NIVA

REPORT SNO 3987-99

Industrial Pollution Prevention Programme (IPPP)

Travel report. Visit to Environmental Council of Zambia (ECZ) 20.9. - 01.10.98

Norwegian Institute for Water Research

REPORT

Main Office
P.O. Box 173, Kjelsås
N-0411 Oslo
Norway
Phone (47) 22 18 51 00
Telefax (47) 22 18 52 00
Internet: www.niva.no

Regional Office, Sørlandet
Televeien 1
N-4890 Grimstad
Norway
Phone (47) 37 29 50 55
Telefax (47) 37 04 45 13

Regional Office, Østlandet
Sandvikaveien 41
N-2312 Ottestad
Norway
Phone (47) 62 57 64 00
Telefax (47) 62 57 66 53

Regional Office, Vestlandet
Nordnesboder 5
N-5008 Bergen
Norway
Phone (47) 55 30 22 50
Telefax (47) 55 30 22 51

Akvaplan-NIVA A/S
N-9005 Tromsø
Norway
Phone (47) 77 68 52 80
Telefax (47) 77 68 05 09

Title	Serial No.	Date
Industrial Pollution Prevention Programme (IPPP) **Progress report** **Visit to Environmental Council of Zambia (ECZ)** **20.09. - 01.10.98.**	3987 - 99	3o. 11. 1998.
	Report No. Sub-No. O - 98161	Pages Price 60
Author(s) Karl Jan Aanes	Topic group	Distribution
	Geographical area Zambia	Printed NIVA

Client(s)	Client ref.
Environmental Council of Zambia (ECZ), Water Pollution Unit and Norwegian State Pollution Control Authority.	

Abstract

A visit to ECZ was paid by Mr. Karl Jan Aanes, NIVA, with the intention to assess the capacity of the chosen laboratories in Zambia to analyse water samples in the Water Quality Survey Programme. Along with the visiting of laboratories a field trip was carried out to collect water samples from the upper part of Kafue and the main tributaries from mine sites. Parallel samples were taken and analysed both at laboratories in Zambia and at NIVA to conduct a preliminary intercalibration between the selected labs. The intention was to evaluate their potential for a possible participation in the programme.

4 keywords, Norwegian	4 keywords, English
1. Vannkvalitet	1. Water quality
2. Laboratorier	2. Laboratories
3. Gruveforurensing	3. Pollution from mines
4. Kafue - Zambia	4. Kafue River - Zambia

Karl Jan Aanes.

Karl Jan Aanes
Project manager

ISBN 82-577-3583-3

Dag Berge

Dag Berge
Head of research department

1. Status of the project – further plans and progress.

Sunday the 20th of September

Arrival in Lusaka via Johannesburg at midday. In the afternoon a meeting was held in Lusaka between SFT's project leader Christel Benestad and the Norwegian consultant Karl Jan Aanes (NIVA) to prepare the forthcoming meetings with the group at ECZ responsible for the activity connected to water- and recipient quality in the IPPP project. In the meeting it was focused on the limited progress in the project so far, the increasing lack of man capacity at ECZ to deal with this part of the IPPP project and the possibilities to increase the progress in the future. NIVA and SFT agreed upon that after this visit it should be a discussion on the capability at ECZ to proceed with the water project in the Industrial Pollution Prevention Programme.

The 21st and 22nd of Sept.

Meetings was held at ECZ between the water group at IPPP represented by Chris Kashinga (WQ - Component Manager), Israel Sandona and Douglas Nkolonganya together with Christel Benestad and Karl Jan Aanes. In the meetings it was focused on :

- **A** Work done so far in 1998 at ECZ connected to the IPPP water project
- **B** Evaluation of selected laboratories for air and water samples in Zambia
- **C** The field trip to upper Kafue (Why, where, what and how)
- **D** Initiating the monitoring program in Upper Kafue to be run through the hydrological year 1998 - 1999
- **E** Parallel water sampling to check quality standard of relevant parameters at a lab in Zambia.
- **F** Activities for the rest of 1998 and plans/budget for 1999.

In the afternoon the 22nd of Sept. a meeting was held at NORAD, Lusaka with the project leader for the Industrial Pollution Prevention Programme in Zambia, Gulbrand Stuve, together with Christel Benestad and Karl Jan Aanes for mutual information about the water aspects in the programme.

A Since the visit to Norway in January 1998 and in accordance with the plans worked out there, a draft edition of the report named "The state of the art on water quality of the upper Kafue River" have been lounched. The report was basen on a literature review and was compiled by Dr Thomson Sinkala at the Geological Dept., research co-ordinator at the University of Zambia, Lusaka. The idea behind the study was to review past and on-going studies in the Kafue basin, collect data about the pollution and the water quality and identify areas of deficiencies requiring incorporation, step by step into the future monitoring programs for the Upper Kafue River. Such knowledge is fundamental as a platform for developing a relevant monitoring program for this river system. Because of the lack of manpower at ECZ they had to use an external consultant for this work. By doing that they missed one important intention behind this exercise reviewing older data; to build up a deeper knowledge at ECZ on water quality and pollution problems in this very important water resource for Zambia.

From the Sinkala's review it was seen that effluents from the mining industry in the upper part of Kafue had an impact on the water quality, down to the Kafue Hook, about 700-km downstream the mining area. He pinpointed also that since often the studies are of short duration, there is now a need for a long term and a more complete strategy for the monitoring of the water quality in

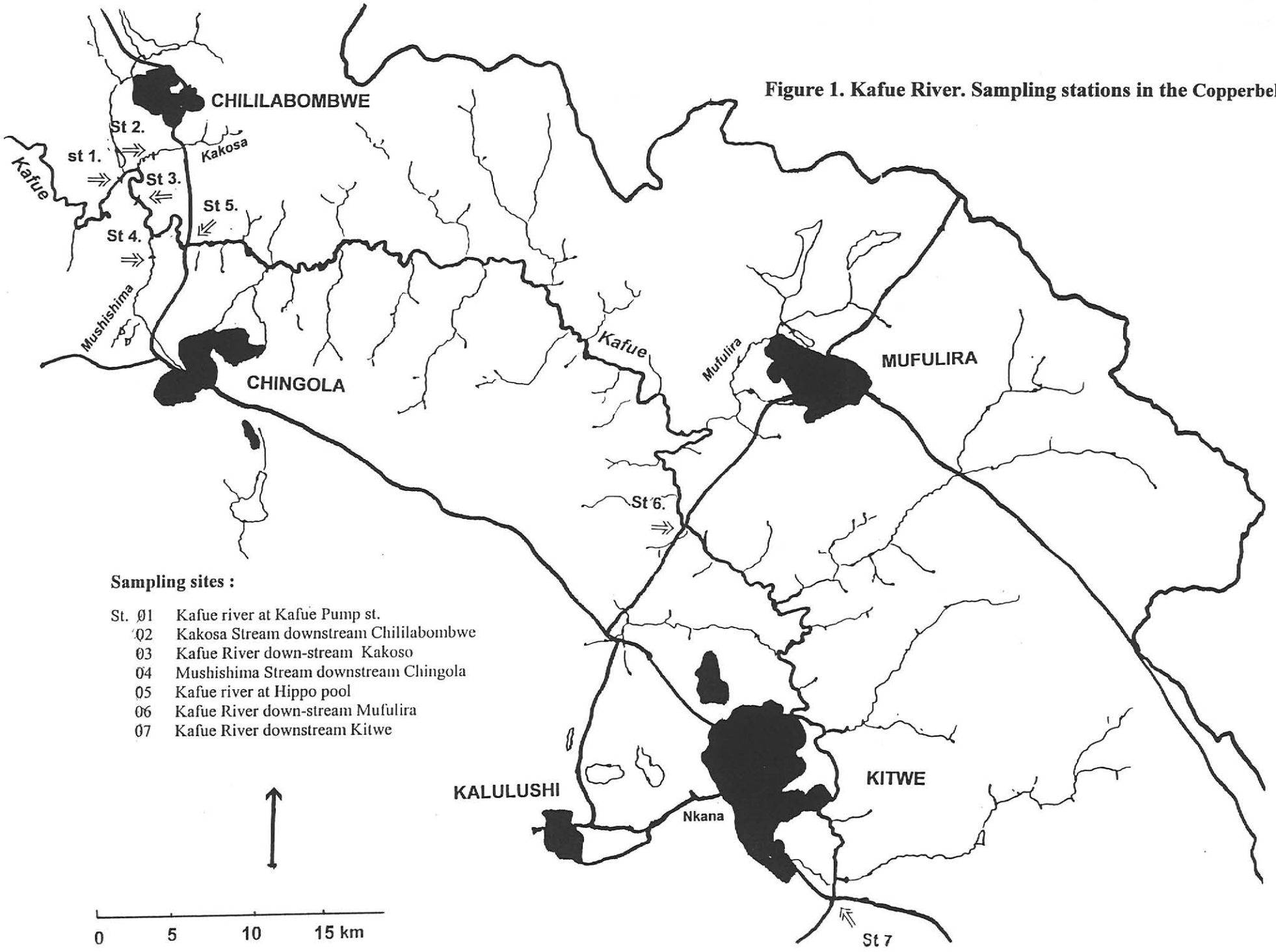


Figure 1. Kafue River. Sampling stations in the Copperbelt.

this river. It was also stressed that co-ordination with other on-going monitoring programs in the catchment area is important, for instance the effluent control done by the different mines (editor's own addition). As a task to consider in the near future is to locate resources developing a water quality database. This is a subject of high priority due to the large amount of data held in a haphazard way by to many authorities.

B With this monitoring program the intention was to put up a standard for future studies on water quality at ECZ. The need for high quality measurements was agreed upon. During the workshop last year in Chisamba, "The ECZ stakeholders consultative workshop on the Kafue River Water Quality Survey ", it was by many of the speakers underlain the importance that it was a waste of time and money to collect data witch not have a good international quality standard. The work plan agreed upon was after assessment of relevant laboratories in Zambia, to do an inter-calibration to select the most promising among the laboratories, to do the water analysis in the monitoring programme. This was a priority task to be done before starting a monitoring programme, and it was also stressed at the study tour paid by the water group at ECZ to Norway early this year. Very little progress was seen on this field before this visit, apart from a list received in May 1998 of 11 potential laboratories in Zambia, which could be assessed for this work. Any other information about the laboratories was missing.

During this tour an important task was therefore to visit the listed laboratories and make an assessment of their capability to take part in the monitoring programme. This was co-ordinated with the air group who had the same needs to find a good laboratory for analysing their air samples. A plan was already set up in the programme for both of the groups and with some small alterations we were able to go together when the evaluation was done. In connection with our meeting there was presented a report (see Appendix 1) named: Assessment of selected laboratories in the Copperbelt prepared by Chris Kasinga and Douglas Nkolonganya dated May 1997 (?). The report is focusing on many important aspects but was not detailed enough to let us select "our" laboratory at this stage. It would have been of interest to have had such a report at an earlier stage.

C & D Together with the assessment of the quality standard among laboratories in the Copperbelt area there was also an object to validate the selected sampling sites already picked out by ECZ, initiating a monitoring program in Upper Kafue, and to collect parallel water samples for analysing both in Zambia and Norway.

Trough discussions several object was for the monitoring were revealed. To focus on industrial pollution in general and concentrate on activities in Ndola, or concentrate on an impact study on mining and the pollution problems generated. This could be done on one mine site describing different sources and the effect in the recipient or by focusing on the water quality on a certain stretch at the river and try to get an impression of how effluents from different mine sites affected the water quality in Upper Kafue. The last option was selected which meant that sampling sites were located to the main tributaries from mines, in addition to upstream and downstream sites in Kafue River (Fig. 1). A set of relevant parameters was agreed upon and a sampling frequency with weekly sampling during the rainy season and monthly during the dry season was proposed. One the other hand limited resources to cover the expenses for field work and analysis gave some limitations. This in addition to the uncertainty already mentioned connected to the analytical quality needed. It was therefore decided to start with a limited monitoring programme running the hydrological year 98/99, and combine it as much as possible with the ongoing effluent control run by the mines. The programme will give the opportunity for some training and experience (on job training), and trough the treatment of the collected data, gain knowledge about the variations in the water quality through the different seasons. To develop a more permanent monitoring programme for the Upper Kafue River, when the laboratory facilities and resources are available, such experience and information is crucial.

E To be able to get some information about the common quality standard in Zambia on relevant parameters for a monitoring programme adapted to Kafue it was agreed upon that on the first sampling trip parallel samples should be collected and analysed at NIVA and a Zambian laboratory. ECZ and NIVA had on the field trip brought their own sampling bottles prepared by using common procedures at each institution.

F Activities at ECZ for the rest of 1998 will mainly focus on clarifying the laboratory situation, and together with the Norwegian consultants on air and water conduct the sampling programme and go through relevant reports and papers mentioned in Sinkala's review. The work with a database for results from the on-going monitoring (ECZ/NIVA), and relevant data from the effluent control done in the same area (ZCCM), should be started. The plans and budget for 1999 will be rearranged in close contact with SFT/NIVA and in accordance with the discussions during this visit.

Activities at NIVA in the near future will be to analyse and prepare results from the study with parallel sampling when the data are available, finish the travel report, advise and support ECZ/SFT on water related questions in the IPPP programme, and together with the Norwegian air pollution consultant come up with some proposals to solve the problems met with lacking laboratory quality in Zambia.

Visit to Copperbelt 23. 9. - 26.9. 1998. Travel report.

Purpose :

2. Conduct a field trip to the upper part of Kafue together with main tributaries from the mines in the area. Validate the selected sampling sites.

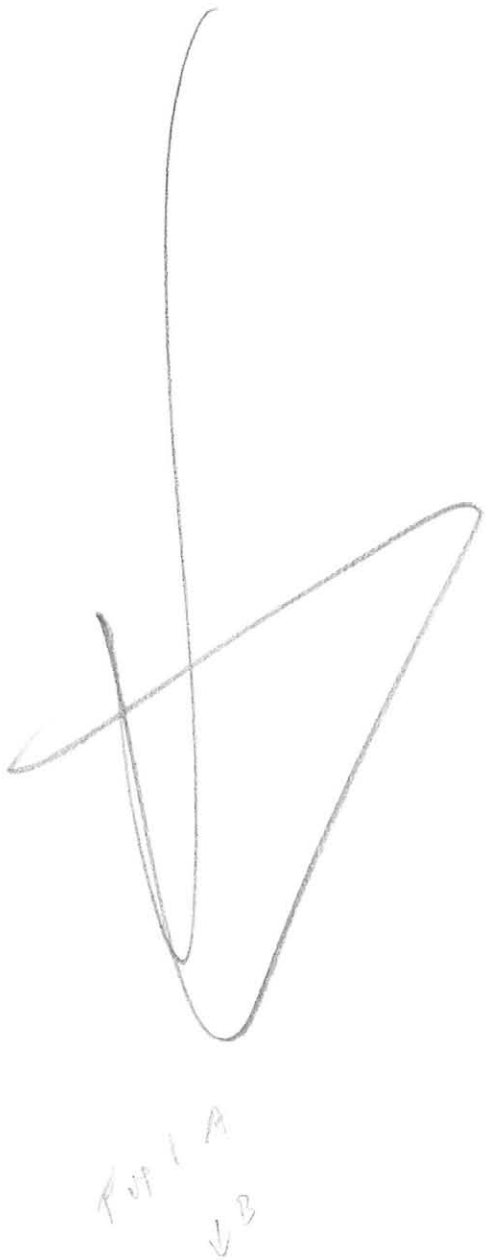
3. Assess the capacity and quality of the chosen laboratories in Zambia to evaluate their potential for analysing water samples in the Kafue River Water Quality Survey Programme.

22nd September

Afternoon 22nd September departure from Lusaka and travelled by car to Ndola with Chris Kashinga, Israel Zandonda and Douglas Nkolonganya.

23rd September

Meeting in the IPPP water group finalising the sampling program and the timetable for evaluation of laboratory facilities in the Copperbelt co-ordinated with IPPP's air group.
Travelling to Chililabombwe. Meeting with people responsible for the environment at the mine. A sampling trip to the River Kafue upstream the mining activity was performed together with a representative from the mine and mine police. Water samples were collected at the Kafue waterplant pump station.
On the way home to Ndola water samples were taken downstream ZCCM's mine activity at Chililabombwe in Kafue River at Hippo pool.



Sampling stations. Kafue River Water Quality Survey Programme.

24th September

Evaluation of laboratory facilities in the Copperbelt together with the IPPP air group.

Kalulushi laboratory, Zambia Consolidated Copper Mines Ltd. (ZCCM).
Meeting with Environmental Manager James Kalowa and Laboratory Manager J. M. Hamududu. The Kalulushi laboratory has a status as a reference lab. for the different laboratories in the ZCCM group. The number of employees was 24 and six of them had a BSc degree. The laboratory is now being privatised and will in the near future have to rely on their own ability to raise grants through projects. To day water samples are collected and analysed on a weekly basis. They are equipped with a Perkin Elmer UV/V spectrophotometer on which they analyse nitrates and sulphate from water, and three Atomic Adsorption Spectrophotometers (AAS) for analyses of heavy metals mainly for exploration. Detection limits were 0.05 ppm for Cu, 0.25 ppm for Pb and 0.005 for Cd. A dihydride generator are used together with AAS to analyse for Hg, As and other trace elements. On an AAS Perkin Elmer AS-700 they do measurements of Pb, bismuth and antimony down to 0.3 μg/g. With an ICP Perkin Elmer Optima 3000 they were able to analyse 70 elements. Trace elements such as Sc and As, are analysed. The detection limits for Pb and Zn with the ICP method was 0.3 μg/g and 0.05 mg/g respectively. Typical levels analysed at the Kalulushi lab. are about 10-100 times higher than water from mines in Norway.

A list of analysis and prices practised at the Kalulushi Lab. is given in Appendix 3 .

Copperbelt University, Kitwe
At the Institute of Environmental Management in Kitwe we had discussions and were guided around by Dr. Maseha (Head of the Institute) and Fred Chileske (Assistant Dean). The Institute of Environmental Management is divided into four areas: Water, air, solid waste and legislation and management. A presentation of the institute and a water analysis price list are given in Appendix 4.

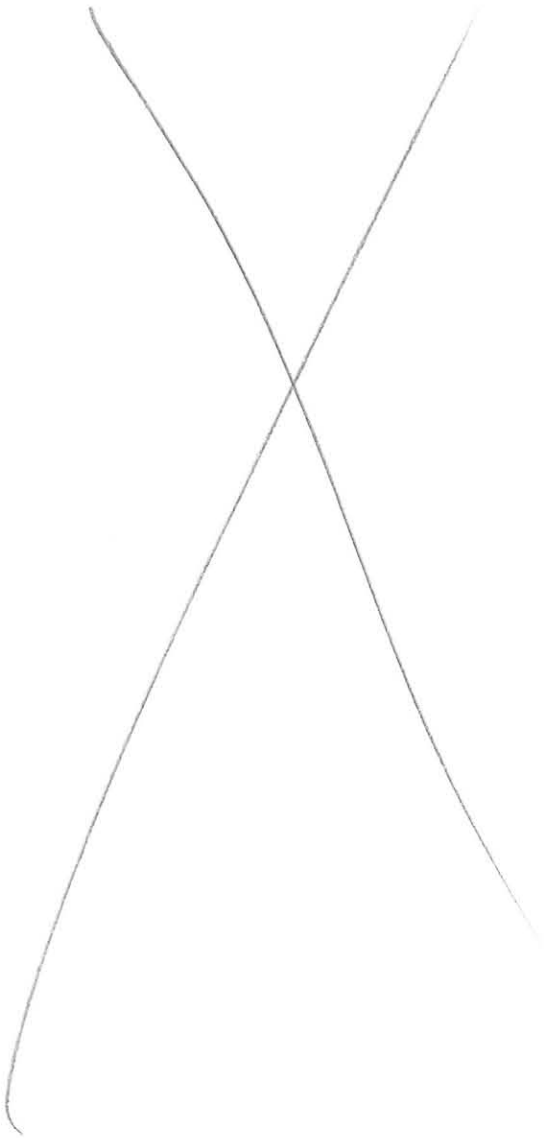
The laboratory of the institute is in an up-grading phase and will at the moment function as a training laboratory for the students. It has neither equipment nor employees for environmental analysis on a routine basis.

Mine Safety Department, Kitwe.
Meeting with Senior Inspector of the Environment, Dr. Christopher Nkandu. The department in Kitwe is mainly working with safety and health for the mining industry in the Copperbelt, but has also some experience with pollution problems generated by the mining industry in the River Kafue. Measurements of dust concentration and SO2 in the working environment are one of the main topics. To handle the different samples at the laboratory in Kitwe there were employed two graduated chemists, one inspector, two research assistants and one lab assistant. The environmental sector of the laboratory is more recent and there was no extra capacity at the moment to analyse water samples from the monitoring program.

Mufulira laboratory, ZCCM.
Meeting with Head of Environmental Division William Muhula and Mr Kululushi. Most of the environmental analyses are based upon water samples. The water analyses are done on several AAS instruments and an ICP, the last being used for elements such as Fe, Mn, Co and Cu on routine bases.

25th September

Continuing the sampling programme in the upper part of Kafue together with the water group at ECZ. Parallel water samples were taken from Kafue River downstream Kakoso, at Chingola in Mushishima stream, in Kakoso stream from Chililabombwe, in Kafue downstream Mufulira and in Kafue downstream Kitwe. In Figure 1, a map of the Upper Kafue River is shown with the different sampling stations marked.



Sampling stations. Kafue River Water Quality Survey Programme.

downstream Kitwe. In Figure 1, a map of the Upper Kafue River is shown with the different sampling stations marked.

26th September
Saturday at lunchtime the mission to Copperbelt was finished and we returned to Lusaka.

28th September
In Lusaka, working on the mission report and planning the activities in Zambia before leaving. Co-ordination of the laboratory visits around Lusaka with the air group.

29th September

Meteorological Institute in Lusaka
Together with the air group we visited the Meteorological Institute in Lusaka and had a meeting with senior forecaster Mr. Jacob Nkomokimand, Mr Niambi and Mr Nawa. The intention with this visit was to get an overview over the meteorological stations in the catchment area of the Upper part of the River Kafue and to collect information about their locations and parameters measured.

In Figure 2, a map is shown with the different meteorological stations in Zambia. Co-ordinates of each station are listed in appendix 5, together with some meteorological data (e.g. rainfall).

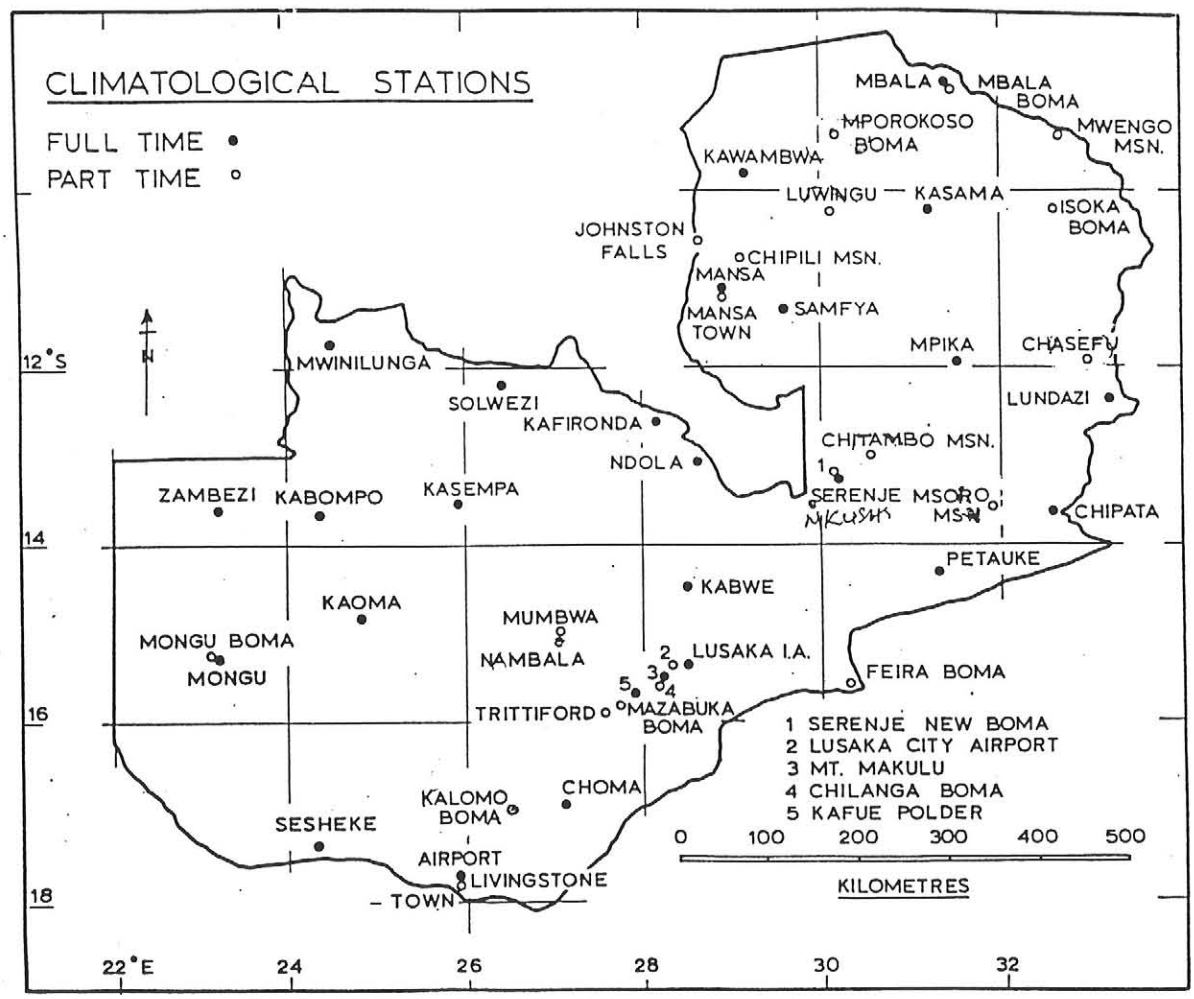


Figure 2. Climatological stations in Zambia.

The National Council for Scientific Research, Zambia, NCSR.

The NCSR laboratories for environmental research are located outside Lusaka on the road to the airport. We visited several laboratories at NCSR. The first lab division we were shown was the Nuclear analytical Laboratory connected to the Radioisotopes Research Unit. At this department there were three scientists and four technicians working mostly with research, also having the possibility to do contract work. In this lab there was among other instruments a neutron activator, a mass spectrometer, a XRF analyser and an ASS, which was down. Instruments from the other labs included a Mossbauer spectrometer, for analysis of ferromagnetic materials and a neutron generator for analysis of heavy metals together with a gamma spectrometer, an IR spectrophotometer (Philips PU-9714, not operative), and two UV-visible spectrophotometers (DMS 100S Varian and UV-240 Graphtcort).

At the wet chemistry laboratory, which was divided into two departments, there were engaged four persons working with physical, chemical and microbiological analyses. The impressions from this department was that over some years now the resources for maintenance have been lacking and there were clearly a need for renovation and cleaning together with a supplement of some new equipment. In the appendix 6 there is given a list of analytical services and prices available at the wet chemistry laboratory at the moment. In Table 1 names of the scientists working at the NCSR are shown.

Table 1. Scientists working at the NCSR.

Nuclear Analytical Laboratory		Wet Chemistry Laboratory	
Dr. Nomai	Head Chemist	M. Maswabi	Inst.
G. M. Chishimba	Physicist	R. Katebe	Tech. Microbiology
P. Hayumbu	Chemist	P. Shaba	Microbiology
P. C. Chigali	C.T.O. Chemist	S. Mansange	Tech. Chemist
D. M. Sikabbubba	S.T.O. Chemist		

University of Zambia

At the University of Zambia just outside Lusaka we visited the laboratory at the Department of Environmental Engineering. This Environmental Engineering Lab. is rather new, it was nice and clean but the equipment and instruments relevant for the IPPP project were mostly lacking. There were two technicians working at the laboratory. In the appendix 7 there is given a list of analytical services and prices available at the Environmental Engineering Lab.

The National Council for Scientific Research, NCSR.
Head Quarter Laboratory, Mount Makula.

This laboratory which are located in the neighbourhood to Chilanga Cement factory have earlier been supported by NORAD and trained by Norwegian experts (Helge Stray, Dyno). At Mount Makula we had a meeting with chief technician Rabby. S. Banda and principal technician Chikale Sylvester. Its main activity has been on soil characterisation in Zambia and to do soil analysis for soil scientists and farmers. At this laboratory there were employed 15 persons, one senior chemist, two assistants and a chief technician. Two of the scientists have a PhD degree. Of relevant instruments there was an old AAS and a spectrophotometer. They had high quality equipment for making de-ionised and distillated water.

30th September

NORAD Lusaka

In a summary meeting with Gulbrand Stuve co-ordinator at NORAD for the IPPP project the main objects of our mission to Zambia was on the agenda. Present at this meeting at NORAD in Lusaka was from the air group, Bjarne Sivertsen NILU and Bwembya Mwanza ECZ and from the water group, Karl Jan Aanes NIVA.

An introduction to our study to look for a qualified laboratory to do the analysis needed in the water and air project was given. None of the laboratories visited are at the moment able to do the analysis with the needed precision for the future environmental monitoring programme on ambient air and water. At least 0,5 mill NOK have to be spent at the selected lab for up-grading a long with a training programme to secure the quality of the analysis. Such a new lab will be designed to analyse both samples from air and water, and may also be used for samples of vegetation, freshwater organisms, soil and waste. Establishing such a lab may be based upon a share of contribution from the IPPP air, waste and water component.

Laboratories in Zambia. Evaluation of quality

A total of eight laboratories were visited during this mission to Zambia. The objectives of this visits were to find a good quality chemical laboratory in Zambia capable of performing analyses of environmental samples from water and air at low concentrations concerning toxic metals and other relevant components.

The results from visiting five laboratories in the Copperbelt area and three laboratories in the Lusaka area (reported in the previous pages), gave the impression of a very varied quality status. To be able to select a proper candidate for the analysis needed in the IPPP project a summary classification was necessary to perform. An evaluation was done, in co-operation with NILU and Mr. B. Mwanza from the air group, based upon an objective classification of the following seven criteria:

1. Cleanliness, potential contamination indoor and outside the laboratory,
2. The present concentration levels normally analysed for relevant parameters
3. Earlier experience in analyses of environmental samples
4. Personal experience and training
5. Personal capacity
6. Instruments available at present
7. Interests and future prospects related to environmental analyses

From the evaluation of laboratories undertaken, four laboratories were classified in priority sequence:

- The National Council for Scientific Research, Zambia. Environmental Laboratory located just outside Lusaka.
- The NCSR Mount Makula Laboratory 15 km south of Lusaka,
- ZCCM laboratories in Mufulira and in Kalulushi

The NCSR's Environmental Laboratory is located in a clean environment away from local pollution sources, it has a multiple of instruments at different laboratory facilities and it seemed to have a well equipped staff. Their interest in undertaking the task as an environmental laboratory was also positive. As at all other laboratories the wet chemistry laboratory will have to be rehabilitated and a clean room plus a room for balances will have to be prepared. They will also have to procure an ion chromatograph for SO_2 analyses (this was the case for all laboratories visited), more sensitive balances and various clean benches and tools. A good quality Atomic Absorption Spectrometer should be obtained within one of the laboratories at NCSR.

4. Initiating a monitoring program on water quality in Kafue River. Collect a set of parallel water samples to be analysed both at laboratories in Zambia and at NIVA to conduct a preliminary comparison of the standard of quality at selected labs.

Upper Kafue. Monitoring of water Quality.

During the field trip to Copperbelt a validation of the selected sampling sites was carried out and a set of water samples was taken from the River Kafue and from some of the main mine tributaries. This sampling event represented the starting of a limited one-year monitoring programme of the water- and recipient quality in this river system. Sampling methods were discussed at the site and parallel sampling was conducted on this field trip to get some information about the quality of analysis done at one of the laboratories used by ECZ for effluent control in Zambia.

Materials and methods.

Water samples were taken during the field trip to Copperbelt at 7 stations in Kafue and from some of the mine effluents. The distributions of the sampling sites are from the Kafue Bridge downstream the town Kitwe and up to the Kafue Pump station upstream the tributary from Chililabombwe. The sampling sites are marked on the map in Figure 1. The different methods used for the physico-chemical measurements are listed in table W in the appendix.

Results

The results from the analysis of water samples taken during the field trip to Copperbelt (23.-25. September) are listed in table 2. The values given are on unfiltered samples.

In Figure 3 the results from analysis of the major anions and cations are presented graphically in ionic diagrams, so called Maucha diagrams (Maucha 1932, Hutchinson 1975). This is a convenient method of indicating the ionic composition of the water, and have been used e.g. to visualise the influence of mine effluents (e.g. Ca and SO4) in a river system (Aanes 1980). In the graphical presentation the area of the circle representing the total ionic concentration or electrical conductivity and the areas of the segments are proportional to the equivalent concentration of the major anions and cations in the water sample.

In Figure 4 (AL, MN, Fe and Cu) and in figure 5 (Zn, Cd, Pb and) graphical presentations are given for the concentration of heavy metals in the water samples collected from Upper Kafue River system.

Table 2. Monitoring of water quality in Kafue River, Zambia. Results from analysis taken on water samples collected in the Cooperbelt Area, 23. - 25. September 1998.

Station	Locality	pH	Conductivity mS/m	Alkalinity Mmol/l	Turbidity FTU	Cl mg/l	SO4 mg/l	Ca mg/l	K mg/l	Mg mg/l	Na mg/l
St. 01	Kafue River at Kafue Pump St.	7.75	18.2	1.762	0.66	3.7	3.8	16.1	0.53	9.25	5.3
02	Kakosa Stream downstream Chililabombwe	**8.22**	42.7	**2.778**	**54**	2.7	79	36.4	**8.70**	16.7	5.26
03	Kafue River downstream Kakoso	8.07	30.7	2.247	19	3.2	38	26.4	4.30	12.9	5.36
04	Mushishima Stream downstream Chingola	8.10	34.8	2.227	4.3	0.5	67.5	30.2	1.79	15.8	4.37
05	Kafue river at Hippo pool	8.16	30.6	2.257	2.4	3.6	40.0	30.1	4.20	14.2	5.89
06	Kafue River downstream Mufulira	7.88	41.8	1.906	1.8	3.7	110	44.2	5.00	17.0	7.00
07	Kafue River downstream Kitwe	7.81	**55.1**	1.986	3.0	**4.4**	**174**	**65.3**	6.10	**25.3**	**11.3**

Station	Locality	Al µg/l	Mn µg/l	Fe µg/l	Co µg/l	Cu µg/l	Zn µg/l	Se µg/l	Ag µg/l	Cd µg/l	Pb µg/l
St. 01	Kafue river at Kafue Pump St.	20	12	218	0.18	4.3	0.6	< 0.6	< 0.2	<0.006	0.08
02	Kakosa Stream downstream Chililabombwe	**2220**	392	**3100**	**250**	**11500**	12	2	0.5	0.04	**6.8**
03	Kafue River down-stream Kakoso	610	128	581	35	860	4	1.5	0.5	0.015	1.3
04	Mushishima Stream downstream Chingola	255	**533**	347	21	510	4	1.5	0.5	0.015	0.44
05	Kafue river at Hippo pool	97	109	133	12	309	3	1.5	0.5	0.015	0.44
06	Kafue River down-stream Mufulira	82	270	349	12	186	5.8	1.5	0.5	0.015	0.78
07	Kafue River downstream Kitwe	95	246	227	69	81	**7**	**3**	**1**	**0.03**	1.8

4 and 5 Conduct a preliminary comparison of the standard of quality at selected labs and draw up their potential for a possible participation in the programme.

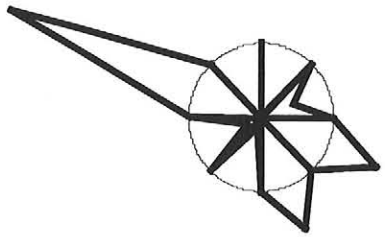
By using the results of the analyses on parallel water samples delivered from the two laboratories it is possible to do the first steps in a work to compare the quality. Important information will be available on the standard of quality at the selected Zambian lab compared to the Norwegian lab, which are our national reference lab for analysis of water quality. This comparison should be done as one of the priority activities connected to the water project in the Industrial Pollution Prevention Programme (IPPP) early in 1999.

If the deviation between the results from the analysis are not accepted, resources should be allocated to this topic to secure that the measurements collected in the first year of monitoring program of the water and recipient quality in this part of Kafue River are as good as possible. It could be of value to follow up this parallel water sampling and analysing one or two times more during the field period.

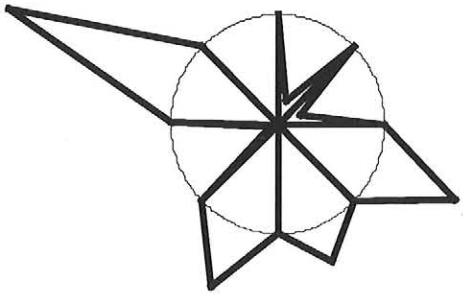
6. Other issues

Figure 3. Modified Maucha diagram of mean ionic composition and total ionic concentration in water samples collected 23. – 25. September 1998.

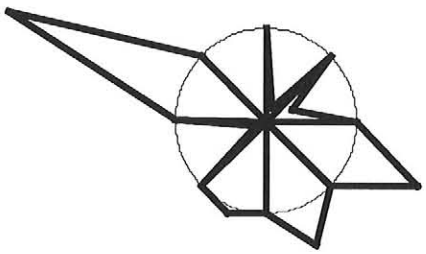
St.1 Kafue River at Kafue Pump st.



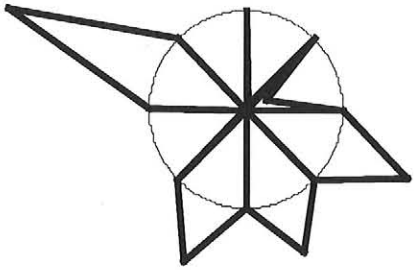
St.2 Kakosa Stream downstream Chililabombwe



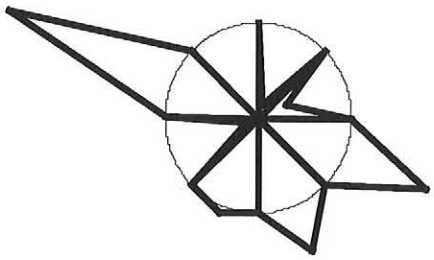
St.3 Kafue River downstream Kakoso



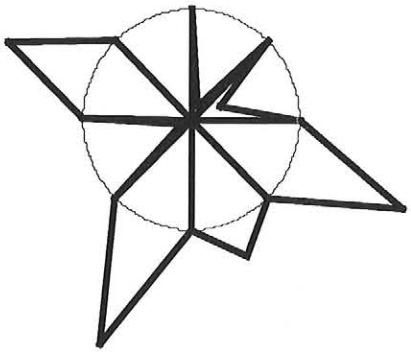
St.4 Mushishima Stream downstream Chingola



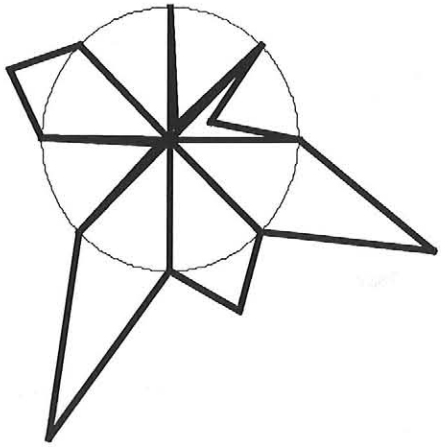
St.5 Kafue River at Hippo pool

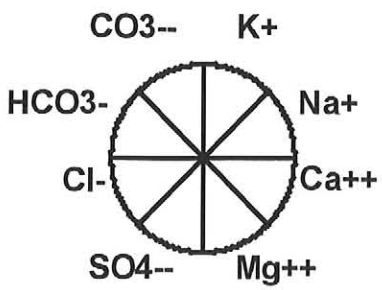


St.6 Kafue River downstream Mufulira



St.7 Kafue River downstream Kitwe





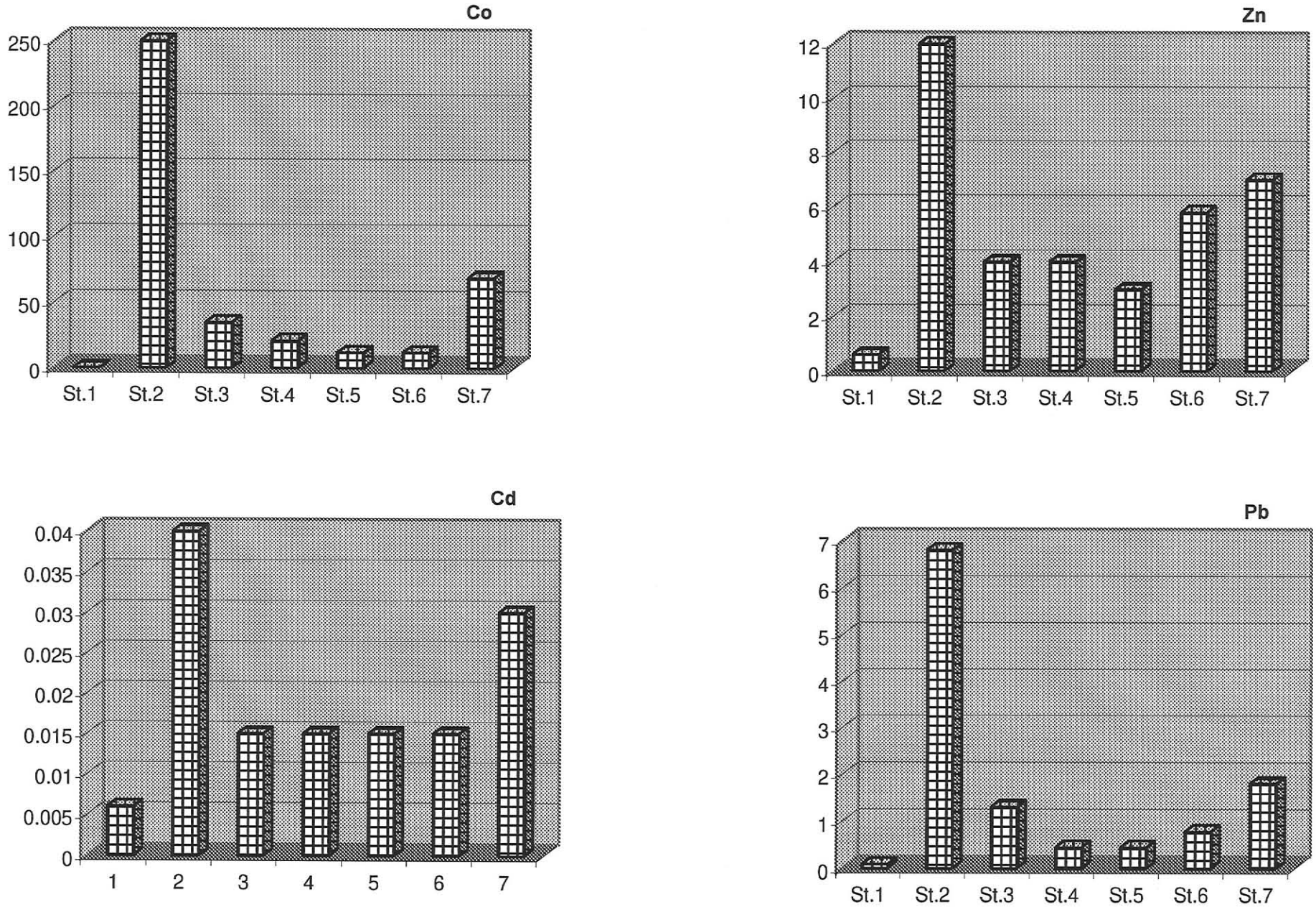
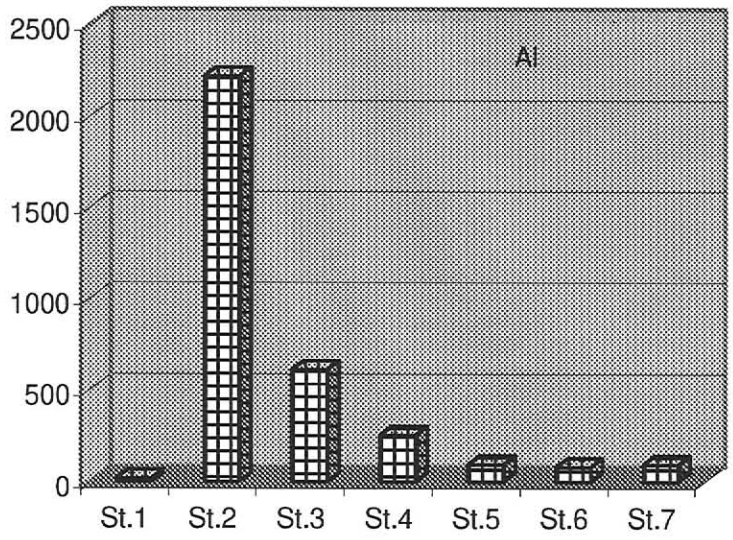
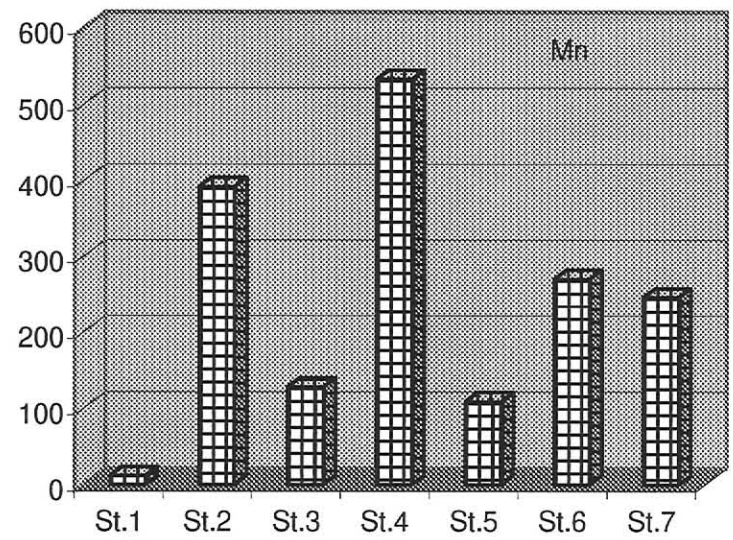
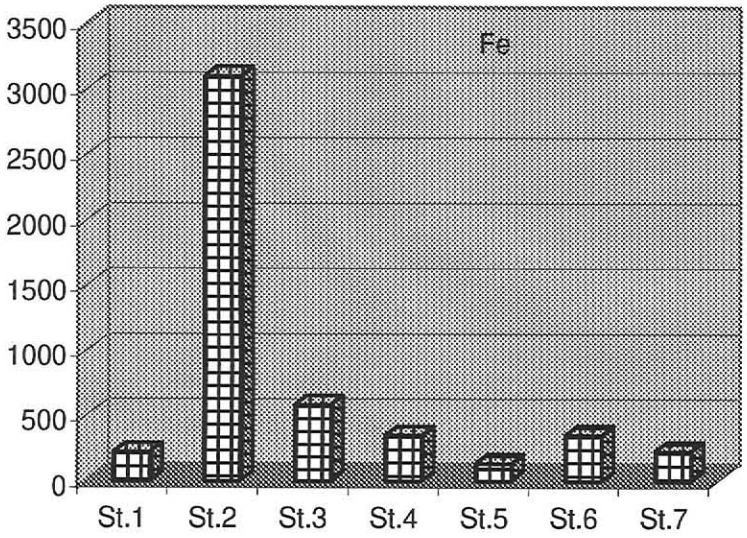


Figure 5 . The heavy metal content in water samples (μg/l)collected 23. – 25. September 1998.







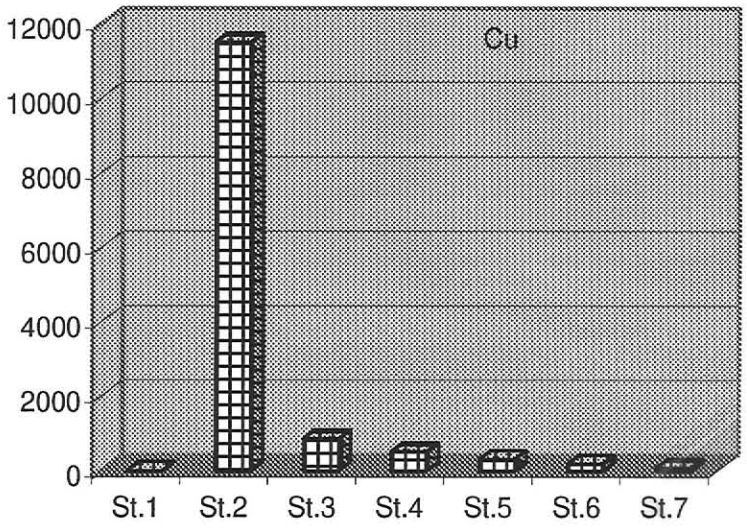


Figure 4 . The heavy metal content in water samples (μg/l) collected 23. – 25. September 1998.

References

Aanes, K. J., 1980. A preliminary report from a study on the environmental impact of pyrite mining and dressing in a mountain stream in Norway. In: Advances in Ephemeroptera Biology. Ed. John F. Flannagan and K. Eric Marshall. Plenum Publ. Corp., New York. Pp. 419 -442.

Hutchinson, G. E., 1975. A treatise on limnology. Vol. 1, part 2 – Chemistry of lakes. John Wiley & Sons. 1975. Pp. 541 – 1015.

Guerreiro, C. and B. Sivertsen. 1998. Ambient air quality monitoring system for Zambia. Mission Report no. 1 to Zambia Sep-Oct 1988.

Kashinga, C. and D. Nkolonganya. 1997. Assessment of selected laboratory in Copperbelt. ECZ May 1997. 6 p.

Kashinga, C. and D. Nkolonganya. 1997. Assessment of potential sampling points and establishment of discharge points for industrial/mining and sewage effluents into the Kafue River and its tributaries on the Copperbelt. ECZ Sept. 1997. 9 p.

Maucha, R., 1932. Hydrochemische Metoden in der Limnologi. Die binnengewässer, 12. Stuttgart, Schweizerbartsche Verlagsbuchhandlung, 173p.

Robertson, S., Kirsten. 1996. Environmental impact Statement, Mufulira Division, Mufulira Mining Licence Area – ML 15. Vol. 4.2. Appendices E-K. Environmental Engineering Studies.

Robertson, S., Kirsten. 1997. Environmental impact Statement, Nkana Division, Nkana Mining Licence Area – ML 3. Vol. 4.2. Appendices E-K. Environmental Engineering Studies.

Sinkala, T., 1998. State of the art on water quality of the Upper Kafue River, Zambia. Draft Report. ECZ April 1998.

Sorte, G. and K. J. Aanes. 1997. Industrial Pollution Prevention Programme (IPPP). Travel report. Visit to Environmental Council of Zambia 22.11.-06.12.1997.

Appendix

1) Copy Report : Kashinga, C. and D. Nkolonganya. 1997. Assessment of selected laboratory in Copperbelt. ECZ May 1997. 6 pp.

2) Copy Report : Kashinga, C. and D. Nkolonganya. 1997. . Assessment of potential sampling points and establishment of discharge points for industrial/mining and sewage effluents into the Kafue River and its tributaries on the Copperbelt. ECZ Sept. 1997. 9 pp.

3) Kalulushi laboratory, ZCCM. Analytical service facilities, price list and quality description.

4) Copperbelt University. Institute of Environmental Management – description and price list water analysis.

5) Meteorological stations Zambia with rainfall normals for Lusaka, Ndola, Kafironda and Solwez.

6) NCSR, Zambia. Environmental Research Laboratory : Charges for analytical services.

7) UNZA, University of Zambia. Laboratory for Environmental Engineering: Charges for water and waste water quality tests.

Appendix

1) **Copy Report : Kashinga, C. and D. Nkolonganya. 1997. Assessment of selected laboratory in Copperbelt. ECZ May 1997. 6 pp.**

INDUSTRIAL POLLUTION PREVENTION PROGRAM

WATER QUALITY AND REGULATION PROJECT

REPORT ON

ASSESSMENT OF SELECTED LABORATORY IN COPPERBELT

PREPARED BY

Chris Kashinga
and
Douglas Nkolonganya

May, 1997

SUMMARY

Before commencing with a monitoring programme for the upper Kafue river it was required that the quality standard of the selected laboratories be assessed and organise an inter-calibration. The assessment has been conducted by using questionares and holding discussions with the personnel of each of the selected labobratories. Among the Information collected include the following:

- Main objective/mission of laboratory
- Number of Professionals, Technicians and supporting staff
- The equipment used and its status
- The parameters analysed, method and detection limits
- Type of samples analysed
- Quality assurance and control measure followed.
- Accreditation of laboratories

The information collected will now enable the Water Quality & Regulation IPPP component team to draw up a programme of inter-calibration of the selected laboratories and work out a collective action plan among the stakeholders.

INTRODUCTION

Five laboratories have been selected in the Copperbelt province to be used for analysis of our water quality samples when the monitoring work commences. The Ndola City Council lab in Ndola, the Mine Safety dept. lab in Kitwe, the Copperbelt University Environmental lab, the Kalulushi Technical services lab and the Nchanga mine Analytical lab.

A four days trip was conducted to assess the status of the laboratories and to discuss the usage modalities. The information collected will help us in the linking of laboratories as regards quality control and assurance and working out a collective action workplan.

OBJECTIVES

The immediate objectives for the trip were:

- To collect information on the status of the selected laboratories.
- Discuss modalities for using the selected laboratory facilities and their services.

EXPECTED OUTPUTS

The expected outputs were:

- Information on the status of the selected laboratories collected
- Modalities for using laboratory facilities and services from selected laboratories worked out.

INFORMATION COLLECTED

Ndola City Council Laboratory

Mission: The main mission of the laboratory is to manage the quality of freshwater and wastewater.

Number of Personnel: One professional, four Technicians and two supporting staff.

Equipment: The Laboratory has all the necessary equipment, however, the Atomic Absorption Spectrophotometer and flame photometer are awaiting servicing.

Type of samples analysed: Freshwater, Wastewater and Bilogical material excluding Sludges and Sediments

Parameters analysed: Physical, Chemical, Biological and Metalic parameters.

Quality Assurance: Carries out internal control & self regualtion of technicians

Accreditation: No accreditation

Mine Safety Department Environmental Section Laboratory

Mission: The main mission of the laboratory is to analyse samples to ensure mining companies comply to relevant Act and Regulation.

Number of Personnel: Five professional, four Technicians and one supporting staff.

Equipment: The Laboratory has all the necessary equipment all in a good condition.

Type of samples analysed: Mainly Freshwater and Wastewater. Can also analyse, Sludges and Sediments

Parameters analysed: Physical, Chemical, Biological and Metalic parameters.

Quality Assurance: Not developed yet.

Accreditation: No accreditation

Institute of Environmental management Laboratory

Mission: The main mission of the laboratory is to analyse environmental samples.

Number of Personnel: Adequate qualified staff.

Equipment: The Laboratory has all the necessary equipment and are in excellent conditions.

CONCLUSION

All the five selected laboratory have accepted and will be willing to analyse our samples when the monitoring work commences. The status of all the laboratories is now well known. Among other thing all the laboratories are well equipped, however in order to know which laboratory can analyse samples to our expectation there is need to set up an external quality assurance and control programme among the selected laboratories. This programme is expected to commence in the first two weeks of June.

Appendix

2) Copy Report : Kashinga, C. and D. Nkolonganya. 1997. . Assessment of potential sampling points and establishment of discharge points for industrial/mining and sewage effluents into the Kafue River and its tributaries on the Copperbelt. ECZ Sept. 1997. 9 pp.

INDUSTRIAL POLLUTION PREVENTION PROGRAM

WATER QUALITY AND REGULATION PROJECT

REPORT ON

ASSESSMENT OF POTENTIAL SAMPLING POINTS AND ESTABLISHMENT OF DISCHARGE POINTS FOR INDUSTRIAL/MINING AND SEWAGE EFFLUENTS INTO THE KAFUE RIVER AND ITS TRIBUTARIES ON THE COPPERBELT.

PREPARED BY

Chris Kashinga
and
Douglas Nkolonganya

23rd September, 1997

EXECUTIVE SUMMARY

Effluent from mining/industrial activity and sewage treatment facilities, runoffs from mine tailings dams, farmlands and urban residential areas have been identified as the main sources of pollutants into the Kafue River and its tributaries in the project working area. The project area spans from Ranglans Farm in Chilabombwe to Ndubeni at Kafulafuta in Ndola rural.

Pollution emanating from run offs from farmlands and residential areas is especially apparent during the rainy season when rain water flows to streams, carrying along residual agrochemicals and waste from residential areas. The impact of such will be evaluated when the rains start. However, the impact of mining/industrial activity and raw or partially treated sewage on the quality of the water in the Kafue river spans all seasons although the volumes of the effluents are augmented by rain water in the rainy season.

Its for this reason that the program has started with a survey of all perennial effluent/waste water discharge points into the Kafue River and its tributaries.

References

Aanes, K. J., 1980. A preliminary report from a study on the environmental impact of pyrite mining and dressing in a mountain stream in Norway. In: Advances in Ephemeroptera Biology. Ed. John F. Flannagan and K. Eric Marshall. Plenum Publ. Corp., New York. Pp. 419 -442.

Hutchinson, G. E., 1975. A treatise on limnology. Vol. 1, part 2 – Chemistry of lakes. John Wiley & Sons. 1975. Pp. 541 – 1015.

Guerreiro, C. and B. Sivertsen. 1998. Ambient air quality monitoring system for Zambia. Mission Report no. 1 to Zambia Sep-Oct 1988.

Kashinga, C. and D. Nkolonganya. 1997. Assessment of selected laboratory in Copperbelt. ECZ May 1997. 6 p.

Kashinga, C. and D. Nkolonganya. 1997. Assessment of potential sampling points and establishment of discharge points for industrial/mining and sewage effluents into the Kafue River and its tributaries on the Copperbelt. ECZ Sept. 1997. 9 p.

Maucha, R., 1932. Hydrochemische Metoden in der Limnologi. Die binnengewässer, 12. Stuttgart, Schweizerbartsche Verlagsbuchhandlung, 173p.

Robertson, S., Kirsten. 1996. Environmental impact Statement, Mufulira Division, Mufulira Mining Licence Area – ML 15. Vol. 4.2. Appendices E-K. Environmental Engineering Studies.

Robertson, S., Kirsten. 1997. Environmental impact Statement, Nkana Division, Nkana Mining Licence Area – ML 3. Vol. 4.2. Appendices E-K. Environmental Engineering Studies.

Sinkala, T., 1998. State of the art on water quality of the Upper Kafue River, Zambia. Draft Report. ECZ April 1998.

Sorte, G. and K. J. Aanes. 1997. Industrial Pollution Prevention Programme (IPPP). Travel report. Visit to Environmental Council of Zambia 22.11.-06.12.1997.

Appendix

1) Copy Report : Kashinga, C. and D. Nkolonganya. 1997. Assessment of selected laboratory in Copperbelt. ECZ May 1997. 6 pp.

2) Copy Report : Kashinga, C. and D. Nkolonganya. 1997. . Assessment of potential sampling points and establishment of discharge points for industrial/mining and sewage effluents into the Kafue River and its tributaries on the Copperbelt. ECZ Sept. 1997. 9 pp.

3) Kalulushi laboratory, ZCCM. Analytical service facilities, price list and quality description.

4) Copperbelt University. Institute of Environmental Management – description and price list water analysis.

5) Meteorological stations Zambia with rainfall normals for Lusaka, Ndola, Kafironda and Solwez.

6) NCSR, Zambia. Environmental Research Laboratory : Charges for analytical services.

7) UNZA, University of Zambia. Laboratory for Environmental Engineering: Charges for water and waste water quality tests.

Appendix

1) **Copy Report : Kashinga, C. and D. Nkolonganya. 1997. Assessment of selected laboratory in Copperbelt. ECZ May 1997. 6 pp.**

INDUSTRIAL POLLUTION PREVENTION PROGRAM

WATER QUALITY AND REGULATION PROJECT

REPORT ON

ASSESSMENT OF SELECTED LABORATORY IN COPPERBELT

PREPARED BY

Chris Kashinga
and
Douglas Nkolonganya

May, 1997

SUMMARY

Before commencing with a monitoring programme for the upper Kafue river it was required that the quality standard of the selected laboratories be assessed and organise an inter-calibration. The assessment has been conducted by using questionares and holding discussions with the personnel of each of the selected labobratories. Among the Information collected include the following:

- Main objective/mission of laboratory
- Number of Professionals, Technicians and supporting staff
- The equipment used and its status
- The parameters analysed, method and detection limits
- Type of samples analysed
- Quality assurance and control measure followed.
- Accreditation of laboratories

The information collected will now enable the Water Quality & Regulation IPPP component team to draw up a programme of inter-calibration of the selected laboratories and work out a collective action plan among the stakeholders.

INTRODUCTION

Five laboratories have been selected in the Copperbelt province to be used for analysis of our water quality samples when the monitoring work commences. The Ndola City Council lab in Ndola, the Mine Safety dept. lab in Kitwe, the Copperbelt University Environmental lab, the Kalulushi Technical services lab and the Nchanga mine Analytical lab.

A four days trip was conducted to assess the status of the laboratories and to discuss the usage modalities. The information collected will help us in the linking of laboratories as regards quality control and assurance and working out a collective action workplan.

OBJECTIVES

The immediate objectives for the trip were:

- To collect information on the status of the selected laboratories.
- Discuss modalities for using the selected laboratory facilities and their services.

EXPECTED OUTPUTS

The expected outputs were:

- Information on the status of the selected laboratories collected
- Modalities for using laboratory facilities and services from selected laboratories worked out.

INFORMATION COLLECTED

Ndola City Council Laboratory

Mission: The main mission of the laboratory is to manage the quality of freshwater and wastewater.

Number of Personnel: One professional, four Technicians and two supporting staff.

Equipment: The Laboratory has all the necessary equipment, however, the Atomic Absorption Spectrophotometer and flame photometer are awaiting servicing.

Type of samples analysed: Freshwater, Wastewater and Bilogical material excluding Sludges and Sediments

Parameters analysed: Physical, Chemical, Biological and Metalic parameters.

Quality Assurance: Carries out internal control & self regualtion of technicians

Accreditation: No accreditation

Mine Safety Department Environmental Section Laboratory

Mission: The main mission of the laboratory is to analyse samples to ensure mining companies comply to relevant Act and Regulation.

Number of Personnel: Five professional, four Technicians and one supporting staff.

Equipment: The Laboratory has all the necessary equipment all in a good condition.

Type of samples analysed: Mainly Freshwater and Wastewater. Can also analyse, Sludges and Sediments

Parameters analysed: Physical, Chemical, Biological and Metalic parameters.

Quality Assurance: Not developed yet.

Accreditation: No accreditation

Institute of Environmental management Laboratory

Mission: The main mission of the laboratory is to analyse environmental samples.

Number of Personnel: Adequate qualified staff.

Equipment: The Laboratory has all the necessary equipment and are in excellent conditions.

Type of samples analysed: All types of samples

Parameters analysed: Physical, Chemical, Biological and Metalic parameters.

Analytical Services laboratory, Technical services

Mission: The main mission of the laboratory is to analyse mining samples and store data for all Mine Division.

Number of Personnel: 10 professionals, 10 Technicians and 5 supporting staff.

Equipment: The Laboratory has all the necessary and is operational.

Type of samples analysed: Freshwater, Wastewater, Bilogical material, Sludges and Sediments

Parameters analysed: Physical, Chemical, Biological and Metalic parameters.

Quality Assurance: Check samples as well as standard reference materials are incorporated in analysis.

Accreditation: BSEN ISO 9002 Quality system.

Nchanga Division Analytical Services Laboratory

Mission: The main mission of the laboratory is to analyse the quality of fresh water and wastewater samples taken by Nchanga mines.

Number of Personnel: 11 professional, 9 Technicians and 4 supporting staff.

Equipment: The Laboratory has all the necessary equipment and are operational.

Type of samples analysed: Freshwater, Wastewater and Bilogical material excluding Sludges and Sediments

Parameters analysed: Physical, Chemical, Biological and Metalic parameters.

Quality Assurance: Reference standards are used.

Accreditation: BSEN ISO 9002

INTRODUCTION

As a prelude to drawing a sampling Programme, a thorough understanding of sources of effluents, their points of discharge and receiving streams need to be acquired.

The water quality team surveyed all outside drains from all ZCCM's Divisions and their points of discharge into local streams and the Kafue river.

In addition all effluent discharge points from sewage treatment facilities were also surveyed.

OBJECTIVES

- identifying major sources and producers of liquid waste.
- establishing discharge points for liquid waste
- identifying local streams receiving effluents from producers of liquid waste.
- assessing potential sampling points on all local streams and the Kafue River
- assessing sampling points being used by ZCCM and local authorities.

Expected Outputs

- All major sources of liquid waste on the Copperbelt identified.
- All points of effluents discharge into the receiving streams and the Kafue river identified.
- All streams receiving effluents/wastewater of any sort identified.
- Sampling points being used by ZCCM assessed.
- the river system network in the project catchment area understood by the project team before drawing up a sampling programme.

ACTIVITIES - INFORMATION GATHERED

Chilalabombwe

Konkola Division (ZCCM) & Chililabombwe Municipal Council.

There are basically two types of effluents in Chililabombwe namely mine and sewage effluents and urban run off during the rainy seasons. The receiving streams are Lubengele and Kakoso.

1. Kakoso Stream

This stream receives all mine effluents via a combined drain.
The mine effluent comprises;

(i) excess underground water from the mine

(ii) all the water from surface drains in the plant

(iii) tailings from the concentrator

Kakoso stream also receives sewage effluents from Chilalabombwe Municipal Council ponds and ZCCM - Konkola Division ponds.

2. Lubengele Stream

Lubengele stream receives mainly run off from the residential areas and the plant during the rainy season.

Pollutants of concern

1. Suspended solids
2. Dissolved solids
3. Total coliform
4. Heavy metals

Both the Lubengele and the Kakoso streams are tributaries of the Kafue River .

3 Kafue River

Effluents from the Golf Course Oxidation Ponds are discharged straight into the Kafue River

Contact person at Konkola: Mr Machona Tel. 02/384221

Chingola -

Nchanga Division (ZCCM) and Chingola Municipal Council.

There are mainly three types of waste water streams discharged into local streams in Chingola and these are: Mine tailings, sewage effluents and run off from waste rock dumps.

1. Chingola stream

This stream receives mine effluents from the Tailings Leach Plant (TLP). The tailings are discharged into a Pollution Control Dam (PCD) before they are discharged into Mushishima river via a spillway.

The Mushishima River drains into the Kafue River.

2. Mushishima River.

The Mushishima receives effluents from the TLP through the PCD spillway.

The Mushishima drains into the Kafue River upstream of the two water intake points for the Chingola Municipal Council and ZCCM - Nchanga Division.

3. Nchanga Stream

The stream receives effluents from the concentrator and sewage from ZCCM - Nchanga Division sewage treatment facility. The water intake point for Chingola Municipal Council is located downstream of the Nchanga stream draining point into the Kafue River.

Pollutants of Concern.

1. Suspended solids
2 Dissolved solids
3. Heavy metals
4. Total Coliforms
5. Sulphates

Contact persons: Mrs S Chita - N. Division, Tel. 02 344481
Mr G Kalusa - C.M. Council, Tel 02 312199

Mufulira

Mufulira Division, Mufulira Municipal Council and Kafironda Explosives Co.

There are mainly two types of discharges into local streams namely sewage and mine effluents.

1. Mufulira stream

All mine effluents are discharged into the Mufulira stream which is a tributary of the Kafue River.

Sewage effluents from Butondo B area ponds, Kankoyo North and South Ponds and the Kantanshi Big ponds are also discharged into the Mufulira stream.

2. Luansobe stream

Luansobe stream only used to receive mine effluents from the Kankoyo shaft but the shaft has since been closed.. This means that no effluent/wastewater is discharged from this source into the Luansobe stream.

3. Kafironda stream

This stream used to receive effluent from Kafironda Explosive manufacturing company but the company has changed its technology to a zero discharge one as such no discharge of any kind is evident.

Contact Person: Mr O Malenga Mufulira Division Tel: 02/410586

Kitwe

Kitwe - Nkana Division (ZCCM), Kitwe City Council

Types of effluents in Kitwe include urban run-off, mine effluents, sewage and industrial effluents.

1. Mindolo stream

This stream receives underground water from the Mindola Shaft and also sewage from the Kitwe Teachers Training College.

2. Kitwe stream

The Kitwe stream receives effluents from industries such as Cadbury Scheweppes, National Breweries Ltd (NBL), Copperbelt Bottling Company, Barlows and many others which are not even licensed.

Whenever there is a leak on the sewer line which runs parallel to the stream, sewage is discharged into the Kitwe stream. The stream does not receive any mine effluent whatsoever. Urban run off from the town centre and the Chisokone market finds itself in the Kitwe Stream.

3. Wusakile stream

All effluents from No 4 Acid plant and the concentrator at Nkana mine are discharged into the Wusakile storm drain which eventually discharges into the Wusakile stream which is a tributary of the Kafue river.

4. Luanshimba stream

This stream receives effluent from the concentrator during the rainy season and whenever there is an operational problem in the plant.

5. Mululu stream

The Mululu stream serves as a sink for tailings overflow from Tailings Dam 33C (TD33C) as well as for run off during the rainy seasons.

6. Chibuluma stream

When effluent is discharged from TD33C, which is an emergency dam, the overflow is discharged into Mululu and Chibuluma streams.

7. Uchi Prior

Process wastewater from the smelter, cobalt plant, acid plant, refinery and plant drains flow in Uchi Prior before it is discharged into the Kafue river.

The Uchi prior comes as two drains from the plant which are the South and the North Uchi before they combine to give rise to the Uchi Prior drain.

Kalulushi

Chibuluma Mine

1 Fikondo stream

All excess underground water from No 7 shaft at Chibuluma Mine and all the sewage effluent from Chibuluma township is discharged into the Fikondo stream. Underflow from the Mindola dam also reports to the Fikondo Stream.

The Fikondo stream is a tributary of the Mwambashi river which is itself a tributary of the Kafue river.

Chambishi

Chambishi - Chambishi Mine, Kalulushi Municipal Council.

1. Chambishi stream

This stream recieves process water from Chambishi mine and all plant drains. The chambishi stream drains into the Mwambashi river which in turn drains into the Kafue.

2. Musakashi stream

All tailings from the Cobalt Plant at Chambishi are conveyed to the Musakashi dam via a pipeline. Water flows from Musakashi dam as the Musakashi stream and drains into the Kafue river.

3. Lulamba stream

The Lulamba stream receives raw sewage from the Chambishi township (mine and council) and drains into the Kafue river.

Contact Person: Mr Mphish

Luanshya

Luanshya Mine

Tailings from Luanshya Mine are pumped to Musi dam 81/2 km from the plant. Whenever there is a pump failure, pipeline rupture or thickener failure in the plant, the tailings are discharged directly into the Luanshya river.

1 **Luanshya river**

The river receives tailings from the plant in emergency cases. The Luanshya river is a tributary of the Kafubu river, which itself drains into the Kafulafuta which is a tributary of the Kafue river.

2. **Nkulumashiba stream**

The Nkulumshiba stream receives sewage effluents from the 750 Mpatamata ponds and discharges into the Kafue.

3. **Fisanas stream**

Undergrund water from shaft No. 18 through stations No. 7421 and 743 is discharged into Finsansa stream.

Contact Person Mr N Phiri. Tel 02/544196

FUTURE TRIPS

We intend to wind up the survey with a one week visit to Kitwe and Ndola to specifically look at Industrial discharges into local streams and the Kafue river.

In the meantime we are making arrangements for a Stakeholders workshop scheduled for 26th - 28th November, 1997 in Livingstone.

Achievements

The team managed to survey all discharge points for Mine effluents and sewage effluents in the following towns; Chingola, Chililabombwe, Mufulira, Luanshya, Kalulushi and Kitwe.

Constraints

Due to limited time in Kitwe the survey was limted to mine effluents and sewage while industrial effluents where overlooked. The City of Ndola was not surveyed at all, for the same reason.

Appendix

3) Kalulushi laboratory, ZCCM. Analytical service facilities, price list and quality description.

ZAMBIA CONSOLIDATED COPPER MINES LIMITED
OPERATIONS CENTRE - TECHNICAL SERVICES
P O Box 260071
Kalulushi
Zambia
Tel : +260-2-748046 Fax: +260-2-733697

ANALYTICAL SERVICE FACILITIES

INTRODUCTION

The Analytical Services Department of the Technical Services Function of Zambia Consolidated Copper Mines Limited (ZCCM) is based at Kalulushi and forms part of the Operations Centre of the Company. The laboratory provides comprehensive analytical services to other departments of the Centre. These departments include Metallurgical Investigations, Engineering, Environmental and Mining Services. Analytical services are also provided to the Operating Divisions of the Company and are further extended to outside organisations.

Departmental activities include sample preparation, analysis, storage and documentation in respect of samples from metallurgical testwork, process and troubleshooting, geological project survey, investigation of plant component failures, quality assurance testing of new products, biological specimens, non-routine samples from allied industries involved in various engineering and chemical manufacturing processes.

Classical and instrumental methods are employed to meet the varied requirements commensurate with the broad spectrum of clients, the choice of technique being dependent upon the nature of sample, analyte and its level of concentration. The Department is adequately equipped and the most commonly used instruments include X-ray fluorescence spectrometers, optical emission spectrometer, flame atomic absorption spectrophotometers (AAS), graphite furnace AAS with Zeeman background correction, infrared spectrophotometer, inductively coupled plasma optical emission spectrometer, Leco carbon and sulphur analyser and Leco induction furnace with autotitrator.

Certificate No. FM 26316

QUALITY

The quality of service is monitored and controlled through collaborative in-house laboratory exchange programmes coordinated by the laboratory at Corporate level and third party reference through umpire laboratories at international level. A fully documented Quality System has been established in the Department which, as an absolute minimum, complies with the requirements of the BS EN ISO 9002 Quality System Standard. The Department gained accreditation to this standard on 18 November 1993. As a requirement of the accreditation, the BSI Quality Assurance Auditors assess the department's performance at six monthly intervals.

Enquiries to:

The Head of Analytical Services
Zambia Consolidated Copper Mines Limited
Operations Centre - Technical Services
P O Box 260071
Kalulushi
Zambia
Tel: +260-2-748046 **Fax: +260-2-733697**

1.0 ANALYTICAL FEES

1.1 Sample Preparation

	US $
Drying	1.00
Crushing	3.00
Milling/Splitting/Homogenising	3.00
Screen Analysis	3.00

Charges apply to a sample of 5Kg or less. Larger samples will attract an additional US $0.50 per Kg.

1.2 Sample Storage

Samples are stored free of charge for periods as specified in our ZCCM Standard Method of Analysis No. 132: "Retention of Samples in Analytical Services Laboratories". Thereafter, samples will be discarded unless instructions for continued storage are received. A fee of US $5.00 per box will be levied every six months.

1.3 Water Analysis

1.3.1 *Domestic Water/Full Potability Tests*	*US $*
pH, Conductivity, TDS, TSS, Al, As, Cd, Co, Cr, Cu, Fe, Mg, Mn, Pb, Se, Zn, Cl_2, SO_4^{2-}, NO_3^-, NO_2^-	160.00

1.3.2 *Boiler Water*	*US $*
pH, Conductivity, TDS, Total alkalinity, Total hardness, Cl^-, SO_3^{2-}, PO_4^{3-}, L.I.	50.00

1.3.3 ***Metallurgical Process Solutions and Effluent Samples***

		US $
pH		3.00
Conductivity		3.00
Residual chlorine		3.00
TDS		6.00
TSS		6.00
Total element (except As, Bi, Se, Sb, Sn, Hg)		9.00
Dissolved element (except As, Bi, Se, Sb, Sn, Hg)		9.00
Ca hardness		6.00
Total hardness		6.00
Total alkalinity		6.00
Sulphate (SO_4^{2-})		9.00
Sulphite (SO_3^{2-})		9.00
Nitrite (NO_2^-)		12.00
Nitrate (NO_3^-)		12.00
Chloride (Cl^-)		12.00
Phosphate (PO_4^{3-})		12.00
Fluoride (F^-)		12.00
Cyanide (CN^-)		12.00
As, Bi, Se, Sb, Sn, Hg each		12.00

1.4 **Precious Metals**

		US $
Au		15.00
Ag		12.00
Ag + Au		25.00
Pt		15.00
Pd		15.00
Au + Pt + Pd		40.00

1.5 **Ores and Metallurgical Plant Products**

1.5.1 ***Series 1:***

		US $
Al, Bi, Ca, Cd, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Na, Zn	1st element	12.00
	Each additional element	10.00

1.5.2 ***Series 2:***

		US $
As, B, Ba, Be, Cr, In, Li, Mo, N, P, Sb, Se, Si, Sn, Te, Ti, V, W	1st element	15.00
	Each additional element	12.00

1.5.3 ***Series 3:***

	US $
Acid soluble copper	10.75
Each additional element	9.00

1.6 **Hydride Generation/Cold Vapour - Solid Samples**

		US $
As, Bi, Se, Sb, Sn, Hg	1st element	20.00
	Each additional element	15.00

1.7 **Combustion Techniques**

	US $
Carbon, Sulphur	15.00

1.8 **Infrared Analysis**

	US $
Qualitative Identification	20.00
Entrained organic content	15.00

1.9 **Oils and Related Materials**

1.9.1 ***Rubbers***

	US $
Total sulphur	12.00
Sulphur of Vulcanisation	12.00
MgO	12.00
ZnO	12.00

1.9.2 ***Oils***

	US $
Zn or any other metal by AAS	12.00
S by Lab-X2000 (XRF)	15.00
Sulphated Ash	12.00

1.10	**Coal and Coke**	*US $*
	Ash content	3.00
	Volatile matter	3.00
	Moisture content	3.00
	Proximate Analysis	20.00
	Ultimate Analysis (C, H, N)	30.00

1.11	**Geochemical Exploration Samples** (Soils and sediments)	*US $*
	Co, Cu, Fe, Mn, Ni, Pb, Zn	50.00

1.12	**22 Elements by ICP Optical Emission Spectrometry** (Geochemical Exploration Soils and sediments)	*US $*
	Ag, Al, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Li, Mg, Mn, Mo, Na, Ni, Pb, Ti, Tl, V, Zn	120.00

1.13	**22 Elements by ICP Optical Emission Spectrometry** (Geochemical Exploration Liquor Samples)	*US $*
	Ag, Al, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Li, Mg, Mn, Mo, Na, Ni, Pb, Ti, Tl, V, Zn	100.00

1.14	**Steel/Alloy Analysis for 15 Elements by Spark Emission Spectrometry**	*US $*
	C, Si, Mn, P, S, Cr, Mo, Ni, Al, B, Co, Cu, Ti, V, W	100.00

2.0 OTHER CHARGES

2.1 *Administrative Charges*

A charge is levied for each batch of samples submitted irrespective of batch size or sample type as follows:-

	US $
Handling charges including results by fax/post	20.00

2.2 *Umpire or Arbitration Samples*

An additional charge of 100% of the normal amount is made.

2.3 *General*

The Analytical Services Department is equipped to carry out certain analyses other than those listed in this document, and has access to laboratories elsewhere. Special rates can be agreed upon for large batches of samples exceeding 20. Please contact us to discuss your specific requirements.

PRICES EXCLUDE VAT

ALL FEES ARE EFFECTIVE AS FROM 1 APRIL 1998

TJP/dmc

Appendix

4) Copperbelt University. Institute of Environmental Management – description and price list for water analysis.

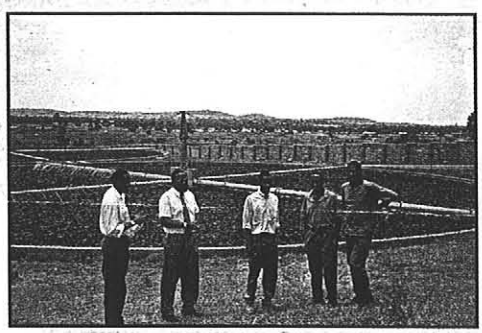
INSTITUTE OF ENVIRONMENTAL MANAGEMENT

"The Habitat - Our Concern"

THE INSTITUTE

The Institute of Environmental Management is a non profit non-governmental organization based within Copperbelt University (CBU). The Institute aims to contribute to the environmental sustainability of Zambia and the Southern Africa region through human resource development in the area of environmental technology. In particular, the Institute's objectives are:

- facilitate the flow of environmental knowledge;
- provide environmental training and experiences;
- offer short courses and workshops;
- engage in pure and applied research;
- undertake environmental research projects and related testing and monitoring.



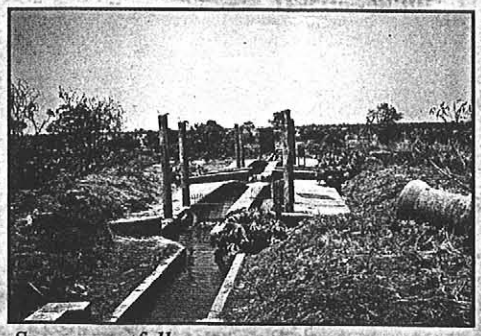
Ndola waste treatment plant

Water treatment plant maintenance

MISSION

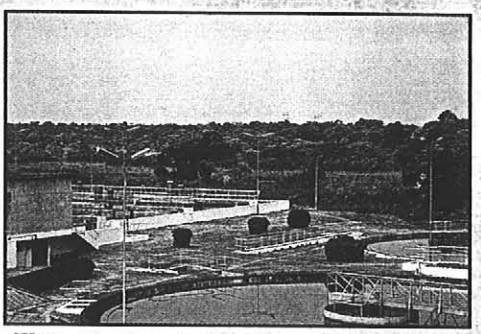
The mission of the Institute of Environmental Management is to promote environmental training, studies, research, and public education in environmental technology and environmental management in Zambia with particular emphasis on environmental problems and issues in the Copperbelt region of the country. Its mandate is to develop sustainable environmental training programmes and services that respond to the needs of the general public, private industries, and public sector organizations within the Copperbelt region as well as in the rest of Zambia and Southern Africa.

Ndola water intake

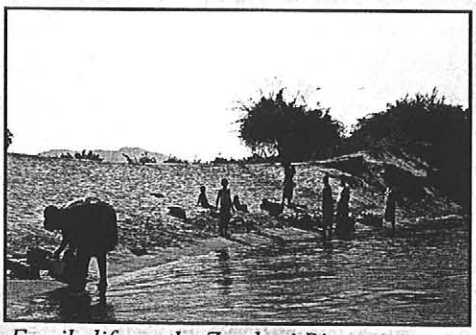


Sewage outfall

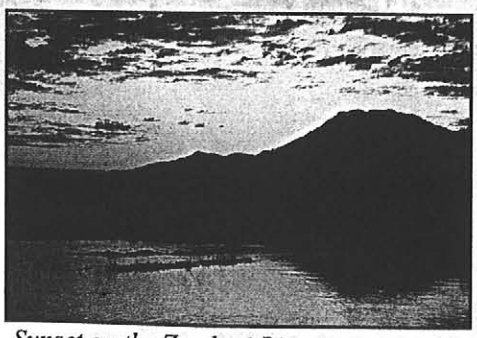
Water Hyacinth in a lagoon



Water treatment plant



Family life on the Zambezi River



Sunset on the Zambezi River

HISTORY

The Institute of Environmental Management was developed from the Association of Canadian Community Colleges (ACCC) Water and Waste Management Project funded by the Canadian International Development Agency (CIDA).

Based on regional requirements for industrial, public and private environmental training and need for a regional, non profit, non-governmental environmental research and testing facility, the Institute of Environmental Management was established in 1997.

To realize the establishment of the Institute of Environmental Management, it was essential to have the cooperation, funding and assistance of the Higher Diploma studies, a Norwegian Agency for Development (NORAD) project and the Chemical Engineering Diploma, Environmental Technology option.

OBJECTIVES

The main objectives of the institute are:

Public Service

- Facilitate the flow of environmental knowledge between the university and the broader community, including governments (national and municipal), the private and public sectors and the general public at large.
- Make the public aware of environmental problems and the need for a clean environment.

Formal Education

- Provide theoretical and practical environmental training and experiences for degree and diploma students at the Copperbelt University.

Extension Training

- Offer local industries' needed short courses and workshops that will develop competent environmental personnel within the region.
- Upgrade current employees so that industries can meet and comply with Zambia's environmental legislation and the legislation governing the Southern Africa region.
- Offer short courses, workshops and seminars on international environmental protocols, declarations and problems.

Research

- Engage in pure and applied research related to the management of Zambia's environment and the environment of the Southern Africa region.
- Facilitate interdisciplinary collaboration for research and instruction on matters relating to the environment and related human interactions, using current university expertise and resources.

Consulting

- Undertake environmental research studies and projects for external clients on a contract basis.
- Provide environmental testing and monitoring services for external clients on a fee-for-service basis.
- Provide advice on environmental matters and problem solving.

The Institute of Environmental Management has six (6) main programmes as follows:

1) Environmental short courses, seminars and workshops for both private industries and public sector organizations.
2) Practical environmental training for CBU students.
3) Environmental awareness education events and programmes.
4) Environmental testing and monitoring services for external clients.
5) Applied research studies and projects for private and public sector organizations and groups.
6) Environmental information clearinghouse.

Mine tailings

RESPONSIBILITIES AND RELATIONSHIPS

The Institute is responsible for:

- Maintaining and managing its own finances and generating funds as a non profit, non-governmental, self funding organization.
- Promoting contract work with outside groups including testing and monitoring services.
- Undertaking special research projects and consultancies.
- Maintaining the environmental laboratory and classroom equipment.
- Developing and offering high quality and timely short courses, seminars and workshops to external groups/clients
- Establishing an environmental laboratory and classroom schedule that allows the university to train diploma and degree students during the academic session.

Slag heap from copper mine

Partnership

- The Institute's success and continued progress will be based on a foundation of cooperation and sharing with its partners. A list of partners will include partnerships within the university system, industry, commerce, non-government organizations and government. The Institute will strive to actively seek out potential contract work and employee training with industry partners and identify their needs on a continual basis.

Raw sewage stream

ORGANIZATION STRUCTURE

Advisory Board

Terms of Reference

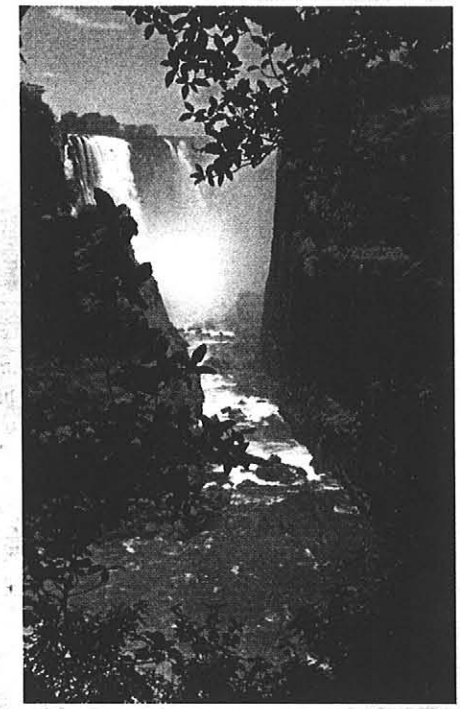
- To advise and assist the Management Team of the Institute as to achievement of the goals and objectives.
- To assist in the development of philosophies and directions of the Institute.
- To insure the management, operations and fiscal functions of the Institute are transparent.
- To identify markets for the Institute programmes.
- To seek local and international funding for the Institute.

Solid waste in city centre

Composition

- The Advisory Board is comprised of eight (8) members of whom five (5) come from outside the university.

Solid waste dumping site



Address: Institute of Environmental Management
C/O School of Technology
PO Box 21692 Kitwe, Zambia

Telephone: 02-228212/02-222066/02-222194
Fax: 02-222469

E-mail: cbu@zamnet.zm
Subject: Institute of Environmental Management

Communications should be addressed to the Director

Produced by

Association of Canadian Community Colleges

Algonquin College
College of the North Atlantic
Lethbridge Community College
Northern Alberta Institute of Technology
University College of Cape Breton

NOTE This document presents the conceptual and operational guidelines of the Institute of Environmental Management at the Copperbelt University. Being a new institution and undergoing constant refinement some provisions are subject to change by the Advisory Board at anytime.

INSTITUTE OF ENVIRONMENTAL MANAGEMENT

"The Habitat - Our Concern"

Institute of Environmental Management
C/O School of Technology
PO Box 21692 Kitwe, Zambia

Telephone:02-228212/02-222066/02-222194
Fax:02-222469
E-mail:cbu@zamnet.zm
Subject: Institute of Environmental Management
Communications should be addressed to the Director

WATER ANALYSIS PRICE LISTING

JULY 1,1998

1. Domestic Water - Partial Potabilility Test — K80,000.00

   pH, Conductivity, Total Dissolved Solids,
   Total Suspended Solids, Turbidity,
   Total Coliform Count, Fecal Coliform Count,
   Nitrate, Nitrite, Sulphate, Chlorine, Fluoride.

2. Industrial Process Solutions and Effluents — K120,000.00

   pH, Conductivity, Total Dissolved Solids,
   Total Suspended Solids, Nitrate, Nitrite,
   Sulphate, Chlorine, Phosphate, BOD
   Dissolved Oxygen, Total Coliform Count
   Fecal Coliform Count

3. Boiler Feed Water — K40,000.00

   pH, Conductivity, Total Dissolved Solids,
   Total Suspended Solids, Total Hardness
   Sulphate, Chlorine, Phosphate.

4. Parameters

Test	Cost (Kwacha)
BOD	30,000.00
Calcium Hardness	5,000.00
Chlorine	3,000.00
Conductivity	3,000.00
DO	3,000.00
Fecal Coliform Count	25,000.00
Flouride	7,000.00
[illegible]	7,000.00
Nitrite	7,000.00
pH	3,000.00
Phosphate	7,000.00
Total Coliform Count	25,000.00
Total Dissolved Solids	5,000.00
Total Hardness	5,000.00
Total Suspended Solids	5,000.00
Tuirbidity	3,000.00

Charges will be constantly reviewed and adjusted according to prevailing costs of reagents and related testing costs.

1 US $ ≈ 2000 Kwacha

Appendix

5) Meteorological stations Zambia with rainfall normals for Lusaka, Ndola, Kafironda and Solwez.

Meteorological stations Zambia.

CLICOM ID	1ST(°C) YEAR	MM	1ST(mm) YEAR	MM	LAT. DG	MN	LONG. DG	MN	ELEV. (m)	STATION NAME					
'CHIPAT01'	1973	01	1973	01	13	33	32	35	1032	' CHIPATA MET '					
'CHOMA001'	1973	01	1973	01	16	51	27	04	1267	' CHOMA MET '	'1278?				
'ISOKA001'	1973	01	1973	01	10	10	32	38	1360	' ISOKA MET '					
'KALABO01'	1973	01	1973	01	14	57	22	42	1053	' KALABO MET '	'14 59	22 38	1278?		
'KABOMP01'	1973	01	1973	01	13	36	24	12	1075	' KABOMPO MET '					
'KABWE001'	1973	01	1973	01	14	25	28	29	1165	' KABWE MET '					
'KABWE002'	1973	01	1973	01	14	24	28	30	1207	' KABWE AGROMET '					
'KAFIRO01'	1973	01	1973	01	12	36	28	07	1243	' KAFIRONDA AGROMET '					
'KAFUE001'	1973	01	1973	01	15	46	27	55	987	' KAFUE POLDER '					
'KAOMA001'	1973	01	1973	04	14	48	24	48	1152	' KAOMA MET '					
'KASAMA01'	1973	01	1973	01	10	13	31	08	1384	' KASAMA MET '					
'KASEMP01'	1973	01	1973	01	13	32	25	51	1134	' KASEMPA MET '					
'KAWAMB01'	1973	01	1973	01	09	48	29	05	1324	' KAWAMBWA MET '					
'LIVING01'	1973	01	1973	01	17	49	25	49	986	' LIVINGSTONE MET '					
'LUNDAZ01'	1973	01	1973	01	12	17	33	12	1143	' LUNDAZI MET '					
'LUSAKA01'	1973	01	1973	01	15	25	28	19	1252	'LUSAKA CITY AIRPORT '					
'LUSAKA02'	1973	01	1973	01	15	19	28	27	1154	'LUSAKA INT. AIRPORT '					
'MAGOYE01'	1973	01	1973	01	16	08	27	38	1018	' MAGOYE AGROMET '					
'MANSA001'	1973	01	1973	01	11	06	28	51	1259	' MANSA MET '					
'MBALA001'	1973	01	1973	01	08	51	31	20	1673	' MBALA MET '					
'MFUWE001'	1973	01	1973	01	13	16	31	56	570	' MFUWE MET '					
'MISAMF01'	1973	01	1973	01	10	11	31	13	1535	' MISAMFU AGROMET '					
'MONGU002'	1973	01	1973	01	15	15	23	09	1053	' MONGU MET '					
'MPIKA001'	1973	01	1973	01	11	45	31	26	1402	' MPIKA MET '					
'MSEKER01'	1973	01	1973	01	13	39	32	34	1025	' MSEKERA AGROMET '					
'MTMAKU01'	1973	01	1973	01	15	33	28	15	1213	' MT. MAKULU AGROMET '					
'MUMBWA01'	1973	01	1973	01	14	59	27	04	1218	' MUMBWA MET '					
'MWINIL01'	1973	01	1973	01	11	45	24	26	1363	' MWINILUNGA MET '					
'NDOLA001'	1973	01	1973	01	13	00	28	39	1270	' NDOLA MET '					
'PETAUK01'	1973	01	1973	01	14	15	31	17	1036	' PETAUKE MET '					
'SAMFYA01'	1973	01	1973	01	11	21	29	32	1172	' SAMFYA MET '					
'SENANG01'	1973	01	1973	01	16	07	23	16	1027	' SENANGA MET '					
'SERENJ01'	1973	01	1973	01	13	14	30	13	1384	' SERENJE MET '					
'SESHEK01'	1973	01	1973	01	17	28	24	18	951	' SESHEKE MET '					
'SOLWEZ01'	1973	01	1973	01	12	11	26	23	1333	' SOLWEZI MET '					

```
'ZAMBEZ01'  1973 01  1973 01  13 32  23 07  1078  '    ZAMBEZI MET      '
'GWEM2558'  1973 01  1973 01  16 30  27 36  0000  ' GWEMBE BOMA AGRIC  '
'GWEM5022'  1973 01  1973 01  16 16  28 25  0000  '   CHAANGA AGRIC     '
'GWEM5195'  1973 01  1973 01  16 39  27 47  0000  '  GWEMBE-MUNYUMBWE   '
'GWEM5310'  1973 01  1973 01  17 12  27 30  0000  '   BULEYA MALIMA     '
'GWEM5320'  1973 01  1973 01  17 20  29 12  0000  '  MAAMBA COLLIERY    '
'GWEM5322'  1973 01  1973 01  17 25  27 12  0000  '                     '
'KABW0420'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KABW0425'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KABW0549'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KABW2228'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KABW2440'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KABW2459'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KALO5559'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KALO5640'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KATE1165'  1973 01  1973 01  00 00  00 00  0000  '                     '
'KATE1399'  1973 01  1973 01  00 00  00 00  0000  '                     '
'LUAG0230'  1973 01  1973 01  00 00  00 00  0000  '                     '
'LUAG8661'  1973 01  1973 01  00 00  00 00  0000  '                     '
'LUSA2175'  1973 01  1973 01  00 00  00 00  0000  '                     '
'MAZA2423'  1973 01  1973 01  00 00  00 00  0000  '                     '
'MKUS0680'  1973 01  1973 01  00 00  00 00  0000  '                     '
'MKUS0850'  1973 01  1973 01  00 00  00 00  0000  '                     '
'MONZ2577'  1973 01  1973 01  00 00  00 00  0000  '                     '
'NAMW2800'  1973 01  1973 01  00 00  00 00  0000  '                     '
'PETA0195'  1973 01  1973 01  00 00  00 00  0000  '                     '
'LUSITU01'  1980 10  1988 10  00 00  00 00  0392  '   LUSITU MET        '
'MKUSHI01'  1993 01  1993 01  00 00  00 00  1250  '   MKUSHI MET        '
'MANSA002'  1991 10  1991 10  00 00  00 00  0000  '   MANSA AGROMET     '
'CHIPEP01'  1993 07  1993 07  00 00  00 00  0000  '   CHIPEPO MET       '
```

5-Year Rainfall Normals (mm)	LUSAKA CITY AIRPORT Lat: 15° 25'S Long: 28° 19'E Elevation: 1252 m Period: Jul 1993 - Aug 1998												
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Monthly Mean	0	0	1	14	73	92	214	141	44	34	2	0	611
Monthly Max	0	0	7	39	114	149	297	217	91	107	12	0	825
Year of Max	1993	1993	1993	1994	1993	1996	1997	1996	1996	1997	1996	1994	1996/97
Monthly Min	0	0	0	0	42	20	92	73	6	0	0	0	405
Year of Min	1993	1993	1994	1993	1995	1995	1995	1994	1994	1996	1994	1994	1994/95
Daily Max	0	0	7	31	48	60	50	46	30	76	7	0	
Day of Max	1	1	30	23	28	31	9	10	2	1	25	1	
Year of Max	1993	1993	1993	1994	1993	1997	1998	1997	1996	1997	1996	1994	
Raindays ≥1mm	0	0	0	1	7	10	15	14	6	1	0	0	54
Raindays ≥5	0	0	0	1	7	10	15	13	5	1	0	0	52
Raindays ≥10	0	0	0	1	6	9	13	13	5	1	0	0	48
No of Years	5	6	5	5	5	5	4	4	5	4	5	5	4.8

4-Year Rainfall Normals (mm)	NDOLA MET Lat: 13° 00'S Long: 28° 39'E Elevation: 1270 m Period: Jul 1993 - Jul 1998												
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Monthly Mean	0	0	6	26	151	250	252	258	148	29	7	0	1122
Monthly Max	0	0	10	93	231	411	381	357	222	47	19	0	1314
Year of Max	1993	1993	1997	1994	1995	1995	1997	1995	1998	1997	1996	1994	1995/96
Monthly Min	0	0	0	1	23	119	160	157	103	1	0	0	908
Year of Min	1993	1993	1993	1993	1994	1994	1995	1998	1994	1995	1994	1994	1994/95
Daily Max	0	0	8	76	90	60	56	51	60	29	15	0	
Day of Max	1	1	19	31	26	31	10	1	16	4	20	1	
Year of Max	1993	1993	1995	1994	1995	1993	1997	1994	1998	1997	1996	1994	
Raindays ≥1mm	0	0	1	3	13	21	22	22	13	3	1	0	99
Raindays ≥5	0	0	1	3	12	19	21	20	12	3	1	0	92
Raindays ≥10	0	0	1	2	11	17	20	18	11	2	1	0	83
No of Years	6	4	4	4	4	4	4	5	5	4	4	4	4.3

5-Year Rainfall Normals (mm)	KAFIRONDA AGROMET Lat: 12° 36'S Long: 28° 07'E Elevation: 1243 m Period: Jul 1993 - Aug 1998												
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Monthly Mean	0	0	12	19	127	239	322	354	168	19	11	0	1266
Monthly Max	0	0	57	67	181	343	436	401	307	69	38	0	1205
Year of Max	1993	1993	1997	1994	1997	1996	1998	1994	1998	1997	1996	1994	1996/97
Monthly Min	0	0	0	1	47	149	206	155	33	3	0	0	985
Year of Min	1993	1993	1993	1996	1996	1995	1996	1997	1994	1996	1995	1994	1995/96
Daily Max	0	0	38	37	83	62	91	58	61	31	13	0	
Day of Max	1	1	19	31	19	15	10	19	17	4	19	1	
Year of Max	1993	1993	1997	1994	1995	1997	1998	1994	1996	1997	1996	1994	
Raindays ≥1mm	0	0	1	4	12	18	25	24	15	5	1	0	105
Raindays ≥5	0	0	1	3	10	17	23	23	13	3	1	0	94
Raindays ≥10	0	0	0	3	9	16	21	22	13	2	1	0	87
No of Years	6	6	5	5	5	5	5	3	5	5	4	4	4.8

4-Year Rainfall Normals (mm)	SOLWEZI MET Lat: 12° 11'S Long: 26° 23'E Elevation: 1333 m Period: Jul 1993 - Aug 1998												
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Monthly Mean	0	0	2	17	155	263	301	197	307	19	8	0	1264
Monthly Max	0	0	4	48	235	309	499	203	327	29	24	0	-999999
Year of Max	1993	1993	1997	1994	1997	1996	1998	1994	1998	1994	1996	1994	1996/97
Monthly Min	0	0	0	0	69	181	177	185	137	8	0	0	999999
Year of Min	1993	1993	1994	1996	1996	1995	1996	1997	1997	1998	1994	1994	1994/95
Daily Max	0	0	3	21	65	74	72	39	84	9	11	0	
Day of Max	1	1	29	27	19	10	28	13	15	19	25	1	
Year of Max	1993	1993	1993	1993	1997	1996	1998	1995	1998	1994	1996	1994	
Raindays ≥1mm	0	0	1	3	13	22	26	23	18	4	1	0	111
Raindays ≥5	0	0	0	3	10	21	25	20	18	4	1	0	102
Raindays ≥10	0	0	0	3	10	20	22	18	18	3	1	0	95
No of Years	4	5	4	5	5	4	5	4	3	2	3	4	4.0

Appendix

6) NCSR, Zambia. Environmental Research Laboratory : Charges for analytical services.

NATIONAL COUNCIL FOR SCIENTIFIC RESEARCH

ENVIRONMENTAL RESEARCH LABORATORY

REVISED CHARGES FOR ANALYTICAL SERVICES - 1997

DRINKING WATER COST PER SAMPLE

	(Cost) K
pH	4,500
Conductivity	4,500
Turbidity	4,500
Total Suspended Solids	4,500
Total Dissloved Solids	4,500
Chloride	13,000
Sulphate SO_4	8,000
Nitrate (NO_3^-)	8,000
Calcium Hardness	12,000
Total Hardness	12,000
Sodium	10,000
Potassium	10,000
Magnesium	12,500
Calcium	12,500
Iron	15,000
Manganese	15,000
TOTAL	**165,500**

MICROBIOLOGY

			Cost (K)
Plate Count	22°C		15,000
Plate Count	37°C		15,000
Coliforms			20,000
E. Coli			25,000
		Total	75,000
		TOTAL	**240,000**

NOTE: *LABOUR CHARGE*

Labour charge for any analysis	**K 30,000**
GRAND TOTAL	**K 270,000**

Appendix

7) UNZA, University of Zambia. Laboratory for Environmental Engineering: Charges for water and waste water quality tests.

Fees for water and waste water quality tests – 1st June 1998
Laboratory of Environmental Engineering
UNZA

Physical

Parameter	Price	Method
pH	4500	Electrometric
Turbidity	5500	Photometric
Conductivity	4500	Electrometric
Total dissolved solids (TDS)	6500	Gravimetric
Total suspended solids (TSS)	6500	Gravimetric

Chemical

Parameter	Price	Method
Total hardness	7000	Titremetric
Ca Hardness	7000	Titremetric
Carbonate hardness	7000	Titremetric
Iron	11000	Phenanthroline spectrophotometric
Ammonium	8000	Nessler spectrophotometric
Sulphate	11000	Turbidimetric
Chloride	7000	Titremetric
(Residual) Chloride	2500	Comparator
Fluoride	11000	Electrometric
Nitrate	11000	Electrometric
Dissolved Oxygen	4500	Winkler
Nitrite	11000	Spectrophotometric
(Ortho-) Phosphate	11000	Vanamolybdic spectrophotometric
Total Phosphate	11000	Vanamolybdic spectrophotometric
Chemical Oxygen Demand	20000	Dichromate spectrophotometric
Metals	8000 first 1500 others	Atomic absorption Spectrometric

Micro-biological

Parameter	Price	Method
Biological Oxygen Demand	17000	Winkler
Total coliforms	7000	Membrane filtration
Faecal coliforms	6000	Membrane filtration
Faecal streptococci	7000	Membrane filtration
Fungi/Yeast count	7000	Pour plates
Plate count	7000	Pour plates