Nile Basin Initiative
Nile Trans boundary Environmental Action Project

Training Modules and Materials
Identification of Key Water Quality - Variables and
Design of Quality Assurance program

FINAL REPORT

Prepared by
Ababu Teklemariam (PhD)
(National Consultant)

December 2006
Addis Ababa

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EXECUTIVE SUMMARY

This report is prepared for the Nile transboundary environmental action project. The objective of this consultancy work was to develop training modules and materials, identify key parameters and design water quality assurance program in the Nile Basin countries. There are a number of places available for training of staff in water quality monitoring. Addis Ababa University and Arbaminch University are potential places for offering advanced level training in water quality monitoring. The universities possess staff with qualified skill and more or less adequate laboratories to offer these trainings. A number of regional training sites have been identified. The ones in Addis Ababa, namely, The Water works development Enterprise, The environmental Protection Authority lab, The Geological Survey of Ethiopia Laboratory, The Ethiopian quality and standards authority laboratory have more or less the laboratory capacity and staff with adequate qualification to offer basic training water quality analysis and basic water quality monitoring. The regional laboratories and water quality centers are not well staffed and are not well equipped to do complete analysis of water quality and need to be upgraded in these respects.

Training in water quality monitoring is considered at 3 levels. At the upper level (level 1) for personnel in designing and managing water quality monitoring networks, for level 2 (middle level personnel) for supervising field and laboratory analysis and level 3 personnel who carry out the routing water quality analysis and assessment. There are 12 modular units of teaching and the trainees belonging to the various categories of training will be given the training which can be made flexible depending on other considerations.

The pollution status of the different river basin has been discussed, while major sources of industrial pollution are limited, emphasis has been given to non-point sources of pollution. Monitoring location based on Sander's method has been applied to the river reaches. Transboundary analysis for the water quality variables has been discussed and recommendation is made for list of variables to be monitored. Water quality parameters that can be measured by school and the community have been identified. The current quality control and quality assurance provisions and practices are found to be not adequate. Accordingly a system of quality assurance and quality control measures has been designed with a view to increasing the performance and reliabilities of water quality monitoring undertakings within and across regions.

Acknowledgement

The work of this report could not have been accomplished with out the sincere help of individuals and organizations. I am obliged to thank all of whom for their help and assistance. I thank first W/o Wubua Mekonen, coordinator of the Nile Environmental Action Plan for facilitating my duties and for the keen interest she has for the accomplishment of the work. Thanks are due to Ato Yohannes Gebermedhin, Head of the Water Resources Development Urban Water Supply Service Department under the ministry of Water Resources (WRDUWSSD) for his much considerate help while I was seeking information and relevant documents at the ministry of water resources. Thanks are also due to Ato Solomon GebreTsadik, a chemist in the water works design and supervision enterprise, Ato Abiy Girma, team leader of the water quality control team in WRDUWSSD - both under the ministry of Water Resources- for offering me their sincere help. I am also thankful to the librarians both at the Environmental protection authority and the ministry of water resources for availing me of the documents I needed for the work.

Finally, I would like to thank W/o Wubua Mekonen, Ato Abiy Girma and Ato Mulugeta Hailesilassie for their critical comments and suggestions later during the evaluation of the draft of this report in November 2006.

Ababu Teklemariam (PhD)
Thursday, December 21, 2006

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BACKGROUND

The Nile Transboundary Environmental Action Project (NETAP) is one of the eight projects under the Nile Basin Initiative (NBI) shared vision program and is of five years duration. The main objective of this project is to provide strategic environmental framework for the management of transboundary waters and environmental changes in the Nile basin.

The basin wide water quality monitoring component is one of the six components of the NTEAP. This component will initiate a basin-wide dialogue on water quality management and improve the understanding of transboundary water quality issues, improve capacities for monitoring and management of water quality and initiate exchange and dissemination of information on key water quality issues.

The objectives of the consultancy mission under the above framework were as follows:

1. To design and develop specific training modules target4d at the different Cadres of staff depending on the national need
2. To characterize, identify and recommend key water quality parameters of Cross-border and Trans boundary and basin wide importance.
3. To design a quality assurance program both at the national and Tran boundary level.

The scope of the work was outlined as follows:

A. Training modules:

1. Examine the status and type of training facilities especially in the water and environmental sector in the country
2. Assess the nature and type of training being offered and at what level and by which institutions.
3. Assess the capacity of the training institutions to offer water quality monitoring training on a full time or part time basis at both national and regional levels.
4. Outline the type of courses being offered indicating the modules and units taught and the duration and if the courses are national or regional in nature.

5. Assess the existing national technical capacity for overall water quality monitoring and assessment taking in to consideration sampling, testing, data generation, analysis and interpretation.

6. Based on the need to monitor the Nile River and its many tributaries as one system and based on the assessed existing technical capacity shortfall within the country, design appropriate training module/course on water quality monitoring and assessment of the different levels of man power.

7. Other than training courses and modules/courses recommend other training materials that can be use to train communities and other stakeholders at the catchments level in order to enhance their perception of water quality issues and create awareness about water quality management

B. Water Quality Parameters

1. Based on the local situation and from the available secondary data sets, indicate the water quality parameters that are regularly tested for in the country.
2. Indicate the adequacy of the laboratory facilities and state whether the parameters tested, adequately describe the status of water quality in the Nile basin, and if the parameters are too few what additional parameters should be analyzed.
3. Give an inventory of the major pollution sources, possible with the geo-references, indicating the pollutants emanating from them and state whether proper monitoring is being carried out for these pollutants and make recommendations for the testing of all key parameters of transboundary importance.
4. From your experience indicate which parameters could be regarded as national, cross border and transboundary basin-wide importance. Suggest which of the existing water quality monitoring stations should be considered to be part of the proposed regular River Nile water quality monitoring network stations.
5. Make suggestions on how the deficit between the parameters being analyzed and those that should be analyzed can be bridged.

6. Propose a list of the parameters that can be conveniently tested for in the field by NGOs, CBOs and institutions at schools by use of portable equipment.
7. Indicate any other parameters that you consider should be tested for regularly as part of the wider critical monitoring of the Nile Basin environment.

C. <u>Design of Water Quality Assurance Program</u>

1. Indicate the type of method being used for water quality sampling and testing both in the laboratory and in the field
2. If any water quality assurance programs are in existence which is the corresponding laboratories, nationally regionally or internationally.
3. Indicate the efficiency and accuracy of the reported water quality analytical results.
4. Indicate the parameters featured in the water quality assurance program and give an indication of the performance of the corresponding laboratories.
5. Based on the above and in order to enhance the integrity of the results produced by the laboratories, design an appropriate water quality assurance program, and propose the parameters of Trans boundary significance that should be featured in the program.

<u>Expected Outputs</u>

A comprehensive report containing among other items, the following:

<u>Training:</u>

1. Designed training modules or courses
2. List of national training facilities with their capacities and courses offered
3. List of recommended training materials to be used for the training of Communities, institutions and schools.

Water Quality Parameters

a) List of routinely analyzed water quality parameters, and the parameters that could be tested but are not tested.

b) List of parameters considered to be of cross –border, Trans boundary and basin wide significance.

c) Geo-referenced list of main sources of pollution and the identified pollutants

d) List of parameters not tested for but which you consider to be of environmental significance.

e) List of parameters that can be tested for by communities, institutions and schools.

Quality Assurance:

A well designed and implementable water quality assurance program complete with list of the recommended parameters, corresponding laboratories and proposed frequency.

Approach followed for the consultancy undertaking included:

1. Literature Survey – book and journals and articles on the internet.
2. Survey of existing documents related documents, 4 of which were supplied by the coordinator of NTEAP coordinator.
3. Review of other documents, research projects and master plan studies,
4. Interviewing personnel
5. Visits and personal observations

A - TRAINING MODULES:

A -1 STATUS AND TYPE OF TRAINING FACILITIES ESPECIALLY IN THE WATER AND ENVIRONMENTAL SECTOR IN THE COUNTRY

AND

A – 2 ASSESSMENT OF THE NATURE AND TYPE OF TRAINING BEING OFFERED BY INSTITUTIONS.

There are a number of training sites available that offer training related to water and the environment at different level of training qualification. These trainings range from post-graduate degree level training to training given to field personnel in water quality monitoring and laboratory assistants. These facilities are briefly described below:

Addis Ababa University

Addis Ababa University is currently offering two post graduate level training programs through the faculties of science and faculty of engineering. The geology department of the faculty of science offers M.Sc. level training in environmental science where as the Chemical Engineering department of the faculty of technology offers M.Sc. level training in environmental engineering. These institutions have modules that are partly relevant to the training objective of the Nile water quality monitoring initiative and are potential candidates for offering higher level training in water quality monitoring design and supervision.

Arbaminch University

The Water technology Institute under Arbaminch University was established in 1987 for the purpose of delivering training at degree diploma and certificate level in hydraulic, irrigation and sanitary (environmental) engineering. Since its establishment the institute has produced hundreds of graduates at under graduate degree, diploma and certificate level in these subject areas. In addition the institute has offered tailor made training in water quality analysis, water treatment, water works operator training, irrigation management, etc to trainees up on the demands of the regions and NGOs operating at various localities in Ethiopia. The department of water and environmental engineering operating under this institute offers B.Sc. level training in areas of water and environmental engineering and can be considered as a useful partner in the water quality monitoring training program proposed.

Water Technology Institute has also started M.Sc. level training in Hydraulic and in Irrigation engineering since 2002 and has produced a number of graduates in the field of hydraulic/hydrology and irrigation engineering. An M.Sc. program in water and environmental engineering has also been proposed and this program will start in the 2007/2008 academic year.

There is the water quality laboratory under the department of water and environmental engineering. The laboratory has a reasonably complete list of equipments and capabilities for the analysis of physical, chemical and bacteriological parameters. Analysis for ions and nutrients using titrimetric, gravimetric and spectrophotometric methods are being routinely carried in research and consultancy undertakings. Bacteriological test of rural water supply source sample is also regularly carried out. In addition analysis for aggregate organics such BOD, COD and pV are also carried. Recently the laboratory has acquired new instruments such Atomic absorption spectrometer and uV range photometer for detection of organic compounds in water.

The department of applied chemistry in Arbaminch University has an analytical chemistry laboratory with a list of useful advanced instruments such as the atomic absorption spectrometer, gas chromatography, HPLC, ion chromatography, etc. Many of these equipments are already in operation and are being also used by the department of water and environmental engineering for training and research. These laboratory capabilities can be considered as useful assets for offering training in advanced instrumental analysis.

Other Regional Universities in Ethiopia

Of the currently existing 9 universities in Ethiopia and 13 more that are under the stage of establishment, the ones existing in the Nile Basin are Bahirdar and Mkelle Universities. These universities have faculties of engineering and in which the civil engineering program is a one of the programs of training offered leading to B.Sc degree. Although these programs may not offer much specifically in terms of the objectives of water quality monitoring training envisaged in the Nile Basin Initiative, these universities may be considered as future possible foci for training during the stages of decentralization of the training activities.

Regional Training Sites

Of all the regions, training related to water quality analysis and monitoring are largely offered in Addis Ababa. The capacities of the regions including those regions housing the Nile basin in the Ethiopian part (Gambella, Tigray, Amahara, Benishangul and Oromia) is limited. These regions have in the past trained their staff either in Addis Ababa or even abroad in water quality analysis (Fitsum, 2005). All of these regions have reasonably adequate laboratory facilities for basic water quality analysis (Chemical, physical and bacteriological) and almost invariably lack and advanced instrument for the analysis of trace metals as well as persistent organic compounds. In addition the qualification of the regional laboratories is also limited. These regional centers may be considered as future sites for local training of laboratory technicians.

Training Sites in Addis Ababa

There are a number of organizations that are involved in water quality analysis activities and related training and research activities in Addis Ababa. Some of these organizations were visited and the findings of the visits have been summarized below. The table below shows the list of major organizations in involved in water quality analysis activities which may also include a training component.

Table 1: the list of major organization in involved in water quality analysis activities which may also include a training component.

Organization	***Remark***
Environmental protection Authority	*Has a laboratory for water and waste water analysis. The laboratory is also willing to offer training in water quality analysis / monitoring.*
Ethiopian nutrition and health research institute	*Has laboratories for research purpose*
Addis Ababa water and sewerage authority	*Has laboratory for internal routine water and waste water quality control*
Ethiopian Geological Survey	*Has laboratory for hydro geochemical analysis largely for the survey's use but training can also be offered there.*
Ethiopian agricultural research organization	*Has laboratory for research purpose*
Addis Ababa University	*Offers post graduate level training in environmental science and*

Organization	*Remark*
	engineering. Has laboratories for physico-chemical and advanced instrumental analysis as well as isotope determination in the departments of geology and chemistry under the faculty of science.
The Water Works Design and Supervision Enterprise	*Has water and soils laboratory. It is a profit making government organization and offers training in water quality analysis*

Out of the above sites organization the following laboratories were identified and visited during the course of the consultancy work:

1. The Water works design and supervision Enterprise
2. The environmental Protection Authority lab
3. The Geological Survey of Ethiopia Laboratory
4. The Ethiopian quality and standards authority laboratory

<u>The Water works Design and supervision Enterprise</u>

This laboratory is managed by the water works development enterprise which is operating as an independent enterprise and is located in the basement floor of the Ministry of Water Resources building in Addis Ababa. The laboratory has capabilities of analyzing the routine water quality analysis including bacteriological examination (MPN test and membrane filtration technique), physical and aesthetic parameters (Colour, Conductivity, pH, Solids, Turbidity, etc). Spectrophotometer operating in the visual range is also available capable of measuring nutrients, metals and non metals capable of being measured using colorimetric techniques. In addition the laboratory has titration and gravimetric analysis apparatus which are being routinely used for the analysis of sulfates, chlorides and the like. Aggregate organic analysis (BOD and COD) are also analyzed in this laboratory.

The laboratory has atomic absorption spectrometer (AAS) which was meant for analysis of heavy metals. However, information from the lab personnel suggested that the equipment is not being operated due to some technical problem.

The laboratory is being managed by a senior chemist and has a number of technical assistants with experiences in field and laboratory analysis.

The environmental Protection Authority lab

The Environmental protection authority laboratory is also located in Addis Ababa in the EPA compound. The Laboratory has soil and water analysis components. The water analysis part of the laboratory is well equipped with equipments capable of measuring wide range of physical, chemical and bacteriological analysis. The laboratory has also capabilities of carrying out bacteriological analysis. In addition the following equipments exist in this laboratory for advanced instrumental analysis:

1. Atomic absorption spectrometer
2. uV-Visible spectrophotometer
3. Gas chromatographic apparatus
4. HPLC

However, these equipments have not been commissioned for operation due to accessories problems and technical problems that are related to electrical installation components.

The laboratory has a biochemist with M.Sc qualification, a Biologist (MSc) and a Chemist one with MSc and another with BSc qualification.

3. The Geological Survey of Ethiopia Laboratory

The geological survey laboratory is located in Addis Ababa and is part of the Ethiopian Geological Survey. There are five different laboratory components in this lab out of which the water analysis laboratory is one. This laboratory is capable of carrying our complete cation and anion analysis including boron, silica, nitrite, etc. In addition atomic absorption spectrometer is available in this laboratory which is regularly used for environmental trace metal analysis. Equipment such as HPLC and GC do not exist as the laboratory manager explained that persistent organics are not a priority/objective of measurement in the laboratory.

There is one analytical chemist with M.Sc qualification in the water analysis laboratory as well as 3 chemists with B.Sc out of whom one has long years of experience.

The Ethiopian quality and standards authority laboratory

The Ethiopian quality and standards authority laboratory is located in Addis Ababa within the authority's compound. This laboratory has also experience of analyzing chemical, physical and bacteriological analysis of water. Equipment therefore exists for gravimetric, titrimeteric and uv-visible range spectrophotometer analysis. Various types of ion selective electrodes also exist for specific ions analysis. The laboratory also has an atomic absorption spectrometer through which heavy metals are routinely being analyzed for in this laboratory. The laboratory is being managed by a chemist who has an M.Sc qualification. Technical assistants are also available. The laboratory used to have several additional chemists with B.Sc and above qualification and who were also given training while on the job. Unfortunately, these personnel have now left the authority for other jobs (information from Ato Amha, head of the laboratory).

A-3 THE CAPACITY OF THE TRAINING INSTITUTIONS TO OFFER WATER QUALITY MONITORING TRAINING ON A FULL TIME OR PART TIME BASIS AT BOTH NATIONAL AND REGIONAL LEVELS.

Addis Ababa University

Addis Ababa University as explained earlier offers M.Sc trainings in environmental science as well as environmental engineering. The environmental science M.Sc program offered at the geology department of the faculty of science deal with the science of the environment, of ecology and pollution. The environmental engineering M.Sc program offered at the chemical engineering department of the faculty of technology deal with the science of the environment, with environmental management, environmental impact assessment and environmental laboratory analysis. It also deals with pollution and its management. The Courses offered in this program are indicated below.

Table 2: Environmental Engineering Courses at Addis Ababa` University (M.Sc) program

Course Number	Course Title	Credits
ChEg 6001	Advanced Computational Methods	3
ChEg 6301	Environmental Chemistry	3
ChEg 6303	Environmental Microbiology	2
ChEg 6331	Advanced water and waste water treatment	3
ChEg 6333	Air Pollution and control	3
ChEg 6002	Experimental design and analysis	3
ChEg 6312	Environmental systems analysis	3
ChEg 6372	Environmental policy and regulation	2
ChEg 6334	Solids and hazardous waste management	3
ChEg 6382	Environmental engineering laboratory	1
ChEg 6072	Research methods and presentation	2

Course Number	Course Title	Credits
ChEg 7311	Environmental impact assessment and risk analysis	3
ChEg 7371	Energy, environment and economics	2
ChEg 7381	Environmental engineering project	4
ChEg 7331	Sustainable development and cleaner production technologies	2
ChEg 7333	Ground water contamination and pollutant transport	2
ChEg 7335	Ecology and ecosystems dynamics	2

Arbaminch University

The water and environmental engineering department in water technology institute of the Arbaminch University currently offers B.Sc. degree level training in water and environmental engineering. Major courses related water and the environment exist which include environmental chemistry and microbiology, water supply and treatment, ground water engineering, waste water engineering, water quality management, industrial water and waste engineering, air and noise pollution engineering, etc.

The water quality management course includes topics in water quality monitoring. In addition there are three environmental engineering laboratory courses covering the whole range of water quality analysis including also data analysis. The list of major courses offered in this program is given in the table below.

Table 3: Water and Environmental Engineering Courses at Arabminch University (M.Sc) program

Course Number	**Course Title**
WENE 240	Environmental Engineering laboratory analysis I
WENE 341	Environmental engineering laboratory analysis II
WENE 344	Environmental engineering laboratory analysis II
WENE 130	Introduction to environmental engineering
WENE 132	Environmental chemistry
WENE 236	Water supply engineering
WENE 331	Water treatment engineering
WENE 333	Waste water engineering I
WENE 336	Waste Water engineering II
WENE 338	Water quality management
WENE 431	Solid waste management
WENE 433	Industrial water and waste engineering
WENE 439	Air and noise pollution engineering
WENE 435	Ecology and environmental management
WENE 432	Computer application in environmental engineering
WENE 434	Alternative energy resources

In addition starting from the 2007/2008 academic year two post graduate programs will begin offering M.Sc level training in environmental science and in environmental engineering. The water and environmental engineering component includes a full course in design of water quality monitoring system. The list of courses in these two programs is given in the table below.

Table 4 M.Sc course in environmental science and environmental engineering at Arbaminch University

M.Sc in water and environmental engineering course	**M.Sc in environmental science courses**
Environmental microbiology and biochemistry	Environmental microbiology and biochemistry
Applied environmental chemistry	Applied environmental chemistry
Advanced Computation methods and applications	Computer programming and numerical techniques
Advanced probability and statistics for environmental engineering	Probability and statistics for environmental sciences
GIS and remote sensing	Remote sensing and GIS application
Advanced environmental engineering unit processes	Water quality and waste water management
Water and waste water engineering pilot plant laboratory	Environmental hydrology
Environmental hydrology	Air pollution and control
Air pollution and control	Industrial and hazardous waste management
Design of water treatment systems	Solid waste management
Environmental hydraulics	Meteorology and air quality modeling
System analysis and optimization in environmental engineering	Environmental impact analysis
Legal, environmental and administrative aspects of water	Ecology and environmental management
Solid waste management	Environmental biotechnology
Water and environmental quality modeling	Environmental analytical chemistry
Advanced waste water treatment design	Environmental laboratory analysis
Ecology and environmental sanitation	
Hydrology and ground water engineering	

M.Sc in water and environmental engineering course	M.Sc in environmental science courses
Meteorology and air quality modeling	
Environmental Risk management	
Design of water quality monitoring systems	
Industrial and hazardous waste management	

Other Regional Universities in Ethiopia

Of the currently existing 9 universities in Ethiopia and 13 more that are under the stage of establishment, the ones existing in the Nile Basin are Bahirdar and Makelle Universities. These universities have faculties of engineering and in which the civil engineering program is one of the programs of training offered leading to B.Sc degree. Although these programs may not offer much specifically in terms of the objectives of water quality monitoring training envisaged in the Nile Basin Initiative, these universities may be considered as future possible foci for training during the stages of decentralization of the training activities. However, it is not considered necessary at this stage to elaborate on the aspects of training program as in any case new program designs need to be introduced for these universities to be directly relevant to the water quality monitoring training envisaged.

Regional Training Sites

The capacities of the regions including those regions that are housing the Nile basin in the Ethiopian part (Gambella, Tigray, Amahara, Benishangul and Oromia) are limited. These regions have in the past trained their staff either in Addis Ababa or even abroad in water quality analysis (Fitsum, 2005). Currently there is no information concerning training offered in water quality related subjects at regional level.

Training Sites in Addis Ababa

As explained earlier, there are a number of organizations that are involved in water quality analyses activities and related training and research activities in Addis Ababa.

Some of these organizations were visited and the assessment of the nature of the training being offered is provided below.

The Water works Design and supervision Enterprise laboratory

The capabilities of the laboratories and the qualification available have been mention already. This laboratory has been giving in the past training in water quality analysis including field testing of water for technical staff drawn from the regions. Owing to the equipment available these trainings included the common physical, chemical and bacteriological parameters except the trace heavy metals and persistent organics which require advanced instrumentation. Heavy metals analyses that do not require low level of detection are analyzed by the spectrophotometer (visible range) available in the lab. Analysis for BOD and COD are also being done in this laboratory.

Therefore, it can be planned to consider this laboratory as a place for training in basic water quality analysis including most of the physical. Chemical and bacteriological analysis. The detail is summarized at the end of this section.

The environmental Protection Authority lab

As explained earlier, the water analysis part of the environmental protection laboratory is well equipped with equipments capable of measuring wide range of physical, chemical and bacteriological analysis. The laboratory has also capabilities of carrying out bacteriological analysis. This laboratory can also give training in basic water quality analysis and monitoring including most of the physical. Chemical and bacteriological analysis. However, the advanced instruments such as the atomic absorption spectrometer have not yet been commissioned and need to be started up before training using these instruments can begin.

The Geological Survey of Ethiopia Laboratory

The geological survey laboratory is located in Addis Ababa and is part of the Ethiopian Geological Survey. This laboratory is capable of carrying our complete cation and anion analysis including boron, silica, nitrite, etc. In addition atomic absorption spectrometer is available in this laboratory which is regularly used for environmental trace metal analysis. Equipment such as HPLC and GC do not exist as the laboratory manager explained that persistent organics are not a priority/objective of measurement in the laboratory.

This laboratory can also give chemical analysis for cations and anions which is done commonly in ground water analysis. It may be considered training place for analysis of ground water samples and for trainings related to ground water quality monitoring. The staff in this laboratory also have good experience in hydro-chemical analysis.

The Ethiopian quality and standards authority laboratory

The Ethiopian quality and standards authority laboratory is located in Addis Ababa within the authority's compound. This laboratory has also experience of analyzing chemical, physical and bacteriological analysis of water. Equipment therefore exists for gravimetric, titrimeteric and uv-visible range spectrophotometer analysis. Various types of ion selective electrodes also exist for specific ions analysis. The laboratory also has an atomic absorption spectrometer through which heavy metals are routinely being analyzed for in this laboratory.

While this laboratory may be considered as training site for many of the chemical, physical and bacteriological analysis including trace metals analysis, there may be a problem of getting adequate staff to do the training. The laboratory has also not been giving training frequently.

A – 4 EXISTING NATIONAL TECHNICAL CAPACITY FOR OVERALL WATER QUALITY MONITORING AND ASSESSMENT TAKING IN TO CONSIDERATION SAMPLING, TESTING, DATA GENERATION, ANALYSIS AND INTERPRETATION.

In Ethiopia (Fitsum, 2000) there is lack of comprehensive and regular water quality monitoring undertaking. The drawback is reflected through:

1. Lack of clear implementation plan of water quality monitoring at the upper sectoral level
2. Lack of institutional and organizational arrangement for implementing the water quality monitoring program
3. Lack of proper allocation of funds
4. Shortage of man power committed to water quality monitoring
5. Lack of skill and knowledge in relation to water quality monitoring and management
6. Lack of proper laboratories and facilities at regional level

As a result few water quality monitoring plans have been implemented and reported. A case in point here is the water quality monitoring of the Awash River which was initiated by the Ministry of Water Resources in 2002 and another initiative on the same river by the Environmental Protection authority. Document containing proposal for water quality monitoring on the Awash River is available from the Ethiopian environmental protection authority and some of the findings contained in the report have been highlighted in this report.

There is limited experience of projects aimed at systematic assessment of water quality. The rapid water quality assessment program jointly carried out by UNICEF and Ministry of health is one example and there is a documented report of the implementation of this project.

Currently there is already a plan in place for monitoring and assessment of the waters within the Nile Basin regions, including of course Ethiopia.

Capacity at the Federal Level

The Ethiopian Environmental Protection Authority

The Ministry of Water Resources is at present in the process of implementing a field water quality monitoring. The EPA has some experience in field monitoring exercise. The staff have undertaken field sampling equipment and are competent in its use (EPA report, July 2002). The EPA has also reported to have been equipped with the following field and laboratory equipments (table provided below).

Table5: Field equipment available with the EPA – Addis Ababa

Meter Name	**Test parameters**
WTW Multiline p4 Universal Pocket meter	pH, Conductivity, Dissolved Oxygen, TDS, Salinity, Temperature
Field Armoring FM/ML	
Hach portable Turbidimeter	Accessory for probes
Merck Spectroquant Nova 60A portable spectrophotometer with battery	A wide range of chemical compounds
Hach portable turbidimeter	Turbidity

Characteristics	**Parameter**
General	Appearance, Odour, Taste, Turbidity, Colour, Conductivity, Temperature, pH, Total dissolved solids, Dissolved oxygen, Redox potential, Hydrogen sulphide, Total alkalinity, Total acidity, Hardness
Solids	Total solids , fixed solids, volatile solids, suspended solids, settleable solids
Organic	Total organic carbon, Chemical oxygen demand, biochemical oxygen demand
Other inorganic and organic	Total Nitrogen, Inorganic nitrogen, Organic nitrogen,

Characteristics	**Parameter**
variables	ammonia, total phosphorous, orthophosphate, silicates, carbon dioxide,
Major cations	Sodium, potassium, calcium magnesium
Trace metals	Total iron, iron, manganese, , Nickel, cobalt, copper, cadmium, Chromium, zinc, Silver, mercury, Arsenic selenium
Major anions	Bicarbonate, carbonate, chloride, sulphate, nitrate
Other anions	Nitrite, fluoride, boron, Cyanide, Phenol, surfactant, anionic

The above capacity is believed to be adequate for many analyses. However, an instrument such as the atomic absorption spectrophotometer has to be commissioned yet. The above capacity, therefore, express potential capacity in such respects. The above tables do not clearly indicate capability for bacteriological analysis though it is presumed that the analytical instruments exist.

The EPA has prepared a water quality monitoring strategy for the Awash river basin (June, 2002). In the report containing the strategy a clearly written justification and approach have been followed in setting the monitoring objective and detailing with the implementation strategy of the monitoring programme. This report clearly shows that there exists a capability at the EPA level to offer basic training in water quality monitoring and assessment.

There is limited experience reported, however, in data interpretation and analyses in formation management (data base management). This shortfall can be addressed through appropriately designed modules.

The Water Works design and Supervision Enterprise

The laboratory of the WWDSE also has a field and analytical capability for water quality analysis similar to that of the EPA, except for the trace metals analysis that require advanced instruments such the atomic absorption spectrometer. The WWDSE also has long experience water quality analysis and also has offered training to trainees drawn from the NGOs and the various regions. The staff are also well trained and quite competent to carry out water quality monitoring and offer training in water quality monitoring.

The capability of WWDSE can be exploited for training in water quality analysis, field testing and water quality monitoring.

Regional Capacities and Staff Qualifications

At the regional level (for the regions located within the Nile Basin) there are laboratories established for water quality analysis. The regions that are part of the Nile Basin, Tigray, Oromia, Amahra, Gambella, Benishangul, have all single regional water quality laboratory while Amhara region has in addition 10 zonal laboratories. Oromia has also basic laboratories in 12 zones.

The laboratory in Gambella region has the capacity for basic physical, chemical and bacteriological analysis as well nutrients. The same can be said for the central laboratory in Tigray region. The laboratory in Tigray has chemists, biologists and technical assistants (diploma) for carrying out the analysis. Beneshangul Gumuz and Amahara also have similar capacity laboratories meant for basic chemical and physical analysis.

The staff profile in all the regional laboratories is limited. There is no reported staff profile for the Beneshangul –Gumuz analytical laboratory.

The zonal water quality laboratories in the regions have staff profile that is below the recommended in the Ethiopian guideline for drinking water quality which recommended 4 professional staff at the regional level, 4 sub professionals at zonal and 2 technicians at the basic laboratory level.

In all the regional laboratories simple portable equipment is available including the visual range spectrophotometer. All regions face shortage of chemicals and reagents which are difficult to directly get from the local market.

All the regional laboratories (except the one located at the EPA office in Addis Ababa) do not have advanced instrument such as atomic absorption spectrometer, HPLC, gas chromatograph. The ones in the EPA are not installed.

The assessment of the capacities of the regions shows that the laboratories shall be upgraded and expanded in order to develop in to regional monitoring sites. The staff also needs to be trained and adequate number of staff shall be employed in order to meet the demand of water quality monitoring. `

The limited experience in water quality monitoring , the lack of adequate and skilled manpower in analytical, statistical, management and data analysis and reporting technique call for an effective training module that will address the training need at the various level of managing the quality f the Nile water basin.

Based on the overall assessment of the different stakeholders involved in water quality monitoring the following shortfalls can be identified.

1. Knowledge of water quality characteristics, identification of the different types of water pollution and their impact on the environment. This training is essential to the lower level staff at the zonal and regional level as a common knowledge basic to water quality monitoring.
2. Knowledge of the principles of water quality monitoring and assessment. Understanding the task of monitoring. Understanding the scope of water quality monitoring and assessment is essential for people involved in water quality monitoring tasks.
3. Understanding the principle behind the assessment of the different water sources. Monitoring and assessment of the different sources of water will give depth and width required in water quality assessment of the different water sources.
4. Understanding the water quality issues arising out of trans-boundary rivers. There is lack of experience in dealing with water quality issues of transboundary importance.
5. Design of water quality monitoring system. Water quality monitoring system design requires an extensive knowledge of goal setting, deciding on sampling space and frequency, identification of key water quality parameters, network design, etc.
6. Basic principle of sampling and design of sampling program. The knowledge range can be expanded through training in the various aspects of sampling design and equipments dealing with sampling.

7. Training on water quality standards and guidelines, expanded knowledge of water quality standards and guidelines is essential in understanding the water quality monitoring and assessment undertaking and in setting monitoring strategy.

8. Understanding the physical chemical and biological analysis of water. These trainings are required at various levels.

9. Training on environmental quality standards and the effluent characteristics for different polluting industries. This knowledge is important for the Nile Basin water quality monitoring knowledge and information in this area is often limited.

10. Field sampling and sanitary survey.

11. Physical, chemical and biological analysis, this training is particularly useful for the lower and midlevel man power that could expand and update their knowledge or in the case of the lower level staff could learn first hand these methods.

12. Advanced Instruments Analysis (GC, HPLC, AAS, etc). Experience in advanced instrumental analysis is limited and must be emphasized for staff at all levels.

13. Quality Control and Quality assurance. There is limited experience in quality and control and quality assurance in general in the country and this part of the training must be emphasized.

14. Statistical Methods in data analysis. There is limited application of statistical techniques for data validation and interpretation. This training will help fill the knowledge gap in this area.

15. Water Quality Modeling. Water quality monitoring data can only be interpreted through coupling with the pollution impact model. Often not a course regularly given. Water quality management training program can be given to higher level staff.

16. Community participation in water quality monitoring. The involvement of the stakeholders and the community in water quality monitoring is a helpful approach. This requires skill training in dealing with communities and in selling the ideas and objectives of water quality monitoring. Community skills and community participation also can be given

17. Data analysis interpretation and data base design. This is also an area where training is lacking and can be considered relevant.

18. Eco-toxicity and biological indicators of pollution. The experience of monitoring through toxicity test and biological monitoring is limited and such training will help in expanding the knowledge of biological monitoring.

A-5 DESIGN OF APPROPRIATE TRAINING MODULE/COURSE ON WATER QUALITY MONITORING AND ASSESSMENT OF THE DIFFERENT LEVELS OF MAN POWER.

Training needs based on observed shortfalls in Water Quality Monitoring

The shortfalls some of which were discussed in the previous section can be addressed in preparation of training module for effective future water quality monitoring of the Nile river basin. These short falls take account the general condition of water quality monitoring in the country, the shortfalls at the federal level and shortfalls that exist at the regional and zonal. The level of shortfall expands as one moves from the federal to the regions and zones. Therefore various training needs can be identified for the different levels of manpower required at the different levels of management of the Nile River basin.

Definition of Target Levels of man Power

For the purposes of designing the training modules, the following target levels of man power can be identified:

Level I

Skilled man power required for design and supervision of water quality monitoring network, system and water quality management of the Nile basin for trainees composed of the top water quality monitoring staff of the regions Also dealing with data analysis and interpretation and upper level of quality assurance across regions and zones. Training might possibly include community and stakeholder participation as well as project management techniques.

Level II

Skilled man power required for implementing field and laboratory water quality monitoring and analysis at the regional levels. Responsible for supervising technical staff and implementing quality control system, Generating and disseminating data as well as making data analysis.

Level III

Technical staff training in water quality sampling and analysis. Training requirement includes sampling from different sources, sampling techniques for different parameters, basic knowledge of the chemical, physical as well as biological characteristics of the different water sources and pollutants, training in physical, chemical and biological analysis of the different types sources of water and effluents. Training also includes basic safety in laboratories, handling and storage of chemicals, handling and disposal of hazardous substances, etc.

Therefore, the following table shows the training topics that will be covered at each level of the training. The details of the training modules are also attached at the end of the report.

Table 6 Module Design and Module application for Different Levels of Training

Module Number	**Module Topic**	**Training Level I**	**Training Level II**	**Training Level III**
Unit 1b	Design of Sampling program	√	√	√
Unit 1	Design of sampling and monitoring systems	√	√	
Unit 2	Water quality characterizations and impacts of pollution on	√	√	√

Module Number	Module Topic	Training Level I	Training Level II	Training Level III
	water quality			
Unit 3	Physical and chemical Indicators of water quality	√	√	
Unit 4	Biological indicators of water quality	√	√	
Unit 5	Water Quality Standards and Guidelines	√	√	√
Unit 6	Physical Chemical Techniques		√	√
Unit 7	Data Analysis and data management	√	√	
Unit 8	Equipment Maintenance	√	√	√
Unit 9	Laboratory management	√	√	√
Unit 10	Laboratory organization and safety	√	√	√
Unit 11	Field Analysis	√	√	√
Unit 12	Community Participation and volunteer water quality monitoring.	√	√	√

The depth of treatment of this module will be different for the different levels of man power required. This can also be adapted depending on the background of the trainees.

Table 6B: TRAINING CONTENTS AND LEVELS OF THE PROPOSED TRAINING SITES

S.No.	Proposed Training Site	Type and level of training	Specific Training Content
1	Addis Ababa University, Faculty of Science	**Level I.** Skilled man power required for design and supervision of water quality monitoring network, system and water quality management of the Nile basin for trainees composed of the top water quality monitoring staff of the regions Also dealing with data analysis and interpretation and upper level of quality assurance across regions and zones. Training might possibly include community and stakeholder participation as well as project management techniques.	Level I. Design of Sampling program, Design of sampling and monitoring systems, Water quality characterizations and impacts of pollution on water quality, Physical and, chemical Indicators of water quality, Biological indicators of water quality, Water Quality Standards and Guidelines, Physical Chemical Techniques, Data Analysis and data management, Equipment Maintenance, Laboratory management, Laboratory organization and safety, Field Analysis, Community Participation and volunteer water quality monitoring.
2	Addis Ababa University Faculty of Technology	**Level I as above**	As above
3	Arbaminch University, Department of Water and Environmental Engineering	**Level I as above and Level II** Level II. Skilled man power required for implementing field and laboratory water quality monitoring and analysis at the regional levels. Responsible for supervising technical staff and implementing quality control system, Generating and disseminating data as well as making data analysis.	Level II training also including modules related to level I but focusing training for implementation of water quality monitoring at the regional levels. Water quality characterizations and impacts of pollution on water quality, Physical and, chemical Indicators of water quality, Biological indicators of water quality, Water Quality Standards and Guidelines, Physical Chemical Techniques, Data Analysis and data management, Equipment Maintenance, Laboratory management, Laboratory organization and safety, Field Analysis, Community Participation and volunteer water quality monitoring.
4	The Water works design and supervision Enterprise	**Level III.** Training for technical staff training in water quality sampling and analysis. Training requirement includes sampling from different sources, sampling techniques for different parameters, basic knowledge of the chemical, physical as well as biological characteristics of the different water sources and pollutants, training in physical, chemical and biological analysis of the different types and sources of water and effluents. Training also includes basic safety in laboratories, handling and storage of chemicals, handling and disposal of hazardous substances, etc.	Level III training includes. Sampling. Field testing of water quality. Physical and, chemical Indicators of water quality, Biological indicators of water quality, Water Quality Standards and Guidelines, Physical Chemical and biological analysis Techniques, Laboratory organization and safety. Community Participation and volunteer water quality monitoring.
5	The environmental Protection Authority lab	**Level III as above**	Level III content as above
6	The Geological Survey of Ethiopia Laboratory	**Level III as above**	Level III content as above

S.No.	Proposed Training Site	Type and level of training	Specific Training Content
7	The Ethiopian quality and standards authority laboratory	**Level III as above**	Level III content as above
8	Regional Laboratories within the Nile Basin regions in Ethiopia.	Level III limited to **on the job training** in water quality analysis of basic parameters and Volunteer training in water quality analysis and field monitoring.	Sampling. Field testing of water quality. Basic Physical Chemical and biological analysis Techniques. volunteer water quality monitoring

Table 6C: CAPACITY BUILDING AND STAFF TRAINING REQUIREMENTS FOR THE PROPOSED TRAINING SITES.

S.No.	Proposed Training Site	Capacity Building Requirement	Human Resources Development Requirement (Training/Recruitment)
1	Addis Ababa University, Faculty of Science	The Chemistry, biology and geology departments combined have reasonably complete list of equipments and capabilities for the analysis of physical, chemical and bacteriological parameters. Advanced instruments such as the atomic absorption spectrometer, gas chromatography, HPLC, ion chromatography, etc are also available. The supply of reagents, standards and chemicals may be needed.	The university has well qualified staff to carry out the training. Additional training of staff abroad in advanced water quality monitoring and in advanced instrumental analysis for environmental variables may be considered.
2	Addis Ababa University Faculty of Technology	The laboratory facility at faculty of Technology is very limited and requires upgrading.	The university has well qualified staff to carry out the training. Additional training of staff abroad in advanced water quality monitoring and in advanced instrumental analysis for environmental variables may be considered.
3	Arbaminch University, Department of Water and Environmental Engineering	The laboratory has a reasonably complete list of equipments and capabilities for the analysis of physical, chemical and bacteriological parameters. Analysis for ions and nutrients using titrimetric, gravimetric and spectrophotometric methods are being routinely carried in research and consultancy undertakings. The department of applied chemistry in Arbaminch University has an analytical chemistry laboratory with a list of useful advanced instruments such as the atomic absorption spectrometer, gas chromatography, HPLC, ion chromatography, etc. Many of these equipments are already in operation and are being also used by the department of water and environmental engineering for training and research.	The university has well qualified staff to carry out the training. Additional training of staff abroad in advanced water quality monitoring and in advanced instrumental analysis for environmental variables may be considered.
4	The Water works design	The laboratory in this enterprise lacks working instrument for trace	Training of staff in advanced water quality monitoring and

S.No.	Proposed Training Site	Capacity Building Requirement	Human Resources Development Requirement (Training/Recruitment)
	and supervision Enterprise	metal analysis (AAS) and for the analysis of trace organics (GC and HPLC). These equipments need to be provided. However, basic facilities for physical, organic and bacteriological analysis are available.	advanced water quality analysis abroad may be needed.
5	The environmental Protection Authority lab	Instruments available at the EPA laboratory such as the Atomic absorption spectrometer, uV-Visible spectrophotometer, Gas chromatographic apparatus, HPLC need to be commissioned. Additional parts and chemical standards need to be made available.	Training of staff in advanced water quality monitoring and advanced water quality analysis abroad may be needed.
6	The Geological Survey of Ethiopia Laboratory	The laboratory facilities are largely for inorganic cations and anions analysis. If complete analysis training is desired, additional equipments are needed which may be difficult to provide due to the limited scope of the geological survey laboratory duties.	Training of staff in advanced water quality monitoring and advanced water quality analysis abroad may be needed. However, the scope of the laboratory to offer training is limited as explained already.
7	The Ethiopian quality and standards authority laboratory	The laboratory is well equipped. However, provision of reagents and chemicals need to be planned for the analysis of trace organics using gas chromatography. Capability also exists for the trace analysis of heavy metal using atomic absorption spectrophotometer.	Training of staff in advanced water quality monitoring and advanced water quality analysis abroad may be needed. Enough number of staff currently are not available. Hence additional staff (B.Sc and above) in Chemistry, biology and environmental engineering need to be recruited.
8	Regional Laboratories within the Nile Basin regions in Ethiopia.	Both the zonal and regional laboratories shall be equipped with equipment for the common physical and chemical analysis including spectrophotometer, titration and gravimetric apparatus, ion selective electrodes.	The staff at the regional laboratories shall receive training in the higher institutions sited above in water quality analysis and water quality monitoring and in operation of instruments for advanced analysis. A minimum requirement of B.Sc in Chemistry or Environmental Engineering shall be specified for the training staff.

A- 6 OTHER TRAINING MATERIALS THAT CAN BE USE TO TRAIN COMMUNITIES AND OTHER STAKEHOLDERS AT THE CATCHMENTS LEVEL

The following training modules are proposed for the training of communities and other stakeholders at the catchment level. The objective of training communities in water quality monitoring is to help with the efforts of environmental protection, fill the man power gap and inculcate environmental values among the society so that they act as important partners and force in environmental protection and prevention of pollution.

Table 6D: Training module for Community participation in water quality monitoring

Module Number	Module Topic	Sub topic	Subjects Covered
1	Elements of water and its quality	Basic Concepts	Basic concepts: the hydrological cycle. The living stream environment. Stream classification. Water quality and sources of water pollution.
		Designing the water quality monitoring study	Reason for monitoring. Use of monitoring data. The use of data of monitoring. Parameters to monitor. How good should the data be? Where will monitoring takes place? Data presentation and data credibility
		Safety consideration	Safety during stream monitoring. Safety in laboratory and handling of chemicals. First aid kit
		Equipment for field activity	For enhancing the community effectiveness and safety
2	Watershed Survey Methods		How to conduct watershed survey The visual assessment
3	Macro invertebrates and habitats		Stream habitat walk Stream side bio-survey Intensive stream bio-survey
4	Metric for stream health		Selecting stream health to determine the health of stream.
5	Water Quality Conditions		Quality assurance and quality control. Stream flow Dissolved Oxygen, Biochemical Oxygen Demand** Temperature, pH, Disk Transparency, Phosphorous, Nitrates, Total Solids, Conductivity Alkalinity, Faecal Coliforms**
6	Managing and Presenting Monitoring Data		Managing data Presenting data Producing reports

** BOD and Coliform analysis are recommended based on the assumption that senior high school students are offered training for this purpose and can do the analyses as required.

B. WATER QUALITY PARAMETERS

B-1 WATER QUALITY PARAMETERS THAT ARE REGULARLY TESTED FOR IN THE COUNTRY.

The following data obtained from various sources is indicative of the types of variables that are being regularly tested for in the country.

Ground water

It is not possible to say parameters are being regularly tested for in Ethiopia in the absence of a clear implementation program for water quality monitoring. However, from the available data it is possible to identify the parameters that are being tested in many cases when analyses are being carried out for the ground water. The parameters that are regularly tested in the country include: color, Electrical conductivity, Hardness, total alkalinity, pH, TDS, Nitrate, Nitrite, Chloride, Fluoride, Sulfate, Phosphate, Sodium, potassium, Iron and manganese

Surface water Rivers)

Parameters being analyzed for surface water sources commonly include: turbidity, Conductivity, Total dissolved solids, pH, Nitrate, Chloride, Carbonate, bicarbonate, sulphate, phosphate, Sodium, Potassium, Calcium, magnesium.

Surface Water (Lakes)

For lake water the following parameters are often being analyzed. pH, total dissolved solids, conductivity, transparency, temperature, chlorophyll a, Bioassay, dissolved oxygen, calcium, magnesium, chloride, Silica, carbonate, bicarbonate, hardness

Potable water

Parameters that are being routinely analyzed for potable water sources include: pH, conductivity, hardness, alkalinity, calcium, magnesium, total dissolved solids, turbidity, faecal coliforms and some what less frequently nitrate, sulphate, Fluoride, chloride, sodium, and potassium.

Waste water Effluent

Parameters that are being analyzed on industrial effluents are variable and they depend on the type of industries established. Parameters that are analyzed include: BOD, COD, Ammonia, Nitrate, Nitrite, Sulphate, Phosphate, Chloride, Alkalinity, Acidity, H_2S, pH, Suspended solids, Fixed and volatile solids, Settleable solids, heavy metal including cadmium, chromium, Lead, Nickel, Zinc, Copper, Iron and manganese.

B-2 THE ADEQUACY OF THE LABORATORY FACILITIES AND STATE WHETHER THE PARAMETERS TESTED, ADEQUATELY DESCRIBE THE STATUS OF WATER QUALITY IN THE NILE BASIN, AND IF THE PARAMETERS ARE TOO FEW WHAT ADDITIONAL PARAMETERS SHOULD BE ANALYZED.

Adequacy of laboratory facilities

Regional Laboratories:

Many of the regional laboratories located within the Nile basin have shortage of equipment and consumables for complete chemical analysis (Fitsum, 2003). The equipments in Gambella are limited to equipment for basic parameters such as pH, dissolved oxygen, conductivity. They have also equipment for bacteriological analysis and spectrophotometer which can be used to analyze compounds and elements using colorimetric techniques. Considering the sampling and analysis requirements these equipments are not enough. Analysis of trace metals and persistent organics require equipment such as atomic absorption spectrophotometer and gas chromatography, and are not available in the regions. Even flame photometer required for the analysis of potassium and sodium is not available.

The Tigray, Benishangul, Amhara and Oromoia regional laboratories have more or less similar capacities and suffer from the same draw back.

For field analysis many of the chemical analysis with few exceptions can be analyzed by using field portable test kits. While these equipment are handy and faster to analyze with, they will have to be calibrated against known standard solutions and quality control problems related to limits of detection, matrix effects, reagent purity, etc need to be sorted out properly.

It can be said that the regional laboratories in Gambella, Benishangil, Oromia, Amahara and Tigray that are within the Nile Basin need to be upgraded both with respect to equipment and chemicals. Considering the geographic dimensions of the regions it is necessary to have complete regional laboratory accompanied by a number of zonal laboratories of intermediate capacities. The regional laboratories should have capabilities of trace metal analysis and analysis for persistent organics. These equipments call for gas chromatography and atomic absorption spectrometer.

Both the zonal and regional laboratories may be equipped with equipment for the common physical and chemical analysis including spectrophotometer, titration and gravimetric apparatus, ion selective electrodes.

The limited qualified staff available in the region is another draw back that should be addressed through an appropriate training program.

Capabilities of the EPA laboratory

The environmental protection authority has the following capabilities (Table below).

Table 7: Capacities of the Environmental Protection Authority Laboratory

Characteristic	Parameter
General	Appearance, odor, Taste, Turbidity, Color, Electrical conductivity, temperature, pH, total dissolved solids, dissolved oxygen, redox potential, hydrogen Sulphide, total alkalinity, hardness
Solids	Total solids, fixed solids, total suspended solids, total settleable solids
Organic	Total organic carbon, chemical oxygen demand, biological oxygen demand
Other Inorganic and Organic variables	Total nitrogen, inorganic nitrogen, organic nitrogen, ammonia, total phosphorous, inorganic phosphorus, orthophosphate, silicate, carbon dioxide hydroxide.
Major Ions	Sodium, potassium, calcium, magnesium
Trace Metals	Total iron, iron, manganese, nickel, cobalt, copper, cadmium, chromium, zinc, silver, mercury, arsenic, selenium
Major anions	Bicarbonate, carbonate, chloride, sulphate, nitrate
Other anions	Nitrite, fluoride, boron, cyanide, Phenol, anionic surfactants

From the above list of parameters that can be analyzed it appears that some of them necessitate the operation of advanced instrumental equipment such as the atomic absorption spectrometer. Equipment for BOD, COD analysis exist including also the Kjeldhal apparatus for nitrogen analysis, and ion selective electrodes for the analysis of chemicals such as Fluoride. Equipment for field sampling is also available in addition; the WTW Multiline P 4 Universal pocket meter is capable of making simultaneous analysis of pH, dissolved oxygen, TDS, salinity, temperature.

The Merck Spectrquant Nova 60A portable spectrophotomer that operates with battery is also available that can be used for on-site monitoring of water quality.

The bacteriological analysis equipments are available and the laboratory has the technical capacity to make bacteriological analysis.

Capabilities of the Ethiopian water works design and supervision enterprise laboratory.

Except for the atomic absorption spectrometer, the laboratory is capable of analyzing many of the chemical, physical and bacteriological parameter. Field monitoring and analysis with portable spectrophotometer also exists in this laboratory which is used for field testing and rapid analysis.

Ground water

The parameters that were quoted as being analyzed include: color, Electrical conductivity, Hardness, total alkalinity, pH, TDS, Nitrate, Nitrite, Chloride, Fluoride, Sulfate, Phosphate, Sodium, potassium, Iron and manganese. Additional parameters are necessary in order to assess the quality of ground water quality in the basin.

Organic compounds

Organic constituents such as aromatic hydrocarbons, chlorinated alkenes and chlorinated ethenes may have carcinogenic effect in humans and may have to be monitored. The table below shows some of these compounds included in the Ethiopian

Guideline specification for drinking water quality. It should be noted that the occurrence of these compounds in the Nile Basin regions in Ethiopia is seldom reported and the recommendation of the guideline for drinking water quality is adopted here based on an assumed future potential for occurrence, the monitoring frequency of which will have to be decided accordingly.

Table 8: The Ethiopian guidelines Specification for Drinking Water Quality (Organic Compounds)

Aromatic hydrocarbons	**Chlorinated Alkanes**	**Chlorinated Ethenes**
Benzene	Carbon tetrachloride	1,1, dichloroethene
Benzo Pyrene	1,2 dichloroethene	Trichloroethene
		Tetrachloroethene

Organochlorine compounds that may come in the form of organochlorine pesticides include a number of chlorinated hydrocarbons and related compounds that contain functional groups incorporating oxygen and or sulpher. The analysis for these parameters may be important as the basin is predominantly inhabited by people who use land for agricultural produces. The table below shows examples of some of the organo-chlorine compounds that may be analyzed by gas chromatographic techniques. The actual specification in future for monitoring may be limited based on prevalence and use of these chemicals in industries and agriculture.

Table 9: Organochlorine Pesticides

α -BHC	Heptachlor Epoxide	o-p DDT
PCNB	Endosulfan I	p-p ddd
Lindane	P,p DDE	Endosulfan II
Dichloran	Dieldrin	p-p-DDt
Heptachlor	Captan	Mirex
Aldrin	Endrin	Methoxychlor

Organo-phosphorous compounds Restriction on the use of chlorinated pesticides has given rise to other pesticides such as organo- phosphorous compounds. It may be useful to analyze for some of the organo-phosphorous pesticides described below using again gas choromatographic techniques. The actual specification in future for monitoring may be limited based on prevalence and use of these chemicals in industries and agriculture.

Table 10: organo-phosphorous compounds

Compound	Compound	Compound
Azinphos methyl	Malathion	Phorate
Carbophenotion	Prathion ethyl	Ronnel
Diazinon	Parathion methyl	Dimethotate

Heavy Metals

Analysis of the heavier metals may be needed in order to assess the existence of trace pollution by heavy metals. Depending on the existence of the pollution sources the following metals may be determined:

Table 11: Analysis for Metals

Aluminum	Iron	Strontium	
Cadmium	Manganese	Tin	
Chromium	Mercury	Vanadium	
Cobalt	Molybdenum	Zinc	
Copper	Nickel		
Lead	Silver		

Non-metallic Constituents

Depending on the risk of pollution (natural or anthropogenic) the following non-metals may have to be analyzed: Arsenic, Boron, bromide, Cyanide, Fluoride, Nitrogen compounds, phosphorous and Sulphide.

The parameters that may be analyzed are included in the table below.

Table 12 Parameters for Analysis of ground water sample

Physico-chemical (inorganic)	**Heavy Metals**	**Organic compounds/ Pesticides**	**Salinity/Alkalinity**
Total dissolved solids	Aluminum	Dieldrin	Sodium absorption ratio
Transparency	Iron	Aldrin	Salinity
Odor, color, turbidity	Manganese	DDTs	Alkalinity
Temperature	Cadmium	Atrazine	
pH	Chromium	Lindane	
Electrical Conductivity	Copper	Aldicard	
Dissolved Oxygen	Lead	Organo-phosphorous pesticides	
Calcium	Mercury		
Magnesium	Nickel		
Sodium Potassium	Selenium		
Chloride	Zinc		
Sulfate			
Alkalinity			
Nitrate			
Nitrite			
Ammonia			
Phosphorous			
Silica			
Fluoride			
Faecal Coliforms			
Arsenic			
Boron			
Cyanide			
Chloride			
Sulfide			

Surface water (Rivers)

Parameters being analyzed for surface water sources commonly include: turbidity, Conductivity, Total dissolved solids, pH, Nitrate, Chloride, Carbonate, bicarbonate, sulphate, phosphate, Sodium, Potassium, Calcium, magnesium. Monitoring of surface water need to include many other parameters of phisico-chemical indicators of water quality. In addition monitoring should include biological indicators to investigate possible ecosystem change. The river discharge should be monitored by establishment of gauging station and the presence of discharge measurement will form the basis for estimating pollutant load from rivers which is important for modeling water quality changes downstream. The following parameters may be needed for the analysis of surface waters (rivers).

Table 13: Parameters for the analysis of river water samples

Physico-chemical (inorganic)	**Physico-chemical (organic)**	**Trace Elements**	**Organic Traces**	**Biological Parameters**
Odor and color	BOD	Arsenic	Anionic surfactants	Total coliforms
Turbidity	COD	Boron	Mineral Oil	Faecal coliforms
Temperature	Total Organic carbon	Cadmium	Phenolic compounds	Faecal streptococci
Suspended solid	Organic Nitrogen	Lead	Hydrocarbons	Chlorophyll a
Dissolved solid		Mercury	Pesticides	Trophic and Saprobic levels
Residue and floatable substance		Nickel		Bentic organisms
Sediment samples		Zinc		Toxicity test using fish
Ammonia				
Calcium				
Fluoride				
Iron				
Magnesium				
Manganese				
Nitrate				
Sodium				
Sulphate				
Sulphide				
Nitrogen				
Potassium				
pH value				
Conductivity				
Dissolved Oxygen				
Hardness				
Carbon dioxide				
Chloride				

Surface Water (Lakes)

For lake water the following parameters are often being analyzed. pH, total dissolved solids, conductivity, transparency, temperature, chlorophyll a, Bioassay, dissolved oxygen, calcium, magnesium, chloride, Silica, carbonate, bicarbonate, hardness

The following compounds may be necessary for complete characterization of lakes water sources (FItsum, 2005).

Table 14: Parameters for the analysis of lake water samples

Physico-chemical (inorganic)	**Physico-chemical (organic)**	**Heavy Metals**	**Pesticides**	**Salinity/Alkalinity**
Total dissolved solids	BOD	Aluminum	Dieldrin	Sodium absorption ratio
Transparency	COD	Iron	Aldrin	Salinity
Total Suspended Solid	Total Organic Carbon	Manganese	DDTs	Alkalinity
Temperature	Organic Nitrogen	Cadmium	Atrazine	
pH		Chromium	Lindane	
Electrical Conductivity		Copper	Aldicard	
Dissolved Oxygen		Lead	Organo-phosphorous pesticides	
Calcium		Mercury		
Magnesium		Nickel		
Sodium Potassium		Selenium		
Chloride		Zinc		
Sulfate				
Alkalinity				
Nitrate				
Nitrite				
Ammonia				
Phosphorous				
Silica				
Fluoride				
Faecal Coliforms				
Arsenic				
Boron				

Potable (drinking) water

Parameters that are being routinely analyzed for potable water sources include: pH, conductivity, hardness, alkalinity, calcium, magnesium, total dissolved solids, turbidity, faecal coliforms and some what less frequently nitrate, sulphate, Fluoride, chloride, sodium, and potassium.

According to the Ethiopian drinking water guideline specification in connection with health effects and the use of water for various purposes the following list of determination may be needed with varying levels of frequency;

Table 15: the Ethiopian guideline specification in connection with health effects and the use of water for various purposes

Aesthetic and Bacteriological Quality	**Physical and inorganic parameters**	**Organic Constituents**	**Heavy Metals**	**Pesticide**	**Disinfection products**
E-coli	Arsenic	Benzene	Aluminum	DDT	Chlorine
Faecal streptococci	Barium	Banzo pyrine	Iron	Alderine	Chlorophenol
Color	Boron	Carbon tetrachloride	Manganese	Dieldrin	Trichlorophenol
Odor	Cyanide	1,2, dichloroethane	Cadmium	Chlordane	Trihalomethane
Turbidity	Fluoride	Chlorinated ethanes	Chromium	Pentachlorophenols	Chloroform
Suspended solids	Lead	1,1, dichloroethene	Copper		
Dissolved solids	Manganese	Trichloroethene	Lead		
Temperature	Nitrate	Tetrachloroethene	Mercury		
Total solids	Nitrite		Nickel		
	Selenium		Selenium		
	Aluminum				
	Ammonia				
	Chloride				
	Hydrogen Sulphide				
	sodium				
	Potassium				

Aesthetic and Bacteriological Quality	Physical and inorganic parameters	Organic Constituents	Heavy Metals	Pesticide	Disinfection products
	pH				
	Alkalinity				
	Hardness				
	Ammonia				
	Carbon dioxide				
	Sulphate				
	Dissolved oxygen				
	Calcium				
	Magnesium				
	iron				

Waste water Effluent

Parameters that are being analyzed on industrial effluents are variable and they depend on the type of industries established. Parameters that are analyzed include: BOD, COD, Ammonia, Nitrate, Nitrite, Sulphate, Phosphate, Chloride, Alkalinity, Acidity, H_2S, pH, Suspended solids, Fixed and volatile solids, Settleable solids, heavy metal including cadmium, chromium, Lead, Nickel, Zinc, Copper, Iron and manganese.

According to the EPA specification the following significant parameters have been identified (table below):

Table 16: Parameters for the analysis of industrial effluents

Industry	Group I*	Group II**
Aluminum works	Suspended solids, free chlorine, fluoride, oil and grease, pH	Total dissolved solids, Phenol, Aluminum
Cane Sugar processing	BOD5, pH, suspended solids, settleable solids, total coliforms, oil and grease, toxic materials	Alkalinity, Nitrogen (total), temperature, total dissolved solids, color, turbidity, foam
Beverage Industry	BOD5, pH, suspended solids, Settleable solids, total coliforms, oil and grease, toxic materials	Nitrogen, Phosphorous, Temperature, Total dissolved solids, Color, Turbidity, Foam
Fruits and vegetable	BOD5, COD, pH	Color, Faecal coliforms, total phosphorous,

Industry	Group I*	Group II**
industry		suspended solids, temperature, total organic carbon
Livestock feeding	BOD_5, COD	Faecal coliforms, Nitrogen, Total solids, Phosphate, pH, TOC
Diary industry	OD, COD, pH, Suspended solids	Chlorides, color, Nitrogen, Phosphorous, Temperature, Total organic carbon, Toxicity, Turbidity
Fertilizer Industry	Ammonia, chloride, total chromium, dissolved solids, nitrate, sulphate, suspended solids, urea and other organic nitrogen compounds, zinc calcium, dissolved solids, fluoride, pH, phosphorous, suspended solids, temperature	Calcium, COD, gas purification chemicals, total iron, oil and grease, pH, phosphate, sodium, temperature, acidity, aluminum, arsenic, iron, mercury, nitrogen, sulphate, uranium
Cement, lime asbestos industries	COD, pH, phosphorous, sulphate, suspended solids, temperature	BOD5, chromium, zinc, copper, iron, tin, silver, nitrates, synthetic resins, total dissolved solids
Leather tanning and finishing	BOD_5, COD, chromium, grease, pH, suspended solids, total solids	Alkalinity, color, hardness, nitrogen, sodium chloride, temperature, toxicity
Meat processing industry	BOD_5, pH, suspended solids, settleable solids, oil and grease, total coliforms, toxic materials	Ammonia, turbidity, total dissolved solids, phosphate, color
Metal finishing	COD, oil and grease, heavy metals, suspended solids, cyanide	
Pulp and Paper	BOD_5, COD, pH, total suspended solids, coliforms, total and faecal, color, heavy metals, toxic materials, turbidity, ammonia, oil and grease, phenols, sulphite	Nutrients, nitrogen and phosphorous, total dissolved solids
Plastic materials industry	BOD_5, COD, pH, total suspended solids, oil and grease, phenols	Total dissolved solids, sulphates, phosphorous, nitrate, organic nitrogen, ammonia, cyanides, toxic additives and materials, chlorinated benzenoids, polynuclear aromatics, zinc, mercaptans
Steel	Oil and grease, pH, chloride, sulphate, ammonia, cyanide, phenol, suspended solids, iron, tin, temperature, chromium, zinc	
Textile mills	BOD_5, COD, TOC, pH, suspended	Heavy metals, color, oil

Industry	Group I*	Group II**
	solids, chromium, phenolics, Sulphide, alkalinity	and grease, total dissolved solids, sulphides, temperature, toxic materials
Organic chemical industry	BOD_5, COD, pH, total suspended solids, free-floating soils	Total organic carbon, organic chloride, total phosphorous, heavy metals, phenol, cyanides, total nitrogen,

*Group I Consists of the most significant parameters for which effluent limits will most often be set
**Group II consists of some additional parameters for which effluent limits can be set on an individual basis.

B-3 INVENTORY OF THE MAJOR POLLUTION SOURCES,

The Nile transboundary environmental analysis on the Ethiopian portion of the Nile basin report (May 2001) puts deforestation, soil erosion, over grazing, desertification, and sanitation, loss of bio diversity, floods, and droughts. Silts will fill dams constructed in Sudan and Egypt. Because of heavy deforestation the forest cover is being depleted in Western Ethiopia.

The report explains the presence of serious water borne disease in the area. The most serious are malaria, bilharzias and diarrhea. Basin- wide diarrhea is related to contact with and consumption of drinking water caused by discharge of partially treated or untreated sewage, compounded by insufficient hygiene education.

In the downstream countries, Sudan and Egypt, agricultural runoff brings pollutants. In Egypt the water quality of the Nile declines dramatically on its way from Aswan to the Delta, with decreasing levels of dissolved oxygen and increasing total dissolved solids. The drainage canals that collect water from agricultural areas also receive increasing quantities of untreated or partially treated industrial waste water, solids waste or sludge. Concentrations of salts, organic matter, nutrients, coliforms, heavy metals and pesticides are high especially in the northern parts of the delta.

Non-point source pollution are also reportedly high in the downstream countries. These are particularly associated with excessive use of agricultural chemicals: pesticides and fertilizers. These chemicals enter the river system lakes and reservoirs of the basin. The results have included increased nutrient levels, eutrophication, fish mortality, growth of unwanted organisms and deteriorating water quality to the detriment of all users (Nile transboundary environmental analysis report, May 2001).

Sedimentation problems are also apparently high in the area and are closely related to soil erosion problems. The effects are manifested through increasing siltation of reservoirs, decrease in power production, deteriorating water quality in reservoirs and irrigation canals.

Water weed infestation also has increased because of increase in nutrient levels in the rivers.

<u>Water quality monitoring and pollution control in the Nile Basin</u>

The Nile basin transboundary environmental analysis emphasizes on establishment of basin wide water quality monitoring program which can facilitate sampling at strategic points of the course of the river. Such data collected and managed at the respective national levels and exchanged where appropriate will allow for improved planning, zoning, development and conservation of water resources. A comprehensive basin wide overview of water quality and trans-boundary assessment and action requires establishment of common and accepted methods of measuring key water quality parameters.

Water quality which currently is being threatened in the more industrialized areas of the Nile – such as the Delta, will be increasingly under stress with growth in local industries and urbanization. To assure a sustainable development path for the basin measures for pollution prevention and environmental monitoring need to be available including the technical, regulatory, and institutional and human capacity to implement these.

B-3-1 MAJOR POLLUTION SOURCES WITHIN THE NILE BASIN IN ETHIOPIA

The Baro-Akobo Basin

The Baro Akobo basin is largely rural area settlement and there is not much information available as to the development in terms of industrialization. The only development undertakings that have influence in water quality of the Baro river are limited mining activities and agricultural practices that may be accompanied by the use of polluting chemicals (fertilizers and pesticides).

In general within the Ethiopian part of the Nile basin (Baro-Akobo) does not seem to pose significant problems. There does not appear to be significant water quality problem except in the localized areas. In the Baro-Akobo basin no problem exist form industrial discharge of wastes. Consideration over sedimentation arising from the extensive erosion within the upper catchment should be of concern to both Ethiopia and the downstream riparian countries as this affects environment and use of water.

Mining activities:

Since ancient times the three mineralized belts have been known for their gold and local people have exploited platinum and iron ore as well as gold. Mining is an artisan activity at present.

Baseline Water Quality Data of Surface and Under Ground Water in the Baro-Akobo Basin

In earlier studies (Master plan report, volume II, 1996) samples of water from rivers, springs, wells and test boreholes were collected and analyzed for inorganic chemical content. A total of 399 samples were analyzed. Sample analysis made of Gambella plains were found to range in total dissolved solids (TDS) from 72 to 955 mg/L. Most tested water was found to be chemically suitable for human drinking. With the exception of a few samples of highly mineralized water which ranged 2300 mg/L of TDS. All waters in the central and eastern sectors of the Baro-Akobo basin were tested to be potable.

Location of Pollution Sites for Baro-Akobo River Basin.

The majority of the population in the Baro-Akobo river basin is rural that is significantly higher than the national average. The region's economy is dominated by agriculture. Major Industrial sites are almost non-existent and there is not much record available concerning the impacts of polluting effluents from industries in to the basin. However, due to the large volume of water that passes as transboundary discharge the effects of effluent discharges from the few industries may be very limited.

Lack of appropriate domestic waste disposal system, the increasing agricultural practices coupled with the application of agricultural chemicals (pesticides and fertilizers) may point to the importance of non-point sources of pollution and the need to place monitoring strategy according to the discharge of streams, population density with some focus on possible point sources of pollution (such as the major industrial sites mentioned above).

Owing to the absence of major point polluting sources, it might be appropriate to locate the pollution sites with respect to rivers confluence by adapting Sander's method of locating monitoring station. The Sander's method of locating river monitoring site for pollution identification and the location of the monitoring sites has been applied, the results of which are indicated in the figure below. The Sanders method is also explained below.

Location of Pollution (Monitoring) sites by sander's Method

Sanders based macro location of sampling points based on either:

1. location by the number of contributing tributaries
2. location by the number of pollutant discharges
3. Location by means of BOD loadings.

Owing to the absence or lack of data concerning pollutant discharges as well as BOD loadings, only location with respect to the number of contributing tributaries will be used in this paper.

Stream ordering will be done in accordance with number of contributing tributaries and for any hierarchy level, the centroid will be found by dividing the total stream order in to two and continuing this procedure for higher level of hierarchy.

According to the third level of hierarchy, 9 sampling points have been identified that are shown in the table below:

Table 17: Sampling Location for monitoring Pollution in Baro Akobo Basin

Sampling Point	**Description of sampling point**
1	Birbir river after confluence with Geba
2	Near Bonga after confluence of Baro and Birbir rivers
3	Gilo river before confluence with Betawuhan
4	Gilo river after confluence with Betawuhan
5	Baro river before confluence with Alwero river
6	Alwero river before confluence with Baro river
7	Gilo river before confluence with Pibor river
8	Pibor river before confluence with Gilo river
9	Final outlet after confluence of Baro, pibor and Gilo rivers

The figure below shows the indicated monitoring sites for pollution determined after applying Sander’s method.

The figure below shows the indicated monitoring sites for pollution determined for **Tekeze River Basin**

Location of Monitoring Sites in the Tekeze Basin Using Sander's Method

Owing to erosion and the predominantly rural settlement and the use of agriculture for subsistence coupled with the lack of major industries in the area points to the fact that non-point sources of pollution may carry more impact than point sources of pollution. The Sander's method has been applied for locating monitoring station using number of streams as variable. The Sander's method has already been described.

The result of stream monitoring location after applying the Sander's method is given in the figure below. In addition the description of the sample collection sites or stream are integrated in the table below.

Module Structure

UNIT 1. DESIGN OF SAMPLING AND MONITORING SYSTEMS

Objectives: (Sampling)

- To train water quality technical staff and laboratory analysts in basic water quality sampling techniques for water quality monitoring.
- To introduce participants to equipments and types of sampling devices.
- To train the trainees in basic sampling procedures for sampling from the different water sources.
- To introduce basic techniques of sample storage, preservation and preparation for sampling.
- To train the trainees in locating sampling station and in deciding on sampling frequency.

Objectives: (Monitoring)

1. To introduce the relationship between water quality and physical, biological and chemical processes
2. To introduce the objectives and steps of water quality monitoring tasks
3. To introduce the different monitoring set up between natural and waste water
4. To introduce the design of sampling location and frequency as well as network design.
5. To introduce the design of analysis methods

6. To introduce the basic requirements of data analysis, interpretation and information dissemination

Duration: (72 +65 = 137 hours = 3 ½ weeks)

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants: Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

1.1 Design of Water Quality Monitoring Systems (72 Hrs)
1.2 Design of Sampling Program (65 Hrs)

Module Design for 1.1. Design of Water Quality Monitoring Systems (72 Hours)

Module Number	Module Topic	Duration	Sub topics and activities
1.1.1	Factors affecting design of Monitoring systems	3 hrs	-distribution of chemicals in aqueous phase - accumulation and release of bottom deposits - accumulation and release by aquatic biota - inputs from atmosphere and land - anthropogenic inputs
1.1.2	Logical Design of Monitoring System	3 hrs	- Basics steps of the design of Monitoring systems - Information required at steps of the Monitoring systems
1.1.2.1	Step 1 Objective of Monitoring	3 hrs	- Short term and long term objectives of water resources management. - Problems in water resources management that require solution and require water quality Monitoring - Scheduling of Monitoring programs
1.1.2.2.	Step 2a Setting up models of Monitoring systems for natural water	3 hrs	- Collection of information on water quality - Water quality changes and trends - Relationship between pollution loads and water quality changes. - Determining unknown sources - Setup of monitoring and Early warning systems - Emergency and cleanup system setup
1.1.2.3	Step 2b Setting up models of Monitoring systems for waste water	3 hrs	- Assessment of detrimental effects - Feasibility studies of treatment alternatives - Studies on alteration to production processes - Determination of types and quantities of waste discharged. - Recycling and valuable byproducts from wastes. - Control of spills of hazardous materials
1.1.2.4	Step 3 Identification of Water Quality Parameters	6 hrs	- Review of Water quality criteria and tolerance limits. - Historical data and report analysis - Screening tests of pollution sources - Model system - Determination of levels of Monitoring required for data interpretation - Examples of water quality parameters (general, phsico-chemical, biological, microbiological). - Setting up grades of Monitoring related to hazard levels
1.1.2.5	Step 4 Sites and Frequency of Monitoring	6 hrs	- Factors that govern sites and frequency of Monitoring. - Hydrodynamic Properties versus sites and frequencies - Environmental conditions - Pollution input rates and decay - Application of remote sensing in sites location for Monitoring. -
1.1.2.6	Step 5 Design of analysis methods	12 hrs	- Guidelines in selection of analysis method (number of samples, frequency, geography, time, sensitivity, detection limit, accuracy and precision) - Method selection for field analysis - Laboratory equipment and space requirement for selected

Module Number	Module Topic	Duration	Sub topics and activities
			methods. - Requirements and provisions for field analysis. - Selection of methods for mobile laboratory analysis
1.1.2.7	Step 6 Data Processing	18 hrs	- Standards and uniformity for data expression. - Accuracy and precision. - Statistical analysis - Graphical representation of data
1.1.2.8	Step 7 Data Interpretation	12 hrs	- Correlation among water quality variables. - Steady state and transient correlations - Chemical equilibrium models (ex. Cation/anion balance) - Dynamic modeling (spatial and temporal scale)
1.1.2.9	Step 8 Information Dissemination	3 hrs	- Social, political and economic requirements
			-

Module Design for 1.2. Design of Sampling program (65 hours)

Module Design for 1.2. Design of Sampling program			
Module Number	**Module Topic**	**Duration**	**Sub topics and activities**
1.2.1	Aim and consequence of sampling programs	2 hrs	-aim of sampling programmes -consequence of sampling programmes -Economics of sampling - sampling requirements: validity and representative ness Factors involved in the design of sampling programmes
1.2.2	Sample validity	3 hrs	-factors affecting sample validity(time, frequency, location, statistics) -
1.2.3	Sample Representative ness	3 hrs	-Factors affecting sample representative ness (size, mode of collection, container, transportation, preservation and storage)
1.2.4	Sampling Position	6 hrs	-Micro and macro location of samples -Factors affecting sample location; quality variation, physical, chemical and biological characteristics of parameters leading to heterogeneity, -preliminary Monitoring for sample location -Location and seasonal water quality variations -Convenience requirements -composite sampling Tests for micro location of samples: mixing, stratification.
1.2.5	Sampling from streams and rivers	6 hrs	-equipment for sampling - Local features affecting quality. Long-term versus short term variations - Longitudinal and cross sectional variation in quality. -Location requirement for an effluent

Module Design for 1.2. Design of Sampling program			
Module Number	**Module Topic**	**Duration**	**Sub topics and activities**
1.2.6	Sampling from lakes and reservoirs	6 hrs	-Influence of stream input on lake water quality. - Variation lake water quality with depth -factors influencing lake water quality variation with depth. -seasonal and climatic effects -determination of sampling points in lakes for parameters.
1.2.7	Sampling from ground water, treatment plant and distribution systems	6 hrs	-effect of aquifer characteristics sample location - nature if pollutant transport and sampling requirements -sampling location for treatment effluent. -sampling location determination within distribution systems
1.2.8	Time and Frequency of sampling	6 hrs	-sampling for quality characterization and quality control. - Determination of sampling frequency in rivers -application of statistics for determining number and frequency of samples. -determination of sampling frequency for water quality control purposes. -spatial correlation of water quality. -determination of frequency and location for composite sampling.
1.2.9	Sample Representative ness	6 hrs	- Volume of sample requirements. - Manual sampling techniques Sampling requirements for the various water quality parameters. -sampling container types and sample container preparation - Security provision of sampling sites. -contamination sources and methods of removal. -Filtration of samples
1.2.10	Sediment Sampling	6 hrs	-Types of sediments encountered. -types and nature of rivers and their effect on sediment sampling. Types of sediment sampling devices: dredged sampler, grab and core samplers.
1.2.11	Sample transportation and storage	6 hrs	- Equipment and precaution for sample transportation. - Climatic effects on sample transportation. - Common reaction occurring during sample storage. - Special storage and immediate treatment - On site treatment for stability of samples ex. Fixing Dissolved oxygen by Winkler method. -
1.2.12	Sample Preservation	6 hrs	- Preservation for metals analysis - Preservation for avoiding biological action. - Types of preservation for different sampling techniques. - Effect of preservatives on the analyte.

Module Design for 1.2. Design of Sampling program			
Module Number	**Module Topic**	**Duration**	**Sub topics and activities**
			- Determination of volume of preservative. -
1.2.13	Sample identification and labeling	3 hrs	- Labeling requirement for surface water - Labeling requirement for ground water
			-

UNIT 2: BACKGROUND TO WATER QUALITY MONITORING

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. Characterizing the water qualities of different water sources.
2. Assisting the water quality changes of different water bodies
3. Identification of water quality parameters that are of trans boundary importance
4. The different water quality standards applicable.
5. Understanding the global and local concerns of water quality
6. Understanding the implication of pollution on the water qualities of different water systems.

Duration: 109 hours = 3 weeks

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants:

Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

2.1. Water quality definitions and Characteristics (17 hrs)
2.2. Water quality monitoring and assessment (17 hrs)
2.3. Parameters of transboundary importance (16 hrs)
2.4. Global and Local state of water quality and water quality monitoring Initiatives (6 hrs)
2.5. Threats to water sources and Impacts of water pollution (27 hrs)
2.6. Water quality parameters standards and guidelines (26 hrs)

Module Design for 2.1. Water quality definitions and Characteristics (17 hours)

Module Number	Module Topic	Duration	Sub topics and activities
2.1.1	Definition of water quality	2 hrs	-Definition. Factors affecting water quality - Expression of water quality -importance of water quality
2.1.2	Surface waters	3 hrs	- Hydrological characteristics of surface waters, mixing and residence times
2.1.3	Lakes and Reservoirs	3 hrs	- causes of stratification, -Thermal stratification -seasonal variation in lake characteristics and lake morphometry
2.1.4	Rivers	3 hrs	-Classification of rivers and morphology of rivers River flow and surface characteristics. - Climate and surface characteristics of rivers. - factors influencing sediment loads on rivers
2.1.5	Ground Water	3 hrs	-Occurrence and geological formations, types of aquifers -Confined and unconfined aquifers -factors affecting ground water geochemical processes. -Pollution and contaminant transport in ground water
2.1.6	Natural Processes affecting water quality	3 hrs	-natural events- torrential rainfall, hurricane, landslides -Changes due to Seasonal overturn in lakes -hydrological, chemical, physical and biological processes affecting water quality. - Factors affecting homogeneity of water quality in water bodies. -Natural factors leading to presence of toxic and undesirable compounds in water.

Module Design for 2.2. Water quality Monitoring and assessment (17 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
2.2.1	Water quality and monitoring background	2 hrs	Definition of water quality monitoring. Definition of water quality assessment -Differences between monitoring and assessment - Relationship between water quality monitoring and assessment
2.2.2	Aspects of Water Quality monitoring	3 hrs	-Complexity of water quality monitoring and multidisciplinary requirements. - Scopes and elements of water quality monitoring. - System approach to monitoring (dealing with technical, legal institutional, financial, social and political issues). - Classification of monitoring programmes (routine monitoring, impact surveys, special monitoring…) -stochastic nature of water quality. -hierarchical approach to water quality monitoring
2.2.3	Quality Assessment of surface water	3 hrs	-Uses of surface water - Chemical and physical characteristics of surface water - Effect of pollution discharges ion surface water - Factors influencing assessment of surface water quality sources. . Parameters essential to the analysis of surface water.
2.2.4	Quality assessment of ground water	3 hrs	- Uses of ground water - Chemical and physical characteristics of ground water - Effect of pollution discharges on ground water - Factors influencing ground water quality. . Parameters essential to the analysis of ground water.
2.2.5	Quality assessment of drinking water	3 hrs	-Drinking water quality requirements - Factors influencing of drinking water quality. . Parameters essential to the analysis of drinking water.
2.2.6	Quality assessment of domestic and industrial waste water	3 hrs	-Major wastewater pollutants and their impact on the environment - Chemical and physical characteristics of waste water - Effect of pollution discharges ion waste water - Factors influencing assessment of waste water quality sources. . Parameters essential to the analysis of waste water.

Module Design for 2.3. Parameters of transboundary importance (16 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
2.3.1	Transboundary international environmental laws and agreements	3 hrs	- overview of international environmental law - International agreements on the use and protection of transbondary water sources
2.3.2	Factors for the Selection of water quality parameters of transboundary importance	4 hrs	-Major issues to be considered in basin scale selection of water quality parameters. - monitoring objectives, system approach to basin wide monitoring network, variables that characterize biochemical composition of aquatic systems, pollution, impact assessment and economics of monitoring.
2.3.3	Techniques of variable selection of transboundary importance	3 hrs	-selection of base (background) variables - setting of significance levels to base variables. -selection based on transbondary impacts -selection based on basin wide water uses -selection of variables based on evaluation of composite significance of local and transboundary (basin wide) importance.
2.3.4	Transboundary correlation of water uses and impacts	3 hrs	-methods for variable selection using serial correlation of upstream water uses and down stream impacts and vice versa.
2.3.5	Transboundary correlation variables to be monitored	3 hrs	- Application of correlation to determine degree of independence of variables monitored at different boundaries. - Entropy techniques for optimal design of water quality monitoring network with implication on variables to be monitored at determined sites.

Module Design for 2.4. Global and Local state of water quality and water quality monitoring initiatives at regional and global level (6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
2.4.1	Global and local state of water quality	3 hrs	-Global water quality concerns. -Water quality parameters that have significant impacts on a global scale -Factors influencing variation in local state water quality variations. -Characterization of local state water quality variation.
2.4.2	Water quality monitoring at regional and global level.	3 hrs	-International convention on the protection of fresh water sources and the environment. -The global environmental monitoring program (GEMS) The World Hydrological Cycle Observing System (WHYCOS) -regional agreements on the reduction of transboundary impacts of pollution. - Water quality monitoring experiences in developed and developing countries. -Shortcomings of current monitoring practices.

Module Design for 2.5. Threats to water sources and Impacts of water pollution (27 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
2.5.1	Water use and water quality deterioration.	3 hrs	- Classification of common water uses and levels of contamination. - Fresh water deterioration at global level.
2.5.2	Pollution arising from human activities	12 hrs	- Types of contaminants and sources. -Factors influencing the effect of point source on receiving water body.
2.5.3	Water Pollution and Human Health	12 hrs	-Classification of water borne diseases. -Water Washed and water related diseases. -Chemicals causing undesirable health effects in humans

Module Design for 2.6. Water quality standards and Guidelines (26 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
2.6.2	Water quality requirements and standards	3 hrs	- Classification of utilization of water - Definition of requirements and standards.
2.6.2	Steam Quality Standards	3 hrs	-Usability and ecological requirements of surface water. - Quality requirements for fishing, recreation and bathing. - Water quality parameters guideline values for stream water quality
2.6.3	Quality of Bathing	2 hrs	-water quality requirements for recreational waters
2.6.4	Aquatic Organisms	3 hrs	- water quality standards for the protection of fish and other aquatic organisms
2.6.5	Quality of Ground Water	3 hrs	- Characteristics of contaminant transport in ground water. - quality standard for ground water based on drinking and irrigation requirements
2.6.6	Standards for Drinking Water	3 hrs	- Requirements of potable water. - Primary and secondary standards. - Drinking water quality standards for: treated water, untreated water, piped supplies, unpiped supplies.
2.6.7	Domestic and Industrial waste water	6 hrs	-composition of raw waste water. - Quality of secondary and tertiary effluents. - Quality of waste water acceptable for discharge to the sea. Quality of industrial effluent acceptable for discharge in to municipal sewers - Quality of waste water acceptable for discharge to the sea. Quality of industrial effluent acceptable for discharge in to sea.
2.6.8	Irrigation water	3 hrs	- Water quality requirements for different crops -Relationship between water quality and irrigation performance -Quality standards for irrigation water

UNIT 3: PHYSICAL-CHEMICAL INDICATORS OF WATER QUALITY

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. Definition of physical and chemical characteristics
2. Physical, chemical properties and
3. Organoleptic properties and health effects of chemicals.
4. Identify the common physical and chemical parameters and the methods used for their determination
5. Visiting the laboratories in Ethiopia where the physical and chemical analyses are performed.

Duration: 73 hours = 2 weeks

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants:

Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

3.1. Definition (6 hrs)
3.2. Common Parameters (43 hrs)
3.3. Selected Methods (6 hrs)
3.4. Analysis Demonstration (18 hrs)

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Module Design for 3.1. Definition (6hrs)

Module Number	Module Topic	Duration	Sub topics and activities
3.1	Introduction	6 hrs	- Definition of physical and chemical characteristics. -physico chemical properties. -organoleptic properties - health effect of chemicals through inhalation and dermal absorption

Module Design for 3.2. Common Parameters (43 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
3.2.1	Description of common physical parameters	5 hrs	Colour, temperature, odor, turbidity, solids
3.2.2	Description of Inorganic and non-metallic constituents.	12 hrs	pH, Alakalinity, acidity, hardness, boron, chloride, chlorine residual, cyanide, fluoride, silica, soldier, sulfate
3.2.3	Description of metallic constituents	5 hrs	Calcium, magnesium, Iron, sodium potassium,
3.2.4	Description of nutrients	12 hrs	Nitrogen, ammonia, Nitrite, total organic nitrogen, nitrate, Phosphorous: ortho phosphate, total and acid hydrolysable phosphates.
3.2.5	Description of organic constituents	9 hrs	Biochemical oxygen demand, chemical oxygen demand, grease oil, phenols and surfactants. Pesticides and individual organics.

Module Design for 3.3. Selected Methods (6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
3.3.1	Method description	6 hrs	A selected set of suitable methods (described in module 6 in detail) will be introduced here for the parameter described above.

Module Design for 3.4. Analysis Demonstration (18 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
3.4.1	Analysis practical.	18 hrs	A demonstration of the selected methods above in the laboratory for each of the physic chemical parameters listed-

UNIT 4: BIOLOGICAL INDICATORS OF WATER QUALITY

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. Understanding the relationship between biological organisms presence and physico-chemical characteristics of water quality.
2. Understanding the different biological and microbiological indicators if water quality.
3. Identifying the significance of the various biological indicators of water quality in use.

Duration: 134 hours = 4 weeks

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants:

Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

4.1. Definition (9 hrs)
4.2. Significance (9 hrs)
4.3. Application and Interpretation (24 hrs)
4.4. Demonstration and Practice (33 hrs)
4.5. Biological Indicators: micro-organisms, animal-kingdom, bio-accumulation, eco-toxicity (12 hrs)
4.6. Techniques and methods in biological examination of water (20 hrs)
4.7. Microbiological Bioassays and Microscopy (3 hrs)
4.8. Primary productivity, total coliforms, faecal coliforms (15 hrs)
4.9. Sludge water and phyto and zoo-plankton (12 hrs)

Module Design for 4.1. and 4.2 Definition, significance and identification (18hrs).

Module Number	Module Topic	Duration	Sub topics and activities
4.1.1	Introduction Biological Indicator organisms	3 hrs	- Relationship between physical and chemical characteristics and the presence of biological organisms. - Use and limitations of biological methods. - Objectives and purposes of biological monitoring in relation to water quality. - Definition and description of common biological indicator organisms: Peryphiton, Microphyton, benthic microinvertabrates, nematological examination, fish,
4.1.2	Introduction microbiological indicator organisms	6 hrs	- Definition of Coliform group of bacteria and background to the Coliform test. - -Description of Coliform tests: membrane filter technique. The MPN index, the faecal streptococci test, heterotrophic plate count.
4.2.1	Significance of biological indicator organisms	3 hrs	- Significance of common biological indicator organisms: Peryphiton, Microphyton, benthic microinvertabrates, nematological examination, fish,
4.2.2	Significance of microbiological indicator	3 hrs	- Significance for assessing the extent of pollution and sanitary quality.
4.2.3	Identification of biological indicator organisms	3 hrs	- Keys to major groups of aquatic organisms. - Keys to identifying microscopic organisms. -

Module Design for 4.3. Application and Interpretation (24 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
4.3.1	Plankton	3 hrs	- Evaluation of trophic condition. -evaluation of stage of self purification. -enumeration of microorganisms biochemical processes.
4.3.2	Nekton	3 hrs	- Degree of reduction in fish species. - Abundance, size, age and growth rate of fish. - Rate of accumulation of substances hazardous to man.
4.3.3	Tripton	3 hrs	-identification of the sources of pollution.
4.3.4	Benthos	3 hrs	-assessment of general condition over longer period. - characterizing of lotic waters. -monitoring of the effect of discharge of sewage. - Evaluation of extent of self-purification. - Regional classification.
4.3.5	Microbenthos	3 hrs	-assessment of pollution of shores, streams, fish ponds, ditches, wells, pipes.
4.3.6	Benthic microinvertabrate	3 hrs	- Assessment of change in water quality. Toxicity, salinity and pH, temperature, turbidity and suspended solids.
4.3.7	Macrophytes	3 hrs	-assessment of presence of herbicides, toxic pollution. -assessment of degree of eutrophication.
4.3.8	Primary productivity	3 hrs	-oxygen balance measurements of polluted stream - Assessment of effect of domestic waste and toxicity.

Module Design for 4.4. Demonstration and Practice (33 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
4.4.1	Screening tests to determine toxicity of chemicals	12 hrs	-screening tests using fish. -screening tests using macro invertebrates. -screening tests using macrophytes. -screening tests using algae. -screening tests using bacteria
4.4.2	Establishment of water quality criteria	12 hrs	- Introduction: standards and guidelines. - Lethal and sub lethal toxicity test using fish. - Field observation on fish. -Test using other organisms. -Artificial ecosystems.
4.4.3	Effluent	3 hrs	- Effluent monitoring test using fish.
4.4.4	Legal tests	3 hrs	- General considerations -Dilution test using specified percentage of kill
4.4.5	River monitoring tests	3 hrs	- General considerations. - Methods using fish

Module Design for 4.5. Biological Indicators: micro-organisms, animal-kingdom, bio-accumulation, eco-toxicity (12 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
4.5.1	Biological Indicators	3 hrs	Definition, importance and scope of application
4.5.2	Microorganisms	3 hrs	List of organisims used as indicator of water quality.
4.5.3	Bio accumulation	3 hrs	Bio accumulation properties with different chemicals and
4.5.4	Eco toxicity	3 hrs	The toxicity effect of chemicals on biological organisms. The use of biological indicators of water for toxicity.

Module Design for 4.6. Techniques and methods in biological examination of water (20 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
4.6.1	Biological tests	2 hrs	Preliminary consideration
4.6.2	General aspects	1 hr	Objectives, types of test, selection of test organisms, test end-points, apparatus, procedure, expression of
4.6.3	Screening Tests	3 hrs	--screening tests using fish. -screening tests using macro invertebrates. -screening tests using macrophytes. -screening tests using using algae. -screening tests using bacteria
4.6.4	Test for establishing water quality criteria	3 hrs	- Introduction: standards and guidelines. - Lethal and sub lethal toxicity test using fish. - Field observation on fish. -Test using other organisms.
4.6.5	Effluent monitoring tests	3 hrs	- Effluent monitoring test using fish.
4.6.6	Legal tests	2 hrs	- General considerations -Dilution test using specified percentage of kill
4.6.7	River monitoring tests	3 hrs	- General considerations. - Methods using fish
4.6.8	Detail description of screening tests	3 hrs	-screening test using zebra fish. -screening test using Daphna magna. - screening tests using aquatic macrophytes - screening test using algae

Module Design for 4.7. Microbiological Bioassays and Microscopy (3 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
4.7.1	Bioassays	3 hrs	- Definition. - Description of the bioassay techniques. - Materials and methods. -organisms used in the bioassay procedure -quality control of the bioassay process

Module Design for 4.8. Primary productivity, total coliforms, faecal coliforms (15 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
4.8.1	Primary productivity	3 hrs	- scope - principles, -instrument and chemicals -standardization -analysis of chlorophyll content
4.8.2	Coliform Tests	12 hrs	- Introduction -Quality assurance and quality control - Laboratory apparatus -washing and sterilization - preparation of culture media -samples -Plate count - multiple tube fermentation technique -Membrane filter technique Fecal streptococci test pseudo - Iron and sulpher bacteria

Module Design for 4.9. Sludge water and phyto and zoo-plankton (12 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
4.9.1	phytoplankton	6 hrs	- scope - field of application - definitions -principles -sampling -frequency -location Equipment -volume, preservation, labeling Sample analysis Membrane filter concentration techniques
4.9.2	zooplankton	6 hrs	- scope - field of application - definitions -principles -sampling -frequency -location Equipment -volume, preservation, labeling Sample analysis Total counting Sub sampling Filtration Interference Expression of results

UNIT 5: WATER QUALITY STANDARDS

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. Understanding the background to water quality standards, laws and regulation for enforcement.
2. Understanding the different chemical, physical and biological standards of water quality and the health related impacts.
3. Understanding the environmental quality standards and the environmental impacts associated with the parameters
4. The Nile basin pollution control standards
5. Identifying the acceptable levels of pollutants.

Duration: 108 Hours = 3 weeks

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants:

Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

5.1. Drinking water quality standards (39 hrs)
5.2. Environmental quality standards (45 hrs)
5.3. Drinking water pollution control standards within the Nile Basin countries (18 hrs)
5.4. Acceptable levels for various elements ((6 hrs)

Module Design for 5.1. Drinking water quality standards (39 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
5.1.1	Introduction	6 hrs	-consumer perception of water quality - Factors considered in setting guideline values. - Guideline setting for toxic chemicals. -WHO guideline values for drinking water quality standards. -Laws, standards and regulations for applying standards. -Compliance and surveillance. -Sanitary surveys, Setting priorities for monitoring. - Personnel and Resource requirement for monitoring - Remedial action and risk assessments.
5.1.2	Microbiological Aspects	9 hrs	-Bacteriological quality of drinking water. - Guideline values for the different water sources used for drinking. - Sample collection, storage and transport. -The virological quality of drinking water. - Confidence limits of bacteriological quality measurements, MPN values. - Sampling frequency, required accuracy and quality assurance requirements. Monitoring for bacteriological quality from the different water sources. - Remedial measures.
5.1.3	Biological Aspects	6 hrs	- Drinking water standards against biological organisms. - Requirements for quality of different sources against biological organisms (eg. Giardia). - Recommendation of water quality against helminthes, monitoring and remedial measures. -Free living organisms: occurrence, recommendation of quality of water, monitoring, and remedial measures.
5.1.4	Chemical and Physical Aspects	18 hrs	-the health effect of chemical contaminants. - Basis of setting guideline values and uncertainties. -inorganic constituents of potential health significance. -Health related organic contaminants. - Risk versus benefit of organic contamination. - Tentative guidelines based on toxicity and carcinogenicity. . Description of Compounds of health significance. - Aesthetic and Organoleptic aspects. - Guideline values for aesthetic constituents.

Module Number	Module Topic	Duration	Sub topics and activities
			- Sampling frequency, required accuracy and quality assurance requirements. Monitoring for aesthetic and organoleptic l quality from the different water sources. - Remedial measures.

Module Design for 5.2. Environmental quality standards (45 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
5.2.1	Air quality (atmospheric standards	12 hrs	-Types of air pollutants and their sources of emissions. Ambient air quality standards. - Standards for carbon monoxide, particulates, Sulpher dioxide, nitrogen oxides, chloro-floro carbons, carbon tetrachloride, methyl chloroform, - Tolerance limits for ambient air pollutants Gaseous emission standards for pesticides. - Emission standards for chemical industries. - Emission standards for iron and steel industries. Emission standards of gases from mining and metallurgy. -emission standard for petroleum refinery. -Emission standards for pulp and paper industries. - Emission standards for soap, detergent, sugar processing and tannery industries.
5.2.2	Standards for the discharge of effluent in to sewers or water bodies	12 hrs	- Significant waste water parameters for selected industries. - Effluent standard for brewery waste. - Effluent standard for agricultural chemicals. - Effluent standards for iron and steel industries. - Effluent standards for metal working, plating and finishing. -Effluent standards for food processing industries. - Effluent standards for petroleum refinery. - Effluent standards for pharmaceutical industries. - Effluent standards for plastic and synthetic industries. - Effluent standards for pulp and paper industries. - Effluent standards for soap, detergent, sugar processing and tannery industries.
5.2.3	Standard for soil quality	12 hrs	- Industrial Effluent standards for disposal on to soil - Domestic waste effluent standards for disposal on to soil -agricultural waste standard for disposal o to soil.
5.2.4	Noise standards	3 hrs	- Noise exposure limit for Ethiopia. - Calculation of equivalent 8-hour noise exposure.
5.2.5	Waste Management standards	6 hrs	-Process changes to industrial waste treatment. -Standards related to good house keeping. -standards related to chemical treatment. - Standards related to application of membrane processes. -Standards related to performance of waste stabilization ponds. - Standards related to sludge disposal.

Module Design for 5.3. Drinking water pollution control standards within the Nile Basin countries (18 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
5.3.1	Pollution control standards against microbial pollutants	6 hrs	- Disinfection treatment, sanitary survey of polluted sources. Cross-connection and back-siphonage control. Protection of water sources.
5.3.2	Pollution control standards against biological organisms	6 hrs	- source protection , choice of source and treatment method, reduction of nutrient levels, covering tanks, disinfection, chemicals and algaecides
5.3.3	Pollution control standards against chemical and physical pollution	6 hrs	- Treatment and source protection requirements and standards for the various physical and chemical pollutants on drinking water.

Module Design for 5.4. Acceptable levels for various elements (6hrs).

Module Number	Module Topic	Duration	Sub topics and activities
5.4.1	Water quality standards	6 hrs	Description of acceptable values of various elements in water, soil and air from ecological, water use and health point of view.

UNIT 6: PHYSICAL CHEMICAL TECHNIQUES

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. Understanding the various physical and chemical parameters and the method of determination and the equipment in use.
2. Understand the principles of operation of instruments used in the instrumental method of analysis
3. Understand the procedures for the analysis of
   - 1.1. physical and aesthetic water quality parameters
   - 1.2. metals
   - 1.3. Inorganic and non-metallic constituents
   - 1.4. Aggregate and individual organic constituents.

Duration: 373 hours = 10 weeks

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants:

Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

6.1. Techniques and methods in analysis of physical and chemical parameters and sample preparation (97 hrs)

6.2. Instrumental methods of analysis: chromatography, HPLC, AAS, Digestion (total nitrogen, heavy metals) (132 hrs)

6.3. Determination of Physical and Aesthetic Parameters Gravimetric , precipitation, biomass determination) (36 hrs)

6.4. Determination of Metals (42 hrs)

6.5. Determination of Inorganic non-metallic Constituents (36 hrs)

6.6. Determination of Aggregate and individual Organic Constituents (30 hrs)

<u>Module Design for 6.1. Techniques and methods in analysis of physical and chemical parameters and sample preparation (97 hrs)</u>

Module Number	Module Topic	Duration	Sub topics and activities
6.1.1	Fundamentals of chemical analysis	40 hrs	- chemical equilibrium in homogenous systems, Acid-Base equilibra, complex formation, redox system, heterogeneous equilibra
6.1.2	Sample preparation by Solvent Extraction	18 hrs	- Extraction methods, theory of solvent extraction, partition coefficient, Apparatus for solvent extraction, Application of solvent extraction in water quality analysis, (oil and grease, pesticide residues, heavy metals, chlorophyll a)
6.1.3	Sample Preparation by digestion	12 hrs	Selection of acid for digestion of metals, digestion procedure, Types of digestion techniques: nitric acid digestion, nitric acid-perchloric acid digestion, dry ashing, and microwave assisted digestion.
6.1.4	Solid Phase Extraction	6 hrs	Technique of solid phase extraction
6.1.5	Titrimetry(Volumetry)	9 hrs	-<u>Acidimetric and alkalimetric titration</u>, the titration curve, titration of a strong acid with a strong base. Titration of a weak acid/base with a strong base/acid., Grant titrations. - <u>Complexometric titration</u>, complexing agents, indicators in complexometric titration, application of complexometric titration in water quality analysis. -<u>Electro chemical titration</u>, potentiometric, amperometric and conductometric titration. Application of; ectrochemical titration in water quality analysis.
6.1.6	Gravimetric techniques	12 hrs	-techniques of gravimetric analysis, weighing procedure and sources of errors in weighing, desiccators and crucibles, sample filtration and equipment used for filtration, manipulation associated with filtration and ignition processes, washing, contamination of gravimetric precipitates: co precipitation, occlusion. transfer of precipitate, use of ash less paper. Applications of gravimetric techniques in water quality analysis.

Module Design for 6.2. Instrumental methods of analysis: chromatography, HPLC, AAS, GC, etc (132 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
6.7.1	Chromatography	12 hrs	-Fundamentals of chromatographic separations, mobile phase and stationary phase, chromatogram, partition coefficient, selectivity factor, capacity factor, kinetic theory, theoretical plates
6.7.1.1	Gas Chromatography	24 hrs	-components of a gas chromatograph, sample injection systems, Types of detectors (thermal conductivity, electron capture and flame ionization detectors), -application of gas liquid chromatography in water quality analysis,
6.7.1.2	Liquid Chromatography (HPLC, etc)	24 hrs	- Separation Principles(adsorption, distribution, ion exchange, exclusion) - Packing column for HPLC, basic layout of HPLC. Solvents used. Injection system. -Detectors for HPLC (absorbance detectors, fluorescence detectors, refractometer detectors). - partition chromatography, adsorption chromatography, ion chromatography, gel and thin layer chromatography -application of liquid chromatography in water quality analysis.
6.7.2	Atomic emission spectrometry	24 hrs	-introduction, principle of operation, Sources of radiation: flame emission -plasma emission (direct current plasma, inductively coupled plasma and microwave induced plasma. -principle of operation of spectrometer, detection. Application of atomic emission spectrometry in water quality analysis.
6.7.3	Atomic absorption spectrometry	24 hrs	-Principle of operation, source of free atoms (atomizer), detectors, sensitivity, chemical and spectral interferences. -application of atomic absorption spectrometry in water quality analysis.
6.7.4	uV-VIS spectrometry	24 hrs	-principles, absorbance, transmittance and Beer/s law, filter photometers, application of uV-VIS spectrometer in water quality analysis.

Module Design for 6.3. Determination of Physical and Aesthetic Parameters (36 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
6.3.1	Introduction	3 Hrs	-Definition of physical and aesthetic parameters, -quality assurance and quality control associated with physical and aesthetic parameters
6.3.2	Color	3 Hrs	Definition, pretreatment for turbidity removal, Visual comparison method, spectrophotometric method, Tristimulus filter method
6.3.3	Turbidity	3 Hrs	Introduction, sources and significance, Nephelometric method
6.3.4	Odour	3 Hrs	Causes of odour in water, the threshold odour test, calculation of the threshold odour number
6.3.5	Acidity	3 Hrs	Sources of acidity in water, the significance of measurement of acidity in water, Procedure for the determination of acidity by alkalimetric titration, interferences and expression of results.
6.3.6	Alkalinity	3 Hrs	Definition of alkalinity and sources of alkalinity in water, the importance of measurement of alkalinity in water, determination of alkalinity by acidic titration, determination of alkalinity by potentiometer titration. Calculation the species of alkalinity: carbonate, bicarbonate, hydroxides etc.
6.3.7	Hardness	3 Hrs	Definition of hardness in water. Sources of hardness. The importance of measurement of hardness in water. Determination of hardness by calculation. Determination of hardness by EDTA titration.
6.3.8	Conductivity	3 Hrs	Definition and units of measurement. Causes of variation of conductivity for natural and polluted waters. Laboratory measurement of conductivity using conductivity meter. Calculation of conductivity theoretically from individual ionic composition.
6.3.9	Salinity	3 Hrs	Definition and units of measurement, Causes of salinity in water. Determination of salinity by argentometric titration, by conductivity method.
6.3.10	Floatables	3 Hrs	Definition and sources of occurrence in water and waster waters. The effect of presence of floatables in water. Determination of floatables using gravimetric techniques.
6.3.11	Solids	3 Hrs	Definition and importance. Classification of solids: total, filterable, fixed and volatile solids. Determination of solids using gravimetric method.
6.3.12	Redox-potential	3 Hrs	Definition and sources of high redox potential in water. Electrode determination of redox potential.

Module Design for 6.4. Determination of Metals (42 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
6.4.1	Introduction	3 Hrs	Significance and effects of presence of metals in water, sources of metals present in water, techniques used for the determination of metals in water. Sample preparation for the determination of metals: extraction and digestion.
6.4.2	Aluminum	3 Hrs	The extent of presence of aluminum in water. Sources of aluminum in water. Sample handling and preservation. Determination of Aluminum by spectrohphotometric method using Erichrome cyanine R dye. Aluminum determination by atomic absorption method
6.4.3	Cadmium	3 Hrs	Sources of cadmium in surface and ground water. Toxic effects of cadmium to man and the environment. Sampling and sample preparation for cadmium determination. Determination of Cadmium by atomic absorption spectrometric method.
6.4.4	Calcium	3 Hrs	Sources of Calcium in water. The effects of presence of calcium in water. Sampling and sample handling for Calcium determination. Determination of Calcium by 1) EDTA titration 2) Atomic absorption spectrometer.
6.4.5	Chromium	3 Hrs	Sources of chromium in water forms of chromium present (hexavalent and trivalent) and their relative occurrence. Sampling handling. Determination of total chromium and hexavalent chromium by 1) atomic absorption spectrometer 2) by spectrophotometric method.
6.4.6	Copper	3 Hrs	Sources of copper in water. Effects of copper on the environment. Sampling handling. Determination of copper by atomic absorption spectrometer. Determination of copper spectrophotometrically, neocuproine method.
6.4.7	Iron	3 Hrs	Sources of iron in water. The species of iron and their chemical speciation. The effect of the presence of various forms of iron in water. Sample handling. Determination of iron by 1) atomic absorption spectrometer 2) Spectrohpotometrically using phinantroline method.
6.4.8	Lead	3 Hrs	Sources and distribution of lead in water sources. Toxicity of lead to organisms. Sample handling. Determination of lead using 1) atomic absorption spectrometer 2) Spectrophotometrically using Dithizone method.
6.4.9	Magnesium	3 Hrs	Sources of Magnesium in water. The effects of presence of Magnesium in water. Sampling and sample handling for Magnesium determination. Determination of Magnesium by 1) EDTA titration 2) Atomic absorption spectrometer.
6.4.10	Manganese	3 Hrs	The sources of Manganese in water. The effects of presence of manganese in water intended for various uses. Sample handling. Determination of manganese in water using 1) atomic absorption spectrometer and 2) spectrophotometrically after oxidation by ammonium peroxydisulfate.

6.4.11	Mercury	3 Hrs	Sources of mercury in water. Toxicity of Mercury to man and organisms and transformation of Mercury in tissue and cells. Sample handling. Determination of Mercury using atomic absorption spectrometer.
6.4.12	Potassium	3 Hrs	Sources and occurrences in water. Determination of Potassium using flame emission spectrometry.
6.4.13	Sodium	3 Hrs	Sources and occurrences in water. Determination of Sodium using flame emission spectrometry.
6.4.14	Zinc	3 Hrs	The sources of Zinc in water. The effects of presence of Zinc in water intended for various uses. Sample handling. Determination of zinc in water using) tomic absorption spectrometer.

Module Design for 6.5. Determination of Inorganic Non-metallic Constituents (36 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
6.5.1	Arsenic	3 Hrs	Origin and occurrence of Arsenic. Toxicity of Arsenic to man. Forms of occurrence. Sample handling. Determination of Arsenic 1) by atomic absorption spectrometer 2) by photometer using Silver diethel diatocarbamate.
6.5.2	Boron	3 Hrs	Sources and occurrences of Boron in water. Effects of boron o agricultural crops. Determination of Boron Photometrically using Curcumin method.
6.5.3	Carbonate , bicarbonate and Carbon dioxide	6 Hrs	Sources and occurrences. The carbonate chemistry of water. Importance of carbonate species in water. Sample handling. Determination of Carbonates mathematically after alkalinity determination (total alkalinity and carbonate alkalinity determined). Nomograph method.
6.5.4	Chloride	3 Hrs	Source and occurrence in water. Significance of presence of chloride in water. Determination potentiometrically using Silver Nitrate.
6.5.5	Cyanide	3 Hrs	Sources and occurrences. Toxicity and chemistry of Cyanide. Sample handling. Determination of Cyanide 1) by Argentometric titration 2) photometrically using Pyridine.
6.5.6	Fluoride	3 Hrs	Sources and occurrences. The health effect of consumption of Fluoride in man. Sample handling. Determination of Fluoride by 1) ion selective electrodes 2) photometrically by Lanthanium Alizarin complex method.
6.5.7	Nitrogen	3 Hrs	Sources and occurrences. The importance of presence of nitrogen species in water. The chemistry and biology of nitrogen occurrence in water. Determination of nitrogen species using 1) Kjeldhal method 2) spectrophotometric method.
6.5.8	Dissolved Oxygen	3 Hrs	Sources and occurrences in water. Application of oxygen measurement for ecological evaluation and control of waste water treatments. Determination of dissolved oxygen using 1) the modified Winkler method 2) electrode method.
6.5.9	Phosphorous	3 Hrs	Forms and occurrences of phosphorus in water. The sources of phosphorous in water and the effect on the environment. Sample handling and digestion. Determination of orthophosphate photometrically using ammonium molybdate.
6.5.10	Silica	3 Hrs	Sources and occurrence of silica in water. The effect of presence of silica on water use. Sample handling. Determination of silica photometrically using hetro-poly blue method.
6.5.11	Sulphate	3 Hrs	Sources and occurrences. Health effects. Determination of Sulfate 1) spectrophotometrically using turbidimetric method 2) Gravimetrically 3) by EDTA titration.
6.5.12	Sulphide	3 Hrs	Forms and occurrence. Effect if presence of sulphide in water. Determination of sulphide Determination of sulphide by 1) titration (iodometric method) 2) photomterically using dimethyl –p- phynil diamine.

Module Design for 6.6. Determination of Aggregate and individual Organic Constituents (30 Hrs)

Module Number	Module Topic	Duration	Sub topics and activities
6.6.1	Introduction	3 Hrs	Importance of measurement of aggregate organic constituents. Sample collection and preservation. Quality assurance and quality control.
6.6.2	Biochemical Oxygen Demand	3 Hrs	Definition and importance of BOD measurement. The kinetics of BOD reduction. Determination of BOD using 1) the 5 day BOD test 2) using the ultimate BOD test and 3) Using respirometer
6.6.3	Chemical Oxygen demand	3 Hrs	Definition and importance of COD measurement. Sample handling. Determination of COD 1)) by open reflux method (titration) 2) closed reflux titrimetric method 3) closed reflux colorimetric method.
6.6.4	Total Organic carbon	3 Hrs	Definition and importance of measuring TOC. Determination of TOC using high temperature combustion.
6.6.5	Dissolved Organic Halogen	3 Hrs	Definition and forms of occurrences. Sources and condition of occurrences of halogenated organic compounds. Determination by adsorption pyrolisis titrimetric method.
6.6.6	Oil and Grease	3 Hrs	The sources of oil and grease in water. The effect of oil and grease on efficiency if water and waste water treatment. Determination of oil and grease using Soxlhet extraction.
6.6.7	Phenols	3 Hrs	Occurrence of phenols in water. Reaction of phenols with chlorine. Determination of phenols photometrically using chloroform extraction method
6.6.8	Surfactants	3 Hrs	-Forms and classification of surfactants. Effect of presence of surfactants. Determination of surfactants by sublation.
6.6.9	UV-absorbing organic constituents	3 Hrs	Uv absorption and relationship with colour and organic matter. Determination of UV absorption by ultraviolet absorption method.
6.6.10	Individual organics	3 Hrs	Introduction, Sample collection and preservation. Determination using 1) gas chromatography 2) HPLC.

UNIT 7: DATA ANALYSIS

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. The various units of measurement used in water quality analysis.
2. The objective, approaches and procedures for quality control/quality assurance in water quality monitoring works.
3. Statistical methods and models of water quality.
4. Techniques used in data representation
5. Water quality modeling
6. Application of water quality data
7. Understanding the aspects of data integrity and accuracy.

Duration: 336 Hours = 9 weeks

Venue: water and environmental testing laboratory or training institute in Ethiopia.

Participants: Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

7.1. Units applications (6 hrs)

7.2. Analytical quality control and quality assurance (45 hrs)

7.3. Statistical models in data analysis (84 hrs)

7.4. Data representation (27 hrs)

7.5. Application of water quality data (24 hrs)

7.6. Water quality models (132 hrs)

7.7. Data integrity and accuracy (18 hrs)

Module Design for 7.1. Units applications (6 Hrs)

Module Number	Module Topic	Duration	Sub topics and activities
7.1.1	The SI System of Units	3 Hrs	-Units of mass, volume, pressure, mass concentration, etc
7.1.2	The IUPAC nomenclature	3 hrs	Description of details of IUPAC nomenclature

Module Design for 7.2. Analytical quality control and quality assurance (45 Hrs)

Module Number	Module Topic	Duration	Sub topics and activities
7.2.1	Introduction and Definitions	6 Hrs	-Definition of quality assurance and quality control. -Needs and Requirements of quality assurance and quality control -Steps in water quality monitoring exercise and the QA/QC requirements in each step. -Current drawbacks of water quality data results I Ethiopia
7.2.2	Approach in analytical quality control	12 Hrs	- Selection of method to fit required standard. - Estimation of laboratory standards. - spiking recovery -control charts for routine analysis -inter-laboratory control using check samples - Selectivity/Specificity, Limit of Detection , Limit of Quantitation , Linearity, Accuracy , Trueness, Sensitivity, Ruggedness (or Robustness), Recovery
7.2.3	QA/QC in sampling	6 Hrs	- Steps in sampling program - Quality assurance in field sampling: for the different water quality parameters. -QA/QC in sample storage - QA/QC in sample preparation. -grab samples/composite sample
7.2.4	QA/QC in laboratory equipment and standards	6 Hrs	- Glassware and reagents. - equipments and accessories - preparation of standard solution
7.2.5	QA/QC in Sample analysis	3 Hrs	- Sources of errors in water quality analysis - memory effects in advanced analysis -avoidance of matrix effects -limit of detection and limit of quantitation. -Internal standards and certified reference materials. Control charts in QA/QC.
7.2.6	Tools of method validation	12 Hrs	Blanks, Reagent blanks, Sample blanks, Samples/test materials, Fortified materials/solutions, Spiked materials ,Incurred materials, Independently,

Module Number	Module Topic	Duration	Sub topics and activities
			characterized materials, Measurement standards, Reference materials, Certified Reference materials, Statistics, Replication
7.2.7	QA/QC in data handling and data analysis	12 Hrs	-errors arising during data analysis and data management. -Quality checks in data recording. -detection of incorrectly entered data -limit of detection and missing values. Expression of results -accuracy and precision -Supporting sample information recording.

Module Design for 7.3. Statistical methods in data analysis (84 Hrs)

Module Number	Module Topic	Duration	Sub topics and activities
7.3.1	Treatment of single parameter data	24 hrs	-Mean and standard deviation - data distribution (normal, student's t) -Confidence limits of mean and distribution -Simulation of series of measurements (time series analysis) -Testing for deviations: t-test, outlier test, multiple range test, - - Analysis of variance. - Width of distribution: the F-test, Bartlett test. -Charting a distribution: histogram, chi-square test, probability charts, conventional control charts.
7.3.2	Treatment of multiple parameter data	6 Hrs	-correlation among data. - linear regression -non-linear regression and modeling
7.3.3	Related topics	12 Hrs	- standard additions, comparison of more than two means, two-way analysis of variance, chemometrics and experimental design, factorial design, optimization methods: simplex optimization,
7.3.4	Further Treatment of multivariate data	18 hrs	Principal component Analysis, Factor analysis, Cluster Analysis and quick statistics.
7.3.5	Statistical modeling for water quality monitoring network design	24 hrs	- Correlation function, detection of trend, determination of periodic fluctuations, criteria for analysis of sampling frequency, Fisher's information measure, spectral methods.

Module Design for 7.4. Data representation (27 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
7.4.1	Reporting Analytical Results	3 Hrs	- Rounding off and number of figures in analytical results.
7.4.2	Types of Report	3 Hrs	- Study plan report -Protocols and method report -Data report -Interpretative report
7.4.3	Structure of a report	3 Hrs	- Summary - introduction -Study area -Methods -Results -Analysis of results -Significance of results -Recommendations -References -Recommendation
7.4.4	Graphical representation of data	18 hrs	- Scatter plot Scatter plot matrix -Bar graph with 95% confidence limit Spatial Isopleth plot of water quality parameters -Combination of temporal and spatial isopleth plot - Framed rectangle graphs on maps -Hysterisis plot Time series graph -frequency distribution and histogram -ion concentration diagrams (vector graph) - Pattern diagrams and pie diagrams. - Logarithmic nomogram Three dimensional water quality profile -Box and Whisker plot

Module Design for 7.5. Application of water quality data (24 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
7.5.1	Application of water quality data	24 hrs	-Description of quality at national and regional level -Regulatory function and water quality data - post-audit water quality management - Environmental impact assessment - Comprehensive assessment of river basins - Report of compliance to international standards or action plans. Use of data for determining water quality index. - Monitoring of point source and diffuse pollution. - Data Application in water quality modeling. -Establishment of relationship between land use and water quality at watershed level. -identification of pollution sources and pollution distribution in ground water systems. -water quality monitoring network design. - Characterization of industrial effluents. -Assessment of long term trends in water quality.

Module Design for 7.6. Water quality models (132 Hrs)

Module Number	Module Topic	Duration	Sub topics and activities
7.6.1	Modeling mixed water systems	12 Hrs	1. -Reaction kinetics 2. -mass balance, steady state solution 3. -particular solution. 4. -feed forward system of reactors Computer models for well mixed reactors
7.6.2	Modeling partially mixed water systems	12 Hrs	1. -Diffusion 2. -Plug flow and mixed flow reactors 3. -steady state solution 4. Simple time variable and advanced time variable solutions
7.6.3	Modeling environments of water quality	24 Hrs	1. -Rivers and stream – dispersion and hydraulics 2. -Estuaries, lakes and impoundments 3. -sediments
7.6.4	Modeling of Dissolved Oxygen and pathogens	24 Hrs	1. -BOD and oxygen saturation 2. -Gas transfer and oxygen re-aeration 3. Nitrogen modeling 4. Photosynthesis 5. Sediment oxygen demand 6. Pathogens modeling
7.6.5	Eutrophication and temperature modeling	24 Hrs	1. The eutrophication problem and nutrients 2. Phosphorous loading concept 3. Heat budgets 4. Thermal stratification 5. Microbe/substrate modeling 6. -Plant growth and non-predatory losses 7. Nutrient food chain modeling 8. Eutrophication in flowing waters
7.6.6	Chemical modeling	36 Hrs	1. Equilibrium chemistry 2. Coupling equilibrium chemistry and mass balance 3. pH modeling 4. Toxic substances modeling 5. Mass transfer-sorption and volatilization 6. Photolysis, hydrolysis and biodegradation 7. Toxicant modeling in flowing waters 8. Toxicant/food chain interaction

Module Design for 7.7. Data integrity and accuracy (18 Hrs)

Module Number	Module Topic	Duration	Sub topics and activities
7.7.1	Nature of Errors in analytical results	6 Hrs	1. Classification of errors 2. Relative importance of different errors 3. -Statistical approach to quantification of random errors 4. - Preliminary estimation of analytical errors: bias, precision.
7.7.2	Basic Data Checks	12 Hrs	1. Check for errors: decimal position error, incorrect sample identification, double reporting of ions, faulty analytical technique 2. major ion balance error 3. -comparison of electrical conductivity and total dissolved solids 4. -Comparison total dissolved solids calculated and dry residue 5. Control charts to check for data outliers

UNIT 8: EQUIPMENT MAINTENANCE:

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. Understanding the maintenance requirements of the different equipments used in water quality analysis.

Duration: 24 hours = 1 week

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants:

Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

8.1. General equipment maintenance, preservation, calibration and general care. (6 hrs)
8.2. Replacement of consumable parts, battery, etc. (6 hrs)
8.3. AAS, pH meter, HPLC, GC. (6 hrs)
8.4. Conductivity meter. (6 hrs)
8.5. Spectrophotometer (6 hrs)
8.6. Flame photometer (6 hrs)

Module Design for 8.1. General equipment maintenance, preservation, calibration and general care. (6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
8.1.1	General equipment maintenance, preservation, calibration and general care.	6 hrs	Types of equipment used in water quality laboratories Equipment maintenance and care Safety requirements

Module Design for 8.2. Replacement of consumable parts, battery, etc. (6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
8.2.1	Replacement of consumable parts, battery, etc	6 hrs	Equipments and parts requirements Types of replacement parts Replacement of Batteries

Module Design for 8.3. AAS, pH meter, HPLC, GC. (6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
8.3.1	AAS, pH meter, HPLC, GC.	6 hrs	General maintenance, care and repair of advanced instruments. Atomic absorption spectrometer HPLC Gas Chromatography etc

Module Design for 8.4. Conductivity meter. (6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
8.4.1	Conductivity meter	6 hrs	General maintenance , care and repair of conductivity meter

Module Design for 8.5. Spectrophotometer(6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
8.5.1	Spectrophotometer	6 hrs	General maintenance , care and repair of Spectrophotometer

Module Design for 8.6. Flame photometer (6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
8.6.1	Flame photometer	6 hrs	General maintenance , care and repair of Flame photometer

UNIT 9: LABORATORY MANAGEMENT

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. Identifying the facility requirements of and layout of the different water quality monitoring laboratories.
2. management of laboratories for chemical analysis
3. management of laboratories for biological analysis
4. management of bacteriological analysis
5. Acquiring the actual practical experiences by visiting laboratories in Ethiopia.

Duration: 70 Hrs = 2 weeks

Venue: A water and environmental testing laboratory or training institute in Ethiopia.
Participants: Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

9.1. Introduction: Water quality Laboratory (6 hrs)
9.2. Laboratory for chemical examination (21 hrs)
9.3. Laboratory for Biological Examination (15 hrs)
9.4. Laboratory for Bacteriological examination (12 hrs)
9.5. Tour of water quality laboratories (16 hrs)

Module Design for 9.1. Introduction: Water quality Laboratory (6 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
9.1.1	Introduction	6 hrs	Design of laboratory facility in response to functional requirements. Requirements of a multi-function laboratory Requirements of monitoring laboratory Requirements of a research laboratory Selection of equipment and accessories.

Module Design for 9.2. Laboratory for chemical examination (21 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
9.2.1	Floor Space Requirements	3 hrs	Factors determining allocation of laboratory space
9.2.2	Chemical and Equipment Requirements	3 hrs	Common chemical analysis parameters Separate Rooms for groups of analysis – Basic parameters, photometry, heavy metals, spectroscopy, chromatography, etc.
9.2.3	Basic Analysis	3 hrs	Parameters routinely analyzed in basic lab Tables and bottles requirements for Storage equipment for BOD Hood requirement for COD analysis Requirements for safe disposal of mercury Requirements and safety for the placement of photometers Lighting and working area requirements for titration. Separate room requirements for gravimetric analysis Requirements for analytical balances
9.2.4	Heavy metals Analysis	3 hrs	Space and room requirements for AAS Space for preparation of solutions
9.2.5	Spectroscopy and Chromatography	3 hrs	Categories of chromatographies in use Temperature and ventilation requirements Requirements for safe disposal of solvents
9.2.6	Central store room and wash room	3 hrs	Provision for ventilation and gas exhaust Storage space for dirty and clean glassware Room requirement for storing chemicals Classification of chemical store rooms with parameters – safety requirements. Space requirements for equipments
9.2.7	Safety and room for personnel	3 hrs	Protection against explosion. Fire blankets and emergency shower Safety glasses and first aid kits Training requirements for safety

Module Design for 9.3. Laboratory for Biological Examination (15 Hrs)

Module Number	Module Topic	Duration	Sub topics and activities
9.3.1	Structure of the laboratory	3 Hrs	Activities of the biological section of the laboratory Light positioning for the laboratory Laboratory bench requirements Seat heights for comfort and long working times Electricity, water and gas requirements
9.3.2	Microscopes and ancillary equipment	3 Hrs	Types of microscopes required Resolution and other provisions Inverted and stereoscopic microscopes
9.3.3	Photometric equipment	3 Hrs	- photometer and fluorimeter required in biological room
9.3.4	General equipment	3 Hrs	Glassware, pipettes, burettes Heating block Single and electro balance Sieves for sorting Shakers for tubes Electronic particle counter
9.3.5	Sampling and onsite working equipment	3 Hrs	Sampling gear and nets Dissolved oxygen meters Boat and outboard motor Buoyancy aid and life jackets

<u>Module Design for 9.4. Laboratory for Bacteriological examination (12 hrs)</u>

Module Number	Module Topic	Duration	Sub topics and activities
9.4.1	Structure of the laboratory	3 Hrs	Height for comfortable working position Bench lighting Sink and tap for hand washing Uv lamps for disinfection Regulation against food and drinks
9.4.2	Sampling equipment	3 Hrs	Sampling bottle and samplers
9.4.3	General Equipment		Flasks, beakers, pipettes, cylinders, etc pH and analytical balance Petri dishes and racks filter holders, sterile syringes gas burner, oven and autoclave incubator, water bath, equipment for colony counting storage room for samples and refrigerators storage cabinets
9.4.4	Minimization of risk of cross contamination	3 Hrs	Examination of water and division of work areas
9.4.5	Laboratory Acquired Infection	3 Hrs	Precautions required against

Module Design for 9.5. Tour of water quality laboratories to be used in the training module (16 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
9.5.1	Tour of water quality lab	16 hrs	This tour is arranged with the purpose of identifying the space and arrangement of labs and how the different functional equipments are met, how equipment and ancillary facilities are provided what security and safety precautions have been provided.

Unit 10: Laboratory organization and Safety

Objectives: At the end of this module training, the trainees will be able to acquire Knowledge of:

1. Basic laboratory safety rules
2. The safety requirements and procedures of chemical laboratories
3. The safety requirements and procedures of biological laboratories
4. Handling and toxic and hazardous substances
5. Storage and transport of laboratory chemicals
6. Handling laboratory accidents

Duration: 54 Hours = 1 week

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants: Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

10.1 Safety in the laboratory – basic rules (3 hrs)

10.2 Chemical Laboratory (3 hrs)

10.3 Microbiological Laboratory (3 hrs)

10.4 Toxic and Hazardous Substances (18 hrs)

10.5 Storage and Transport of Laboratory Chemicals (3 hrs)

10.6 Safety in fire (12 hrs)

10.7 Demonstration of how to handle some laboratory accidents (12 hrs)

Module Design for 10.1. Safety in the laboratory – basic rules (3hrs)

Module Number	Module Topic	Duration	Sub topics and activities
10.1.1	Basic rules	3 hrs	The need for setting rules in the laboratory. Accidents in risks to humans and the environment due to lab accidents

Module Design for 10.2. Chemical Laboratory (3 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
10.2.1	Safety requirements of chemical laboratory	3 hrs	Qualification of personnel Safety manuals Displays on walls about basic safety rules Ventilation requirements Safety equipments required in the chemical analysis laboratory

Module Design for 10.3. Microbiological Laboratory (3 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
10.3.1	Safety requirements of microbiological laboratory	3 hrs	Need for separate laboratory Disinfection requirements of working surfaces Sterilization of equipment Disposal of items and disinfection requirements Disinfection of disposal boxes.

Module Design for 10.4 Toxic and Hazardous Substances (18 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
10.4.1	Safety in use handling and storage of toxic chemicals	6 hrs	Labeling requirements of reagents Safety cabinet for storage Cleaning requirements of bottles Prevention against contact with chemical: inhalation, skin contact, etc. Disposal of hazardous wastes.
10.4.2	Handling requirements of common hazardous substances	12 hrs	Acids and alkalis Arsenic Azides Cyanides Mercury Perchloric acid Compressed gases Volatile organic compounds Biohazards

Module Design for 10.5. Storage and Transport of Laboratory Chemicals (3 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
10.5.1	Storage and Transport of Laboratory Chemicals	3 hrs	Storage container requirements Volume and location of storage Ventilation requirements Storage of flammable gases Storage of organic solvents Labeling and display of labels in safety cabinets.

Module Design for 10.6. Safety against fire (12 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
10.6.1	Rule for safety in case of fire	6 hrs	Use of anti bumping chips Safety against Refrigeration of ignitable liquids Precaution against electrostatic charging Provision of fire exit Fir protective aids and fir alarms Emergency calls Training for fire protection and prevention
10.6.2	Rules for fire fighting	6 hrs	Procedures for fire fighting Handling fire victims Safety instructions Activation of fire alarm Dealing with electric supplies Dealing with uncontrollable fire

<u>Module Design for 10.7 Demonstration of how to handle some laboratory accidents (12 hrs)</u>

Module Number	Module Topic	Duration	Sub topics and activities
10.7.1	First aid	3 hrs	Instruction charts First aid kits Telephone numbers
10.7.2	Aid for burns	3 hrs	Physician help Treatment of burn due to Fire, acid, alkali, hydrofluoric acid, iodine, phenol, eye burns
10.7.3	Aid for cuts	3 hrs	Procedure for dealing with cuts
10.7.4	Aid for poisoning	3 hrs	Emergency treatment Dealing with unconscious victim

UNIT 11: FIELD ANALYSIS

Objectives: At the end of this module training, the trainees will be able to acquire knowledge of:

1. Advantages and conditions necessitating field analysis and the precautions to e taken.
2. Procedures for field analysis of selected water quality parameters.
3. Quality assurance and quality control .procedures in the field.
4. Sanitary survey techniques
5. Non-analytical methods of quality control.

Duration: 60 Hours = 2 weeks

Venue: water and environmental testing laboratory or training institute in Ethiopia.

Participants:

Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

11.1 Field analysis and Sanitary Survey techniques (54 hrs)

11.2 Non-analytical methods of quality control. (6 hrs)

Module Design for 11.1. Field analysis and Sanitary Survey techniques (54 hrs)

Module Number	Module Topic	Duration	Sub topics and activities
11.1.1	Introduction	6 hrs	Advantages of field analysis Condition under which field analysis is required Limitations of field analysis Precaution required during field analysis, staff training requirements.
11.1.2	Field analysis procedure	24 hrs	Temperature, Transparency pH Conductivity Field method for dissolved oxygen Faecal colifirms
11.1.3	Quality Assurance in the field	6 hrs	Staff training, sampling requirements, method validation.
11.1.4	Boats for field analysis	3 hrs	- Size requirement. Safety requirements.
11.1.5	Mobile laboratory	3 hrs	- Requirements of mobile laboratory. - Conditions under which a mobile laboratory may be used.
11.1.6	Sanitary Survey Techniques	12 hrs	Condition necessitating sanitary survey Factors influencing frequency of sanitary survey Role of public relation and community participation in sanitary survey. Role of sanitary survey in setting water quality monitoring priority Personnel requirement for sanitary survey Importance of sanitary survey in rural water supply Risk assessment and remedial action Follow-up action following remedy

Module Design for 11.2. Non-analytical methods of quality control (6 Hrs).

Module Number	Module Topic	Duration	Sub topics and activities
11.2.1	Non-analytical methods of quality control	6 hrs	Good field practices for collection of water quality samples Causes of contamination and analyte loss during field sampling Sample storage Sample preparation Data Handling and analysis

UNIT 12: COMMUNITY PARTICIPATION IN WATER QUALITY MONITORING

Objectives: At the end of this module training, the trainees will be able to acquire Knowledge of:

1. Roles of community in development
2. Approach to community participation.
3. Ecology, the environment and health.
4. Techniques of water quality monitoring

Duration: 206 Hours (6 Weeks)

Venue: A water and environmental testing laboratory or training institute in Ethiopia.

Participants:

Senior technical laboratory staff from the Nile basin Regions:

Course Languages: English/Amharic.

Basic Topics

12.1 Ecology (12 hrs)
12.2 Environment (18 hrs)
12.3 Community Participation Techniques (24 hrs)
12.4 Elements of Stream (24 hrs)
12.5 Watershed Survey Methods (6 hrs)
12.6 Macro-invertebrates and habitats (12 hrs)
12.7 Metric for steam health (6 hrs)
12.8 Water Quality Conditions (80 hrs)
12.9 Managing and Presenting Monitoring Data (24 hrs)

Module 12: Training module for Community participation in water quality monitoring (206 Hours)

Module Number	Module Topic	Duration	Sub topic	Subjects Covered
12- 1	Ecology	12 hrs	Introduction to Ecology	Food chain and metabolism Aerobic and anaerobic decomposition
12- 2	Environment	18 hrs	Introduction to the environment	Biogeochemical cycles Geology and soils Relationship between population, urbanization and environmental stress Relationship between sanitation and health
12-3	Community Participation Techniques	24 hrs	Community participation	Roles of community in development Top-down versus bottom-up approach Community survey techniques Approach to community campaign and community participation Project cycle and project management
12-4	Elements of Water nd its quality	12 hrs	Basic Concepts	Basic concepts: the hydrological cycle. The living stream environment. Stream classification. Water quality and sources of water pollution.
		6 hrs	Designing the water quality monitoring study	Reason for monitoring. Use of monitoring data. Parameters to monitor. How good should the data be? Where will monitoring takes place? Data presentation and data credibility
		3 hrs	Safety consideration	Safety during stream monitoring. Safety in laboratory and handling of chemicals. First aid kit
		3 hrs	Equipment for field activity	For enhancing the community effectiveness and safety
12-5	Watershed Survey Methods	6 hrs		How to conduct watershed survey The visual assessment
12-6	Macro invertebrates and habitats	12 hrs		Stream habitat walk Stream side bio-survey Intensive stream bio-survey
12-7	Metric for steam health	6 hrs		Selecting stream health to determine the health of stream.
12-8	Water Quality Conditions	80 hrs		Quality assurance and quality control. Stream flow Analysis for Dissolved Oxygen, Biochemical Oxygen Demand Temperature, pH, Disk Transparency, Phosphorous, Nitrates, Total Solids, Conductivity Alkalinity, Faecal Coliforms
12-9	Managing and Presenting Monitoring Data	24 hrs		Managing data Presenting data Producing reports

SUMMARY OF THE TRAINING MODULE STRUCTURE AND DURATION OF TRAINING

Module Number	Module Topic	Duration (Hrs)	Training Level I	Training Level II	Training Level III
Unit 1a	Design of Sampling program	65 hours	√	√	√
Unit 1b	Design of sampling and monitoring systems	72 hours	√	√	
Unit 2	Water quality characterizations and impacts of pollution on water quality	109 hours	√	√	√
Unit 3	Physical and chemical Indicators of water quality	73 hours	√	√	
Unit 4	Biological indicators of water quality	134 hours	√	√	
Unit 5	Water Quality Standards and Guidelines	108 hours	√	√	√
Unit 6	Physical Chemical Techniques	373 hours		√	√
Unit 7	Data Analysis and data management	336 hours	√	√	
Unit 8	Equipment Maintenance	24 hours	√	√	√
Unit 9	Laboratory management	70 hours	√	√	√
Unit 10	Laboratory organization and safety	54 hours	√	√	√
Unit 11	Field Analysis	60 hours	√	√	√
Unit 12	Community Participation and volunteer water quality monitoring.	206 hours	√	√	
	Total Duration	**1684 Hours (42 Weeks)**			

Fig 2. DETERMINATION OF POLLUTION MONITORING SITES FOR THE TEKEZE RIVER USING SANDER' S METHOD OF CLASSIFING STREAM CATCHMENT

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Location of Pollution Sites for Abbay River Basin.

Some 91% of the population in the Abbay river basin is rural that is significantly higher than the national average (basin study 1999). The region's economy is dominated b agriculture. Major Industrial sites are limited; the most conspicuous ones are the Bedele beer factory, the Fincha sugar factory and the Bahirdar Textile factory. There is not much record available concerning the impacts of polluting effluents from these industries in to the basin. However, due to the large volume of water that passes as transboundary discharge the effects of effluent discharges from the few industries may not be exaggerated. However, research studies have indicated that local ecosystem damage and deterioration of water quality have already occurred owing to the discharge of untreated waste water effluent from the Fincha sugar factory.

On the other hand due to the intensive agriculture in the eastern and central part of the basin, the sediment load carried by the rivers is high. In addition lack of appropriate domestic waste disposal system, the widespread agricultural practices coupled with the application of agricultural chemicals (pesticides and fertilizers) may point to the importance of non-point sources of pollution and the need to place monitoring strategy according to the discharge of streams, population density with some focus on possible point sources of pollution (such as the major industrial sites mentioned above). The Sander's method of locating river monitoring site for pollution identification and the location of the monitoring sites has been applied, the results of which are indicated in the figure below. The Sanders method has already been explained above in connection with location of monitoring sites for the Baro Akobo basin.

According to the analysis the following points /sites have been identified for water quality monitoring:

Table19: Pollution monitoring sites location after Sander's method was applied.

Sampling Point	Description of sampling point	UTM North Position	UTM East Position
1	At the border outlet of the Abbay River		
2	At the border: Outlet of Golegu river		
3	At the border, outlet of Rahad river		
4	At the border: Outlet of the Rahad river		
5			
6	Abbay river before confluence with the Dabus river tributary		
7	Abbay river after confluence with the Fincha river tributary		
8	At the outlet from Lake Tana in to the Abbay river		
9	At the outlet from Lake Tana in to Beles River		
10	Abbay river before confluence with Guder river		
11	Abbay river before confluence with Diodesa river		
	Abbay river before confluence with the Beles river.		

Fig. 3 DETERMINATION OF POLLUTION MONITORING SITES FOR ABAY RIVER USING SANDER' S METHOD OF CLASSIFING STREAM CATCHMENT

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B-4 PARAMETERS REGARDED AS NATIONAL, CROSS BORDER AND TRANSBOUNDARY BASIN-WIDE IMPORTANCE.

Multi-functional approach

Various functions and uses - both human and ecological - of water bodies can be identified from existing policy frameworks, international conventions, bilateral and multilateral agreements and strategic action plans for river basins and seas uses may compete or even conflict, in particular if water is scarce or its quality deteriorating. A multi-functional approach tries to strike a balance between all desired uses, including ecosystem functioning. It allows the introduction of a hierarchy in uses and provides flexibility for the different levels of development of water resources management policies and for prioritization in time. This could be important for those countries where basic needs like the supply of wholesome drinking water are so urgent that other uses will have lower priority, or for countries where water resources have deteriorated to such an extent that "higher" uses can be gradually restored only over a long period of time and in priority order.

The selection of variables at the different scales, i.e., national, cross-border and transboundary importance is obtained by investigating the anticipated water and the impacts that a use of water has imposed on the river. In order to identify variables of transboundary importance, variables that are important for water use downstream (Sudan and Egypt) must be combined with variables that will help to assess the impact of water use upstream of the border, i.e., in the Abbay, Tekeze and Baro-Akobo basins.

For the purpose of identifying variables of transboundary importance it is necessary to identify the water use demand in the down stream countries, Egypt and Sudan. The Nile water in the Sudan forms wetland that buffers stream flows and water quality. At the same time the Nile water maintains the natural ecosystem and is home to many land and aquatic species.
About 500,000 residents in Sudan depend on the swamps and plains of the greater Sudd for their livestock and crop production. fisheries and wild food collection.

In terms of irrigation, Egypt and Sudan share the majority of irrigated uses of the Nile. To those people living downstream, the water based ecosystem also provides wild plant, animal and fish food, fuel and construction material when these materials are otherwise unavoidable or unavailable.

The Nile also provides use to urban dwellers for inhabitants in Egypt and Sudan. These people depend directly on the domestic, commercial and industrial water supplies and hydropower provided by the Nile as well as the indirect benefits associated with food production, waste disposal and economic activity in a variety of sectors.

Impacts of water use and land activities on the Ethiopian side of the basin include: Deforestation, overgrazing, soil erosion and desertification Fertilizers and pesticides from their use on agriculture and pollutants from limited industrial uses.

The table below gives the downstream water use requirement monitoring variables taking in to account the anticipated water uses in Egypt and Sudan and selection of variables is according to Chapman (Chapman, 1992).

The number of asterisks shown next to each variable indicates the significance of that variable in defining the background water quality, i.e., variables with three asterisks are the most important and those with one asterisk have the least significance for the monitoring programme. Essentially base variables should be monitored at stations.

Table20: Selection of water use oriented variables with respect to industrial and non-industrial uses of the water in Sudan and Egypt of the Nile basin. (Adapted from N.B. Harmancioglu. Water Quality Monitoring Network Design pp191-pp194.)

Variable	Non-Industrial Water Uses				Industrial Water Uses				
	Fisheries and Aquatic Life	Domestic water supply	Irrigation	Livestock watering	Energy production	Iron and steel	Paper	Petroleum	Food Processing
General Variables									
Temperature	***					***			
Color		**					*		
Odor		**							***
Suspended Solids	***	***			**	**	*	***	**
Turbidity/transparency	***	***					**		**
Conductivity	*	*	*						
Total dissolved solids	*	*	***	*	***	**	***	*	***
pH	**	*	**		***	**	**	***	***
Dissolved Oxygen	***	*	*		*	***	*		
Hardness	*	**			***	**	***	***	***
Chlorophyll a	**	**							
Nutrients									
Ammonia	***	*			*				*
Nitrate/Nitrite	*	***		**			*		
Phosphorous/Phosphate	*						*		
Organic Matter									
Total Organic carbon		*							
COD	**								
BOD	***	**							
Ions									
Sodium		*		***					
Potassium									
Calcium			*	*	***		*	***	*
Magnesium		*			*		*	***	*
Chloride		*	***		**	**	*	***	***

Variable	Non-Industrial Water Uses				Industrial Water Uses				
	Fisheries and Aquatic Life	Domestic water supply	Irrigation	Livestock watering	Energy production	Iron and steel	Paper	Petroleum	Food Processing
Sulphate		*		*	**	**	**	*	***
Carbonate Components					***		***	*	*
Inorganic variables									
Hydrogen Sulphide									**
Fluoride		**	*	*				*	**
Boron			**	*					
Cyanide	*								
Silica					*		*	*	*
Trace Elements									
Heavy metals	**	***	*	*					
Arsenic and Selenium	**	**	*	*					
Aluminum					*				
Copper					*				
Iron					*		*	*	**
Manganese					*		*		*
Zinc									
Organic Pollutants									
Oil and Hydrocarbon	*	**	*	*	*	*			*
Organic solvent	*	***		*					*
Phenols	*	**		*					*
Pesticides	**	**		*					*
Detergents	*	*		*		*			*
Microbiological Indicators									
Faecal Coliform		***	***						
Total Coliform		***	*						
Other pathogens		***	*						

Variable	Non-Industrial Water Uses				Industrial Water Uses				
	Fisheries and Aquatic Life	Domestic water supply	Irrigation	Livestock watering	Energy production	Iron and steel	Paper	Petroleum	Food Processing

Table21: Selection of impact oriented variables with respect to industrial and non-industrial impacts in Ethiopia

(Adapted from N.B. Harmancioglu. Water Quality Monitoring Network Design pp191-pp194.)

Variable	Non-Industrial Water Uses						Industrial Water Uses				
	Municipal waste water	Urban Runoff	Agricultural activities	Solid wastes	Hazardous wastes	Atmospheric transport	Food processing	Mining	Chemical	Paper	Textile
General Variables											
Temperature	*	*	*				*	*	*	*	*
Color	*	*	*				*	*	*	*	*
Odor	*	*	*				*	*	*	*	*
Residues	*	*	***	***	**		*	*	*	*	*
Suspended Solids	***	**	***	**	**		*	***	*	***	***
Conductivity	**	**	**	***	***	***	***	***	*	***	***
Alkalinity				**		***					
pH	*	*	*	**	***	***	***	***	***	*	*
Redox Potential	*	*	*				*	*	*	*	*
Dissolved Oxygen	***	***	***	***	***		**	***	***	***	***
Hardness	*	*	*		*	*	*	*	*	*	*
Nutrients											
Ammonia	***	**	***	**			***	*	**	*	*
Nitrate/Nitrite	***	**	***	**		***	**		*	*	*
Organic Nitrogen	***	**	***	**			**		*	*	*
Phosphorous/Phosphate	***	**	***	*		*	**		**		*
Organic Matter											
Total Organic carbon	*	*	*				*	*	**	***	*
COD	**	**	*	***	***		*	*	***	***	*
BOD	***	**	***	**			***	*	**	***	***
Ions											
Sodium	**	**	**				*	*	*	*	
Potassium	*	*	*				*	*	*	*	*
Calcium	*	*	*				*	*	*	*	*
Magnesium	*	*	*				*	*	*	*	*

Variable	Non-Industrial Water Uses						Industrial Water Uses				
	Municipal waste water	Urban Runoff	Agricultural activities	Solid wastes	Hazardous wastes	Atmospheric transport	Food processing	Mining	Chemical	Paper	Textile
Carbonate Components					**		*	*	*		
Chloride	***	**	***	**			*	***	**	*	***
Sulphate	*	*	*			***	*	*	**	***	*
Inorganic variables											
Sulphide	**	**	*		*			*	***	***	*
Fluoride	*	*						*	**		*
Boron			*					*	*	*	*
Cyanide	*	*						*	*		*
Silica	*	*						*	*		*
Trace Elements											
Heavy metals								***	**	*	***
Arsenic		*	***	**	***	*		*	*		*
Selenium		*	***	*	*			*	*		*
Aluminum						**					
Copper	*	*	**	***	**	*					
Iron	**	**		***	**	*					
Mercury	*	*	***	***	***						
Zinc		*		***	***	*					
Cadmium		*		***	***	*					
Chromium		*		***	**	*					
Lead	**	***		***	**	**					
Organic Pollutants											
Oil and Hydrocarbon	**	***		**	*				**		*
Organic solvent	*	*		***	***				***	***	*
Phenols	*			**	**		*		***	***	*
Pesticides		*	***	**	***	***	*		***		
Detergents	**		*		*		**		***	*	**
Fats	*	*					**				
Methane											
Other Organics											
				***					***	***	
Microbiological Indicators											

Variable	Non-Industrial Water Uses						Industrial Water Uses				
	Municipal waste water	Urban Runoff	Agricultural activities	Solid wastes	Hazardous wastes	Atmospheric transport	Food processing	Mining	Chemical	Paper	Textile
Faecal Coliform	***	**	**	***			***				
Other Pathogens	***		**	***			***				

Table22: Transboundary Water use-water Impact Score Matrix for the Nile Basin (Ethiopia – Egypt – Sudan)

Parameter	Water use score			Impact Score			Total Score		
	3	**2**	**1**	**3**	**2**	**1**	**3**	**2**	**1**
Dissolved Oxygen	2	0	4	9	1	0	11	1	4
Suspended Solids	3	3	1	5	3	2	8	6	3
Chloride	3	2	2	4	3	2	7	5	4
Conductivity	0	0	3	7	3	1	7	3	4
BOD	1	1	0	5	3	1	6	4	1
pH	1	2	3	5	1	5	6	3	8
Faecal Coliform	2	0	0	3	2	0	5	2	0
Nitrate/Nitrite	1	1	2	3	3	3	4	4	5
Pesticides	0	2	2	4	1	2	4	3	4
Hardness	4	2	1	0	0	10	4	2	11
Total Coliforms	1	0	1	3	1	0	4	1	1
Sulphate	1	3	3	2	1	6	3	4	9
Sulphide	1	3	3	2	1	6	3	4	9
COD	0	1	0	3	3	4	3	4	4
Ammonia	1	0	3	2	3	3	3	3	6
Heavy metals	1	1	2	2	1	0	3	2	2
Mercury	0	0	0	3	0	2	3	0	2
Arsenic	0	2	2	2	1	5	2	3	7
Phenols	0	1	3	2	2	3	2	3	6
Organic Nitrogen	0	0	0	2	3	3	2	3	3
Phosphorous/Phosphate	0	0	1	2	3	2	2	3	3
Chromium	0	0	0	2	3	3	2	3	3
Lead	0	0	0	2	3	0	2	3	0
Turbidity/transparency	2	2	0	0	0	0	2	2	0
Residues	0	0	0	2	1	7	2	1	7
Carbonate Components	2	0	2	0	1	4	2	1	6
Calcium	2	0	4	0	0	8	2	0	12
Organic solvent	1	0	3	1	0	1	2	0	4
Zinc	0	0	0	2	0	2	2	0	2
Cadmium	0	0	0	2	0	2	2	0	2
Other Organics		0	0	2	0	0	2	0	0
Iron	0	3	1	1	3	1	1	6	2
Detergents	0	0	4	1	3	3	1	3	7
Sodium	1	0	1	0	3	4	1	3	5
Copper	0	0	1	1	2	3	1	2	4
Odor	1	1	0	0	0	8	1	1	8
Total Organic carbon	0	0	1	1	1	6	1	1	7
Alkalinity	0	0	0	1	1	0	1	1	0
Magnesium	1	0	4	0	0	8	1	0	12
Temperature	1	0	0	0	0	8	1	0	8

Parameter	Water use score			Impact Score			Total Score		
	3	**2**	**1**	**3**	**2**	**1**	**3**	**2**	**1**
Other Pathogens	1	0	1	0	0	0	1	0	1
Fluoride	0	2	0	0	1	4	0	3	4
Color	0	1	1	0	0	8	0	1	9
Boron	0	1	1	0	0	5	0	1	6
Oil and Hydrocarbon	0	1	5	0	0	0	0	1	5
Fats	0	0	0	0	1	2	0	1	2
Aluminum	0	0	1	0	1	0	0	1	1
Redox Potential	0	0	0	0	0	8	0	0	8
Silica	0	0	1	0	0	5	0	0	6
Cyanide	0	0	1	0	0	4	0	0	5

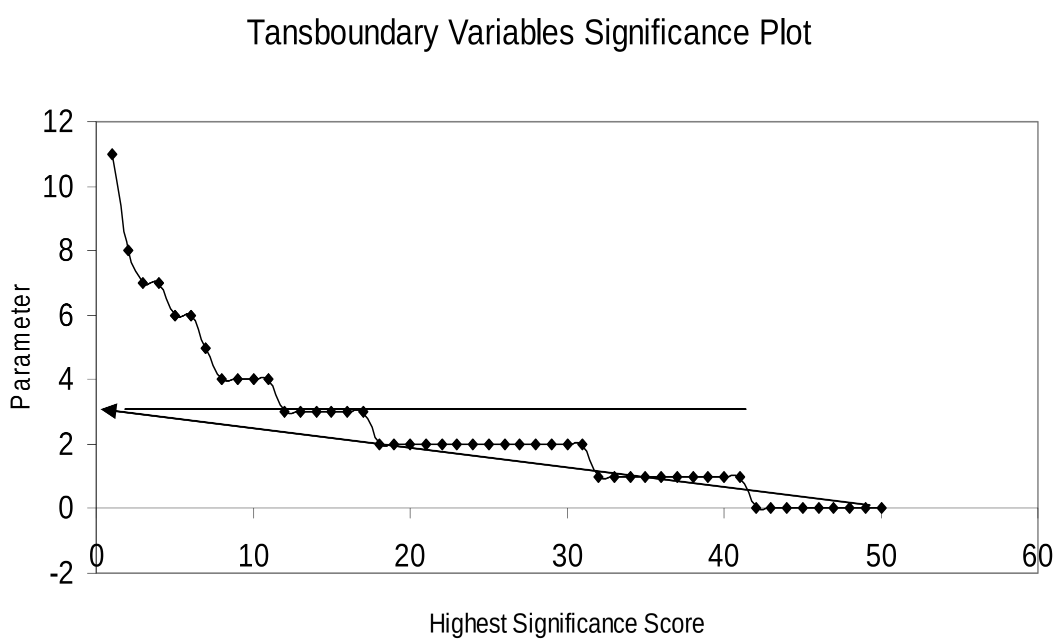

Fig. 4 Transboundary variable significance plot

From the analysis of above, it is apparent the following variables have transboundary importance:

Parameters of Transboundary Significance

1. Dissolved Oxygen
2. Suspended Solids
3. Chloride
4. Conductivity
5. BOD
6. pH
7. Faecal Coliform
8. Nitrate/Nitrite
9. Pesticides
10. Hardness
11. Total Coliforms**
12. Sulphate
13. Sulphide
14. COD
15. Ammonia
16. Heavy metals (including Cadmium, chromium, lead, Zinc and Cobalt)
17. Mercury (Separately)

(** The objective of monitoring for total coliforms is to estimate the density of bacterial contamination in general, determine a source of pollution, enforce water quality standards or trace the survival of microorganisms.)

It has to be noted this analysis is approximate and does not take account of complete inventory of water uses and impacts on water sources.

B-5 SUGGESTIONS ON HOW THE DEFICIT BETWEEN THE PARAMETERS BEING ANALYZED AND THOSE THAT SHOULD BE ANALYZED CAN BE BRIDGED.

As it appears analysis for heavy metals and for organic compounds will require the use of advanced instruments and appropriate training of staff in sampling, analysis and data interpretation. This aspect has been discussed earlier in this report.

B-6 LIST OF THE PARAMETERS THAT CAN BE CONVENIENTLY TESTED FOR IN THE FIELD BY NGOS, CBOS AND INSTITUTIONS AT SCHOOLS BY USE OF PORTABLE EQUIPMENT.

The following parameters can be monitored at the watershed level (contributing streams) by communities, school and institutions:

1. Stream flow
2. Dissolved Oxygen
3. Biochemical Oxygen Demand (If training is offered to senior high school students)
4. Temperature
5. pH
6. Disk Transparency
7. Phosphorous
8. Nitrates
9. Total Solids
10. Conductivity
11. Alkalinity
12. Faecal Coliforms (If training is offered to senior high school students)

B-7 OTHER PARAMETERS THAT YOU CONSIDER SHOULD BE TESTED FOR REGULARLY AS PART OF THE WIDER CRITICAL MONITORING OF THE NILE BASIN ENVIRONMENT.

In addition to the parameters highlighted above, it may be helpful to apply biological monitoring in order to assess the health of aquatic ecosystem. In addition monitoring of the health of the population and the prevalence and incidence of water borne disease may also be helpful.

It is of course assumed that associated river discharge measurements are carried out on the Transboundary Rivers in order to provide complete information on pollutant loads.

A systematic analysis and assessment of water quality, flow regimes and water levels, habitats, biological communities, sources and fate of pollutants, as well as mass balance derivations, should be conducted in order to provide reliable information.

Ground water quality monitoring within the basin is also essential in order to assess the impacts of water uses and because of the interrelationships between surface and ground water.

Intensive baseline water quality monitoring is essential in order to provide the pollution picture and state of water quality in the basin. So far the water quality reports are derived from older master plan studies and from some monitoring done for research and for implementing certain projects.

C. DESIGN OF WATER QUALITY ASSURANCE PROGRAM

Quality control *refers* to operational techniques and activities that are used to fulfill requirements for quality. The terms internal quality control" and "external quality control" are commonly used. The former refers to activities conducted within a laboratory to monitor performance and the after refers to activities leading to comparison with other reference laboratories or consensus results amongst several laboratories.

Quality assurance Quality assurance (QA) refers to the full range of practices employed to ensure that laboratory results are reliable. The term encompasses internal and external quality control, but these specific aspects of AQA will be covered later. Quality assurance may be defined as the system of documenting and cross referencing the management procedures of the laboratory. Its objective is to have clear and concise records of all procedures which may have a bearing on the quality of data, so that those procedures may be monitored with a view to ensuring that quality is maintained.

C-1 TYPE OF METHOD BEING USED FOR WATER QUALITY SAMPLING AND TESTING BOTH IN THE LABORATORY AND IN THE FIELD

In connection with quality assurance and quality control for water quality sampling and testing both in the laboratory and in the field, there is no widely accepted procedure being duplicated across the board of measurements and reports of water quality monitoring often miss out on the *actual* quality assurance and quality control that was followed in sampling and testing both in the field and in the laboratory.

It is anticipated that the necessary QA/QA will be followed depending on the standard operation procedure specification for quality assurance and quality control. For example the standard methods for the examination of water and waste water (20th edition) describes briefly the QA/QC required for sampling and testing for every parameter. Nonetheless, this is not detailed and does not contain many aspects of QA/QC that are to be considered to ensure that measurement uncertainties are reduced, errors of measurement are minimized and mistakes are avoided.

The one documented experience is presented here from the document prepared for the ***Water Quality Monitoring Strategy for the Awash River Basin***. With respect to sampling, the following quality control and quality assurance specification are included:

Table23: Water Quality Monitoring Strategy for the Awash River Basin

S.No	**Monitoring Activity**	**Prescribed QA/QC procedure**
1	Preparation of sampling checklist	A sampler is required to prepare detailed checklist before departing in to the field
2	Field visit program	Itinerary of field visit program detailing the schedule of activities is outlined
3	Receiving Laboratory results	A protocol of recording received samples is specified including record of delivery date. Results are entered in to data base.
4	Field personnel responsibilities	The hierarchy and role of each field personnel is defined
5	Records and labeling of samples	Specification on labeling including water proof writing and typical labeling information: date, location, sampler's name, etc
6	General site observation	Requirement for recording of site information and site features.
7	Recording of results	Specification of units to be used and number of decimal places for each parameter
8	Proforma Field Sheet	A typical layout of field record sheet containing valuable field sampling information
9	Sample delivery	Maximum delay time for sample delivery is specified
10	Preserving samples	Procedure and precautions for sample preservation is specified
11	Safety during sampling	Safety procedure against infection and chemical injury is specified.
12	Protection against contamination	Procedure specified on avoiding trace contamination from the environment and from the sampling bottle.
13	Sampling from several sources	Specification of procedure and precaution for sampling from different sources of water
14	QA/QC specification for parameters	Specification of sampling, preservation, collection, storage and analysis for parameters to be determined
15	Equipment calibration and standard Operating Procedure	Specification of detailed procedure for the calibration and operation of field and lab equipments (ex. pH meter)
16	Standard Operation Procedure for Parameters	Detailed specification of standard operating procedure for determination of parameters
17	Recording of Information and data analysis reporting	Specification of data: general information, sample information, laboratory derived information, results,
18	Assessment of results	Specification for assessment of results is specified.

C-2 WATER QUALITY ASSURANCE PROGRAMS THAT ARE IN EXISTENCE

Apart from the above stated procedures a complete and detailed specification of quality assurance and quality control is not available. Many of the reported results did not include or never contained method validation. Therefore, in some cases it is not possible to validate the results with respect to the methods employed. Method validation is normally carried out by analyzing for:

1. Selectivity/Specificity
2. Limit of Detection
3. Limit of Quantitation
4. Linearity
5. Accuracy
6. Truness
7. Precision
8. Sensitivity
9. Ruggedness

Method documentation protocols if existed are not normally referred to in the results. Therefore, it is not possible to ascertain if method documentation protocols exist or if existed are being followed on or if these protocols are being updated.

In many cases internal laboratory quality management system is not in place. Quality management system addresses issues such as quality manual, standard operating procedure, reference material, equipment calibration, internal audit, document control system, etc.

Internal laboratory quality assurance and quality control procedure is not well documented and in many cases it is not certain if such procedures are ever designed and or are being followed up on.

Table 23B: Definitions of Method Validation Parameters

Method Validation Parameter	Definition
Selectivity/Specificity	Selectivity: The ability of the method to determine accurately the analyte of interest in the presence of other components in a sample matrix under the stated conditions of the test. Specificity is a state of perfect selectivity
Limit of Detection	LoD:The lowest concentration of analyte in a sample that can be detected LoD = B+3S0 or 0+3S0 (for fortified samples; typically, three times the noise level) B=Blank S0=standard deviation of 10 measurements
Limit of Quantitation	The Limit of Quantitation is the content which is equal or grader than the lowest concentration point on the calibration curve (i.e. what level can be measured) LoQ = B+10S0
Linearity	Correlation coefficient, sufficient when $r^2 > 0.99$ or 0.98 for very low concentrations *<u>Criterion No 1</u>*: $R=kC^n$ logR=nlogC+logk, LogR=f(logC), n=slope $1.1 \geq n \geq 0.9$ (R:Response of the blank, k sens.,C conc, n coeff.) *<u>Criterion No 2:</u>* Response of the sample minus the response of the blank divided by the concentration as a function of the concentration value
Accuracy	The closeness of a result to a true value (=trueness+precision).
Truness	The closeness of agreement between the average value obtained from a large set of test results and an accepted reference value.
Precision	How close results are to one another
Sensitivity	The change in the response of a measuring instrument divided by the corresponding change in the stimulus
Ruggedness	Intra-laboratory study to check changes due to environmental and/or operating conditions. Usually it is part of method development Deliberate changes in Temperature Reagents (e.g. different batches) Extraction time Composition in the sample, etc

C-3 EFFICIENCY AND ACCURACY OF THE REPORTED WATER QUALITY ANALYTICAL RESULTS.

Considering the gap in effective quality control and quality assurance, it is not possible to determine the extent of reliability of the data results reported. In many cases it is not stated if repeated measurements are carried out and if the reported data was obtained through a single measurement only. The number and location of sampling may not have been properly designed and it is not certain if the sample analysis results are representative or the number of samples was too few or was too many reflecting on the efficiency of sampling and analysis results.

Even in some case, the units of measurements are not specified, the results are specified with many decimal places that are beyond the limit of detection of the instrument used or in some cases there are too few decimal places resulting in round off error results.

Some times it is not clear if the analysis for some parameters such as phosphorous, for example, represent, the total phosphorous, or the orthophosphate, or acid hydrolysable phosphorous. Measurement of Nitrate is in some case stated as mg/L of NO_3^- or in other case as mg/L of N.

C-4 DESIGN OF AN APPROPRIATE WATER QUALITY ASSURANCE PROGRAM, AND PROPOSED PARAMETERS OF TRANS BOUNDARY SIGNIFICANCE THAT SHOULD BE FEATURED IN THE PROGRAM.

The following quality control and assurance program is summarized that is thought to assure the validity of methods, integrity and precision of analysis results and uniformity of standards of performance across Laboratories:

Table 24: Design of Quality Assurance/Quality Control for Water Quality Monitoring

QA/QC Parameter	Quality Control / Quality Assurance sub-Parameter	Quality Control and Quality Assurance Provisions
Organizational Structure	1. Laboratory manager	1. Laboratory manager to oversee The Laboratory Manager (1) oversees the daily operations of the laboratory (2) directs technical personnel in the proper performance of laboratory procedures and the reporting of results, (3) ensures that appropriate methods are used, (4) plans activities leading to testing and modification of analytical procedures, and (5) designs and implements a comprehensive QA/QC program. The Laboratory Manager is responsible for initiating the QA/QC program, providing information and training to the staff, and periodically reviewing QA/QC activities. Qualification M.Sc
	2. Laboratory Coordinator	The Laboratory Coordinator oversees the daily operations of the laboratory, ensures that the equipment is properly maintained and calibrated, orders supplies and equipment, and oversees and performs analytical work. The Laboratory Coordinator implements the QA/QC program in the daily tasks of conducting analyses, performing quality control checks, and calculating and reporting results. Qualification M.Sc/B.Sc
	3. Chemical Safety Officer	The Chemical safety Officer oversees safety operations in the laboratory with assistance from the Laboratory Manager and Laboratory Coordinator.
	4. Laboratory and Field Staff	The laboratory and field staffs are responsible for correctly implementing collection and analysis procedures and for identifying and working with supervisors to correct and avoid potential problems. Qualification B.Sc / Diploma

QA/QC Parameter	Quality Control / Quality Assurance sub-Parameter	Quality Control and Quality Assurance Provisions
Analytical Methods	Documentation of different methods and QA/QC with respect to each	Documentation of analytical methods categorized in to: compliance. Official, provincial and experimental methods.
Training	Laboratory manager	Is responsible for ensuring that all staff receive appropriate training, new staff are properly oriented and safety training are given to all concerned
Safety	Safety plans and provisions	-Safety against fire, chemical spills, electric shore. Wearing disposable gloves, safety glasses, and overcoat. Provision of safety eye washes and showers. Immunization of staff. Testing of fire extinguishers. Disposal of hazardous waste
Laboratory Materials and Equipment	Log books of QA/QC for equipment and materials	- Use of daily log books to record operating times. Maintaining general cleanliness. Restricting access and traffic. Regular cleaning and preventive maintenance.
	Laboratory Water	Quality check for conductivity and turbidity, colony count, heavy metal, etc. Quality control action line development
	Analytical balances	Checking and calibration, resting on level surface, regular cleaning.
	Hoods	Regular cleaning and checking that the hood operates at correct vacuum pressure
	pH, conductivity and turbidimeter	Keep log book of calibrations, calibrate according to manufacturers instructions, and discard working solution.
Internal Analytical Quality Control	Choice of analytical method	Use a method that fits the purpose of water quality monitoring.
Choice of analytical method	Linearity	The calibration point should be determined and a linear response curve demonstrated if possible. If the calibrations do not show a linear response, linear transformation of the data should be investigated.

QA/QC Parameter	Quality Control / Quality Assurance sub-Parameter	Quality Control and Quality Assurance Provisions
	Limit of Detection	The lowest concentration of the variable that can be distinguished from zero with 95 per cent confidence should be determined.
	Precision	Within day and between day coefficients of variation should be performed at three concentration levels.
	Accuracy	Analysis of reference materials with known concentrations of the variable (i.e. CRMs) or comparison analyses with existing methods in other laboratories where possible.
Method Validation	Calibration Check	Standard solutions should be analyzed from time to time within the required range of concentration. Linear response is typical ($r^2 = 0.99$).
	Use of Blanks	Analysis of method blanks and field blanks
	Recovery Checking	A specimen spiked with a known amount of the variable should be tested in each batch and the closeness of fit to the expected value calculated.
	Precision and Accuracy check	Using duplicate analysis or using pooled reference material or using certified reference material.
	Bacteriological Analysis	Use official method. Reagent and media prepared according to method and date of preparation is labeled. Preparation of media and buffer quality control log book. Filter blank to confirm sterility of samples. Positive and negative control to test integrity of medium.
External Quality Control	Method of control	External quality control (EQC) is a way of establishing the accuracy of analytical methods and procedures by comparing the results of analyses made in one laboratory with the results obtained by others conducting the same analysis on the same material. This is usually accomplished by one laboratory, the reference laboratory, sending out sets of specimens with known and unknown concentrations of variables to all of the participating laboratories. Each participant analyses the specimens for the specified variables and reports the results to the reference laboratory.
Sampling and Sampling	Documentation and sampling	Procedure for sampling should be carefully documented. Strictly adhere to standard operating procedures for sampling. Ensure all equipment is clean and in working order. Record all conditions which applied during

QA/QC Parameter	Quality Control / Quality Assurance sub-Parameter	Quality Control and Quality Assurance Provisions
Management		sampling. Take strict precautions to avoid contamination.
	Sampling Method Requirements	Standard operating procedure must be documented detailing: field sample collection procedures and methods, field analysis, equipment, decontaminating sampling equipment, preventive maintenance, sample identification, preparation of sample containers.
	Sample handling	Sub sampling, splitting, sample treatment should be recorded.
Field Quality Control	Field replicate samples	In order to ensure a preservative is contaminate free, it must be tested before it is used for sample preservation. Summit preservative reagents blank prior to the use of a new lot of preservative. The field reagents blank should not exceed 1/10 of practical quantification limits.
	Preservative reagent blank	Field replicate samples will be collected and analyzed to evaluate sampling precision. A field replicate is a sample taken at the same location and depth as a sample. The replicate and sample should be taken in quick succession of each other. One of the bottle sets will be labeled as primary sample and one will be submitted to the laboratory blind with a fictitious sample identification number. The blind field will be analyzed in the same manner as the primary samples. A field replicate should be collected once every 20 samples. The relative percent difference should not exceed 20%.
	Equipment blank	To ensure the sampling device has been effectively cleaned, fill the device with deionized water or pump deionized water through the device, transfer to sample bottles, preserve, and return to the laboratory for analysis. The field equipment blank should be processed at beginning sampling day. This may be performed in the regional office prior to going to field. One equipment blank sample will be collected per month per person. The equipment blank should not exceed practical quantification limits.
	Performance Evaluation samples	Every year a total of four double-blind water matrix PE samples will be submitted to the analytical laboratory to evaluate analytical accuracy. The PE samples will be

QA/QC Parameter	Quality Control / Quality Assurance sub-Parameter	Quality Control and Quality Assurance Provisions
		submitted once every quarterly. The PE samples will contain known concentration of analytes. The laboratory results will be evaluated against the certificates of analyses by the district quality. Officer to ensure that laboratory maintains good performance. Double blind PE samples will be obtained from a commercial vendor. The PE samples will be shipped from the field or regional office lab to the analytical laboratory in the containers identical to those used for the field samples
	Bacteriological Analysis	Holding time of 6 hours for compliance purposes. 24 hours for non-compliance purposes. Samples are kept on ice and processed within 48 hours. Samples must be submitted using request form.
Data Quality Control	Handling data	Record of all sample information, use of data base system. Standardization of information format.
	Detection of Incorrectly entered data	Visual observation, statistical test, The use of statistical quality assurance scheme.

C-5 EMPHASIS ON ANALYTICAL QUALITY CONTROL

Method Validation: can be done by group of laboratories through collaborative studies and by inter-laboratory comparisons. Method validation in a single laboratory can be done by comparisons of the results with that of certified reference materials and by comparing the results with other methods that are already validated. The analytical requirements of method validation should be addressed answering questions such as.

a. What are the analytes of interest?
b. What are the expected concentration levels
c. Are there any interferences?
d. How was the sampling done?

Depending on the category of the method, the extent of method validation can be determined as per the table given below.

Table 25: Extent of Method Validation

Category of the method	Action
Inter-laboratory tested	Precision, trueness
Inter-laboratory tested but it applies with different material, different instrument	Precision, trueness, limit of detection, selectivity
Established but not tested	Many
From bibliography, with reference to performance characteristics	Many
From bibliography, without reference to performance characteristics	Many
In-house method	Full validation

A check must be made on the performance characteristics of the method involving:

1. Selectivity/Specificity
2. Limit of Detection
3. Limit of Quantitation
4. Linearity
5. Accuracy
6. Trueness
7. Precision
8. Sensitivity
9. Ruggedness (or Robustness)
10. Recovery

Validation as an internal quality control should incorporate:

- a. QC samples and the use of control charts
    - i. Warning and action limits
    - ii. QC samples to be within limits

iii. Realistic limits on the control chart

b. Various types of blanks to correct the response
c. Replicate analysis to check changes in precision
d. Blind analysis to check precision
e. Standards and chemical calibrations to check the stability of the response

Validation as an external quality control should also incorporate:

a. Proficiency testing
    i. Monitor of laboratory performance
    ii. Highlight reproducibility
    iii. Monitor of traceability
    iv. Recognized by accreditation bodies

<u>Method documentation and Protocol.</u>

Method documentation protocol should be established including the following components:

- Update & Review Summary
- Title
- Scope
- Warning & Safety precautions
- Definitions
- Principle
- Reagents & Materials
- Apparatus and equipment
- Sampling and samples
- Calibration
- Quality Control
- Procedure
- Calculation
- Reporting procedures including expression of results
- Normative references
- Appendix on method validation
- Appendix on measurement uncertainty

1. The laboratory Environment.
    a. Provision of legislation and according legal status to laboratories.
    b. Internal laboratory management
    c. Establishment of an accreditation body

d. Specification of suppliers, equipment and certified reference materials.
e. Establishment of calibration laboratories.
f. Establishment of certification body.
g. Provision of legislation and according legal status to laboratories.

Internal laboratory management

There has to be adequate supervision of testing and calibration staff. The laboratory technical management should have the overall responsibility for the technical operations and should appoint a member of staff as quality manager. Documented policies, systems, programmes, procedures and instructions should be established to the extent necessary to assure the quality of the tests and/or calibration results. These documents shall be communicated to, understood by, available to, and implemented by the appropriate personnel.

- Quality manual: The laboratory's quality system policies and objectives shall be defined in a quality manual. The overall objectives shall be documented in a quality policy statement. The quality manual should contain a list of available standard operation procedures. There have to be standard operation procedures for all relevant procedures. Guidelines for calibration, for calculation of detection limits, for calculation of control charts, etc should be prepared.
- Standard Operation Procedure: Should contain general description of the method
- Underlying standard, sampling and conservation, range of application, interferences, necessary equipment, chemicals (purity, where to buy) measurement. It should also contain calibration, evaluation, control charts, other quality assurance measures, use of reference materials, presentation of results, limit of detection, limit of determination responsibilities.
-
- Reference Material: The laboratory should keep a list of reference materials which will have to be in the quality manual.
- Environmental Conditions: There has to be given description of the rooms, requirements for accommodation and environmental conditions.
- Equipment: Equipment together with software significant to the test and calibration should be recorded and stated.

- Defective and Incorrectly Working Testing Equipment: Should be taken out of service. There has to be regulation on how the equipment has to be labeled and what must be arranged.
- Internal Audits. To show that the operation of the laboratory is in compliance with its quality system.
- Document control System: Internally generated or obtained externally and dealing with: regulations, standards, other normative documents, test and/or calibration methods, as well as drawings, software, specifications, instructions and manuals. Every document must be clearly identified in the control system together with its revision status. Numbering system can be used that includes labeling the numbering status. Documents shall be reviewed and approved by authorized personnel.
- Master List: A master list of documents shall be prepared that indicates the revision status and precludes the use of obsolete and invalid documents.
- Document Approval; authorized editions of appropriate documents are available at all locations where operations essential to effective functioning of the laboratory are performed; documents are periodically reviewed and, where necessary, revised to ensure that continuing suitability and compliance with applicable requirements; invalid or obsolete documents are promptly removed from all points of issue or use, or otherwise assured against unintended use; obsolete documents retained for either legal or knowledge preservation purposes are suitably marked
- Document Approval System: documents shall be uniquely identified indicating the date of issue and/or, revision identification, page numbering, the total number of pages or a mark to signify the end of the document, and, the issuing authority (ies).
- Quality Policy: The quality policy is one of the essential things in a quality system. the whole system should only reflect the quality policy in the daily work and put the policy into concrete terms the policy shall be issued under the authority of the chief executive It is very important to have a clear statement, how crucial quality is in the work of his/her laboratory

Inter-laboratory testing

Inter-laboratory testing is performed by taking randomly selected sub-samples from a source of material and distributing them simultaneously to participating laboratories for concurrent testing. The type of tests involved include:

1. Method validation
2. Proficiency testing
3. Reference material characterization.

1. Inter-laboratory testing for Method Validation:

The aim will be for efficient characterization of a method in which laboratories shall use the same method. Normally the laboratory should use its routine method and the choice might be limited by regulations. The organizer of the testing should ask for details to conduct a method specific evaluation and to give comments on the methods used.

2. Proficiency Testing

The objective is to get an indication of the performance of an individual laboratory or a group of laboratories as a whole. This is appropriate since the laboratories work under routine conditions and this procedure helps in improving the quality of performance by these laboratories. The basic concern here is the accuracy. The laboratory, for itself can determine the bias or imprecision in its own procedure and whether this was responsible for its inaccuracy. The laboratories will have the benefit of uncovering errors that could not be discovered through internal quality control. This procedure will be helpful as a certification of competence for the accreditation authorities.

3. Reference Material Characterization

The objective is to determine the best possible value of the concentration of the analyte in the reference material. The precise concentration of the analyte must be determined by more experience laboratories.

CONCLUSION

There are a number of places available for training of staff in water quality monitoring. Addis Ababa University and Arbaminch University are potential places for offering advanced level training in water quality monitoring. The universities possess staff with qualified skill and more or less adequate laboratories to offer these trainings.

A number of regional training sites have been identified. The ones in Addis Ababa, namely, The Water works development Enterprise, The environmental Protection Authority lab, The Geological Survey of Ethiopia Laboratory, The Ethiopian quality and standards authority laboratory have more or less the laboratory capacity and staff with adequate qualification to offer basic training water quality analysis and basic water quality monitoring. The regional laboratories and water quality centers are not well staffed and are not well equipped to do complete analysis of water quality and need to be upgraded in these respects.

The existing laboratories in the above agencies while some of them have been equipped with instruments for trace metals and trace organics analysis, the equipment either are not commissioned or are malfunctioning, Experience in this area is lacking and there are problems of getting chemicals for these analyses.

Apart from drawbacks in laboratory equipments, there is generally lack of experience in water quality monitoring works and data analysis and interpretation. Quality control and quality assurance policies and practices are not very common. These shortfalls have been addressed in the module design.

Training in water quality monitoring is considered at 3 levels. At the upper level (level 1) for personnel in designing and managing water quality monitoring networks, for level 2 (middle level personnel) for supervising field and laboratory analysis and level 3 personnel who carry out the routing water quality analysis and assessment.

There are 12 modular units of teaching and the trainees belonging to the various categories of training will be given the training which can be made flexible depending on other considerations.

Documents have been examined regarding routinely analyzed parameters and are included in this report. In addition variables that need to be monitored based on the environmental peculiarities of the Nile basin have been included.

The pollution status of the different river basin has been discussed, while major sources of industrial pollution have been identified emphasis has been given to non-potential solution. Monitoring location based on Sander’s method has been applied to the river reaches.

Transboundary analysis for the water quality variables has been discussed and recommendation is made for list of variables to be monitored. Water quality parameters that can be measured by school and the community have been identified.

The current quality control and quality assurance provisions and practices are found to be not adequate. Accordingly a system of quality assurance and quality control measures has been designed with a view to increasing the performance and reliabilities of water quality monitoring undertakings within and across regions.

Training modules that have been designed include more or less all aspects of the water quality monitoring undertaking and should help in many ways in meeting the qualified human power requirement in water quality monitoring.

REFERENCES

1. Andrew E, Knaak and aul D. Anckorn. Quality Assurance and Quality Control Procedures for an urban Water Quality Monitoring Program.
2. Anthony Turton and others. Transboundary River Basins.Proposed Principles and Discussion Papers.
3. Arcadis Euro Consults. Transboundary Water management as an International Good. 2000.
4. Cisneros. B.J. Water Availability Index based on Quality and Quantity. Its Application In Mexico. Water Science and Technology. Vol. 34, No.12.
5. Continental Consultants. Ethiopian Guideline Specification for Drinking Water Quality. March 2002. Addis Ababa.
6. Costica Sofroni. Romanian, Hungarian and Ukrenian Transboundary Basin. November 2002.
7. Ecological Monitoring and Assessment Network, Canada. Linking Ecological Monitoring to Decision making at Community and Landscape Scales. September 2004.
8. European Water Pollution Control. Guidelines for Water Quality Monitoring and Assessment of Transboundary Rivers. Volume 7. No.5 1997.
9. Federal Ministry of Health. Ethiopia. Rapid Assessment of Drinking Water Quality in the Federal Republic of Ethiopia. January 2006.
10. Fitsum Merid. National Water Quality Monitoring Baseline Report. Final Report. May 2005.
11. G. E. Batley. Quality Assurance in Analytical Chemistry. Marine Pollution Bulletin. Volume I. 1999.
12. Harmancioglu, N.B, Fistikoglu, O, Ozkul, S.D., Singh, V.p amd M.N Alpasaln. Water Quality Monitoring Network Design.
13. Ian Spellberg. Monitoring Ecological Change. Cambridge University Press. 1991.
14. International Union for Conservation of nature. Principles of International Environmental Law.
15. K. Kudaiberginuly,. Ensuring River Water Quality across Borders. January, 2005.
16. Mendham J. Text book of Quantitative Chemical Analysis, Pearson Education Limited. 2005.
17. Ministry of Water Resources. Abbay River Basin Integrated Development Master Plan Project.
18. Ministry of Water Resources. Baro Akobo River Basin Integrated Master Plan Study.
19. Ministry of Water Resources. Environmental Impact Assessment for Tekeze River Basin Master Plan Projects.
20. Ministry of Water Resources. Tekeze River Basin Integrated Development Master Plan Project.
21. Ministry of Water Resources. The Baro-Akobo Integrated Development Master Plan Study.
22. Ministry of Water Resources. Water Supply and Sanitation Project. Environmental and social management framework.
23. Mohammed M.A. Industrial Pollution and Its Impact on the Little Akaki River. Faculty of Engineering, Louhgborough University.
24. Nataleeia Alexiva. Management of Transboundary Rivers on EU External Border In Northern Europe, 2003.
25. Neal D. Boebneke. Laboratory Experiments in Environmental Chemistry. Printice Hall. 2000.

26. New England Regional Water Quality Program. Volunteer water Quality Program New England Collaboration.
27. Nile Basin Initiative. Nile Basin Regional Water Quality. Monitoring Baseline Study Report. August 2005.
28. Nile Basin Initiative. Project Implementation Plan. Working document. December 2002.
29. Nile Basin Initiative. Transboundary Environmental Analysis. May 2001.
30. Ohio Water Microbiology Laboratory. Quality Assurance Quality Control Manual.
31. Omwenga, J.M. Training Modules in Basic Water Quality Monitoring Techniques.
32. Ongley. E.D. Matching Water Quality Programs to Management Needs in Developing Countries. The challenge of Program modernization. Volume 7, 1997.
33. San Franssico Estuary Institute. Quality Assurance Program Plan. February 2004.
34. Sanders G. Thomas. Design of Networks for Monitoring Water Quality.
35. Schuylkill Center for Environmental Education. Volunteer Water Quality Monitoring Field Manual.
36. Tashi Sering. Managing a Transboundary River.
37. The Ethiopian Environmental Protection Authority. A water quality monitoring strategy for the Awash River Basin. Addis Ababa. June, 2002.
38. The Ethiopian Environmental Protection Authority. National Project on Ecologically sustainable Industrial Development. Volume I. Situation Analysis.
39. The Ethiopian Environmental Protection Authority. National Project on Ecologically sustainable Industrial Development. Volume II, the Industrial Sector.
40. The Ethiopian Environmental Protection Authority. National Project on Ecologically sustainable Industrial Development. Volume III, Tools for Policy Implementation.
41. The Ethiopian Environmental Protection Authority. National Project on Ecologically sustainable Industrial Development. Volume IV. Industrial Pollution Prevention and Regulation. June 2001.
42. UN/ECE Task Force on Monitoring and Assessment. Guidelines on Monitoring and Assessment of Transboundary Rivers, March 2000.
43. United Nations Environment Program. Operational Guide for Data Submission. Global Environmental Monitoring System(GEMS). Water Program.
44. United States Environmental Protection Agency. Volunteer Stream Monitoring. A Methods Manual. November 1997.
45. University of California. Analytical Chemistry Laboratory Guide.
46. World Health Organization. Examination of Water for Pollution Control. Volumes I, II and III.
47. Xinaho Wang. Using GIS to evaluate the relationship between land use and Water Quality at a Watershed Level.
48. Zemansky. G.M. Interpretation of Ground Water Geochemical Data.