Nile Basin Initiative
Nile Transboundry Environmental Action Project

Training Modules and Materials, Identification of Key Parameters and Quality Assurance Program for Water Quality

Professor Saad Hassan (Ph.D.,D.Sc.)
Director of the Reference Laboratory (Water)
Faculty of Science, Ain Shams University
Cairo, Egypt

April 2007

Executive Summary

This report was designed within the Nile Basin Initiative : Nile Transboundry Environmental Action Project (NTEAP) to offer some training modules and material on water quality assessment and to evaluate water quality in Nile River in Egypt.

Chapter (1) deals with evaluation of both technical and training capacity of water quality monitoring and assessment National Laboratories in Egypt. Three main national monitoring networks are available for evaluation of water quality of Nile River. These are the Central Laboratories of Ministry of Water Resources and Irrigation (MWRI), Ministry of Health and Population (MOHP) and Egyptian Environmental Affairs Agency (EEAA) . Coastal water monitoring networks are those of the National Institute for Oceanography and Fisheries (NIOF) and Institute of Graduate Studies and Research (IGSR). A list of 39 laboratories dealing with water quality monitoring and assessment is also given. However, 4 water assessment laboratories are only accredited. Training capacity, on the other hand , is limited.

Chapter (2) describes detailed proposals for water quality monitoring and assessment training modules . These cover quality measures and safety of the laboratory, sampling, test parameters, instrumental techniques, field procedures, quality control/quality assurance plan , and source of water contaminants.

Chapter (3) includes some training materials and key subjects for use to create awareness about water quality management for communities, stakeholders, Non Governmental Organizations (NGO's), Community Based Organizations (CBO's), institutions, schools and volunteers..

Chapter (4) reports and provides an inventory about the major industrial, agricultural and domestic pollutants and their sources in all parts of the Nile River in Egypt from Aswan in the south to the final destination points in the Mediterranean sea. Although the organic load is fairly high, the water quality is quite good indicating high self assimilation capacity of Nile River. The major contaminants are pathogenic microorganism , organics, pesticides and heavy metals. National , cross-boarder , and trans boundary pollutants are discussed. Parameters commonly monitored in the National Laboratories for water quality assessment and suggestions for other additional parameters are given.

Chapter (5) provides a designed water quality assurance program to be used at the national and/or regional levels for enhancing the integrity and credibility of data quality produced by the monitoring laboratories. A module for Quality Assurance Manual is also given.

Contents

List of Tables

Table

List of Figures

Figure

List of Abbreviations & Acronyms

AAS	Atomic absorption spectrometry
APHA	American Public Health Association
BOD	Biological oxygen demand
CBO's	Community Based Organizations
Cl	Chloride
CLEQM	Central laboratory for environmental quality monitoring
Cl_2	Chlorine
COD	Chemical oxygen demand
CV	Coefficient of variation
d	Day
DANIDA	Danish International Development Assistance
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved oxygen
EC	Electrical conductivity
EEAA	Egyptian Environmental Affairs Agency
EHD	The Environmental Health Department
FTIR	Fourier transformer infrared
GC	Gas chromatography
GLP	Good Laboratory Practice
HPLC	High pressure liquid chromatography
ICP	Inductive coupled plasma
IGSR	Institute of Graduate Studies and Research
IQC	Internal quality control
ISE	Ion selective electrode
ISO	International Standardization Organization
LLD	Lower limit of detection
m^3	Cubic meter
MALR	Ministry of Agriculture and Land Reclamation
MOHP	Ministry of Health and Population
MPN	The most probable number
MQO	Measurement quality objectives
MSDS	Material safety data sheets
MWRI	Ministry of Water Resources and Irrigation
NGO's	Non-Governmental Organizations
NH_3	Ammonia
NIOF	The National Institute for Oceanography and Fisheries
NO_2	Nitrite

NO_3	Nitrate
NR	not reported
PAH's	Polyaromatic hydrocarbons
PO_4	Phosphate
POP's	Persistent Organic Pollutants
Q	Quantity
QA	Quality assurance
QC	Quality control
RSD	Relative standard deviation
SOP's	Standard operation procedures
T. Alkal.	Total alkalinity
T. Hard.	Total hardness
TDS	Total dissolved solids
THM's	Trihalomethane
TKN	Kjeldahl total nitrogen
TMDL	Total maximum daily load
TN	Total nitrogen
TOC	Total organic carbon
TOD	Total oxygen demand
TP	Total phosphate
TSS	Total suspended solid
USAID	United States Agency for International Development
VOC's	Volatile organic compounds
WHO	World Health Organization
WQI	Water quality index
WQM	Water quality management
WRI	Water Research Institute

Chapter 1
Technical and Training Capacity

1.1. Introduction

The Nile River runs about 6,650 km through six countries starting from Burundi ended to the Mediterranean Sea. The last 1,600 km of the river goes through Egypt. The main part of water resources come from Ethiopia Blue Nile, and the rest from Uganda White Nile [1]. On the other hand, Egypt has a long coastline, extending for about 2 500 km, together with a continuous continental shelf of about 53 000 km^2 bordering the country on the north along the Mediterranean Sea coast and to the east along the Red Sea, with the Suez and Aqaba Gulfs. Moreover, Egypt has coastal lagoons opening to the Mediterranean Sea (Maruit, Edku, Burollus, Manzala, Port Fouad and Bardawil) and two opening to the Suez Canal (Timsah and Bitter Lakes), with two closed lakes (Qarun and Wadi Al Raiyan), and the great reservoir behind the Aswan High Dam (Lake Nasser) [2]. These high resources of water necessitate regular monitoring of water quality by different Governmental laboratories.

1.2. Technical capacity

Three main national monitoring networks are available in Egypt for evaluation of water quality of surface water. The first is that of the Ministry of Water Resources and Irrigation (MWRI). This network extended from Lake Nasser, Aswan in the south along the Nile River, its branches, canals, rayahs till the north coast covering a distance of 32700 Km besides 20000 Km drains. The total monitoring sites for sampling are 232 (Table 1).

Table (1) MWRI water quality monitoring stations for Nile River [3]

Location	Nasser lake	Nile River	The two branches of Nile River	Delta canals	Upper Egypt drains	Delta and Fayom drains
No of monitoring stations	4	29	7	48	29	115
Frequency of monitoring/year	2	2	12	12	2	12

The assessment is carried out by the Central Laboratory of the Ministry of Water Resources and Irrigation (MWRI). Quality of effluent discharged to Nile River is compared with the standards of Law 48/1982.

The second water quality monitoring network is that of the Ministry of Health and Population (MOHP). Table (2) presents the number of sampling locations in the different Governorates.

Table (2) MHOP water quality sampling locations for Nile River [3]

Governorate	**Aswan**	**Sohag**	**Asuite**	**Menia**	**Beni-Seuif**	**Greater Cairo**	**Garbia**	**Dakahlia**	**Domietta**	**Alexandria**	**Port saeid**	**Total**
No of monitoring stations	**11**	**13**	**20**	**13**	**8**	**18**	**24**	**5**	**7**	**6**	**9**	**134**

The Central Laboratories of The Environmental Health Department (EHD) of the Ministry of Health and Population (MOHP) and their branches in all Governorates (118 branch) are responsible for sampling and analysis of all intakes and treated outflows of drinking water treatment plants [4]. In case of non-compliance of drinking water quality, especially with respect to bacterial contamination, MOHP takes action. Furthermore, MOHP monthly monitors the ambient conditions of the Nile (134 locations) immediately upstream and downstream of industrial and agricultural drain discharge points to assess its suitability as a source of drinking water supply. The MOHP is also monitors the discharge from major wastewater treatment plants on a quarterly basis. The program includes 86 of the 104 operating plants throughout Egypt. The results of this program are transmitted to MWRI immediately after completion of each quarterly survey. The majority of the 86 plants are non-compliant with the requirements of Law 48/1982.

The third water quality monitoring network is that of the Egyptian Environmental Affairs Agency (EEAA). This network monitors on quarterly basis the quality of Nile River water by sampling and analysis from 69 locations nearby most industrial pollution sources on the Nile [5]. The Soil, Water and Environment Research Institute of the Ministry of Agriculture and Land Reclamation (MALR) is responsible for research on many subjects related to water and soil quality. The Central Laboratories of the Holding Company for Drinking Water and Wastewater and the National Authority for Drinking Water and Wastewater and all laboratories in water treatment plants in 24 Governorates continuously monitor the quality of drinking water produced from all these plants as well as the quality of water intake from the Nile River and its branches and canals.

The National Institute for Oceanography and Fisheries (NIOF, Ministry of Higher Education and Scientific Research) in Alexandria, Hurgada and Suez and Institute of Graduate Studies and Research (IGSR, Ministry of Higher Education and Scientific Research) in Alexandria through contracts with the Egyptian Environmental Affairs Agency (EEAA) monitor the quality of Mediterranean and Red Sea coastal water on a quarterly basis. NIOF is responsible for sampling and analysis of coastal water collected from 22 stations spread on the Suez Gulf, Aqaba Gulf and Red Sea [6]. The parameters tested are : dissolved oxygen, nitrite, nitrate, transparency. pH, conductivity, salinity, total dissolved solids, silicates, total phosphorus, total nitrogen, ammonia, chlorophyll-a, and total and fecal coliform. IGSR through 30 stations spread along the Mediterranean sea from Salloum in the west to Rafah in the east collect water samples for the analysis of the same parameters [7]. Both institutes issue quarterly reports for EEAA.

Discharge to coastal water should be comply with Law 4/1994. The National Research Center (Ministry of Higher Education and Scientific Research, Cairo) collects and evaluates surface water, coastal water and wastewater samples to assess their quality in the "Water Unit" through some research projects. Technical capacity of the major national water quality monitoring and assessment laboratories is illustrated in Table (3). Detailed information about these laboratories are given in Annex (1). These laboratories collect water samples from different origins and locations for chemical ad bacteriological analyses, generate data , interpret , discuss and issue periodical official reports .

Table (3) List of the main water quality monitoring and assessment laboratories in Egypt

Laboratory name	Laboratory address
Soil & Water Analytical laboratory	Drainage Research Institute
Quality Control Chemical Analysis Lab.	Ministry of Agriculture
Reference Lab, Faculty of Science*	Ain Shams Univ., Ministry of higher Education & Scientific Research
Tabbin Institute for Metallurgical Studies	Ministry of Industry
Water Pollution Research Department #	National Research Center, Ministry of Higher Education & Scientific Research
Center of Environmental Hazard Mitigation (CEHM)	Cairo University, Ministry of high Education
Central Lab of Environmental Quality Monitoring (CLEQM)#*	Ministry of Water Resources & Irrigation
Land, Water and Environmental Research Centre	Ministry of Agriculture
Integrated System Unit for Agricultural Waste Recycling, Water and Environment	Agriculture Research Center, Ministry of Agriculture
Green Lab.	Private
Cairo Central Center (EEAA)*	Ministry of Environment
Central Lab for Water (Fostat)	National Authority for Potable Water in Great Cairo
Environmental Health Department #	High Institute of Public Health, Alexandria
Soil, Water and Plant Analytical Lab.	El-Fayom Branch, Cairo Univ.,Faculty of Agr.
Imbaba Environmental Monitoring Center #	Ministry of Health and Population
Water, Wastewater, Instrumental and Environmental Lab.	Chemistry Authority, Ministry of Industry
Lab 4, Water, Land and Environment	Research Institute, Ministry of Agriculture
Tanta Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Mansoura Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Abbasa Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Zagazig Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Fostat Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Kafr El Sheik Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Domietta Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Adlia Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
New Azab Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Beni Sweif Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Menia Drinking Water Central Laboratory	Drinking and Wastewater Holding Company
Seuof Alexandria Drinking Water Central Lab.	Drinking and Wastewater Holding Company
Nozha Alexandria Drinking Water Central Lab.	Drinking and Wastewater Holding Company
Water Quality Lab.	Ministry of Agriculture
Behera Central Drinking Water Lab.*	Drinking and Wastewater Holding Company
Environmental Monitoring Central Lab #	Ministry of Health and Population
National Institute for Oceanography and Fisheries ,NIOF #	Ministry of Higher Education & Scientific Research
Institute of Graduate Studies and Research ,IGSR#	Alexandria University
Central lab, Desert Institute	Ministry of Agriculture
Tebbine Institute for Environ. Studies,	Ministry of Industry, Helwan
Microanalytical lab	Faculty of Science, Cairo University
Central lab	Ministry of Health and Population

* Accredited # offer training.

1.3. Training capacity

Simple courses for 3-6 days on the national level on water and wastewater sampling and analysis were offered to many analysts working in water quality laboratories during the last three years. The course modules involved :

- Classical methods of common analysis.
- Sampling of different types of water.
- Physical methods of water analysis (pH-turbidity- conductivity).
- Chemical methods of water analysis (nitrate – ammonia – phosphates – chloride – sulfate – BOD – COD)
- Biological methods of water analysis (total coliform – fecal coliform – streptococci)

These courses demonstrate and illustrate the procedural steps for sampling, analysis and calculation [8]. The training is carried out in some National Research Institutes, Universities and Central Laboratories of the Holding Company for Drinking Water and Wastewater. The training is financially supported by the United States Agency for International Development (USAID) and the Danish International Development Assistance (DANIDA) and supervised by local senior analysts, researchers and University Professors. Some of these training were also organized by private consultancy offices. The training was not continuous and insufficient to cover all issues in the field.

Instruments dealers were also participated in few occasions in short training or presentations (one day) on the principles, operation and applications of some selected equipment in some central laboratories. However, most of water quality analysts suffer from lack of knowledge and skills about operation and application of modern instruments (atomic absorption spectrometry – inductively coupled plasma - chromatography- total organic carbon – infrared spectrometry) due to unavailability. Some of these instruments are present only in few and not all central laboratories of water assessment.

It is noteworthy that almost all Water Central Laboratories (35 -40) have good seminar class rooms equipped with audio-visual equipments suitable for training. These laboratories can receive trainees on both part time and full time bases provided that the trainers are available and financially supported. Some Universities and Research Institutes can offer tailored courses only on a part time bases.

On the other hand, most of water quality assessment laboratories have no quality control/quality assurance programs and have little experience about advanced statistical evaluation of the results or technical validation methods of analytical procedures. These items did not received in the past suitable attention or have been ignored due to lack of trainers specialized in these topics. Among all water quality laboratories in the country, only 4 laboratories apply ISO

17025 and have been accredited during the last three years. Few other laboratories are on the accreditation list. This item is of crucial importance because without data quality verification, the obtained results lose their credibility. Nevertheless, most of the laboratories follow up the "Good Laboratory Practice, GLP" principle.

Chapter 2
Water Quality Monitoring and Assessment Training Modules

Suggested training modules on water quality monitoring and assessment are described on the following pages.

2.1. Module objectives

These modules are designed to provide various levels of trainee (with most up-to-date knowledge, techniques, methodology and procedures in the field of water sampling and analysis [8 -18] . These include:

- Use of modern automated instruments (AAS, ICP, GC, HPLC, FTIR, ISE) for water quality assessment.
- Illustrate the sources of natural, domestic and man-made contaminants in various types of water.
- Quality control/quality assurance guidelines in water assessment laboratories and their application to generate data of high quality.
- Data presentation and interpretation according to the international directions and standards.
- Comparison of national, regional and global water quality.
- Exchange ideas and experiences to enhance technical capabilities.

2.2. Module participants

- All personnel's involved in routine chemical and biological analysis of different types of water.
- All technicians, analysts , senior analysts and quality managers working in water treatment plants.
- Researchers in water institutes and universities dealing with water quality assessment.
- Analysts and technicians in environmental laboratories concerned with evaluation of water quality.

2.3. Module languages

- English.
- Arabic.

2.4. Module duration and teaching cost

- Two weeks , 96 hours lectures and discussions.
- One week,48 hours on-the-job practical training.
- Total cost for up to 20 participants is US$ 10000 -12000.The cost covers preparation of the course , the training, training materials (soft and hard), lab consumables and Hi tea break every day for 18 days.

2.5. Training location

- Central Laboratory of Drinking Water (The Holding Company for Drinking Water and Wastewater, Cairo) and Environmental Health Department of the Ministry of Health and Population can host the training programs provided that the instructors and materials are available.
- The Central Laboratory for Environmental Quality Monitoring (CLEQM) can offer training in most modules.
- Modules 1-13 except modules 1, 8 and 9 can be given by most institutes offering training in water analysis (see Table 3).
- Modules 1-13 as described in this manual can only be given by the Reference Laboratory (Water), Faculty of Science, Ain Shams University, Cairo since all these modules have been already given 6 times in organized workshops by the present author and his group.

2.6. Training modules

1.Requirements of water quality assessment laboratories.
2.Water sampling.
3.Water quality and test parameters.
4. Instrumental methods of water analysis.
5.Techniques used for water quality analysis.
6. Field water sampling and analysis.
7.Sediment sampling and analysis
8.Assessment of data quality.
9.Quality control/quality assurance.
10.National and international water quality standards.
11.Safety in water quality laboratories.
12.Sources of water contaminants.
13.Water quality assessment.

2.7. Module 1:
Requirements of water quality assessment laboratories

2.7.1. Management requirements

- Laboratory organization and responsibilities.
- Quality system.
- Documents , records and reports control.
- Control of non-conforming testing and calibration.
- Corrective actions.
- Preventive actions.
- Internal audit.
- Management review.

2.7.2. Technical requirements

- Personnel training records.
- Standard operational procedures (SOP's).
- Method validation (limit of detection - accuracy – trueness - precision – sensitivity – range – selectivity – linearity – ruggedness – speed – cost).
- Calibration and maintenance of equipments.
- Measurement traceability.
- Quality control/quality assurance plans.
- Participation in proficiency testing or intra laboratory comparison programs.

2.8. Module 2
Water Sampling

- Sampling goals : educational monitoring - water quality assessment - permitting studies – waste- load allocation studies - habitat studies.
- Types of samples: grap – composite - time composite - integrated.
- Method of sampling: manual – automatic - from bridges - from boats - depth - stream sampling.
- Sampling containers : container materials - container caps - container structures - disposable containers -container washing - container wrapping.
- Container preparation for analysis of: metals – nutrients - non organics – organics - microbiology.
- Sampling volume and holding time .

- Sampling timing and frequency .
- Sample preservation : preservation guidelines - addition of chemicals - pH control – freezing – refrigeration -alternative methods .
- Chain of custody procedures: sample labels - sample seal - log book – records - analysis request sheet - sample delivery form - sample received form - sample test assignment form.

2.9. Module 3
Water quality and test parameters

Test parameters and their significant:

- **Physical** : total dissolved solids - total suspended solids – settleable solids - pH – conductivity – temperature – odor– color – turbidity – radiations.
- **Organics**: oil and grease – phenols – detergents (cationic, anionic, neutral) – pesticides – volatile organic compounds (VOC's) – basic and acidic organics – poly aromatic hydrocarbons (PAH's) - chlorophyll-a.
- **Inorganic anions** : phosphate – sulfate- sulfide – chloride – fluoride – nitrate – nitrite – cyanide – carbonate – bicarbonate .
- **Inorganic cations**: ammonium - sodium – potassium – calcium – magnesium – barium –chromium – copper – iron – manganese – zinc – nickel – cobalt – mercury – arsenic – silver – lead .
- **Gases**: dissolved oxygen – dissolved carbon dioxide - residual chlorine.
- **Microbiology** : fecal coliform – fecal streptococci - total coliform – pseudomonas aeruginose – staphlococcus aureus – salmonella – vibrio cholera – sulfur bacteria – iron bacteria - viruses – protozoa, algae - fungi.

2.10. Module 4
Instrumental methods of water analysis

- Atomic absorption spectrometry (flame and flameless) : inorganic cations (heavy metals, toxic metals, alkaline earth metals).
- Inductively coupled and direct current plasma : inorganic cations (heavy metals, toxic metals, alkaline earth metals , refractory metals).
- Flame photometry: sodium – potassium – calcium – barium -strontium.
- Ion chromatograph : inorganic anions and cations.
- Gas-liquid chromatography: organics.
- High pressure liquid chromatography: organics.
- Potentiometry with ion selective electrodes: pH - some inorganic anions and cations.

- Spectrophotometry : color - some organics and inorganics.
- FTIR: oil and grease.
- Conductometry : total dissolved solids.
- Turbidometry : suspended solids.

2.11. Module 5
Techniques used for water quality analysis

- Biological oxygen demand (BOD).
- Chemical oxygen demand (COD).
- Total oxygen demand (TOD).
- Total organic carbon (TOC).
- Kjeldahl total nitrogen (TKN).
- Microbiological investigation using most probable number and membrane filter methods.
- Solvent and solid phase extraction of organic compounds.
- Clean-up of organic extractants for chromatographic measurements.
- Sample digestion (microwave – autoclaving - direct heating).

2.12. Module 6
Field water sampling and analysis

- Preparation for the field trip.
- Field quality assurance.
- Field quality control.
- Prevention of sample contamination and losses.
- Calibration of field instruments.
- Measurement of field parameters(temperature – electrical conductivity – pH value – dissolved oxygen – dissolved carbon dioxide - redox potential – residual chlorine.
- Data report.

2.13. Module 7
Sediment sampling and analysis
2.13.1. Sediment sampling

- Composite random sediment sampling.
- Benchmark sediment sampling.
- Grid sediment sampling.
- Landscape directed sediment sampling.

- Sampling depth.
- Samplers (slot – pumbing – integrated – bedload – difference – Guillotin – suspended coring – spoon and scoop – dredge .
- Sampling handling.

2.13.2. Sediment analysis

- Sediment preparation (drying – grinding – sieving – extraction – digestion).
- Sediment salinity analysis.
- Sediment fertility analysis.
- Sediment physiochemical characteristics.
- Sediment full analysis (total organic carbon – lead – nickel – copper – zinc – cadmium – chromium – iron – manganese – mercury – arsenic – selenium - aluminum – boron – molybdenum – magnesium – sodium – potassium – calcium - chemical oxygen demand – total phosphorus – total Kjeldahl nitrogen – ammonia – nitrate - cyanide – chloride - oil and grease – insecticides – pesticides – herbicides – poly aromatic hydrocarbons – poly chlorobiphenyls – trihalomethane – volatile sulfides – pH – conductivity– moisture retention - appearance – texture – particle size – bulk density – lime requirement – cation exchange capacity – gypsum content - odor – color – radioactivity – shear strength sediment - oxygen demand – bioassay – macroinvertebrata.

2.14. Module 8
Assessment of data quality

2.14.1. Nature and sources of errors

- Random errors.
- Systematic errors.
- Gross errors.
- Rounding errors.

2.14.2. Statistical evaluation

- Measurement of data central tendency.
- Measurement of data dispersion.
- Standard deviation.
- Within-batch standard deviation.
- Between-batch standard deviation.
- Pooled standard deviation.
- Reproducibility and repeatability.

- Comparison of two standard deviations.
- Confidence interval of a mean.
- Comparison of two mean values.
- Lower limits of detection and quantification.
- *F*-test and *t*-test.
- Graphing (spatial-trend and time-history graphs).

2.15. Module 9
Quality control/quality assurance

- Equipments calibration :methods and schedules.
- Control charts (X-, R-, r- and D-charts).
- Types of internal quality control samples.
- Daily interpretation of control charts.
- Long term use of control chart data.
- Results uncertainty.
- Standard addition(spiking technique).
- Analysis of blind samples.
- Analysis of split samples.
- Repeated (or duplicate) analysis.
- Blank assessment.
- Use of certified reference materials.

2.16. Module 10
National and international water quality standards

- Standards of drinking water quality (ministerial decree 108 /1995.
- Standards of treated wastewater quality for discharge to River Nile (Law 48/1982)
- Standards of treated wastewater quality for discharge to coastal water (Law 4/1994).
- Standards of wastewater quality for discharge to the sewer system (Ministerial Decree 44/2000).
- National, cross-boarder and trans-boundary parameters.
- Global, regional and national water quality and standards.

2.17. Module 11
Safety in water quality laboratories

- Chemical hygiene responsibilities.
- Chemical inventory, storage and handling.

- Material safety data sheets (MSDS).
- Chemical spills and spill clean up.
- Hazardous waste disposal.
- Safety showers and eye wash station.
- Personal protective equipments.
- Fire types, safety and distinguishing.
- Safety of electricity, water and gas lines and connections.
- Proper handling and storage of compressed gas cylinders.
- Emergency procedures.
- First aid kit.
- Handling of laboratory accidents.

2.18. Module 12
Sources of water contaminants

- Human , plant and animal wastes.
- Industrial wastes.
- Agricultural wastes.
- Soil runoff.
- Erosion of natural deposits.
- Corrosion of drinking water and plumbing pipes.
- Leaching of linings of water storage tanks and distribution lines.
- Discharges from dry cleaners and fuel stations.
- By-products of water disinfection.
- Discharges from water treatment plants.
- Discharges from agricultural drains.

2.19. Module 13
Water quality assessment

- Identification of beneficial uses of water resources.
- Selection of key water quality parameters.
- Identification of existing water quality standards.
- Identification of indicators of impairment (exceedence of criteria).
- Analysis of water quality data.
- Identification of potential pollution sources.
- Preparation of water quality report.
- Preparation of water quality index (WQI).
- Conclusion of assessment.
- Future monitoring and research needs.

2.20. Field test parameters for NGO's, CBO's, and volunteers

2.20.1. The use of portable equipment

Parameters for water quality assessments that can be tested by non-governmental organization (NGO's), community based organizations (CBO's), volunteers, institutions and school students using portable low cost equipment are given in Table (4). The instruments used are commercially available in the market from many dealers, simple to operate, easy to calibrate, require little manipulations, with small sizes and weights (pocket type), and relatively cheap [20,21].

Table (4) Water quality field parameters to be tested with portable pocket instruments

No	Parameter	Indicator of	Instrument used	Calibration check
1	pH	Acidity/alkalinity	pH- meter Glass-reference electrode Buffer solutions	daily
2	Dissolved oxygen (DO)	Survival of aquatic life	Oxygen meter Oxygen electrode	Daily
3	Temperature (C)	Survival of aquatic life	Thermometer or pH-meter	Daily
4	Conductivity(EC)	Total dissolved electrolyte solids	Conductivity meter Conductivity cell	daily
5	Total dissolved solids (TDS)	Salinity	Conductivity meter Conductivity cell	daily
6	Turbidity	Total suspended solids	Turbidity meter Turbidity kit	daily
7	Biological oxygen demand (BOD)	Organic pollutants load	BOD bottles Oxygen meter Oxygen electrode	daily
8	Ammonia (NH_3)	Domestic and animal pollution	Digital pocket colorimeter	monthly
9	Chlorine (Cl_2)	Water disinfection	Lovibond color comparator kit	monthly

2.20.2. The use of simple test kits

Complete water test kits are recently developed and become commercially available from H_2OKITS.Com, Division of A.S.N.F. LLC, 430 Rummer Roag, Marietta, OH 4570 [22] for testing up to 13 different water parameters including: Bacteria, Nitrates, Nitrites, Hydrogen Sulfide, Total Hardness, Total Alkalinity, Total Chlorine, Free Chlorine, Chloride, Copper, Sulfate, Iron, and pH. The tests require no technical training, instrumentation, powders, liquids or tablets [It utilizes strips of papers previously loaded with some suitable reagents to induce chemical reaction associated with color formation whose intensity can be correlated with a provided scale and related to the concentration. Sensitivity, range and test time are given in Table (5).

Table (5) Performance characteristics of water kits

Test	Sensitivity	Test range	Result time
Iron	0.1 ppm	0 to 1 ppm	15 seconds
Copper	0.5 ppm	0 to 2 ppm	30 seconds
Chloride	250 ppm	0 to 500 ppm	25 seconds
Nitrate	2.0 ppm	0 to 50 ppm	1 minute
Nitrite	0.2 ppm	0 to 3 ppm	1 minute
pH	1.0	2 to 12	20 seconds
Total Alkalinity	40 ppm	0 to 500 ppm	20 seconds
Total Chlorine	0.2 ppm	0 to 10 ppm	20 seconds
Total Hardness	50 ppm	0 to 1000 ppm	20 seconds
Free Chlorine	0.05 ppm	0 to 10 ppm	20 seconds
Sulfate	250 ppm	0 to 500 ppm	20 seconds
Hydrogen Sulfide	0.3 ppm	0.2 ppm to 2 ppm	30 seconds
Bacteria	1 colony per 100 ml	present / absent	48 hours

Fig.(1) Water quality test kit (H2OKIT)

Chapter 3
Training Materials for Awareness of Communities and Stakeholders

Problems with water quality are often as severe as problems with water availability, but less attention has been paid to them, particularly in developing regions. In Europe and North America, water quality and pollution have been major issues for decades. Pollution has become one of the major problems facing many regions today. Water quality management (WQM) in Egypt as well as in many African countries is a complex problem with large economic component. Different required disciplinarians are not available so far. Gab between policy preparation, implementation and research is exist. Availability of data base is not exist and possibility of data exchange is difficult. No central point to disseminate data or information is available. Although many stakeholders are involved in the water quality issue , no central body to communicate with them. Moreover, sufficient awareness for water uses and polluters do not received reasonable attention . The Ministry of Water Resources and Irrigation in Egypt (MWRI) issued a Ministerial Decree No 432(2001) to allow public participation in the decision making process. This step was followed with formation of a steering committee in MWRI headquarter to facilitate public participation and a series of awareness workshops on public contributions has been organized. This encourages communities and stakeholders to have a say in the water quality management. In order to create and maximize awareness, some training materials can be used for high lighten the water quality issues [23-27]. Knowledge about many of the following subject should be offered.

3.1. Diseases related to water quality and sanitation

Safe water and adequate sanitation are crucial for public health. Many diseases are connected to water pollution , sanitation problems , unavailability of adequate safe of drinking water and absence of hygiene requirements. Facts, statistics, treatment, prevention methods and current outbreak information for at least 25 common diseases associated with water quality and sanitation are available [23]. These diseases are:

- Anemia .
- Arsenicosis.
- Ascariasis
- Campylobacteriosis.
- Cholera.

- Cyanobacterial Toxins.
- Dengue and Dengue Haemorrhagic Fever.
- Diarrhea .
- Drowning .
- Fluorosis
- Guinea-worm disease (Dracunculiasis).
- Hepatitis.
- Japanese Encephalitis.
- Lead poisoning.
- Leptospirosis
- Malaria .
- Malnutrition .
- Methaemoglobinemia .
- Onchocerciasis (River Blindness).
- Ringworm (Tinea) .
- Scabies .
- Schistosomiasis.
- Spinal Injury.
- Trachoma.
- Typhoid and Paratyphoid Enteric Fevers.

3.2. Link of water quality and public health

There is a strong link between poor water quality supply and inadequate sanitation on public health. Many death among infants and young children are due to dehydration or other complications of waterborne bacterial infections. Each year an estimated 4 billion episodes of diarrhea result in an estimated 2 million deaths, mostly among children. Waterborne bacteria infections may account for as many as half of these episodes and death [23]. On the other hand, improving of health is connected with the improvement of water quality. The following data support this fact :

Table (6) Morbidity and mortality rates of some important water quality related diseases [23]

Disease	Case per year, (x 10^3)	Death per year, (x 10^3)
Cholera	384	11
Typhoid	500	25
Giardiasis	500	Low
Amoebiasis	48000	110
Diarrhoea	1500000	4000
Ascariasis	1000	20
Trichuriasis	100	Low
Ancylostoma	1500	60
Dracunculiasis	>5000	-
Schistosomiasis	200000	800
Trachoma	360000	9000 (blind)

Table (7) Reduction in morbidity for different diseases as a result of improvement in water supply and sanitation [23]

Diseases	Projected reduction in morbidity, %
Cholera, typhoid, eritis Diarrhoeal diseases,	80 – 100
Dysentery, gastroent	40 – 50
Dracunuliasis	100
Schistosomiasis	60 – 70

Knowledge about issues related to water quality may be also considered:

- Quality of drinking water .
- Contamination of shallow underground water.
- Effect of water storage tanks on water quality.
- Functioning of municipal water distribution systems.
- The status of sanitation overall the country.
- Profitional organizations and official authorities responsible for water quality.
- Laws, Ministerial Decrees , standards an guidelines on water quality.
- Methods used for water purification and disinfection.
- Methods used for wastewater treatment.

3.3. Field appraisal forms and field trips

Increase the public interest and engagement of non-Governmental Organizations (NGO's) and Community Based Organizations (CBO's) in water quality programs, campaigns, projects and related activities including policy making. Trips to some nearby communities for water management assessment can be arranged. Maps and field appraisal forms for use in the trips are prepared to cover the following items, among others, for water sources.:

- Quality.
- Coverage.
- Storage.
- Distribution.
- Sanitation.
- Health.
- Irrigation demand.
- Geomorphology.
- Well details .

3.4. Courses, seminars and public talks

Activities including public awareness raising campaigns, preparation of courses, organization of seminars and workshops, issuing fact sheets , designing illustrative materials, stickers, posters and colorful door hangers for the public and media to cover water quality issues are recommended. Courses cover the following subject may help. Water quality and human health.

- Water quality and society needs.
- Water quality and pollution.
- Water quality and personnel ethics.
- Water quality and sustainable civilization.

3.5. Key elements for water supply

Quality: Safe and causes no diseases.
Quantity : enough water for everyone to drink, cook and bath (30-100 liters/person/day).
Cost: Within everyone's reach.
Coverage: Availability to everyone in the community.
Continuity: Availability all day and everyday.

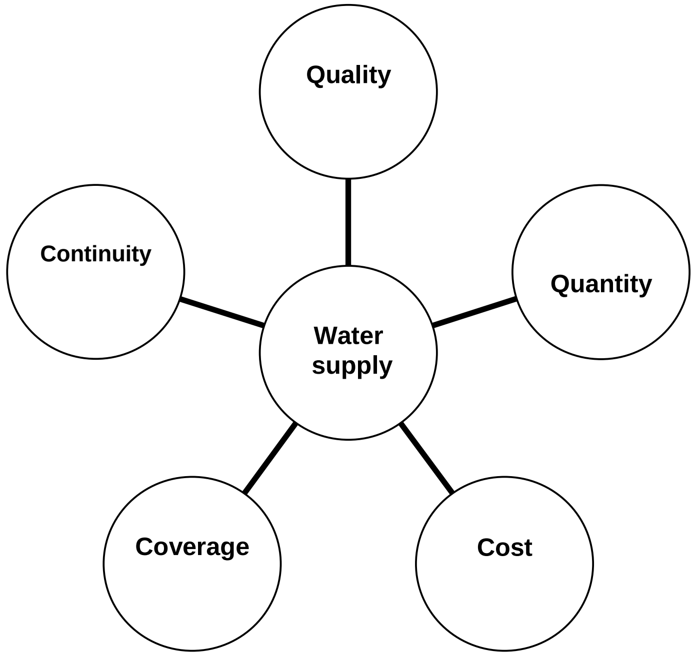

Fig.(2) Requirement of water supply

3.6. Water quality management

Water quality management deals with all aspects of water quality problems relating to the many beneficial uses of water such as :

Intake uses: including water for domestic, agricultural and industrial use purposes.

On site uses: including water consumed by swamps, wetlands, evaporation from water bodies, natural vegetation and un- irrigated crops and wildlife.

Flow uses: including water for estuaries wastewater dilution, navigation, hydroelectric power production and fish wildlife and recreation purposes.

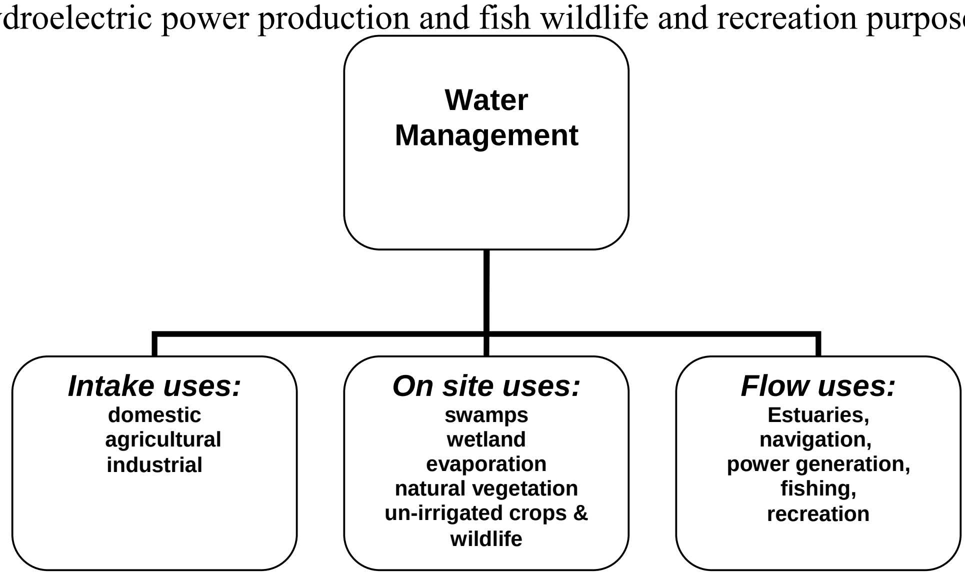

Fig.(3) Water management

3.7. Key actions to address water quality management

The following key elements can be covered to enhance awareness about water quality management:

- Water resource protection.
- Water pollution prevention.
- Control of industrial waste discharge.
- Recycling and reuse of industrial and domestic wastewater.
- Revision and modification of land irrigation systems.
- Influence of agricultural runoff.
- Protection of underground water.
- Protection of aquatic ecosystem.
- Protection of fresh water living resources.
- Help legal instrument to protect water quality resources.
- Monitoring of water quality parameter for safe consumption.
- Water quantity requirements for different uses.
- Minimum quantity of water required for effective hygiene.
- Quantity and accessibility: how much do people use?.
- Quantity and cost: what influence does this have on use ?.
- Other factors that may affect quantities of water used.

Effective implementation of water demand management, water quality management and overall integrated water management requires understanding of the water managers to their responsibility to educate the public and themselves, to encourage involvement of stakeholders in planning and decision making, facilitate an effective multidisciplinary approach and utilize appropriate technology.

3.8. Data collection

As a part of water quality management awareness program, data should be collected from different sources (official , non-governmental, universities, research institutes, media, scientific journals) and disseminated.

3.8.1. Descriptive data

These are typically used for government policy and planning and for public information. These include:

- Status and trend of important water bodies.
- Conformance of water bodies to use specific water quality objectives such as fisheries, recreation, etc.
- Transboundry issues including obligations towards international treaties.

3.8.2. Public health data

These are:

- Data on the types and levels of pathogens and chemicals in water bodies.
- Results of fish tissue monitoring for health related purposes.
- Report on hospital cases related to water quality problems.
- Data on the use of net pipes made of poly(vinyl chloride), asbestos-cement , and coal tar linings tubes.

3.8.3. Regulatory data

These are:

- Effluent permitting to discharge wastewater to water bodies and law enforcement.
- Identification of containment requiring control measures.
- Emergency plans to respond to issues related to water quality.
- Actions taken in cases where oil, chemicals and toxics are discharged to water bodies.

3.9. Test parameters and water quality

The quality of water is determined by the level of pollutants present that change the physical, chemical and biological characteristics of water.

- The physical parameters and characteristics include:

Temperature – electrical conductivity -color – turbidity – suspended solids – dissolved solids. High turbidity helps pathogenic microorganisms to be shielded and pesticides and heavy metals to be adsorbed on mud particles. Excess TDS lead to objectionable taste and corrosion of the distribution systems.

- The chemical parameters and characteristics include:

pH – alkalinity – acidity – hardness – dissolved oxygen – oxygen demand - residual chlorine – nitrate – nitrite – ammonia – fluoride - arsenic - aluminum - lead - trihalomethane (THM's) – pesticides – heavy metals - organic pollutants. Excess nitrate is linked to methaemaglobinamenia in infants (blue – baby syndrome). Nitrate oxidizes normal haemoglobin to methaemoglobin which is unable to transport oxygen to the tissues. This may results in cyanosis (a dark blue coloration) and in some case, asphyxiation and death. Nitrite is 10 times more potent than nitrate. Excess fluoride lead to dental or skeletal fluorides High levels causes reduced cognitive development and intellectual performance of children.

- The microbiological parameters are used to test water quality. These are mainly the indicator bacteria: Escherichia coli – Faecal coliform – faecal streptococci.

- Cyanobacteria (blue – green algae): These produce toxins and present in lakes and reservoirs used for drinking water supply.
- Actinomyces and cyanobacteria : these cause turbidity, taste or odor

3.10. Water quality monitoring

Water quality monitoring program has the advantages of :

- Protection of human health.
- Compliance with standards and guidelines.
- Situation analysis/ impact assessment.
- Environmental change and trends.
- Rapid detection of faults and failure.
- Prioritization of remedial actions.
- Adequate quality of service

3.11. Water disinfection

The key disinfectants used to provide safe drinking water are chlorine, chloramines, chlorine dioxide and ozone. Chlorine is most commonly test for disinfection of both drinking water and wastewater. Chlorine-by products are harmful compounds such as trihalomethane, halogenated acetonitrile, chloral hydrate chlorophenols and other product. Balance between chemical health risk and the presence of harmful microorganism is considered.

3.11.1. Household chlorination

- Used as short-term solution in our breaks
- Dosing tablet or solution
- Supported by health and hygiene education and risk reduction
- Expensive and not fully effective

3.11.2. Chlorination in piped systems

- Chlorine is added post-treatment.
- Maintain a residual at all points in network.
- At least 0.2 mg/L free residual chloride .

3.12. Institutional responsibilities for water quality

- Monitor water supply quality.
- Monitor and protect natural water quality and control pollution.
- Sampling of water from all suppliers
- Enforce compliance and standards.
- Establish water drinking and sanitary codes.

- Protect and manage water resources.
- Supply water meeting all national standards to consumers.
- Exercise quality control and allow access to data.

Chapter 4
Water Quality Parameters and Major Pollution Sources

Water quality of the Nile River is seriously threatened by untreated industrial discharges, agricultural wastes, sewage, and municipal wastewaters. An estimated 28,000 industrial enterprises are established in Egypt from which about 700 are considered as heavy industries. In addition, the Aswān High Dam, which was completed in 1970, has reduced the flow of the Nile and trapped the nutrient-rich silt. To compensate for the loss of the silt and to increase crops , farmers make more use of chemical fertilizers, herbicides and pesticides which affect the quality of water by adding exogenous pollutants. Furthermore, the reduced flow of the river increases the concentration of pollutants in the remaining river water.

4.1. Industrial activities

Industrial activities release to surface or groundwater considerable concentrations of chemical pollutants including organics, inorganics and microbiological substances. Such waters endanger public health through the direct or indirect and affect the ecosystem [28]. The Nile River from Aswan to Delta Barrage receives wastewater discharge from 112 point sources, of which 45 are from major industrial sources and 67 points are agricultural drains. Physico-chemical characteristics of the industrial outlets from Aswan to Delta Barrage reveal that most of these violate the standards given in Article No. 61 of Law 48/1982 regulating discharge of industrial wastewater into the Nile River.

In general the major sources of industrial organic pollutants in the Nile are food and sugar factories. The food industry discharges large volumes of water. Several studies revealed that untreated industrial wastewaters of more than 350 factories were discharged directly into the Nile and the Mediterranean. Most of these discharges contain known toxic and hazardous chemicals such as detergents, heavy metals and pesticides. The discharge of oil and grease originates from navigation ,untreated domestic wastewater [29], oil and soap industries generate waste with high pH values and contain oils and grease , suspended solids and high BOD and COD [30].

In Shoubra El Khaima (north of Cairo) huge volumes of untreated industrial wastewater are daily discharged into agricultural drains. The textile industries representing 48.3% of the total number of industrial plants are the main contributors (almost 52%) to organic load. Table (8) shows the distribution of organic load among the various industrial sectors [31].

Table (8) Organic load contributed by the various industrial sectors in Shoubra El-Khaima [31]

Type of load	Miscella-Neous	Oil & soap	Starch yeast glucose	Pulp and paper	Metal industries	Plastic and rubber	Textile and dyeing	Total load
COD, Kg/day	1366.9	7006	3239.4	2322.3	11676.3	236.7	26372.3	52219.9
BOD, Kg/day	244.9	4568	1148	661.7	1257.7	77.9	8533.9	16492.1

"The State of Environment in Egypt" handbook for the year 2005 [5] reported that at present 116 factories were directly discharge the wastewater to Nile River, 83 of which have already stopped their direct industrial discharge and either switched to the sewer system or recycle or established treatment plants. The industrial wastewater discharged from Helwan area (south of Cairo) was about 45 million m^3/yr .Now , the number of industrial facilities that directly discharge to Nile River was significantly reduced. The remaining 33 factories are now taking steps toward compliances.

The metropolitan area of Alexandria accommodates many industrial facilities in the vicinity of surface waters, e.g., in Amiria at the Lake Marriott, near the Mahmoudia Canal, etc. Out of 1243 industrial plants 57 were identified as major sources of marine pollution either directly or indirectly via Lake Marriott. Paper, textile and food industries contribute 79% of the total organic load [32].

Recent comprehensive data (2005) collected for analysis of Nile River water from Aswan in the south to the northern coastal governorates (Domietta, Alexandria and Port Saeid) are given in Tables (9 & 10). Samples were periodically collected from 279 different locations in 11 Governorates by MOHP [4] .Each location was monthly monitored over the year 2004. It can been seen that the quality of water depends on the nature of pollutants and the pollution sources in each Governorate which may increase in one governorate and decrease in the next. Tables (9 & 10) illustrates the highest and lowest concentration levels of each parameter at the beginning of Nile River in Aswan to the end before discharge in the Mediterranean [4].

Table (9) Physicochemical characteristics of Nile River water in different Governorates [4]

Parameter	Aswan	Sohag	Asuite	Menia	Beni-Seuif	Greater Cairo	Garbia	Dakahlia	Domietta	Alexandria	Port saeid
pH	7.5-7.9	7-8.2	7-8.9	7.4-8.3	7.6-8.7	7.7-8.5	7.3-8.7	7.1-7.6	7.6-8.3	6.5-8.7	7.4-8.7
EC, μS/ cm	258-280	280-340	202-630	210-300	280-985	392-488	328-995	320-570	368-580	434-630	301-525
NH_3, mg/L	Nil	Nil	0.08-0.7	0.05-0.2	0.01-0.4	0-0.05	0.01-4.5	0.1-0.5	0.02-0.6	0.1-0.5	0.06-0.1
NO_2, mg/L	Nil	Nil	0.01-0.34	0.02-0.07	0-0.02	0-0.02	0.02-0.6	0.01-0.04	0.05-0.2	0.1-0.9	0.01-0.04
NO_3, mg/L	Nil	Nil	Nil	0.01	Nil	Nil	0-0.8	0.1-0.5	0.2-0.8	0.4-5.3	NR
PO_4, mg/L	Nil	0.01-0.3	0.01-0.9	0.06-0.8	0.04-0.2	Nil	0.01-0.1	0.05-0.2	0.3-1.8	0.1-0.7	0.2-0.9
T. Alkal.,mg/L	105-136	120-150	118-320	110-200	134-278	158-184	120-200	120-196	142-260	108-192	150-170
T. Hard., mg/L	100-120	90-140	108-250	110-140	104-284	138-170	152-324	120-210	120-218	108-200	70-148
Cl, mg/L	18-22	10-24	12-34	12-20	10-64	20-41	14-44	12-46	18-78	30-92	26-48
Sulfide, mg/L	Nil	0.1	Nil	0.02-0.6	0.08-0.44	NR	NR	NR	NR	0.08-0.8	0.08-0.7
TSS, mg/L	28-34	NR	27-36	12-20	24-48	12-46	4-96	6-32	6-88	56-102	14-78
Fluoride, mg/L	0.4	NR	0.3-0.7	0-0.7	0.3-0.5	0.3-0.4	0.1-0.7	0.2-0.4	NR	0.3-0.6	0.1-0.9
Oil and grease, mg/L	Nil	NR	Nil	0.8-5	NR	Nil	4-80	Nil	0-64	NR	6-26
Silicate, mg/L	5-10	10-12	2-7.5	0.1-8	NR	1-5	1.1-5.5	1.5-4	3-6.5	1-6	8-55
Sulphate, mg/L	20-22	NR	14-50	19-30	NR	20-34	15-40	NR	40-97	26-88	NR
DO, mg/L	4-6.1	6-10	5-9.8	0.6-8.2	5.7-10.9	6.9-7.1	1.5-8.2	4-8	3.6-8.1	3-7.1	4.9-8.5
BOD, mg/L	4.2-4.8	2-4	1.6-5.5	4-10	1-4.9	1.1-8.1	1.5-9.5	1.8-3.8	4.1-12.2	1.2-6.6	NR
COD, mg/L	8.5-12	10-12	5.5-12.8	7-17	5-12.8	6.8-21.5	4-22	5.7-10.8	7.7-28.8	8-30	3.5-44.8
TDS, mg/L	164-188	153-340	158-320	160-210	185-544	204-357	287-490	194-344	276-478	250-424	220-425
No of monitoring points	22	30	45	26	16	36	38	16	14	14	16

NR : not reported

Table (10) Metal contents of Nile River water in different Governorates **[4]**

Parameter	Aswan	Sohag	Asuite	Menia	Beni-Seuif	Greater Cairo	Garbia	Dakahlia	Domietta	Alexandria	Port saeid
Magnesium, mg/L	7.2-12	9.6 – 16.8	9.1 – 25	9.6 – 14.4	8.6 – 16.8	9.1-19.2	36-100	10.6-17.7	12.5-30.7	10.5-24.9	1.9-13.4
Iron, µg/L	Nil	1 – 20	3 – 130	10 – 300	200 – 1600	10-950	20-200	50-150	50-140	100-300	10-600
Zinc,µg/L	118-401	119 – 358	213 – 824	NR	130-456	104-310	98-157	112-198	140-351	84-192	8-250
Manganese, µg/L	Nil	0-10	2 – 200	NR	NR	NR	100-150	50	20-100	NR	NR
Lead ,µg/L	13-69	20 – 181	22 – 198	NR	21 – 229	13-47	15-44	12-50	17-66	16-39	9-46
Nickel ,µg/L	17-103	12 - 86	18 -135	NR	17 – 92	12-47	7-44	11-48	18-63	14-34	14-71
Mercury, µg/L	0 – 3	0.3 – 52	0.7 – 6	NR	0.2 - 3	0.17-0.8	0.3-2.7	0.33-0.9	0.8-3.2	0.4-0.9	0.2-0.8
Copper ,µg/L	50 – 282	46 – 185	129 – 687	NR	0.57 – 318	25-119	15-125	36-191	27-127	14-141	116-201
Chromium, µg/L	15 – 138	13 – 100	31 – 396	NR	10 – 101	6-42	2.6-27	3.6-46	13-51	11-33	2-33
Cadmium, µg/L	2 – 17	2 – 85	2 – 83	NR	2.4 - 41	0.1-4	2.2-9.2	1.4-3.8	2-26	1.7-42	1-4.7
Silver ,µg/L	11 - 98	8 – 78	21 – 198	NR	9 – 84	1-19	2.7-25	0.5-37	10-64	15-43	6-39
Aluminum, µg/L	27 - 94	19 – 130	28 -142	NR	16 – 175	17-61	25-125	16-78	36-109	17-57	35-77
Arsenic ,µg/L	13 – 79	23 – 161	16 – 61	NR	17 – 47	5-46	6-36	4.7-41	11-37	12-28	7-30
Tin, µg/L	9-90	17-89	8 - 97	NR	5 - 87	1.8-177	10-151	2-19	2-38	5-23	5-69
Selenium, µg/L	3 – 20	2 - 20	3 - 22	NR	3.3 - 11	2.4-9.3	1.5-73	1.8-7	2.8-11	3-8.9	1.4-7.2

NR : not reported

The above results (Tables 9 and 10) demonstrate gradual increase in the concentration levels of total dissolved solids, chemical oxygen demand, chloride, hardness, and sulfate along the Nile River. On the other hand the Nile River water coming from Sudan is free from oil and grease, ammonia, nitrite, nitrate phosphate, sulfide , iron and manganese. These parameters appear in Nile River water starting from Asuite with fluctuated concentrations at the different Governorates, but their levels increased from south to north. These parameters originated from industrial and agricultural activities around the Nile River. Phosphate and sulfate are products of phosphate fertilizer industry (2 large factories directly located on the Nile in Asuite and Greater Cairo) . Nitrate, nitrite and ammonia are products of nitrogenous fertilizers discharged in the wastewater to the Nile River through the drains and also released from domestic effluents and nitrogenous fertilizer industry(2 large factories directly located on the Nile in Aswan and Talkha). Iron and manganese appeared in Nile River water due to the iron and steel industry complex in Cairo and some iron workshops in almost all governorates and the presence of large area of iron ores in Aswan.

Table (11) presents the major industrial pollution sources and the pollutants emanating from them from Aswan to Delta Barrage [33]. Fig.(4) shows a map with industrial distribution. Other undefined sources as agricultural drains usually contain high levels of ammonia, nitrite, nitrate, phosphate, suspended solids, pesticides, herbicides, metals, dissolved solids, fluoride organic load and sulfate.

Table (11) Major industrial pollution point sources discharging into the Nile River (from Aswan to Delta Barrage[33]

No.	Location from Aswan High Dam (Km)	Point source	Emitted pollutants
1	50.000	Kom Ombo Sugar Ind.	Organics , suspended solids, metals, sulfates
2	63.600	Ekleet power station	Metals , nitrates , phosphate
3	119.600	Kaleh power station	Metals , nitrates , phosphate
4	122.450	Edfu Paper Pulp A	Organic , sulfate, chloride, ammonia , suspended solids
5	122.500	Edfu Paper Pulp B	Organic , sulfate, chloride, suspended solids
6	123.000	Edfu Sugar Ind.	Organics, suspended solids, sulfate
7	147.000	Sebaia Phosphate Ind.	Phosphate, silicates , fluoride , suspended solids
8	204.500	Armant Sugar Ind 1	Organics, suspended solids, sulfate
9	204.505	Armant Sugar Ind 2	Organics, suspended solids, sulfate
10	204.510	Armant Sugar Ind 3	Organics, suspended solids, sulfate
11	257.000	Ques Sugar Ind.	Organics, suspended solids, sulfate
12	265.400	Ginning Mill	Organic, suspended solids , metals
13	314.000	Dishna Sugar Ind.	Organics, suspended solids, sulfate
14	337.500	Aluminum Ind.	Metals, silicates, fluoride
15	343.200	Naga Hammadie Sugar A	Organics, suspended solids, sulfate , metals
16	343.250	Naga Hammadie Sugar B	Organics, suspended solids, sulfate , metals
17	443.200	Onion Ind.	Organics, suspended solids
18	445.600	Souhag Oil Ind.	Organics , oil and grease , suspended oil , alkalis
19	445.605	Coca-Cola Ind.	Organics , phosphate , suspended solids , alkalis
20	454.700	Seflak Ind.	Metals , suspended solids,
21	552.200	Mankabad Pipe 1	Metals, suspended solids
22	552.205	Mankabad Pipe 2	Metals, suspended solids

23	552.210	Mankabad Pipe 3	Metals, suspended solids
24	904.000	Hawamdia Chemical 1	Organics, sulfate , nitrate , ammonia , phosphate , metals
25	904.008	Hawamdia Chemical 2	Organics, sulfate , nitrate , ammonia , phosphate , metals
26	904.300	Hawamdia Chemical 3	Organics, sulfate , nitrate , ammonia , phosphate , metals
27	904.350	Hawamdia Chemical 4	Organics, sulfate , nitrate , ammonia , phosphate , metals
28	909.200	Helwan Power station	Organics, sulfate , nitrate , ammonia , phosphate , metals
29	911.400	Chemical Ind.	Metals, nitrates, phosphates
30	911.400	Hawamdia Sugar Moulas	Organics, suspended solids, sulfate ,
31	912.100	Hawamdia Sugar Pipe 1	Organics, suspended solids, sulfate
32	912.105	Hawamdia Sugar Pipe 2	Organics, suspended solids, sulfate
33	912.115	Hawamdia Sugar Pipe 3	Organics, suspended solids, sulfate
34	912.120	Hawamdia Sugar Pipe 4	Organics, suspended solids, sulfate
35	912.125	Hawamdia Sugar Pipe 5	Organics, suspended solids, sulfate
36	912.130	Hawamdia Sugar Pipe 6	Organics, suspended solids, sulfate
37	915.000	Iron Steel Ind.	Metals , nitrates ,phosphate
38	916.550	Kotstica starch & Glucose	Organics, suspended solids , alkalis
39	916.551	Kotstica starch & Glucose	Organics, suspended solids , alkalis
40	939.600	El Nasser Glass Tube 1	Metals , silicates , sulfate
41	939.605	El Nasser Glass Tube 2	Metals , silicates , sulfate
42	939.610	El Nasser Glass Tube 3	Metals , silicates , sulfate
43	939.615	El Nasser Glass Tube 4	Metals , silicates , sulfate
44	939.620	El Nasser Glass Tube 5	Metals , silicates , sulfate
45	947.900	Delta Cotton Kanater	Suspended solids , organics

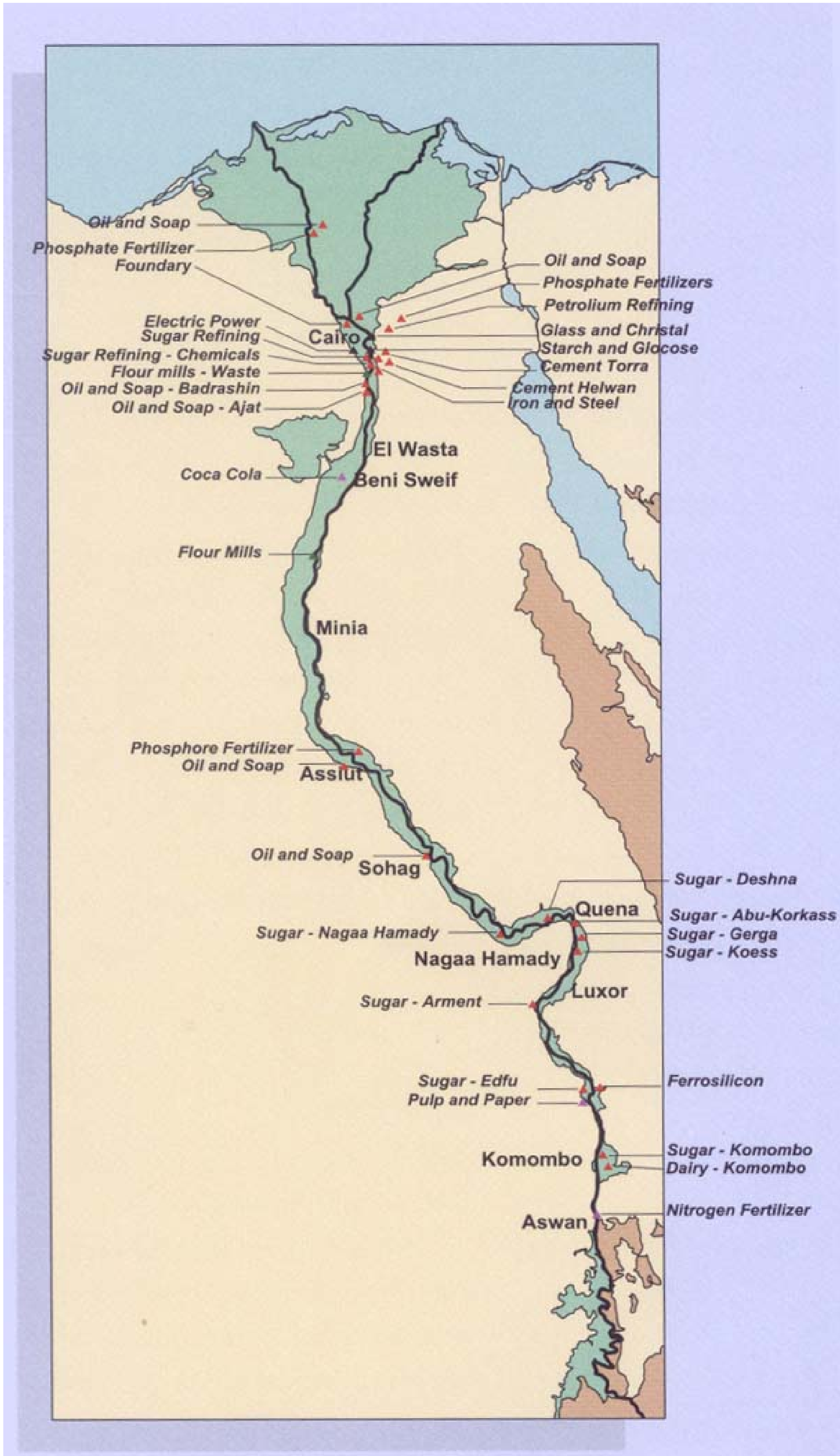

Fig.(4) Industrial activities as sources of pollution on the Nile River

4.2. Domestic activities

The rural areas in Egypt accommodate about half of the population (35 million persons), 95% of the people have no access to sewer systems or wastewater treatment facilities. The “septic tank” is the most common disposal facility. The final destination of such waste is either the drains or the Nile River.

4.3. Agricultural activities

The intensive use of chemical fertilizers, herbicides and insecticides was essential to increase the yield of the crops of the limited available land. The commonly used phosphorus and nitrogen containing fertilizers, are usually drained into the surface and groundwater systems along the Nile. The use of these sources for drinking water supply is at risk [34]. The increased load of silt-free Nile water by nutrients from fertilizers provides habitat to the Bilharzia snails and algae. Furthermore, the heavy application of pesticides with most crops poses serious environmental risk. Some chlorinated pesticide residues and their metabolites were found in many canals and drains with concentrations far below the guidelines set by WHO [35].

The agricultural drainage water collectively forms about 17×10^9 m^3/ year, 65% of which discharged into the sea and only 20% is reused. In the Nile downstream direction ,the water quality gradually deteriorates. This is due to poor wastewater treatment practice, direct discharge of both domestic and industrial wastewater, and uncontrolled mixing with water from polluted agricultural drains. This type of water contains high levels of various pollutants, such as faecal bacteria, heavy metals and pesticides. Some drains are considered as open sewage system that smell badly due to the production of hydrogen sulfide gas [36].

4.4. Ambient water quality in Nile River from Aswan to Delta Barrage

The water quality of the Aswan High Dam Reservoir (5000 km^2 and 164×10^9 m^3) is generally good (total dissolved solids: TDS < 200 ppm). However, due to its depth and seasonal variation in temperature, thermal stratification results in low levels of dissolved oxygen. The TDS level in the Nile gradually increases from 164 -188 mg/L at Aswan to 204 - 357 mg/L near Cairo. The oxygen concentration recovers as a result of atmospheric reaeration and increases from 4 – 6 mg/L at Aswan to 6–10 mg/L at 200 km downstream Aswan. The inputs of sewage along the river reduce the oxygen content especially in the vicinity of big cities [28]. Industrial waste of sugar mills and sewage are characterized by high biological oxygen demand due to high organic content which causes reduction in dissolved oxygen in the immediate downstream. Near Greater Cairo, the oxygen content reaches a level of 1–5 mg/L in some locations [37]. Some heavy metals are also detected such as chromium near Assiut in Upper Egypt. Bacterial contamination as faecal and total coliform bacteria concentration is high around Kafr-El-Zayat in Lower (North) Egypt. The most probable number (MPN) of faecal coliform peak up to 5000/100 mL or more downstream from major municipal waste discharges and declined to levels of 200–1000 MPN/100 mL in intervening rayahs. Navigation activities on the Nile are diverse, commercial and public transportation. River fleet, some 9000 units, contributes to pollution by oil and grease, hydrocarbon fuels and occasionally by municipal wastewater.

In general, the quality of water in the main stream of the River Nile in the south is relatively good [33]. Significant changes appeared downstream of the river as the river flows through the densely populated urban and industrial centers. Agricultural return flows, domestic discharges, industrial wastes , and oil and wastes from passenger and river boats contribute in the pollution of water. The results of the last monitoring campaign in 2001 by MWIR [33] are presented in Table (12).

Table (12) Water quality of Nile River from Aswan to Delta Barrage [33]

Parameter	COD mg O_2/L	BOD, mg O_2/L	TDS mg/L	Fecal coliform, MPN/100 mL
Concentration range, found	5 – 21.5	1.6 – 8.1	164 – 357	30 – 1200
Maximum allowable, Law 48/82	10	6	500	NR 1000*

NR: not reported.
* WHO guidelines , 1989.

4.5. Water quality in the Damietta branch

Major sources of pollution to Damietta branch are Talkha fertilizers factory, High Serw 1 Drain and High Serw Power station. Monitoring data collected on February 2004 indicates that the concentration levels of dissolved oxygen ranged from 7.7 mg O_2/L at its southern part to 6.2 mg O_2/L at the northern part. TDS increased from 240 mg/L up to 478 mg/L but the values are still within the permissible limits .Nutrients concentrations (nitrogen & phosphorus) were within the permissible limits. The chemical oxygen demand exceeded the standard set by law 48/1982 (Table 13) . However, the concentrations were similar to those of the Nile water from Aswan to Delta Barrage [33]. The BOD values comply with the consent standard, except at one location at the end of the branch. FC counts exceeded the WHO Guidelines in almost all sampling sites due to heavy discharge of human wastes in Damietta branch

Table (13) Water quality in Domietta branch [33]

Parameter	COD mg O_2/L	BOD, mg O_2/L	DO mg O_2/L	TDS mg/L	Fecal coliform, MPN/100 mL
Concentration range, found	7 -23	1.73 – 7.42	4.1 – 12.2	235 - 372	1000-3500
Maximum allowable, Law 48/82	10	6	5	500	NR 1000*

NR: not reported
***WHO guidelines**

4.6. Water quality in Rosetta branch

Rahawy drain (which receives part of Greater Cairo wastewater), Sabal drain, El- Tahrrer drain, Zawiet El-Bahr drain and Tala drain are the main sources of pollutants discharged into he Rosetta branch of Nile River. Rosetta branch also receives wastewater from Maleya and Salt and Soda companies At Kafr El-Zayat. Ambient water quality status of Rosetta Branch is presented in Table (14) . Dissolved oxygen concentrations ranged from 5.1 mg O_2/L at the southern part to 6.3 mg O_2/L at the northern part of the branch. Nutrient concentrations are within the permissible limits. COD and BOD values exceeded the standards, but were similar to those recorded for Damietta branch. TDS ranged from 370 at Delta barrage up to 475 mg/L . FC displayed counts ranged from 250 - 1300 [33].

Table (14) Water quality of Rosetta branch [33]

Parameter	COD mgO_2/L	BOD, mg O_2/L	DO mg O_2/L	TDS mg/L	Fecal coliform, MPN/100 mL
Concentration range, found	14 - 25	4.6 – 7.8	5.1 – 6.3	370 - 475	250 -1300
Maximum allowable, Law 48/82	10	6	5	500	1000*

*WHO guidelines

4.7. Water quality in canals and rayahs

Water quality monitoring of irrigation canals is very limited. Most of the canals have water quality similar to that of the intake from the Nile. Twelve canals and rayahs have been monitored during the February 2001. The data indicate that dissolved oxygen, BOD and total solids concentrations in all surveyed canals and Rayahs are either within the permissible limits or slightly higher (Table 15). With regard to COD values, only El-Lahoun and Sako complied with the standard values. With the exception of Ibrahimia Canal and El-Beherri Rayah, fecal coliform counts in all surveyed canals exceeded the WHO Guidelines (1000 MPN/100 mL). This indicates the presence of human wastes. Heavy metals concentrations in canals and Rayahs were within the permissible limits [33].

Table (15) Water quality in canals and rayahs [33]

Canal & Rayah	DO, mg O_2/L	COD, mgO_2/L	BOD, mgO_2/L	TDS, mg/L	TSS, mg/L	Fecal coliform, cell/100 mL
Canals & rayahs (total 12)	5 – 8.1	10 - 25	1.7 – 5.8	200 – 305	6 - 29	650 - 10000
Maximum allowable, Law 48 (1982)	5	10	6	500	--	1000*

* WHO guidelines for unrestricted irrigation , 1989.

4.8. Water quality in agricultural drains

Physico-chemical characteristics of water in 43 major drains starting from Khour El-sail , Aswan (9.9 Km apart from Aswan Dam) to Khour sail Badrashin (910 Km from Aswan Dam) are presented in Table (16). The concentration variation does not follow any systematic trend but rather depends on the domestic, agricultural and industrial activity in the area. The data indicate that out of the

43 drains, only 10 are complying with the standards set by Law 48/1982 (Article 65) regulating the quality of drainage water which can be mixed with fresh water. The remainder of the drains exceed the consent standards in one or more of the parameters. The worst water quality is that of Khour El-Sail Aswan, Kom Ombo, Berba and Etsa drains [33].

The highest organic load is discharged from Kom Ombo drain (218.1 ton COD/d, 59.7 ton BOD/d). This is followed by El-Berba drain (172.7 ton COD/d; 59.7 ton BOD/d). These two drains contribute 76% of the total organic load (calculated as COD) discharged into the Nile by drains from Aswan to Delta Barrage. This is followed by Etsa drain which contributes about 11% of the total COD load (56.8 ton COD/d). This heavy load of organic is due to the sugar cane industrial complex [33].

Delta drains contain high concentrations of various pollutants such as organic matter (BOD, COD), nutrients, fecal bacteria, heavy metals and pesticides. These drains received agricultural discharges and untreated or poorly treated wastewater (domestic & industrial).

The water salinity of the southern part of Nile Delta drainage is 750 - 1000 mg/L, in the middle parts of Delta is 2000 mg/L and in the northern parts is 3500 - 6000 mg/L [33].

Delta and Fayoum drains receive about 13.5 x 10^9 m^3/year. Almost 90% of which is contributed from agricultural diffuse source, 6.2% from domestic point sources, 3.5% from domestic diffuse sources and the rest (3.5%) from industrial point sources (Table 17). on the other hand, Bahr El-Baqar receives the greatest part of waste water (about 3 x 10^9 m^3/year). This is followed by Bahr Hados, Gharbia, Edko and El-Umoum, with an average flow of 1.75 x 10^9 m^3 /year for each. The wastewater received by the rest of the drains is less than 0.5x 10^9 m^3 /year for each. Bahr El-Baqar drain receives the highest loads of COD and BOD followed by Abu-Keer drain. Also, El-Gharbia Main receives significant amounts of organic pollutants [33].

Table (16) Water quality of Eastern Delta, Middle Delta, and upper Egypt agricultural drains [33]

Drains	BOD mg O_2/L	COD mg O_2/L	Coliform bacteria MPN/100 mL
Eastern Delta, (10 drains)	40 - 162	30 - 132	21 – 42 x 10^4
Middle Delta, (13 drains)	24 - 150	31 - 225	21 – 56 x 10^4
Western Delta, (8 drains)	24 - 60	32 - 117	21 – 56 x 10^4
Upper Egypt, (43 drains)	1 - 43	2 - 144	2.5 x 10^2 – 3.5 x 10^4

Table (17) presents the volumes of effluents discharged to agricultural drains from different sources.

Table (17) Effluents (m^3/day) discharged to agricultural drains [33]

	Domestic point sources m^3/day	Industrial point sources, m^3/day	Domestic diffuse source, m^3/day	Agricultural diffuse source, m^3/day	Total , m^3/day
Total, m^3/day	2311740.0	180458.0	1294747.0	33412752.5	37199697.5
Total billion m^3/year	0.84	0.066	0.47	12.2	13.6
Ratio, %	6.2	0.5	3.5	89.7	

4.9. Bahr El-Baqar drain

Bahr El-Baqar drain (106 km long) has two main branches: Qalubia drain (73.2 km) and Belbaise drain (66 km). Belbaise drain collects treated and untreated sewage and industrial wastewater from the eastern zone of Greater Cairo. Qalubia main drain with its 14 branches (intermediates) collects treated and untreated wastewater from the heavily populated area of Shobra El-Khemma and its large industrial area, together with the urban communities of Qalubia and Sharkia Governorates [33]. Thus, Bahr Al-Baqar drain receives a very high organic load from domestic (point & diffuse sources) and industrial sources (Table 18).

Table (18) Loads of pollution received by Bahr Al-Baqar drain [33]

Source	Q m^3/d	Load (kg/d)					
		BOD	COD	SS	TDS	Oil&Grease	Heavy metals
Domestic point sources	1840000	356450	630850	327000	1363400	28200	1530
Domestic diffuse sources	122795	55257	73677	61397	96008	-	–
Industrial point sources	55938	28755	71108	31616	44834	5638	34
Total	2018733	440462	775635	420013	1505242	33838	1564

4.10. El-Gharbia drain

El-Gharbia drain receives domestic diffuse, domestic point source and industrial point source effluents due to the absence of sanitation systems in this catchment area [33]. About 61.1% of the BOD load received by this drain is from domestic diffuse sources, 21.4% from domestic point sources and the rest from industrial sources (Table 19).

Table (19) Loads of pollution received by El-Gharbia drain [33**]**

Source	Q m^3/d	Load (kg/d)					
		BOD	COD	SS	TDS	O&G	Heavy metals
Domestic point sources	156500	47516	57959	50972	214404	–	–
Domestic diffuse sources	293315	142693	213430	146049	226774	-	–
Industrial point sources	44460	32283	76383	26499	77546	18211	9
Total	494275	222492		223520	518724	18211	9

4.11. Edko drain

Edko drain in Behera Governorate provides El-Mahmoudia canal with irrigation and drinking water. The passes through highly populated governorate .The quality of water in the drain system (main drain and its branches) is deteriorating due to dumping of domestic wastewater. Most of the organic load received by this drain is from domestic diffuse sources (90.2%). Domestic point sources represent only 3.2% and the rest (6.7%) is contributed from industrial sources (Table 20) [33].

Table (20) Loads of pollution received by Edko Drain [33]

Source	Q m^3/d	Load (kg/d)				
		BOD	COD	SS	TDS	O&G
Domestic point sources	20.000	882	1540	802	15850	–
Domestic diffuse sources	55276	24321	26145	27361	43668	–
Industrial point sources	7970	1872	2993	7328	5388	1195
Total	83246	27075	30678	35491	64906	1195

4.12. Mouheet drain

El Mouheet drain in Giza is considered as one of the most polluted main drains, coming second only to Bahr El-Bagar drain in the Eastern Delta. The situation of El Mouheet drain is of greater concern than Bahr El-Bagar as it dumps its water into the Nile (Rossetta Branch) via Rahawy drain while Bahr El-Baqar empties into Lake Manzala. The total length of the drain is 70.2 km from the beginning to Rahawy pump station. The main drain starts at El-Badrasheen and ends at Mansouria. It receives water from six intermediates on the right side dumping its water in Gennabiete El Mouheet El Youmna drain. Gannabiete El Mouheet El-Youmna has 11 intermediates coming from the right side and one from the left. It also receives drainage water from Gannabiete El mouheet drain El-Yousra, with its one intermediate on the left side. The whole system dumps into the Nile through Rahawy Pump Station on the Rossetta Branch. This pump is not working now since the water is flowing to the Nile by gravity, due to high water levels. Two main treatment plants are located within the drainage basin of El mouheet drain: Abu Rawash and Zenein plants with maximum effluents of 700,000 and 400,000 m3/day, respectively. There are limited treatment plants within the drain catchment area [33].

4.13. El-Salam canal

An estimated 2 x $10^9 m^3$ /year of drainage water from Bahr Hadous, Lower and Upper Serw togetherand Farasqour drains is discharged into El-Salam canal [33].A 94.3 % of the water received by Bahr Hadous drain comes from agricultural diffuse sources and a 4% is received from domestic diffuse sources. However the latter source contributes by at least 95% of the organic load expressed as BOD (Table 21).

Table (21) Loads of pollution received by Bahr Hadous drain from different sources [33]

Source	Q m^3/d	Load (kg/d)			
		BOD	COD	SS	TDS
Domestic point sources	80000	1680	3680	1600	61360
Domestic diffuse sources	207754	77459	110211	81782	179722
Industrial point sources	6135	1768	2606	2965	61360
Total	293889	80907	116497	86347	302442

Loads of pollutants received by Faraskour and El-Serw El-Asfal drains are presented in Tables (22 & 23).

Table (22) Loads of pollution received by Faraskour drain [33]

Source	Q m^3/d	Load (kg/d)			
		BOD	COD	SS	TDS
Domestic point sources	2490	223	337	220	1657
Domestic diffuse sources	13272	6450	9356	4870	10484
Industrial point sources	NA	NA	NA	NA	NA
Total	15762	6673	9733	5090	12141

Table (23) Loads of pollution received by El-Serw El-Asfal drain [33]

Source	Q m^3/d	Load (kg/d)			
		BOD	COD	SS	TDS
Domestic point sources	7710	897	1402	666	5203
Domestic diffuse sources	18769	8113	11823	6751	15568
Industrial point sources	NA	NA	NA	NA	NA
Total	26479	9010	13225	7417	20771

The water quality of Faraskour, Serw and Hadous drains, at their ends before mixing with El-Salam canal is presented in Table (24).

Table (24) Water quality of El-Salaam canal [33]

Parameter	COD mgO_2/L	BOD, mg O_2/L	TDS mg/L	Fecal coliform, MPN/100 mL
Concentration range, found	19.2 -256.0	10.0 -150	242 - 1048	200 - 170000
Maximum allowable, Law 48/82	10	6	500	1000*

*WHO guidelines

In general, the above water quality data [4,33] pointed out to the following conclusions :

(1) Although high organic loads are discharged from some drains and industrial activities to the Nile River, the quality of water in the main part of the Nile River from Aswan to Delta Barrage is reasonably good indicating a continued high self-assimilation capacity of the Nile River

(2) The agricultural drains are severely contaminated compared to Nile River and canals because the drains receive all types of agricultural and industrial wastewater. Four drains have been identified as major sources of pollution in Upper Egypt. These are Kom-Ombo, Berba, Khor El-Sail Aswan and Etsa drains.

(3) Most of the drains in the Delta receive high loads of pollution far in excess than their assimilation capacity.

(4)The main pollutants in Nile River are the pathogenic microorganisms , organic compounds , pesticides and heavy metals.

4.14. Pollution trend in Nile River cross boarder and trans boundary pollutants

The quality of Nile River water that reached the boarders of Egypt shows the type of cross boarder pollutants These are total dissolved solids (164-188 mg/L),sulfate (20-22 mg/L), silicate (5-10 mg/L), fluoride (0.4 mg/L), total suspended solids (28-34 mg/L), chloride (18-22 mg/L) and organics (COD 8.5-12 mg/L, BOD 4.2 - 4.8 mg/L).

Although almost all these parameters are properly monitored in the local laboratories, the data should be obtained through a quality control/quality assurance programs. On the other hand, chlorinated pesticides specially those related to the Persistent Organic Pollutants, POP's (e.g. DDT and its metabolites) are still in use in many countries in Africa. These substances have the capacity to migrate through water and air for long distances and resist chemical decomposition, biodegradation and photo degradation. These substances should be monitored.

4.15. National pollutants

These are either pure national or build-up pollutants. Pure national pollutants means that these parameters were not detected in the in-take water in Aswan but appear in the Nile water due to local activities of different nature. These are : oil and grease (maximum of 8 mg/L) , sulfide (maximum 0.8 mg/L), phosphate (maximum 1.8 mg/L), nitrate (maximum 5.3 mg/L), nitrite (maximum 0.9 mg/L) and ammonia (maximum 4.5 mg/L). The concentration levels of other parameters (total dissolved solids, COD, BOD, sulfate, silicates, fluoride, total suspended solids, chloride total hardness, total alkalinity and electrical conductivity) increased about 2 to 5.5 times. Due to the increase production and consumption of phosphate fertilizers in Egypt, the levels of phosphate, fluoride and sulfate should be regularly monitored.

It is recommended that the Central Laboratory for Environmental Quality Monitoring (CLEQM) can be considered to be a part of a regional regular Nile River water quality monitoring network of stations.

4.16. Tested parameters of water quality

4.16.1. Drinking water

The Ministerial decree 108(1995) includes the standards of drinking water. These are : Color –taste- odor –turbidity –pH – free chlorine – total dissolved solids - iron – manganese – copper – zinc- total hardness – calcium – magnesium – sulfate – chloride – sodium – aluminum – barium – lead – arsenic – cyanide – silver – cadmium – selenium – mercury – chromium – nitrate – nitrite – ammonium – fluoride- pesticides- total count bacteria –total coliform – fecal coliform – streptococcai – pathogenic viruses – protozoa – psudomenus – sulfur bacteria – THM's – halogenated hydrocarbons –hydrocarbons – bromate –chlorite -chloramines – phenol , α and β radiations

Most of the water quality central laboratories perform all such parameters except those for organic pollutants, trihalomethanes (THM's) and pesticides due to the absence of the required instrument, cost of chemicals, reagents and standards. All laboratories including those of water treatment compact units regularly analyze at least residual chlorine, turbidity, pH, conductivity, total dissolved solids and coliforms every day.

4.16.2. Nile River

The law 48(1982) includes the standards of water quality for River Nile and its branches. These are: Color – total dissolved solids – ash of total dissolved solids - temperature – dissolved oxygen – pH – chemical oxygen demand – biological oxygen demand – total organic nitrogen – ammonia - oil and grease – total alkalinity – sulfate – sulfide – total organic phosphorus - mercury – iron – nickel - manganese – copper - zinc – silver –surfactants - nitrate – fluoride – phenol – arsenic – cadmium – chromium – cyanide – lead -

selenium – total coliform – suspended solids – ash of suspended solids - residual chlorine, hardness – chloride.

Many of these parameters are monthly analyzed by MHOP, EEAA and CLEQM laboratories depending on their technical capability. The final reports of both ministries include results for all these parameters with the exception of pesticides, surfactants and phenols. In general these annual reports usually contain useful data to evaluate and characterize the quality of Nile River water. Due to high consumption of surfactants in Egypt and its direct discharge from the rural areas to the Nile River, it is recommended to include this parameter among the list of analysis. Aluminum levels should also be continuously monitored because all drinking water treatment plants use alum as coagulant in the treatment process and discharge the backwash and sludge directly to the Nile. Accurate measurement of this element requires nitrous oxide flame atomic spectrometry.

.

4.16.3. Coastal water

Law 4 (1994) includes the standards of coastal water quality. These are: Temperature – pH – color – Biological oxygen demand – chemical oxygen demand – total dissolved solids – volatile solids – suspended solids – turbidity – sulfides – oil and grease – phosphates – nitrates – phenol – fluoride – aluminum – ammonia – mercury – lead – cadmium – arsenic – chromium – copper – nickel – iron – manganese –zinc – silver – barium – cobalt – pesticides – cyanide – surfactants - fecal coliform.

4.16.4.Wastewater

Standards for water quality discharged to the sewer net are given in the Ministerial Decree 44(2000).The standards are :
Temperature – pH – biochemical oxygen demand – chemical oxygen demand – suspended solids –sulfides – oil and grease – phosphates – nitrates – phenol – fluoride – ammonia – mercury – cadmium – tin – chromium –nickel –zinc – silver – formaldehyde - pesticides – cyanide – surfactants fecal coliform.

Chapter 5
Quality Assurance Program

5.1. Quality assurance plan

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. A sound water quality sampling and analysis program is commonly include a detailed Quality Assurance/Quality Control Plan that describes:

- Data quality objectives .
- Equipment maintenance and calibration.
- Chain of custody for samples.
- Quality control checks .
- Data reduction, validation, and reporting.

It is unfortunate that only 3 laboratories for water quality assessment are accredited, so far, in Egypt (see Table 3). At least 5 laboratories are either apply for accreditation or underway to do so. One of the technical requirements for accreditation (according to ISO 17025) is to have and implement Quality Control/Quality Assurance Programs. However, most of assessment laboratories follow "Good Laboratory Practice Principle" and generate good data, and they need only proper and systematic documentation. On the following pages, an outline of a designed water quality assurance program is given [38-52].

5.1.1. Objectives

The ambient monitoring data of Nile River are used to support a number of other activities including Total Maximum Daily Loads (TMDL); waste discharge permitting; water and watershed management by local governmental entities and others; and reporting of general water quality to the public. Sampling ranging from daily to quarterly at fixed locations for various durations of time (weeks, months, years) are collected and analyzed for some parameters.

Long-term locations at: (i) Aswan or Nasser Lake to be used for both trend analysis and water quality characterization before contamination with local pollutants. (ii) locations downstream of major areas likely to impact water quality for detecting trends in water quality that may be changed as a result of the effects of urban centers, land use activities and industrial activities.

Basin locations to characterize water quality, support planned TMDL activities, confirm suspected water quality problems, detect partition sources of water quality degradation, characterize water bodies not previously monitored; and support the waste discharge permitting process.

The monitoring program is focused primarily on conventional local and trans boundary parameters such as temperature, pH, dissolved oxygen, and fecal coliform bacteria (*E. coli*.) . Other parameters susceptible to change due to anthropogenic sources are also measured such as nutrients (total phosphorus (TP), soluble reactive phosphorus (SRP), total nitrogen (TN), nitrate plus nitrite nitrogen (NO_3+NO_2), ammonia nitrogen (NH_3)), total suspended solids, conductivity, and turbidity. Persistent organic pollutants (e.g. DDT) which are extensively used in Africa for malaria and detected in Nile water should also be followed. Africa has a high stockpile of such pesticides.

The role of the ambient monitoring program is to provide timely water quality data and periodic data analysis reports, and to make these data and reports available to other potential users (governmental agencies, educational institutions, consulting firms, and individuals). Specific objectives of the stream monitoring program are as follows:

(1) Determination of water quality at the sampling sites in relation to the national water quality standards.

(2) Assess the status of water quality in the country.

(3) Provide analytical water quality information about data variability and trend.

(4) Provide timely and high-quality data for water purification stations and other users.

(5) Provide a data base to be used on development of new water quality standards.

(6) Used for establishment of national water quality index (WQI).

(7) Establishment of the total maximum allowable daily pollutant Loads (TMDL) causing water quality violations.

(8) Ranks water quality relative to its desirable or natural state, thus measuring the degree to which water quality is affected by human activity.

(9) Describes the state of the water column, sediments and aquatic life.

(10)Ranks suitability for various uses, including uses by humans, aquatic life, and wildlife, wherever such uses are naturally sustainable.

5.1.2. Measurement quality objectives (MQOs)

Measurement Quality Objectives (MQOs) (i.e., the acceptance criteria) are indicated by data quality indicators (Table 25). These are quantitative measures of the performance of laboratory and field results and are expressed as precision, bias, accuracy , uncertainty, within-batch deviation , between-batch variability and lower detection limits.

Table (25) Measurement quality objectives, data quality objectives

parameter	Accuracy (% from true value)	Precision (% relative standard deviation	Lower reporting limit
Field parameters			
Conductivity	80%	7%	10 µS/Cm
Dissolved oxygen	80%	7%	0.2 mg/L
pH	80%	7%	0.1 unit
Temperature	80%	7%	0.2°C
Lab parameters			
Ammonia-N	85%	5%	0.01 mg/L
Nitrate +Nitrite-N	85%	5%	0.01 mg/l
Total nitrogen	85%	5%	0.025 mg/L
Soluble reactive phosphorus	85%	5%	0.003 mg/L
Total phosphorus	85%	5%	0.01 mg/L
Turbidity	85%	5%	0.5 NTU
Suspended solids	85%	5%	1 mg/L
Fecal coliform	NA	25%	1 colony/100 mL

5.1.3. Sampling design

Near-surface grab samples are collected at all selected locations once each month. This sampling frequency was chosen in order to optimize the probability of statistically detecting trends. Sample collection generally occurs at a set time each month. Standard parameters monitored at all stations are: electrical conductivity suspended solids, total phosphorus, total dissolved oxygen, turbidity, total ammonia, pH, fecal coliform bacteria, total nitrate + nitrite, temperature, soluble reactive phosphorus, total nitrogen. Generally 12 samples are collected and analyzed for water quality parameters at each location. The barometric pressure is simultaneously recorded and used to determine percent oxygen saturation. Whenever possible metals concentrations are monitored. Table (26). Water quality parameters monitored monthly as part of water quality assessment of ambient Nile River stream monitoring program.

Table (26) Test parameters for water quality assessment

Electrical conductivity	**Total suspended solids**	**Total phosphorus**
Dissolved oxygen	Turbidity	Total ammonia
pH	Fecal coliform bacteria	Nitrate-nitrite, total
Temperature	Phosphorus (soluble, reactive)	Total nitrogen

5.1.4. Representativeness

Long-term sampling locations are usually selected near the bottom end of the river and thus are expected to represent the impact of cumulative effects in the watershed. Long-term locations may not necessarily be representative of “typical” water quality. In the watershed water collection consists of a single, near surface water sample taken from bridges or, in a few cases from the riverbank, where the river appears to be well mixed vertically and horizontally. Although vertical heterogeneity of sediment-associated chemical species does occur ,homogeneity is assumed for the objectives of characterization and trend analysis. This assumption should not be made for some parameters if the data are to be used for loading analyses. The time of day when samples are collected is determined by the logistics of sampling all locations and delivering the samples to the lab for timely analysis. All measurement and analytical procedures are documented so that the data will be comparable with samples collected and analyzed in a like manner.

5.1.5. Field procedures

Water samples for dissolved oxygen, pH, specific conductivity, and turbidity determinations are collected by lowering a stainless steel bucket (APHA, 1998) to about 30 cm below the water surface. The sampler is dropped quickly through the surface layer to minimize the collection of floating or micro-layer contaminants. Water for total suspended solids is collected directly in a sample bottle attached to the bucket. Water for nutrient analyses is collected in an acid washed bottle attached to the bucket. Water for fecal coliform bacteria determinations is collected by lowering an autoclaved bottle inserted into a bottle holder designed to orient the mouth of the bottle to the flow. The dissolved oxygen sample is collected in a 300 mL bottle held inside the bucket. Temperature is measured directly in the stream using a long-line thermistor.. The bottle is stoppard, capped with a water seal and stored in the dark. Dissolved oxygen samples are either measured in situ with oxygen meter or titrated (modified Winkler titration; APHA, 1998) upon returning to the laboratory within 12 to 96 hours after collection. Aliquots are poured from the stainless bucket into cups for pH and conductivity measurements (Table 27), and into a Nalgene bottle that is sent to the lab for turbidity measurement. While the meters are equilibrating, the nutrient bottle is agitated and an aliquot poured into an acid washed Nalgene bottle for total nutrient determinations at the lab. The rest of the water in the nutrient bottle is filtered in the field through a 0.45 µm membrane filter into a brown Nalgene bottle for dissolved nutrient determinations at the lab. (Table 28).

Table (27) Parameters measured in the field

Variable	Method	Resolution
Temperature	Thermistor	0.1°C
pH	Glass electrode	0.1 unit
Dissolved oxygen	Titration	0.1 mg/L
Electrical conductivity	Electrode	1 µS/cm

Table (28) Containers type, volume, preservatives and holding time of water samples for laboratory analysis

Parameter	Container type	Sample volume (mL)	Preservation	Holding time
Turbidity	Poly	500	Cool to <4°C	48 hrs
Suspended solids	Poly	1000	Cool to <4°C	7 days
Total phosphorus	Poly	125	Adjust to pH < 2 w/H_2SO_4 and cool to <4°C	28 days
Soluble reactive phosphorus	Brown poly	125	Filter in field and cool to <4°C	48 hrs
Nitrate + nitrite-N	Poly	125	Adjust to pH < 2 w/H_2SO_4 and cool to <4°C	28 days
Ammnia-N	Poly	125	Adjust to pH < 2 w/H_2SO_4 and cool to <4°C	28 days
Total nitrogen	Poly	125	Adjust to pH < 2 w/H_2SO_4 and cool to <4°C	28 days
Fecal coliform	Autoclaved glass or poly	250	Cool <4°C	24 hrs

All samples requiring laboratory analyses are placed in the containers provided by the lab and labeled with the date, sample site, sample identification number (previously assigned by the lab for each sample), sampler's initials, and the chemical analyses requested. Preservatives, if required, are typically added to the bottle by the lab prior to sampling. Samples are then placed on ice and delivered to the lab according to procedures prearranged with the lab. Field measurements and comments are recorded on a form prepared prior to the sampling trip. Sampling equipment is rinsed thoroughly with de-ionized water after processing samples. The nutrient sampler is acid-rinsed.

5.1.6. Laboratory procedures

laboratory analyses and laboratory procedures are following Standard Operating Procedures and other guidance documents. Analytical methods and lower reporting limits are listed in Table 29.

Table (29) Laboratory analytical methods and reporting limits.

Parameter	Sample matrix	Number of samples/year	Method	Reference	Lower reporting limit
Ammonia-N	Total	12	Phenate	$SM4500NH_3H$	0.01 mg/L
Fecal coliform	–	12	Membrane filter	SM9222D	1 colony/ 100 mL
Nitrate + nitrite-N	Total	12	Cadmium reduction	$SM4500NO_3I$	0.01 mg/L
Soluble reactive phosphorus	Dissolved	12	Phosphomolybdic /ascorbic acid	SM4500PG	0.003 mg/L
Suspended solids	Total	12	Gravimetric	EPA160.2	1 mg/L
Total nitrogen	Total	12	Persulfate digestion, cadmium reduction	SM4500NB	0.025 mg/L
Total phosphorus	Total	12	Persulfate digestion, Phosphomolybdic /ascorbic acid	SM4500PI	0.01 mg/L
Turbidity	Total	12	Nephelometric	SM2130	0.5 NTU

5.1.7. Quality control program

Standard Operating Procedures (SOP's) for the analysis of each parameter and their Quality Assurance Manual and QC program includes the analysis of reference materials, check standards, duplicates, matrix spikes, control chart and blanks.

5.1.7.1. Check standards

Precision is addressed by the analysis of check standards (water with a known concentration of analyte) equal to about 10% of the total number of analyses. The mean value for a statistically significant number of check standard results may be used to judge whether there is any bias due to calibration. If the 95% confidence limit on the mean value does not include the true or reference value then bias due to calibration may be present. Generally, calibration standards are set by MEL as needed to bracket the concentration in particular samples. The check standards should equitably span the range of the expected results, ideally approximately 0.2 and 0.9 of the upper value for the range of calibration..

5.1.7.2. Duplicate samples

These are simply two identical samples collected and handled in the same way. They measure the precision of your methods.

- **Field duplicates** are two samples collected in the field from the same location at the same time; these measure the precision of your entire procedure (sampling, storage and handling, and laboratory analysis).
- **Laboratory duplicates** are two samples split from a single sample once it has arrived at the laboratory. These test the precision of the laboratory methods only.

Laboratory sample splits are analyzed on one of each pair of field-split samples. Using the same sample that was split in the field allows better partition sources of error between lab and field. Frequently, MEL will split additional samples as well.

5.1.7.3. Matrix spikes

Matrix interference leading to bias is assessed by analyzing river water that has been spiked with a known quantity of the analyte. The quantity of analyte added should not produce a final concentration that is excessively high when compared to the highest range of data Spike amounts should approximately double the concentration in the sample prior to spiking.

5.1.7.4. Recovery (accuracy)

Recovery is defined as the 'fraction of the analyte determined after addition of a known amount of the analyte to a sample'. In practice, control samples are most commonly used for spiking. The sample as well as the spikes are analyzed at least 10 times, the results averaged and the relative standard deviation (RSD) calculated.

The recovery is calculated with:

Recovery, % = [(X_s – X)/ X_{add}] x 100
where
X_s = mean result of spiked samples
X = mean result of unspiked samples
X_{add} = amount of added analyte

5.1.7.5. Blanks

Blanks are samples containing pure, uncontaminated water. Blanks contain none of the measured parameters and are used to identify contamination that might occur in the field or laboratory.

- **Field blank** is a blank sample that is placed in a sample bottle at the field site, and is handled the same as a normal sample. It identifies contamination that might occur in the entire procedure (from field sampling to laboratory analysis).
- **Laboratory blank** is prepared at the laboratory, and tests for laboratory contamination only.

5.1.7.6. Trueness

This is expressed by the equation:
Trueness ,% = (X / μ) x 100
where
X = mean of test results obtained for reference sample
μ = "true" value given for reference sample

5.1.7.7. Bias

It is more commonly used than trueness, and expressed by the equation:
Bias, % = [(X – μ) / μ} x 100

5.1.7.8. Precision

Replicate analyses performed on a reference sample can be used to determine trueness or bias, as described above, as well as a standard deviation of the mean as a measure for precision. However, for precision alone also control samples and even test samples can be used. Numerically, precision is expressed by the relative standard deviation *(RSD)* or coefficient of variation *(CV)*
Precision, % = (S/X) x 100
where
X = mean of test results obtained for reference sample
S = standard deviation of x.

$S^2 = \sum (X_1 - X)^2 / n-1$
n = degree of freedom

5.1.7.9. Reproducibility

This is a measure of the spread of results when a sample is analyzed by different laboratories .This is a measure of agreement between results obtained with the same method on identical test or reference material under different conditions (execution by different persons, in different laboratories, with different equipment and at different times). The measure of reproducibility R is the standard deviation of these results s_R, and for a not too small number of data ($n < 8$) R is defined by (with 95% confidence):

$R = 2.8 \times s_R$

(where $2.8 = 2\sqrt{2}$ and is derived from the normal or Gaussian distribution; ISO 5725).

5.1.7.10. Repeatability

The measure of agreement between results obtained with the same method on identical test or reference material under the same conditions (job done by one person, in the same laboratory, with the same equipment, at the same time or with only a short time interval). Thus, this is the best precision a laboratory can obtain: the within-batch precision. The measure for the repeatability r is the standard deviation of these results s_r, and for a not too small number of data (> 10) r is defined by (with 95% confidence):

$r = 2.8 \times s_r$

5.7.1.11. Control charts

Control charts are used for recording internal quality control data .The principle of control charts is that IQC data can be graphically plotted so that they can be readily compared and interpreted. Various types of control charts can be used such as X-chart and R-chart. X-chart is a graph with time (or assay batch) on the x-axis and the concentration of the variable in the reference material on the y axis. The mean of a number of control values obtained over a suitably long period of time is used as the central line in the chart. Two other lines above and two below the central line are also drawn. These are the upper and lower warning limits and the upper and lower action limits. The limits are based on two and three times the standard deviation of the batch means, respectively. Provided the distribution is normal, 95 per cent of results from assays in control will fall between the two warning lines. Action lines are normally placed at three standard deviations to either side of the target line and 99 per cent of normally distributed results should be between the action lines. Examples of typical X-charts are shown in Figure (5).

An R-chart is a similar control chart in which the mean range of repeated measurement is used as the central line, the control values being the difference between highest and lowest response value for a control sample in one batch. R-charts are normally used only with action limits. In the regular day-to-day use of the control charts, an aliquot from an appropriate reference material is analyzed with every batch of samples and the measured concentration of the variable in the aliquot is plotted on the chart.

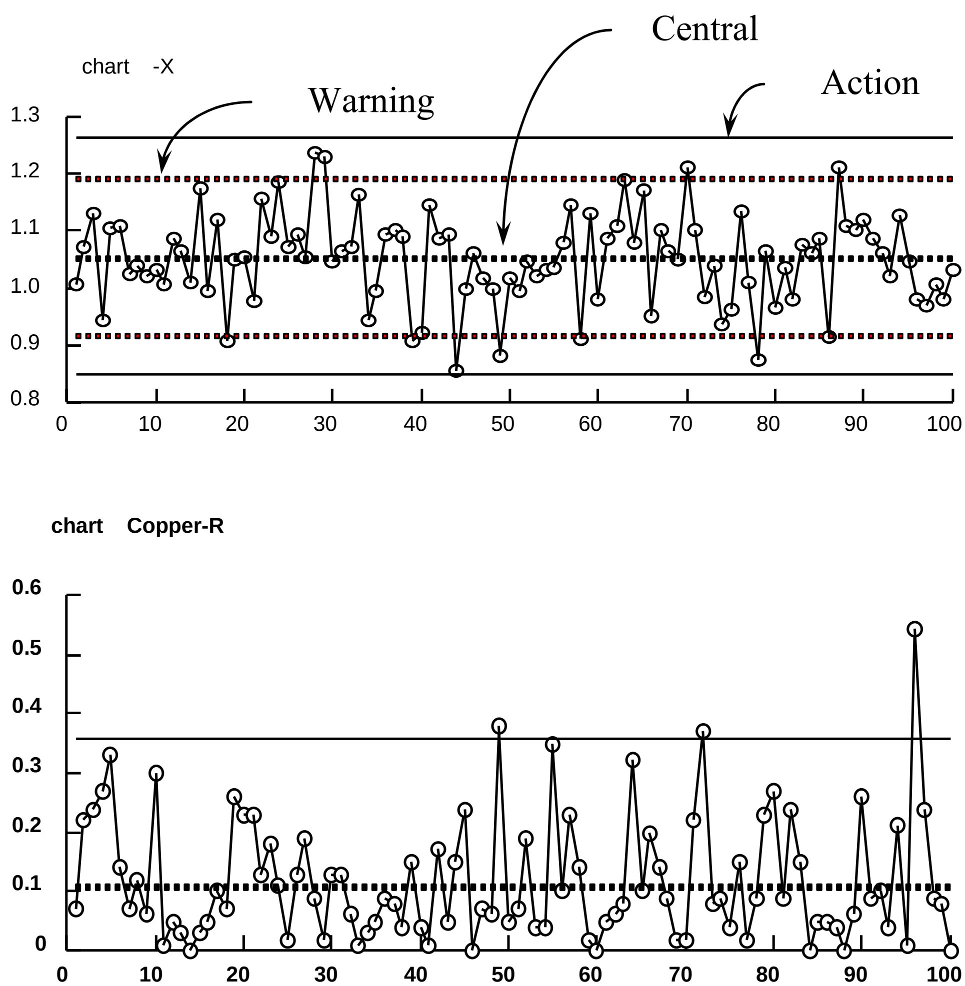

Fig. (5) Typical X-chart and R-charts.

Out-of control situation exists when; 1 control value outside the action limit, 2 consecutive control values outside the warning limits, 7 consecutive values with raising or failing tendency. In addition, 10 out 11 consecutive control values on one side of the central line in case of X-chart and 7 consecutive values above the central line in R-charts are also considered as out- of –control (ISO 13530).

Out-of control situation requires prompt detailed checking of the analytical method and rejection of the assay data. Results outside the action limits should prompt detailed checking of the analytical method and rejection of the assay data.

5.7.1.12. Lower limit of detection

It is the concentration of the analyte giving a signal equal to the blank plus 3 × the standard deviation of the blank . Because in the calculation of analytical results the value of the blank is subtracted (or the blank is forced to zero) the detection limit can be written as:

LLD, MDL = $3 \times s_{bl}$

At this limit it is 93% certain that the signal is not due to the blank but that the method has detected the presence of the analyte (this does not mean that below this limit the analyte is absent).

5.7.1.13. Field QC replicates

Short-term, temporal variability is assessed by collecting two samples sequentially, 15-20 minutes apart at 10 of the 12 monthly QC locations per region per year (the other two months are designated for blank samples). Results from the first sample are stored as the standard results. The second set of results is labeled as a QC sample. The difference between these results is used to calculate the expected variance that is due to short-term in-stream factors, field collection and processing, and laboratory analyses. The duplicate sample is split into two separate sub-samples for field measurements and processing, and submission to the lab. One set is given the “duplicate” label and the other is labeled “split” for data management purposes. These field-splits are used to calculate the variance that is due to field collection and processing, and laboratory analyses. The difference between split sample variance and the original sample variance is due to short-term in-stream processes.

5.7.1.14. Field blanks

Sample contamination is assessed by the submission of eight field blanks at random intervals throughout each year. These are “transport blanks” for parameters where there is no field processing of the sample (total suspended solids), and “rinsate blanks” for other parameters. Blanks results are expected to be below reporting limits.

5.7.1.15. Instrumentation

The pH and conductivity meters are calibrated daily according to the manufacturer's directions. The pH meter is checked immediately after calibration, at midday, and at the end of the day by recording the measurement of a low ionic strength pH 7 buffer. It is also checked whenever a measurement exceeds water quality standards criteria. If the difference between the meter measurement and the expected pH exceeds 0.10, the instrument is recalibrated and the sample re-measured .The conductivity and temperature meters are relatively stable; the conductivity calibration is generally checked only at the end of the day (100 µS calibration and check standards), and temperature calibration at the beginning of the sampling trip.

5.7.1.16. Corrective action

An appropriate series of corrective actions can be taken to keep the quality control, these are :

- Review quality control limit calculations for obvious errors.
- Rest the data for outliers, exclude any that are identified as such, and re-calculate control limits.
- Review matrix spike preparation procedures to determine if any errors were made.

The laboratory continually monitors their results for quality control sample determinations and takes appropriate action to correct problems. Frequently, samples may be re-analyzed after an analytical problem is corrected. This is also the case for field measurements with respect to check standard results. Due to sample holding time limitations, re-analysis is usually not possible if problems are discovered in field QC data. Corrective courses applying to subsequent data collection are possible, however.

If data are compromised due to poor precision, the source of the variability will determine the course of action that is required. Possible actions include 1) changing the standard operating procedures or instrumentation for field personnel; 2) informing the laboratory when lab error appears to be the source (and possibly changing analytical methods); and 3) re-evaluating the required precision, when it appears that the required error is unattainable. A persistent, consistent bias in the data may warrant adjusting the values, otherwise the corrective action for bias will be to inform the lab, which will be expected to address the problem. Significant changes in methods, instrumentation, or protocols will be made only after it has been documented that these changes will not bias the data.

5.7.1.17. Summary of an internal quality control program

For each parameter

- Analyse five standard solutions at six different known concentrations covering the working range to develop a calibration curve or, when a calibration curve already exists, analyze two standard solutions at different known concentrations covering the working range to validate the existing calibration curve.
- Analyze one method blank per set of 20 samples.
- Analyze one field blank per set of samples.
- Analyze one duplicate of a sample chosen at random from each set of up to 20 samples.
- Analyze one specimen that has been spiked with a known amount of the variable as a recovery check. This specimen should have a matrix similar to those of the samples being processed.

5.7.1.18. Data management procedures

Our data are managed first by recording data for parameters measured in the field manually on a standard form and entered by the sampler into a temporary computer access table upon return to the laboratory. Rough validation rules prohibit obviously incorrect data from being entered. A hardcopy of the temporary table is printed and the sampler reviews the data prior to moving it into the final results table. After field and laboratory data are entered, an evaluation of results is performed .

5.7.1.19. Reports

These reports are identified as being based on preliminary data. After a full month's data are available, all results are reported and all results exceeding water quality criteria or the usual range of results from a particular location are identified. Upon completion of the data collection activities, the previous year's program is summarized in an annual report .This report includes an analysis of field and some lab QC data collected during the year as well as an appendix listing known changes to the monitoring program that could potentially affect the data.

5.7.1.20. Data review, verification, and validation

Data verification prior to reporting includes an on-going evaluation of their QC results (using control charts, etc consists of a computer assessment of the data and associated field QC data):

- Each result is compared to historic data from that collection location during the same season. The datum is 'flagged' if it lies more than 2.5 standard deviations from the mean.
- The values of replicated samples are flagged if the coefficient of variation of the replicates or split samples exceeds 20%.
- The datum is flagged if the holding time was exceeded.
- If internal logic checks (total phosphorus greater than soluble reactive phosphorus or total nitrogen greater than nitrate/nitrite plus ammonia) are violated, then all data values involved are flagged.

5.7.1.21. Data quality assessment

Result-level data validation procedures are conducted monthly as described . QA assessments is made by comparing calculated percent of relative standard deviations (% RSD) to those specified in MQOs (Table 25).

$\% RSD = 100 \times (S/X) = 100 \times \sqrt{[(r_1 - r_2)^2 / 2 \; / \; (r_1 - r_2)/2]}$

Where S is the standard deviation, X is the mean, and r_1 and r_2 are paired results, typically a known value (e.g., of a check standard) and the analytical result or measurement of the known value.

The results of the analysis of blank samples and known standards will be used to determine overall bias of the results.

5.2. Quality assurance manual

A manual describes and document all quality assurance activities and actions is to be prepared according to the following guidelines:

5.2.1. Introduction

Quality
Quality control
Quality assurance
Scope of laboratory activity.

5.2.2. Laboratory quality policy

Objectives.
Resources.
Management.

5.2.3. Laboratory organizational structure and responsibilities

General
Personnel files
Personnel training
Personnel definitions

5.2.4. Laboratory facilities

General
Cleanliness
Safety
Security

5.2.5. Sample handling processes

General
Sample collection
Sample representative ness
Sample preservation
Sample storage
Sampling security

5.2.6. Sample tracking

General
Chain-of custody
Problems with samples
Sample holding times
Waste handling

5.2.7.Analytical procedures

General
Glassware cleaning procedure
Reagent preparation
Standards
Methods of analysis (SOP's)

5.2.8. Quality control procedures

General
Quality definitions
Control charts
Sample spike /matrix spike
Duplicate and split samples
Lower detection limits
Equations

5.2.9. Instrumentation

General
Log books of testing equipment (inventory).
Instrument calibration procedures
Calibration schedules
Preventive maintenance
Service agreements
Instrument downtime
Maintenance log

5.2.10. Analytical data

General
Data quality objectives
Raw data
Data validation
Data entry
Data acquisition (manual – electronic)
Accuracy and precision
Data reporting

5.2.11. Corrective actions

General
Standard procedure
Feedback.
Quality audit.

5.2.12. Record keeping practices

General
Laboratory notebooks
Computer files
Records maintenance.
Historical file of records.

References

[1] S.Myllyla (1995) *Cairo- A Mega-City and its Water,* The third Nordic Conference on Middle Eastern Studies Ethnic encounter and Culture Change, Joensun, Finland .

[2] Food and Agriculture Organization of the United Nations, FID/CP/EGY, (2004), *Egypt Fishery Country Profile.*

[3] *General Report on Water Quality in Egypt* (2005) Ministry of Water Resources and Irrigation and Ministry of Health and Population (in Arabic).

[4] *National Network for Water Quality Monitoring of Nile River and its branches* (2005), Environmental monitoring and workplace studies Center (MOHP), Imbaba, The Annual Report (in Arabic).

[5] *The State of Environment in Egypt* (2006), State Ministry Of Environment (in Arabic).

[6] NIOF (2006) *Fourth Report of Environmental Data from Coastal Areas of Suez Gulf, Aqaba Gulf and Red sea Proper During September 2006*

[7] IGSR (2006) *Fourth sampling Cruise Report for Mediterranean Monitoring Programme*.

[8] APHA, (1998). *Standard Methods for the Examination of Water and Wastewater*, 20th edition. American Public Health Association, Washington.

[9] M.P.Berndt, B.G.Katz (2000) *Quality Assurance Plan for Water Quality Activities in the orth lorida*, Progrm Office, Florida District, US Geological Survey, Report 00-426, Florida.

[10] F.M.Garfield (1997) *Quality Assurance Principles for Analytical Laboratory*, AOAC International USA.

[11] G.Katerman, L.Buydens (1993) *Quality Control in Analytical Chemistry*, 2ne edition, Wiley-Intersciece, New york .

[12] J.P. Dux, (1990) *Handbook of Quality Assurance for the Analytical Chemistry Laboratory*. 2nd edition, Van Nostrand Reinhold, New York.

[13] F.M. Garfield, (1991) *Quality Assurance Principles for Analytical Laboratories*. 2nd edition, AOAC International, Arlington, VA.

[14] R. Caulcutt, and R. Boddy, (1983) *Statistics for Analytical Chemists*. Chapman & Hall, London.

[15] Analytical Methods Committee, Royal Society of Chemistry (1992) *Proficiency testing of analytical laboratories*. The Analyst, **117**, 97-104.

[16] D. Wrye, (1993). *Basin Approach to Water Quality Management: Program Description.* Washington State Department of Ecology, Olympia, WA.

[17] ISO/IEC 17025 (1999) *"General requirements for the competence of testing and calibration laboratories"*

[18] W. Ward, (2002). *Stream Sampling Protocols for the Environmental Monitoring and Trends Section.* Washington Department of Ecology, Environmental Assessment Program, Olympia, WA. Publication No. 01-03-036.

[19] D.P. Lettenmaier, (1977). *Detection of Trends in Stream Quality: Monitoring Network Designand Data Analysis.* Technical Report No. 51, University of Washington, Department of Civil Engineering, Seattle, WA.

[20] B. Hopkins, (1993). *Freshwater Ambient Monitoring Report for Water year 1991*. Washington State Department of Ecology, Ambient Monitoring Section, Publication #93-75, Olympia,WA

[21] R.M. Hirsch, J.R. Slack, and R.A. Smith. (1982). *"Techniques of trend analysis for monthly water quality data."* Water Resources Research 18(1): 107-121.

[22] (http.//www.h2Okits. com)

[23] *WHO Guidelines for Drinking Water Quality*, (1996) Vol II 2nd Edition, WHO ,Geneva.

[24] *Water Quality Monitoring- A How to Guide* (2007) Chehalis iver Council, Washington USA, http://www.crcwater.org/index.html.

[25] J.A.Baldwin, S.N.Bhatnagar (1996) *Reaching the Unreached: Challenges or the 21st century, Sustainability through training*, 22nd WEDC conference, New Delhi, India.

[26] *Water for people,* (2007), Denver, USA, http://www.waterforpeople.org.

[27] J.Bartram and R.Ballance (1996). *Water quality Monitoring- A practical guide to the design and implementation of freshwater quality studies and Monitoring programme* UNEP/WHO.

[28] S. Abdel-Dayem (1994). *"Water quality issues in Egypt."* Italian–Egyptian Study Days on the Environment, Cairo 9–20 October, pp. 81–92.

[29] H.I.Abdel-Shafy, S.A.Hassan, R.O. Aly and N.M. El-Wattar, (1998). *"Impact of heavy metals released from fungicide on the environment of Egypt."* Al-Azhar J. Agricult. Res. 28:183–194.

[30] S.I.Abou-Elela and F.Zaher (1998) *"Pollution prevention in oil and soap industry. A case study."* Water Quality International IAWQ 19th Biennial International Conference, 21–26 June, Vancouver, Canada, pp. 133–138.

[31] F.A.EL-Gohary (1994). *"Industrial wastewater management in Egypt."* Italian–Egyptian Study Days on the Environment, Cairo, 9–20 October.

[32] A.Hamza and J. Gallup (1982). *"Assessment of environmental pollution in Egypt: Case Study of Alexandria Metropolitan."* WHO, pp. 56–61.

[33] *Survey of Nile System, Pollution Sources* (2002) Report No 64, Ministry of Water Resources and Irrigation, Egypt.

[34] J.Welsh (1991). *"Preserving the option, food productivity and sustainability."* Issues in Agriculture 2. CGIR, Washington, D. C.

[35] S. Abdel-Dayem and M.B.Abdel-Ghani (1992). *"Concentration of agricultural chemicals in drainage water."* Proceedings of the 6th Conference International Drainage Symposium. Nashville, Tennessee, USA.

[36] H.I.Abdel-Shafy , R.O.Aly (2002), *Water issue in Egypt: Resources, Pollution and Protection Endeavors*, Central Eur. J.Occupat.& Environm. Med. volume 8, 3-21.

[37] R.Kelly and J. Welsh (1992). *Egypt Water Quality Management Action Plan, Phase 2.* A study submitted to USAID/Egypt and the Government of Egypt, Cairo.

[38] M.Parkany (1993) *Quality Assurance for analytical Laboratories,* The Royal Society of Chemistry, Cambridge, UK.

[39] R.M. Hirsch, R. B. Alexander, and R.A. Smith. (1982). *"Selection of methods for the detection and estimation of trends in water quality."* Water Resources Research 27(5): 803-813.

[40] W.J. Ehinger, (1995). *Freshwater Ambient Water Quality Monitoring, Final Quality Assurance Project Plan*. Washington Department of Ecology, Environmental Investigations and Laboratory Services Program, Ambient Monitoring Section, Olympia, WA.

[41] US Environmental Protection Agency (2002). *Guidance on Environmental Data Verification and Data Validation*, EPA/240/R-02/004. U.S. Environmental Protection Agency, Washington, DC,USA.

[42] T.A.Ratliff,jr (1993) *The laboratory Quality Assurance System*, 2nd edition, Manual of Quality Procedures with related Forms, Van Nostrand Reinhold, New York.

[43] H.Gunzler (1994) *Accreditation and Quality Assurance in Analytical Chemistry*, Springer, Berlin .

[44] W.A. Shewhart, (1986) *Statistical Method from the Viewpoint of Quality Control*. Dover Publications, New York.

[45] A.J. Duncan, (1986) *Quality Control and Industrial Statistics*. 5th edition, Irwin, Burr Ridge, IL.

[46] D.A. Arvin, (1995), *A workbook for preparing surface water quality assurance plans for districts of the US geological Survey*, Water Resources Division, US geological Survey, Denver , Colorado

[47] D.Hallock, W.Ehlnger (2003) *Quality Assurance monitorig Plan, Stream Ambient Water Quality Monitoring,* Pub.No. 03-03-200 , Washington State Department of Ecology.

[48] US Environmental Protection Agency (1983). *Methods for Chemical Analysis of Water and Wastes*, EPA-600/ 4-79-020. U.S. Environmental Protection Agency, Cincinnati, Ohio, USA.

[49] J.C. Miller, and J.N. Miller, (1992) *Statistics for Analytical Chemistry*. 3rd edition, Prentice-Hall, Inglewood Cliffs, NJ.

[50] ISO (1984) *Development and Operations of Laboratory Proficiency Testing* Guide 43(E),International Organization for Standardization, Geneva.

[51] ISO (1994) *Quality Management and Quality Assurance-a Vocabulary*. International Standard ISO 8402, International Organization for Standardization, Geneva.

[52] R.J. Mesley, W.D. Pockington, and R.F. Walker, (1991) *Analytical Quality Assurance-a Review*. The Analyst, **116**, 975-990.