrs. Petronella Sesika.



New sites selected for the national air quality monitoring program for Botswana

Site Name: Tsogang Primary School (Tsholofelo District)

Type of area: Residential

Area description: Partly fenced school property. Sandy ground. Densely built-up area. Dense vegetation.

Objectives: To measure air pollution in the residential area of Gaborone.

Parameters: SO_2, NO_2, PM_{10}, PAH

Air Intake: About 3.5 m above ground

Comments: It has been suggested to install 24-hour average SO_2 and NO_2 samplers at this site. However, continuous monitors should be considered for this site, if continuous monitors will be installed on most of the other sites in the new national air quality monitoring program for Botswana.

Appendix H

Analysis results of passive samplers (Selebi-Phikwe and Francistown)

Report for measurements of SO_2-gas in air using passive sampling.

Report date: 05.03.97
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Measurement report NILU-U-19
Project no.: O-96082

Sampler identification	From date	From. hr	To date	To hr	Number of days	SO_4-S µg/ml	SO_4-S µg/m^3	SO_2 µg/m^3
Plot 1852, SO_2-3	30.01.97	09:07	13.02.97	11:30	14.1	1.01	9.37	18.74
Plot 1840, SO_2-4	30.01.97	09:20	13.02.97	11:45	14.1	0.84	7.79	15.58
Plot 1831, SO_2-5	30.01.97	09:32	13.02.97	11:50	14.1	0.85	7.89	15.77
Plot 284, SO_2-6	30.01.97	09:45	13.02.97	11:55	14.1	0.62	5.75	11.50
Plot 293, SO_2-7	30.01.97	09:53	13.02.97	12:27	14.1	0.59	5.47	10.95
Plot, 302, SO_2-8	30.01.97	09:57	13.02.97	12:30	14.1	0.57	5.29	10.58
Ind. ave., SO_2-9	30.01.97	10:15	13.02.97	14:55	14.2	0.66	6.08	12.16
Plot 5086, SO_2-10	30.01.97	10:43	13.02.97	15:05	14.2	0.45	4.15	8.29
Plot 1048, SO_2-12	30.01.97	11:02	13.02.97	15:45	14.2	0.31	2.86	5.71
Plot 1024, SO_2-13	30.01.97	11:10	13.02.97	15:50	14.2	0.34	3.13	6.26
Plot 1034, SO_2-14	30.01.97	11:17	13.02.97	16:40	14.2	0.45	4.15	8.29
Plot 2346, SO_2-15	30.01.97	11:31	13.02.97	*****	14.0	0.68	6.35	12.71
Plot 2333, SO_2-16	30.01.97	11:42	13.02.97	16:20	14.2	0.89	8.20	16.40
Plot 2297, SO_2-17	30.01.97	11:47	13.02.97	*****	14.0	0.90	8.41	16.82
Rail Tr. , SO_2-19	30.01.97	12:02	13.02.97	10:05	13.9	20.13	189.42	378.85
Railw. St, SO_2-20	30.01.97	12:15	13.02.97	09:55	13.9	4.85	45.64	91.28

Report for measurement of NO_2-gas in air using passive samplers.

Report date: 05.03.97
Page: 2

Measurement report NILU-U-19
Project no.: O-96082

Sampler identification	From date	From. hr	To date	To hr.	Number of days	NO_2-N µg/ml	NO_2-N µg/m^3	NO_2 µg/m^3
Blue Jacket Street, N-1	31.01.97	10:43	14.02.97	15:55	14.2	0.24	1.86	6.12
Blue Jacket Street, N-2	31.01.97	10:53	14.02.97	15:50	14.2	0.39	3.03	9.95
Blue Jacket Street, N-3	31.01.97	11:00	14.02.97	15:40	14.2	0.33	2.57	8.45
Blue Jacket Street, N-4	31.01.97	11:10	14.02.97	15:35	14.2	0.25	1.92	6.32
Blue Jacket Street, N-5	31.01.97	11:40	14.02.97	15:21	14.1	0.14	1.09	3.58
Blue Jacket Street, N-6	31.01.97	11:45	14.02.97	15:15	14.1	0.29	2.24	7.36

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ABSTRACT

Mission 2 was undertaken as part of the annual meeting between NORAD and Department of Mines 4 February 1997. Discussions and decision on the new national air quality monitoring program for Botswana was performed after the annual meeting. Passive samplers for SO_2 and NO_2 were installed in Selebi-Phikwe and Francistown. The samplers measured air pollution from the BCL smelter and traffic, respectively, during the 2 first weeks of February 1997. The samplers have been analysed at NILU. The results are presented in the report. Status reports are included in the report as Appendices.

NORWEGIAN TITLE

Overvåkningsprogram for luftkvalitet i Botswana. Rapport nr. 2.

KEYWORDS		
Monitoring Program	Passive sampling	Status Reports

ABSTRACT (in Norwegian)

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