EARTHWATCH

GLOBAL ENVIRONMENT MONITORING SYSTEM

GEMS
REPORT SERIES
NO. 12

NAIROBI
SEPTEMBER 1992

WHO/WMO/UNESCO/UNEP

GEMS/WATER

Report of a workshop on water quality monitoring and assessment
23 March - 3 April 1992, Arusha, Tanzania

with project sponsorship from
FINNIDA
and in collaboration with
The ROBENS Institute of Health and Safety, University of Surrey
and
Hydrometeorological Survey Project, Nile Basin

Editor: Jamie Bartram, Robens Institute

United Nations Environment Programme

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Preface

The World Community faces many environmental and developmental problems of which pollution of freshwater is not the least. Freshwater is a finite resource, essential for agriculture, industry and human existence. Without water of adequate quantity and quality sustainable development is not possible.

As part of the global community's effort to address issues associated with the sustainable development and management of freshwater resources, UNEP and WHO, in cooperation with WMO and UNESCO, initiated in 1977 the first global programme on monitoring of water quality in rivers, lakes and reservoirs, and groundwater: the GEMS/Water programme.

The GEMS/Water programme is a component of the UN-system wide Global Environment Monitoring System which aims at providing, through monitoring and assessment the data and information required to support sustainable and rational management of natural resources.

GEMS/Water now has 15 years of substantive achievements behind it. In 1991, the second phase of the programme was launched to better adapt the programme to the changing needs of the decade ahead.

The workshop on water quality monitoring and assessment, held in Arusha, Tanzania from 23 March to 3 April 1992, mainly for the Nile riparian countries, is one of the many activities conducted during the first two years of the implementation of phase II of the programme. This publication constitutes the report of that meeting.

The report summarises the workshop objectives, technical programmes, major findings and recommendations. It contains reports on the status of water quality monitoring in the participating countries, as well as proposals for country action plans for the next six to nine months.

It is hoped that this report will carry forward the success of the workshop and further support the strengthening of water quality monitoring and assessment capabilities in the Nile riparian countries and the regional cooperation initiated at Arusha.

I wish to thank the Robens Institute of Health and Safety, University of Surrey, the United Kingdom, for its excellent organisation of the workshop and for the production of this report; FINNIDA, the development aid agency of Finland for its financial support and input to the draft handbook used at the workshop, and Hydromet as a co-organiser and the regional focal point for the participation of the Nile riparian countries in the global GEMS/Water programme. I also wish to express my sincere thanks to all participants, for their active participation and contributions which made this workshop such a success.

M. D. Gwynne
Assistant Executive Director, UNEP
&
Director
Global Environment Monitoring System

Summary

The GEMS/Water Workshop on Water Quality Monitoring and Assessment was held at the Training Centre for Development Cooperation, Arusha, Tanzania from 23rd March to 3rd April 1992. It was attended by 23 participants from 10 African countries (Burundi, Egypt, Ethiopia, Ghana, Kenya, Nigeria, Rwanda, Sudan, Tanzania, Uganda) and a group of international experts. A complete list of participants is presented in Annex 1.

The meeting was organised by the Robens Institute of the University of Surrey, UK with the Hydromet Survey Project on behalf of UNEP and WHO with financial support from FINNIDA.

The event had an ambitious series of objectives. These included the review of the first draft of a new Manual on Water Quality Monitoring which had been specifically developed for use in Africa. Strengthening of national water quality monitoring and assessment capabilities was also planned and undertaken through the provision of training and of a forum for discussion and fostering of regional cooperation. Participants also prepared workplans for improvement of water quality monitoring in their countries within their own fields of responsibility. These identified limitations to water quality monitoring and outlined key actions necessary to overcome them. Furthermore, it was intended that the event would provide impetus for GEMS-Water in the region, both through heightening awareness at the level of the participants and through the raised profile generated by the participation of international dignitaries in the initiation of the course. Finally, in order to further regional cooperation participants revised and amended a proposal for submission to the Global Environmental Facility and proposed that a follow up event be undertaken within a year of the course.

The draft Manual on Water Quality Monitoring which had been prepared before the course was reviewed. This had been drafted with support from FINNIDA and was intended to present the key basic information relevant to the design and implementation of monitoring and assessment in the context of water resource management in Africa. The review was undertaken through evening groupwork sessions and discussions by two groups. One group dealt primarily with the technical details of the chapters and provided chapter-by-chapter recommendations. The other group dealt with the overall review of the manual and considered structure, content, omissions, redundancy, presentation and level of detail. The detailed comments of the two groups are presented as Appendix 6. The review was concluded with a general discussion which identified the following major points:

1) The manual met the minimum needs of monitoring orientated exculsively towards the GEMS-Water programme but several key additions were necessary to ensure that it was generally applicable for the development of national monitoring programmes in Africa;

2) Two major areas of omission were identified which should be addressed by the addition of entirely new chapters. These chapters should cover firstly practical aspects of running a water quality monitoring programme (including management, infrastructure, staffing, inter-institutional coordination and logistics); and secondly application of data to management of water quality issues in African countries.

3) There was concern that the focus of the Manual be more clearly defined in terms of target audience, content, level of detail and scope;

Training provided during the course covered chemical, physical, microbiological and biological monitoring both in the laboratory and in the field; consideration of aspects of surface and ground water characteristics with emphasis on sampling; data interpretation and transfer both within national programmes and between these and the GEMS-Water Global Data Centre. Teaching and discussion incorporated formal presentations, discussions, field work and demonstrations.

The course received considerable attention within Tanzania and contributed to increasing international awareness of the need for water quality monitoring and assessment and the GEMS-Water programme. The inaugural event was opened by the Tanzanian Minister of Water, Energy and Minerals, and attended by the Ambassadors of Rwanda and Sudan, the High Commissioner of Uganda and a representative of the Embassy of Zaire as well as representatives of relevant UN agencies (WHO, FAO, WMO and UNDP).

Participants from each country worked together during the course to develop 'country workplans'. Each of these was specific to the area of responsibility of the participants themselves. The workplans outlined water quality monitoring and assessment activities, taking acccount of national

participation in the GEMS-Water programme, identified key limitations to the effectiveness of these proposed activities for the coming 12 month period, which would help to overcome these and summarised anticipated outputs for this period.

The relevance of the Global Environment Facility (GEF) for monitoring activities necessary for management of the major African watersheds the region was discussed and a funding proposal previously drafted by UNEP covering three watersheds (Nile, Niger and Zambesi) was reviewed and amended. This proposal was then discussed with the GEF adviser for international waters, further modified and forwarded to GEF for consideration and is presented as appendix 7 to this report.

Major recommendations emerging from the course included:

1) the need to promote regional cooperation;

2) the need to overcome funding restraints with special reference to transport and procurement of equipment and consumables;

3) enhanced communication (within the region and with international centres);

4) the need for training to focus on African issues;

5) the need to enhance the awareness of decision makers regarding the importance of water monitoring, assessment and management issues;

6) the advisability of a follow-up meeting to further foster national and regional activities, provide further training and continue handbook review following field testing;

7) the need for additional training; priority areas included AQA/QC, especially training for local application; biological monitoring; field techniques; sediment sampling; and data management.

Immediate outputs of the course include an exhaustive review of the 'Manual on Water Quality Monitoring'. National capabilities for water quality monitoring and assessment have been strengthened though the provision of training and regional cooperation fostered through the provision of a forum for discussion and exchange of experiences. The GEMS-Water programme itself has also been strengthened through exposure of both participants and regional dignitaries.

In the medium term, the recommendations of the manual review process will be incorporated and the second draft of the manual subject to field testing in the region prior to final publication. The workplans produced during the course and equipment to be provided will ensure that national monitoring and assessment activities will be consolidated and expanded. Finally, in the longer term, the GEF proposal developed at the course should provide a focus for further regional coordination and if approved will assist in overcoming some of the limitations common to the countries of the region.

Collecting depth samples from Duluti Lake

Testing for nitrate in water using a colour-match comparator

Collecting a sample for investigation of the macroinvertebrates in a shallow water course.

I Opening of the Workshop

Mr. S. G. Mkuchu, Director of Operation, Maintenance and Water Laboratories for MAJI Tanzania, acted as master of ceremonies, introducing first Mr. Birger Egekvist, Principal of the MS/Training Centre for Development Cooperation, who welcomed the guests and participants and described the increased importance of international training and development workshops in the work of the Centre.

Mr. M. Tawfik, Director of the Hydromet Survey Project, thanked the Minister for attending the inauguration and thanked UNEP/GEMS for their efforts in organising the workshop. He stressed the importance of workshops in regional co-operation and spoke of the importance of water in human society, saying that despite the achievements of the UN Water Decade substantial progress needed to be made in the future. He encouraged the participants to obtain the maximum benefit from the workshop and to use the experience gained in their national programmes.

Dr Veerle Vandeweerd of UNEP, GEMS-PAC, welcomed the participants on behalf of UNEP, the UNEP Executive Director, (Dr. Mostafa Tolba) and the Director of GEMS, (Dr. M. Gwynne). She thanked the Tanzanian Government, the TCDC and the funding agency, FINNIDA. Dr Vandeweerd acknowledged the role of the Robens Institute, University of Surrey and welcomed the UN agency representatives and Hydromet staff. She emphasised the importance of the quantity and quality of water resources in sustainable development. Reliable monitoring data is essential for effective resource management and Dr. Vandeweerd outlined the progress of GEMS/Water in the development and support of monitoring and assessment in participating countries. She described co-operation between GEMS/Water and Hydromet and spoke of the important roles of the workshop in fostering regional co-operation and in reviewing the new handbook of water quality monitoring. The workshop is intended to be the first of a number of support activities for GEMS participation in the countries of the Nile region and in Nigeria and Ghana

His Excellency the Ambassador for Rwanda, Mr. Thomas Munyanenza, thanked the Minister, UNEP and the workshop organisers for their efforts, stressing the importance of water resource development in Rwanda.

His Excellency the Ambassador for Sudan, Mr, Charles Manyang D'Awol wished the workshop a successful outcome and spoke of the unique nature of water in development and of the great importance of co-operation on shared international water resources,

His Excellency the High Commissioner for Uganda, Mr. Ben Matogo, welcomed the opportunity to speak in the inauguration. He spoke of the special need in Uganda to supplement existing efforts for conservation and water resources management. Uganda has abundant water resources but is vulnerable to fluctuating availability of water owing to meteorological variation. Government and people are making great efforts to harness natural water resources for the benefit of humans and animals.

The representative of His Excellency the Ambassador for Zaire, Professor Asangama spoke of the importance of water resources and of Zaire's programmes in conservation and environmental protection. He emphasised the value of co-operative programmes and looked forward to future workshops in French.

Dr. E. A. Duale, World Health Organization Representative for Tanzania and Seychelles, welcomed all present on behalf of WHO. He spoke of the health and development roles of water quality management and hoped that the workshop would aid the formulation of programmes for water resource management.

Mr Shalid Najam, the deputy representative of the Food and Agriculture Organization in Dar-es-Salaam, in his address, thanked GEMS and the course organisers for inviting the FAO to the inauguration ceremony. He stressed the importance which the FAO places on water quality monitoring, assessment and water resource management, in striving to reach sustainable agriculture and the alleviation of poverty and malnutrition in FAO member states. The FAO provides assistance to the Tanzanian government for a variety of programmes, including village irrigation schemes, especially for smallholders and women. The FAO believes that there is also enormous scope for collaboration with GEMS in Tanzania. Mr Najam wished the participants of the course a useful and beneficial stay and hoped that the course would enable them to apply new techniques to both regional and country specific situations.

Mr. Paul Matovu, UNDP Assistant Regional Representative, communicated the apologies of the UNDP Representative for Tanzania who regretted his inability to attend owing to previous commitments. UNDP supported the workshop and endorsed the efforts of UNEP, WHO, WMO, FAO and UNESCO in GEMS/Water. UNDP considers water an important sector for support, welcomed progress in Tanzania in water development and would be interested in the follow-up activities to the workshop. These would be considered as priorities for support in the next five year assistance plan. Mr. Matovu noted the presence of the Ambassadors and the Minister as evidence of the growing importance of water resources management in the region.

Mr. Mkuchu invited the Honourable Jakaya M. Kikwete MP, Minister for Water, Energy and Minerals for the Republic of Tanzania to open the Workshop. The Minister said that he was honoured to open the GEMS/Water Workshop on Water Quality Monitoring and Assessment and welcomed everybody to Arusha on behalf of the Government of Tanzania. He thanked the Arusha Regional Authorities, the TCDC and the people of Arusha for their hospitality. He spoke of the importance of water pollution control in ensuring good human health and stressed the importance of the workshop. Tanzania has played a strong role in monitoring, analysis and data submission in GEMS/Water and has welcomed regular feedback on results. The Minister outlined the aims of the workshop and noted the opportunity for the countries of the region to cooperate within the GEMS/Water objectives. He pointed out the critical importance of water in society and requested assistance in further building national capability. The workshop should address practical and infrastructure needs, the Minister said, and the Governments of the region looked forward to the results. The Government of Tanzania would make every effort to implement recommendations, he said. The Minister concluded with thanks to UNEP, the Robens Institute, the Ambassadors and the TCDC for their efforts. He then declared the workshop officially open. (A transcript of the Minister's speech is presented as annex 3).

Demonstration of the Oxfam-DelAgua Water Testing Kit

II Proceedings of the Workshop

II.1 Participants Introduction
Jamie Bartram

Following the formal introduction to the workshop, the participants were introduced. Each participant was asked to interview his or her neighbour for five minutes and to investigate their name, job, their expectations of the workshop and a personal detail of some type. Each participant then gave a short introduction of their neighbour to the workshop participants.

II.2 Workshop Objectives & Structure
Jamie Bartram

Following the introductions of the participants, minor changes to the workshop programme were agreed in order to reflect the participants perceived needs from the workshop.

The workshop was then introduced in the context of an initiative comprising, three key activities:

1. The development of a handbook appropriate for East African conditions

2. The provision of top-up training

3. To give momentum to the GEMS-Water Programme in the region.

In order to achieve the latter, time would be dedicated to the development of country work plans and of a regional strategy for water quality monitoring. Furthermore, some support would be available for provision of key items of equipment.

The workshop would begin with introductory sessions: between participants; of GEMS-Water; to the workshop and to the *Manual on Water Quality Monitoring*. On the second day, the workshop would cover aspects of laboratory development and monitoring. From the third day activities would focus on analytical aspects. On Wednesday and Thursday, physical and chemical analysis in conjunction with consideration of the lake environment would be covered. On Friday, hydrology and groundwater would be covered and the theme of laboratories continued in analytical quality control and quality assurance. Work at the weekend would be limited to a half day on Saturday during which priorities for laboratory development in each of the participating countries would be identified. During the second week the analytical work would continue on Monday and Tuesday covering microbiology and biomonitoring linked to considerations of river environments. By Wednesday of the second week consideration of analytical aspects and laboratory development would be completed and the remaining time would be dedicated to: data handling, statistics and reporting; water quality assessment; development of sampling networks, development of country workplans; and general recommendations from the workshop.

Theory, practical and field work would be balanced in an 8am to 5pm day. In addition to this, short groupwork sessions would be held each evening. These would be used to consider especially the review of the handbook - both chapter-by-chapter and overall in terms of content and structure. Group work sessions would also be used for the development of country plans and the development of regional strategy.

The workshop would therefore be very intensive and it was important to recognise the desired outputs of the workshop. These were summarised as:

- manual review
- overall (content, depth)
- chapter-by-chapter
- planning for field-testing over next six months
- training (top-up, of participants)
- development of country workplans (which should not be vague, but which will ensure that significant quantities of real data would be produced (this would be linked to identifying key equipment shortfalls)
- work towards a regional strategy. The role of Hydromet as a regional organisation should assist this.
- a report on the workshop (which would serve to increase awareness at various levels)
- planning towards a further meeting in perhaps six to nine months, for further assessment of the manual considering information management in more detail, and exchanging experience gained in the interim.

II.3 Progress Evaluation
Chair: Jamie Bartram
Rapporteur: Joseph Boutros

After completion of one week of the workshop, the objectives of the training workshop were recalled in order to evaluate the progress achieved towards fulfilling each of them. The objectives were:

Review of the *Manual on Water Quality Monitoring*;
Training;
Country action plans;
Regional strategy;
Report;
Need for further meeting;
Regional and inter-regional cooperation.

Review of the Manual of Water Quality Monitoring

Participants were working in two groups. The first group had reviewed chapter 2 and were about to complete the revision of the whole structure of the book and the parts which were omitted from the present draft. The second group had reviewed chapters 1,3,4 and 5.

The revision of the handbook was progressing as planned. Five chapters out of ten had been reviewed during the first week of the workshop.

Training

Since the training was still halfway and many subjects were not yet covered, the achievement of training goals could not be assessed. Nevertheless the following comments were received on the training:

- lectures should emphasise field experience and practical aspects.
- sampling techniques were new to most participants
- practicals were especially useful to non-analysts

Regional Strategy

The first group had prepared a regional strategy plan which would be submitted to the workshop organisers.

Report on Training Course

The report was being prepared and was expected to be ready at the end of the workshop. It was agreed that the report should contain the outputs of the handbook review; the country reports and action plans, and an outline of the workshop as delivered.

Further Meeting

The participants agreed that a further meeting in a few months time would be required to be conducted in East Africa in order to:

- Review the Regional Strategy
- Evaluate the execution of action plans and discuss experience.
- Comment on the *Manual on Water Quality Monitoring* and the participants comments after actually trying it.

In selecting the venue for the next meeting it would be advantageous to hold it near Lake Victoria due to its importance and possibly, in a country with little GEMS-Water activity to date, in order to maximise the benefit of the publicity generated nationally.

Regional and Inter-regional Cooperation

Communications between countries and regional and international organisations is hindered by the lack of facilities. The meeting discussed the various possibilities and found that E.Mail has problems while the facsimile is considered to be generally effective, does not present many problems and is relatively less expensive. It was recommended that facsimile facilities be established in GEMS/Water national focal points to facilitate coordination and communications where they do not already exist.

II.4 Workshop Evaluation

A workshop evaluation was performed, the findings of which are presented as Annex 8 to this report.

II.5 General Recommendations for Future Development

After the training workshop had almost been completed and after reviewing the *Manual on Water Quality Monitoring* the participants made the following recommendations which were aimed at improving the GEMS/Water project and national water quality monitoring programmes.

1. In addition to the national GEMS/Water centres, there is a need to form Regional Co-ordinating Centres. Some of the activities of the Regional centres could include:

   To organise training
   To standardise methods used in GEMS/Water for the particular region
   To identify and standardise equipment required by projects

2. In order to overcome existing problems in executing GEMS/Water it may be advisable to form a trust fund specifically for the African region. This fund would be used in the purchase of laboratory consumables, equipment and training.

3. There is an urgent need to improve communication networks between GEMS/Water Stations and with international agencies.

4. GEMS/Water co-ordinating activities within a regional co-ordinating centre should be executed by a team of experts of GEMS/Water nominated from participating countries of the Regional Co-ordinating Centre.

5. In order to improve GEMS/Water monitoring performance there is a necessity to arrange from time to time courses, seminars and/or workshops. These events will enable participants to exchange experience, learn new techniques and address GEMS/Water common problems calling for joint action. Sediment sampling, biomonitoring and a follow up meeting after the review of the manual are specific areas meriting attention.

6. Since the Draft GEMS/Water *Manual on Water Quality Monitoring* is intended for use in the African Region, it would have been better if people from the continent had contributed to it.

7. In order for the GEMS/Water project to succeed, there is need for it to be supported by policy makers. This calls for them to be made aware of the project and the role they are expected to play. Such an exercise could best be achieved if a workshop for policy makers is organised.

8. On circulation of the final report of the workshop it was recommended that the report be submitted to the Ministry or organisation which had sent representatives to the workshop through the Chief Executive of the Ministry or organization. Copies can then be sent to any interested party such as Technical Committee Members of the Hydromet Survey Project.

III Water Quality Monitoring and Assessment

III.1 Introduction to GEMS/Water

Martial Dray and John Jackson

GEMS/Water, the global freshwater quality monitoring programme, was the first programme to examine the quality of the world's fresh waters and began in 1977. The basic objectives of the programme from its inception have been to support and strengthen national networks for water quality monitoring and to establish a global basis for collection and comparison of water quality data.

In the 1970s and 1980s, Africa tackled the problem of water quantity. In the 1990s water quality is fast becoming a parallel priority. A number of water management problems are of particular importance for Africa. For example, poor water quality associated with inadequate sanitation is a continuing concern, especially for ground water deterioration in vulnerable fissured aquifers.

Discussion of water quality problems should not focus exclusively on drinking water. Other sectors - such as agriculture and industry - are significant consumers and polluters of water. Nevertheless, poverty remains a key issue in water quality management - the poor may not be able to afford the improved water supply and sanitation necessary for improvement of human health and environmental quality. In many cases, they are obliged to drink freely available water of dubious quality from ponds, swamps and rivers.

There are increasingly urgent needs for effective legislation and regulations to maintain environmental quality. However, continuity and availability of water quality data have remained problematical, impeding effective management in part because of inter-institutional conflicts and limited resources.

In theory, there should be sufficient quantities of water to meet the needs of Africa's population but migration to coastal areas and cities is leading to problems such as water shortage and saline intrusion into coastal aquifers.

Phase II of GEMS/Water was initiated in 1990. The programme was revised to meet changes in national and global needs for water quality monitoring data and to strengthen and develop the themes of Phase I. Phase II objectives emphasise assessment of water quality status, trends and their causes, the geographical setting of water quality issues and the provision of information for effective management. In addition, more emphasis will be placed on the fluxes of nutrients and pollutants to the sea from large river basins. A continuing fundamental objective of the programme is to support and strengthen national water quality monitoring programmes including provision of technical assistance and international cooperation.

Sampling station categories have been modified to meet the revised objectives. Baseline stations, situated on water bodies isolated from direct human influence, will continue to supply background data on of natural water quality and global trends. Trend stations will monitor water quality trends and status in drainage basins exposed to human activities. Global river flux stations will be sited at the mouths of major rivers to monitor fluxes of nutrients and pollutants from the basin to the sea. Increased attention will be given to the development of ground water monitoring and multimedia techniques.

A number of assessment activities have been planned, some of which have produced results such as *Water Quality Assessments*. A revised *Operational Guide* and newsletters have been produced and data quality assurance will continue. One of the initial activities in Phase II has been the production of the GEMS-Water *Manual on Water Quality Monitoring*, under discussion in the workshop.

Discussion

Participants addressed the question of how GEMS/Water Phase II could be implemented in Africa. Significant influences included poor follow-up by international agencies; the past lack of emphasis on monitoring in aid programmes (which is now being addressed with greater realism and as a higher priority); and the low priority accorded to environmental monitoring by governments. Funding was said to be a central problem - environmental protection was frequently displaced in government funding priorities by more politically pressing problems. Training was also identified as a continuing necessity. The presence of the Minister and Ambassadors at the inauguration was cited as an example of the increasing political priority given to water resources and water quality management. Drinking water quality was highlighted alongside general water quality. The importance of initiating monitoring within limited resources was discussed and the flexibility of the GEMS/Water programme cited as useful in this respect. The present workshop was part of the forward strategy and aimed to identify, discuss and outline implementation of important issues for national networks and GEMS/Water as a whole.

III.2 Hydrology, Water Quality and Environment
Naginder S Sehmi

The science of hydrology deals with water on the hard surface: its occurrence, circulation, distribution, chemical and physical properties; and its interaction with the environment including living things. The World Meteorological Organization (WMO) is responsible for promoting and strengthening the national agencies dealing with operational aspects of hydrology (networks, data processing, design data, forecasting) leading to the assessment of the quantity and quality of water.

Adverse economic conditions are the root cause of the trend towards the "close to collapse" state of these agencies. Water quality monitoring is still in its infancy in Africa. These being non-revenue producing activities, they are usually starved of the necessary funds. At the same time many countries are faced with increased demands for data for national development projects and the international programmes such as GEMS and Climate Change.

In recent years flash floods and deteriorating quality of water in urban and industrialised regions have begun to have serious environmental impacts in Africa. Water quality and quantity in natural water courses are inter-related and reduction in basic water quality data and research activities can adversely affect formulation of development projects.

About 40 per cent of the WMO technical cooperation funds are used for national and regional projects dealing with water resources. The Hydrometeorological Survey of Lakes Victoria, Kyoga and Mbutu Sese Seko (HYDROMET) is an outstanding example of such assistance.

Government funding for monitoring may be obtained by undertaking studies, reporting to government and making recommendations. The responsibility for proposing such reports and studies lies with national experts themselves. Dependence on external expertise will not lead to sustainability of the national agency concerned, both in terms of funds and competence.

Monitoring is non-revenue producing and generally presents a low priority for government funding when compared with, for example, water supply, health services, poverty alleviation etc. Thus, it is rarely possible to obtain funds to generate data with which to prepare studies and reports. It is generally necessary to undertake monitoring and produce studies and reports in order to obtain funding.

Discussion

Data and findings - which should come first? It was agreed that some data and reporting needed to come first in order to facilitate aquistion of funding.

III.3 GEMS-Water Network

Parameters Considered in GEMS/Water
Martial Dray.

The choice of analytical variables is linked to the objectives of monitoring and to the pollution suspected. It is therefore related to the type of station: baseline station, trend station or global flux station.

1. For baseline stations it is only necessary to consider basic elements and a limited number of variables, including some metals of global importance for health.

2. For trend stations it is necessary to check factors which may influence water quality in the catchment. Thus, additional variables deal with:

   Organic pollution
   Irrigation
   Agrochemicals
   Toxic industrial effluent
   Mining pollution
   Acidification

3. Global flux stations are situated on continental water discharge into the sea or major lakes.

   In this case, in addition to the basic variables information is needed about flux, ie, the discharge of the river itself and of main contaminants - organic and metallic, dissolved and particulate.

A description of the basic variables was presented, indicating for each one, the origin of the element and also any negative effects on humans, animals and vegetation.

Selection of Global Network Stations
Martial Dray

A presentation of the total network of stations was displayed and which new monitoring stations are expected for the end of the second phase. Following previous discussions, a detailed definition of baseline stations was provided.
The GEMS/Water project objectives were also outlined. It was recalled that the global water quality monitoring is based on the active participation of

member states which routinely monitor the quality of their water resources at selected locations.

The global major quality issues were presented according to their importance, and magnitude. In turn, these were contrasted with the African Water Quality as highlighted by the first phase of GEMS/Water.

The presentation concluded by looking at what useful output could be expected from GEMS-Water activities for participating countries and what feed-back its national programmes should anticipate. Support for development of national capabilities was also discussed.

Hydrometric Data Requirements for the GEMS Water Programme
Martial Dray

Rivers are a reflection of the environment and the condition of a catchment area, integrating water quality influences. It is therefore necessary to measure, evaluate and calculate the flux of contaminants at the outflow of a river basin. During the second phase of GEMS/Water, a large number of African river stations will be added to the programme in all categories of station. This leads to the necessity of obtaining hydrological data from gauging stations at sites for water level control and discharge control.

If we wish to focus on metal and organic contaminants, sampling particulate matter and total suspended solids (TSS) is required. This in turn requires appropriate instrumentation.

For mass flow computation, time series data are necessary, together with information on other elements of the river basin, such as quantity, intensity and duration of precipitation. Information on topography, mean altitude, river classification or stream order, water level of lakes and ground waters are also needed. Sampling methodology, frequency and site selection were outlined.

Additional points of importance are:

- Curve stage/discharge, highlighting the problem of hysteresis and the stability of the rocky threshold.

- Methods for discharge measurements (mechanical, chemical and isotopic)

- The understanding of floods through hydrograph separation.

It was emphasised that the frequency of analyses given by GEMS/Water are guide values and should be adapted to local or national conditions.

Discussion
The question was raised of the effectiveness of cooperation between those responsible for managing quantity and quality of water. It was felt by most speakers that in the countries of the region, co-operation was generally good and that hydrographical information was provided in a form useful to water quality managers.

III.4 River Monitoring
Martial Dray

Key elements of river monitoring such as site refinement, sampling facilities and sampling devices were presented and the detailed recommendations made in this regard in the *GEMS/Water Operational Guide* explained. Additional recommendations were made, based on personal experience of sediment transport in small watersheds in France.

For frequency of sampling it was particularly underlined that it must be adapted to each case in relation to knowledge of the physical parameters of the river.

For guideline values, reference was made to the WHO *Guidelines for Drinking Water Quality* and for the other uses (agriculture, aquatic environment) reference came from recent publications (89-91) and standards from other countries.

Three case studies of polluted rivers were presented, these being the River Morogoro (Tanzania), the Indius (Pakistan) and a collection of 10 major rivers in Thailand.

Discussion
After presentation of the paper a discussion followed. Participants wanted to know:-

1. The relationship between velocity, discharge and water level with regard to sediment sampling frequency.

2. The importance of water quality indices.

3. The proper definition for a baseline station.

On the relationship between velocity, discharge and water levels in rivers as it influences sampling frequency, the most important sediments influencing water quality are fine sediments which contain for instance nitrates, phosphorus, heavy metals and organic substances. In order to identify the sampling frequency for a river, one needs to sample very frequently until it is established which sampling period gives the maximum fine sediments. Such an exercise is also determined by the ability of the sampling office and available financial resources.

On water quality indices an explanation was given that they provide very useful information on the various uses of water depending upon the quality.

On the proper definition of a baseline station, there was a prolonged debate. It was finally agreed that, for the purposes of GEMS/Water, a baseline station is a station located in an area where there are no local sources of contamination of the water source.

III.5 Lake Monitoring
John Jackson

Lakes share some features with rivers. However, their different physical, chemical and biological characteristics mean that lakes are used in unique ways, respond in particular ways to pollution and require specific monitoring and management strategies. A lake is part of a drainage basin and effective management of quantity and quality must be at the basin level.

The fundamental elements of lakes are their physical characteristics - bathymetry, inflows and outflows of water, residence times, water balance and water movements. Water currents - both horizontal and vertical (thermally-induced), have dominant roles in the movement of water, nutrients and contaminants. Thermal stratification may occur at certain times - poor circulation results and the layers above and below the thermocline may develop different chemical characteristics with important implications for water quality. The mixing of tropical lakes takes a number of forms.

The trophic status of lakes is a basic element in water quality assessment - eutrophication from high nutrient inputs is of increasing concern in many parts of the world. Chemical changes and the responses of biological community may have severe effects on quality which, when combined with physical stratification, lead to further difficulties such as oxygen depletion and release of toxic substances from sediment.

The design of sampling programmes depends upon the selection of objectives. Surveys of physical, chemical and biological characteristics are valuable for understanding individual lakes and are essential for analysis of impacts and effective management. Monitoring may be undertaken to identify quality status and long and short term trends. The use of such programmes, adapted to the particular characteristics of a lake, can lead to source control and water quality management, both for the lake and for the drainage basin as a whole.

Discussion
The water balance equation which had been presented was discussed.

Sampling depth in relation to the thermocline, as proposed in the draft manual was also discussed. The manual suggested that samples should be taken one metre above and one metre below the thermocline. In practice, sampling would depend on the gradient of the thermocline and sampling to such a high degree of precision was dependent on a very clearly defined thermocline.

III.6 Ground Water Monitoring
Martial Dray

Groundwater is a component of a catchment area and should be considered as such.

- water quality relies mostly on geology, and tectonics -
- peizometric maps promote understanding of ground water flow
- pumping tests give information on permeability and porosity (or storage characteristics).
- the relationship between surface water (river or reservoir) and groundwater must always be controlled.
- Isotope techniques can be used for determination of the origin of water (O-18) and sometime for indicating the presence of old ground waters (for example in the Nubian Sandstones along the Nile).

The minimum annual sampling frequency is twice, once at low level and once at high level of the water table, but varies with the size of the aquifer and degree of fissuring, especially for karstic aquifers.

Discussion
It was generally felt that faecal contamination of ground water was an important issue in the region, especially for shallow wells. Latrines were cited as a primary source of contamination in rural areas, while in urban areas infiltration from dams and industrial pollution from storage facilities such as grease pits

were of increasing concern. The need for legislation and regulation of industrial activity was highlighted. It was suggested by some participants that enterprises which drilled wells were not thorough enough in researching possible polluting influences in the area of a planned borehole.

III.7 Biological Monitoring
John Jackson

Biological monitoring is in essence the examination of biological responses to environmental conditions, either natural or anthropogenic. In the same way that chemical analyses are indicators of pollution presence and effects, so biological techniques can provide sensitive indicators of the environmental effects of human activity. It must be stressed that for effective management, biological and chemical techniques should be used in parallel. Many uses of water are biological - degradation of organic wastes, fisheries or human drinking water, for example - and poor water quality has significant impacts on these uses. Water quality is a factor of many chemical variables which interact in a complex ecosystem - biological monitoring gives a direct indicator of effects which can be of great use in management.

Biological monitoring demonstrates an integrated response to the range of chemical substances in the water and integrates this response over time. It may be significantly cheaper than physico-chemical analyses and may indicate where physico-chemical monitoring may be most effectively conducted. However, the credibility of biological methods depends on expert design and periodical review, particularly to ensure that the methods can screen out natural variability. Understanding natural processes of ecosystems is necessary to the design of new methods.

A basic division of biological techniques into tissue analysis, toxicity testing, environmental toxicology, community effects and biological indices was made for the purposes of the presentation. Particular attention was given to the discussion of diversity indices as indicators of community change and examples from the River Lee in London were described. Such discussion provided the basis of the practical work to be undertaken. Diversity indices generally assume that as pollution stress increases, diversity decreases.

Biological monitoring has arisen from the recognition in management of the biological basis for use - concepts of quality are increasingly being based upon biological effects in a number of countries.

Discussion
After the lecture, since biomonitoring was a new subject to most participants of the workshop, the discussion centred on how useful biomonitoring is in water quality monitoring compared to usual techniques of monitoring water quality by laboratory analytical methods.

III.8 Microbiological Monitoring
Jamie Bartram

Indicators and Methods
Jamie Bartram

Water-borne infectious disease is a severe global problem and is due to a wide range of pathogens including bacteria, 'parasites' and viruses. Methods for quantifying many of these pathogens may be slow, expensive or non-existent. However, risk is largely associated with the presence of faecal contamination and it is therefore accepted practice to rely on indictors of faecal contamination to determine the hygienic quality of water.

The ideal characteristics of a faecal indicator organism were outlined and contrasted with the most commonly used indicators. The general appropriateness of *E.coli* was emphasised and the acceptability of faecal coliforms as a substitute highlighted. The use of other indicators under special circumstances and for certain purposes was mentioned and emphasis given to faecal streptococci and sulphite-reducing clostridia.

The membrane filtration and most probable number techniques for microbial enumeration were outlined and the advantages and disadvantages of each discussed.

Discussion
The following questions were raised:-

1. The MPN method takes some days before one can get results. What should one do in an area which does not have a reliable power supply in order to obtain reliable bacteriological results.

2. Bacteriological water analysis in developing countries are hampered by the high costs of the media and their preservation. What should be done?

3. The difference between coliform and coliphage.

On what to be done with the MPN method which is long and needs a constant power supply, it was explained that the availability of power problem can be overcome since equipment is now available for MF testing which incorporates rechargeable batteries and furthermore, there are a number of methods developed to reduce the number of steps normally required as outlined in the draft *Manual on Water Quality Monitoring*.

On the high costs of media and difficulties in preserving bacteriological water samples. It was explained that although costs are high in developing countries which import them, they are cheaper in the countries where they are produced. The cost of a membrane filter in East Africa was quoted as US Dollar 1.0 while in the UK it costs US Dollars 0.20. Similarly, short shelf-life of media bought in ampoules could be overcome by selection of culture media which were more stable and were supplied in small quantities of powder in sealed containers.

On the difference between coliforms and coliphage it was clarified that coliphage are considered especially useful as indicators of virus survival. This indicator had advantages and disadvantages and is as yet not recommended for routine use.

On-site Microbiological Testing/Sample Preservation For Microbiological Analysis
Jamie Bartram

The difficulties encountered in preserving samples for microbiological analyses were presented and options for overcoming them discussed.

Obtaining reliable results for microbiological analyses depends on very rapid sample processing (for instance within two hours) or adequate sample preservation and transport. Adequate sample preservation requires rapid cooling. Plunging sample bottles into a mixture of ice and water is appropriate, but placing sample bottles in a cold box with 'ice pax' would not produce the rapid cooling necessary.

In light of the above, the advantages of on-site testing for microbiological analyses were discussed. Various portable kits are now available which enable on-site sample processing. Most incorporate an incubator and some also include a rechargeable battery enabling operation where electricity supplies are unreliable.

Sampling procedures for microbiological analyses were also discussed at length and particular emphasis given to obtaining representative samples and avoiding contamination during the act of sampling.

The advantages and disadvantage of laboratory or field bacteriological testing; were discussed and consensus reached that this depends upon circumstances. If samples can be transported to the laboratory in less than four hours then laboratory analysis is adequate, and may be preferred. If a longer time is required, then samples may be preserved in an iced cool box and transported to the laboratory as fast as possible or processed on-site. However, if one is in a situation where even preserved samples will not reach the laboratory within the required time then bacteriological analysis should be carried out in the field.

Microbiological Sampling: Sampling, Sample Preservation and Transport and On-site Testing.
Jamie Bartram

The need to minimise sample storage times and for samples to be rapidly cooled was highlighted and the implication of this for sampling strategies outlined.

The advantages of on-site testing using portable equipment were outlined with respect to minimising sample deterioration and sometimes - reducing transport requirements. The wide variation in characteristics of different on-site testing kits were mentioned and the desirability of independence from unreliable mains electricity supplies mentioned.

If transport of samples to a centralised laboratory were contemplated, then bottles reserved exclusively for microbiological testing should he sterilised before use and kept clean during transport. Bottles should have screwcaps and often incorporate a cover. Labels on bottles should include the time of sampling.

Key aspects of sampling procedure which differ from those for other analyses were mentioned.

Field Trip and Field Measurement
Jamie Bartram, John Jackson

The workshop participants travelled to Usa River in order to sample the lake and its inflowing and outflowing streams for microbiological control and for biological determination.

The group was divided into two sections, to undertake both the biological determination and microbiological control, which were carried out at the dam and in the inlet stream.

The DelAgua kit was demonstrated as was how to take and analyse samples, for thermotolerant coliforms. Then participants prepared their equipment for sampling in different parts of the river. For the use of other microbiological techniques, water samples were taken in sterilised bottles for use that afternoon.

Sampling was conducted at two sites. The sampling started with a quantitative kick sample of the stream to assess the range of species of benthic macro invertibrates. This was followed by the definition of a sample area of the stream which was divided into sampling units. The latter were selected at random within the sample area and samples taken with a Surbér sampler. The invertebrates from the sampling unit were sorted from sediment and taken back to the laboratory for analysis. The invertebrates in the samples were identified to family level and a Shannon index (H') was calculated using $\log_e$ to indicate diversity.

In the field a rough evaluation of stream discharge was performed using the surface velocity, the average depth and the width of the river.

Samples were analysed for thermotolerant coliforms using DelAgua, Millipore and Paqualab kits.

Some elementary chemical controls (conductivity, F, NH_3, NO_3, HCO_3) were undertaken. A general discussion of biomonitoring followed including presentation of the results of the biological determination.

Results:

Site 1 = Inlet Spring

Sample 1 (quantitative)	
Diptera:Tipulidae	1
Diptera:Atherix sp	1
Ephemeroptera:Baetidae	1
Coleoptera Larva	1
Sample 2 (quantitative)	
Coleoptera larva 1	14
Decapoda - crab	2
Coleoptera larva 2	1

Sample 3
(not analysed)

Sample 1 4 species 4 individuals H'= 1.38
Sample 2 3 species 17 individuals H'= 0.57

Site 2 = Outflow stream (qualitative)

Odonata: Zygoptera	1	1
	2	1
Decapoda		1
Coleoptera larva		1
Ephemeroptera:	Baetidae 1	14
	Baetidae 2	3
	Baetidae 3	2
	Caenidae	4
Chironomidae		2
Hemiptera Heteroptera:	Corixidae	6
	Naucoridae	1

11 species 36 individuals
H' = 1.54

Analytical Data From the Various Water Samples

Sample	Conduct µ san	F mg/l	NH_3 mg/l	NO_3	pH	HCO_3 mg/l	Faecal coli	Q l/s
Outlet stream	190	1.75	<0,1					90
Outlet lake	210	2.0	<0,1					
inlet spring	206		<0,1		7.1	112		140
inlet into the		2.25	0					
lake	145	2.0						
Cauper stream	152		<0,1					
tap water	235		<0,1	0.8		114		

III.9 Chemical and Particulate Analysis

Particulate Analysis
Joseph Boutros

Particulate matter is the insoluble matter present in the water under the conditions of the sample at the time of examination. It is of great significance in drinking water and many industrial uses. The nature of particulate matter and its composition help in identifying contamination and tracing it.

Particulate matter analysis is essential for the global river flux monitoring stations.

Outlines of the methods used to determine total residue, fixed and volatile solids, dissolved solids and suspended solids were given.

Tests for particulate matter and residue are basically empirical and their results depend upon the filter used and the temperature of drying and ignition.

Due to the role particulate matter plays in defining the pathways and fluxes of pollution, it is now being carefully analysed. Particulate matter can be divided into suspended matter and deposited sediment. Suspended matter is of primary importance in the transport of nutrients, contaminants and for refractory substances.

GEMS/Water defines the particle size of particulate matter to be greater than 63 µm.

Bottom or deposited sediments can also be a useful matrix to assess contamination.

It is generally recognised that a 'menu' approach to toxic chemical identification is incomplete and therefore inexpensive biological screening tools should be used to reduce the amount of chemical work and provide information concerning both the biological condition of the water and ecological significance of the chemical data.

The analyses to be conducted on particulate matter are: nutrients (organic N and total phosphorus); organic carbon; and particulate matter quality (Al, As, Cd, Ca, Fe, Pb, Mn, Hg, Se, Zn).

Outlines of the methods used to analyse particulate matter were briefly given.

Chemical Analysis
Joseph Boutros

The control of correctness of results by using ionic balance was described; as was how this could be compared with measured conductivity and these related to the equivalent conductance of the ions estimated.

The lecture covered the following analyses and gave the various options, the range in which they could be used and how to store the samples prior to analysis: temperature, pH, electrical conductivity, turbidity and transparency, acidity and alkalinity, nitrate, nitrite, Nitrogen ammonia, nitrogen kjeldahl, dissolved oxygen, BOD, COD, carbon, (total, organic and inorganic), chloride, metallic ions. A brief description of the atomic absorption spectrophotometer, which is widely used in the analysis of metallic ions and its major components was also given. Similarly a description of gas chromatography and its design and principle of operation was given.

Sample Preservation for Chemical and Particulate Analysis
Francis Gumbo

It is of great importance that samples are representative of the water body as a whole. Representative sampling locations are needed and care should be taken to avoid sample contamination. Sampling data should be properly recorded and after sampling, the sample should be transported to the laboratory as soon as possible.

Sampling for bacteriological analysis requires equipment such as sterilised sample bottles, cool boxes, durable tie-on tags, waterproof markers, a weighted bottle frame and nylon line for bridge and depth sampling. Techniques used in sampling tap water, wells and surface waters were described, together with preparation and transport to the laboratory. Ice boxes are an essential item of equipment.

For sampling for physical and chemical analysis, specific types of containers are required. Polyethylene or borosilicate glass bottles are used, according to the variables to be measured. Washing and preparation of sample bottles is an important consideration. Sampling from various water bodies, preservation, labelling and field record sheets and transport require planning and standardised procedures. Samples should be sent to the laboratory as soon as possible to minimise physical and chemical changes.

Various preservation techniques for water samples and particulate matter are used such as cooling, and/or adding preserving chemicals depending upon the variables to be measured.

Discussion

Sampling of Lake Tankganyika was discussed. An elaborate strategy would be needed to tackle such a complex aquatic system, requiring a range of techniques. The question of Duluti Lake being used as a drinking water source for Arusha was raised - it was suggested that the costs involved for treatment would be high.

Visit to Duluti Lake

A visit was made to Duluti Lake to demonstrate sampling and sample preservation for chemical and particulate analysis.

Workshop participants were divided into two groups. Each group undertook both depth sampling from the centre of the lake and sampling from the lake margins.

Laboratory Practical

Joseph Boutros and Francis Gumbo

The workshop was divided into four groups, which rotated about four work stations such that each person was involved in the execution of a range of different techniques.

A list of the results obtained was presented and discussions held on the results themselves and on the validity of different methods. The results of these and previous analyses are presented below.

Duluti Lake - Discussion of Practical

Martial Dray, Jamie Bartram and John Jackson

The observations, samples and analyses of the practical on Duluti Lake provided a wide range of information which raised interesting questions regarding the limnology, health aspects and trophic status of the lake.

The lake is situated in a crater with a very small and steep drainage basin. It seems most likely, given no surface water inflows or outflows, that the lake is fed by groundwater. This hypothesis could be tested by comparing the chemistry and water table levels of the lake and ground waters in boreholes in the surrounding country over time.

The lake has an extremely small forested drainage basin relative to lake area, it is seven metres deep and is used for recreation, fishing, irrigation and perhaps drinking water. No stratification had been observed and a dense population of blue-green algae dominated the water column. It may be the case that low nitrate was measured because of a high standing crop. A papyrus island was observed. The lake is thought to be eutrophic, with probably a low rate of nutrient input from a small basin. The absence of any outflow means that the lake accumulates nutrients, the only sink being the sediment.

Results of Analyses

Variable	Sample 1	2	3	4	January 92
Temperature °C	27.2	27.6	28.3	28.3	
pH	6.5	7-8	7-8	7.1	8.6
Turbidity NTU/JTU	12	10		9	0
Secchi depth m	0.6	0.6	0.6	0.6	
Settleable matter g/l				2.75,200	
Alkalinity mg/l	82	76	74	188	182
Conductivity µS/cm2	416	505	415	415	400
Total Hardness mg/l	100	100	100		91
Ca Hardness mg/l	100	100	100	100	20
Chloride mg/l	120	117	117		13
Nitrate-N mg/l		0.024	0.025	0.040	
Nitrite mg/l	0.011	0.012			
Ammonia mg/l	0.25	0.22		0.38	0.12
Iron mg/l				0.29	0.014
Sulphate mg/l				15	
Manganese mg/l				0.013	
Fluoride mg/l	1.5	1.5	>1.5	>1.5	

Depth samples: surface, 1,3 and 7m

Temperature difference: 0.8°C

Conductivity difference: 8µScm^{-1}

The lack of thermal stratification indicates the possibility that continual nutrient cycling occurs between sediment and water.

Local knowledge suggests the presence of bilharzia in the lake and human activity on the shores may lead to faecal contamination of the water. Sanitation would control faecal contamination. The elimination of bilharzia vector snails in such an enclosed catchment might be possible. The large numbers of blue-green algae in the water might result in taints and toxins, which would be quality issues if the water were used for drinking water supply, a possibility which has been seriously considered.

The use of the water for supply would be dependent upon recharge from groundwater and rain. The use of the lake for recreation and boating from the club may lead to faecal contamination and the problem of mosquitoes as malaria vectors is an additional consideration. Treatment of the water for supply would be possible, for instance for faecal contamination but problems might occur for instance chlor-phenol production from algal end-products and re-growth in organically rich, warm water. Whether it would be more economic to use alternative sources would need to be investigated. The lake was already used for irrigation and water for animals and the presence of blue-green algal blooms might be important for the latter.

The initiation of monitoring of the lake's water quality would depend on a justification of quality monitoring and management in terms of quality requirements by different users. Possible uses are drinking water, irrigation and recreation. These uses have quality requirements and management (either restricting use or managing water quality) would depend on monitoring data. A monitoring strategy would ideally be based upon the identification of present status, quality influences in the basin (such as land use and human activities) and trends, resulting in the provision of options for action (is action required? source control? remedial action?).

Management of human health aspects seems possible but management of eutrophication and remedial action would be more difficult. The absence of outflows, the small rate of input of nutrients and the shallow water mean that options for action may be limited.

Visit to Laboratories

Dr Francis Gumbo coordinated visits to two laboratories near Arusha.

The first visit was to the Tropical Pesticides Research Institute. Participants were introduced to the Institute by Mr A O Moshi who outlined the history of the Institute,

Participants were shown around the principal laboratories.

In the first laboratory, Mr Moshi outlined a human health impact assessment project for exposure to organophosphorus pesticides. This includes collection of national data, assessment of pesticide users, development of a database on pesticide use and work with medical staff. Project progress to date included the development of a portable ELISA-based meter for measurement of haemoglobin and chlolinesterase activity in blood. Other important activities in this laboratory included:

1. the identification of a new degradation product of dieldrin: Tanzadrin (the normally recognised degradation product is Photodieldrin;

2. recognising the risk associated with discharge of Toxaphene (a dip for combating ticks) from dipping sites. Toxaphene is especially toxic to fish and dumping has been responsible for major fish kills. TPRI uses fish indicators (analysis of flesh); and

3. assessment of pesticides from natural products.

In the pesticide analysis laboratory, pesticides are registered (ie licensed for use in Tanzania). Pesticides may receive full registration, provisional registration, registration for research and investigation, or registration for restricted use. TPRI also has an inspection system. Inspectors are empowered to enter premises and vessels, inspect animals, impound substances, take samples for analysis (if doubt exists about their quality or registration); and can initiate court actions. Inspectors are also responsible for licensing individuals who undertake fumigation and pest control.

The TPRI radioactivity laboratory was also visited and is equipped for both gamma and beta counting. The lab undertakes counting on water samples and once it has tritium-enrichment apparatus will undertake tracing work.

The visit to the MAJI laboratory in Arusha was conducted by Mr Mjengera. The laboratory comprised a small room with running water and a water still. Analytical equipment presently in use comprises a Hach kit (for chemical analyses) an

OXFAM-DelAgua kit (for Microbiological analysis, turbidity and chlorine residual) and digital titrators using disposable cartridges for calcium and magnesium. The laboratory is staffed by three technicians, who have each completed a three year training course in water analysis in Dar es Salaam. Principal activities in the laboratories are the microbiological monitoring of the Arusha Water supply system (monthly) and work on assessment of de-fluoridation of drinking water.

De-fluoridation has focussed on use of bone char and magnesite; both give good removals although the latter leaves a high pH. Analytical quality control is undertaken using standard solutions prepared 'in house'.

III.10 Health Aspects of Water Quality
Jamie Bartram

Water-related diseases may be classified as infectious and non-infectious.

Infectious water-related diseases have traditionally been classified according to infectious agent or disease caused. These classifications are rarely useful from the standpoint of control. An alternative classification is based on mechanisms of disease transmission and control; disease being classified into one or more of the categories water-borne; water washed; water-based; or water-related insect vector.

Water-washed disease were defined as those whose transmission will be reduced following an increase in the volume of water used for hygiene purposes, irrespective of the quality of that water. Examples of water-washed diseases include diseases of the intestinal tract transmitted by the faecal-oral route (which are also water-borne); skin and eye infections (such as bacterial skin sepsis, fungal infection and trachoma) which are not faecal-oral and not water-borne; and diseases transmitted by lice and mites which may themselves be controlled by good hygiene (such as louse-borne relapsing fever; louse borne typhus).

Schistosomiasis and guinea worm were given as examples of very different water-based diseases which were important in the region and their transmission cycles outlined alongside options for control by environmental management.

With regard to diseases with water-based insect vectors, malaria and onchocerciasis were discussed at length and control of their vectors contrasted with other similar diseases.

Problems associated with chemical (ie non-infectious) constituents arise primarily from adverse effects after prolonged exposure. Health-related inorganic constituents were discussed and the example of fluoride used as a substance eliciting both positive and negative health effects. Similarly, constituents affecting the aesthetic quality of water were discussed with copper as an example and organic contaminants using DDT as an example.

To conclude, the bases for calculation of WHO guideline values were summarised including total intake from various sources; per capita consumption, available data on disease whether from epidemiological or laboratory studies; and a safety factor.

Discussion
On the question of how to establish national water quality standards, it was emphasised that when setting such standards one has to take into consideration health effects of the contaminant and water intake, dietary contributions from non-water sources and economic implications. Standards should be set on the basis of health risk and not compromised. However, implementation should take into account specific national factors.

The importance of copper was discussed. Copper is an essential element in human metabolism and it is non-toxic. Its presence in water supply although not a health hazard, may interfere with the domestic use of the water because in public water supplies, copper increases the corrosion of galvanised iron and fittings which results in the staining of laundry.

Schistosomiasis control was also discussed at length and a number of environmental management measures outlined which, if adopted, could reduce the danger of schistosomiasis to public health. Schistosomiasis is caused by people getting into contact with cercariae in water which are released from infected snails. To avoid transmission, snails may be killed, for instance by water level management. However, the snails are resistant to drying to some extent. Other possible measures include draining of drains, introducing molluscicides to the water bodies to kill the snails, reduction of human contact, improved sanitation and treatment of the human population.

The occurrence of river blindness in West Africa and the difficulties encountered in controlling the disease were discussed. It was recounted by West African participants that resettlement of high-risk communities had been very successful. Spraying the larvae with insecticides also contributes to controlling disease incidents.

III.11 Quality Assurance and Quality Control

Principles of Quality Assurance and Quality Control
Jamie Bartram

Mechanisms by which analysts ensure that they obtain valid results were outlined, including certified reference materials, validated (standard) methods, external and internal quality control schemes and laboratory accreditation.

Quality control and quality assurance were separately defined and a distinction made between precision and accuracy. Examples of data analysis for both internal and external quality control were given, including control charts (Schwart diagrams) for internal analytical quality control (AQC) and reporting of external AQC results through normalised results and Youden diagrams.

The special problems of AQC for microbiological analysis were presented and alternative strategies based on quality assurance principles outlined.

Discussion of AQC concluded with a comparison of internal and external AQC. Questions passed during the presentation indicated that none of the 12 analysts present worked in a laboratory running an internal AQC programme and that only one had participated in an external AQC scheme - that of USEPA for GEMS/Water from which two samples had been received during four years.

Principles of good laboratory practice (GLP) and quality assurance were outlined under the general headings of 'management', 'facilities and staff'; and 'procedures' and the need to employ these principles in all stages from sampling to reporting emphasised. Preparation of an analytical SOP (Standard Operating Procedure) was presented as an example.

Differences between laboratory-based and on-site analyses were highlighted and discussed, the problems associated with quality assurance of the latter highlighted and strategies to help overcome this limitation summarised.

Discussion
The issue was raised of how to judge the proportion of resources which ought to be devoted to quality assurance and quality control. This was generally felt to be very difficult, but was suggested to depend on the turnover of samples in a laboratory , a higher proportion of resources being required for a small turnover. The difficulty of field QA/QC had been highlighted, but it was felt to be perfectly practical to subject kit tests used in the laboratory to QC. The identification of problems was discussed. Field QA/QC could be implemented, it was suggested, through good training, effective supervision, sterile sample analysis and strict equipment review. Proper techniques for sample collection were fundamental to QC.

Quality Assurance and Quality Control in the GEMS/Water Programme
Joseph Boutros

One of the essential components for ensuring accurate and reliable results is analytical quality control (AQC) which refers to routine application of procedures for controlling the measurement process. It was found that following standard procedures alone without applying a QC programme has lead to erroneous results in many cases.

Since the overall success of GEMS/Water depends in part on the fulfilment of its second objective (to improve the validity and comparability of water quality data within and among member states), great emphasis should be devoted to the establishment of AQC programmes in all participating water laboratories.

The organisation of an AQC programme for GEMS/Water laboratories was described, together with procedures for conducting a within-laboratory AQC programme using calibration, method blanks, field blanks, precision, recovery sheets and accuracy checks.

Global and Regional coordination for AQC were mentioned. The purpose, distribution and types of the GEMS/Water quality control samples were given in detail. The GEMS/Water Performance Evaluation Study was also described (purpose, distribution, reporting and evaluation).

Discussion
Rejection of samples or data under QA/QC was discussed. It was suggested that check lists of QC criteria should be used and that the sample should fulfil requirements at each stage of the sampling and analytical process or be rejected. Examples of incorrect sampling vessels and blank contamination were given.

It was suggested by one participant that in QA exercises, results from simple equipment should not be compared with those from sophisticated equipment. However, it was stressed that results from basic equipment had proved equally accurate to those from sophisticated equipment in past exercises. It was pointed out that sophisticated equipment in many cases merely increased turnover or improved detection limits.

Clarification of the structure of GEMS/Water was requested at this point. The co-operative nature of the network was emphasised together with the national basis of the programme.

Data from monitoring are submitted and statistics published, assessments are made and support activities implemented. The present training workshop was given as a good example of the recent initiative on national and regional training through GEMS/Water, building national capabilities and strengthening regional co-operation.

III.12 Water Quality Assessment
John Jackson

Water quality assessment is an essential element of overall water resource management. Water quality assessment aims to explain, understand and communicate the complex environmental interactions associated with the hydrosphere and to provide practical options for policy and management. Such assessment draws upon and generates a wide range of information on the natural characteristics and processes of water bodies, human activities and impacts, quality trends, options for management and remedial action and evaluations of their effectiveness, potential policy and planning strategies.

Hydrological, physical, chemical and biological information are combined to reach an integrated scientific perception of the whole resource. This is combined with information on quality demands to perform use-related quality assessment or with information on effects of changing quality for impact-related quality assessments. Examples of assessment, such as pollutant pathways and fate, modelling and temporal or spatial variation, were given. The basic structure (objectives, design, monitoring, assessment) is intended to lead to information for management and subsequent action. Assessments for more complex ecosystems and management approaches need to draw on a wider range of information resources and integrate this information to address assessment objectives.

The example of the Rukwa Water Master Plan of the Tanzanian Ministry of Water and Energy, was given as a major assessment which addresses the political position of water resources in the economic and social activities of the region. Such an assessment draws on a wide range of information sources to show the importance of water quality and resources in development plans.

Assessment is concerned with understanding water resources and their quality influences, suggesting management options and evaluating success. The simple approach can be most effective - can the system be described? Does monitoring give the required information? Is management effective? The answers which assessment provides to these questions provide the basis for rational management of water resources of quality.

III.13 Data

Water Quality Data Interpretation
Ed Ongley

This presentation focused on the uncertainty in making reliable environmental interpretations from monitoring data. Participants were shown that having a good set of data does not always mean that they can make meaningful statements about such issues as cause and effect; loadings; regulatory effectiveness; and toxic substances. The problems of data inadequacy are a consequence of:

1. inappropriate inclusion (water, sediment, biota)
2. poor selection of sampling frequency
3. improper assumptions about station selection
4. mixed populations of cause and effect in time series data.

In many cases, inadequate definition of programme objectives leads to inappropriate data and inefficient sampling programmes.

Data Reporting and Validation
Ed Ongley

Successful participation by countries in the GEMS/Water data programme requires that the Global Data Centre in Canada has on file, up-to-date information for the country and for each station in the country GEMS/Water network. This information is provided to the Global Data Centre on three forms: the country fact sheet, station forms and data reporting forms.

The Country Fact Sheet contains information about the participating laboratories, the national coordinator for the country, and other information that needs to be kept up-to-date.

The Station Forms contain information about each sampling station in the GEMS/Water network.

Data are reported on the GEMS/Water "GLOWDAT" form for each sample date. Although there is room for 84 parameters, most countries are able to submit only some of the possible parameters. The sample station number and other essential data are entered on the GLOWDAT sheet, followed by the analytical or measured values for each parameter which is entered with the analytical method code. The method code is an essential part of the data submission on the GLOWDAT sheet; different methods can give different results, therefore the Global Data Centre needs to know which method you used.

Countries can also submit data directly in electronic form, usually on a floppy diskette in ASCII format, following the format of the GLOWDAT form.

Data Validation is an important component of the work of the Global Data Centre.

The first check on the data is by the national GEMS/Water Coordinator when he/she receives data from participating laboratories. The coordinator should check that: the data sheets are complete; the data seem reasonable (for example, nitrate has not been recorded in the phosphorus column); and that the reporting units are the same as those required on the GLOWDAT form.

When the GLOWDAT sheets are received at the Global Data Centre, the data are entered in the global data bank and are checked for obvious errors (e.g. wrong units, abnormally large/small values, transcription errors). In such circumstances the sheets are usually sent back to the national coordinator for advice. In 1992, other verification checks will be added, such as calculation of ionic balances (when there are enough data to do this), and a comparison of submitted data with historical data from the same site.

Statistics and Output Options
Ed Ongley

Participants were introduced to the RAISON/GEMS software that is being used to carry out data base management, elementary GIS functions and data analysis. A range of typical statistical and graphical outputs were shown using data from a number of GEMS stations around the world. Examples included analysis of data by station, by river basin, and for global conditions. Chapter 10 of the Operation Guide Illustrates the type of annual data report that GEMS/Water will be producing for each country. Through arrangement with UNEP, the Global Data Centre can make the RAISON/GEMS Software available to countries that have need for basic software capability in their water quality programmes.

Following the lecture by Dr Ongley, participants discussed data management, treatment, analysis, interpretation and storage. There was a general agreement that in most countries especially in the developing world there is a lot of data on water quality which is minimally being used as it needs to be properly analysed, interpreted and stored.

Having being shown examples of GEMS Water statically treated data, from Tanzania and various other countries participants appreciated the excellent work being done by the CCIW in Burlington but they wondered how that kind of data treatment technology could be made available in that they could use it in their home countries. It was agreed that interested countries should follow it up with GEMS/Water at WHO and UNEP.

Practical on Data Reporting
Ed Ongley

The objective of the practical was to ensure correct transmission of data to the Global Data Centre in Canada.

A typical set of data that might be received by a national GEMS/Water co-ordinator from a country laboratory was distributed to participants. The data included: parameter, description of analytical method and value. The objective was to transfer this information to the GLOWDAT form, and to recognise and correct the errors that were contained on the data sheet. A range of typical reporting errors was built into the data sheet. Participants used the Phase 2 GLOWDAT Form, together with the methods codes in chapter 9 of the Operational Guide.

IV Country Reports

Full copies of all country reports are presented as Annex 4 to this report; summaries covering the most salient points are presented below.

Burundi - Mr Aloys Rurantije

Water quality is going to become one of the greatest worries of the different Authorities in charge of water in Burundi.

Hydrology Service
This is part of the Burundi Geographical Institute (IGEBU) - within the ministry of tourism and environmental management. The Hydrology Service is entrusted with calculating river flow , gathering hydrological data, and taking samples for analysis.

Evaluation of Water Quality at the IGEBU
Water quality evaluation will never be truly valuable because there is a lack of facilities:

1. No appropriate laboratory;
2. No equipment and consumables;

In reality only pH, temperature and suspended solids can be measured.

Methods Used
1. pH: measured with pH meter and glass electrode
2. Temperature: measured with a thermometer
3. Suspended solids:
   a) filtration of the sample;
   b) use of a precision balance, after drying at 100°C, to calculate weight of suspended materials,

Data
The samples are taken at some sixty functioning hydrological stations. The first samples date from 1987. The data have not yet been published, but they are available for inspection at the Burundi Geographical Institute.

Funding, Equipment and Cooperation
Funding is granted by the Burundi government, and the major part of the project equipment from WHO.

Evaluation of water quality has not yet been recognised for its true worth within the Geographical Institute, national cooperation between the departments services concerned in this area is virtually non-existent.

Future Projects
In the future, a specific aim will be to reconcile the problem of water quality within the Burundi Geographical Institute. There could also be cooperation with other interested departments/services in the country also involved in this area.

Ethiopia - Mr S Tadesse

One of Ethiopia's most important natural resources is its relatively abundant supply of water. The country has 14 major river basins covering an area of 1,245,500 km^2, with an estimated mean annual surface run-off of 111.62 billion cubic meter (BCM) and a potential safe yield of ground water of 2.6 BCM per annum.

The rich water resources are mainly utilized for irrigation, hydropower generation and industrial processes, besides their use for drinking and other domestic purposes. With the country's rapidly growing population, water therefore has a critical role to play in the development of the nation's economy and clean domestic water supplies are essential for the health of the people. About 85.5 per cent of the population obtain their water from unreliable or contaminated sources. The careful management of national water resources is therefore given utmost priority in Ethiopia.

Ethiopia has no properly established water quality monitoring network. However, hydrological and meteorological monitoring networks have been in existence for sometime. The need for a water quality monitoring network has been recognised by the Ethiopian Valleys Development Studies Authority, EVDSA (a lead agency in the planning, development and protection of the country's inland water resources) and essential steps to help with the establishment of the network are now being undertaken.

From a limited number of sporadic and project specific studies, it is known that pollution of Ethiopia's water resources is already a problem - from industry (especially around the national capital Addis Ababa but also in rural areas from cottage and agro-industries like coffee washing plants), agrochemicals, municipal and domestic sources. The problem is likely to become worse unless steps are taken both to tackle existing pollution and to prevent the development of new sources.

Discussion
Fluoride in water problems prevail in one region and research work is being done but no remedial measures are taken.

Ghana - Mr S. A. Larmie

Surface water quality monitoring has been achieved in three ways:

1. **Research activities**: The Water Resources Research Institute (WRRI) and the Institute of Aquatic Biology (IAB) of the National Council of Scientific and Industrial Research (CSIR) undertake surface water monitoring in Ghana. As an example, Ankobora River has been investigated for the impact of mining activities on the river quality.

2. **Ad hoc activities**: Ad hoc monitoring activities arise during feasibility studies for water projects.

3. **Monitoring networks**: Continuous water sampling from about 54 stations in all the major river basins of the country was incorporated into the hydrological network programme in the early sixties. In 1985 there was a programme to develop a network to generate quality data to assess continuously the quality of surface water resources. In 1988, there was a project aimed at establishing a network of ground water monitoring stations in the country.

The Hydrology Division of the Architectural and Engineering Services Corporation (AESC) is the main government institution in charge of gathering hydrological data. Their role has now been ignored. Various agencies pooled their resources and began a sampling programme in 1987 and now there are 28 stations on 6 river basins. A monthly sampling programme is being implemented. A country-wide network of 15 laboratories belonging to Ghana Water and Sewerage Corporation (GWSC), the Water Resources Research Institute (WRRI) and the Institute of Aquatic Biology (IAB) exists. The WRRI labs in Accra are mainly used.

The country has participated in the GEMS/Water project since Feb 1991 under the Ghana National Committee for the International hydrological programme. Due to the limited resources it was agreed to limit monitoring activities to a few stations namely, Dalon, Daboasi, Weija and Kpong. Not all parameters are determined.

Discussion
The importance of a network for GEMS/WATER was raised. Consideration should be given during the training workshop to establishment of networks in GEMS/Water participating countries.

Kenya - Mr E N Nyaga

The National Water Quality Monitoring Network Programme was consolidated in the fiscal year 1981/82, incorporating the GEMS/Water programme.

The Monitoring Programme was designed for:

- Control of water pollution from existing and upcoming industries;
- Water development; and
- Water quality data collection for water resources quality assessment and future planning.

In the design of the network, all five catchment areas were covered. These are:

- The Lake Victoria Catchment Basin which drains an area of 49000 km^2, there are 34 network stations of which 5 are GEMS/WATER stations.
- The Rift Valley Catchment Basin
- The Athi River Catchment Basin
- The Tana River Catchment Basin
- The Ewason Ngiro(N) Catchment Basin

Each station, where possible, was located at or close to a hydrological gauging station. At the same time, stations were chosen on the basis of the socio-economic implications of water quality.

Samples collected have been analysed at fledgling laboratories where few parameters are tested. The Central Water Testing Laboratory is equipped with some modern but non-operational instruments ranging from AAS to automatic burettes.

The programme could benefit from non-routine specialised analyses. At other laboratories including those of:

University of Nairobi
Government Chemist
Kenya Bureau of Standards
Materials Testing Laboratories
Mines and Geology Laboratories
Kenya Industrial Research Institute
Kenya Agricultural Research Institute

During the period 1982-1988 the programme generated substantial data.

Discussion
It was discussed and agreed that field testing will help release the load from the main labs and is easy to finance and run.

Nigeria - Prof D Afolabi

The major water drainage systems are:

1. Niger River Basin
2. Lake Chad
3. Atlantic Ocean, West of River Niger
4. Atlantic Ocean, East of River Niger

Ground water sources are mainly from sedimentary and crystalline basement aquifers. Although water quality data exist, these are not available from a network. To correct this deficiency, GEMS/Water in Nigeria has been institutionalised. The policy-making body (which is the GEMS/Water National Technical Committee) consists of members from nine water-related agencies or departments:

Twelve GEMS/Water monitoring stations have been proposed by the National Technical Committee as follows:

1. Baseline Stations
   - Entry point of River Niger into Nigeria
   - Entry point of River Beume into Nigeria

2. Impact Stations: - Groundwater
   - Solisto
   - Maideugeri
   - Koks

   - Surface water
   - Bouay
   - Asamabiri
   - Kainja Lake
   - Lake Chad
   - Cross River at Oron
   - Rivers Osen & Ogen at Lagos
   - River Kadmua at Kadmua

In addition the mandate, policy goals, priority objectives and national action plans of the Federal Environmental Protection Agency (FEPA) were presented and its constraints identified.

Discussion
FEPA is the highest body responsible for environmental protection in the country and is the lead organisation for water quality and monitoring.

Sudan - Mr S Y Izzeldien

The water resources of Sudan are the River Nile, rainfall and groundwater.
Responsibility for water is divided between the Ministry of Irrigation and Water Resources (planning, development and management resources); the National Urban Water Corporation; and the National Rural Water Corporation (responsible for provision and quality monitoring in urban and rural areas respectively); the National Chemical Laboratory; and the Ministry of Health (setting standards and monitoring the quality of drinking water and health implications).

Most population is concentrated along the Nile. Water from the Nile and its tributaries are treated with lime and aluminium sulphate followed by sedimentation, rapid sand filtration and chlorination. Water is supplied without treatment in some areas. Away from the Nile and its tributaries open dug wells, boreholes and Hafirs are commonly used.

The principal laboratory involved in monitoring water quality is the Central Laboratory (Mogren) of the NUWC. Analyses are undertaken, albeit with largely outdated equipment 14 parameters and compared with national standards and WHO Guidelines. The National Chemical Laboratories also undertake drinking water monitoring, including approval of new sources.

Two of the four GEMS/Water stations in Sudan are currently operating. Samples from both are analysed by the National Chemical Laboratories.

Recognised water quality problems include high levels of suspended sediment (during the flood season); high algal growth (after the flood season); and faecal indicator bacteria in surface waters. Other problems include sulphate in the area of the White Nile and nitrate and fluoride in the west of the country. The east suffers from high nitrate levels and the coast from chloride because of saline intrusion.

Discussion
Participants from various countries discussed the quality of the transboundary Nile waters. In response to discussion, it was stated that issues such as fluoride, iron and nitrate were ground water quality problems but that there appeared to be little hydrological connection between the Nile and Sudanese aquifers. Boreholes where high fluoride was detected were closed to prevent ill effects, the Sudan's standard for fluoride being 1.3 mg/l (WHO guideline 1.5 mg/l).

Tanzania - Mr P Kiliho

Tanzania has many fresh water sources including three large lakes: Tanganyika, Victoria and Malawi.

Water quality monitoring started in the fifties on an irregular basis before legislation was passed in 1971 to supply potable water to people within 400m of a source.

Most surface water sources in the country are bacteriologically polluted due to their openness. Chemical pollutants originate from discharge of untreated industrial effluents into water bodies. The nature of the bedrock or aquifer in the case of groundwater sources may give rise to high fluoride or iron in boreholes in some parts of the country.

There are three major sources of pollution by the population: domestic waste, industrial waste and agrochemical discharges into water bodies.

There are a total of 15 water quality analytical laboratories in the country excluding water works laboratories.

Physico-chemical and bacteriological parameters are analysed in the laboratory or in the field.

Discussion

Tanzanian authorities recommend all types of drinking water to be boiled even treated waters due to the possible presence of unpredicted contaminants. A fluoride limit of 8 mg/l is used and research has been conducted on fluoride removal.

Uganda - Mr A N Geri

The report showed that only 20 per cent of the population have access to safe drinking water. By the early 1970's an elaborate hydrological monitoring network of all major water bodies had been set up. Later more stations were established bringing the total number to 24.

During the war of 1979, the Central Laboratory lost equipment and much data. Some national stations were revived by Hydromet but by 1982 all water quality monitoring activities had come to a standstill. In 1986 the government with assistance from UNICEF revived the central laboratory with some instruments and equipment. The laboratory now concentrates on:

1. Rural water supplies
2. Urban water supplies
3. Revival of monitoring network.

At present:

1. Surface waters, especially around major urban centres are becoming gradually polluted.
2. Ground water is generally acceptable in quality except for some contamination as a result of human activities. A national water resources master plan has been drawn up and is soon to be implemented. The plan aims at assessing both the quantity and quality of water resources.

Discussion

Iron contamination in ground water caused the users to abandon some boreholes and resort to lakes and streams which are contaminated. It was pointed out by the workshop participants that there are some simple methods of treating such waters, some of which are published and available. Iron in ground water is common in the region.

V Manual on Water Quality Monitoring

Introduction
Dick Ballance

It was emphasised that the document provided to participants was still incomplete as contributions were still awaited from some of the eighteen authors and that this meeting should review it critically. Unnecessary material could be deleted, incomplete material could be expanded, and missing material could be identified. Some items of missing material were identified; one of these being a list of reviewers. Such a list would included participants in the meeting and should credit them for their contribution to the review process.

A brief, chapter-by-chapter review of the draft was given. It was suggested that participants, when reading the daft, should consider the advisability of moving the laboratory procedures in chapter 6 and 7 into either a separate volume or to a separate part of the manual.

V.1 Manual Objectives and Intended Audience
Matti Viitasaari

Professor Viitasaari presented the objectives and intended audience of the draft manual as outlined in the preface of the same. There was prolonged discussion regarding whether these objectives had been met whether the manual met the needs of the intended target audience and whether this was the correct target audience.

Participants highlighted the deficiencies and omission which had become evident during the review process. The manual met the needs of the stated target audience (ie, planners and managers) but was neither generally appropriate for national water quality monitoring programmes (rather than GEMS-specific activities) nor functioned as a 'recipe book'.

V.2 Review of the Manual
Matti Viitasaari

During the workshop, participants thoroughly reviewed the *Manual on Water Quality Monitoring*. The purpose of this session was for the participants to highlight the main points arising from the manual review and to air to the workshop organisers their feelings on the manual.

Workshop participants were informed by Professor Viitasaari that the Manual was intended as a practical guide for those who will plan and carry out various aspects of water quality monitoring in developing countries that do not yet have a water quality monitoring programme. It should also be of special interest and value to those involved in related field operations, (field staff) since it will increase their understanding of the objectives and operational procedures of water quality monitoring programmes.

Review of the Manual - Discussion
Chair: Jamie Bartram

Having reviewed the manual during the preceding two weeks, the discussion centred on major issues for its improvement. The following major points were made:

1. The manual met the minimum needs of monitoring orientated exclusively towards the GEMS-Water programme but several key additions were necessary to ensure that it was generally applicable for the development of national monitoring programmes in Africa; Specifically, several additional parameters should be incorporated including BOD in surface waters, and manganese and iron in groundwaters.

2. Two major areas of omission were identified which should be addressed by the addition of entirely new chapters. These chapters should cover firstly practical aspects of running a water quality monitoring programme (including management, infrastructure, staffing, inter-institutional coordination and logistics); and secondly application of data to management of water quality issues in Africa.

3. There was concern that the focus of the Manual be more clearly defined in terms of target audience, content, level of detail and scope;

4. An appropriate title reflecting the contents of the manual should be given.

5. The book should also contain more illustrations (figures and pictures).

6. There was general agreement that the size of the book should be handy to carry and read. Hard cover or plastic binding was recommended.

V.3 Field Testing of the Manual

Chair: Jamie Bartram

The extensive review of the draft manual by the participants meant that it would have to be revised in order to produce a second draft suitable for field testing. The role of existing literature in monitoring and assessment programmes was discussed. Participants had access to a variety of literature and some criteria documents. Assessments of water quality or national plans were used in addition to manuals such as the WMO *Manual on Water Quality Monitoring*. Mention was made of standard methods from sources such as the APHA *Methods for the Analysis of Water and Wastewater*. In general, access to literature seemed uneven and only one participant mentioned the use of the GEMS/Water *Operational Guide* in the laboratory. Seven participants worked with protocols specific to their laboratories and sampling was undertaken by laboratory staff, so specific protocols for sampling staff were perceived not to be required.

It was suggested that the manual would provide a useful addition to existing materials, where these were available. Sudan, Tanzania, Nigeria, Kenya, and Ethiopia all have plans for monitoring and assessment expansion and consolidation, (subject in all cases to approval and funding).

In all countries, the manual would provide a useful resource and could be a valuable tool in expanding and developing monitoring and assessment.

VI Country Work Plans

Chair: Jamie Bartram
Rapporteur: Joseph Boutros

The chair outlined themes which participants might consider in preparing their country plans. These were as follows:

Role of participants in their national organisations
Sampling sites:
- a - Operational GEMS Stations
- b - Selected non-operational stations
- c - Proposed stations

Analysis:
- a - Analysis already undertaken (GEMS)
- b - Analysis proposed

Frequency of monitoring
Key (minor) items of equipment required for action plan
Identification of key problems of plan of action

Following prolonged discussion, it was agreed that country workplans would be developed such that each encompassed an achievable series of activities which would lead to successful reporting of GEMS-Water monitoring in the short term. The nature of these activities would vary between countries depending, for example on whether personnel present were either already authorised to report data, or could take that decision, or required permission in order to initiate reporting. Whatever, progress at the technical level could be made.

Country workplans would each be presented under four broad headings:

1. present situation
   - sampling sites
     - identified
     - sampled
   - analytical range
   - reports
     - nationally
     - to national WHO office/Burlington
2. identification of key problems
   - if reporting is not regularly undertaken, which stages are preventing it occurring (eg. key items of equipment missing).
   - if reporting is already undertaken, what steps could be taken to consolidate this progress or improve it (increased sampling range, increasing number of sites). In this context it was noted that regular sampling over a small number of sites is more informative than sporadic reporting from a large number of sites.
3. support/requirements
   Where key support items or activities can be identified they should be highlighted. This support may be technical (for example key stems of basic equipment or consumables) or otherwise.
4. outputs over next 12 months

Discussion

A long discussion followed on the role of Hydromet in monitoring water quality. Hydromet is extending its involvement from water quantity to include collection of water quality data. This gave rise to concern amongst the participants from the different countries. Participants rejected the idea of Hydromet being involved in sampling and analytical activities and felt that data would be delayed or lost if transmitted to Canada through Hydromet.

Discussions also considered the commitment to execute the action plans. It was concluded that the action plans drafted during this workshop would be considered as proposals where participants do not have the authority to act. Nevertheless, in several countries participants have the authority to implement their plans because of established agreements. Elsewhere participants will make efforts to gain approval for them from their governments, with the help of Hydromet when requested.

It was pointed out by Dr Martial Dray, that WHO is the United Nations executing agency for the GEMS Programme and contacts are generally made with the countries through the WHO representatives whose official points of contact are the Ministries of Health. In countries where a national council exists which is recognised by the government, this body may be authorised to make direct contact with the WHO country representative. Dr Dray also pointed out that phase II of the GEMS/Water programme is for 10 years 1990-2000. In drawing up action plans participants were asked to be practical and choose a limited number of stations which can be monitored for the whole period of phase II.

The Work Plans developed by each country's participant are presented as Annex 5 to this report.

VII East Africa Region

VII.1 The Hydromet Survey Project

Nsubuga Senfuma

The size of the Hydromet Survey Project area and countries participating in the Project were described. A history of the water quality activities in the Project area was given. What had been achieved so far was outlined and the paper highlighted the role the project had played as a Collaborating Centre with the GEMS/Water Programme.

The paper ended by indicating future strategies for the Hydromet Project Laboratory which ranged from chosen collaboration and interaction with other national centres to proposing joint ventures with other laboratories in the region.

Discussion

Regional laboratory functions were discussed at length and an agreement reached that the regional laboratory could be used as a reference laboratory for training, reference work, collecting data, equipping national laboratories etc.

VII.2 Setting up the Hydromet Laboratory in Entebbe

Nsubuga Senfuma.

The Hydromet Survey Project aims at assisting the participating countries in planning for water conservation and development. In 1972 the overall objective was broadened to include water quality assessment and monitoring. The purposes of carrying out analysis of water in the project were:

1. To classify water with respect to the level of mineral constituents.
2. To ascertain the absence or presence of constituents affecting uses of water.
3. To determine the degree of clarity in all water sources and to ascertain the nature of matter in suspension.

To achieve the above objectives a room was provided in which analysis was done. Later a building was constructed which now houses the laboratory. Basic equipment was supplied to the laboratory in addition to the chemicals required. The network design was determined and logistical support was provided.

In 1978-79 the water quality assessment and monitoring activities achieved a new dimension. The water quality project aimed to:

Divert from routine analysis of water to mainly data interpretation.
Integrate water quantity with quality assessment.
Increase frequencies of sampling.

These new objectives called for a new monitoring system and instruments were added.

Discussion

About U$2000 are required every 6 months for travel and U$15000 for equipment and consumables. Participants discussed the cost against the benefits of the laboratory project.

Extensive discussion on water models and their applicability to lakes followed and it was agreed that expert advise is required to decide on the model to be chosen for the lakes of the region.

VII.3 The Hydrology of the Upper Nile Basin

Hayder Yousif Bakhiet

The central feature of the upper Nile basin is Lake Victoria. The Nile flows from Lake Victoria, through Lakes Kyoga and Mobutu Sese Seko, eventually being joined by the Blue Nile at Khartoum and finally flowing into the Mediterranean. The Hydromet Survey Project was set up to collect and analyse hydrometeorological data from the catchments of Lakes Victoria, Kyoga and Mobutu Sese Seko, with the aims of supporting planning by the Nile countries for water conservation and development. The region is dominated by rocks more than 3,000 million years old, in which the Rift Valley has developed as the most significant structural feature. The project region has slightly higher rainfall than other parts of East Africa. Vegetation is influenced by climate and altitude, dominated by savannah forest in the lowlands.

Gauging of tributaries to Lake Victoria defines river inflow and advances in the study of lacustrie swamps and rainfall are making the estimation of contributions from such sources possible. Similarly, data sets for riverine flows and runoff are available for Lakes Kyota and Mobutu Sese Seko. Rainfall is a significant input to the lakes and is exceeded by evaporation for Lakes Kyoga and Mobutu Sese Seko.

Aquifers in the area are generally igneous or metamorphic, resulting in lower yields than from sedimentary aquifers in other areas. Fissured and fractured areas give the highest yields.

Discussion
Discussion followed on the importance of hydrological data for water quality management and the way in which it could be presented for effective communication. The question of fluoride levels in ground water was raised and the additional benefit of hydrological data in prediction and planning for flood control discussed.

VII.4 The Global Environmental Facility (GEF)
Elisabeth Marsollier

The objective of this presentation was to introduce the GEF project proposal on the Nile River, prepared by Hydromet. The proposal was to be revised and improved by the participants during the workshop of the workshop. Review should consider originality, the importance of the Nile Region and aspects of bio-diversity in the document.

The GEF proposal on the Nile River was distributed to all participants.

Background information on GEF was provided to the participants. The GEF document "Criteria for Eligibility and Priorities for Selection of Global Environment Facility Projects" was explained.

Interest was expressed by the group and it was decided to initiate the review with a brainstorming session.

Discussions
The GEF project for the Nile needs to be accepted by all countries concerned. It was suggested that Hydromet could make supportive contacts.

GEF Follow-up
(Chair: Elisabeth Marsollier)

The modified proposal which had been worked on by Group 1 during the evening discussion sessions was distributed to all participants and discussed at length. A number of improvements were proposed. A copy of the proposal is included as Annex 7 to this report.

Clarification regarding the interest in the proposal was to be sought by UNEP from the World Bank and UNDP.

The following components were discussed: potential lead agency, potential executing agency, participating agencies, GEF priority areas relevant to the proposal, approach and costs. The potential lead agency should be either the World Bank or UNDP. The executing agency should be the World Health Organization. The participating agencies should be: the regional co-ordinating bodies (Hydromet for the Nile River Basin, the Niger Basin Authority for the Niger River Basin and SADCC for the Zambezi River), as well as the following UN agencies, UNEP, WMO, UNESCO, FAO and IAEA.

To the present list of the GEF priority areas, community participation and community awareness are added.

A bio-diversity component will be added, by UNEP, to the three projects. This component will be mostly related to large wetlands areas to be protected such as the SUDD and the Nile Delta in the Nile River Basin, and the internal delta of the Niger in the Niger River Basin.

Regarding the approach the following were recommended that:

1. a state of the environment assessment be performed in the three watersheds as well as an identification of the national capabilities,
2. strengthening of national capabilities
3. development of the knowledge base through monitoring activities,
4. incorporating knowledge in the decision-making process, including legislation,
5. monitoring the effectiveness of installed legislation and control measures,
6. improvement of the capability of performing Environmental Impact Assessment,
7. Improving the management of critical ecosystems and more specifically of wetlands.

Regarding the costs to GEF, it was recommended to request from GEF a total budget of US$12 million, e.g. US$5 million for the Nile River Basin, US$5 million for he Niger River Basin and US$2 million for the Zambezi.

VIII Closure

Mr Mkuchu acted as Master of Ceremonies and welcomed the Regional Development Director as guest of honour.

Mr Jorn Kronow, Administrative officer of MS-TCDC, spoke on behalf of the Director of the Centre, hoping that the participants had a pleasant and productive workshop.

Professor Viitasaari wished the participants success in the continuation of the programme which he believed to be of considerable importance in water resource management. He suggested that FINNIDA had a positive attitude to future funding. He welcomed the efforts of development of national monitoring programmes through international co-operation.

Mr Hayder spoke on behalf of Mr Tawfik (Director of Hydromet). He thanked the staff of the Robens Institute for their efforts in organising the workshop and the TCDC for a pleasant stay. He stressed the value of co-operation of GEMS/Water and Hydromet in water quality monitoring to better serve the needs of the countries of the region.

Mrs Margaret Abira spoke on behalf of the participants. She spoke of the value of GEMS/Water in providing support, training and a focus for strengthening the various national programmes. She highlighted the hard and valuable work of the participants at the workshop and thanked the sponsoring agencies, organisers, and participants for their efforts. She particularly mentioned the role of Jamie Bartram in ensuring a successful outcome. She finally recommended the beauty of Arusha and the friendliness of the local people.

Mr Deok-Gil Rhee, congratulated the participants on behalf of Dr M Tolba, Executive Director of UNEP and Dr M Gwynne, Director of GEMS-PAC and thanked all concerned in organising the workshop. He emphasised the essential role of water of good quality in development and outlined the past role of GEMS/Water in monitoring the world's fresh waters and in strengthening national capabilities. He described the value of the workshop in reviewing the manual, fostering regional co-operation and in strengthening national efforts to monitor and assess the quality of water resources. He looked forward to future GEMS/Water activities in the region. Mr Rhee then presented certificates to the workshop participants.

Mr Mkuchu welcomed the Regional Water Engineer who thanked the organisers of the training workshop and introduced the acting Regional Development Director who spoke on behalf of the Principal Secretary of the Ministry of Water, Energy & Minerals. He welcomed the opportunity to meet the participants from the countries of the Nile Basin. He stressed the importance of national development of water resources. He welcomed the location of the workshop in Tanzania and emphasised the continuing important role of Tanzania in GEMS/Water. He thanked the Tanzanian authorities, the people of Arusha and the workshop organisers and participants. He outlined the achievements of the workshop and stated the growing importance of management of water quality in the region for development and human health.

He finally welcomed the future of regional cooperation on Lake Victoria and the River Nile. Support needs in the region include laboratories, training and funding. He drew the attention of governments and donor agencies to the importance of continuing activity on water quality.

He urged the organisers to hold a follow-up workshop in six months time in Tanzania to review progress. He finally recommended the beauty of the area to all present. He wished the participants a safe journey home and declared the workshop officially closed.

Mr Mkuchu proposed a vote of thanks.

ANNEX 1
COURSE PARTICIPANTS

COURSE PARTICIPANTS

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ANNEX 2

COURSE PROGRAMMME

GEMS-Water Workshop on Water Quality Monitoring and Assessment
23rd March - 3rd April, 1992

PROGRAMME

DAY	TIME	TOPIC
Monday	10.00	Inauguration
23.3.92		Mr Birger Egekvist, Principal, MS/TCDC
		Mr R Munene, FINNIDA
		Mr N Sehmi, WMO
		Mr S Najam, FAO
		Mr M Tawfik, Director, Hydromet Survey Project
		Dr Veerle Vandeweerd, UNEP/GEMS-PAC
	10.30	Words from invited guests:
		His Excellency Mr Edoward Kadigiri, Ambassador of Burundi
		His Excellency Mr Thomas Munyanenza, Ambassador of Rwanda
		His Excellency Mr Charles Manyang D'Awol, Ambassador of Sudan
		His Excellency Mr Ben Matogo, High Commissioner of Uganda
		Dr E A Duale, WHO Representative for Tanzania & Seychelles
		Mr Paul Matovu, UNDP Assistant Resident Representative
	11.30	Arusha Region Commissioner
		Honorable Jakaya M Kikwete (MP), Minister for Water, Energy and Minerals
	12.00	Buffet Lunch
	13.30	Introductions (Jamie Bartram)
	14.30	Coffee
	15.00	GEMS programme: history; GEMS/Water phase 2, (John Jackson and Martial Dray)
	16.00	Objectives, structure and anticipated outputs of the workshop, (Jamie Bartram)
	17.00	Introduction to GEMS-Water draft Manaual for Water Quality Monitoring. (Dr Richard Ballance)
	18.00	Break
	evening	- Group 1: Regional Strategy for GEMS/Water (Chair - Mr Tawfik)
		- Group 2: Review of chapter 1

RAPPORTEUR Day 1 - JOHN JACKSON

DAY	TIME	TOPIC
Tuesday		
24.3.92	08.00	Hydrology, Water Quality and the Environment (Mr Sehmi, WMO)
	09.00	Country reports (chair - Mr Tawfik)
		Uganda (A N Geri); Ghana (S A Larmie)
	10.00	Tea break
	10.30	Country reports continued (chair - Mr Tawfik)
		Tanzania (P Kiliho); Ethiopia (S Tadesse); Nigeria (D Afolabi); Kenya (E N Nyaga);
		Hydromet Regional Report (Senfuma Nsubuga)
	12.30	Lunch
	13.30	Parameters considered in GEMS/Water (Martial Dray)
	14.30	Coffee
	15.00	Case Study: Setting up the Hydromet Laboratory in Entebbe (Mr Senfuma Nsubuga)
	16.00	Disscussion: Water Quality Monitoring within Hydromet
	16.30	The Global Environment Facility (GEF) (Elizabeth Marsollier)
	17.00	Break
	evening	- Group 1: Regional Strategy for GEMS/Water (chair - Mr Tawfik)
		- Group 2: Review of chapter 3

RAPPORTEUR Day 2 - JOSEPH BOUTROS

Wednesday

25.3.92	all am	Visit to Laboratories in Arusha (MAJI and TPRI) (Coordinator - Francis Gumbo)
	12.30	Lunch
	13.30	Particulate Matter Analysis (Dr J Boutros)
	14.30	Coffee
	15.00	Chemical Analysis (Dr J Boutros)
	16.00	Discussion
	17.00	Break
	evening	- Group 1: Review of chapter 2 - Group 2: Review of chapter 4

RAPPORTEUR Day 3 - JAMIE BARTRAM

Thursday

26.3.92	08.00	Strategy for Lake Monitoring Including Sampling Programmes and Frequency (John Jackson)
	09.00	Sample Preservation for Chemical and Particulate Analysis (Francis Gumbo)
	10.00	Tea
	10.30	Visit to Duluti Lake - Sampling and Sample Preservation (Coordinator - Francis Gumbo)
	12.30	Lunch
	13.30	Laboratory Practical of Chemical and Particulate Analysis (Coordinator - Francis Gumbo, Teaching - Joseph Boutros)
	14.30	Coffee
	15.00	Continuation of Laboratory Practical
	16.00	Discussion
	17.00	Break
	evening	- Group 1: Analysis of Omitted Sections of Manual - Group 2: Review of chapter 5 & 6

RAPPORTEUR Day 4 - MARTIAL DRAY

Friday

27.3.92	08.00	Duluti Lake - Discussion of Practical
	09.00	The Hydrology of the Upper Nile Basin (Hydromet- B Hayder)
	09.30	Hydrometric Data Requirements for GEMS-Water programme (Martial Dray)
	10.00	Tea
	10.30	Strategy for Groundwater Monitoring (Martial Dray)
	11.30	Discussion
	12.30	Lunch
	13.30	Quality Assurance and Quality Control-Basic Principles (Jamie Bartram)
	14.30	Coffee
	15.00	QA and QC in the GEMS/Water Programme (J Boutros)
	16.00	Discussion
	17.00	Country Reports - Sudan; Burundi
	18.00	Break
	evening -	free

RAPPORTEUR Day 5 - JOHN JACKSON

Saturday

28.3.92 am ARUSHA - for participants to collect travel cheques, morning free in town.

13.30	Progress Evalation
14.00	Country Work Plans; Discuss and Agree Framework for Development of Action Plans - Chair Jamie Bartram
14.30	Coffee
15.00	Continuation of Country Work Plans
17.00	End of Day

RAPPORTEUR Day 6 - JOSEPH BOUTROS

Sunday

29.3.92 FREE

Monday

30.3.92

08.00	Health Aspects of Water Quality (Jamie Bartram)
09.00	Microbiological Indicators and Methods for Microbiological Analysis (Jamie Bartram)
10.00	Coffee/Tea
10.30	On-site Microbiological Testing/Sample Preservation for Microbiological Analysis (Jamie Bartram)
11.30	Discussion
12.30	Lunch
13.30	Strategy for River Monitoring Including Sampling Programme and Frequency (Martial Dray)
14.30	Coffee
15.00	Biomonitoring (John Jackson)
16.00	Discussion
17.00	Break
evening:	Country Groups, Action Plans for next 12 months

RAPPORTEUR Day 7 - FRANCIS GUMBO

Tuesday

31.3.92

08.00	Field Trip to Usa River (Jamie Bartram & John Jackson) - on-site microbiological testing - sampling for microbiological testing - biomonitoring (macro invertebrates)
12.30	Lunch
13.30	Laboratory Practical - Microbiology (Jamie Bartram)
14.30	Coffee
15.00	Summary of Biomonitoring Practical (John Jackson)
16.00	Discussion
17.00	Break
evening	- Group 1: Overall handbook review (contents, depth, redundancy) - Group 2: Review of chapters 7 & 8

RAPPORTEUR Day 8 - MARTIAL DRAY

Wednesday

01.4.92	08.00	Data Reporting and Validation (Ed Ongley)
	09.00	GEMS/Water Selection of Global Network Stations (Martial Dray)
	10.00	Tea
	10.30	Practical Exercise on Above (Ed Ongley)
	11.30	Water Quality Assessment (John Jackson)
	12.30	Lunch
	13.30	Example Country Workplan (chair: John Jackson)
	14.30	Coffee
	15.00	Discussion of Country Workplans (chair Prof. Afolabi)
	17.00	Break
	evening	- Group 1: Overall Manual Review (contents, depth)
		- Group 2: Review of chapters 9 and 10

RAPPORTEUR Day 9 - JAMIE BARTRAM

Thursday

02.4.92	08.00	Statistics and Output Options (Ed Ongley)
	09.00	Water Quality Data Interpretation (Ed Ongley)
	10.00	Tea
	10.30	General Recommendations for Future Development
	11.30	Strategy for Follow-up of GEF (chair Elizabeth Marsollier).
	12.30	Lunch
	13.30	Manual Objectives and Intended Audience (University of Tampere)
	14.30	Coffee
	15.00	Handbook Review - Discussion (chair Jamie Bartram)
	17.00	End of Day
	evening	Resident Band

RAPPORTEUR Day 10 - FRANCIS GUMBO

Friday

03.4.92	08.00	Field Testing of Manual (University of Tampere)
	10.00	Tea
	10.30	Course Evaluation
	11.30	Closure
		- Mr Jorn Kronow (MS/TCDC)
		- Prof. M Viitasaari (Tampere Univeristy of Technology)
		- Mr Hayder (Hydromet)
		- Mrs Margaret Abira (spokesperson for participants)
		- Mr Deok-Gil Rhee (GEMS-PAC)
		- Regional Water Engineer
		- Regional Development Director
	12.30	Buffet Lunch

RAPPORTEUR Day 11 - JOHN JACKSON

ANNEX 3

Inaugural Speech: Hon Lt Col Jakaya M Kikwete (MP), Minister for Water, Energy and Minerals; Mr Shahid Najam, FAO; Dr Veerle Vandeweerd, UNEP.

SPEECH BY HON. LT. COL. JAKAYA M. KIKWETE, (MP), MINISTER FOR WATER, ENERGY AND MINERALS AT THE OPENING OF THE GEMS - WATER TRAINING COURSE ON WATER QUALITY MONITORING AND ASSESSMENT: ARUSHA 23RD MARCH 1992

Mr. Chairman,
Your Excellencies,
UNEP and WHO Representatives,
Arusha Regional Authorities,
Course Participants,
Ladies and Gentlemen.

I feel greatly honoured to have been invited to officiate the opening of the two weeks GEMS/WATER Training Course on Water Quality Monotoring and Assessment. May I take this opportunity, on bahalf of the Government of tanzania and on my own bahalf to welcome all of you to Tanzania, and in particular to Arusha. For those of you who are visiting Tanzania for the first time, let me assure you that you will enjoy the warm hospitality of our people. Let me also extend special thanks to the Arusha Regional authorities, the Danish Volunteer Training Center and the people of Arusha for the warm reception which has been accorded to us since our arrival.

Mr. Chairman, **today I have been invited to open a very crucial course. I consider the theme of is course important to us because of its subject matter. This is because when we say "Water is life", in this context is embodied in its quality.**

Therefore one can improve the parable and say "safe water is life and polluted water is death." Mr Chairman, the Global Environmental Monitoring of Water Quality and Assessment Course is being held in Tanzania for the first time. I am informed that unlike the previous two courses which centered more on the applicability of the World Health Organisation Guidelines drinking water quality, this year's course will enhance the national capabilities of the Nile Basin Riparian Countries in Water Quality Monitoring and Assessment using appropriate field techniques and data processing facilities, as well as reviewing a hand book on water quality monitoring and assessment methodology devised for the specific needs of the region.

Mr. Chairman, Tanzania started participating in the GEMS/WATER Project since 1980. In executing the project three baseline stations and four impact stations were established and constantly monitored as required by the project implementation guidelines.

Despite various constraints, Tanzania has been able to monitor the water quality of the stations and has been sending analysed and processed data to the data processing center of the World Health Organization (WHO) collaborating centre for surface and ground water quality and Canada Centre for Inland waters, based in Burlington, Ontario Canada for further processing. Our participation has been encouraged by the constant feedbacks we have been receiving from the Data Processing Centre in Burlington.

This kind of information helps the government to draw programmes and speeds up its efforts in protecting water sources from pollution. On a global scale, water quality data from various chosen stations around the world helps the United Nations'(UN) executing agencies such as United Nations Environmental Protection (UNEP) and World Health Organization (WHO) to draw up action programmes aimed at improving water quality and pollution control for the needy countries.

From the course objectives, it is understood that the countries of the Hydromet Survery Project would be expected to consider forming a network of GEMS/WATER monitoring stations in the Nile Basin. The other countries being represented in the course would also be expected to strengthen the already existing project monitoring stations if they have them and establish new ones. This would be an appropriate step taking into consideration the following broad GEMS/WATER Project objectives:-

(i) To collaborate with member states in strengthening the existing water monitoring systems and establishing new stations;

(ii) To improve the validit and comparability of water quality data within and between member states;

(iii) To assess the incidence and trends of the pollution of water by some persistent and hazardous substances on a long term basis.

The project will assist in initiating and strengthening existing water quality monitoring programmes and obtain water quality data which is needed in planning strategies to enable governments provide the people with water of acceptable quality.

Mr. Chairman, the provision of safe and clean water to the people is an essential element in building a healthy society since it reduces the incidences of water borne diseases which claim the lives of many people. Therefore, drinking water quality is vital part of any national water supply programme. For Tanzania water quality monitoring has been one of the major components of the activities. However, it needs to be strengthened by well trained personnel and improvisation of essential analytical instruments and equipment. This is an area which requires urgent assistance. Knowing the constraints which we face in the execution of the programme, let me take this opportunity to call upon the World Health Organization (WHO) and the United nations Environmental Protection (UNEP) to look into the possibility of providing the required assistance.

For the GEMS/WATER Project to succeed, a survey of the existing national facilities of the countries represented in this course should be conducted with a view of establishinh the needs in terms of personnel, equipment, chemicals, glassware and other essential inputs. Water quality analysis and assessment infrastructure should also be established in countries where it does not exist.

Constant follow-up on the performance of those countries is vital for any meaningful success to be realised. In implementing the project operational and material support from various donors will in most cases be needed. Holding of regular workshops for the participating countries would assist in discussing the
common operational constraints and evaluation. The benefits of such experience shared will have meaningful impact in achieving the desired objectives.

Mr. Chairman, The Governments of Tanzania and the Governments of the countries represented here, are looking forward to fruitful training of the course. The Government of Tanzania will do everything possible to implement the resolutions made during the course. I also call upon other Governments which are represented here to do the same. It is my hope that you will act as good ambassadors in this respect.

Before I conclude my address, I would like to thank World Health Organization (WHO) and Robens Institute of the University of Surrey for organising the course and UNEP for funding it.

I would also like to extend my heartfelt thanks to Your Excellencies for finding time from your busy schedule to attend this historic opening ceremony of the course. I would also once again like to sincerely thank the Danish Volunteer Centre for their excellent arrangements and facilities which I believe will facilitate smooth running of the course.

Let me finish by urging you to take some time off and visit some of the beauties and attractions of our country, which are within an easy reach from where we are.

With these few remarks may I now have the pleasure to officially declare the course open.

Thank you for your attention.

FAO's Opening Speech for Arusha training course

Mr Chairman

Excellencies, Distinguished Participants,

Ladies and Gentlemen.

It is indeed a matter of great honour and pleasure for me to be amongst you during the opening session of the GEMS - Water Training Course of Quality Monitoring and Assessment in the beautiful surroundings of Arusha. I, on my own and on behalf of FAO Dar es Salaam, wish to express our thanks to GEMS and the organisers for having invited us to the inauguration ceremony of this training course the subject matter of which is so important to FAO in its endeavours to help member countries realise the goals of sustainable agricultural development, food security and alleviation of hunger, poverty and malnutrition.

Ladies and Gentlemen,

Fresh water is essential to sustain life, development and environment and necessitates close involvement of the planners, through a concerted and participatory approach. FAO in its programme and activities, at the global, regional and national levels, accords high priority to the integrated water resources development and management, protection and conservation of water resources, water quality and aquatic ecosystems and to water as the major component for sustainable food production. In the process through its technical expertise, Technical Cooperation Programme and the field programmes, FAO assists member nations both at the policy/planning and the project implementation levels in harnessing full potential of water resources, increase water use efficiency, avoid depletion and water pollution and strengthen national and indigenous capabilities to manage water resources rationally and efficaciously.

Cognizant of the need to optimise sustained use of water resources in Tanzania and responding to the country's agricultural and food security requirement, FAO is providing assistance to the government in the development of village irrigation, rehabilitation of traditional irrigation, irrigated rice production etc with major emphasis on small holders and women in irrigation. Besides, one of our projects aims at providing institutional support to the irrigation development and organization in the country. FAO is also engaged in enabling Tanzania to officially and profitably benefit from inland, marine and lake water resources through national and regional projects.

Ladies and gentlemen,

We find that there is enormous scope for FAO to collaborate with GEMS in Tanzanian context and mutually avail of our facilities and expertise in terms of global assessment, data bank on water and natural resources and monitoring methodology to suitably incorporate the same in our programmes and activities with a view to serving the member nations and humanity in a more integrated manner. We therefore, eagerly look forward to the various opportunities lying ahead. Let me also wish the participants of the course a very useful and beneficial stay. I hope that they will be able to assimilate the tools and techniques imparted to them and also gain from each others experience to apply the same for country specific and regional situations. Indeed this will enhance our national institutional capabilities to manage water resources and promote efforts being taken at the regional level.

Thank you.

UNEP's Opening Speech for Arusha training course

Honourable Minister, Your Excellencies, distinguished guests, ladies and gentlemen.

On behalf of the United Nations Environment Programme, UNEP, and its Executive Director, Dr Mostafa K. Tolba, I would like to welcome you, to this WHO/UNEP GEMS/WATER regional training course. I would also like to extend a warm welcome on behalf of Dr Gwynne, Director of the Global Environment Monitoring System. Dr Gwynne had hoped to be with us today but unfortunately had to attend another meeting in Washington.

We wish to thank the Government of Tanzania for hosting this workshop, and the Danish Volunteer Agency for providing us with these excellent facilities. UNEP's thanks go in particular to Finnida for financially supporting this meeting and their input to the preparation of the draft handbook on field techniques for water quality monitoring, which will be discussed during the coming days. The excellent technical support from the WHO Collaborating Centre at the University of Surrey, is also gratefully acknowledged and in particular your contribution, Mr Bartram, to the organisation of the workshop is greatly appreciated.

UNEP welcomes and thanks the co-organiser of the workshop, Hydromet, the regional organisation of technical water experts of the Nile riparian countries, represented here by its director, Mr Tawfik. We also welcomes the presence of WMO in the person of Dr Sehmi who will be with us for the next two days. We are also pleased to have FAO participating. Unfortunately WHO and UNESCO, the other UN organisations involved in the GEMS/WATER programme, were not able to send representatives.

Last but not least we welcome you the government designated experts and country participants from the Nile Basin riparian countries. We are pleased that experts from Ghana and Nigeria are with us and look forward hearing about their experiences in the implementation of the GEMS/WATER programme in West Africa.

Honourable Minister, Your Excellencies, distinguished guests, ladies and gentlemen -

The world community faces many environmental and developmental problems of which the pollution of freshwater resources is not the least. Freshwater is a finite resource, essential for agriculture, industry and human existence. Without water of adequate quantity and quality, sustainable development is not possible. Water pollution and wasteful use of freshwater are threatening development and water resource projects world-wide. It was to address these issues that UNEP and WHO in co-operation with WMO and UNESCO, initiated in 1977 the first global programme on monitoring of water quality in lakes and reservoirs, rivers and groundwater. This GEMS/WATER programme forms part of the Global Environment Monitoring System, commonly referred to as GEMS, which is a collective effort of the world community to acquire through monitoring and assessment the data and information needed for the sustainable and rational management of natural resources.

The GEMS/WATER programme started its second phase in 1991. The major objectives of this second phase are the production of comprehensive assessments on specific freshwater quality issues of global and regional importance, and the strengthening of monitoring and assessment capabilities of participating countries.

As part of this revised and strengthened GEMS/Water programme, the UN agencies participating in the programme, are supporting an initiative to strengthen water resource assessment in the East African region. This training course is part of this initiative.

The GEMS/WATER programme is channeling its activities in the East African region through 'Hydromet', the regional organisation of technical representatives of the riparian countries of the Nile, and supported by their governments.

We, in GEMS/Water, hope that Hydromet, as a regional technical organisation, will play a key role in the improved implementation of monitoring and assessment programmes in the region and will co-ordinate the collaboration of the region with the global Gems/Water programme.

During the preparation of the course, the GEMS/WATER programme produced a new field manual on water quality monitoring and assessment methods. The draft manual is before us for discussion and review. UNEP hopes that as a result of this training course, the handbook will be improved and amended to better reflect the specific needs and requirements of the region and that through your input the handbook will become a more practical and applicable guide to water quality monitoring.

We would like to take the opportunity of all us being here to introduce phase II of the GEMS/WATER programme and to increase the regional participation in the programme. Thus we have invited a number of GEMS/WATER consultants and staff members of collaborating centres and we wish them a warm welcome and pleasant stay in this wonderful country. We hope that as a result of us being here, course participants will be able once back home, to solicit the active participation of their country and region in the GEMS/WATER programme and that you, expert participants, will become key players in the implementation of that programme.

This training course is not a one-off activity. Further proposals to strengthen the activities in the region have been put forward by UNEP, WHO and Hydromet to potential donors. One such proposal deals with a training course to increase the data handling and analysis capabilities at the national level, based on the GEMS/RAISON computer software which will be introduced to you by our Canadian colleagues during this course. Another proposal aims to strengthen laboratory facilities in the region. We can not promise that donors will be forthcoming but we can assure you that, together with Hydromet, we will try our very best to make these plans become reality. We of course depend on your participation and continuous support.

Hopefully this course will mark the beginning of increased participation of the countries of the region, and of Ghana and Nigeria in the GEMS/WATER programme so leading to the strengthening of the national water quality monitoring capabilities. UNEP wishes you all success in your deliberations.

Thank you

ANNEX 4

Country Reports

Hydrological Activities in Burundi

Burundi is a country rich in hydrography. It is divided into two large, principle watershed basins:

1. The Ruvubu basin (Nile);
2. The Lake Tanganika basin.

The hydrological reserve includes sixty stations spread amongst the two watershed basins and are equipped with limnological keys for each of the measurement sections.

Apart from the limnological observations, which have been taken over a long period of time, measurements of speed and flows were started in 1960.

In 1974 two services were set up in Burundi:

1. The Hydromet project which occupied the Ruvubu basin;
2. The Italian project (ITS) which occupied the Lake Tanganika basin.

The two services evolved up to 1980, the year in which the Burundi Geographical Institute was created. The Institute has as an objective; getting all base data in the country (agrometerological, hydroclimatographical, hydrogeological, topographic, cartographic, etc). Thus, it has assisted in the creation of a National Hydrology Service.

The services biggest programmes are the following:

1. Evaluate quantity and quality of all the water courses in the country;
2. Determine annual water measurement;
3. Analyse and publish all collected data.

The programme has been followed, except in the area of water quality which has come up against two constraints:

1. The lack of laboratory and equipment;
2. The lack of qualified personnel.

However, since 1987 measurements have been made at the sixty hydrological stations.

In reality, these parameters are measured:

1. pH;
2. Temperature;
3. Suspended solids.

Given that the great demand for the data adds to the argument that the service should be permanent ...

Water quality evaluation is becoming one of the biggest of the programmes.

Alongside the hydrological service, there is REGIDESO (the countries water and electricity service) who are interested in water consumed in urban centres, where the highest priority is to bring water quality in line with water quality standards set by the WHO.

Today, the country is doing everything to face this principle problem which constitutes a danger for all living things.

COUNTRY REPORT (EGYPT)

Introduction

Egypt is located at North East Africa and boarded with Libya from West and Sudan from South and Mediterranean in the North and red sea in the east. The population of Egypt is about 55 million inhabitant and the climate is typical to Mediterranean climate. The total area of the public is about 1.0 million sq. km. The river Nile runs from South to North, the Nile valley which is inhabited by 96% of the total population.

The river Nile is considered as the main water resource in Egypt, it flows from the equatorial lakes passing through Sudan until it enters lake Nasser. The river Nile is regulated with series of several barrages from Aswan up to Mediterranean, in Cairo the Nile divides into two main branches and another two sub branches. The ground water is also another resource of Egypt water resources and the major part of it is lying in the western desert of Egypt and also in Sinai desert and the other in delta.

The rainfall is very little and not considered as one of the water resources of the country.

Water Activity

The sources of pollution in Egypt are as follows:

Agriculture - the irrigation water is heavily polluted from chemicals which are used for fertilising and draining in River Nile, land is going out of production at a frightening rate. Ground water becomes poisoned by salt that will be concentrated by inefficient irrigation, also ground water is contaminated with nitrates from a chemically supported agriculture.

Human misuse of River Nile

Industry - most of it discharges their disposal in the River Nile.

Sea Water - at the coast the sea water penetrated to pollute the under ground water.

Water veds - Hayysent water is a good environment of Belharsia and water borne diseases.

Water Quality Networks

In the past the universities and governmental laboratories like laboratories of ministry of health and agriculture are used to carry all research works and special studies on pollution untile high Aswan Dan side effects research institute (HADSERI) involved in management and operation of water quality laboratories. The river Nile protection and development project (RNPD) planned to establish a new lab, this new lab, will be a support unit for the water quality pollution control department of HADSERI to fulfil the following objectives;

1 water quality monitoring network of the River Nile activities
2 special studies on pollution control
3 water quality modelling
4 research work

The project was completed in June 1989.

Selection of Water Quality Parameters

In order to achieve a manageable workload on the River Nile and to fulfil HASSERI water quality monitoring network objectives, proper analytical parameters should be selected to reflect the actual river and stream conditions.

The following parameters should be analysed in the laboratory and in situation:

pH, Temperature, conductivity, TDS (Total Dissolved Solids), Oil and grease, suspended solids, colour, turbidity, BOD, COD, TOC, Alkalinity, Hardness, Carbonates, Bicarbonates, Sio2, Ca, Na, K, Mg, S, Cl, F, So_4, Phosphorus (total), Ortho Phosphorus, No_3, No_2, NH_3, Kjeldahl N, Heavy metals, MBASS test for surfactant, Microscopical examination for algae, feacal coliforms.

Parameters that are affected by delays in analysis should be measured at the time of sampling (in the field) using direct measuring instruments to determine pH, dissolved Oxygen, Temperature and electrical conductivity.

Hadseri Water Quality Laboratory Instruments and Equipments

The following section provides detailed information about the equipment and instruments in the HADSERI water quality laboratory.

Refrigerated/Incubator, Muffle furnace, Automatic water distiller, Automatic autoclave, Hot plate (jumbo size), Hot plate (normal size), Incubator for micro organisms, Electronic water bath, Electronic precision balance, Immersion cooler unit, Hot plate with magnetic stirrers, Centrifuge, Macro kjeldahl digestion apparatus, filtration system, Fume hood, electronic analytical balance, Hot plate, Digital pH, mv/temperature meter, Heating mantel, Drying oven, Deep freeze.

Action Plan

Permanent joint technical commission of Nile water took the responsibility of all technical and hydrological aspects of the River Nile to reduce the losses of the Nile water at the swamps and to increase it's natural flow through upper Nile projects.

The pollution of water in Egypt became very high and no doubt that the pollution of River Nile are reducing the quality of water available for human use. PJTC as a national body concerning about Nile water is going to establish it's own laboratory for monitoring pollution in several stations covering all the River Nile.

We expected from GEMS more co-operation to identify important size for network to collect samples and analyses it with more priority.

WATER QUALITY IN ETHIOPIA
CURRENT STATUS

1. INTRODUCTION

One of Ethiopia's most important natural resource is its relatively abundant supply of water. The country has 14 major river basins covering an area of 1,245,500 Km^2, with an estimated mean annual surface run-off of 111.62 billion cubic meter (BCM) and a potential safe yield of ground water of 2.6 BCM per annum. However, the quality status of the country's water resources remain unknown except for some sporadic and project specific studies done over a few of the river basins.

The r.ch water resources are mainly utilized for irrigation, hydropower generation and industrial processes, as well as for drinking and other domestic purposes. Consequently most rivers and streams have become recipients for different types of waste materials generated from various sources, although the extent varies from one basin to another depending on the type of the development activities introduced.

The Ethiopian Valleys Development Studies Authority (EVDSA) is one of the lead agencies in the planning, development, conservation and protection of inland water resources. According to its mandate EVDSA is to 'undertake environmental studies and research with a view to controlling depletion or pollution of natural resources in the valleys; initiate policy, and upon approval, supervise the implementation of the same'. Therefore, being one of the most important and valuable natural resources of the country, water is given high priority in the program of environmental studies and monitoring initiated by EVDSA.

2. WATER QUALITY MONITORING

In Ethiopia both a Hydrological Network (river and stream gauging) and a Meteorological Network have been in existence for sometime. However, there is no properly established water quality monitoring network at present. Nevertheless, the importance of establishing a nation-wide water quality monitoring network has been recognized by EVDSA and was specifically mentioned during the preparation of the country's preliminary water resources development master plan (WAPCOS, 1990).

Essential steps to help with the establishment of this network are now being undertaken. In particular a proposal to conduct a nation-wide inland water quality survey has been drafted recently and it is expected that this survey will provide base-line data for almost all of the river basins and guidance for the establishment of a national water quality monitoring network in Ethiopia. The survey is also considered necessary to assess properly the extent of pollution problems in the country and to provide a factual basis for the preparation of standards, regulations and pollution control strategies.

It is hoped that the data generated by a water quality monitoring network will indicate the effectiveness of the regulations and strategies in tackling pollution problems and any additional measures that may need to be taken to solve them. Furthermore, we strongly hope that this training course will help to guide us in the establishment of this network.

3. EXISTING INFORMATION ON WATER QUALITY

The limited amount of available data make it difficult to indicate the status of water quality in Ethiopia. There has been very little systematic assessment of water quality in the country. Most of the available data is related to specific schemes, resulting in information for a small number of sites over limited periods of time. The available information are mainly contained in the studies made by HALCROW (1975; 1978; 1983-85), Tate and Lyle (1984), Sogreah (1965), MacDonald (1985), Nedeco (1982), WRDA (1985) Komolrit and Zewdie (1974), Zewdie (1976), and Wood & Talling (1988). Wood & Talling (1988) summarized the findings of more than 50 publications which are relevant to chemical and related biological features of the water of Ethiopian lakes. There is little recent data on which an up-to-date review of water quality trends can be based.

The available data indicate a progressive deterioration of water quality in some parts of the country. A typical example is that of the Awash Valley where most of the irrigation schemes and industrial activities are located. In this basin salinity shows a progressive increase from the Upper down to the Lower part of the valley, mainly resulting from irrigation activities (HAlCROW, 1989). In the Upper Basin of the Awash Valley where the capital city (Addis Ababa) is situated, water quality is very poor due to industrial, municipal and domestic pollution. In addition, eutrophication as a result of leaching of nutrients and fertilizer, and contamination of water with toxic pesticide residues have been indicated in some areas of the Awash Valley (WRDA, 1985).

Another important water quality problem has been observed in the Abijata-Shala National Park (in the Rift Valley Lakes Basin) which is known for its bird life. Diversion of lake feeder rivers, and abstraction of lake water for irrigation developments and soda ash extraction have resulted in a reduction of Lake Abijata water level, and increases in salinity and alkalinity of the lake water. These phenomena have brought significant changes in chemical and biological processes in and around Lake Abijata (Kebede & Hillman, 1988). Massive fish kills and a decrease in the bird population have been observed in the area, which could be due to changes in the composition of the phytoplankton and invertebrate fauna upsetting the complex food relationships of the ecosystem.

River, spring and shallow well waters form the major sources of drinking water in Ethiopia. Where these water sources are the dominant supply, microbiological and biological quality is often poor, encouraging the spread of water-associated diseases. Hence, water-borne, water based and other water related vector-borne diseases are prevalent in the country. Of these, enteric diseases (diarrhoea, dysentery, etc.), protozoan infections (e.g. amoebiasis) and helminthic infections such as ascariasis, bilharziasis, onchocerciasis and filariasis (Komolrit & Zewdie, 1974) are the most serious ones. Much of these health problems stem from the lack of safe drinking water and disregard for sanitation essentials.

The other important health problem related to water quality is fluorosis which is prevalent in the Awash Basin, particularly in the middle valley, and around Lake Awassa in the Rift Valley Lakes Basin. In the Awash Basin river and well waters are the major sources of drinking water. These sources contain high fluoride levels (0.3 - 2 mg/l for Awash River and other superficial waters; less than 5mg/l for cool well waters /< 25^0C/; up to 10 mg/l for hot springs; up to 15 mg/l for hot well waters /> 25^0C/; and up to 30 mg/l for lake waters), and has posed serious risks of bone fluorosis in adults and mottling of teeth in children (Zewdie, et al., 1977).

4. THREATS TO WATER QUALITY

In Ethiopia, although there is no comprehensive water quality assessment nor monitoring program, the few available sporadic studies done in the past have indicated that water pollution is a serious problem in some parts of the country. Visual inspection of rivers and streams in some areas depict that the situation has further intensified with the increase in population, industrialization, agricultural and other development activities since no corrective measure has been taken. For example, water pollution assessments in the upper part of Awash Basin have indicated a high degree of pollution of the Little and the Great Akaki Rivers which drain the majority of Addis Ababa. Extremely high coliform counts, high Biochemical Oxygen Demand (BOD) and very low Dissolved Oxygen (DO) were recorded for these rivers (Komolrit and Zewdie, 1974). Visual inspection of the streams reveals gross pollution, the growth of sewage fungus and deposits of faecal and other obnoxious materials. Nevertheless, more than 10,000 people living between Addis Ababa and Lake Aba Samuel use this water for drinking, livestock watering and for all other domestic purposes (Zewdie, 1976).

4.1 INDUSTRIAL POLLUTION

Industrial pollution is a problem that has received little attention in Ethiopia. It is neither monitored nor controlled; there is no legislation to regulate industrial effluent nor proper planning procedures which might help to avert new problems.

Today there are about four hundred and fourteen registered manufacturing industries owned by both Government and private sectors. More than 50% of the country's industrial establishments are found in and around the national capital Addis Ababa, while the remaining are in eastern Shewa region and Eritrea.

Although the industrial base of the country is at too low a level to create a widespread water pollution problem, most of the existing industries discharge their waste directly into surface water without any or inadequate treatment. The majority of these industries are located along rivers or streams from where they can draw water for their processes and into which they discharge their wastes. Tanning, brewing, textile, chemical, food processing, pulp and metal industries are amongst those which contribute to the pollution of surface waters, in addition to urban sewage (treated and untreated) (Mebratu, 1990).Tanning, textile and beverages are three of the dominating industrial sectors in the country. The majority of the factories under these sectors discharge their effluent into nearby rivers or streams or ponds without any form of treatment. The frequency of discharge is continuous and the mode of discharge is open in many cases. Most of the time the recipient rivers or streams are utilized either for all purposes or partial purposes by downstream users.

Most industries have no waste treatment facilities. In those few cases where treatment facilities have been installed, the facilities are generally inadequate, poorly maintained or incorrectly operated. Thus water bodies which receive the untreated waste generated from various industries suffer the most significant pollution (Komolrite and Zewdie,1974; Zewdie,1976; Mebratu, 1989, 1990; EVDSA 1991).

The problem of industrial pollution is further aggravated by a number of small scale industries and several cottage type agro-industries developed in different parts of the country. Although not assessed, the water pollution resulting from these sectors can be quite significant. In particular coffee washing plants, which are mostly established along the river courses, discharge large quantities of highly polluting organic waste water into streams and rivers and gross pollution is the result.

4.2 AGRICULTURAL POLLUTION

Agricultural activities have introduced several polluting substances such as chemical fertilizers, insecticides, herbicides, organic matter (animal wastes), etc. into water bodies through surface runoff, erosion, irrigation return flows and precipitation.

In Ethiopia, pesticides and herbicides are commonly used on state farms, and fertilizers on both state farms and in peasant agriculture. However, the extent of utilization differs. The type of pesticides mostly used in the state farms include chlorinated hydrocarbons, organo-phosphorus compounds and carbamate compounds. The type of fertilizers used are basically of nitrogen and phosphorous origins. What is more, the continuation in the use of pesticides like DDT and Lindane, whose residues are persistent for longer periods, can contaminate both aquatic and terrestrial environments, accumulating in the food chain. Both of these chemicals are toxic and their use has been banned in many countries.

Agricultural pollution is likely to rise with increased use of commercial fertilizers and pesticides. According to information obtained recently from the Agricultural Inputs Corporation, Ministry of Agriculture, the total

annual use of agricultural chemicals has already increased from 1,048,060 Quintals in 1985 to 2,502,715 Quintals in 1990 for commercial fertilizers, and from 146,775 Kg & 150,310 liters in 1987 to 868,489 Kg & 477,799 liters in 1991 for pesticide.

4.3 MUNICIPAL AND DOMESTIC POLLUTION

The vast majority of the Ethiopian population are without adequate sanitation and millions of people defecate openly on land or surface waters. In either case surface waters or ground waters will be subjected to faecal pollution leading to wide occurrence of water borne diseases. In cities and towns surface streams and drains act as open sewers. Water bodies are largely contaminated by septic tank overflows and waste waters from different institutions and domestic sources. Dumping of solid waste from markets, food stalls and from individual homes to surface waters is also a serious problem in urban areas and this had made the water even more polluted and unsightly. The danger of faecal pollution is more serious because the majority of the population do not have access to a safe water supply. According to a 1984 Central Statistical Agency (CSA) report 85.5%, of the general population ~~85.5%~~ obtain their water supply from unreliable and contaminated sources.

5. NATIONAL ACTION PLAN REGARDING WATER QUALITY MANAGEMENT.

Ethiopia has no approved overall environmental action plan nor a specific one for water quality. However, EVDSA (1991) has proposed a short, medium and long term environmental protection and management action plan of which Water Quality forms a part, in terms of developing an environmental monitoring network and establishing standards and legislation and initiating enforcement procedures.

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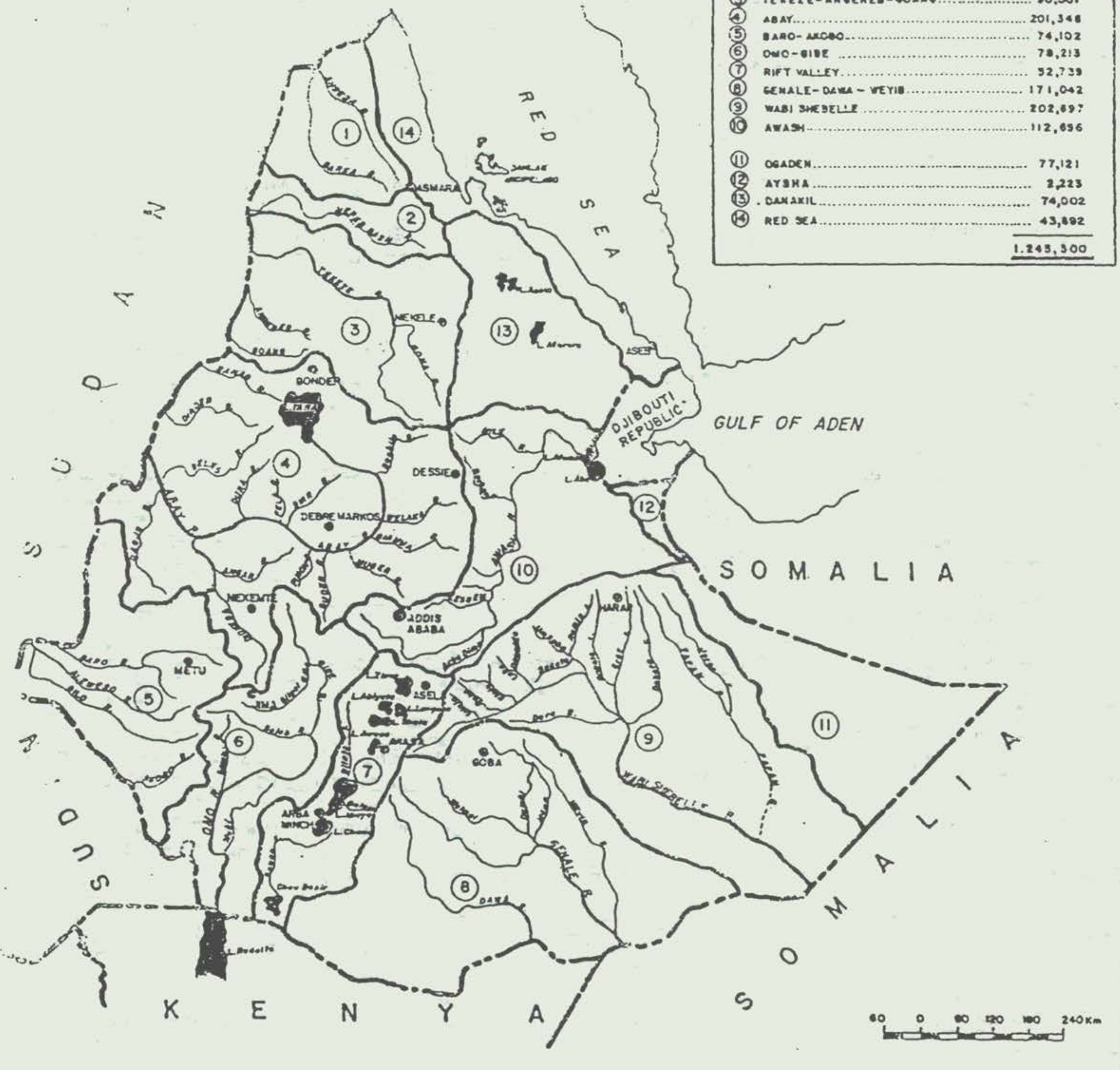
ETHIOPIAN MAJOR RIVERS' CATCHMENT

LEGEND

	CATCHMENT	AREA IN KM^2
①	BARKA – ANSEBA	[illegible]
②	MEREB – GASH	23,332
③	TEKEZE – ANGEREB – GOANG	90,001
④	ABAY	201,346
⑤	BARO – AKOBO	74,102
⑥	OMO – GIBE	78,213
⑦	RIFT VALLEY	52,739
⑧	GENALE – DAWA – WEYIB	171,042
⑨	WABI SHEBELLE	202,697
⑩	AWASH	112,696
⑪	OGADEN	77,121
⑫	AYSHA	2,223
⑬	DANAKIL	74,002
⑭	RED SEA	43,692
		1.245,300



BASIN	CATCHMENT AREA Km^2	MEAN ANNUAL SURFACE RUN-OFF (Bm^3/annum)	GROUND WATER POTENTIAL Bm^3/annum
ABBAY	201,346	52.62	1.80
R.VALLEY LAKES	52,739	5.64	0.01
AWASH	112,696	4.60	0.14
OMO-GHIBE	78,213	17.96	0.18
GENALE-DAWA - WEYIB	171,042	5.88	0.03
WABE-SHEBELLE	202,697	3.16	0.04
BARO-AKOBO	74,102	11.81	0.10
TEKEZE-ANGEREB - GOANG	90,001	7.63	0.20
MEREB-GASH	23,932	0.88	0.05
BARKA-ANSEBA	41,694	0.36	0.05
RED SEA	43,692	0.22	0.05
OGADEN	77,101	-	-
DANAKIL	74,002	0.86	-
AYSHA	2,223	-	-
TOTAL	1,245,500	111.62	2.6

FLOURIDE CONCENTRATION IN AWASH BASIN

SOURCE	FLOURIDE CONC.
Awash River and other Superficial waters	0.3-2 mg/l
Cool well waters (<25°C)	<5 mg/l
Hot springs	Up to 10 mg/l
Hot well waters (>25°C)	Up to 15 mg/l
Lake waters	Up to 30 mg/l

Profile of the Factories Effluent (Textiles)

Name of the Factory	Volume of Effluent (cu-m/d)	Temperature of Effluent (C)	Frequency of Discharge	Treatment Before Discharge	Mode of Discharge	Effluent Discharged Into	Utility of Potential Body
Akaki Textile	960-1440	25-30	continuous	Partial	Open	Akaki	A.P
Asmara "	360	20-22	intermitant	No	"	Goddif (SS)	P.P
Awassa "	1344	38	continuous	Yes	Closed	Swampy Area	N.P
Bahir Dar "	N/A	N/A	"	Yes	Open	N/A	-
Combolocha "	3160	30	"	Yes	"	Borkena	A.P
Debre Brehan Wool	216	Ambient	"	No	"	Shirxille (SS)	P.P
Dire Dawa Textile	1920	30-50	"	No	"	Maibeka	P.P
Britrea "	N/A	N/A	"	No	Closed	Drainage	N.P
Ethiopia "	192	30	"	No	"	Bore Well	N.P

Profile of the Factories Effluent (Tannery)

Name of the Factory	Volume of Effluent (cu-m/d)	Temperature of Effluent (C)	Frequency of Discharge	Treatment Before Discharge	Mode of Discharge	Effluent Discharged Into	Utility of Potential Body
1. Addis Tannery	155	15-25	continuous	No	Open	Akaki	A.P
2. Asmara "	75 cu.m/hr	25-30	every 3 hrs	No	"	Maibela (TR)	A.P
3. Awash "	1000	15-24	continuous	No	"	Akaki	A.P
4. Combolcha "	300	25-30	"	No	"	Borkena (TR)	A.P
5. Ethiopian Pickling	380	20	"	No	"	Akaki	A.P
6. Ethiopian Tannery	N/A	25	"	Yes	"	Awash Lake	A.P
7. Modjo Tannery	N/A	23-28	"	No	"	Modjo (TR)	A.P
8. Qey Bahir Tannery	N/A	25-30	"	No	"	Maibeka	A.P

TR: Tributary River
SS: Seasonal Stream
A.P: All Purpose
P.P: Partial Purpose
N.P: No Purpose

Profile of the Factories Effluent (Beverage and Sugar)

Name of the Factory	Volume of Effluent (cu-m/d)	Temperature of Effluent (C)	Frequency of Discharge	Treatment Before Discharge	Mode of Discharge	Effluent Discharged Into	Utility of Potential Body
1. Addis Ababa Brewery	690	Ambient	continuous	No	Open	Akaki (TR)	A.P
2. Asmara Brewery	640	"	"	No	Closed	Sewage	N.P
3. Awash Winery	N/A	"	"	No	Open	Akaki	A.P
4. Harar Brewery	700	"	"	Yes	"	Stream	P.P
5. Mekannisa Distiller	72	70	intermittent	No	"	Akaki	A.P
6. Meta Brewery	560	30	continuous	No	closed	Sebeta (SS)	P.P
7. Metahara Sugar	9000	Ambient	"	No	open	Ponds	irrigation
8. Shoa Sugar	5000	30	"	No	"	"	"
9. Wonjl Sugar	5000	25-40	"	No	"	"	"

Results of Analytical Investigation for Three Selected Factories in Addis Ababa

Name of the Factory	PH	TSS mg/l	BOD mg/l	COD mg/l
1. Awash Tannery	11.94	3424	1785	3000
2. Akaki Textile	11.87	805	675	1500
3. Mekannisa Distillery	4.69	504	855	1490

Source: Preliminary Country Paper of Ethiopia for the UNIDO Program on Industrial Waste Water Purification, by Desta Mebratu, 1990; page - 25.

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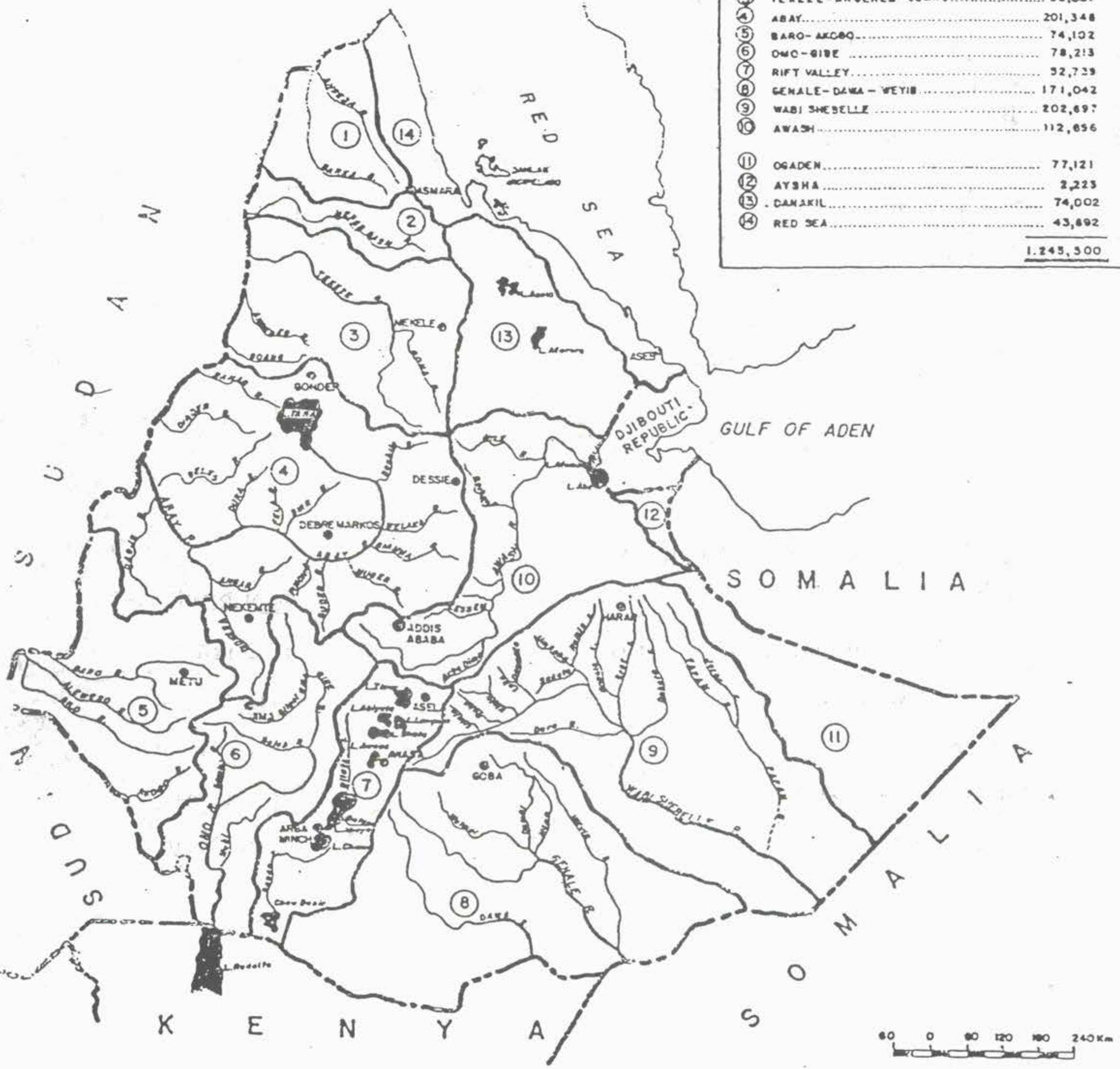
7	RIFT VALLEY	52,739
8	GENALE-DAWA – WEYIB	171,042
9	WABI SHEBELLE	202,697
10	AWASH	112,856
11	OGADEN	77,121
12	AYSHA	2,223
13	DANAKIL	74,002
14	RED SEA	43,692
		1.245,500



BASIN	CATCHMENT AREA Km^2	MEAN ANNUAL SURFACE RUN-OFF (Bm^3/annum)	GROUND WATER POTENTIAL Bm^3/annum
ABBAY	201,346	52.62	1.80
R.VALLEY LAKES	52,739	5.64	0.01
AWASH	112,696	4.60	0.14
OMO-GHIBE	78,213	17.96	0.18
GENALE-DAWA - WEYIB	171,042	5.88	0.03
WABE-SHEBELLE	202,697	3.16	0.04
BARO-AKOBO	74,102	11.81	0.10
TEKEZE-ANGEREB - GOANG	90,001	7.63	0.20
MEREB-GASH	23,932	0.88	0.05
BARKA-ANSEBA	41,694	0.36	0.05
RED SEA	43,692	0.22	0.05
OGADEN	77,101	-	-
DANAKIL	74,002	0.86	-
AYSHA	2,223	-	-
TOTAL	1,245,500	111.62	2.6

FLOURIDE CONCENTRATION IN AWASH BASIN

SOURCE	FLOURIDE CONC.
Awash River and other Superficial waters	0.3-2 mg/l
Cool well waters (<25°C)	<5 mg/l
Hot springs	Up to 10 mg/l
Hot well waters (>25°C)	Up to 15 mg/l
Lake waters	Up to 30 mg/l

Profile of the Factories Effluent (Textiles)

Name of the Factory	Volume of Effluent (cu-m/d)	Temperature of Effluent (C)	Frequency of Discharge	Treatment Before Discharge	Mode of Discharge	Effluent Discharged Into	Utility of Potential Body
Akaki Textile	960-1440	25-30	continuous	Partial	Open	Akaki	A.P
Asmara "	360	20-22	intermitant	No	"	Goddif (SS)	P.P
Awassa "	1344	38	continuous	Yes	Closed	Swampy Area	N.P
Bahir Dar "	N/A	N/A	"	Yes	Open	N/A	-
Combolocha "	3160	30	"	Yes	"	Borkena	A.P
Debre Brehan Wool	216	Ambient	"	No	"	Shirxille (SS)	P.P
Dire Dawa Textile	1920	30-50	"	No	"	Maibeka	P.P
Britrea "	N/A	N/A	"	No	Closed	Drainage	N.P
Ethiopia "	192	30	"	No	"	Bore Well	N.P

Profile of the Factories Effluent (Tannery)

Name of the Factory	Volume of Effluent (cu-m/d)	Temperature of Effluent (C)	Frequency of Discharge	Treatment Before Discharge	Mode of Discharge	Effluent Discharged Into	Utility of Potential Body
1. Addis Tannery	155	15-25	continuous	No	Open	Akaki	A.P
2. Asmara "	75 cu.m/hr	25-30	every 3 hrs	No	"	Maibela (TR)	A.P
3. Awash "	1000	15-24	continuous	No	"	Akaki	A.P
4. Combolcha "	300	25-30	"	No	"	Borkena (TR)	A.P
5. Ethiopian Pickling	380	20	"	No	"	Akaki	A.P
6. Ethiopian Tannery	N/A	25	"	Yes	"	Awash Lake	A.P
7. Modjo Tannery	N/A	23-28	"	No	"	Modjo (TR)	A.P
8. Qey Bahir Tannery	N/A	25-30	"	No	"	Maibeka	A.P

TR: Tributary River
SS: Seasonal Stream
A.P: All Purpose
P.P: Partial Purpose
N.P: No Purpose

Profile of the Factories Effluent (Beverage and Sugar)

Name of the Factory	Volume of Effluent (cu-m/d)	Temperature of Effluent (C)	Frequency of Discharge	Treatment Before Discharge	Mode of Discharge	Effluent Discharged Into	Utility of Potential Body
1. Addis Ababa Brewery	690	Ambient	continuous	No	Open	Akaki (TR)	A.P
2. Asmara Brewery	640	"	"	No	Closed	Sewage	N.P
3. Awash Winery	N/A	"	"	No	Open	Akaki	A.P
4. Harar Brewery	700	"	"	Yes	"	Stream	P.P
5. Mekannisa Distiller	72	70	intermittent	No	"	Akaki	A.P
6. Meta Brewery	560	30	continuous	No	closed	Sebeta (SS)	P.P
7. Metahara Sugar	9000	Ambient	"	No	open	Ponds	irrigation
8. Shoa Sugar	5000	30	"	No	"	"	"
9. Wonjl Sugar	5000	25-40	"	No	"	"	"

Results of Analytical Investigation for Three Selected Factories in Addis Ababa

Name of the Factory	PH	TSS mg/l	BOD mg/l	COD mg/l
1. Awash Tannery	11.94	3424	1785	3000
2. Akaki Textile	11.87	805	675	1500
3. Mekannisa Distillery	4.69	504	855	1490

Source: Preliminary Country Paper of Ethiopia for the UNIDO Program on Industrial Waste Water Purification, by Desta Mebratu, 1990; page - 25.

1. WATER QUALITY MONITORING SYSTEMS AND ACTIVITIES IN GHANA

1. Water Quality Monitoring Systems

Surface water quality monitoring activities have been achieved through three distinct objectives in Ghana (Larmie et al, 1991). These comprise ad hoc activities under water development projects, research projects and finally through the implementation of data collection networks.

1.1 Research Activities

The Water Resources Research Institute (WRRI) and the Institute of Acquatic Biology (IAB) are two diferent institutes of the national Council for Scientific and Industrial Research(CSIR) and by virtue of their work functions undertake surface water quality monitoring in Ghana.

Research projects of various durations, sampling frequencies and laboratory analysis to investigate water quality problems have been carried out by these two institutes. Some of the study areas are shown in figure 1.

The Ankobra River for example has been investigated for the impact of the mining activity on the river quality (Osafo, WRRI,1988) and also the spatial and temporal variation of quality constituents in the Densu River (Amuzu, WRRI,1975). Studies initiated by Institute of Aquatic Biology(IAB) showed increasing seasonal levels of inorganic phosphates and nitrate-nitrogen in the Oti and White Volta Rivers because of the use of agro-chemicals(IAB,1979). Such reports are very well documented and afford the opportunity to establish the quality conditions of these rivers.

1.2 Ad hoc Activities

Ad hoc monitoring activities arise during feasibility studies for water projects. Consequently, water sampling and laboratory analysis are performed over a limited time period to assess river water quality in relation to the objectives for which the projects are intended.

Though considerable information has been generated over the years, an appraisal of such data to assess general quality conditions of surface waters has revealed that most of the projects have relied only on spot samples taken and are silent onfuture water quality monitoring activities. Secondly, data acquired are very isolated and scattered and the time frames under which these projects are undertaken are too different for meaningful analysis to be achieved.

1.3 Monitoring Networks

The development of the existing hydrological networks in Ghana have followed mainly water development projects. However, continuous surface qater sampling from about 54 stations on all the major river basins of the country was incorporated into the hydrological networks programme in the very early sixties.

water quality in areas associated with mining, manufacturing, agricultural and other activities. In the third phase, the network is developed to include the study of man-made lakes and reservoirs.

Since the inception of the programme in 1985, the southernmost sections of all the coastal rivers have been continuously monitored on monthly basis. A report on this first phase of the project establishing the seasonal pattern of river water quality variation and status has been finalised for publication.

Within the second phase, a study on the Ankobra River has been completed to confirm the impact of mining activities on the river (Osafo, 1988).

This was implemented through a working arrangement involving river water sampling and laboratory analysis between the Architectural and Engineering Services Corporation(AESC) Hydrology division and the Ghana Water and Sewerage Corporation(GWSC) regional laboratories respectively. These two organisations are government-owned and are both involved in water monitoring. For various reasons, the records available show enormous gaps.

2. Development and implementation of the monitoring networks

2.1 Surface water quality

The aim of the programme which began in 1985 was to develop a network to generate relevant quality data to assess continuously the quality of surface water resources.

This was to help evaluate water pollution control measures and ensure rational water development and utilization(WRRI,1986). In the development of the project, major goals set included the following:

i) a review and analysis of all available data on surface waters generated from previous networks and water development projects with a view to abstracting information on their quality status for publication.

ii) design a network to monitor and assess surface water quality taking into account specific quality problems in the areas of domestic, municipal, industrial, and agricultural water uses.

iii) prepare a programme and plan for implementing the network based on collaborative action among the diferent water and related agencies;

iv) implement the network to generate consistent data to set national water quality standards to be supported by appropriate legislation and enforcement to protect the aquatic environment.

Because of limited resources at the onset of the project implementation, it was planned for execution in three phases (figure 2). The first involved field measurements of water quality parameters on major rivers in the country. The second phase in addition to the first to be devoted to the study of human impact on

2.2 Groundwater quality

The immediate objective of the network development which was initiated in 1988, was to establish a network of groundwater monitoring stations for the country by which:

- baseline quality and level of groundwaters can be established
- changes in quality and levels over time arising from various activities may be assessed.

The long-term objective was to obtain information for the rational management and planning of groundwater in the country.

The design of the monitoring networks was based on the UNESCO/WMO (1982) guidelines. It consisted of density determinations using information on geology and climate. All the geologic regions of the country were considered.

The implementation of the monitoring programme is yet to be fully realised. The working documents are still under review by the participating institutions.

However, some work has been done by the Water Resources Research Institute within the Accra Plains of Ghana. Groundwater quality and levels have been monitored from a network of 30 boreholes for the past 10 years.

3. Institutional Arrangements

The modalities for inter-institutional collaboration for the respective networks were first discussed and adopted at national workshops convened and organised by the Water Resources Research Institute(WRRI) and the Ghana National Committee for the International hydrological Programme(IHP).

The workshops for surface water and groundwater quality were held in 1985 and 1990 respectively. Over 80 water scientists and engineers participated in both workshops.

The scope of institutional collaboration focussed on the following areas:

- the campaign for resources for project implementation
- work programme (field sampling and laboratory work)
- review and pubication of data
- analytical quality control.

3.1 Field measurements and sampling

The Hydrology Division of the Architectural and Engineering Services Corporation (AESC) is the main government institution charged with the responsibility of gathering hydrological data. However, over the years because of the harsh economic climate, their functions have been somewhat ignored by the central government.

Various agencies eg. the research institutes, with interest in hydrological data therefore pooled their resources together to implement the sampling programme. This was began in 1987 and so far the network in existence include 28 stations on 6 river basins. A monthly sampling programme is being implemented.

3.2 Laboratory Analysis

Physico-chemical parameters are analysed for. These include:

the cations (sodium, potassium, calcium, iron, magnesium), anions (chloride, sulphate, bicarbonate), temperature, pH, alkalinity, conductivity, dissolved oxygen, solids (total, dissolved, suspended) and hardness.

A network of 15 laboratories spread over the country and belonging to the Ghana Water and Sewerage Corporation (GWSC), the Water Resources Research Institute (WRRI) and the Institute of Aquatic Biology (IAB) were selected for collaboration. Presently, the WRRI laboratory in Accra is mainly used.

3.3 Data reporting and interpretation

To date, most of the data collected has been handled by the WRRI. Monthly reports of field activities are also sent to the other participating agencies. A programme is not yet developed to institute accuracy control checks though it has been suggested.

3.4 Publications

A number of publications have been issued by the WRRI covering activities undertaken to the present time. A report was produced in 1989 which gave the quality status of some major coastal rivers at their southernmost ends. The Ankobra River has also been studied for the impact of mining activities within its basin. A report on an appraisal of laboratory activities towards the implementation of an analytical quality control scheme is underway.

6. International Activities

The country is participating in two international programmes in water quality monitoring namely the GEMS/water project and the lake environment education project of the International Lake Environment Committee (ILEC).

6.1 GEMS/Water

The GEMS/Water project started in Ghana in February, 1991 under the Ghana National Committee for the International Hydrological Programme(IHP). The Secretariat is at Water Resources Research Institute(WRRI).

The implementing organisations are:

- Ghana Water and Sewerage Corporation(GWSC),
- Architectural and Engineering Services Corporation (Hydrology Division),
- Institute of Aquatic Biology (Council for Scientific and Industrial Research), and
- Water Resources Research Institute (Council for Scientific and Industrial Research)

It is being funded by the central government.

The Monitoring Network

Considering the limited resources available to start such a project, the following were arrived at:

- To sample at only Dalon, Daboasi, Weija and Kpong.

- Sampling points were to be at Ghana Water and Sewerage Corporation intake points and also samples were to be taken before the abstraction of water for treatment.

- Surface samples (about 60cm from surface of water) were to be adopted.

- Ghana Water and Sewerage Corporation(GWSC) was to sample at all the four stations once every month. The parameters to be determined are;

  Alkalinity, ammonia, chloride, calcium, iron, manganese, magnesium, nitrate, nitrite, pH, silica, sulphate, temperature, total suspended solids, total coliforms, faecal coliforms.

- Institute of Aquatic Biology (IAB) was to sample at Dalon, Weija and Kpong whilst Water Resources Research Institute was to sample at only Daboasi. These two institutes were to determine the following parameters;

  Potassium, CCJ, Copper, Lead, zinc, Dissoved oxygen orthophosphate, Total Phosphorous, cadmium, Eletrical conductivity, Transparency and Fluoride.

  The frequency of sampling was three times in a year.

  - 1st sampling: Lastweek in February (dry season)
  - 2nd sampling: Mid July (onset of rains)
  - 3rd sampling: Last week in September (peak of rains)

- Throughout the sampling, the heights of the various rivers and reservoirs as indicated by the Architectural and Engineering Services Corporation(AESC) gauges were to be recorded.

- The Hydrology Division of Architectural and Engineering Services Corporation was to take all the hydrological parameters at all the four stations.

- Results of analysis were to be forwarded to the secretariat followed by meetings to discuss the results and problems encountered during sampling and analysis.

Description of sampling stations (Refer to figure 3)

The Dalon Station:
Located on the White Volta, upstream of the village of Dalon, on Latitude 9deg 41min 21sec W, Longitude 1deg 4min 52sec W. There is a low level of pollution within this basin. Infact, the impact of human activities in the Upper basin of the White Volta is minimal. It is used as water supply for Tamale and also for fishing.

The Weija Station:
It is on the Weija reservoir (Weija is a village close to the dam). Located on Latitude 5deg 33min 33sec N, Longitude 0deg 21min 16sec W.

The water here is utilised for Accra drinking water supply as well as for irrigation and fishing purposes. The Densu river which comes into the reservoir drains a region with multiple agricultural activities and the Weija site has to be considered as a multi-impact station.

The Daboasi Station:
This is located on the Pra river, upstream of the Daboasi village on Latitude 5deg 6min 36sec N, Longitude 1deg 39min 48sec W.

The whole Pra basin is strongly disturbed by mining activities (gold, diamond etc). A great portion of the basin is also affected by agricultural activities. Some ten kilometers downstream the chosen site, the Pra river is subject to seasonal tidal influence.

The Kpong Station:
This is located on a small reservoir on the Volta river, downstream the Akosombo dam. Latitude 6deg 10min 22sec N, Longitude 0deg 3min 0sec E.

This artificial water reservoir has been built to provide drinking water to Accra and Tema. It is also utilised for fishing as well as for irrigation and recreation. Apart from a direct impact of the villages established, the Kpong reservoir is also affected by textile factories discharges.

Progress to date

Since the inception of GEMS/Water project in February, 1991, all the four stations have been sampled by the various organisations according to their sampling programmes. Results of analysis for 1991 are being compiled at the secretariat for onward submission to the data centre in Canada.

Problems Encountered

- Not all parameters indicated in the GEMS/Water guidelines were determined because of lack of equipment.
- Only four stations were sampled because of lack of resources such as equipment, transport and manpower.
- Borehole sampling has not been included.
- Uniform analytical methods were not adhered to because most of the laboratories lacked modern analytical equipment and also adequate copies of GEMS/Water Operational Guide.
- Inter-laboratory analysis was not performed because of lack of a project vehicle, and equipment.

Future Activities

To include borehole water sampling and increase surface water sampling stations whenever enough funds and other requisite facilities can be mobilised..

6.2 Lake Environment Education Project (ILEC)

Some primary schools around the Weija Reservoir have been chosen to constitute the model for the project in Africa through which hydrological and other data is being compiled for the international handbook.

7. References

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2. SURFACE WATER QUALITY STATUS OF GHANA AND SOME NATIONAL ACTION PLANS FOR WATER QUALITY MANAGEMENT

1. Water Resources of Ghana

Ghana is a West African country with an area of 239,753 sq kms. The present population is anticipated to be in the region of 15 million people as against the 14 million people obtained from the last census in 1984.

The climate is tropical and the mean monthly temperature is always above 25oC. The extreme south-western part of Ghana is the wettest part of the country. It receives more than 190 cm of rain in a year. Rainfall decreases from here towards the north to about 100 cm a year. The driest area in the country is found in the south-east coastal plains where the mean annual is a little less than 75 cm in a year.

1.1 Surfacewater

The country is drained by 3 major river basin systems. These comprise the Coastal, Volta, and the Southwestern systems. The total mean annual discharges vary from 200 million cubic metres on the minor coastal rivers to over 24,000 million on the Volta systems.

Rivers which are exploited for water supply purposes include the Volta, Densu, Ayensu, Pra, etc. The Lower Volta (downstream of the Akosombo dam) and Densu alone supply the needs of the almost 2 million people in the Accra and Tema metropolis. The Volta has been dammed at Akosombo and Kpong for the generation of 912 and 160 MW of electrical power respectively. Various irrigation schemes are also operational within many river basins.

1.2 Groundwater

Figure 1 gives a hydrogeological map of Ghana. The various rock formations of importance include the Voltaian and the Birrimian. Yields within the formations vary considerably. The formation with the highest yield is the Birrimian which occupies about 27% of the country. Over 71% of boreholes drilled in this formation gave yields higher than 1000 gal/hr.

Groundwater is important as a water supply source for the rural communities. It is exploited by scattered populations of 5,000 people or less. Boreholes are drilled and fitted with handpumps. Over 10,000 boreholes and dugwells are in use in the country presently. Various government and non-government organisations are still in the business of providing borehole water to rural communities.

1.3 Rainwater

Harvested rainwater is an important source of water to many rural communities who do not have easy access to potable water. The rain is mainly harvested from their roofs and is only available during the wet months of the year.

It is however a very tehnologically appropriate means of water provision which must be adequately researched and promoted for rural use. There is no data immediately available on the present level of exploitation.

2. Description of river basins

The various river basins are described in Table 1 and also shown in Figure 2. The largest basin by far is the Volta which happens to be an international resource draining six countries in the sub-region. The total catchment area of the rivers approximate the land area of Ghana which suggests that the country is densely drained by its surface waters.

Table 1 River Basins of Ghana

River Basin	Catchment Area(km2)	Length(km)	% total area
Densu	2564	116	1.1
Ayensu	1709	98	0.8
Tordzie	3590	201	1.6
Tano	14877	494	6.5
Bia	6500	303	2.8
Pra (Ofin, Birim)	23207	314	10.2
Amisa	2606	76	1.1
Nakwa	2800	77	1.2
Volta (White, Black, Oti, Lower)	166353	5547	72.7
TOTAL	228741	7392	100.0

3. Inventory of point and non-point sources of pollution impacting on water quality

These can essentially be categorised into industrial, agricultural and municipal waste sources.

3.1 Industrial Waste Sources

These are located mainly in the southern half of the country. The rivers and streams which receive their effluents are given in the table below.

Table 2 List of major industrial waste sources and receiving streams and rivers

Type of industry	Receiving stream
Gold, silver mining	Jimi (Ofin), Asuokofie (Ankobra), Huni (Ankobra), Owere (Pra)
Diamond mining	Asukese (Pra), Supong (Birim), Amor (Birim)
Glassware	Bonsa (Ankobra)
Manganese mining	Bonsa (Ankobra)
Natural rubber	Ofin
Beer and soft drinks	Korle Lagoon, Sisai (Ofin), Kobi (Ofin)
Canned fruits and vegetables	Densu
Sugar and alcohol	Lower Volta
Textiles	Lower Volta
Leather	Aberewaatea (Ofin)
Palm Oil Milling	Butre (Ankobra)

3.2 Agricultural Waste Sources

The use of agro-chemicals in the country is presently not very widespread but the potential is there for very massive application in the years ahead.

Moreover, the present application has not been systematically monitored to help quantify the extent of leaching into water sources, both ground and surfacewaters.

However, cases of fish kills have been reported in for example the Oti River, as a result of massive application of agro-chemicals during rice cultivation.

Excessive weed growth in the Oti and Densu Rivers and also in reservoirs and lakes which poses water abstraction and treatment problems has also been a seasonal nuisance.

3.3 Domestic Waste Sources

Over 30% of the total population dwell in densely populated towns and cities for which domestic waste treatment facilities are essentially absent. The need for systems of water sanitation has been realised but has not been implemented because of lack of funds and other logistic support.

Indeed, household and other wastewaters are released into small open gutters and ditches which may eventually empty into major streams. This source in Ghana may essentially be considered as a non-point source of water pollution. The decay and destruction of organic wastes occur in the open ditches with consequent aesthetic and health problems.

4. Description of Pollution Sources

The type of river pollution found to have the greatest adverse impact in Ghana is the effluents from industrial houses (Mensah,1976). Little or no effluent treatment facilities have been installed in almost all the industrial establishments. The description is limited to only point sources and of some industries.

Gold mining

The effluents from the gold mines contain sand particles, cyanide, arsenic, lime, iron, copper, zinc and traces of gold. An earlier survey made by Mensah, 1976 showed that, over 300 million litres of effluents are released into Ghanaian streams every month. These volumes of effluents are particularly harmful to aquatic life during the low flow periods of the year.

Copper , zinc, cyanide and arsenic are lethal to aquatic and human life. Iron may precipitate on exposure to air and stain laundry and utensils. Carbon particles may be deposited at the botton of the river and suffocate benthnic organisms. They may also reduce the light penetration into the water and therefore reduce the rate of photosynthesis in aquatic plants. They make water unsightly and are a nuisance aesthethically.

The monitoring of water quality of the Ankobra River showed cyanide levels as high as 6.8 mg/l.

Diamond mining

The diamond mines release effluents containing high levels of dissolved and suspended solids as well as oil into our water bodies. The effluents are very turbid but there is no data available on their chemical composition. Over 230 million litres of effluents are released into our rivers every month.

Natural Roll

The actual composition of the effluents is not particularly known but contain dirt and serum from latex. The serum contains proteins and the effluent is acidic. About 7 million litres of effluents are released into the Offin River every month.

Textile

The manufactured products include printed and dyed fabrics. Effluents from the industry which enter the Lower Volta River contain high concentrations of ionic substances, organic colour and reactive dyestuffs. The volume of effluents discharged from the factory is about 120 million litres every month.

The soluble salts render the water hard and therefore unsuitable for many uses. Phenol gives it a bad taste. Recent monitoring activities on the Lower Volta indicated relatively higher temperatures (by about 2oC) at about 100m downstream of the effluent discharge points and reductions in dissolved oxygen concentrations.

Breweries

Effluents also contain mineral acids, detergents, dirt from bottle washings etc. The total volume of effluents from this source has not been fully measured.

Leather and tanning

The putrefaction of the proteins introduced into the water courses by the effluents from this industry has resulted in very bad smells and unaesthetic conditions. The chromium compounds give colour to the water and therefore makes it unsuitable for many uses.

Food Cannery

About 2 million litres of effluents are released into the Densu River. The effluents contain among others, fruits and vegetable juices and pulp and their dirty washings. Putrefaction and odour and excessive growth of weeds occur in the water course and in the Weija reservoir downstream. The Biochemical Oxygen Demand in the effluent has been calibrated in a water quality model to be in the region of 2000 mg/l (Larmie, 1988).

5. Some results of field investigations

Various studies have been undertaken within the scope of some research activities to ascertain the quality status of some of the river bodies (Larmie et al, in prep). These include the Offin, Ankobra, Densu, Oti, the Lower Volta Rivers and the Volta and Weija Reservoirs. The first three are briefly presented in this report.

A water quality status map for Ghana is further developed in figure 3. It shows areas of good, doubtful and bad raw water quality

Offin River Quality Survey

The Offin is a major tibutary of the Pra River. It is about 281.6km long with a total drainage area of 9570 sq km. The Offin was monitored to estimate its solute load and also of its tributaries (Amuzu,1978).

The study showed that the concentration of dissolved constituents increased in the downstream direction. This was attributed to the leaching of soil particles by the river water and additional contributions from its tributaries.

The major area of pollution in the catchment was around Obuasi which is drained by the Kwabrafo River, a tributary of the Offin. The tributary is highly polluted and was reflected in the high cyanide levels, relatively low dissolved oxygen most of the time, consistently high TDS, chloride etc.

It was estimated that the Offin delivers approximately 99,490 metric tons of solutes annually to the Pra River and the Kwabrafo tributary contributes about 35,000 tons.

Ankobra River Quality Survey

The river is approximately 222 km long and covers an area of approximately 8366 km2. The basin is sparsely populated and cash crop farming activity is on a very small scale. There is considerable mining operations within the basin as well as stretches of rubber plantation which feed the rubber and tyre factory within the basin (Osafo, 1988).

The results of the investigation showed that the quality of the river water was generally poor. The quality becomes poorer in the downstream waters where most industrial activities including gold mining are located. Large quantities of untreated mine effluents are discharged into the river. Cyanide levels exceeded 5.0 mg/l in some sections of the river.

Densu River Quality Survey

The Densu is a coastal river which is about 116 km long. It drains an area of about 2564 km2.

It was concluded from the study that the Densu River which is essentially a semi-urban river system may be generally classified as a good source of water supply along most of its stretches (Amuzu,1985). Some areas however, were very bad especially where community refuse is dumped by the river banks and are subsequently washed into the river.

Table 3 Comparison of some physico-chemical characteristics for the 3 river basins

Parameter	Densu				Offin				Ankobra			
	Range	Mean	Std Dev	N	Range	Mean	Std Dev	N	Range	Mean	Std Dev	N
Conductivity	122-1000	313.1	148.9	105	65-5000	539.3	833.7	101	40-1420	283.5	263.5	116
Calcium	3.0-57.0	19.2	8.9	105	1.0-190	20.6	34.1	101	4-48.1	17.7	11.2	116
Sodium	-	-	-	-	4.0-630	61.5	88.5	101	1-14.0	1.2	1.8	116
Magnesium	1.0-30.9	8.3	3.9	105	0.1-86.1	8.3	12.2	101	1-248.1	12.7	28.3	116
Iron	0.1-2.7	0.6	0.4	105	0.1-22.0	2.1	3.4	101	0.0-9.3	0.9	1.4	116
Potassium	-	-	-	-	0.5-434.8	27.1	50.9	101	0.0-11.5	0.9	1.5	116
.oride	2.0-224.0	27.9	35.7	105	2.0-58.0	11.9	9.9	101	1.0-264	17.1	33.8	116
Sulphate	1.0-134.0	18.4	24.8	105	21.1-274.8	81.9	60.9	101	0-149.0	13.6	24.6	116
Bicarbonate	58.0-346.0	125.6	70.9	105	4.9-126.9	23.6	24.8	101	6.7-483.1	83.6	62.5	116
Diss Solids	-	-	-	-	18-1494.0	259.7	281.2	101	10-1338	212.2	248.0	116
Nitrate	0.0-1.0	0.2	0.2	105	0.0-1.5	0.4	0.3	101	6.7-483.1	83.6	62.5	116
Phosphate	0.0-1.2	0.2	0.2	105	0.0-2.0	0.1	0.4	101	-	-	-	-

6. Some Action plans for water quality management

Plans underway include to institutionalise environmental impact assessment methods to protect aquatic life and promote sustainable and meaningful development. Proposals have therefore been prepared by Ghana National Committee for the IHP for use by all agencies seeking to develop water resource in Ghana.

National water quality criteria have not been properly formulated. Hence World Health Organisation (WHO) standards are mostly used. Appropriate and flexible water and wastewater criteria are being planned at national workshops for adoption.

Enactment of environmental protection laws particularly for the aquatic environment, to be enforced through the Environmental Protection Council of Ghana is yet to be realised.

Other programmes include participation in the IDEA Project (Institutional Development for Environmental Action) of the Commonwealth Consultative Group on Technology Management (CCGTM) within the Commonwealth Secretariat. This is an action research programme being carried out by a small, task oriented network intended to generate solutions to specific, difficult environmental problems in about seven countries including Ghana. It also seeks to analyse these processes to generate transferable learning about environmental management. Finding solutions to urban pollution and other water quality management problems in the Densu Basin is the core of the Ghana programme.

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HYDROMET SURVEY PROJECT

By Nsubuga Senfuma

Participating Governments

Burundi, Kenya, Egypt, Sudan, Tanzania, Rwanda, Uganda and Zaire. Ethiopia plays an observatory role.

Project Area

The project covers the upper Nile Basin drainage area of the lakes Victoria, Kyoga and Mobutu Sese Seko (see attached map). Basin coverage by country is as follows:

Uganda	-	163,000 km^2
Kenya	-	45,000 km^2
Tanzania	-	124,000 km^2
Rwanda + Burundi	-	67,000 km^2
	Total	411,000 km^2

This area of 411,00 km^2 represents the total coverage of the Upper Nile basin which is from the southern shore of Lk Victoria to the Sudan-Uganda border. It can be seen that with Rwanda and Burundi excluded, the area in Uganda alone accounts for about 50% of the project area.

Water Quality Activities

Water quality activities in the project dates as far back as 1972. The original objectives of these activities was mere assessment of the water quality characteristics, sediment content and pollution load of the waters in the project area. This therefore led to the establishment of a water quality assessment network of about 25 stations. Most stations were National Stations. They were only upgraded to regional stations by giving them grid references. Six of these stations were located on the three main equatorial lakes and the rest were on rivers. Table No. 1 below shows the names and locations of these stations.

TABLE 1

No.	Catchment	Location	Station No.	Analysis
1.	L. Victoria	R. Magogo Main bridge	0113012 (T)	WQ & SM
2.	L. Kyoga	R. Enget/Dokolo Rd.	0201032 (U)	,,
3.	L. Kyoga	R. Namatala Mbale	0203022 (U)	,,
4.	L. Victoria	R. Awach Kaboun	0119292 (K)	,,
5.	L. Albert	R. Waki Biso Rd.	0301052 (U)	,,
6.	L. Victoria	R. Ngono	0115192 (T)	,,
7.	L. Victoria	R. Kakinga	0117092 (U)	,,
8.	Albert Nile	R. Nile (Panyango)	0400052 (U)	,,
9.	L. Victoria	R. Nyando	0104252 (K)	,,
10.	L. Victoria	R. Simiyu	0112012 (T)	,,
11.	L. Victoria	R. Magogo	0113032 (T)	,,
12.	L. Victoria	R. Mara	0107072 (T)	,,
13.	L. Albert	Kyoga Nile	0301102 (U)	,,
14.	L. Victoria	R. Gucha-Migori	0106142 (K)	,,
15.	L. Victoria	R. Kagera	0115152 (T)	,,
16.	L. Victoria	R. Kibos	0119293 (K)	,,
17.	L. Victoria	R. Sio	0101022 (K)	,,
18.	L. Victoria	R. Ruvuvu	0115172 (B)	,,
19.	L. Victoria	R. Ngono	0115182 (T)	,,
20.	L. Albert	Butiaba	0300011 (U)	WQ Only
21.	L. Kyoga	Bugondo	0200021 (U)	,,
22.	L. Victoria	Bukoba	0100111 (T)	WQ & SM
23.	L. Victoria	Mwanza	0100101 (T)	,,
24.	L. Victoria	Kisumu	0100031 (K)	,,
25.	L. Victoria	Entebbe	0100011 (U)	,,

WQ = Water Quality Analysis
SM = Sediment Analysis

Analysis performed was routine and concentrated mainly on conventional ions i.e. Na, K, Mg, Ca, Cl, HCO_3, SO_4 and NO_3, and some physical parameters like pH, colour, turbidity and conductivity.

In 1978, the objective was expanded from mere data collection to include data application. The best tool, of course, in data application is the mathematical model. To develop a mathematical water quality model of the upper Nile lake systems, the original 25 stations were scaled down to 15, and the focus was mainly in assessing the limnological characteristics of the three lakes. This exercise, as you may note, was lacking in the original water quality activities. This added activity was sponsored by UNEP and lasted up to 1980.

In addition to the parameters listed above, new parameters were analyzed at each of the 15 stations and the emerging data used in the development of the mathematical model for the upper Nile basin. These parameters were:- temperature, Dissolved oxygen, Secci disc, Biomass, Chlorophyll, nutrients like phosphates, silica and nitrogen in all their forms (organic and inorganic), and primary productivity of lakes.

GEMS/Water Activities

This project was launched in 1976. In 1977, Hydromet started active participation and took part in some of the preparatory meetings for the launching of these activities. In the early 80's Hydromet was actually chosen as a regional collaborating centre for Eastern African countries. As a collaborating centre, it was responsible for:-

(a) Receiving and validating data collected from the National centres in the region (Uganda, Kenya, Tanzania, Burundi and Rwanda).
(b) Remitting the data to Canada.
(c) Ensuring regular flow of data from the national centres to Canada.
(d) Coordinating regional inter-calibration studies i.e. distribution of test samples and collection of analysis results.
(e) Preparation and submission of regular reports to WHO and Canada on GEMS/Water activities in the region.

In accordance with these duties, in 1980, the data collected during the development of the Water quality model was submitted to Canada. Initially, this data was being collected from 15 stations (excluding those in Rwanda and Burundi). Later on in the same year, one new station was established bringing the number to sixteen.

The stations selected were basically of three types:-

(a) Baseline Stations

These were station with very little if any pollutants from external sources. The water can be taken potentially as storage for future use. The quality of water at such a station can be regarded as the true natural state of the water.

(b) **Impact Stations**

These are stations located in areas where the intended use of the water is adversely affected by man's activities.

(c) **International Significance Stations**

These are stations located at international political and geographical boundaries.

Below is a list of the stations and their types:

TABLE 2

COUNTRY	No. of Stn	LOCATION	TYPE
KENYA	2	Lk. Victoria; Kisumu	(a)
	1	Lk. Victoria	(b)
	1	R. Nzoia	(a)
TANZANIA	2	Lk. Victoria; Mwanza+Bukiba	(a)
	1	Lk. Victoria	(b)
	1	R. Ruvuu; at bridge	(a)
	1	R. Kagera; at bridge	(a)
UGANDA	1	Lk. Victoria; Murchison Bay	(a)
	2	Lk. Victoria; Entebbe+Ssese	(b)
	1	Lk. Victoria/Nile; Jinja	(a)
	1	Lk. Kyoga	(a)
	1	Lk. Albert	(a)
	1	Lk. Albert/Nile	(c)
	1	R. Malaba; Malaba bridge	(c)

The frequency of sampling was always dictated by available resources. However, whenever resources allowed, stations were visited once every month. The civil strife in Uganda lead to the total collapse of this arrangement. The laboratory was vandalised and everything in it destroyed. Water quality activities were forced to a halt and remained so for the period 1982-1990. Through the concerted efforts of the participating countries and government of Uganda, the laboratory has been renovated and reactivated since late 1990.

Table No. 3 shows some of the instruments available and analysis carried out using them:

TABLE 3

INSTRUMENT	PARAMETER ANALYZED/USE
1. Flame Photometer	Sodium, Potassium, Lithium
2. Spectrophotometer	Phosphates, Nitrates, Ammonia-N, Nitrites, Fluorides, Iron, Manganese, Silicates, Chlorophyll.
3. HACH Drel/5	------- do -------
4. PH and Specific Ion Analyzer	PH, Fluorides, Dissolved Oxygen, etc
5. Turbidimeter	Turbidity
6. Conductivity Meter	Electrical Conductivity, Conductance
7. Hot Plates	Evaporation, Digestion, etc
8. Fridges	Cold Storage
9. Autoclaves	Sterilisation
10. Ovens	Drying
11. Dry Bath Incubators	Bacterial Incubation
12. Millipore Field Kit	Total Coliform, Fecal Coli Counts
13. Electronic Balances	Weighing
14. Secci Disks	Transparency

Constraints

The laboratory despite its recent renovation has not been able to effectively assume its collaboration role as a regional centre for the following reasons:-

(a) Lack of information about activities of other national centres except for Uganda.

(b) Break down in communication, and lack of interaction, between the centre and other bodies like WHO, UNEP and GEMS/Water Head Office, until very recently when Hydromet was called to participate in the Rostov and now in Arusha.

Future Strategies

1. Closer collaboration and interaction with Uganda's national Centre which, so far, is the only active centre and holds most of the project's stations.

2. Identification of any other active centres in the region especially those of Kenya, Tanzania, Rwanda and Burundi; assist these centres by way of helping them in locating stations and later incorporate them in the GEMS activities.

3. Joint Ventures with National Centres in Undertaking Lake sampling
   - gear
   - experience
   - logistical requirement

4. Training

REPUBLIC OF KENYA

Ministry of Water Development

WATER QUALITY MONITORING NETWORK PROGRAM

BACKGROUND

The fresh water resources of Kenya are finite while their demand are constatnly increasing for development in the water sector in particular and for socio-economic development in general. Concommitantly, the water quality, which is critical to the multipurposes water uses, is changing almost at the same pace with development in other sectors.

However, the water quality of most major surface water bodies is still unimpaired inspite of continuous discharges of effluents into streams and lakes. The unimpaired state may not be sustained particularly in the absence of consitent and reliable data on the water quality trends in our water bodies.

Having realised this, the Ministry of Water Development initiated a "Water Quality Monitoring Program" in 1982 whose broad objectives were:-

i) to establish a network of water quality monitoring stations spread all over the major surface water resources.

ii) to collect water quality data from all the stations

iii) to assess the impact on water resources from existing water pollution sources.

iv) to maintain a water quality data bank for use in planning and future development activities as well as for protection and conservation of the water resources.

v) to establish ambient water quality stream standards.

vi) to establish a referral base for water quality changes vis-a-vis environmental impact of socio-economic development.

The initial stages of this program were not very successful mainly due to logistical problems as well as financial limitations. Inspite of this, we have continued to improve andimplement the program on the basis of the following outline.

MODE OF OPERATION

To implement this program, it was expedient to select areas which had, and were likely to be major centers of economic and developmental activities. These were invariably areas of high to medium potential, urbanised areas and standing water bodies (Lakes and impoundments). Figure 1 shows the distribution of the network stations and Figure 2 shows the Drainage Basins in Kenya.

These are set out as follows:-

1. AREA 1: LAKE VICTORIA DRAINAGE BASIN

There are seven major rivers draining a total area of approximately 49,000km^2 of high potential agricultural activity, high population density and nine major urban centers.

There are 31 network stations distributed in the major rivers while only two stations are in Lake Victoria albeit within the littoral zone. These are distributed as follows:-

The details of the stations are in Appendix 1

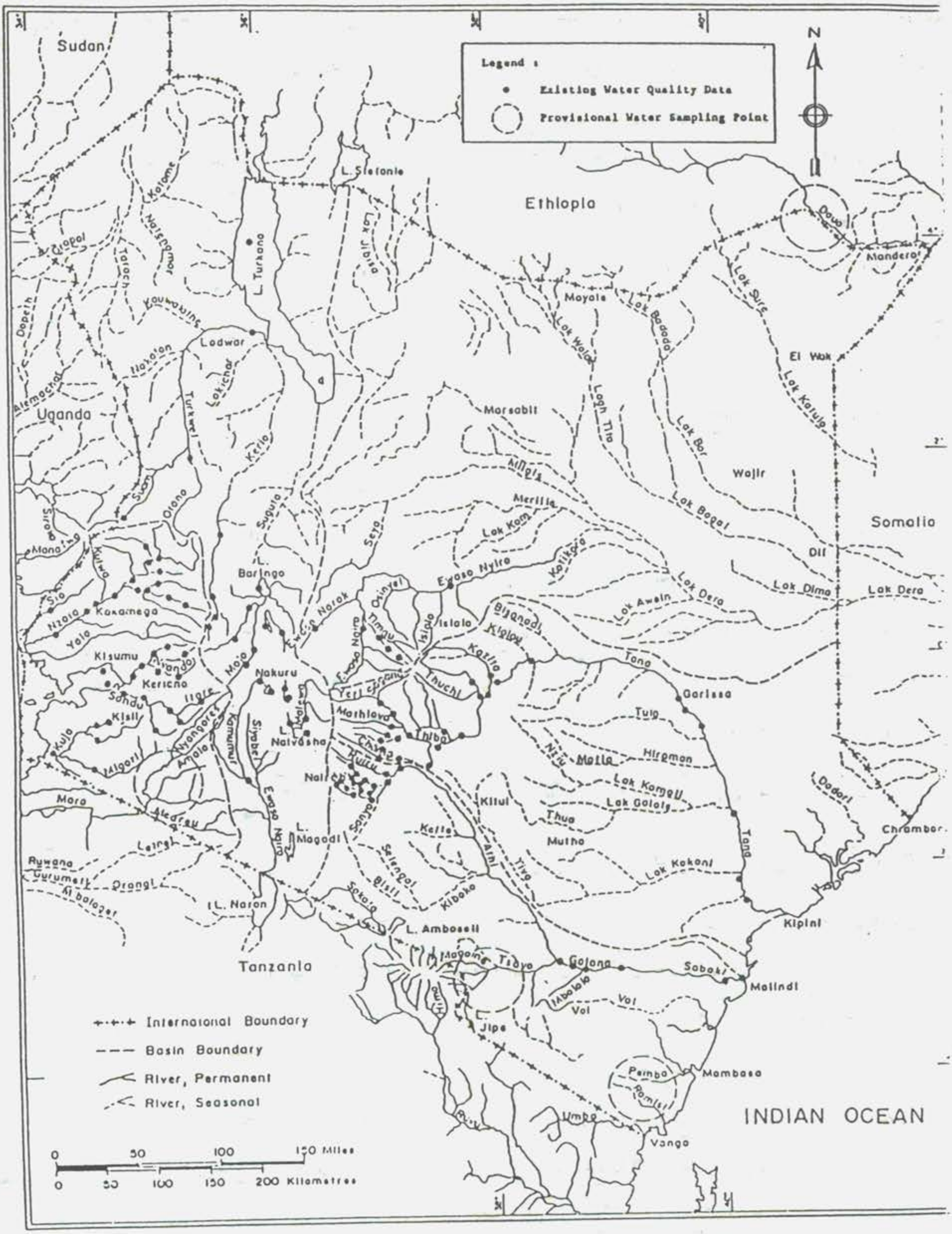

Fig. 1 SURFACE WATER SAMPLING POINTS

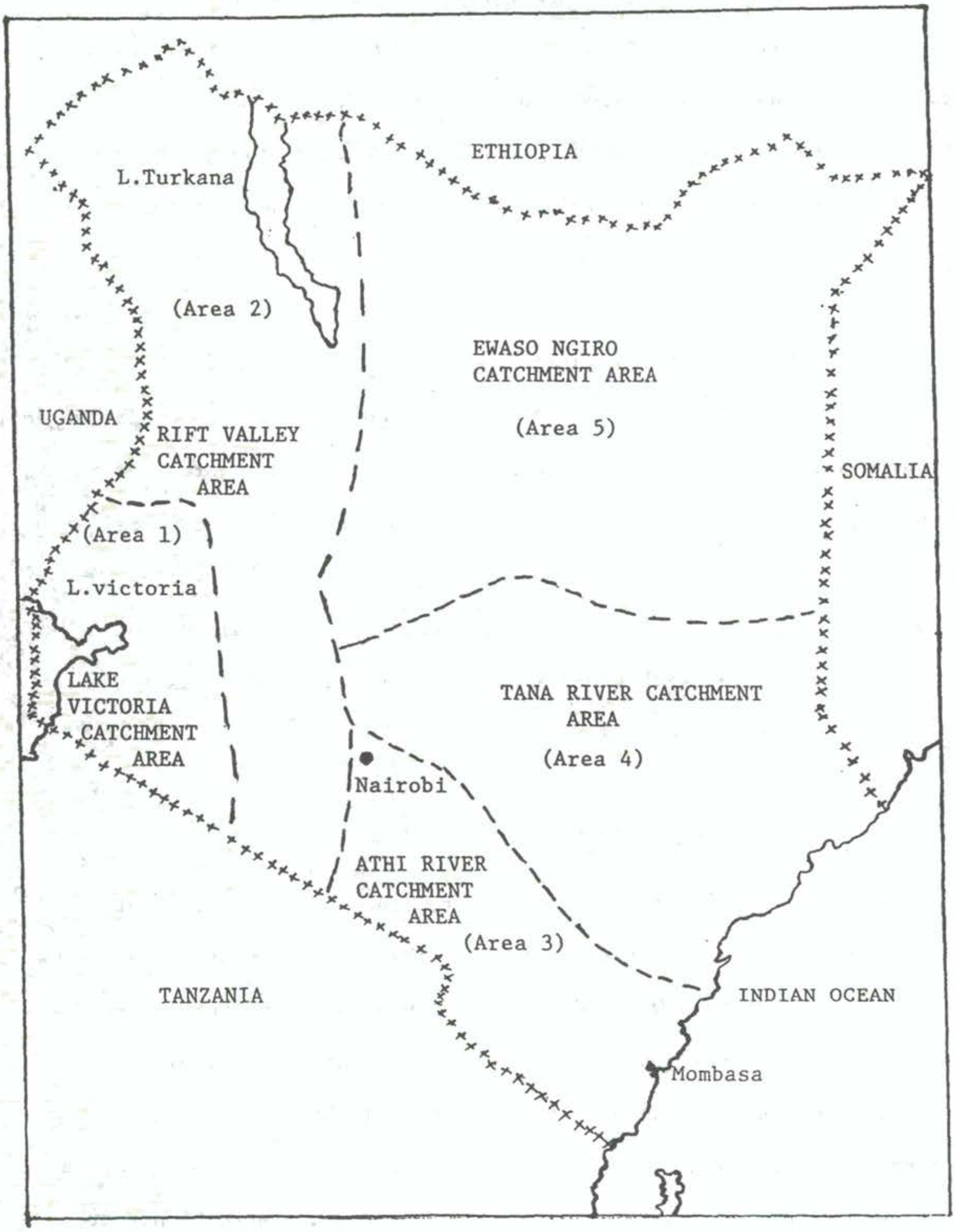

Fig. 2 Drainage Areas in Kenya

2. AREA II: RIFT VALLEY DRAINAGE BASIN

This drainage basin covers an area of about 127,000km^2. However, there are very few perennial streams viz. the Turkwel and its tributaries, the Ewaso Ngiro South, Malewa, Gilgil and the Perkera. The basin is, however, sparsely populated, is of low to medium potential and not well urbanised or industrialised. There is no discharge going out of the basin.

There are 24 network stations. 17 stations are distributed in rivers while the rest are located in different lakes viz. Baringo, Naivasha, Bogoria, Magadi, Elementaita, Nakuru and Turkana. In this region, most of the water quality aspects would not be expected to change in streams due to limited social economic activities except in the region of lakes Nakuru and Naivasha. However, of special importance are the exological, limnological and socio-economic aspect associated with the lakes which are all alkaline except L. Naivasha. Details of the stations are in appendix 2

3. AREA III: ATHI RIVER DRAINAGE BASIN

The Athi river basin including the South Coast, drains in area of about 70,000km^2. However, the largest flow of the Athi river is contributed by numerous perenial streams which drain the Kikuyu escarpent North-North West of Nairobi. These streams drain a very active, high potential and urbanised region which also includes the city of Nairobi and its satelite towns. There is very insignificant contribution of flow from other seasonal tributaries downstream of Fourteen Falls. Initially there were 86 network stations established on the headwaters of the Athi. However, they were reduced to 24 which are distributed among the rivers major tributaries and in the coastal rivers. The details are in Appendix 3.

4. AREA IV: TANA RIVER DRAINAGE BASIN

The Tana river basin covers an area of about 132,000km^2 and drains just over 62,000km^2 and has an estimated mean annual run-off of $4.69 \times 10^9 m^3$ This flow is contributed by 22 major tributaries draining the eastern slopes of the Aberdares and the Southern slopes of Mt. Kenya and the Nyambene range. These are areas of high agricultural activity, high population density and relatively high urbanisation.

There are 20 network stations, 14 of them distributed among the major tributaries while the rest are located in the middle and the lower zones of the river. The Tana river has far-reaching socio-economic implications. The river borders the arid and semi-arid areas of the country. It is, therefore, the obvious sources of water for domestic purposes, agriculture (it is currently exploited for irrigation) and hydro-power.

Details of the Network stations are in Appendix 4.

5. AREA 5: EWASO NGIRO DRAINAGE BASIN (NORTH)

This is the largest drainage basin covering an area of about 205,000km^2 There are basically 5 perenial tributaries of the Ewaso Ngiro North draining the Northern slopes of the Aberdares, the Northern and Western slopes of Mt. Kenya and North Eastern parts of the Nyambene range. The main river, however, disappears in a swampy expanse along its course in the arid North-Eastern region of Kenya.

There are 6 Network stations distributed along the river and its tributaries

Details of the station are in Appendix 5

LAKES

There are eight major lakes viz. L. Turkana, Bogoria, Baringo, Nakuru, Elementaita, Naivasha, Magadi and Victoria. Three others viz. Amboseli Solai, Jipe and Logipi are seasonal. Lakes Victoria and Naivasha are fresh water while the others are alkaline-saline except L. Turkana and Baringo which are border-line. All the lakes except L. Victoria are closed -basin and are therefore subject to concentration of dissolved substances and accumulation of sediments and pollutants.

The ecology, Limnology and water quality aspects of these lakes have not been studies. The water quality aspects are important in respect of:

i) domestic water sources - fresh water lakes
ii) agricultural water sources - fresh water lakes
iii) industrial water - fresh water and brackish lakes
iv) ecological aspects - all lakes
v) aesthetic and tourism aspects - all lakes
vi) fisheries aspects - all lakes
vii) pollution aspects - all lakes

GROUND WATER

There are about 10,000 bore-holes and an indeterminate number of shallow wells spread all over the country. The existing information on ground water quality is scanty and scattered.

While it has been argued that ground water quality in most parts of the country is generally poor. It is nevertheless important to maintain consistent and reliable data on the water quality changes in respect of:-

i) domestic water sources
ii) agricultural water sources
iii) water pollution aspects
iv) data base.

SAMPLING REQUENCY

In order to establish a strong and reliable baseline data bank, it was necessary to start with a vigorous sampling frequency to cover all the designated network stations and all the seasonal variations for at least two years.

A sampling frequency of four times a year was started to coincide with the major seasons. viz February/March, March/April, June/July, October/November.

WATER (QUALITY) VARIABLES

The variables tested include the following:-

- Temperature
- pH
- Conductivity
- Dissolved Oxygen
- Nitrate
- Nitrite
- Ammonia
- Calcium
- Sodium
- Chloride
- Sulphate
- Alkalinity
- TSS
- Phosphorus
- BOD
- COD
- Magnesium
- Potassium

The other variables which are analysed on a selective basis are:

- Total and Fecal Coliforms
- Transparency
- Arsenic
- Cobalt
- Lead
- Fluoride
- Zinc
- Boron
- Chlorophyll
- Manganese
- Cadmium
- Iron
- Mercury
- Cyanide
- Copper

The other variables whichused to be analysed on a selective basis include Pesticides such as DDT, Dieldrin,Aldrin, TOC, Kjeldahl Nitrogen, silica, Hydrogen Sulphide, PCBs, Aluminium, Discharge and Water level.

The selection of the variables depended on the location of each stations, the availability of analytical capacity, capability and the program for which the station established.

ORGANISATION

Before 1984, the National Water Quality Monitoring Network Program was organised, administered and implemented from the headquaters, Nairobi. A team of three personnel used to cover all network stations taking water samples, field measurements and submitting the samples to the National Water Testing Laboratory, Nairobi. The analytical results obtained were stored in individual files for each station. Data accumulated are transfered into data registers.

In 1984, the functions of the Ministry were decentralised and, consequently the operations of the Network Program. The decentralization was based on District administrative boundaries while Network station are based on river basins and sub-basins. In addition, the funding as well as operational components such as transport, purchase offield equipment, administrative organization were also changed.

This arrangement disrupted the organised implementation of the program resulting in haphazard collection and delivery of samples, frequency of sampling and consequently unreliable analytical data and, in some network areas, a complete absence of any data.

Notwithstanding the poor implementation, the data so far collected, have enabled us to asses the water quality aspects of the surface water resources and at the same time the data are useful in planning a better program, asses the trends of water quality degradation and map out strategies for management of water resources.

In this connection, we have solicited for logistical and technical support in initiating and implementing two aspects of water quality management. These are (1) Water Quality Forecasting Systems and (2) Models of Release and

Transport of Hazardous Materials into Inland Water bodies.

CONSTRAINTS

The implementation of the Water Quality Monitoring Program has been constrained by logistical, technical administrative limitations and inadequate facilities and to a lesser extent, personnel. Some of the limitations can however be improved by re-organisation of the program, acquisition of equipment and training of personnel.

SUMMARY OF NETWORK STATIONS

Catchment	AREA $x10^3$ km^2	AMR6 $x10^6$ m^3	TYPES OF STATIONS EIA	DET	PES	REF	CQ	GEMS
L. Victoria	49	7300	18	17	13	11	13	5
Rift Valley	127	800	19	1	1	1	4	1
Athi River	70	1300	15	6	7	2	7	3
Tana River	62	4700	12	1	1	2	14	2
Ewaso Ngiro	205	740	3	-	-	-	3	-

KEY

AMR - Annual Mean run-off

EIA - environmental Impact Assesment

DET - Detergents

PES - Pesticides

REF - Reference

CQ - Catchment Quality

GEMS - Global Environmental Monitoring Systems (Water)

R E P U B L I C O F K E N Y A

Ministry of Water Development

WATER RESOURCES MANAGEMENT

POLICY OBJECTIVES

The Government Policy on Water Resources Management and development, is broadly

covered under the policy objectives on environmental management while the policy on water, just like other sectors, is covered under specific policy objectives.

In setting goals for environmental management and protection, the policy statement therefore is ...... the Government considers environment to be the total exological processes and life-support systems essential for human survival and well-being and includes man-made facilities and natural ecosystems and phenomena. The Government's fundamental goal with respect to environmental management conservation is to achieve the following objectives.

1. To attain and maintain a quality of environment that permits a life of dignity and well-being of all citizens.
2. To conserve and manage the natural resources including the air,WATER land, flora and fauna.
3. To achieve sustainable utilization of resources and ecosystems of the present while ensuring their potential to meet the needs of the future ....

7. To achieve a coordinative aproach to policy promulgation on environmental matters.

The Government has continued its commitment to proper environmental management through establishment of various environmental institutions. The current Development Plan (1989-1993) lays emphasis on the efficient utilization of resources on a sustainable basis.

In the sector-specific policies in environmental management, the formation of the Ministry of Water Development in 1974 was indeed a timely action.

The development process in Kenya has reached a stage whereby water use interests are exacerbated by the rapidly increasing population which exerts pressure on the resource.

This pressure on the resources will bring about degradation of water quality in the absence of sound management practices in the Water sector and other related socio-economic sectors.

Expanded industrial growth leads to increased environmental deterioration if the establishment of industrial plants is not carefully planned. The major adverse effects include water pollution through discharge of wastes and toxic pollutants, atmospheric pollution and chemical poisoning through accumulation of toxic substances.

Agricultural activities, urbanization with its accompanying infrastructural development also contribute to both organic, inorganic and aesthetic pollution of the water resources.

The Water Act is the primary source of Kenya's policy on water. Under the Act, the Water Resources Authority (currently undergoing ammendements) is the body charged with the duty of long term policy formulation and the environmental management of the water and wetlands resources of the country. Among its functions are: "to investigate the water resources of Kenya, to advise and make recommendations in regard to the improvements, preservation, conservation utilization, protection from pollution and apportionment of water resources as well as making regulations for preventing the pollution of water.

Several other statutes lay the framework for the management of water and wetlands in Kenya. Among the most important are the Agriculture Act; the Irrigation Act; the Forest Act; the Tana and Athi Rivers Development Authority Act; the Lake Basin Development authority act; the Malaria Prevention Act; the Public Health Act; the Trust Land Act and the Land Adjudication Act.

THE WATER QUALITY STATUS

The surface water quality in Kenya is considered relatively good albeit the absence of some data which are critical in determining the extent of pollution of water. This is apparent from the data available on physico-chemical quality of selected streams representing the five drainage basins in Kenya (Tables 1 to 10)

In Tables 1 to 10 the mean values of the results of the basic variables are presented from 1982 to 1987. Generally, three sampling stations are selectected, the first representing the upper zone of the stream, the second representing the middle and the third representing the lower zone of the stream.

Each station is, where applicable, selectively identified to be downstream of an existing or possible water pollution source to facilitate assesement of the extent of water pollution contributed by socio-economic activities such as agriculture, industry and urbanisation or particular point source of pollution.

When analysing the water quality data available, it apparent that there are some incompatible analytical results involving interdependent variables. These are treated with caution due to the many factors which affect and/or influence the data obtained from the time of collcetion of the samples to publishing of results.

Generally, all the streams for which water quality data are available are fresh water. The water is neutral with the pH rarely exceeding 7.5 in all sections of any one stream. However, low pH is sometimes recorded in the upper zones of streams located in the central highlands during some seasons. This is usually attributed to very acidic discharges from wet-processing of coffee in the coffee growing area of Kenya.

In most streams, Electrical conductivity is low, rarely exceeding 250 μs/cm except in river Athi. This is expected considering that the Athi river receives discharges and storm water run-off from the City of Nairobi and drainage from the highlands North-North West of Nairobi.

Most ofthe rivers in Kenya have high values of colour and high turbidity in all zones of the river. This is expected because all our rivers originate from high potential agricultural land where agricultural activities and other pollution sources contribute silt, colloidal substances and refractory materials.

As can be seen from the data presented, the major indicators of water pollution viz parameters such as Dissolved, Biochemical Oxygen Demand,Chemical Oxygen Demand, Coliform organisms etc have not been measured. While this has been due to technical limitations, the 20 minute Permanganate value reported as Oxygen absorbed has been adopted as a guide indication of the absence or presence of organic pollutants.

Overall, the concentration of metal cations is low. However some rivers have higher levels of Iron and Manganese that the levels recommended by WHO for drinking water purposes.

SUMMARY

From the data available it is apparent that the surface water sources are generally are of good quality for most water-related uses either with some treatment or without. However, colour and turbidity are invariably high and, for drinking water purposes, the levels of Iron and Managanese are higher than recommended by WHO.

This notwithstanding, there are several critical parameters which are indicators of pollution which have not been analysed. This has made it difficult to formulate a more comprehensive report which would otherwise present a fairer status of the water quality of surface water sources of Kenya.

CONSTRAINTS

The major constrains in the implementation of this program include logistical organisation, funding, lack of field equipment, inadequate loboratory facilities, transport, technical capabilities and to a lesser account, the geographical distribution of the water resources.

Table 1: WATER QUALITY OF NYANDO RIVER

1PARAMETER	UNIT	Stn Ny 1 RGS 1 GD 7	Stn Ny 6 RGS 1 GD 4	Stn Ny 7 RGS 1 GD 8
pH	--	7.7	7.7	7.5
Colour	mgPt/1	310	63	215
Turbidity	NTU	58	88	282
Oxygen absorbed	mg/1	32	30	32
Conductivity	uS/cm	220	241	928
Iron	mg/1	4.4	6.5	2.2
.anganese	mg/1	0.2	0.2	4.0
Calcium	mg/1	15.7	20	22
Sodium	mg/1	28	16	25
Potassium	mg/1	9	4.7	29
Total Hardness	mg/1$CaCO_3$	60	105	155
Total Alkalinity	mg/1$CaCO_3$	103	104	106
Chloride	mg/1	5.6	4.6	4.4
Fluoride	mg/1	0.6	0.8	1.6
Sulphate	mg/1	1.6	1.8	3.0
Orthophosphate	mg/1	0.34	0.2	0.61
TDS	mg/1	134	150	141
Nitrates	mg/1	1.2	1.5	0.8
:itrites	mg/1	-	-	-
Dissolved Oxygen	mg/1	-	-	-
BOD(5days @ 20°C)	mg/1	-	-	-
COD	mg/1	-	-	-
Total Coliform		-	-	-
Fecal Coliforms		-	-	-
Average Discharge		-	-	--

Table 2: WATER QUALITY OF RIVER MIRIU

PARAMETER	UNIT	Stn Mi 3	Stn Mi 5 RGS 1 JG 1	Stn Mi 6 RGS 1 JG 2
pH	--	7.0	7.3	7.3
Colour	mgPt/1	35	55	71
Turbidity	NTU	11	31	13
Oxygen absorbed	mg/1	50	19	9
Conductivity	uS/cm	45	66	50
Iron	mg/1	0.05	0.7	0.3
Manganese	mg/1	0.1	0.2	0.9
Calcium	mg/1	3	7	4
Sodium	mg/1	1	2	1.5
Potassium	mg/1	-	-	-
Total Hardness	mg/1 $CaCO_3$	20	19	24
Total Alkalinity	mg/1 $CaCO_3$	19	27	33
Chloride	mg/1	4	4	4
Fluoride	mg/1	0.1	0.3	0.4
Sulphate	mg/1	1	0.5	9
Orthophosphate	mg/1	0.4	0.3	0.3
TDS	mg/1	22	31	23
Nitrates	mg/1	1	1.5	1.3
Nitrites	mg/1	-	0.1	0.01
Dissolved Oxygen	mg/1	-	-	-
BOD(5days @ 20°C)	mg/1	-	-	-
COD	mg/1	-	-	-
Total Coliform		-	-	-
Fecal Coliforms		-	-	-
Average Discharge		-	-	-

Table 3: WATER QUALITY OF RIANA/MIGORI/GUCHA RIVER

PARAMETER	UNIT	Stn Mig 1 RGS 1 KC 3	Stn Mig 3 RGS 1 KA 3	Stn Mig 5 RGS 1 KB 5
pH	--	7.4	6.8	7.1
Colour	mgPt/1	308	192	222
Turbidity	NTU	96	209	-
Oxygen absorbed	mg/1	44	79	-
Conductivity	µs/cm	126	83	83
Iron	mg/1	0.4	1.4	0.1
Manganese	mg/1	0.16	0.3	0.3
Calcium	mg/1	7	4	-
Sodium	mg/1	-	-	-
Potassium	mg/1	70	-	-
Total Hardness	$mg/1CaCO_3$	47	38	31
Total alkalinity	$mg/1CaCO_3$	52	52	42
Chloride	mg/1	5	8	4
Fluoride	mg/1	0.7	0.4	2.3
Sulphate	mg/1	0.6	4.3	-
Orthophosphate	mg/1	0.3	0.3	0.36
TDS	mg/1	48	54	-
Nitrates	mg/1	49	7	1.7
Nitrites	mg/1	-	-	-
Dissolved Oxygen	mg/1	-	-	-
BOD(5days @ 20°C)	mg/1	-	-	-
COD	mg/1	-	-	-
Total Coliform	-	-	-	-
Fecal Coliforms		-	-	-
Average Discharge		-	-	-

Table 4: WATER QUALITY OF NZOIA RIVER

PARAMETER	UNIT	Stn NZ 1 RGS 1 BB 1	Stn 10	Stn 14 RGS 1 EE 1
pH	--	7.0	7.5	7.3
Colour	mgPt/1	-	108	135
Turbidity	NTU	52	39	73
Oxygen absorbed	mg/1	22	13	16
Conductivity	uS/cm	149	131	107
Iron	mg/1	7.4	3.7	3.3
Manganese	mg/1	0.1	0.2	0.1
.lcium	mg/1	10	11	7
Sodium	mg/1	6	17	2
Potassium	mg/1	-	2.4	2.1
Total Hardness	mg/1$CaCO_3$	46	43	36
Total Alkalinity	mg/1$CaCO_3$	57	60	32
Chloride	mg/1	5	5.8	4.2
Fluoride	mg/1	0.4	0.3	0.9
Sulphate	mg/1	-	0.9	2.7
Orthophosphate	mg/1	0.04	0.05	0.4
TDS	mg/1	90	80	40
Nitrates	mg/1	-	0.09	0.6
Nitrites	mg/1	-	-	-
. .ssolved Oxygen	mg/1	-	-	-
BOD(5days @ 20°C)	mg/1	-	-	-
COD	mg/1	-	-	-
Total Coliform		-	-	-
Fecal Coliforms		-	-	-
Average Discharge		-	-	-

Table 5: THE WATER QUALITY OF NDARUGU RIVER

PARAMETER	UNIT	RGS 3 CB 2	6km d/s 3 CB 2
pH	--	6.8	7.3
Colour	mgPt/l	185	125
Turbidity	NTU	59	38
Oxygen absorbed	mg/l	7	5
Conductivity	uS/cm	104	150
Iron	mg/l	5	2.6
Manganese	mg/l	0.3	0.2
alcium	mg/l	2	5
Sodium	mg/l	11	14
Potassium	mg/l	10	-
Total Hardness	$mg/lCaCO_3$	17	32
Total Alkalinity	$mg/lCaCO_3$	32	38
Chloride	mg/l	7	8
Fluoride	mg/l	0.3	0.4
Sulphate	mg/l	1.2	0.6
Orthophosphate	mg/l	0.02	0.01
TDS	mg/l	63	90
Nitrates	mg/l	0.2	0.2
Nitrites	mg/l	-	-
issolved Oxygen	mg/l	-	-
BOD(5days @ 20°C)	mg/l	-	-
COD	mg/l	--	-
Total Coliform		-	-
Fecal Coliforms		-	-
Average Discharge		-	-

Table 6: WATER QUALITY OF NAIROBI RIVER

PARAMETER	UNIT	At Museum	D/S Ruaka Confl.	D/S Ngong Confl.	Nairobi falls
pH	--	7.3	7.3	7.4	7.3
Colour	mgPt/1	50	70	15	157
Turbidity	NTU	80	23	32	57
Oxygen absorbed	mg/1	6.4	14	22	8.8
Conductivity	uS/cm	328	340	592	357
Iron	mg/1	8.0	2.7	2.7	3.6
Manganese	mg/1	0.5	1.0	0.4	0.7
Calcium	mg/1	7.8	7.4	14.4	6.6
Sodium	mg/1	45	48	80	34
Potassium	mg/1	11	17	20	12
Total Hardness	mg/1 $CaCO_3$	82	90	76	60
Total Alkalinity	mg/1 $CaCO_3$	83	118	229	139
		50	54	53	31
Chloride	mg/1	0.7	0.8	1.3	0.7
Fluoride	mg/1	2	3	15	5
Sulphate	mg/1	0.05	0.8	0.9	0.02
Orthophosphate	mg/1	257	204	175	261
TDS	mg/1				
Nitrates	mg/1	0.9	0.01	0.3	0.02
Nitrites	mg/1	-	-	-	-
Dissolved Oxygen	mg/1	-	-	-	-
BOD(5days @ 20°C)	mg/1	-	-	-	-
COD	mg/1	-	-	-	-
Total Coliform		-	-	-	-
Fecal Coliforms		-	--	-	-
Average Discharge		-	-	-	-

Table 7: THE WATER QUALITY OF ATHI RIVER

1PARAMETER	UNIT	Stn 15 RGS 3 DA 2	Stn 16 RGS 3 F 2	Stn 19 RGS 3 HA 2
pH	--	7.5	8.1	7.7
Colour	mgPt/l	64	50	45
Turbidity	NTU	15	157	72
Oxygen absorbed	mg/l	28	25	55
Conductivity	uS/cm	373	460	672
Iron	mg/l	1.7	1.7	4.9
Manganese	mg/l	0.7	0.35	0.7
Calcium	mg/l	8	19.6	31
Sodium	mg/l	61	66	90
Potassium	mg/l	-	19.5	246
Total Hardness	mg/l$CaCO_3$	47	110	181
Total Alkalinity	mg/l$CaCO_3$	79	124	134
Chloride	mg/l	32	39.4	61
Fluoride	mg/l	0.9	0.68	0.9
Sulphate	mg/l	8.7	15.8	39
Orthophosphate	mg/l	1.9	0.3	0.06
TDS	mg/l	223	276	414
Nitrates	mg/l	1.0	0.48	0.04
Nitrites	mg/l	-	-	-
Dissolved Oxygen	mg/l	-	-	-
BOD(5days @ 20°C)	mg/l	-	--	-
COD	mg/l	-	-	-
Total Coliform		-	-	-
Fecal Coliforms		-	-	-
Average Discharge		--	--	-
		-	-	-

Table 8 : WATER QUALITY OF TANA RIVER

lPARAMETER	UNIT	stn 12	Stn 17	Stn 19	Stn 20 RGS 4 A 2
pH	--	7.5	6.9	7.2	7.4
Colour	mgPt/1	5	101.8	190	347
Turbidity	NTU	7.6	74	122	165.7
Oxygen absorbed	mg/1	8.7	6.6	5.3	7
Conductivity	uS/cm	139	128	165	194
Iron	mg/1	0.3	3.9	15.7	18
Manganese	mg/1	-	0.2	0.7	0.6
Calcium	mg/1	16.5	14	3.3	16
Sodium	mg/1	10	3.6	5.7	8.4
Potassium	mg/1	2	7.5	3.4	6.8
Total Hardness	mg/1$CaCO_3$	60	39.8	54	69
Total Alkalinity	mg/1$CaCO_3$	51	40.8	53	70
Chloride	mg/1	8.5	8	10.8	10.8
Fluoride	mg/1	0.3	0.4	0.3	0.4
Sulphate	mg/1	2.2	4.7	0.01	0.4
Orthophosphate	mg/1	0.01	0.01	1.0	0.05
TDS	mg/1	83	63	99.2	116
Nitrates	mg/1	-	0.5	0.2	0.3
Nitrites	mg/1	-	-	-	-
Dissolved Oxygen	mg/1	-	-	-	-
BOD(5days @ 20°C)	mg/1	-	-	-	-
COD	mg/1	-	-	-	-
Total Coliform		-	-	-	-
Fecal Coliforms		-	-	-	-
Average Discharge		-	-	-	-
		-	-	-	--

Table 9: WATER QUALITY OF THIKA RIVER

PARAMETER	UNIT	RGS 4 CB 4	4 CB 4/ 4 CC 3	RGS 4 CC 3
pH	--	7.2	6.6	7.0
Colour	mgPt/l	102	33	108
Turbidity	NTU	24	39	51
Oxygen absorbed	mg/l	8.0	6	5
Conductivity	uS/cm	63	226	145
Iron	mg/l	0.5	4	3
Manganese	mg/l	0.03	0.5	0.15
Calcium	mg/l	3.6	4.0	4.9
Sodium	mg/l	7.1	8.6	17
Potassium	mg/l	1.7	22	2.1
Total Hardness	mg/l $CaCO_3$	28	41	26
Total Alkalinity	mg/l $CaCO_3$	27	44	26
Chloride	mg/l	7.5	17	11
Fluoride	mg/l	0.1	0.5	0.3
Sulphate	mg/l	0.8	0.01	1.6
Orthophosphate	mg/l	0.02	64	0.04
TDS	mg/l	38	135	87
Nitrates	mg/l	0.6	0.03	0.1
Nitrites	mg/l	-	-	-
Dissolved Oxygen	mg/l	-	-	-
BOD(5days @ 20°C)	mg/l	-	-	-
COD	mg/l	-	-	-
Total Coliform		-	-	-
Fecal Coliforms		-	-	-
Average Discharge		-	-	-

Table 10: THE WATER QUALITY OF EWASO NGIRO (N) RIVER

PARAMETER	UNIT	RGS 5 E 3	RGS 5 BC 4	RGS 5 AA 1
pH	--	7.6	8.0	7.0
Colour	mgPt/1	-	-	-
Turbidity	NTU	50	45	26
Oxygen absorbed	mg/1	6.6	6.2	8.1
Conductivity	uS/cm	200	234	175
Iron	mg/1	1.4	3.7	2.5
Manganese	mg/1	0.9	0.1	0.2
Calcium	mg/1	4	6	3
Sodium	mg/1	-	-	-
Potassium	mg/1	-	-	-
Total Hardness	mg/1$CaCO_3$	132	63	27
Total Alkalinity	mg/1$CaCO_3$	101	109	50
Chloride	mg/1	22	1.0	6
Fluoride	mg/1	0.8	0.9	0.3
Sulphate	mg/1	2.6	0.01	0.6
Orthophosphate	mg/1	0.08	0.45	0.08
TDS	mg/1	-	-	-
Nitrates	mg/1	2	0.4	0.2
Nitrites	mg/1	-	-	-
Dissolved Oxygen	mg/1	-	-	-
BOD(5days @ 20°C)	mg/1	-	-	-
COD	mg/1	-	-	-
Total Coliform		-	-	-
Fecal Coliforms		--	-	-
Average Discharge		-	-	-

REPUBLIC OF KENYA
MINISTRY OF WATER DEVELOPMENT
CENTRAL WATER TESTING LABORATORY

BACKGROUND

The Ministry of Water Development was created in 1974 and with it the Water Quality and Pollution Control Centre. The latter comprises of Pollution Control Unit, Water Quality Monitoring Unit, Drinking Water Quality Control and Surveillance Unit and the Central Water Testing Laboratory Unit.

The Central Water Testing Laboratory (the laboratory) consists of three sub-units, viz:-
- Raw and potable water laboratory
- Waste water laboratory
- Biological and microbiological laboratory.

These were created by renovating and converting classrooms of former water training school into laboratories.

PRESENT STATUS OF WATER QUALITY CONTROL

The Laboratory carries out physical, chemical, biological and microbiological analyses on a routine basis. About 3 000 samples are received and analysed each year. The samples received include domestic sewage, industrial wastes, raw and treated water (from springs, boreholes, wells, rivers, lakes etc) and sediment load (from dams, rivers etc). The laboratory coordinates analytical work done by smaller laboratories in the provinces and serves as a water quality reference centre. It offers invaluable backup service to the water quality monitoring network in addition to a wide range of clientelle (ref Annex I attached).

MAJOR EQUIPMENT FOUND IN THE LABORATORY

- AAS
- UV-Visible Spectrophotometer
- Flame Photometers
- Analytical Balances
- Top Pan Balance
- Selective Ion Meters
- PH Meter
- Conductivity Meter
- Nesslerizer
- Turbidimeter
- Furnaces
- Oven
- Incubators
- Refrigerators

Deep Freezers
Cold Room
Microscopes
Autoclave
Centrifuge
Heating Mantles
Digestor
Floc Tester
Vacuum Pumps
Water Baths
Kjeltec System
Magnetic Stirrers
Water Still
Water De-ioniser
Portable Water Testing Kit

VARIABLES (PARAMETERS) ANALYSED BY THE LABORATORY

PH
Alkalinity
E Conductivity
Colour
Turbidity (transparency)
Total Dissolved Solids
Total Suspended Solids
Total Hardness
Calcium
Magnesium
Sodium
Potassium
Iron
Manganese
Cadium
Chromium
Lead
Copper
Zinc
Nitrite - N
Chloride
Fluoride
Sulphate
Athophosphate
Free Carbon Dioxide
Dissolved Oxygen
B.O.D.
C.O.D.
Parmanganate Value
Total Coliforms
Sulphides

PARAMETERS NOT CURRENTLY ANALYSED BY THE LABORATORY

Ammonia - N
Nitrate - N
Chlorophyll a
Cyanide
Arsenic
Mercury
Selenium
Aluminium
Boron
Silica
Kjeldahl Nitrogen
T.O.C.
Organochlorine Compounds (pesticides)

These are sometimes analysed with the assistance of other laboratories in the country.

ANALYTICAL QUALITY CONTROL

The laboratory participates in analytical quality control on GEMS standard samples through the American Geological Survey.

Inter laboratory checks are occasionally carried out with other government laboratories which, although they have their own areas of specialisation, handle occasional water samples (ref Annex II attached).

Annex I

CLIENTS OF THE CENTRAL WATER QUALITY TESTING LABORATORY

1. Ministry of Water Development

   - Hydrology Section
   - Drilling Section
   - Ranch Water
   - Pollution Control
   - Water Quality Monitoring Network
   - Water Quality Control and Surveillance
   - Geology
   - Irrigation

2. Universities

   - University of Nairobi
     - Deparments of Geography, Environmental Engineering, Civil Engineering, Chemistry

   - Moi University

   - Jomo Kenya University of Agriculture and Technology (JKUCAT)

   - Kenyatta University

3. Private Companies and Consultants working on water projects

4. Parastatal organisations

5. Relief Agencies and NGOs involved in water projects

6. Local Authorities (water undertakers)

7. Some of the laboratories listed in Annex II

Annex II

OTHER GOVERNMENT LABORATORIES IN KENYA

		Specialisation
1.	Government Chemist	- wide range of products including forensic samples
2.	Kenya Bureau of Standards	- establishment of standards conformity checks
3.	Public Health	- patient specimens
4.	Mines and Geology	- rock / soil samples
5.	Materials Branch	- materials used in government projects
6.	Factories Inspectorate	- air samples / environmental safety samples
7.	Customs Laboratories	- imported goods for tariff classification
8.	National Agricultural Laboratories	- fertiliser, feedstuff pesticide formulation
9.	K.E.M.R.I.	- medical research
10.	K.E.T.R.I.	- trypanosomiasis
11.	K.E.F.R.I.	- forest products
12.	K.I.R.D.I.	- industrial products
13.	K.A.R.I.	- agricultural products
14.	Veterinary Laboratories	- animal research
15.	University Laboratory Services	- miscellaneous research

RWANDA COUNTRY REPORT

1. Introduction:

Departments dealing with water in Rwanda, have always been facing many problems.

- Financial problems
- A very limited number of qualified technicians.
- And lack of apropriate equipment due to lack of funds.
- Transferring of these water departments from time to time, from one Ministry to another, thus causing the departments to have new leaders all the time and this handicaps the good running of work.

2. Hydrological Situation In Rwanda

(a) Hydrological department was once in the Ministry of Agriculture and was then moved to the Ministry of Public Works. Problems they went with, was not a priority to the new Ministry.

(b) When it was still in the Ministry of Agriculture, the hydrological department had a small laboratory run by a French expart but it was only dealing with Sediment measurements; and after a short time the laboratory was stopped, for unknown reasons.

3. Hydromet

(a) Hydromet since its installation in Rwanda in 1972, it was somehow independent,not under any Ministry. It was being supervised by the Project Management at Entebbe - Uganda. In 1978 towards the end of the year, it was put under the Ministry of Transport and Communications.

(b) In Kigali Regional Office - we have been provided with sediment discharge equipment by the Project Management. But because we don't have a laboratory, this equipment has never been used.

4. Water Supply Department

(a) The water supply department is an independent organization,having its own status and its own annual financial budget. There is no clear cooperation between this organization with the other departments dealing with water.

(b) As far as laboratories are concerned,this water supply department has many stations all over the country in which water for house hold uses is purified.

5 Type of Data Collected

Rwanda is divided into two main water shades. The Nile and Zaire river water shades. About 80% of the total water in the whole country flows to the Nile basin and the rest of the water 20% flows to the Zaire river basin.

The hydrological department in the Ministry of Public works has height gauging stations all over the country covering the two water shades, and at good number of stations, discharge measurements are done. Annual hydrological publication is prepared and it is given out to the users. Hydromet is only dealing with the water course of the Nile. And the data collected are the gauge heights and discharged measurements. The collected data is sent to Hydrodmet headquarters for analysis.

6. Assistance from International Organizations

As in other fields, water departments demand help from the International Organizations. In this respect, WMO had suggested that all departments dealing with water be grouped in one organization which they called Institute of Hydrometeorological Research. But due to financial problems, this Institute might not be formed in the near future.

The purpose of wanting to group together all the water departments, was to put together all energy and knowledge for the work efficiency.

COUNTRY PAPER
WATER QUALITY MONITORING SYSTEM, SUDAN

1.0. General Background

Sudan is the largest country in Africa with a total area of 2.5 million square kilometres. It lies between latitudes 4 - 22 N and longitude 22 - 34 E. The climate is tropical in the South, desert and semi desert in the North.

The River Nile, its tributaries, rainfall and groundwater represent the water resources in the country.

The quality of water available is at times less than desirable standards (WHO, and local). Excessive level of naturally occurring dissolved solids, turbidity nitrate and fluoride are common in some water supplies.

2.0. Water Authorities

There are different agencies that deal with water in Sudan. The Ministry of Irrigation and Water Resources is responsible for use, planning, development and management of the whole country's water resources. The National Urban Water Corporation and The National Rural Water Corporation are responsible for provision and quality monitoring of urban and rural areas drinking water respectively. The National Chemical Laboratory and the Ministry of Health sets the standards for water use, and monitoring the quality of drinking water and its health implications in the whole country.

3.0. Main Sources of Water Supply

Almost all the urban communities which are situated along the River Nile and its tributaries use surface water as the main source of supply. This water is subjected to treatment with different dosage of aluminium sulphate and hydrated lime (during the flood season). This is followed by sedimentation, and filtration using rapid sand filters. Chlorine is then applied for disinfection, pure water is thus pumped to the storage reservoirs from where it is later pumped to the balanced high level tank and finally reaches the distribution system.

In areas along the Nile where there is no treatment plant, water is pumped directly from the Nile through pipes to the consumer taps without treatment.

In rural areas and urban settlements lying far from the River Nile, open dug wells, boreholes and artificial ponds known as Hafirs are commonly used to serve these communities. Water from boreholes or Hafirs is usually not treated, however, slow sand filtration is sometimes carried out for Hafir water.

4.0. Monitoring of Water Quality

The National Urban Water Corporation (NUWC) which is the sole agent responsible for drinking water provision in the urban areas has the Mogren Central Laboratory which is responsible for water quality control in Khartoum water works and supervise and inspect the other branches distributed in the major urban centres in the country.

The central laboratory (Mogren) of the NUWC consists of a bacteriological and chemical laboratories and is operated by eight technicians. The Laboratories are functioning with outdated equipments mostly provided since the early inception days. At each treatment plant samples are always taken from the intake sites, the filter, and tap water on daily basis as a routine test. A weekly examination is usually done for the boreholes and distribution system for bacteriological test. On monthly basis samples are taken from the Nile, tap and borehole water for the purpose of full chemical analysis.

The parameters for this chemical analysis include the pH, turbidity, conductivity, total hardness, total alkalinity, calcium and magnesium, sulphate, chloride, nitrite, ammonia, silica, suspended and dissolved solids. All the results are compared to the National Standards and WHO guidelines. A monthly report is produced and submitted to the Director General of the Urban Water Co-operation.

Water samples from other parts of the country are sometimes collected and analyzed in the National Chemical Laboratories especially when a water quality problem arises.

Whenever a new borehole is to be open, a water quality test is to be taken before hand by the National Chemical Laboratories (NCL) in order to ensure it complies with national standards. The NCL are monitoring the Blue Nile, White Nile and tap water monthly.

5.0. GEMS Monitoring Stations

GEMS/Water has proposed four station in Sudan However only two of them are currently operating there are on the Blue Nile at Khartoum and on the white Nile at Gebel Aulia. The National Chemical Laboratories analyse the two sites and send the results to GEMS. The groundwater monitoring station at Arbaat near the Red Sea is not in use at present.

6.0. Water Quality Status

The surface water in Sudan is believed to have no industrial pollution or a heavy metal contamination.

Generally, the water quality in Sudan is thus considered to be in a good condition. The records show that the chemical constituents of water especially the Nile water comply with the WHO Standards. However there is a problem of high suspended sediment during the flood season and a high growth of algae after the flood season. In some cases the Nile water has bacteriological contaminations such as coliform bacteria but not considered as seriously affecting the water quality.

As for ground water traces of local contamination are sometimes revealed but does not cover the whole aquifer.

The White Nile area is usually an area of high sulphate concentration. The western area of the country has a problem of nitrate and flouride which sometimes exceeds the permissible level. Whereas, the eastern part of the country suffers from the problem of high nitrate concentration. The Coastal area in particular has a high level of chloride due to the intrusion of the sea.

WATER QUALITY MONITORING IN TANZANIA

1. INTRODUCTION

Geographically, the United Republic of Tanzania is situated in the Eastern part of Africa South of Equator between Longitude 29 degrees and 40 degrees East and Latitude 1 degrees and 11 degrees 75 minutes South. The country shares border with her neighbours Kenya and Uganda in the North, the Indian Ocean to the East,Mozambique and Malawi to the south, Zambia to the South West, Zaire to the west and Burundi and Rwanda to the North West. The country also shares the three great Lakes of Africa namely Victoria with Kenya and Uganda Tanganyika with Zaire, Zambia and Burundi,Nyasa with Malawi and Mozambique. The country's surface area is about 937,062 square kilometers with a population of about 23.2 million people (1988 census). The average annual rainfall is about 1,125 millimeters.

This paper attempts to provide a brief information regarding water quality status and national action plans regarding water quality management as undertaken by the Ministry of Water, Energy and Minerals in collaboratoion with other Ministries and agencies like Local Government (city council), Ministry of Health,National Environmental Management Council.

2.0. HISTORY OF WATER QUALITY MONITORING ACTIVITIES IN TANZANIA

Water quality monitoring activities in this country started on an irregular basis at the chief government laboratories (Ministry of Health)in the early fifties and analysis was carried out by individuals due to certain interests. The Water Development Institution at that time was not required by Law to carry out water quality monitoring.

As time went by and with the government recognizing the need to provide the people with safe/potable water, the question of quality was also emphasized.

In 1971 the Ruling Party decided that in 20 years time all Tanzanian should be supplied with a source of adequate clean and safe water within an easy reach from their household. Infulfiling the Party directive, the then Ministry of Water Development and Power took over the task of water quality monitoring from the Chief Government Chemist (Ministry of Health) and established its own water quality laboratory in Ubungo Dar es Salaam early 1970/71 which is now the Central Laboratory.

The purpose of the laboratory being to check the quality of all newly exploited water sources,the existing water schemes and the potential water supplies.

3.0. WATER QUALITY SITUATION IN THE COUNTRY

Tanzania as is the case in many developing countries some people especially in rural areas are still using untreated water from Lakes, Rivers shallow wells, Springs, Streams and Boreholes some of which are biologically and Chemically polluted. this pollution is either brought about by the consumer themselves during water drawing, bathing, washing or through domestic waste discharge of effluent from industries, runoff from agricultural activities and sometimes due to Natural Mineralization as is the case of occurrence of high concentrations of fluoride in Arusha, Kilimanjaro, Singida, Dodoma,Mwanza,Shinyanga and some parts of Mara, Tanga and Mbeya Regions. Sometimes even the treated water (tap water) is bacteriologically contaminated due to pipe leakages during conveyance, and it has also been noted that sometimes drinking water at household levels is polluted/contaminated through water mishandling procedure during storage. This has been confirmed through source to mouth studies.

An interpretation of the data obtained from the sampling of boreholes, protected springs, open springs,streams, ponds around the country indicates that boreholes are the best water sources. Where borehole water has been found to contain any pollution the source is due to leakages infiltration, of pollutants, leaching of minerals from rising mains, natural mineralization as is the case with many borehole with high

fluoride concentration or the beneficiaries pollute during water drawing (for open well).

Although treated water (from conventional treatment plants) is the best type of water due to the fact that the water is disinfected, sometimes it could also contain faecal coliforms,again this is either due to leakages in the distribution system or due to poor control of disinfectant dosage. Samples analyzed at water laboratories are sometimes found to contain bacteria (faecal coliforms) which represent a health risk.

The quality of drinking water in the investigated sources throughout the country can be summarized as follows:-

(i) Boreholes - suitable for use without treatment provided pump base and sealants are firmly intact.

(ii) Rain water and Protected wells:- Suitable for use without treatment.

(iii) Springs and impoundments - (Moderate quality) but treatment may be required depending on the location of the water source.

(iv) Streams, rivers,lakes, pit sand open wells - worst in quality, should be avoided if possible, otherwise the water from these sources must be treated.

Generally one of the recommendations we give to our customers is that the water must be boiled before drinking even if it is from the boreholes.

3.1 Water Pollution
Three major sources of water pollution are common in Tanzania that's due to industrial effluent discharged in water bodies, domestic waste and agricultural ruonff.

3.1.2. Domestic Waste
Many surface water sources in the country are bacteriologically polluted due to uncontrolled disposal of sewarage and other waste resulting from domestic use of water and improper disposal of domestic solid waste. The discharge of domestic waste waters into the nearby ocean, lakes, and rivers in Tanzania substantially contributes to the pollution of potential drinking water sources. An example is the discharge of the waste from the following towns:- Tanga, Dar es Salaam, Kilwa, Zanzibar, Mtwara and Lindi into the Indian Ocean. While Bukoba, Mwanza and Musoma discharge their domestic waste water into Lake Victoria, Kigoma town into Lake Tanganyika, Morogoro and Moshi empty into Morogoro and Njoro rivers respectively.

3.1.3. Industrial Pollution
Many Industries in Tanzania have been constructed without water treatment facilities. Even thosewith such facilities they breakdown and due to economic situation it may take a long time to repair such that the effluent is left over flowing or discharged directly to the Water bodies. Industries in Morogoro (Tanneries and Canvas mill), Dar es Salaam l(Textile mills, Breweries, Dry,Abators etc),Moshi (Kibo Match and Tanneries), Mwanza (Textile, Edible Oil refinery and Fish processing industry), Tanga (Sisal processing) and Industries in other towns also discharge their effluents in water bodies.

3.1.4. Agricultural Practices
More than 85 percent of the countries population depend on agriculture as their means of earning their living. In order to increase the yield, fertilizers, herbicides, pesticides, insecticides, fungicides etc are used. During heavy rains all these are washed down into the surface water bodies and sometimes into uncovered shallow wells endangering the peoples health.

3-4.0.WATER QUALITY MONITORING SYSTEMS IN THE COUNTRY
The overall objective of the water quality monitoring activities in Tanzania is to ensure that the quality of the water sources in the country is maintained at a satisfactory acceptable level. In fulfilling the above mentioned objective, work has been done on setting systems for water quality surveillance which includes sanitary inspections, Physical-chemical and bacteriological examination of water supply.

The Ministry of Water, Energy and Minerals is trying hard to ensure that clean, and safe water is supplied to the people. To achieve this target, up to now the Ministry has done the following:-

(i) The establishment of the first water quality Laboratory in the country (1970) which now is the Central Laboratory.

(ii) The formulation of Tanzanian temporary standards for drinking water (1973) and temporary standards for effluents and receiving water (1978)

(iii) An introduction of a three year water Laboratory technician's course at the Water Resources Institute (Dar es Salaam).

(iv) The construction and equipping of ten regional/zonal water quality laboratories in addition to the central laboratory.

Todate there are 14 laboratories and the 15 one is under construction in Moshi. Donor agencies and Governments providing some kind of support to these laboratories are as follows:-

1. Dar es Salaam - The Government of Tanzania (Central Laboratory.
2. Kigoma - NORAD
3. Sumbawanga - NORAD
4. Mtwara - FINNIDA
5. Songea - DANIDA
6. Mbeya - DANIDA
7. Iringa - DANIDA
8. Mwanza - SIDA
9. Bukoba - SIDA
10. Musoma - SIDA
11. Shinyanga - Netherlands Government
12. Singida - Australian Government.
13. Tanga - GTZ (Germany)
14. Arusha - GTZ (Germany)
15. Moshi - Tanzania Government and KFW (Under construction)

(v) The introduction of water quality monitoring legislation.
(vi) The execution of water research programmes (Currently Water Defluoridation).

4.1. National Water Quality Monitoring Programme

It is very clear that water quality and effluent standards can best be checked by water quality monitoring programme. The water testing laboratories have been established for the purpose of regularly checking of water quality from the water supply schemes, domestic and industrial effluent, receiving waters, potential water sources e.g. rivers, lakes, springs etc and to examine the quality of the water from the newly exploited water supply sources such as boreholes.

4.1.1. Physical - Chemical Analysis

Irrespective of the size of the population, all types of waters are supposed to be visited at least two times per year. One under dry conditions and once under rainy conditions. Bacteriologically however the number of visits depends on the following factors:-

(i) Size of the population served.
(ii) Risk of pollution i.e. distance from and nature of pollution source.
(iii) Nature and extent of sanitary protection of the source.

Regarding the Nation Water Quality Monitoring Proramme emphasis is placed on water supplies in Urban areas mainly Dar es Salaam, Regional Headquarters, District Headquarters, Large water supply schemes. eg. Handeni Trunk Main, Boreholes and impoundments.

In the case of Dar es Salaam water quality monitoring, there are about 60 sampling stations. Each station has to be visited at least twice in a week to determine the amount of free residual chlorine and to analyze the water bacteriologically.

4.2. GEMS/WATER PROJECT

Besides the National water quality monitoring programme there is also Global Environmental Monitoring system-Water Project. The undermentioned stations are being monitored:-

(i) Lake Victoria - South port(Mwanza)
(ii) Lake Victoria - Bukerebe Island (Mwanza)
(iii) Lake Victoria - North Port (Mwanza)
(iv) Lake Victoria - Bukoba (Kagera)
(v) River Kagera - Nyakanyasi (Kagera)
(vi) River Kagera - Bukoba
(vii) River Ruvu - Mlandizi (Coast)
(viii) River Rufiji - Stiggler's Gorge (Coast)
(ix) Borehole 97/70- Makutopora (Dodoma)
(x) BH/92/78 - Sakina (Arusha)
(xi) River Maji ya - Arusha Chai.

The last two sources are monitored for a specific problem of fluoride.The data obtained from these sources are then despatched to Burlington (Canada Centre for Inland waters) for processing and storage.

5.0 FUTURE WATER QUALITY MONITORING PROGRAMME
A lot of investment is required in order to fully implement the water quality monitoring programme. Given the economic situation of the country, it means that implementation of the programme has to take place in phases. Thus the Ministry will continue to implement the water quality monitoring activities on the following grounds:-

5.1 Construction of Water Laboratories
In order to have an effective monitoring programme for the whole country, besides the 14 laboratories constructed in the forementioned regions efforts are being made to construct laboratories in the remaining 6 regions. Although this might take along time since construction of one laboratory is estimated to cost about Tshs (ten million). and to equipment it cost about Tshs. 20 million. It is also intended to expand the Central Water Laboratory and equip it with facilities for waste water laboratory so that it can carry out analysis of waste water to checkout various pollutants like heavy metals,agrochemicals. Chemical Oxygen Demand etc.

5.2 Rural Water Quality Monitoring Programme
It is also intended to continue with the Rural water quality monitoring programme. This programme was approved by the government in 1989/90 financial year. The aim of the project is to improve water quality services in the country. Through this programme the Tanga and Songea laboratory are being expanded and the Moshi Laboratory is under construction.

5.3 Review of Temporary Standards
The Tanzanian Temporary Standards for Drinking water and Waste water will be reviewed by An inter Ministerial committee.

5 - 5.4. Water Hygiene Committee
This committee is responsible for follow up of all matters related to water quality control. It is aimed that each region should have such committee. The members of the committee are, Regional Development Director, Regional Agricultural Officer, Regional Water Engineer, Industrial Officer, and Regional Chemist. For the time being only three regions have formed such committees so far.

5.6 Training
The Ministry is making efforts to provide a chemist and a microbiologist to each water laboratory. It also intends to provide further training to Chemist and Technicians already working with the laboratories to upgrade their skills and expand their knowledge. Whenever possible. Also the Water Resources Institute will continue to train more technicians in water laboratory technology. Beside this training it is also planned to train some of the laboratory personnel on Instrumentation,data processing, water analysis, and environmental technology.

The Ministry undertakes Defluoridation Research Project in order to solve the problem of high fluoride concentrations in drinking water for fluoride stricken areas mentioned earlier. Beside this research, it is also the intention of this Ministry to carry out a Research on the Improvement of slows and filters so that they suite the prevailing situation of this country as some Regions with slow sand filter has been experiencing big problems with their slows and filters.

6.0. Constraints

The smooth running of water quality monitoring activity is affected by some major constraints like lack of equipments, chemicals, glassware, transport,trained personnel in certain fields like instrumentation etc.

6.1. Chemicals, Glassware, Equipment

The problem which water quality sector faces in the implementation its responsibility is the lack of the forementioned things. Chemicals, Glassware and Equipments are not manufactured in this country. They are bought by businessmen in the country. The cost of which is very high. An example is the price of a combination fluoride Electrode its cost is about pound sterling 437.2 which is equivalent to about TSs 180,000/- This amount is the allocation for two quarters, which means other activities have to be at stand still and the cost of some equipments is the equivalent of the money allocated for the whole financial year.

6.2 Training

Besides the fact that Technicians are trained at the Water Resource Institute and Chemist/Microbiologist at the University of Dar es Salaam,. From time to time they require upgrading trained or further training. Most of this type of training is conducted out of the country, to train one person from the almost impossible. The water laboratory faces one problem in this aspect which is lack of qualified personnel in instrumentation, and other fields.

6.3. Transport

There are 20 regions in this country and also about 200 water sources with exception of few which has more than that. Each of this source is supposed to be visited by the laboratory staff for water sampling and sanitary inspection. It is very unfortuate that all 14 laboratories do not have means of transport. Thus effective monitoring programme is not possible. As a result our monitoring activities are carried out on crisis for example when there is Cholera breakdown is when transport is available without hestation.

WATER QUALITY ACTIVITIES IN UGANDA

BY

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A Country Report Presented at the GEMS-Water Workshop for Water Quality Monitoring and Assessment held from March 23rd to April 3rd in Arusha, Tanzania.

INTRODUCTION

Uganda is an East African country located between latitudes 1° 30' South to 4° 10' North and longitudes 29° 36' East to 35° East. It is bordered to the North by Sudan, to the East by Kenya, to the South by Tanzania, to the Southwest by Rwanda and to the west by Zaire. It has a population of 17 million people and a land area of 235,880 km^2, 18% of which (39,460 km^2) is covered by water. The country's major water bodies are part of the River Nile System and are subdivided into ten sub-catchment areas - Victoria, Kyoga, Albert, Edward, Victoria Nile, Albert Nile, Aswa Nile, White Nile, Kidepo, and Turkana (see map).

Despite these abundant water resources, the technology to harness them is largely lacking in the country so that only about than 20% of the population has access to safe drinking water. For 78% of the population, however, unprotected water from rivers and swamps is available within 1 kilometre.

The management and development of the country's water resources falls under the Water Development Department of the Ministry of Water, Minerals, Energy and Environment Protection located in Luzira, Kampala. The Department's activities pertaining to water resources assessment and monitoring fall under the division of Water Resources. It is under this division that we find the Water Quality and Pollution Control Section responsible for actual collection of water quality data (see attached Organisation Chart).

PAST ACTIVITIES

(a) National Network

The development of the national water quality monitoring network and the history of assessment activities in Uganda is closely associated with the establishment of a national hydrological network. Following the creation of the Water Development Department in 1956 and, later on, the initiation of the Hydromet Survey Project, many hydrological stations were established and fully equipped with recording gadgets. By the early 70's, an elaborate hydrological monitoring network covering all the major water bodies in the country had been set up.

In 1972, Hydromet Survey Project in addition to collecting hydrological data started water quality assessment and established eight water quality stations in the country. Later, the Central Water Quality and pollution Control Centre expanded this network to cover all the major lakes and rivers in the country. Sixteen more stations were set up bringing the number to twenty four. This was facilitated and made possible by the already existing network of hydrological stations and the fact that many of the stations were found to be ideal sites for location of water quality stations. Table No. 1 below lists these stations.

TABLE 1: Stations Making up the National Water Quality Network

LAKE/RIVER	STATIONS	TYPE
Lk. Victoria	Ssese; Bukasa Island Bukakata (OS) Entebbe (OS) Murchison Bay Napoleon Gulf; Jinja Berkeley Bay	Baseline (*) Baseline Baseline (*) Impact (*) Impact (*) Impact
Lk. Kyoga	Kigingi (OS) Masindi Port	Baseline (*) Baseline/Impact
Lk. Bisina	Oseera	Baseline
Lk. Albert	Wanseko Butiaba (OS) Ntoroko	Baseline/Impact Baseline (*) Baseline
Lk. Edward	Kasenyi (OS) Kazinga Channel Nyaweru (OS)	Baseline Baseline Baseline
Lk. Kijanibarora	Kyetaka	Baseline
R. Nile	Jinja (Source of the Nile) Pakwach Laropi	Baseline/Impact Baseline (*) Baseline/Int.front.
R. Mpanga	Ibanda F/P	Baseline/Impact
R. Malaba	Iyolwa Malaba Bridge	Baseline/Impact Impact/Int.frontier
R. Katonga	Katonga Bridge	Baseline
R. Namatala	Namatala Bridge	Baseline

OS = Off-Shore Station
(*) = Stations Operated by Hydromet

Most of these stations were of the baseline type and were used to establish the natural quality of the water and to keep track of quality trends. The frequency of sampling per site depended on available resources and, on average, stations were visited twice a year. Analysis performed on samples was routine and consisted of assessing physical characteristics: Colour, Odour, turbidity, conductivity, pH and TDS; and chemical characteristics Hardness, Alkalinity, Na, K, Mg, Ca, Cl, HCO_3, SO_4 and NO_3. For the hydromet stations, sediment analysis was also performed.

(b) Regional and Global Networks

In 1978, the eight stations operated by hydromet (see table 1) together with seven others in neighbouring Kenya and Tanzania were chosen for development of a water quality mathematical model. Sampling at these stations was done regularly and intensively, some stations being visited up to four times a month. All parameters enumerated above were analyzed and in addition temperature, dissolved oxygen, Secci disc transparency, biomass, chlorophyll, primary productivity and nutrients (phosphorous, Silicon and Nitrogen in all their forms; organic and inorganic) were analyzed. The data obtained was used for formulation of the water quality mathematical model for the upper Nile lake systems.

Around this period also, Hydromet was chosen as a regional collaborating centre for East Africa with regard to GEMS-Water activities. In accordance with this new role, the data obtained in the above exercise and others subsequently collected was remitted to the GEMS-Water head office in Canada.

(c) Civil strife and Destruction of Network

From late 1978 to 1987, Uganda went through an intermittent series of destructive and disruptive civil wars during which activities were abandoned and equipment destroyed. During the 1979 war, the Central laboratory suffered extensive looting and lost all its equipment and much of the data.

Some of the national stations were revived by Hydromet after the '79 war and continued to generate data for the water quality model and GEMS-Water activities. These however, did not survive the civil strife of the eighties and by 1982, virtually all water quality monitoring and assessment activities in the country had come to a standstill.

PRESENT ACTIVITIES

In 1986 the government of Uganda with assistance from UNICEF, in a bid to revive the Central Water Quality Laboratory procured some basic labware and instruments. Table No 3 shows some of the important instruments now available and analysis performed using them.

TABLE 3: Instruments and Parameters Analyzed

INSTRUMENT	PARAMETER ANALYZED/USE
1. Flame Photometer	Sodium, Potassium, Lithium
2. Spectrophotometer	Phosphates, Nitrates, Ammonia-N, Nitrites, Fluorides, Iron, Manganese, Silicates, Chlorophyll.
3. HACH Drel/5	------- do -------
4. PH and Specific Ion Analyzer	PH, Fluorides, Dissolved Oxygen, etc
5. Turbidimeter	Turbidity
6. Conductivity Meter	Electrical Conductivity, Conductance
7. Hot Plates	Evaporation, Digestion, etc
8. Fridges	Cold Storage
9. Autoclaves	Sterilisation
10. Ovens	Drying
11. Dry Bath Incubators	Bacterial Incubation
12. Millipore Field Kit	Total Coliform, Faecal Coli Counts
13. Electronic Balances	Weighing
14. Secci Discs	Transparency

The laboratory is presently headed by a Senior Analyst assisted by an Analyst and four laboratory technicians. Activity in the laboratory since its revival in 1986 has been concentrated in the following areas:-

(a) **Rural Water Supplies**

The laboratory receives and analyzes samples from newly commissioned or rehabilitated boreholes and protected springs all over the country. Many of the samples are brought from foreign funded water projects currently going on in various parts of the country e.g. RUWASA in Eastern Uganda, SWIP and SOGEA in the Southwest, CARE in the North and LWF in the North and North East. Parameters analyzed are mainly physical, chemical and bacteriological and, sometimes, trace elements.

(b) **Urban Water Supplies**

The laboratory provides baseline data for use in the design of new water supplies for big towns. From time to time, it is called upon to assess the suitability of river and lake water for:

- o agricultural irrigation;
- o Livestock watering;
- o Commercial fisheries;
- o Recreation; and
- o Industrial processing.

(c) Revival of Monitoring Network

Efforts are being made to re-establish the country's Water Quality Network and revive regular sampling and monitoring activities. These efforts, however, are being thwarted by a number of constraints namely:-

(1) Low priority rating accorded to water quality activities;

(2) Insufficient budgetary allocations causing:

i - lack of equipment especially deep water sampling gear, sediment samplers, Geiger Muller counter, Atomic Absorption Spectrophotometer, assorted glassware and fume cupboard;

ii - transport, and other logistical, problems.

(3) Lack of skilled and trained manpower.

A few of the old stations have been revisited but due to the above constraints, only a few parameters could be analyzed.

It is intended to establish regional monitoring laboratories whose activities will be coordinated by the Central laboratory.

1.0 Surface Water

Uganda's surface waters, especially around major urban centres, are getting gradually polluted from increasing industrial activity and unchecked discharge into rivers and lakes. examples:

* Dry Cell Industries - discharging untreated effluent with lead residues into Lk. Victoria;
* Jinja factories and algal blooms;
* Sewer lines emptying into Nakivubo channel and eventually Lk. Victoria.

2.0 Ground Water

Most of the boreholes around the countryside yield water of acceptable quality. However, in some regions of the country, some boreholes have been found to contain high levels of ions that either affect the aesthetic property of water or pose a hazard to the health of consumers. e.g.

* Nawaikoke sub-county in Eastern Uganda - high chlorides and hardness (Cl = 1500 mg/l; hard. = 3000 mg/l as $CaCO_3$)
* Nebbi and Arua districts in Northern Uganda - high alkalinity and hardness (Alk_{tot} = 500 mg/l; hard. = 1300 mg/l as $CaCO_3$)
* Kotido district in the North East - lead and Copper contamination of some boreholes (Cu = 2.06 mg/l; Pb = 5.10 ug/l)
* Rakai and Masaka districts - high levels of Iron (> 18.0 mg/l)

These boreholes have become contaminated from natural processes e.g. type of geological formation.

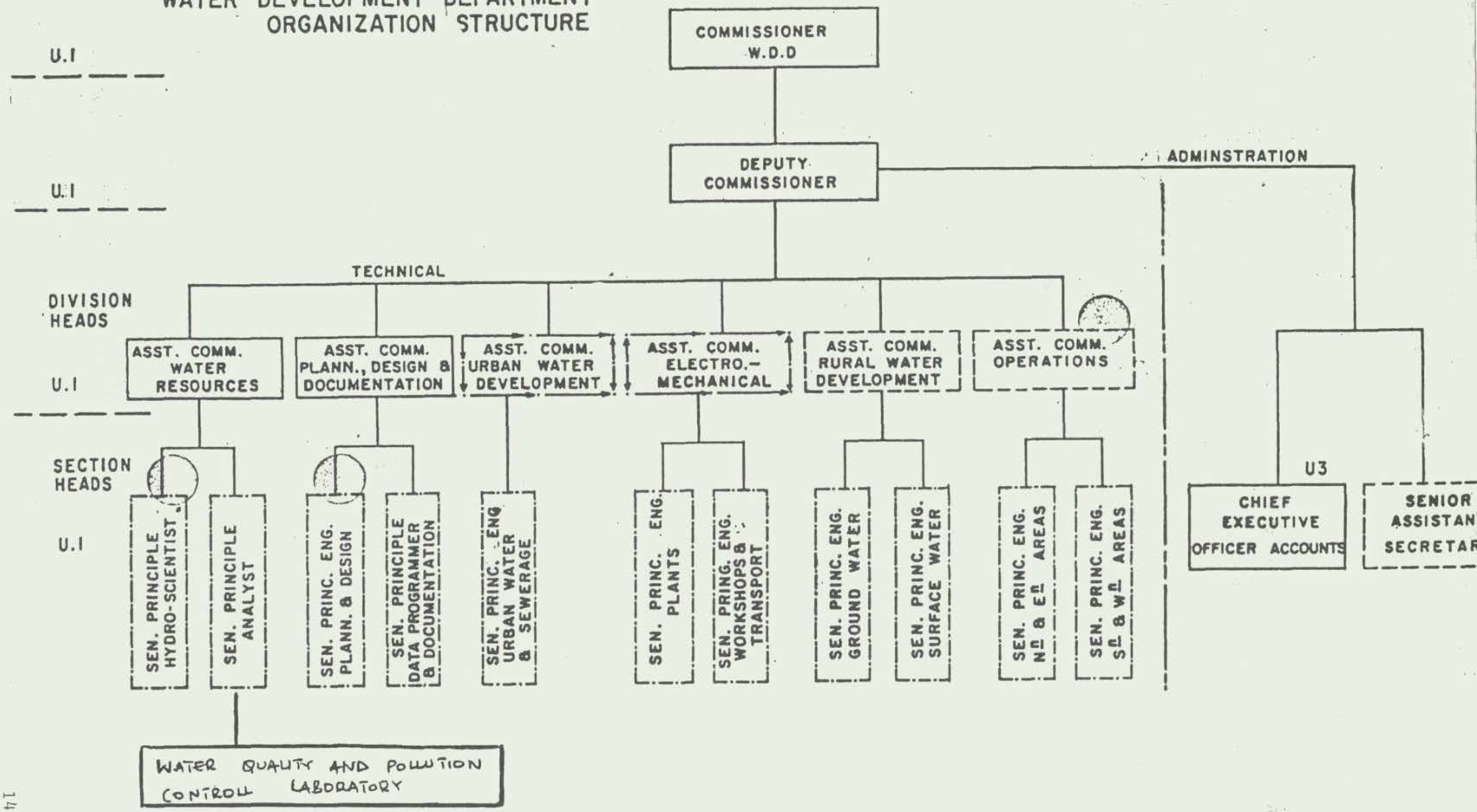
With industrial activities on the increase in many parts of the country, cases of groundwater contamination as a result of man's activities are beginning to emerge. A few are:

* High Cobalt in a spring near Kilembe mine where there is a huge Cobalt dump. This has resulted in death of nearby vegetation and aquatic life in nearby streams and ponds.
* Organo-phosphorous pesticide residues have been found in spring and sub-surface water near Kawanda Agricultural Research Station;

FUTURE ACTIVITIES

A National Water Resources Master plan has been drawn and is soon to be implemented. The main objective of the Master Plan is to assess both the quantity and quality of the county's water resources for integrated and sustainable use and development. The plan will re-establish surface and ground water resources assessment and monitoring networks for both quantitative and qualitative parameters.

WATER DEVELOPMENT DEPARTMENT ORGANIZATION STRUCTURE



ANNEX 5

PROPOSED PLANS OF WORK

Evaluation of Water Quality in Burundi

Water quality is going to become one of the greatest worries of the different Authorities in charge of water in Burundi.

Hydrology Service

This is part of the Burundi Geographical Institute (IGEBU) - within the ministry of tourism and environmental management. The Hydrology Service is entrusted with calculating river flow , gathering hydrological data, and taking samples for analysis.

Evaluation of Water Quality at the IGEBU

Water quality evaluation will never be truly valuable because there is a lack of facilities:

1) No appropriate laboratory;
2) No equipment and consumables;

In reality only pH, temperature and suspended solids can be measured.

Methods Used

1) pH: measured with pH meter and glass electrode
2) Temperature: measured with a thermometer
3) Suspended solids:
   a) filtration of the sample;
   b) use of a precision balance, after drying at 100°C, to calculate weight of suspended materials,

Data

The samples are taken at some sixty functioning hydrological stations. The first samples date from 1987. The data have not yet been published, but they are available for inspection at the Burundi Geographical Institute.

Funding, Equipment and Cooperation

Funding is granted by the Burundi government, and the major part of the project equipment from WHO.

Evaluation of water quality has not yet been recognised for its true worth within the Geographical Institute, national cooperation between the departments services concerned in this area is virtually non-existent.

Future Projects

In the future, a specific aim will be to reconcile the problem of water quality within the Burundi Geographical Institute. There could also be cooperation with other interested departments/services in the country also involved in this area.

EGYPT COUNTRY WORK PLAN

(A) PRESENT SITUATIONS

1. INTRODUCTION

Egypt undertook the responsibility of all technical and hydrological aspects of River Nile to Reduce its pollution. Because of any happened pollution in catchment area of the Nile Basin it will effect on Egypt all riparian countries must be cooperated together since Egypt lies at the Last Reach of the River Nile.

High Aswan Dam side Effects Research Institute (HDSERI) Established a new Laboratory in June 1989 to be support unit for water quality pollution control department of HADSERI to fulfill the following objectives

1. Water quality monitoring network of River Nile activities
2. Special studies on pollution control
3. Water quality modling
4. Research work.

2. SELECTION OF WATER QUALITY PARAMETERS

In order to achieve a manageable work load on the River Nile and fulfile HADSERI water quality monitoring network objectives, proper analytical parameters should be selected to Reflect the actual River and Stream conditions.

The following parameters should be analysed in the Laboratory and site: pH, Temperature, Conductivity, TDS, Oil and grease, Suspended solids, Colour, Turbidity, BOD, COD, TOC, Alkalinity, Hardness, Carbonates, Bicarbonates, SiO, Ca, Na, K, Mg, S, C, F, SO, Poslphorus (Total), Ortho phosphorus, NO, NO, NH, Kjeldahi N, Heavy metals, MBASS test for surfactant, Microscopical Examination faralga, Faecal coliforms.

3. EQUIPMENT ORDERING AND RECEIVING

The laboratory equipment was classified into the following categories:-

(a) General (Basic Equipment)
This equipment is essential to water laboratory to be used as support units for heating, cooling, drying, asting and incubating etc.

(b) Specific Measuring Equipment
Rallying on the method of analysis and sensitively of certain parameters, specific measuring equipment was specified for example a pH meter would be required for measuring ionic strength, a spectrophotometer would be required for measuring anions, a F-lamphotometer would be required for measuring major cations, an atomic absorption spectroscope would be required for measuring heavey metals and/trace element etc.

(c) Water Sampling Sevices and Field Measurement Instruments
The sampling device be defined i.e., a grab sampler is convenient to collect samples from industrial source of pollution while Integrated samples from the River Nile will be taken by a composite sampler.

Parameters that are affected by delay in analysis should be measured at time of sampling (In the field) using direct measuring instruments to determine pH, dissolved oxygen temperature and electrical conductivity.

4. HADSERI WATER QUALITY LABORATORY INSTRUMENTS AND EQUIPMENTS

The following section provides detailed information about equipment and instruments in the HADSERI water quality laboratory.

General Equipments

1. Refrigerated/Incubator
2. Muffle furnace
3. Automatic water distiller
4. Automatic autoclave
5. Hot plate (jumbo size)
6. Hot plate (normal size)
7. Incubator for micro organisms
8. Electronic water bath
9. Electronic precision balance
10. Immersion cooler unit
11. Hot plate with magnetic stirrers
12. Centrifuge
13. Deionizer
14. Macro Kjeldahl digestion apparatus
15. Filtration system
16. Fume hood
17. Electronic analytical balance
18. Hot place
19. Digital pH, temperature meter
20. Heating mantel
21. Drying oven
22. Deep freezer
23. Vacuum and pressure pump
24. Splil steam distiller
25. Water distillation apparatus
26. Binocular microscope

5. SAMPLING SITES

(a) **High Aswan dam** for chemical and physical sampled.
(b) **Isna city** for chemical and physical sampled.
(c) **Nag Hamandi Barrage** for chemical, physical sampled.
(d) **Halwan** for chemical and physical, Biological sampled.
(e) **El Qanater Barrage** for chemical and physical and Biological sampled.
(f) **Alexandria** for chemical, physical and Biological sampled.
(g) **Adfina** for chemical, physical and Biological sampled

6. ANALYSED (RANGE)

Four times per year.

7. REPORTS

Annual Report for National Reports. Other wise there is a Cooperation between HADSERI and Canadian Project.

(B) **Identification of key problems.**
There are lag of:

1. Cooperation between laboratories working in the field of water analyses.
2. Check of Results - External and Internal analyses.
3. Sufficient samples where some equipments were not been utilized.
4. Portable kits for Measurement of sites in Remote sites.
5. Support in regional laboratories which are used only for domestic use.
6. Materials for equipments
7. Transport means.

There are new proposed sites couring polluted industrial area from Halwan to Cairo.

(C) **Support/requirements**
There are need of support to:-

1. Regional laboratory to carry some testes on Biological sampled.
2. A very well trained laboratory analysistes.
3. Materials needed in Basic equipments,
4. Regular training course and special studies on water quality.
5. Portable equipments.

(D) **Anticipated out puts over next 12 month**

1. Increasing samples taken from sites along the River Nile and the Rang of analysing to 8 per/year.
2. Solving the problems due to shortage of materials needed in Basic equipment.
3. Sending regularly Reports to WHO.
4. Increasing the Coordination and cooperation between central and non Central Laboratories to creat completed network for water quality.
5. Cooperation between neighbouring countrys Sudan and Egypt to be easy evaluating pollution.

ETHIOPIA PROPOSED COUNTRY WORK PLAN

1. PRESENT SITUATION

In Ethiopia there is no properly established water quality monitoring network to date. Consequently, the quality status of the country's water resources (both surface and ground waters) remain unknown except for some sporadic and project specific studies done over a few of the river basins.

The importance of establishing a national water quality monitoring network has been recognized by the Ethiopian Valleys Development Studies Authority (EVDSA) and essential steps are now being undertaken. EVDSA has recently drafted a proposal to conduct a nation-wide water quality survey programme which could help in providing a baseline data and guidance for the establishment of the national water quality monitoring network. At present the Authority is looking for potential funding agencies to proceed with the programme as soon as possible and we believe that the assistance of GEMS or UNEP in looking for potential funding agencies is considerably important.

Although the feasibility of the proposed survey strongly depends on the availability of fund, the proposed time frame for the completion of the survey is four years and is divided into four different phases as follows:-

Phase 1: A review of existing data and preparation for a preliminary survey - (6 months)
Phase 2: Execution of preliminary survey and evaluation of results; design of the main survey - (1 year).
Phase 3: Execution of the main survey - (2 years)
Phase 4: Analysis and evaluation of results; preparation of draft standards and regulations; design of monitoring network - (6 months).

2. IDENTIFICATION OF KEY PROBLEMS

The following are some of the key problems identified as far as the absence of monitoring network in Ethiopia is concerned:

- Lack of laboratory and inadequacy of field test equipment and consumables.
- Inadequate trained manpower
- Absence of baseline data and water quality control regulations.
- Finance.

3. SUPPORTS/REQUIREMENTS

In addition to what has been mentioned as a requirement for the proposed nation-wide water quality survey programme, it is possible to undertake water quality assessment in river basins where pollution problems are much pronounced due to increased anthropogenic activities (e.g. Awash Basin), provided that the assistance with the following items is possible.

- consumables for HACH field test kits.
- BOD/DO meter probes and accessories
- Field test kits for Bacteriological analysis with adequate consumables.

4. PROPOSED ACTIVITIES FOR THE NEXT 12 MONTHS

- Competition of phase - 1 (as a whole) and phase - 2 (partial) of the proposed nation-wide water quality survey programme.
- Identification of sampling stations for the assessment of water quality in the Awash Basin.
- Analysis of basic physical and chemical parameters and bacteriological examination for samples to be collected from the stations which will be identified in the Awash Basin.
- Facilitate background conditions for the introduction of GEMS/Water programme in Ethiopia.
- Strengthening the national capability in establishing the national water quality monitoring network in collaboration with other concerned national and international organization.

GHANA Country Action Plan

Present Situation

Sampling Sites (identified)
- Network of 35 stations

Sampling Sites (existing)
- Network of 26 stations

Range of Analysis
- Physical and chemical parameters comprising Alkalinity, pH, temperature, conductivity, DO, potassium, calcium, sodium, magnesium, iron, chloride, sulphate, nitrate, orthophosphate total hardness, total solids, dissolved solids.

Frequency of Sampling
- Monthly for 18 stations
- Quarterly for entire network of 26 stations (existing)

Reporting
- Quarterly data compilation, analysis and publication

GEMS/Water Programme

Sampling Sites (identified)
Surface Water
- Dalon (White Volta River)
- Daboase (Pra River)
- Weija (Weija Reservoir, Densu River)
- Kpong (Kpong Reservoir, Lower Volta River)
- Barekese (Barekese Reservoir, Ofin River)

Ground Water
- Malejor (Accra Plains)

Sampling Sites (Sampled)
- Dalon (Ghana Water & Sewerage Corp, Inst of Aquatic Biology)
- Daboase (Ghana Water & Sewerage Corp, Water Resources Res. Inst.)
- Weija (Ghana Water & Sewerage Corp, Inst of Aquatic Biology)
- Kpong (Ghana Water & Sewerage Corp, Inst of Aquatic Biology)

Range of Analysis

Contribution by Ghana Water & Sewerage Corp (GWSC) laboratories

Alkalinity, pH, temperature, total coliforms, faecal coliforms, calcium, manganese, iron, chloride, ammonia, nitrate, nitrite, sulphate, silica, total suspended solids, magnesium.

Contribution by IAB/WRRI

Dissolved Oxygen, potassium, COD, Copper, Lead, Zinc, Orthophosphate, total phosphorus, cadmium, conductivity, transparency, fluoride.

Frequency of Sampling

- GWSC; frequency of once a month
- IAB/WRRI: 3 times in a year

* 1st sampling - last week in February (dry season)
* 2nd sampling - middle of July (onset of rains)
* 3rd sampling - last week of September (peak of rains)

Hydrology Data Compilation

- By Hydrology Division of Architectural & Engineering Services Corporation to coincide with sampling times on all stations.

Reporting

- Data compiled by secretariat for 1991. Yet to be sent to Burlington.

Support/Requirements

- Laboratory Equipment for GWSC laboratories to improve sampling range.
- Sampling frequency can be improved if transport facilities and more funds are committed by central government (or from other sources) to the programme.
- Inter-laboratory calibration to be initiated with the availability of transport.
- More copies of GEMS/Water operational guide required for all participating laboratories to standardise analytical methods. (6)
- Reagents needed to investigate BOD variations at different standardised temperatures and also membrane lauryl sulphate broth for faecal coliforms.

Anticipated Outputs Over Next 12 Months

- Data compiled for 1991/92 submitted to Burlington
- sampling sites improved to cover 5 surface water stations and 1 ground water station.
- Quality assurance procedures institutionalised for all participating laboratories. Particularly for WRRI lab in Accra and GWSC lab in Tamale.
- Correlated BOD measurements at different temperatures with standard measurements at 20oC.

HYDROMET'S ACTION PLAN - Nsubuga Senfuma (Senior Analyst)

1.0. INTRODUCTION

Hydromet as an institution joined the Global network i.e. GEMS/Water programme in 1977. The laboratory was earmarked for the regional collaborating centre. The Civil Strife in Uganda between 1980 - 1986, destroyed all the infrastructure of the laboratory. In 1990, the laboratory was finally rehabilitated and it has once more revived its Water Quality Monitoring activities.

2.0. PRESENT SITUATION

Of the original 15 water quality sampling stations in the Project area, 8 have been identified to actively participate in GEMS/Water Programme immediately. The eight are distributed as follows:-

4 stations are in Uganda
2 stations are in Tanzania
2 stations are in Kenya

The important feature of these stations is that they are all on Lake Victoria and 8mg one on River Nile. They represent, Impact, Baseline and trend stations.

3.0. PARAMETERS TO BE ANALYSED

All the basic GEMS/Water parameters are going to be analysed.

4.0. CONSTRAINTS AND SUPPORT REQUIREMENTS

The main objectives of selecting monitoring stations on Lake Victoria is that the Lake is becoming eutrophic, has been invaded by water hyacinth, and there is danger that the Lake may be polluted from the now active towns of Kampala, Kisumu and Mwanza Industries. The monitoring programme would have included:-

(i) Chlorophyll a measurement
(ii) Phosphorous and nitrogen fractions measurements.
(iii) Productivity in the Lake in particular in the Bays of Kisumu,Mwanza and Kampala.

But due to lack of primary production kit, the geiger muller conter and the labelled carbon (14) solution productivity in the Lake cannot be effected. In addition the following items are required to support monitoring a programmes in different displines. They are:

(i) Separating funnel glassware for chlorophyll extraction.
(ii) Efficient water still to cope up with increased demand for distilled water.
(iii) Drel 2000 Hach model kit to enable analysis be carried faster in remote parts, where laboratory facilities cannot be reached quickly.
(iv) Occasional replacement of laboratory consumable like chemicals distilling equipment, membrane filters.
(v) Combined oxygen and temperature probe to work in very deep waters.
(vi) Boat, possibly filled with basic research guggets.

5.0. TRAINING NEEDS

Since Hydromet Laboratory is recovering and is slowly building up its Water Quality Monitoring capacity, support will be needed from a Water Quality expert to carry out training on the job for the more specialised analysis like primary production and in identification of dominant species in the endangered Lake Victoria bays. This training can last two to three weeks.

6.0. ANTICIPATED OUT PUT

The laboratory expects to consolidate its activities on the water quality monitoring of the identified eight stations for the next 12 months we do not anticipate major break through until support for the lacking requirement is given.

It is also further planned to initiate AQC within the Hydromet Laboratory and also with the National Laboratory of Uganda.

ACTION PLAN
(DRAFT)

REPUBLIC OF KENYA
MINISTRY OF WATER DEVELOPMENT
NATIONAL WATER QUALITY MONITORING NETWORK -
GEMS/WATER NETWORK

Geographical location:	Kenya
Title of programme	National Water Quality Monirogirng Programme incorporating Global Environmental Monitoring Systems (GEMS/WATER)
Implementing Institution:	Ministry of Water Development
Status:	On-going programme
Programme Funding:	Government of Kenya
Programme Status:	1982 to present

Statement

This is a countrywide national water quality monitoring network covering 107 stations. Eleven (11) of these are GEMS/Water stations. The network stations are distributed in the five (5) water catchment basins in the country. The GEMS/Water stations are distributed in four (4) catchment basins Viz: 5 stations in the Lake Victoria basin, a basin shared by other countries; 3 stations in the Athi River basin, 2 stations in Tana River basin and 1 in Rift-Valley basin.

Samples are collected from each station 4 times a year viz: hot dry season (February/March); wet season (March/April); cold dry season (June/July) and moderately wet season (October/November).

All the samples are shipped to the central water testing laboratory in Nairobi for analysis except for pH, Conductivity, temperature, dissolved oxygen and feacal coliforms. In addition to the other twenty GEMS/Water variables the samples are analysed for ten or so other parameters.

Reports

National Water quality reports are compiled periodically. the reports are used to assess the extent and trend of water quality degradation Vis-a-vis development activities in any one region. They also form basis for siting and or re-location of developments with negative environmental impact.

GEMS/Water quality data are complied and forwarded to the WHO representative in the Ministry for onward transmission to Canada.

Data Storage

The data generated are stored in raw form in files and subsequently transfered into registers. The ministry is currently in the process of computerising its operations and during this exercise we hope to computerise the water quality data for ease of reference, processing and retrieval.

Costing

The total programme operating cost has averaged at US$ 45,000 per annum. Out of this GEMS/Water component consumes approximately 10% ie US$4,500. The apparent low GEMS/Water operating cost is achieved through economics of scale.

Constraints

While this is not an ambitious programme, the programmes implementation and operation have been constrained by:-

1) Institutional and logistical exigencies
2) Financial limitation
3) Laboratory facilities
4) Equipment and to a lesser extent
5) Staff training

In the intervening 10 years and due to the above cited factors among others, it has not been possible to consistently implement the two programmes. invariably, it has not been possible to replace/maintain some of the very old equipment or acquire new ones. This has resulted in inconsistent reporting particularly in GEMS/Water where accuracy, consistency and comparability of data are a priority.

Action Plan

To reactivate and improve the programme the following actions are envisaged.

1) Relocate 5 national water quality monitoring stations to more accessible sites.
2) Relocate stations which are not located at hydrological stations (RGS) to coincide with the nearest RGS. (note: these are apparent from the country report).
3) Re-organise operational strategies (note: this started in January 1992)

To accomplish the whole task of reactivation, the following analytical requirements are necessary:-

1) field water testing kits for bacteriological analysis and a full range of physico-chemical parameters including fluoride (two would supplement the one we have)

2) UV-Visible spectrophotometer for specialised range of parameters such as phosphates.

3) dissolved oxygen meters - three.

4) Assorted accessories and sundries - we can acquire these through local funding.

Anticipated Output

Using the resources we already have subsidised with assistance from GEMS, we anticipate to accomplish the following:

1) sampling of all the stations as per programme
2) field analysis
3) Shipping of samples to the central water laboratory for complete analysis as per programme
4) Compilation of data and submission of the reports to the WHO representative for onward transmission to GEMS headquarters.
5) Re-appraisal of our activities

NB: All water quality data acquired will be processed and harmonised with the existing data for use in water resources management and national development activities.

NIGERIA Proposed Country Work Plan

1.0 Present Situation

At present Nigeria's GEMS/Water programme is at the preparation stage. A national technical committee has been established and has a responsibility for planning issues. This is composed of the following:

a) Federal Environmental Protection Agency (FEPA) - Chairman
b) National Institute for Freshwater Fisheries Research
c) Federal Ministry of Agriculture, Water Resources and Rural Development.
d) Federal Ministry of Health and Human Services
e) World Health Organization (Nigeria Representative)
f) Nigerian Institute of Oceanography and Marine Research
g) Federal department of Meteorology
h) Chad Basin Development Authority

2.0 Sampling Sites

12 sampling sites have been proposed and distributed as follows:

Baseline stations : 2 International Rivers
Trend stations : 2 Ground water, 6 Rivers
Global Flux stations : 2 Rivers

Each of the twelve stations have been assigned to agencies in whose jurisdiction the sampling stations are located. These stations will be sampled monthly for GEMS/WATER basic parameters (except for flux stations which include hydrometric data) and reports sent to FEPA, the coordinating agency from where such reports will be transmitted to the Nigerian WHO office and Burlington. FEPA will sample for use-related parameters, twice a year (one dry season, and one rainy season). FEPA will also be responsible for QC and QA.

3.0 Identification of Key problems

Although the GEMS/Water programme has not taken off, anticipated problems include:

a) standardisation of equipment
b) training of personnel
c) logistics

4.0 Support/Requirements

At the moment, there is no agency undertaking a monitoring programme worthy of reporting to GEMS/Water. The programme will therefore, as a necessity, require extra-budgetary allocation to cover:

a) equipment procurement & consumables (supplementary field equipment - mainly)
b) a national training workshop for at least 24 participants
c) a four-wheel drive for activity coordination and QC/QA.
d) computer and appropriate software

5.0 Anticipated outputs over next 12 months

Since GEMS/Water is yet to take-off it is difficult to anticipate outputs. However, it is expected that within 12 months of take-off, all things being equal, basic data on a monthly basis should be available from all the 12 stations. In addition, a seasonal use-related data generated by FEPA should be available.

RWANDA COUNTRY WORK PLAN

INTRODUCTION

That presented here, are the observations of the author and they do not engage anyone else.

(a) Present Situation Regarding Water System in Rwanda

As I had already stated in my Country Report, in Rwanda, we have several different departments dealing with water. We have:-

1. Hydrological Department, under the Ministry of Public works.
2. Water Supply Department, an independent organization,
3. Hydromet Survey Project which is under the Ministry of Transports and Communications.

- To my knowledge, the Hydrological Department is only concerned with water quantity not water quality, making discharge measurements and water levels only. So no Water Quality Monitoring activities have ever been carried out by this department.

- Water Supply Department, which is dealing with water purification for public consumption, does not necessarily mean that it is carrying out Water Quality Monitoring.

What I know, they have machinery for removing suspended particles from the water and use ready made chemicals bought from outside to eleminate bacterial organisms found in the water.

- Hydrodmet Survey Project, whose role is self explanatory, it deals only with water quantity data collection in the Upper Nil Basin. And the data collected is sent to Hydromet Headquarters for analysis.

(b) Identification of Key problems:

GEMS-WATER is not well known in the country, and if there are some people who have known it before, they are few. And these few people if any, have shown no interest at all or they have been turned down.
As a result, no equipment for Water Quality Monitoring have ever been thought of.

(c) Support - Requirements:

As I had already stated that GEMS-WATER is not well known in the country, I would like to ask the Authorities of the GEMS-WATER, WHO, WMO, UNEP, HYDROMET and other International Organizations concerned with the Environmental Problems, to visit Rwanda and inlight the country's Authorities about the GEMS-WATER activities.

Other things I would like to ask these organizations are:-

- To support the country, by setting up a Water Quality Monitoring Laboratory to be an example so that others may follow progressively. Whether it be on a loan basis or a gift, all means are very highly appreciated.

- To train the personnel, to the standard of ability to carry out all the activities of Water Quality Monitoring.

(d) Anticipated outputs over the next 12 months:-

In this respect, what I would say; when I go back home, I am going to present a written report to my Minister and then approach all the authorities of the water departments. Discuss with tham. The remarks of the Minister to my report and the investigations from the water departments, will be communicated to GEMS-WATER in the nearest future either through WHO Office in Kigali or through other means.

Participant from Rwanda to GEMS-WATER Training Course on Water Quality Monitoring and Assessment.

1.0 SUDAN PLAN OF ACTION

Water resources in Sudan are generally free of man made pollution. However to preserve this natural condition. The following actions have to be taken:-

i) Enhance awareness of the public, the state and the different agencies of the dangers of pollution.
ii) Promote cooperation between the different agencies responsible for Water use.
iii) Increase of the country's ability to monitor, interprate and manage its water quality.

2.0. GEMS Programme

There are two GEMS Stations namely:-

Blue Nile at Khartoum; and White Nile at Gebel Awlia which currently operate and send data to GEMS regularly. In addition to the above stations the other two non-operating GEMS stations namely: Main Nile at Dongola; and Arbaat groundwater at Port Sudan could be operated if the items required under 5 and 6 below are met.

3.0. ANALYSIS

The analysis undertaken for the operating GEMS Station includes: Temp, pH, Calcium, chloride, nitrate, phosphorus, Discharge, Magnesium, Sulphate, Nitrite, BOD, Conductivity, Sodium, Alkalinity, Ammonia, Suspended solids, Dissolved Oxygen, Potassium, Arsenic, Fluoride, Total solids.

For the non-operating stations the following analysis is proposed: Temperature, pH, Conductivity, Dissolved Oxygen, Alkalinity, Nitrate, Ammonia, Discharge, E.Coli.

4.0. FREQUENCY

Once every month for all stations.

5.0. KEY ITEMS REQUIRED

1 - Fluoride electrode reference electrode (for Al, A2, Cl)
2 - Dissolved Oxygen meter (portable)
2 - pH meters
2 - Conductivity meter
2 - APNA methods of water analysis
2 - Kit for ammonia
2 - Kit for Nitrate
1 - Kit for Fluoride
1 - Kit for Sulphate
1 - Iron
1 - Calcium
1 - Phosphorus
2 - E. Coli
2 - Sets of sampling and sample transport equipment.

6.0. PROBLEMS

- Lack of equipments
- Reagents
- Transport means

7.0. ANTICIPATED SITUATION

1. Total of 4 GEMS Stations will be operating within 12 months.
2. Main responsible body will be the NCL with cooperation from the Ministry of Irrigation, the National Urban Water Corporation and the National Rural Water Corporation.

TANZANIA
COUNTRY WATER QUALITY MONITORING NETWORK AND ACTION PLANS FOR NEXT TWELVE MONTHS

1.0 INTRODUCTION

The execution of a well planned water quality monitoring programme in Tanzania started in 1971 when the country committed itself to implement a 20 year water supply Programme which aimed at providing every Tanzania with a source of adequate clean and safe water by 1991. Newly developed water sources had and are being monitored to ensure that the water provided to the people is safe and remains safe when used domestically. In addition to monitoring the quality of newly constructed water schemes, existing water schemes were also being monitored to ensure the quality of water from those water schemes.

It was in the late seventies that the GEMS/WATER project was introduced to Tanzania by the W.H.O. Following the Tanzania Government acceptance to execute the programme, W.H.O. and the Ministry responsible for water affairs recommended possible GEMS/Water stations. Tanzania started monitoring some of the recommended station in 1980. This activity has since been going on till to-day.

2.0 CURRENT STATUS OF WATER QUALITY MONITORING PROGRAMME INCLUDING GEMS/WATER PROJECT

The national water quality monitoring programme is simultaneously being executed with the GEMS/Water project. This is done due to convenience and the available national meagre resources for the purposes.

2.1. National Programme

Despite the unhealthy economy of the country, Tanzania has made an effort to initiate, expand and implement water quality monitoring activities. Of the twenty regions 14 have already been provided with either fully fledged regional water laboratories or basic water laboratories.

The national water quality monitoring programme involves:-

a Regular water quality monitoring, as required by national water quality standards, of all water supply schemes serving the regional and district headquarters.

b Regular monitoring of the quality of water schemes serving many villages. There are in Tanzania some big projects which serve up to more than 60 villages per schemes.

c Regular monitoring of water bodies receiving industrial and domestic waste water-.

d Regular visits to water treatment plants, to check their performance.

e Regular monitoring of potential water sources, such as rivers, lakes, etc.

2.2. GEMS/WATER PROJECT

At the start of the GEMS/Water in 1980 the following stations were selected:-

(a) Ruvu River (Mlandizi)
(b) Makutopora Boreholes (Dodoma)
(c) Lake Victoria (Mwanza South Port)
(d) Kagera River (Nyakanyasi)
(e) Rufiji River (Stieglers Gorge)
(f) Bukerebe Island (Lake Victoria)

The GEMS/Water project has since its introduction been integrated into the existing water quality monitoring network.

Likewise, it is not easy to reach Bukerebe island unless one has a big boat with a motor as the station is in an island which is inside Lake Victoria.

Financial Constraints
The GEMS/Water project does not have funds allocated for its operation. That being the case, its operational costs have been integrated into the activities of the national water quality monitoring programme. Due to meagre financial resources allocated to the national water quality monitoring programme, we are sometimes forced to reduce the frequency of sampling to the GEMS water stations. To illustrate this point see Appendix 1.

Lack of Equipment
In monitoring the GEMS/Water stations, it has been planned that the stations be monitored by the nearest regional water quality laboratory. Where the regional laboratory does not have enough equipment, the analysis is carried out by the Central Water Quality Laboratory in Ubungo Dar es Salaam.

No.	Name of station	Regional Water Laboratory carrying out analysis	Approximate Distance from laboratory
1.	Makutupora Borehole (Dodoma)	Central water Quality Laboratory in D'Salaam	500km from CWQL
2.	Mlandizi (Ruvu River)	Central Water Quality Laboratory in D'Salaam	100 km from CWQL
3.	Mwanza (Lake Victoria) South Port	Mwanza Regional Water Quality Laboratory and C.W.Q.C.	1000km from CWQL
4.	Sakina (Arusha town) Borehole	Arusha (Mini-Lab.) and Central Water Quality Laboratory in D'Salaam	700km from CWQL
7.	Maji ya Chai (Arusha) River	Arusha (Mini-Lab.) C.W.Q.L.	700km from CWQL

Note: C.W.Q.L. = Central Water Quality Laboratory in Dar es Salaam.

From the table above it is obvious that if the regional water quality laboratory is unable to carry out most of the required analysis due to lack of equipment, among others, the water samples would have to be sent to the Central water quality laboratory in Dar es Salaam. However due to the large distances involved, the project could best be served if the missing equipment are provided. For the missing equipment. See Appendix 2.

6.0. FUTURE PLANS

In order to improve the performance of the GEMS/Water Programme, it is intended to do the following:-

(i) Strengthen the water quality monitoring of the existing station GEMS/Water).
(ii) To establish three more stations.

7.0 STRENGTHENING THE MONITORING OF EXISTING GEMS/WATER STATIONS

- Within the existing national water quality monitoring programme, efforts will be made to continue to monitor the GEMS water stations.
- GEMS/Water and donors will be approached to request them to assist in purchase of equipments and

chemicals. Such a step is necessary as the purchase required foreign exchange which is not easily available in the country.

- GEMS/Water will be approached and requested to send us AQC samples. This will greatly help the regional water laboratories in checking their results.
- Transport is a major bottleneck, however, realizing that GEMS/Water may not have the funds, a request for a four wheel drive specifically for GEMS/Water will be made to donors and N.G.O's.
- Efforts will be made to solicit for funds from the government and external sources to enable us to conduct a one week training on GEMS/Water activities.

8.0. ESTABLISHING THREE MORE STATIONS

Despite the various constraints which we have, we intend to establish three more stations. Two of the stations can easily be operated as it is proposed that they be established near regional water laboratories which have most of the equipments required to analyse the gems/Water parameters:-

(i) It is intend to establish a lake station at Kigoma within Lake Tanganyika where we do not have any GEMS/Water station despite the fact that the lake is shared between four countries.

The station will be monitored by the Kigoma Regional Water quality laboratory which is capable of monitoring most of the GEMS/Water parameters.

(ii) It is also intended to establish a station at Kyela in Lake Nyasa. This station will be sampled and analyzed by the Regional Water Laboratory in Mbeya which is also capable of analysing most of the parameters.

(iii) As requested by GEMS/Water it is intended to establish a station at the mouth of Rufiji River, however, due to in accessibility we anticipate irregular water quality monitoring of the station. Thenearest laboratory for this station is the Central Water Quality Laboratory in Ubungo, Dar es Salaam.

UGANDA - Country Work Plan

Present Situation

Twenty four water quality monitoring stations had been established before the demise of the Monitoring activities in Mid 80's. Four of these stations have been identified for immediate monitoring. These are:

Pakwach (Nile)
Kiggingi (lake Kyoga)
Butuaba (Lake Albert)
Ground water Station (Within Victoria Sub Catchment)

These stations have recently been sampled but the data sought was for National purposes. No reports have been made to the National WHO office or Burlington since 1980.

Key Problems

The difficulty in re-starting monitoring has been due to:

1) lack of chemicals and inadequate equipment
2) Transport and other logistical problems for regular sampling especially for far off stations.
3) Poor staffing.

Support Requirements

1) Sampling gear - deep water samples, sediment samples
2) Instruments - Paqualab 50 or equivalent kit with chemicals and powdered nutrients for about 100 tests.
3) Assorted glassware: Beakers (250 ml) Erlenmeyer flasks (250 mls) Sedimentation cones, separating funnels (100 ml)
4) Water still (Glass)
5) Adaptor (input 240 v, 60 Hz; Output 7.5 v DC)
6) Literature - publications and report on current monitoring work being undertaken else where.
7) Vacuum Pump, sample holder with 100 filter paper (GF/o)
8) Distillation Set (with Condenser and collector)
9) Samples for AQC programme

Anticipated output

The four identified sites to be sampled twice a year. All the basic parameters except for ammonia, reactive silica, phosphorous (total) and chlorophyll a will be analysed.

Identification of two more stations for monitoring W.E.F next year (1993).

Work out and institute on AQC and QA Programme for the Central Laboratory.
Close collaboration with Hydrology and Hydrogeological sections.

ANNEX 6

RECOMMENDATIONS FOR REVISION OF THE MANUAL ON WATER QUALITY MONITORING

OVERALL HANDBOOK REVIEW

Recommendations Regarding Structure and Order

(a) Preface should be retitled Introduction.

(b) Chapter 1, Introduction restructured to include some sections of chapter 2 and to constitute the following:- Section 1.1 - 2.6 of the Hand Book. Suggested new title is "GENERAL CONSIDERATIONS"

(c) (i) "Chapter 2 will consist of 2.7 - 2.9, while the old title is retained. However, it is considered desirable that the chapter be rewritten to present a general over-view of this subject. Issues to be addressed should include:-

- Objective
- Design
- Monitoring
- Data Handling
- Interpretation

(ii) A section which contains water quality standards and use in Water Quality Management should be included.

(e) Suggested chronology up to chapter 5

Contents:
Foreword:
Introduction:
Chapter 1: General considerations
Chapter 2: Water Quality Assessment
Chapter 3: Design of a Monitoring Programme

(iii) A new section to follow present chapter 3 is suggested i.e. chapter 4 retains present title, but a new outline of the content is reconstituted to reflect the title as follows:-

Chapter 4: Running a Monitoring Programme
Content:
(i) Staff (Training, Responsibility, Organization
(ii) Laboratory design and infrastructure
(iii) Laboratory Preparation for the field
(iv) Requirements for field work (clothing, safety items etc)
(v) Transport
(vi) Check list
(vii) Sample port (i.e. sample Receipt Bay)
(viii) Check list
(ix) Inter Institutional departmental collaboration (supporting data information
(x) New chapter 4 to contain the following illustrations
- check list
- flow charts
(xi) Present chapter 4 becomes chapter 5 with the title: "SAMPLING"

Chapter 5: Sampling

d) Chapter 3: Section 3.1 and 3.2 to be interchanged chronogically.

e) Chapter 4: Running a Monitoring Programme should also include the following in appropriate sections:-

- Recording
- Storing
- Archiving
- Forms Design

- Field Books
- Laboratory Books

f) Chapter 5: Title: Sampling

Content:

5.1. Introduction
5.2. Water Samplers
5.2.1. Dissolved Oxygen Sampler
5.2.2. Depth Sampler
5.2.3. Multipurpose sampler
5.3. Types of samples
5.3.1. Surface water samples
5.3.2. Groundwater samples
5.4. Guidelines for sampling
5.5. Preparation,transportation and storage of samples
5.5.1. Samples for chemical and physical analysis.
5.5.2. Samples for microbiological analysis.

g) For chapter 6 & Chapter 7 the following changes were recommended:-

Present	Recommended change
5.1. General	6.1. Introduction
6.1. General	7.1. Introduction

Observation	Recommendation
(i) Chapter 6	(i) Chapter 7
(ii) Old 6.1. General	(ii) New 7.1. Introduction
(iii) Some useful parameters omitted in chapter 6	(iii) Chapter 7 to include (a) BOD (b) Organic Carbon (c) Organic Nitrogen (d) Al (e) Fe (f) Mn (g) B (h) Se
(v) (old) Chapter 7 Title not to include in GEMS/WATER	(v) New chapter 8: Microbiological analyses.
(vi) Old 7.1. - General	(vi) New 8.1 - Introduction
(vii) Page 168 misplaced	(vii) Page 168 to go to Appendix and key characteristics of microbiological equipment included on the list to be described.
(viii) Table of Random Numbers omitted	(viii) Table of Random Number to be included in the appendix.
(ix) All chapter contain-Titles and headlines with ununiform fonts	(ix) Uniform fonts to be used for headlines and titles through the text.
(x) Not all figures	(x) All figures to be number appropriately.

are numbered.

(xi) Old chapter 9.1 - General	(xi) New chapter 9.1. - Introduction
(xii) Old chapter 10 sediment not related to water	(xii) New chapter 11 - Write up on sediment and bed load to be related to water quality.
(xiii) New chapter 5 does not have adequate illustration on Microbiological sampling.	(xiii) New 5.4 to contain illustration on Microbiological sampling technique.
(xiv) Audience to which text is addressed not clear.	(xiv) Preface should include audience to which book is addressed; limitation of book should be highlighted.
(xv) Old chapter 10	(xv) New chapter 11
(xvi) Old chapter 10.1 - General	(xvi) New chapter 11.1 - Introduction
(xvii) Lack of reference to GEMS/ Water data reporting format	(iii) Chapter 11 to contain a brief intoduction to GEMS/ Water reporting system and samples of relevant data form to be included in the Appendix
(xviii) Old chapter 10 does not treat statistics sufficiently	(xviii) Appendix with brief explanation of some statistical measures such as mean, standard deviation, confidence limits, confidence interval, statistical tables tables etc. to be included.
(xix) General: a) No reference to some figures in the text.	(xix) a) Figures should be discussed in the text
b) Foot notes to figures are written on top of some figures e.g page 64, 153, 164.	b) Foot notes preferred at the bottom of figures.
c) Page 197, velocity determination not mathematically expressed.	c) Va = (Vo.2d Vo.8d) Va = Average Velocity Vo.2d = Velocity at depth 0.2d Vo.8d = Velocity at depth 0.8d
(xx) Old chapter 11	(xx) New chapter 12: Present outline unsuitable since issues concerning use of monitoring data is not adequately addressed. Therefore, - New Title: Use of Water Quality Monitoring Data - Issues to be addressed include use of data as it relates to: - Information on present status - Impact Assessment - Trends - Pollution Abatement and Remdiation - Regulations and Legislation - Resource Management

Other Recommendations

Missing Sections:

Acknowledgement of Authors
Acknowledgement of Reviewers
- An index to be included

References: References were considered desirable to be included. However, if that is not in agreement with the objectives of the sponsor, a list of books recommended for further reading should be included at the end of each chapter.

CHAPTER BY CHAPTER REVIEW.

CHAPTER 1

1.1 General Considerations

Participants recommended the alteration of the following in the first paragraph;

a)

i The word 'vegetable' in paragraph one to "vegetation".

ii The first sentence also talks about surface and 'underground' water. It should be surface and 'ground-waters'.

iii Revising the arrangement of the natural features to: Geological formation, topographical, meteorological, hydrological and biological. The biological to comprise humans and other animals and vegetation. Geological formation - minerals & other rock formations.

iv The sentence with, "more obvious" and "perhaps" could do without the word "perhaps". (last sentence of paragraph one).

In paragraph two the word 'approximately' does not truly depict the seriousness of the context and should be omitted.

Regarding table 1.1 - Water Quality Monitoring Within a Water Quality Management System. Members failed to understand it and requested a simplified and more elaborate version of the table.

1.2 TROPICAL WATERS

In the sub-paragraph on Swamps, more water is usually lost by evapotranspiration and not only evaporation as earlier stated.

1.2.1 RIVERS

All the paragraphs of this sub-section were accepted by the participants except the second last paragraph which talks of the variation of erosion by some influences. ' Amount of rainfall' should be "amount and pattern of rainfall".

1.2.2 LAKES

A number of complaints were raised about this subsection:

a) Paragraph one is unclear and requires some revision for the readers/users to understand the implication of the text.

b) Participants would like examples of the following lakes, which are classified according to seasonal temperature variation to be included.
- High Altitude Lakes in East Africa
- River lakes
- Solar lakes
- Temporary lakes

c) The issue of stratification is contradictory with the text as presented earlier.

1.2.3 GROUND WATER

This section posed many questions because three-quarters of the subsection was not understood by the participants. The first three paragraphs require re-writing.

a) Paragraph One

- second sentence is not technically or scientifically elaborative. The sentence is not clear.

- The terms 'underground strata' is not correctly used.

- The last sentence about water quality reflecting changes in rain water quality is not clear. More explanation is required.

- "Replenish an aquifer" according to the participants should be 'recharge an aquifer'

b) Paragraph Two

"Underground strata" is not the proper scientific or technical terms. (It does not fit with crystalline rocks). The whole paragraph needs rewriting.

c) Paragraph Three

Needs rewriting, with much more emphasis on how sedimentary rocks are invariably large and sometimes artesian.

1.3 WATER QUALITY

a) Paragraph one on tropical Africa needs revision and examples of areas where high concentrations of potassium and calcium are found (briefly).

b) The Rift Valley lakes being talked of in paragraph three, are mixed with the non-Rift Valley lakes. There is the need to separate the two in order to understand the differences. Also a definition of percentage salinity is required since users/readers may not be familiar with the presentation.

c) Last paragraph, Needs rewriting.

Members would like to know why the comparison between tropical and temperate zones was included.

CHAPTER 2 - WATER QUALITY ASSESSMENT

General criticism:

(i) Theme of chapter not focussed

(ii) Audience for which book is written is not clear.

(iii) Text is not easy to follow.

(iv) Chapter requires re-structuring so that text can flow in a logical sequence.

(i) Figures not clearly produced.

Recommendations

(i) Sections 2.1 - 2.6 should be presented in Chapter 1 since these sections contain general information which are introductory in nature. However these sections should be merged in a coherent manner. A new title for Chapter 1 should therefore be considered to afford an accurate reflection of the new content.

(ii) Chapter 2 which is "Water Quality Assessment" should now contain sections 2.7 - 2.9. However, the content should present an overview of this subject. Issues to be addressed should include:-
- Objective
- Design
- Monitoring
- Data Handling and Processing
- Interpretation

(iii) A section which contains standards and their use in Water Quality Management should be included.

(iv) The section when written should be easy to read highlighting major concepts and avoiding muddling of issues. For example it is not easy to understand some sections without frequently referring to previous sections.

CHAPTER 3 - DESIGN OF A MONITORING PROGRAMME

3.1. Description of the Monitoring Area.

There are internal water bodies which do not discharge into the sea. What can said about them since they form part of the water course system. Not all the falling precipitation ultimately reaches the water course. (comment; Re-phrasing of sentence).

Fig. 3.1; For better understanding ideally requires colouring - A description of the catchment area includes its size not area.

Environmental conditions like vegetation land formation in the text should include human activities after "water bodies".

As a last resort, runoff can be estimated.......... This sentence is redundant and the whole paragraph needs rephrasing with better clearer English. Sentence correction: Municipalities or industries are considered point sources and their importance is dependent on population, size and type of industry. "Pollution from point sources are usually transported"....not contained.

Examples of water uses - TITLE Table 3.1 "COMMON" WATER USES "COMMON" IS OMITTED. Recreation and commercial fishery are contaminating. Other industries should be omitted.

3.2. Objectives of water quality monitoring .....source protection or treatment can be applied.

3.3. Selecting sampling station
Sampling either upstream - downstream water quality changes downstream of rapids.

Table 3.3 requires revision and addition of a column for width and depth of the river where samples are taken. Selection of sites should be made after preliminary investigation. (Additional line to paragraph 2 of 3.3.2.)

Suggestion: Difference between the bottom and upper temperatures determine the presence of a thermocline the position of which can then be investigated if detected.

3.3.3. "Water quality can......" should read.
The quality of ground water depends primarily on the chemical and physical composition of the aquifer. Pollution of the surface (unsaturated) layers may also be significant (e.g. with nitrates). Rain water quality in the catchment area may occasionally also have an effect.

"Poorly constructed wells..." The underlined has no precise meaning and requires explanation. A figure may be helpful.

- Drawdown of the water table is more technical than "amount by which the static water level is depressed.."

- Deteriorate the water quality but not the word change.
Table 3.4: Definitions of baseline and trend stations should not be in the table and should be moved, preferably the last paragraph of subsection 3.4.

3.5. "As a first step in monitoring sample collection should be frequent enough to be able......"

- Annex 1 is not included and Global Flux Stations.
- Example a should be separated.
- E.g. 3 sampling sites not stations and the sites for e.g. 6 16, 6 and 18 are required i.e.why not other tributaries.
- Rephrase key question to state negative effect (e.g. 7).
- Key Question; Monitoring Information Expectations don't favour the objectives and the laboratory analysis paragraph need rephrasing (3.7.1.). One of the factors affecting analytical accuracy is quality of reagents and chemicals. Additional explanation in the Annex of the Youden is needed because it is not known to participants.

- Page 37. Paragraph 3 line 4 "As a last resort.......than estimates" is a redundant sentence.

- Page 39 1st paragraph line 7 "protection or treatment can be applied" or treatment is proposed to be added.

- Page 39 paragraph 4 line 3 "to be monitored" be is missing.

- Page 39 paragraph 4 line 5 "second question might be:" and not should be.

- Page 45 paragraph 1: the whole paragraph has to re-phrased as it is unclear

- Page 46 paragraph 2: first comma after management to be omitted; classed to be classified as consuming; "either" to be removed and "or both" should be added after "contaminating".

- Page 47: Table 3.4., the determination of baseline and trend stations should be removed from the table and placed on page 46 after the 2nd paragraph.

- Page 48: Table 3.5 "Baseline and Trend" should be added is the title of the table after "GEMS/WATER".

- Page 50 line 9 from top, 'sampling sites' inplace of 'sampling stations'.

- Page 52 line 4 from the bottom "Quality control" should be "Quality assurance".

- Page 53 paragraph 3 line 3 "a quality assessment programme" and not "assurance programme.

CHAPTER 4: RUNNING A MONITORING PROGRAMME

- Information like:
  - o brief summary of weather conditions
  - o record of any stabilizing preservative treatment
  - o remarks and observations concerning any unusual conditions.
  - o results of any measurements mode in the field.

Should be included in other forms, for instance, water quality forms, sanitary forms (sanitation) or note books etc. This is as far as samples for chemical and physical analyses is concerned (4.5.1.).

Also under the same heading the following information, after autoclaving, could be included in the other forms or note books.

- o brief summary of weather conditions.
- o record of any stabilising preservative treatment
- o remarks and observations concerning any unusual conditions.

One carries out a microbiological test or examination and not analysis.

CHAPTER 5: PHYSICAL AND CHEMICAL ANALYSIS IN THE FIELD

1. The last sentence of paragraph six subsection 5.1 has a redundant portion. The sentence should end after the word "conditions" and tropical condition should be changed to field conditions.

2. The list of the four manufacturers are best included in the annex and many more should be added to give the users a variety from which to choose.

   Table 5.1. has been recommended for the annex. Arrangement should also be made for measuring deepwells and geothermal water and in particular for temperature measurements. The procedures for these measurement should also be included.

3. 5.4. pH
   Ref larger sophisticated models of potable meters. The following sentence should be added "care should be taken when handling such equipment".

4. 5.4. - pH
   Apparatus and reagents.
   The first sentence requires rephrasing and a variety of standard discs should be included, preferably in the annex.

   The word "distilled" is missing in the paragraph of - pH using pH meter.

   It should also be noted that "some meters have automatic temperature probes.

   5.6. Dissolved Oxygen
   Winkler method; The volume of Vt is in millilitres (ml). That is in the equation given (Number 7 of the procedure).

   First paragraph of electrometric procedure the added reagent is sodium sulphite (Na SO) and not sodium sulphate (Na SO) (i.e. the last sentence of that paragraph).

CHAPTER 8 - PROPOSALS AND AMENDMENTS

Introduction

The last sentence of paragraph four ie, "A common problem with all environmental information is over simplified interpretation by the non-expert", requires further clarification.

Phytoplankton primary production - chlorophylla Procedure number 1. The last portion of the first station should be changed as follows; ie. instead of concentrate the water sample by filtration it should read "concentrate the algeal cells in the water sample".

Community Structure Monitoring

First sentence of paragraph three, the phrase ".... group of organisms" is best represented as "community". And there should be more clarification on the diversity indices for a better understanding.

Key headings nice and

1) Habitat characteristics
2) Sampling theory and planning etc.

Should be given precise numbering since they consider different things with little or no relationship to each other.

Example, 8.2.3 for Habitat characteristics. In equation for degree of precision;

Mean Abundance squared not x squared. Also in the equation for diversity index DI, mean diversity index DI should read as follows;

$$DI, = \frac{DI}{N} \text{ not just } DI = \frac{DI}{N}$$

CHAPTER 9: HYDROLOGICAL AND SEDIMENT MEASURES

AMENDMENTS AND SUGGESTIONS

<u>Rivers</u>

"Rate of discharge", in the last portion of the first line should read, "rate of flow", ie in paragraph one.

The first half of the second line, the word "only" needs erasing as it can confuse the reader. Still on the same paragraph, the last VKXd,KD (last portion) after the word table the following should be included in brackets. (Rate curve on table).

Paragraph 3

A suggestion was made to replace the whole paragraph as it could not be understood clearly, "some rating curves at certain hydrometric gauging stations (characterised by a loop) at a certain stage, the discharge is of two different values depending on whether the stage is increasing or decreasing. For a constant cross+section of a river or stream the discharge is directly proportional to the velocity of flow. So the increasing or rising stage is the water levels before the peak of flow (that can be determined from hydrograph) and the decreasing or falling stage is water levels after the peak. In such cases it is necessary to define whether the sample is taken before the peak (at the rising slope) or after the peak (at the falling stage) in order to determine which section of the loop is the correct one.

9.1.4 <u>Lakes</u> <u>and</u> <u>Reservoirs</u>

- sampling from a lake or reservoir

The last paragraph, the second sentence should be replaced by the following sentence; "normally water quality samples should be taken either at the outflow of the dam or sufficiently far down stream of the dam to avoid turbulence, sediment resuspension and anoxia that can occur below the dam.

9.1.5 Mass flow computation should read, Mass Flux computation and any word "flow" related to mass or instantaneous mass in this particular section should be changed to "flux". Instantaneous Mass Flux Equation has been expressed without a constant and it only refers to calculation for one sample. In this context another more comprehensive formula which can be used for more than one sample is required and this should be indicated that for small streams the units one in grams/second (glsec) and for rivers (big) or water bodies the units are in tons/year.

The sub-section should also be revised to clarify the significance of hydrological measurements in a water quality point of view. For example,

- The discharge dependent and independent parameters
- Confidence in calculations undertaken
- Interpolation of concentrations values from the table and this actually has nothing to do with mass flux.

9.2 Sediment Measurements

9.2.3 Sedimentation in reservoirs, the whole subsection is unclean, further clarification is needed. The equation and last line of the paragraph should be cancelled as it does not convey a concrete meaning to the reader.

Sections (sub sections 9.2.5)

The three samplers mentioned and described have been tried for years without success, so there is no point in including their description.

9.2.6 the description of the various samplers do not really explain what the samplers are and are never identified. The text does not even talk about "wash load" which is the most important part of suspended solids/load and is also practically related to water quality.

In summary, the whole sedimentation section needs consideration in relation to water quality ie. both in practical and theoretical aspects, particularly since sedimentation (wash load) is practically related to water quality.

CHAPTER 10 - REPORTING

10.2 Types of Report (comments and suggestions)

In the following type of report "Protocol and Methods Report", reference should be made of section 3.7 since it defines Quality Assurance in a more precise and understandable language.

Table 10.1, looked at in a scientific or technical point of view, has no meaning to the reader. Therefore it would serve its purpose if the terms and phrases used are explained in the text or in an annex.

10.5; last paragraph about figure 10.3, the second sentence, the basic statistical attributes" are normally described in quarters and halves not percentages.

ANNEX 7

PROPOSED SUBMISSION TO THE GLOBAL ENVIRONMENT FACILITY

Draft proposal to the Global Environment Facility

1. Countries: Africa

2. Title: Shared water resources management in major water sheds in Africa

3. Lead Agency: WHO

Implementing Agencies:
- UN agencies participating in GEMS-WATER programme: WHO, WMO, UNESCO and UNEP,
- Regional co-ordinating bodies for shared water resource management:
Hydromet for the Nile Basin
SADCC for the Zambesi Basin
Niger Basin Authority for the Niger Basin

4. Rationale:

Some of the world's largest freshwater resources are found in Africa. The resources are, compared to the fresh water resources in the more developed part of the world, rather unspoiled. However, rapid population growth, industrial developments and land use practices in the continent threatens to degrade the freshwater resources at a previously unseen rate, repeating mistakes made in countries which industrialized earlier.

The know-how, information requirements and technology, required to prevent the unnecessary degradation of freshwater resources in the region, while at the same time securing the development of the region, is available in the more developed countries of the world. However, in Africa - due to other pressing basic needs - the institutional framework, information base and capabilities to compile and bring to bear this knowledge base is often lacking.

There is an urgent need for a concerted intervention to assure the long term development of major river basins in a sustainable way, in particular River Nile, Zambezi and Niger.

Governments in Africa are aware of this need and are planning active and co-ordinated steps to ensure the sustainable development and management of their shared freshwater resources. However,because most riparian countries in Africa are faced with the challenge to address the urgent basic needs of their population, priority is given to projects covering the immediate needs of the countries. GEF support is, therefore, required for those areas which deal with transboundary issues, aim at the preservation of natural resources for the future generations and assure the development potential on a longer term span. GEF support is for those areas which are not covered by traditional funding sources and developmental programmes.

In the different watersheds covered by this proposal, regional co-ordinating mechanisms exist to support the sustainable management and development of the international river basins.

Under the umbrella of UNEP's Environmental Sound management of Inland Water (EMINWA) programme, concerned Governments in the Zambesi River Basin developed a comprehensive action plan for the development and management of the basin. The Zambesi Action plan has been agreed upon by the governments and signed by the Ministers of the environment. The plan is considered as an important component of the national and regional development programmes of the riparian countries. SADCC, the Southern African Development Co-ordination Conference, the regional co-ordinating mechanism, is responsible for its implementation. Different project components of the action plan are already under implementation. The GEF project will support and carry forward the further implementation of the action plan in those areas which aim at longer term benefits and where traditional funding sources and developmental programmes are lacking.

In the Nile basin, member Governments are deeply concerned by recent indications of pollution of the Nile waters as a result of poor management. Frequent algal blooms, massive, unexplained fish kills, disappearance of certain fish species that once formed major gene-pools and the sudden appearance and prolific spread of the noxious water weed - the water hyacinth,has been experienced in recent years. The basin, spanning an area of 3 million sq km, is inhabited by over 200 million people some of whose history and livelihoods are inextricably linked to the use of the Nile waters. An environmental disaster of even moderate magnitude would not only interfere with the economic development of member countries but would threaten the very survival of their people. The GEF Project will provide the necessary assistance to enable the countries acquire adequate and appropriate information on which to base environmental laws aimed at protecting the vulnerable ecosystems and ensuring sustainable and co-ordinated use of the resources.

In the Niger Basin, though no comprehensive action plan is as yet under development, a strong regional mechanism exist; the Niger Basin Authority, whose five year plans are adopted by the Council of Ministers. The planned activities of the authority are mainly technical in nature and directed towards the development of a comprehensive knowledge base and forecasting and modelling systems. In the Niger basin, the GEF project will assess the situation, highlighting the importance of the instalment of an action plan for the region, and support the institutional capabilities and sustainable management and development of the river basin.

5. The Approach:

This project is largely community oriented and as such, communities will be involved at all the stages of project implementation. It is expected that the output of the project will ensure a community oriented sustainable management of the water resources.

The sustainable development and management of freshwater resources and, therefore, of other natural resources dependent on water, requires in the first place a scientific knowledge base on which to build the decision making process. To support the decision making process and the implementation of action plans, the following activities are required (i) an inventory of the state of art (institutional capabilities,legal instruments, water quality, water availability, pollution sources, geographical characteristics etc); (ii) a strengthening of national and regional capabilities to build up and operate the knowledge base (strengthening monitoring laboratories information processing and transfer systems, develop legal instruments and control measures); (iii) routine operation of the knowledge base; (iv) the incorporation of the knowledge in the decision making process, including legislation and (v) the monitoring of the effectiveness of installed legislation, land-use practices and control measures.

These activities will be developed depending on the specific needs of the regions and the different stages of their developments in the field of shared freshwater resource management.

6. Project objectives:

- Provide the comprehensive knowledge base and institutional capabilities, required to support and allow the implementation of the proposed or operational action plans and regional co-ordinating mechanisms in a sustainable way.

- Provide an effective decision tool to those involved with water resource management and development at the national and regional level, including decision support for (i) emergency situation actions, such as in the case of flooding (real time data) and early warning activities; (ii) preservation of biodiversity and critical habitats; (iii) pollution control; (iv) the establishment of legal instruments and sustainable land use practices; (v) coastal zone protection and (vi) the monitoring of the effectiveness of control measures.

- Assure an acceptable quality of water resources in the region, including coastal water, by improved land-use policies, pollution control measures and institutional framework.

- Assure community participation, at all levels in the implementation of government action plans.

- Assist the countries sharing international river basins in the planning of conservation and development of the resources associated with the river basins in light of the environmental impact and ecological changes resulting from increased human activity and population growth.

7. Major Activity areas:

- Review of state of art, (diagnostic study)* including:-
  - institutional and technical capabilities,
  - review of water quality and quantity problems,
  - legal instruments.
  - controls strategies in place,
- review of land-use pattern, relevant geographical, environmental and socio-economic structures and information sources etc.
  - sources of pollution
  - investments and investments plans.
- long term supportive capacity of the different ecosystems etc.

* Already completed for the Zambezi River Basin.

- Mapping of relevant environmental and socio-economic parameters for use in management, policy development and comprehensive, multi-disciplinary assessments.

- Capacity building with regard comprehensive monitoring and information handling at the national and regional level, including (i) the instalment and operate effective satellite based information gathering and communication systems and modelling and predictive capabilities; (ii) training; (iii) routine quality assurance and main tenance operations; (iv) refurbishing of information gathering and processing stations were required;

- Operation of routine,long-term, monitoring and assessment activities to support decision making process;

- Support the instalment and operation of a legal system and control measures for effective water protection policies at the national and regional levels;

- Develop decision tools]y]d development plans including tools for environmental impact assessments;

- Specific studies for example with regard to critical habitats, biodiversity, land based source of coastal pollution, impact of desertification, deforestation, pastural practices etc.

8. Institutional framework:

The project will be implemented by the competent national and Regional Authorities, so as to ensure the long term and integrated impact of the proposed activities. This project also proposes to draw upon the collected expertise and experience of different UN agencies so as to assure the a concerted input of different national and international organisations and the maximal utilization of the ongoing efforts in the regions. The GEMS/WATER programme will provide the overall co-ordination framework.

Executing agencies: Regional bodies: Niger Basin Authority; SADDC and Hydromet.

Supporting UN agencies:
- Overall co-ordination: UNEP
- Water quality: GEMS/WHO/WMO/UNESCO)
- Hydrometeorology: WMO
- Safe water supply and sanitation: WHO
- Research,training and methodology development: UNESCO and other UN agencies.
- Resource mapping and remote sensing: GRID.
- Management support: UNEP/TEB
- Legal instruments: UNEP/Law Unit.

9. Cost to GEF:

3.2 million US dollar per river basin for a three year period.

10. GEF priority area:

Development of basin-wide monitoring and inventories of pollution sources;
Pollutant transport from international rivers to the near coastal areas;
Improved institutional capabilities;
Preservation of biodiversity.

VV 18.2.92

ANNEX 8

COURSE EVALUATION

COURSE EVALUATION

This workshop may be used as a prototype for others in Africa. If this occurs then these will not incorporate the handbook review but will otherwise be based on this workshop. We would therefore be grateful for your constructive criticism regarding how it could be improved.

1 Participants were from a wide range of professional backgrounds. For you, was the <u>average</u> level of the presentations:

Far too advanced/detailed	-
Too advanced/detailed	-
About right	79%
Too basic/superficial	5%
Far too basic/superficial	-
No response	5%

2 The course workshop included a range of teaching methods, please rank how you would consider the time spent on each:

	far too little	too little	about right	too much	far too much
evening group work	-	47%	47%	5%	-
formal presentations	-	22%	50%	17%	11%
field work	-	42%	53%	5%	-
practicals	5%	42%	47%	5%	-
discussions	5%	21%	68%	5%	-

3 Were there any topics which were not covered during the course which should have been included?

YES	53%
NO	32%
No response	16%

4 Were there any subject which received too little attention during the course?

Responses:

- data processing and management
- field training ref lakes/large rivers/mashes/swamps
- laboratory practicals
- statistics and output option
- water quality activities and overcoming constraints
- microscopic analysis
- water sampling
- hydrology
- AQC (examples) p73
- field practicals
- biodiversity and biomonitoring
- chemical and particulate analysis
- regional cooperation

5 Were there any subjects which received too much attention during the course?

YES	26%
NO	42%
No response	32%

cited:

handbook review x 2
physical and chemical analysis
sampling

(one x suggestion that lectures and practicals should be combined)

6 Where there any topics covered during the course which you feel should be omitted?

YES	79%
NO	0%
No response	21%

7 How successful do you feel the course/workshop has been in achieving its objectives?

	very incompletely achieved	incompletely achieved	adequate	quite successful	very successful
handbook review	-	-	37%	53%	11%
introducing GEMS-Water	5%	-	53%	21%	16%
providing training	-	16%	79%	5%	-
development of country workplans	-	16%	68%	16%	5%
fostering of regional cooperation	-	16%	42%	26%	16%
development of a regional strategy	-	37%	37%	31%	-
planning of a follow-up meeting	5%	31%	31%	16%	11%

8 Do you feel the amount of literature distributed during the course was satisfactory?

YES	58%
NO	37%
No response	4%

9 During the course, some literature was made available to participants, was this: (circle one)

Poor	4%
Adequate	42%
Satisfactory	42%
Very Satisfactory	4%

10 Do you think that the overall length of the course was:

far too short	0%
too short	63%
about right	26%
too long	11%
far too long	0%

11 Do you think the length of the working day during the course was:

far too short	0%
too short	0%
about right	16%
too long	68%
far too long	11%

Any other comments you might like to make:

Insufficient allowance x 4
Need African focus x 3
More case studies x 2
Fluent English-speaking lecturers x 2
Organisation was good
Need a specialised course on biomonitoring
Incorporate self-planned practicals
More field work and practicals
Short notice before course
Insufficient lecturers
Should have been paid for doing book review
Hard chairs
More care with selection of lecturers
Insufficient lectures
Too much focus on GEMS/Water
Not enough sight-seeing
Transcripts of lectures should be available
Minimise overlap between lectures

Poor quality paper & pens	(
No conference bags	(
Tiny cell like room	(
No recreation facilities	(all these comments
Unrealistic per diem	(from one participant
No en suite bathroom	(
Some poor presentation	(
More discussion, less lectures	(
Too wide participant background	(

ANNEX 9

LITERATURE PROVIDED TO COURSE PARTICIPANTS

'Water Quality Assessments', Deborah Chapman (Ed); Chapman and Hall, London, 1992.

'Low Cost Monitoring for Freshwaters: Field Techniques' (K Tomlin and DV Chapman). GEMS-MARC, Kings College, University of London, 1989.

'The Dublin Statement', (International Conference on Water and the Environment). 26-31 January 1992, Dublin, Ireland.

'Meteorology and Hydrology for Sustainable Development', J P Bruce, World Meteorological Organization, 1992.

'Manual on Water Quality Monitoring', World Meteorological Organization, Operational Hydrology Report No 27, 1988.

'Establishing and Equipping Water Laboratories in Developing Countries', World Health Organization. PEP 86/2, Geneva, 1986.

'Manual on Water Quality Monitoring' (Draft) R C Ballance (Ed). UNEP/WHO, 1992.

'Assessment of Freshwater Quality' GEMS-MARC, UNEP and WHO, 1988.

'Fresh water Pollution', UNEP (UNEP/GEMS Environment Library No 6), Nairobi 1991.

'Combating Environmental Pollution', Morris Schaefer, World Health Organization, Geneva, 1991.

'Water Resources Assessment: Progress in the Implementation of the Mar del Plata Action Plan and a Strategy for the 1990s', WMO/UNESCO, 1991.

'Water Quality', WHO and UNEP, 1991.

'GEMS/Water 1990-2000 The Challenge Ahead', UNEP/WHO/UNESCO/WMO; World Health Organization, Geneva 1991.

'Training Course Manual for Water and Wastewater Laboratory Technicians', World Health Organization, Geneva, 1988.