THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF WATER

GUIDELINES FOR WATER RESOURCES MONITORING AND POLLUTION CONTROL

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PREFACE

This guidelines for Water Resources Monitoring and Pollution Control (WRMPC) covers both Ambient Water Quality Monitoring (AWQM) and Effluent Quality Monitoring (EQM).

The document is a guide to monitor the country's ground water and surface waters in rivers, streams, lakes and similar water bodies and marine waters (coastal estuaries and offshore line); including the monitoring of quality of effluent from industries and other regulated wastewater dischargers. The objective is to standardize ambient water quality and effluent quality monitoring procedures to ensure that the water quality monitoring programs follow certain Quality Assurance/Quality Control (QA/QC) protocols and acceptable field methods as a tool towards implementation of EMA, 2004 and Water Resources Management Act, No. 11, 2009.

The primary users of the guideline are the technical Staff of the MoW, Basins Water Boards Offices, Regional and District Offices.

Other users are Government regulators and implementers, consultancy firms, industries, monitoring groups such as Multi-partite Monitoring Teams (MMTs), Students and Researchers.

The manual is intended to be a dynamic document that will be periodically reviewed and updated as deemed necessary.

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EXECUTIVE SUMMARY

Inappropriate water use practices and environmental degradation threatens sustainability of the water resource with potential negative impacts on ecosystem integrity, human health, food security, industrial production, and investment in various social - economical sectors. Furthermore, for the past decades water resources development programmes have been implemented with little regard to environmental protection and conservation.

Water quality management was considered less significance to many technocrats, since there were many alternative ambient sources which could be taped with little to non effort to improve their quality to the acceptable standards. Deterioration of water quality due to human development activities is evident in many parts of the country, such that some of these sources are abandoned or engage costly conventional treatment processes. Inadequate water quality management includes water quality monitoring and pollution control practices, weak enforcement due to lack of defined guidelines and low institutional capacity have led to the escalation of the problem as well as limiting their use and/or made treatment costly.

Current arrangements or guideline for the acquisition of data in order to carry out water quality monitoring are inadequate both in terms of resources and institutional capacity. This guideline is therefore necessary to provide procedures and practices for effective monitoring, inspection and enforcement of regulations for the control of pollution of water sources.

The need for developing monitoring guidelines for water resources pollution control has been expressed in various policies and legislations including:

- The National Water Policy, 2002
- The Water Resources Management Act, 2009
- National Water Sector Strategy, 2006
- The Environmental Management Act, 2004

The main objective of this guideline is to enable any stakeholder (user, developer and regulator) to comply with EMA, 2004 on water pollution prevention and control. In fulfilling the general objective of the guideline, the following are specific objectives:

- to provide quick reference material for personals undertaking water quality monitoring exercise,
- to identify different sources of water resources pollution
- to identify different types of water resources pollution
- to provide water pollution control mechanism.

Policies and legislations concerning water resources pollution prevention and controls are in place; nevertheless the situation in the Country is that water pollution is continuing unabated. This situation has developed due to lack of systematic monitoring procedures

pertaining to water resources pollution due to agricultural, wastewater disposal from industries and municipality, mining, transportation and navigation as well as other human development activities.

Water uses cut across all social and economical activities of human kind. Therefore, its pollution situational analysis has to be looked with respect to social and economical activities which include; ***agriculture, mining, energy, industry, municipal, transport, forest and tourism activities***. The identification of sources and types of water pollution by different social economical activities and control mechanism has been discussed to provide sound monitoring procedures guidelines.

The ambient water quality monitoring procedures is a line of measurement of water quality which provides important information about the integrity of a body of water before interaction with human activities. The most widely used method is the measurement of its physical, chemical and bacteriological constituents. The quality of water is measured or monitored to determine if it meets the prescribed or expected ambient water quality status.
Among others, water quality monitoring results are used as basis for policy or management decisions concerning a water body and its uses.
Ambient water quality monitoring comprise of the following eight (8) basic steps; setting water quality monitoring objectives, assessment of resources availability
Reconnaissance survey, network design, sampling, laboratory work, data management and quality assurance.

Effluent Quality Monitoring (EQM) is also part of water quality management. It addresses the requirements of the Environmental Management Act (EMA) of 2004 on compliance monitoring and self-monitoring by the proponent. The chapter also is intended to guide the Ministry of Water (MoW) inspectors in monitoring the quality of effluent from industries and other establishments whose wastewater discharges are regulated by the government through discharge permits issued by BWBs. It may also serve as reference for other users, such as the industries undertaking self-monitoring to ensure that their discharges meet the effluent quality standards. Hence forth effluent quality monitoring is undertaken by the Ministry of Water primarily to ensure compliance by the industries and commercial establishments with the National effluent standards. Then BWBs monitor the quality of effluent through the permitting system though the industries are encouraged to undertake self-monitoring of the quality discharged.
The effluent or wastewater discharge is monitored for specific effluent quality parameters to ensure that the concentrations are within allowable limits. The monitoring results are used as basis for regulatory and control actions, e.g., issuance of discharge permits,

issuance of notice of violation (NOV), or imposition of fines and penalties or computation of wastewater charges.

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ACRONYMS AND SYMBOLS

Acronyms

AMC	Annual Maintenance Contract
AMD	Acid Mine Drain
AQC	Analytical Quality Control
ARD	Acid Rock Drainage
AWQM	Ambient Water Quality Monitoring
BOD	Biological Oxygen Demand
CIDA	Canadian International Development Agency
COD	Chemical Oxygen Demand
DE	Diatomaceous Earth
EMA- ISP	Environmental Management Act- Implementation Support Programme
EMA	Environmental Management Act
EQM	Effluent Quality Monitoring
GALP	Good Agricultural and Livestock keeping Practices
GDP	Gross Domestic Product
GPS	Global Positioning System
IWRM	Integrated Water Resources Management
MAFSC	Ministry of Agriculture, Food Security and Co-operatives
MDL	Method Detection Limit
MoW	Ministry of Water
MMT	Multi-partite Monitoring Team
MWSS	Municipal Water supply and Sanitation
NAWAPO	National Water Policy
NEMC	National Environment Management Council
NOV	Notice of Violation
NPS	Non-Point Source
NWQMPCS	National Water Quality Management and Pollution Control Strategy
NWSDS	National Water Sector Development Strategy
OSHA	Occupational Safety and Healthy Authority
PMO-RALG	Prime Minister’s Office Regional Administration and Local Government
PPE	Personal Protective Equipment.
QA	Quality Assurance
TBS	Tanzania Bureau of Standards
UWSA	Urban Water supply and Sanitation Authority
WRMA	Water Resources Management Act
WRMPC	Water Resources Monitoring and Pollution Control
WTP	Water Treatment Plant

Symbols

Ag	Silver
Al	Aluminium
As	Arsenic
B	Boron

Ba	Barium
BOD_5	Biochemical Oxygen Demand
Ca	Calcium
CaCl	Calcium Chloride
Cd	Cadmium
CdS	Cadmium Sulfide
Cl	Chloride
CN	Cyanide
Co	Cobalt
CO_2	Carbon dioxide
Cr	Chromium
Cr^{6+}	Hexavalent Chromium
Cu	Copper
$CuSO_4$	Copper Sulfate
DDT	Dichloro Difluoro Trichloroethane
DO	Dissolved Oxygen
F	Fluoride
Fe	Ferrous or Iron
H^{2+}	Deuterium
H_2O	Water
H^{3+}	Tritium
HCl	Hydrochloric Acid
HCO_3	Bicarbonate
Hg	Mercury
K	Potassium
MBAS	Methylene Blue Alkyl Substances
Mg	Magnesium
Mn	Manganese
N	Nitrogen
Na	Sodium
NaCl	Sodium Chloride (common table salt)
NH_3-	Ammonia Nitrogen
Ni	Nickel
N-NO_3	Nitrogen-Nitrate
P	Phosphorous
PAH	Polyaromatic Hydrocarbon
Pb	Lead (Plumbum)
PCB	Polychlorinated Biphenyl
pH	Potential of Hydrogen
PO4	Phosphate
Se	Selenium
Sn	Tin
SO_4	Sulphate
TCE	Trichloroethylene

TDS	Total Dissolved Solids
TSS	Total Suspended Solids
$U^{23\ldots+}$	Uranium
Zn	Zinc

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CHAPTER 1

INTRODUCTION

Survival of mankind depends on the availability of portable water which is a finite resource under pressure and growing scarce as a result of increasing multi-sectoral demands, and is a vulnerable resource because of increasing degradation due to pollution, over-abstraction, poor land use practices, encroachment of land for agriculture, urbanization and industrial development. This scarcity and vulnerability is having a negative impact on important watershed, recharge areas and wetlands.

Increasing human activities and the land use practices in the various catchment areas are impacting on the availability of Water resources through consequent changes to runoff patterns, groundwater recharge mechanisms and the overall water balance of catchment areas.

Inappropriate water use practices and degradation threatens sustainability of the resource with potential negative impacts on ecosystem integrity, human health, food security, industrial production, and investment in various social - economical sectors. Furthermore, water resources development programmes have been implemented with little regard to environmental protection and conservation and therefore needs comprehensive legal framework support for their sustainability.

1.1. Background

Environmental degradation and pollution of water sources from increasing human activities has led to increased water scarcity and pollution vulnerability. The current situation has caused deterioration of the integrity of ecosystems that perform valuable services to the society, including moderating floods and droughts, purifying water and sustaining fisheries and other aquatic resources.

Deterioration of water quality due to human development activities is evident in many parts of the country. Inadequate water quality management including water quality monitoring and pollution control practices, weak enforcement due to lack of defined guideline and low institutional capacity have led to the deterioration of the quality of water resources as well as limiting their use and/or made treatment costly.

The pollution of water resources comes from many sources, including untreated or partially treated sewage, chemical discharges, petroleum leaks and spills, dumping in old or new mines and/or quarry pits, agricultural chemicals washed off or seep underground from farm fields and atmospheric deposition. Pollution can render large quantities of water unsuitable for use, or be used for restricted purposes only.

Current arrangements or guideline for the acquisition of data in order to carry out water quality monitoring are inadequate both in terms of resources and institutional capacity. Hence the need of having comprehensive guideline for water resources pollution monitoring was paramount.

In Tanzania, there are sufficient legal provisions for water resources pollution control measures however; the mechanisms for effective enforcement were missing which leads to preparation of this guideline. The need for developing water resources pollution control and monitoring guidelines have been expressed in various policies and legislations as depicted in the following subsections.

1.2. National Responses to Water Resources Quality Assurance

The Government of United Republic of Tanzania has put in place a good number of policies, strategies and legislations as highlighted below to make sure that water resources are protected and sustainably utilized.

1.2.1 The National Water Policy, 2002

On the issue of Water Quality management and pollution control, the 2002 Water Policy (Section 4.2.2) observes that ***"Pollution from point and non-point sources of water resources is responsible for the deterioration of the quality of water, makes water unusable and its treatment very costly".*** This Policy, therefore, observes that in order to remedy this, water shall be protected from pollution and harmful depletion, and recommends five measures to be taken. One of the measures recommended in the Policy states that: ***"Water quality monitoring and assessment will be undertaken systematically so as to identify extent and status of the quality of the water resources so that problems are detected early and remedial actions employed timely".***

1.2.2 The Water Resources Management Act, 2009

Part VI of the Water Resources Management Act, 2009 addresses the issues of protection of Water Resources. Section 39-(1) of the same Act states that "***An owner or occupier of land on which any activity or process is or was performed or undertaken, or any other situation exists which causes has caused or is likely to cause pollution of water sources, shall take all reasonable measures to prevent any such pollution from occurring, continuing or recurring***"

This Legislation goes further by defining the duties of different institutions and actions to be taken in the whole process of monitoring pollution events and remedial measures which have to be taken.

1.2.3 National Water Sector Strategy

It is observed in the Water Sector Strategy that “Systematic monitoring and assessment of water quality combined with effective control of sources of pollution and application of the “polluter pays” principle will be implemented and supported by the appropriate legal instruments.

The strategy for water quality and pollution monitoring will be to:

- Promote sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development;
- Determine water quality targets for fresh water bodies dependent on their potential use;
- Strengthen measures for effective water quality monitoring;
- Establish mechanisms setting effluent discharge standards for the control of pollution;
- Introduce charges for effluent discharges based on the cost to the environment; and
- Promote an integrated approach to pollution prevention and minimization, based on cleaner production measures, reduced use of resources, recycling and reuse.

1.2.4 The Environmental Management Act, 2004

The Act (EMA, 2004) prohibits environmental pollution as a whole, however, Part V of EMA, 2004 from section 60 to 62 clearly highlights Environmental obligations under water laws, Power of the ministry to advise on the discharge of sewerage and make rules governing issues of permits for the discharge of effluents into water bodies.

Part VIII of EMA, 2004 (Pollution Prevention and Control) ***section 107 and 109*** explain the ***possibility of developing regulations to prevent and control pollution and prohibition of water pollution respectively.***

Therefore, EMA, 2004 has identified existing water resources legislations and went further on management and protection of water resources from adverse development activities which may cause pollution. The guidelines contained in this document are developed in response to the above requirements contained in the policies, legislations and strategies.

1.2.5 National Water Quality Management and Pollution Control Strategy

National Water Quality Management and Pollution Control Strategy (NWQMPC) was developed after being realised that, there are significant legal and institutional changes that has been implemented based on NAWAPO, National Water Sector Development Strategy (NWSDS) 2008 through the Integrated Water Resources Management (IWRM) Model. The model outlines the broad strategic and political directions for the development of the sector. The NWSDS include a simple action plan for water quality management in which the document expand on those directives through the following recommendations not limited to.

More focused strategy and cost-effective water quality monitoring programmes highlighting on development that initially emphasises the provision of safe and clean water for human use.

Identify national priorities for operational water quality management

Improve financial sustainability data quality and efficiency of operations in water quality monitoring through government laboratories.

Improve institutional performance by funding human resources development through training and educational programme.

Enforce regulatory framework which identify actions to improve the implementation of effluent control.

Development of this guideline has incorporated some of the recommendation identified in the NWQMPC and the way to achieve the recommended objectives.

1.3. Objective

The main objective of this guideline is to enable all stakeholders (user, developer and regulator) to comply with EMA, 2004 on water resources pollution prevention and control and to implement the NWQMPC strategy. In fulfilling the general objective of the guideline, the following are specific objectives:

- to provide quick reference material for personals undertaking water quality monitoring exercise,
- to identify different sources of water resources pollution
- to identify different types of water resources pollution
- to provide water pollution control mechanism.

1.4. Rationale

Policies and legislations concerning water resources pollution prevention and controls are in place; nevertheless the situation in the Country is that water pollution is continuing unabated. Pollution undermines the use of an important, and in some cases an increasing, scarcely resource. This situation has developed due to many reasons including lack of capacity to undertake continuously and systematic monitoring processes and lack of monitoring guidelines which is supposed to be a guiding tool towards safeguarding water resources.

The development of this guideline will greatly assist in carrying out continuously and systematic monitoring activities which are expected to result into identification of extent and status of the quality of the water resources so that problems are detected early and remedial actions employed timely. Others include restoration of degraded catchment areas, improved ground water recharge and general control of water resources pollution avenues. In addition to the above benefits monitoring guidelines will assist in; strengthening measures for effective water quality monitoring; improve existing effluents discharge standards and developing up to date database for ambient water quality.

1.5. Scope

This guideline is prepared to guide the setting of water resources quality monitoring objectives, assessing resources available, reconnaissance survey, network design, sampling, laboratory work, data management and quality assurance of the monitoring programme. The guideline also covers the sources and types of pollution and their control mechanism of resource pollution due to agriculture, mining, energy, industries, municipalities, transportation, forestry and tourism activities.

CHAPTER 2

SITUATION ANALYSIS OF WATER RESOURCES POLLUTION AND CONTROL MECHANISM

2.1 Introduction

Water uses cut across all social and economical activities of human kind. Therefore, its pollution situational analysis has to be looked with respect to social and economical activities which include; agriculture, mining, energy, industry, municipal, transport, forest and tourism activities. Specific hazards to water quality in the country are caused by faecal contamination and water borne disease from poor domestic waste management, contaminants from industrial wastewater and sewage from point sources that threaten fish industries and other aquatic resources, sediments, nutrients and agrochemicals released from the catchments, through poor land use managements and uncontrolled discharge of mining wastes that threaten human stocks and wildlife resources. The identification of sources and types of water pollution by different social economical activities and control mechanism is discussed in the following sub sections. The details of sources and types of water pollutions are presented in appendix 1 and pollution control mechanism have been detailed in appendix 2

2.2 Agriculture

The agricultural sector is the leading sector of the economy and accounts for about 45.6 percent of GDP and about 50 percent of foreign exchange earnings. Agriculture, as one of the major economic activities in Tanzania, has much to contribute to water pollution through land tillage, application of pesticides and fertilization. The need to increase crop productivity has led to extensive use of pesticides, fertilizers and promotion of irrigated agricultural practices. Livestock keeping also has similar kind of activities that pollute water bodies by degrading river and lakes banks in the cause of watering process, and through contamination with acarasides and pesticides used in livestock. On the other hand, fishery sector pollutes water through waste waters released from aquaculture effluents and illegal use of organicides. The major source of pollution in land tillage is sediments as a result of loose soil and grasses.

When fertilizers are used in agriculture, they trickle down into water resources to introduce phosphates, nitrates and organic matters in water sources. Application of organo-chlorine pesticides and others are major source of water pollution, however the efforts are already in process to burn the use of organo-chlorines.

In areas where there is excessive irrigation practices, water salinity, hardness, algae formation in stagnant waters, nitrogen and phosphorus leaching to ground water is also highly expected as these are pollutants produced by activities associated by agricultural sector. For more illustrations on the type of the agricultural activities, pollution caused, indicative parameter and recommended monitoring mechanism see table 2 and table 10 attached in appendix 1.

Figure 1 Water use in agricultural activities can affect the entire ecosystem both in quantity and quality

2.3 Mining

The diverse nature of geo-morphological of Tanzania blessed it with abundant and a range of both mineral and hydrocarbon deposits. As such, exploitation of these resources acts as the key driver for national economic growth and gives support to national development goals. However, the extraction of these resources has several impacts to both the environmental and water resources.

The significance of mineral resources is clearly demonstrated by their utilization since the ancient time up to the present days. Geo-resources materials have been the basic elements in producing numerous items such as bricks, roofing materials, flooring, cooking tools, cement, jewellery, fertilizer, perfumes, ceramic, paint, medicine and pharmaceutical products, cars, trains, aircrafts, electric and electronic devices, to mention a few.

The mining sector contributes much to water resources pollution through its diverse and complicated exploration, mining, drilling, processing and extraction activities. Acid Mine Drain (AMD) is generated from exposed mineral deposits, pit water and leakage from processing, storage and unconfined disposal facilities. These mining activities are known to have both onsite and offsite effects on water resources. Some of the current issues/challenges of Tanzanian mining industry in relation to water resources aspects include, abandoned mining sites, malfunctioned storage facilities and illegal mining.

Whilst satisfying the demand to increase the role of the mineral sectors to support the national economy, the government remains committed in protect water resources through the implementation of appropriate laws and regulations. Mineral resources are non-renewable; therefore, their development requires proper management, so that they can be exploited and used beneficially not only for the present, but also for the future generations. For more elastration on type of mining activities, pollution caused and indicative parameter and recommended monitoring mechanism see table 3 and 11 in Appendix1

2.4 Energy

The significance of hydrocarbon resources is clearly demonstrated by their utilization since the ancient time up to the present days. Oil and gas are the most important energy sources and constitute principal components in producing diverse petrochemical products such as plastics, paints, asphalt, fertilizer, lubricants and insecticides, to mention a few; whilst being used as industrial and transport energy source.

Firewood, charcoal, gas, petroleum and coal are the primary source of energy currently being used. Coal, gas and petroleum development potentially affect water resources quality and quantity both during the process of exploration, drilling, mining/extraction, storage and utilization. Water resources sites are commonly encountered during exploration, extraction, transportation and storage facilitations.

To reduce the effect of pollution, the use of different types of energy by various group users, particularly from green sources is being encouraged. Besides, there are also a number of potential renewable energy resources that can be developed in the future. For more elastration on type of mining activities, pollution caused, indicative parameter and recommended monitoring mechanism see table 4 and table 11.

2.5 Industry

Due to economic development, industrialization has become one of the major challenges as far as water resources management is concerned. The demand for fresh water is hugely increasing alongside the increase of waste. Industries contributed about 8.4% to Tanzania's GDP in 2000.The growth in the industrial activities have significant impact on the water supply as well as potential pollution and degradation of water resources due to industrial solid waste; effluent and air emissions if not well managed and allowed to enter water bodies without adequate treatment. As a result the quantity and quality of water is hugely affected.

Industries which are major sources of water resources pollution include: chemicals, leather and tannery, wood and wood products, pulp and paper mills, foods and beverages, wines and spirits, metal and steel, textiles, sisal processing, brewery, thermal plants, paint, cement, garages, sewage treatment plants, various recycling and waste disposal plants.

There are generally three forms of pollutants affecting water resources namely air emissions, solid and liquid wastes. Industrial site storm water, often being taken lightly, usually carries a considerable amount of pollutants that are washed from the various processes in the industry. All these pollutants end up in water sources.

Pollutants that affect water resources could be excessive nutrients, organic matter, suspended solids, toxic chemicals, heavy metals, plastics and floatables, pathogens etc.

The pollutants are capable of causing a wide variety of problems in watercourses or downstream users. Air emission, effluents and solid waste disposed off on land may seep into aquifers and pollute groundwater. The emitted pollutants may consist of constituents that have unique characteristics, which enable them to be deposited near water resources and/or transported over long distance. When the constituents come into contact with receiving water, they can undergo a variety of transformations whose end product(s) can be more or less hazardous than the original compound. For more elastration on type of industrial activities, pollution caused indicative parameter and recommended monitoring mechanism See table 5 and table 12.

Figure 2 Location of an Industry or a Mine in residential settlements coupled with poor land use plan, and lack of enforcement affects the integrity of water resources and environmental health.

2.6 Municipal

Public services do contribute in polluting water resources; the pollution is mainly caused by both liquid and solid wastes. Waste management is gradually becoming a serious concern in Tanzania due to limited sorting at source and improper storage, collection, transportation, treatment and final disposal. This implies that significant proportion of the waste generated end up in the environment in an unacceptable ways of disposal which accentuates environmental and public health risks.

It is estimated also that the quantity of municipal solid waste generated country wide amounts to more than 10,000 tonnes per day. The indicative generation rate ranges from 0.1 – 1.0 kg/cap/day. As much as 50% of solid waste generated in urban areas is not collected and most of the domestic waste, which accounts for about 60 % of the total solid waste generated daily, is disposed off by burning or burying.

Over the years, the city authority has been struggling to cope with solid waste production but is ineffective. The manner, in which these wastes are disposed, resulted into pollution of ground water by leachetes. The trend seems to worsen particularly in urban areas due to concentration of socio-economic activities and escalating population growth.

Domestic wastewater is the most serious source of water pollution since the majority of the population uses onsite sanitation which is either poorly designed or operated and hence pollutes groundwater and surface water resources as well. Wastewater pollution in water resources is also triggered by urbanization and limited awareness of the impact of improper wastewater management to the environment. Only 10-18% of the urban population has access to the sewerage system (UWSAs Annual Report 2009), which further contributes to incidences of water borne diseases. For more details on the type of Municipal activities, pollution caused, indicative parameter and recommended monitoring mechanism see table 6 and table 13.

2.7 Transport

Transportation activities including marine vessels contribute to water resources pollution in various ways, including oil leakage and exhaust depositions and direct discharge of untreated sewage from vessels which pollute both surface and ground water sources. Runoff from roads and parking lots has a high concentration of toxic metals, suspended solids, and hydrocarbons which originate largely from automobiles.

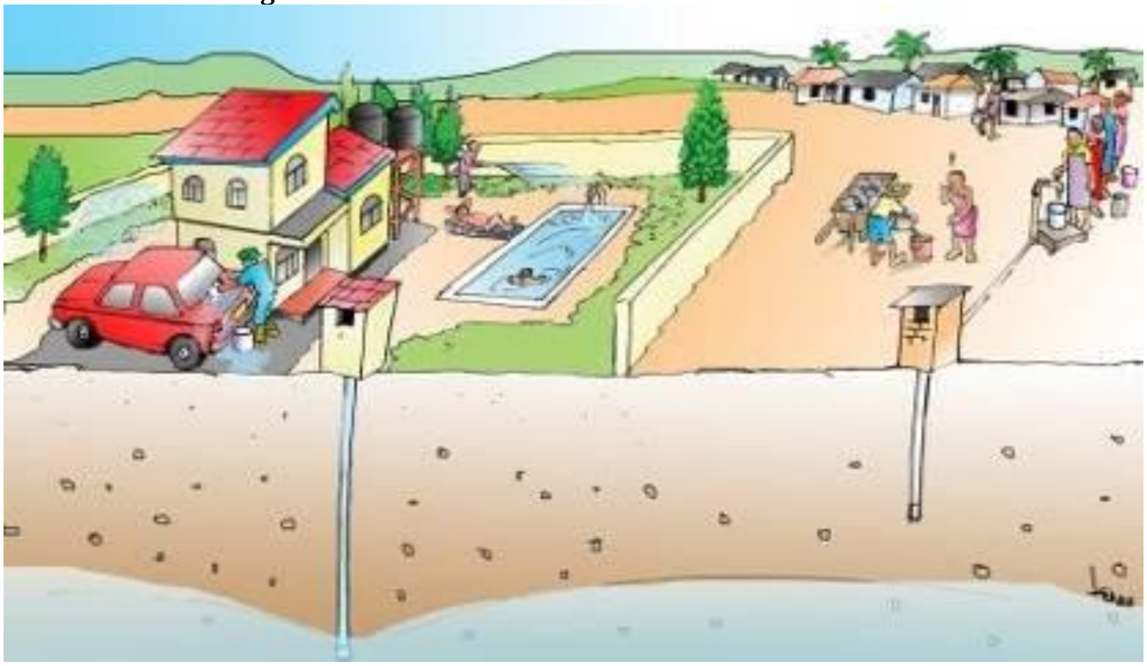
Sources of pollution cause by transportation to water resources can be either point or diffuse sources as listed below:

- Spillage
- Emission

- Leakage
- Waste disposal

Transportation activities lead to pollution of water resources due to disposal of variety of pollutants coming from exhaust fumes and petroleum materials. Types of pollutant are listed in table 7 and table 13 in the appendix1.

Figure 3 Misuse of water and poor disposal of wastewater has an impact to quality and quantity surface and ground water resources.



2.8 Forestry

Sources of non-point source (NPS) pollution associated with forestry activities include removal of streamside vegetation, road construction, timber harvesting, and mechanical preparation for the planting of trees. Harvesting trees in the area beside a stream can affect water quality by reducing the stream bank shading that regulates water temperature and by removing vegetation that stabilizes the stream banks. In forestry however water quality may be impaired through defoliation activities and pesticide application to trees. The expected sources of pollution include organic debris due to decaying trees and shedding leaves through defoliation either naturally or artificially. Pesticides are also applied and hence organo chlorine pesticides and pesticides other than organ chlorines are the major sources of pollution to most water receiving bodies within forest areas. For more detail on type of forest harvesting activities, pollution caused, indicative parameter and recommended monitoring mechanism see table 8 and table 10.

2.9 Tourism

Tourism has major impacts to water quality in terms of pollution and the main sources of pollution are: releasing of waste waters from domestic, swimming pool and aquarium effluents, chlorination of the swimming pool and aquarium ponds; zoo establishment. There are cases where by ornamental plants are planted in hotels for tourist attraction but some are invasive weeds which cause problems in navigation and pollution. The Tourism industry in particular uses water resources for hotels, swimming pools, golf courses in remote crescent environment. This can result in water pollution where there are no waste water treatment facilities. The sources of pollution under this are listed below:

- Effluent contaminants due to waste waters generations
- Chlorine from chlorination of swimming pools and aquarium
- Contamination caused by wild animals
- Organic matters resulting from ornamental plants

For more details on type of tourism activities, pollution caused, indicative parameter and recommended monitoring mechanism see table 9 and table 10.

CHAPTER 3

AMBIENT WATER QUALITY MONITORING PROCEDURES

3.1 Introduction

Measurement of water quality provides important information about the integrity of a body of water. The most widely used method is the measurement of its physical, chemical and bacteriological constituents. The quality of water is measured or monitored to determine if it meets the prescribed or expected ambient water quality status.

Among others, water quality monitoring results are used as basis for policy or management decisions concerning a water body and its uses.

It should be noted that, MoW did some significance initiations on water quality monitoring in river basins. In the year 2010 a "National Water Quality Management and Pollution Control Strategy" (NWQMPCS) was prepared under the Water Sector development Strategy for all aspects pertaining to water and wastewater quality monitoring. Also there was a "Water Quality Monitoring, General Guidelines and Proposed Programmes for Rufiji and Pangani River Basins" prepared in the year 2002 under Water Resources Management Review Programme. In such basins shall use this guideline together with the previous document subject to updates of relevant information.

Procedures for ambient water quality monitoring shall be as stipulated in the following sections.

3.2 Monitoring procedures

A general Ambient Water Quality monitoring complies of the following eight (8) basic steps:

i. Setting Water Quality Monitoring objectives
ii. Assessment Resources Availability
iii. Reconnaissance Survey
iv. Network Design
v. Sampling
vi. Laboratory Work
vii. Data Management
viii. Quality Assurance

3.2.1 Setting Water Quality monitoring objectives

Before formulation of any water quality monitoring programme it is very important to have clear understanding on the monitoring objectives. Everybody in the Basin has to be made aware of the objectives, methodology, quality assurance, data validation and other aspects of the monitoring programme selected. The water quality monitoring must have a purpose and a function in the process of risk assessment and pollution control. In risk management, monitoring is essential in the stage of problem recognition (indication of water quality deviations), the stage of analysis (with respect to the expected changes) and the stage of management (verification or control of strategy results).

A number of purposes for monitoring can be discerned:

- The **signal or alarm functions** for the detection of suddenly source of pollution;
- The **control function** to assess the general quality of water in relation to adopted water quality requirements or objectives, and for verification on the affectivity of pollution control strategies as well as a check on permitted effluent quality compliance; It is most recommended to meet Basin objectives**. In this respect all basin shall conduct the monitoring for the purpose of controlling the general quality of water in relation to adopted water quality objectives.**
- The **trend (recognition) function** based on time series analysis to enable the prediction of future developments;
- The **instrument functions** to help in the recognition and clarification of underlying processes.

Water quality monitoring is carried out for various reasons and the objectives of a particular monitoring programme have a direct bearing on the costs of carrying out the programme.

In this case the objectives of basin water and effluent quality monitoring programmes shall include:

- to attain realistic planning of pollution control strategies;
- to identify nature and magnitude of pollution control required;
- to evaluate effectiveness of pollution control efforts already in existence;
- to identify state and trends in water quality, both in terms of concentrations and effects;
- to identify mass flow of contaminants in surface water and effluents;
- to formulate standards and permit requirements;
- to provide early warning and detection of pollution.

Water quality monitoring is an important aspect of overall water quality management and water resources development. Basins should strive to establish a well planned and well managed (optimised) water quality monitoring system to signal, control or predict changes or trends of changes in the quality of a particular water body, in order to take curative or preventive measures to restore and maintain ecological balance in the water body. Monitoring shall be used for the successful implementation and enforcement of Environmental Management Act (EMA) and Water Resources management Act (WRMA).

3.2.2Assessment of Resources Availability

Once the monitoring objectives are known, it is important to look into the availability of resources for monitoring. Generally a compromise is made between quality and quantity of data required to fulfil certain objective(s) and resources available. Before planning water quality monitoring programme, Basin has to ensure the following resources are available:

- Sampling equipment (i.e. Samplers, containers, preservatives, stickers, makers, and PPE
- Sampling transport such as (Motorised vessels, Field Laboratory Van, Motor tricycle) are recommended depending on the distance and accessibility.
- Laboratory facilities (With enough storage, treatment, analysis and timely reporting result as well as handling and disposal of treated wastewater safely)
- Trained Manpower in adequate number and certified competence levels. (Can be in-house tailor made short courses to advance long courses available local or international).
- Equipment/instruments for desired parameters analysis (i.e. atomic absorption spectrophotometer) for heavy metals and others for specialised parameters.
- Chemicals/glassware and other gadgets for analysis of desired parameters
- Funds for operation and maintenance of laboratory.

The current status is clearly elaborated in the (NWQMPCS).

3.2.3 Reconnaissance Survey

The objective of this water quality monitoring program is for defining pollution, and relating it to its sources. Time should be spent in reviewing all available reports and records concerning the quality of ambient water and of all waste discharges and of the receiving water body to save several days of field work. It is insisted to make a reconnaissance survey of the river catchment during the planning stage, noting all sources of wastes, all entering tributaries that might contribute a potential pollutant, and all uses and abstractions of the water. This action will also include a survey of background information such as geography, topography, climate and weather, hydrology, hydrogeology, land use, urbanization, industrialization and agriculture, including farming in the riverbed. This information will help in an appropriate sitting of sampling locations.

For groundwater quality monitoring network, it is important to conduct survey to identify potential sources of pollution. Generally existing structures (boreholes) in the potentially polluted sites are normally selected for groundwater pollution monitoring. Since variation in groundwater quality is very high and unpredictable, it is practically not possible to cover assessment of groundwater quality of a particular area fully. It is also not practicable to create so many groundwater structures for sampling. Thus, a compromise has to be made between resources available and criticality of information required. It commonly agreed that groundwater quality is generally degraded in the urban, industrial, solid wastes (both municipal and hazardous from industries) dumpsites, petroleum operation sites and agricultural areas. In such areas a reasonable network is adopted for groundwater quality monitoring depending on resources available. Sometimes groundwater structures need (enforced) to be created in view of the criticality of the information needed for a particular area (e.g. in fuel tank farm). Because of the heavy cost involved in sampling and analysis, it is well worth devoting time and effort to careful planning of a monitoring system. See annex 1

This survey will give an overview of the geographical location of the water body to be monitored, its accessibility and all kind of human influences to decide appropriate sampling location and also appropriate number of sampling locations. The survey may include acquisition of following information:

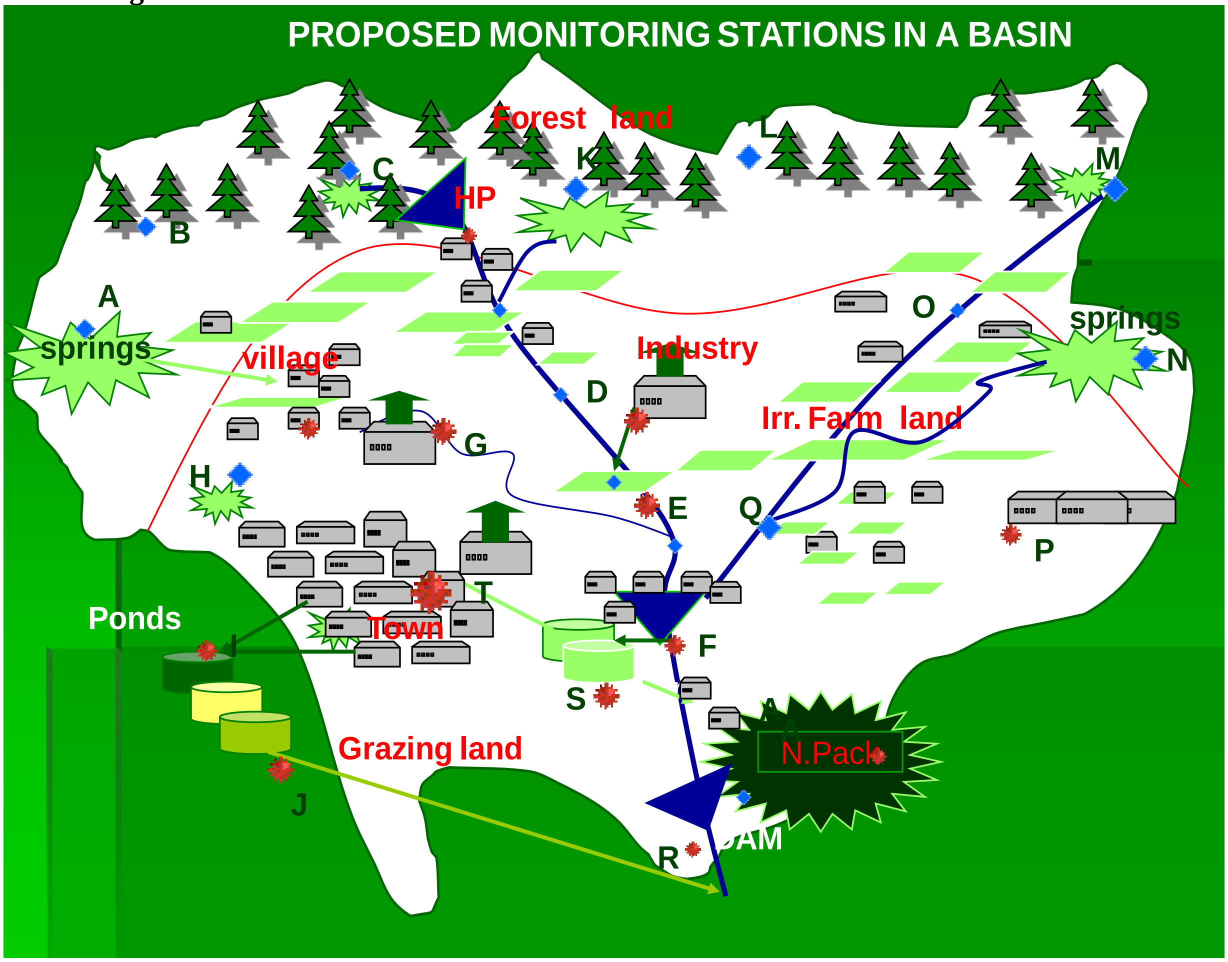
- Location map (with detailed accesses road network, indicating rivers lakes springs and proposed GPS of the sampling stations
- Background information on water body (nearby water bodies)
- Human activities around the water body like mass bathing, melon farming, cattle wading etc
- Identification of potential polluting sources (Mine, industry, Poultry, Ranch)
- Water abstraction – quantity and uses
- Water flow regulation - schedule, quantity etc

The above information will help in proper designing the network and also planning the schedule for sampling.

3.2.4Network Design

In designing the sampling network, one must be familiar with geographical locations of every considerable site. Consider optimum number of sampling location, sampling frequency and parameters required to fulfil the desired objectives. The Excel based programme is given in Annex 1 for demonstration on who to optimise the network. Based on the data collected on the survey made in a route and distances between stations are known, parameter to be assessed at each station are selected , frequency of visiting station in a year are determined, and cost of sample analysis for each parameter can be obtained from the two to three laboratories. Each sampling station must be accessible throughout the year. Once the network design is in place, a trial run should be conducted to verify various assumptions made on time allocated, routes and accessibilities of each station.

Figure 4 Hypothetical monitoring stations in a basin indicating ambient and pollution control monitoring stations.



KEY:

- Sampling stations A-N are for ambient water quality
- Sampling station P-T are strategically established to monitor impact of pollution.
- Hypothetical sampling route was establishes and cost analysed in appendix 6

3.2.4.1 Criteria for Site Selection

After understanding the factors affecting basin water quality thoroughly, it is necessary to select specific reaches or areas of the stream or river to sample. There is no set number of sampling stations that will be sufficient to monitor all the possible types of waste discharges. There is no routine methodology for site selection on a cook book basis.

However, there are some basic rules if carefully followed will result to sound sampling network design. Some general criteria for selecting appropriate sampling sites will be summarized under the following points:

i. Always have a reference station (ambient) up-stream of all possible discharge points. The usual purpose of a monitoring exercise is to determine the degree of man induced pollution, and the damage that is caused to aquatic life. The reference station serves to assess the situation with respect to background water quality and biological aspects, which may vary locally and regionally.
ii. Drinking water intake points, irrigation canal off-take points and tail-end entry point should be considered for monitoring.
iii. Sampling stations should be located upstream and downstream of significant pollution outfalls like city sewage drains and industrial effluent outfalls and at the entry point of the wetland, lake, Dam and on the outlet side of it.
iv. All samples must be representative, which means that the determinants in the sample must have the same value as the water body at the place and time of sampling. In order to achieve this it is important that the sample is collected from well-mixed zone. A homogeneity test must be performed to identify the well-mixed zone.
v. Additional downstream stations are necessary to assess the extent of the influence of an outfall, and you should locate the point of recovery.
vi. In large rivers a balance has to be found between the selection of a few stations giving poor coverage, and the selection of more stations having different substrates and dissimilar fauna, which cannot be compared spatially.
vii. In order to enable comparisons among sampling stations, it is essential that all stations be sampled approximately at the same time. Not more than two weeks should elapse between the sampling of the first and last station in a river or lake system.
viii. Sites for biological sampling should match with sites for chemical sampling.
ix. Biological sampling stations need to be selected with proper attention to representative habitats (kind of substrate, depth and flow). All sampling stations in a certain river should preferably be ecologically similar. To increase biological and chemical comparability, they should have similar substrate (sand, gravel, rock, or mud), depth, presence of rifles and pools, stream width, flow velocity, bank cover, human disturbances, etc.
x. The conventional location of macro-invertebrate sampling stations in rivers arises not only from an assumed uniformity of substrate and fauna, but also from the ease

with which it may be sampled by means of hand nets and stone lifting or kicking, and from the ease of access.

xi. For the estimation of the oxygen exchange rate of the river, a measurement of cross section is required. Any station should be typical with respect to the cross section of the river.

xii. The sampling team normally has to carry an appreciable burden of sampling gear and water samples, and the distance they can walk is limited. Easily accessible sites should be selected. The site should also be accessible under all conditions of weather and river flow. Accessibility is therefore an important consideration.

xiii. With respect to preservation, samples are taken to perform analysis on three types of parameters: for some parameters, such as heavy metals, the samples need not be preserved. For other parameters, samples can be preserved by cold storage or by the addition of certain preservatives (e.g. Nitric Acids). However, samples for analysis of parameters like BOD_5 and bacterial counts cannot be preserved and need to reach the laboratory shortly after taking samples. The need to transport samples to the laboratory will govern the range of determinations which can be carried out for a particular sampling site. **Travel time greater than 24 hours between the site and laboratory is not recommended for BOD_5 and bacterial assessments.**

xiv. The collection of samples can be hazardous at some locations in bad weather (such as high flow). Such sampling sites can better be avoided.

xv. Sometimes there are many disturbing influences in the rivers, especially cattle wading, melon farming, fishing, etc. These disturbances can drastically influence chemical processes and the nature of the biological community.

xvi. Availability of sampling facilities such as bridges, boats, and possibilities for wading is an important criterion in the selection of sampling sites.

xvii. In case of groundwater sampling select only wells (tube well, dug-well, hand pump), which are in use.

xviii. For groundwater pollution monitoring generally existing structures in the potentially polluted sites is selected.

xix. Since variation in groundwater quality is very high and unpredictable, it is practically not possible to cover assessment of groundwater quality of a particular area fully.

xx. It is also not practicable to create so many groundwater structures for sampling. Thus, a compromise has to be made between resources available and criticality of information required. It commonly agreed that groundwater quality is generally degraded in the urban, industrial, solid wastes (both municipal and hazardous from industries) dumpsites, petroleum processing and agricultural areas. In such areas a reasonable network is adopted for groundwater quality monitoring depending on resources available. Sometimes groundwater structures need to be created in view of the criticality of the information needed for a particular area.

xxi. Routine water quality monitoring for potable sources should be implemented in every water supply scheme as an internal check ups and externally by an independent institution under the Director of Water Quality. Sampling network will be determined by the plumbing network of the scheme, its locations and population saved. Sites like upstream the intakes, at the raw water storage, after treatment (clear well), at washout valves, at station before and within distribution networks are recommended. Others are the longest distance point in the network, at lowest pressure zones, at areas with numerous leakages or a previous record of serous contamination or epidemic diseases. Number of stations and frequency of sampling for chemical and microbiological quality analysis are determined by existing human population of the supply area as per National Water Quality standard guidelines 2007.

3.2.4.2 Zoning

There are two general types of zoning in water bodies which are necessary for the planning and execution of large scale sampling programs.

Cross-sectional zoning: A cross-section of the river and lakes will usually reveal gradients in depth, current velocities and sediment and water characteristics.

Longitudinal zoning: On a large geographical scale rivers may be classified in a number of zones: highland brooks and lowland courses both subdivided in upper and lower reaches. Lake Basin and River basin are advised to use respective zoning criteria based on the monitoring objectives.

3.2.5Sampling

3.2.5.1 Planning for Sampling

When planning a sampling programme the number of sampling stations or wells that can be sampled in one day is required. For this is necessary to know the required time needed for sampling, and other actions like routes, tools and staff required. Larger Basins (ie Rufiji) are advised to establish more than two sampling routes so as to save time for analysis, laboratory handling capacity, and cost per each route.

3.2.5.2 Check list for the field visit

Table **1** below contains a list of items which should be checked before starting a sampling mission. Make sure that all the arrangements are made as per the check list at least one day before sampling and you know how to reach sampling site(s). Take help of location map for each site which shows the sample collection point with respect to prominent landmarks in the area. In case there is any deviation in the collection point, record it on the sample identification form giving reason. Note that depending on the local conditions, type of water body, analysis requirements, etc. not all items on the check list may be necessary. Other items, not listed, may sometimes be required. It is always safer to carry a few numbers in excess. If for any reason the laboratory conducting analyses is different from the laboratory preparing sample bottles, ensure that the concerned laboratory is informed of the programme and ready to receive samples, particularly those which would need immediate attention.

Table 1: Checklist for Field Visit

S/N	Item	S/N	Item
01	Itinerary for trip (route, station to be covered, start and return time	08	Personals and sample transport arrangements
02	Area map	09	Sampling site location map
03	Ice box Filled with ice parks or ice	10	Weighted bottle sampler
04	BOD_5 Bottles	11	Rope
05	Special Samples containers, Bacteriological, Heavy metals	12	Sample containers
06	Sample Preservatives e.g. Acid solutions	13	Thermometers
07	Tissue paper	14	Other fields measurement kit as required

3.2.5.3 General Guidelines for Sampling

The following are the general guidelines for sampling:

- Rinse the sample container three times with the sample before it is filled.
- Leave a small air space in the bottle to allow mixing of sample at the time of analysis.
- Label the sample container properly, preferably by attaching an appropriately inscribed tag or label.
- The sample code and the sampling date should be clearly marked on the sample container or the tag.
- Complete the sample identification form for each sample.
- The sample identification form should be filled for each sampling occasion at a monitoring station. Note that if more than one bottle is filled at a site, this is to be registered on the same form.
- Sample identification forms should all be kept in a master file at the laboratory where the sample is analyzed.

3.2.5.4 Surface water Sampling

Samples will be collected from well-mixed section of the river (main stream) 30 cm below the water surface using a weighted bottle or DO sampler.

Samples from reservoir sites will be collected from the outgoing canal, power channel or water intake structure, in case water is pumped. When there is no discharge in the canal, sample will be collected from the upstream side of the regulator structure, directly from the reservoir.

3.2.5.5 Groundwater Sampling

Samples for groundwater quality monitoring would be collected from one of the following three types of wells:

  - *Open dug wells* in use for domestic or irrigation water supply,
  - *Tube wells* fitted with a hand pump or a power-driven pump for domestic water supply or irrigation
  - *Piezometers*, purpose-built for recording of water level and water quality monitoring.

- Open dug wells, which are not in use or have been abandoned, will not be considered as water quality monitoring station. However, such wells could be considered for water level monitoring.
- Use a weighted sample bottle to collect sample from an open well about 30 cm below the surface of the water. Do not use a plastic bucket, which is likely to skim the surface layer only.
- Samples from the production tube wells will be collected after running the well for about 5 minutes.
- Non-production piezometers should be purged using a submersible pump. The purged water volume should equal 4 to 5 times the standing water volume, before sample is collected.

- For bacteriological samples, when collected from tube wells/hand pump, the spout/outlet of the pump should be sterilized under flame by spirit lamp before collection of sample in container.

3.2.5.6 Sample Labelling

Label the sample container properly, preferably by attaching an appropriately inscribed tag or label. Alternatively, the bottle can be labelled directly with a water-proof marker.

Information on the sample container or the tag should include:

Sample code number (identifying location)

- Date and time of sampling
- Source and type of sample
- Pre-treatment or preservation carried out on the sample
- Any special notes for the analyst
- Sampler's name

3.2.5.7 Sample Preservation and Transport

Samples for BOD and Bacteriological analyses should be stored at a temperature below 4°C and in the dark as soon as possible after sampling. In the field this usually means placing them in an insulated cool box together with ice or cold packs. Once in the laboratory, samples should be transferred as soon as possible to a refrigerator.

If samples collected for chemical oxygen demand (COD) analysis cannot be analyzed on the day of collection they should be preserved below pH 2 by addition of concentrated sulphuric acid. This procedure should also be followed for samples for ammoniacal nitrogen[1], total oxidised nitrogen and phenol analysis. Samples which are to be analysed for the presence of metals, should be acidified to below pH 2 with concentrated nitric acid. Such samples can then be kept up to six months before they need to be analysed; mercury determinations should be carried out within five weeks, however. After labelling and preservation, the samples should be placed in an insulated ice box for transportation. Samples should be transported to concerned laboratory as soon as possible, preferably within 48 hours. Analysis of bacteriological samples should be started and analysed within 24 hours of collection. If samples are being brought to the laboratory they should be transported in less than 24 hours.

In a situation where the tasks of sampling (and preservation) and chemical analysis belong to different specialized groups, lack of communication may easily lead to erroneous results. The optimum situation is there, where the entire procedure, from sampling to final analysis, is within the hands of one group of experts. However, this is due to managerial aspects not always possible. Therefore, instead of blaming each other for evident errors in analysis (often without proof), it is essential that both sampling team and chemical analysts work together to optimize the integrated task: the analysis.

3.2.5.8 Sampling devices

Several types of sampling devices are available:

a. Bottle; the same bottle used for storage is used for collection. Only (sub) surface samples can be collected.

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[1] **Ammoniacal nitrogen** (NH_3-N), is a measure for the amount of ammonia, a toxic pollutant often found in landfill leachate and in waste products, such as sewage, liquid manure and other liquid organic waste products

b. Sampler; operated on a line or wire for deep water sampling. Several samplers can be mounted together on one wire. They are closed by messenger (metal weight gliding along the wire) or by electronic means.
c. Pumping; automatic sampling devices, using pumping systems are available. They usually can be preset to desired volume and/or time of sampling; depending on the collection bottles installed, either a series of spot samples or one composite sample may be collected. Sediment For sediment sampling one may use one of the following techniques.
d. Coring; a PVC or Perspex tube (ca. 1 m x 8 cm φ) is used to extract relatively undisturbed sediment.
e. Grabbing; a larger volume of sediment, disturbed, however, can be collected. Useful also for the collection of organisms.

Biota sampling methods for biota may be roughly divided into active and passive methods. Among the passive methods belong:

- Methods that extract and separate the organisms from their habitat (which at the same time will be disturbed);
- Methods that remove an undisturbed part of the habitat from which the organisms are then extracted;
- Among the active methods belong various artificial experimental designs like:
- Colonization substrates from which the biota are collected;
- Exposure techniques with different species by which some environmental problems can be studied under conditions that is under control;

Apart from the organisms that are collected in the above mentioned compartments, such as phytoplankton and bacteria in water samples, meiofauna[2] in sediments, a multitude of special sampling gear has been developed for the collection of organisms.

f. Nets; hand nets for macro-invertebrates, plankton nets with various mesh sizes for phyto- and zoo-plankton, fish nets of various designs like fykes, seines or (beam) trawls;
g. Dredges; like naturalists' dredge, rock dredges, anchor dredge
h. Suction samplers
i. Colonization samplers like baskets filled with various substrates (e.g. bricks) or microscope glass slide holders;
j. Exposure cages of various design for different organisms as molluscs, crustaceans or fish;

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[2] *Meiofauna* are small benthic invertebrates that live in both marine and fresh water environments. The term *Meiofauna* loosely defines a group of organisms by their size, larger than microfauna but smaller than macrofauna, rather than a taxonomic grouping.

k. Collection by hand is an easy and valuable technique, especially for sessile organisms (molluscs, water plants) or floating species (e.g. water hyacinth). For deeper water the use of divers should be considered. An advantage of manual picking is that already during sampling one may select special organisms (e.g. in size/age) and one is more able to prevent damage to the organisms than when using a mechanical device.

A variety of sampling equipment is depicted on the following pages. In some cases the method of applying the instruments is also graphically demonstrated.

3.2.5.9 Types of Samples

Apart from a separation into compartments (water, sediment and biota) different types of samples can be collected:

- ***Grab sample*** (also called spot - or catch samples)

One sample is taken at a given location and time. In case of a flowing river, they are usually taken from the middle of the flowing water (main) stream and in the middle of the water column. When a source is known to vary with time, spot samples collected at suitable time intervals and analyzed separately, can document the extent, frequency and duration of these variations. Sampling intervals are to be chosen on the basis of the expected frequency with which changes occur. This may vary from continuous recording, or sampling every 5 minutes, to several hours or more.

- ***Composite samples***

In most cases, these samples refer to a mixture of spot samples collected at the same sampling site at different times. This method of collection reduces the analytical effort, because variations are middle out in one analysis. It is a useful technique when daily variations occur and seasonal variations are the objective of the programme. If, however, the series of spot samples are not mixed but analyzed individually, also information on the daily variability can be obtained, and afterwards the average can be computed. Sometimes the indication 'time-composite' is used to distinguish from 'location composite' sampling. Time-composite sampling representing a 24-hour period is often used. For many determinations, the time interval between sampling events ranges between 1-3 hours. To evaluate the nature of special discharges (e.g. variable in volume or irregular in time), samples should be collected at time intervals representing the period during which such discharges occur. Especially in effluents, one may sample a volume that is proportional to the discharge (flow based composite). This type of sampling is also required to measure the flux of pollution load discharged through a point source.

Biota that is only active during certain periods of the day (e.g. activity during the night) can only be sampled accordingly. For parameters that will change after collection, and that cannot be preserved, in-situ determinations should be applied if possible. If preservatives are to be added, add them to each sample and not in the end to the composite sample.

- ***Integrated samples***

Sometimes samples are collected at the same location but, due to horizontal or vertical variation in the composition of the river (or in water flow) or lake, they come from different points in the cross-section that are regarded with a different relative importance.

To evaluate the average composition, total load or mass balance, integrated samples are collected, often in proportion to the river flow of the areas of sample collection.

- ***In-situ measurements***

Some determinations are more likely to be affected by sampling and sample storage than others. In several cases the expected changes are so large, that it is impossible to store the sampled material for a correct analysis at a later moment. If possible, these parameters should be analyzed on the sampling site or, even better, in-situ. Most important parameters that should (and can) be analyzed in situ are the pH, dissolved oxygen, temperature, conductivity and sometimes turbidity. For several measurements special portable measuring devices are available.

The estimation on numbers and diversity of organisms is also to be considered as in situ analysis.

3.2.5.10 Documentation of sampling and analysis

A special form has to be prepared where the details of the sampling event and the in-situ/ on site analysis can be filled in. The form ("field data protocol") should at least contain room for the following items:

Field Data protocol

a. Sampling team members
b. Date and time (24 hr method) of collection (time span in case of composite - sampling)
c. Nature of the sample: spot/composite/integrated
d. Results of performed in-situ/on site analyses (water/air temperature, dissolved oxygen, pH (field or lab), conductivity (field or lab), turbidity, macro fauna composition (score), macro fauna diversity (SCI), and 24 hr oxygen production / respiration ratio)
e. Exact sampling location (location along the river, distance from shore) and depth of collection
f. Definition of sampling intervals and volumes in case of composite sampling
g. Maximum depth of the river, lake and current velocity in case of river (only if Actually measured with a current meter)

h. Weather conditions with respect to clouds, precipitation, wind (direction and force)
i. Consistency of sediment (sandy, silty etc.)
j. Comments on smell, colour, discharges etc.
k. Parameter(s) that will be analyzed
l. Sample bottle (number, type, material, volume, and an indication if a preservative is already present)
m. The method of preservation/storage

Especially if a large number of different sample bottles have to be filled for various observations, it is convenient to have a space on the form to tick-off when the sample has been collected. At the end of the sampling event it is then easy to check, if all samples have been collected in the correct number.

3.2.5.11 Analytical result sheets

When offering the samples to the analytical laboratory, each and every series of replicate sample containers has to be accompanied by a prefilled "result sheet". This sheet is marked with sample specifications identical to the specs marked on the bottle. The individual parameters to be measured in the sample are tabulated, together with the units they should be reported in. The sheet leaves space for the analytical lab to fill in the results of replicate analysis.

3.2.6 Laboratory Work

The laboratory in charge should maintain a bound register for assignment of work. This register would link the laboratory sample number to the analyst, who makes specific analyses, such as pH, EC, BOD, etc.

An estimate of time needed for performing the analyses may also be entered in the register. Each laboratory analyst should have his/her own bound register, where all laboratory readings and calculations are to be entered.

When analysis and calculations are completed, the results must be recorded in a register containing data record sheets described in the next section.

3.2.6.1 Laboratory Analysis

The laboratory analysis is to be performed by the laboratory staff within stipulated time and precision. It is observed that many laboratories have their own procedures traditionally being followed. Not only that they also use different units to present the results and sometimes many digits after decimal. This create un-necessary problem in integrating the results. For the reference on water quality parameters refers appendix 3.

3.2.7 Data Management

3.2.7.1 Data Validation

The following data validation check list applies:

- *Absolute checking/Data entry*
- *Checking if data is within the detection limits of a particular method*
- *Checking if the data is within the expected ranges for a parameter*
- *Checking if there are too many (or too few) significant digits reported*
- *Checking if data are physically or scientifically possible (general checks)*
- *Checking correlation of parameters (Some conditional checks like* BOD_5*/COD relation, TC/FC relation)*
- *Checking the correlation between EC and TDS*
- *Checking cation/anion balance*
- *Total coliforms must be greater than faecal coliforms*
- *Total iron must be greater than dissolved iron*
- *Total phosphorus must be greater than dissolved (ortho-)phosphorus*
- *Total iron must be greater than dissolved iron*

3.2.7.2 General checks

Apply general checking as guided below:

- *Total solids ≥ Total dissolved solids*
- *Total solids ≥ Total settleable solids*
- *COD > BOD*
- *Total Coli ≥ Faecal Coli*
- *Total Iron ≥* Fe^{+2}, Fe^{+3}
- *Total P ≥* $PO4^{-3}$
- *EC (µS/cm) ≥ TDS (mg/l)*
- *Total oxidized nitrogen ≥ Nitrate, Nitrite*
- *Total oxidized nitrogen = Nitrate + Nitrite*
- *Total hardness = Ca- hardness + Mg- hardness*

3.2.7.3 Conditional Checks

When there are known correlations between one or more water quality parameters these can be used to check the quality of data collected. Some of the more well known correlations between parameters are:

- Total dissolved solids, specific conductance
- pH and carbonate species
- pH and free metal concentrations
- Dissolved oxygen and nitrate
    - *If pH <8.3 then Carbonate = 0*

- *If DO = 0, then nitrate = 0*
- *If DO >0, then nitrate >0*
- *If DO > 7m, then ferrous ions = 0*
- *If nitrite >0, then ferrous ions = 0*
- *If ferrous ions >0, then nitrite = 0*

3.2.7.4 Data Analysis and Presentation

It is often useful to subject data to some simple statistical analysis. It may be, for example, that such an analysis could be used to summarize the data; to transform them to aid understanding or to compare them with a water quality standard that is couched in statistical terms (annual mean, standard deviation, trend, seasonal changes or a percentile for certain parameters). The data can also be summarized in form of index. Statistical analysis like parametric correlation, seasonal fluctuations, seasonal trends over a period of time are also common. The data after analysis can be presented in different format. For a river usually river profiles are commonly presented. For groundwater contours are plotted over a geographical area.

3.2.7.5 Graphical Presentation

Data can be presented graphically in the following formats:

- *Time Series Graphs*
- *Histograms*
- *Pie Charts*
- *Profile Plots (river profiles)*
- *Geographical Plots (contours)*

3.2.7.6 Data Interpretation

The data interpretation involves understanding on the water chemistry, biology and hydrology. Normally data analyzed and interpreted in terms of chemical quality, quality fluctuations, and their possible effect on different uses and ecosystem. A comparison is made with predefined criteria or standards set for protection of different uses. The quality fluctuation is explained in view of possible sources of pollution and their fates in aquatic environment and their effects.

3.2.8 Quality Assurance

The quality assurance (QA) programme for a laboratory or a group of laboratories should contain a set of operating principles, written down and agreed upon by the Ministry, delineating specific functions and responsibilities of each person involved and the chain of command. The following sections describe various aspects of the programmes.

Sample control and documentation: Procedures regarding sample collection, labelling, preservation, transport, preparation of its derivatives, where required, and the chain-of custody.

Standard analytical procedures: Procedures giving detailed analytical method for the analysis of each parameter giving results of acceptable accuracy.

Analyst qualifications: Qualifications and training requirements of the analysts must be specified. The number of repetitive analyses required to obtain result of acceptable accuracy also depends on the experience of the analyst.

Equipment maintenance: For each instrument, a strict preventive maintenance programme should be followed. It will reduce instrument malfunctions, maintain calibration and reduce downtime. Corrective actions to be taken in case of malfunctions should be specified.

Calibration procedures: In analyses where an instrument has to be calibrated, the procedure for preparing a standard curve must be specified, e.g., the minimum number of different dilutions of a standard to be used, method detection limits (MDL), range of calibration, and verification of the standard curve during routine analyses, etc.

Data reduction, validation and reporting: Data obtained from analytical procedures, where required, must be corrected for sample size, extraction efficiency, instrument efficiency, and background value. The correction factors as well as validation procedures should be specified. Results should be reported in standard units. A prescribed method should be used for reporting results below MDL.

An important aspect of reporting the results is use of correct number of significant figures. In order to decide the number of significant digits the uncertainty associated with the reading(s) in the procedure should be known. Knowledge of standard deviation will help in rounding off the figures that are not significant. Procedures regarding rounding off must be followed.

Analytical quality control: This includes both *within-laboratory* AQC and *inter-laboratory AQC*.

Under the within-laboratory programme studies may include: recovery of known additions to evaluate matrix effect and suitability of analytical method; analysis of reagent blanks to monitor purity of chemicals and reagent water; analysis of sample blanks to evaluate sample preservation, storage and transportation; analysis of duplicates to asses method precision; and analysis of individual samples or sets of samples (to obtain mean values) from same control standard to check random error. Inter-laboratory programmes are designed to evaluate laboratory bias. It may be added that for various determinants all of the AQC actions listed may not be necessary. Further, these are not one time exercises but rather internal mechanisms for checking performance and protecting laboratory work from errors that may creep in. Laboratories who accept these control checks will find that it results in only about 5 percent extra work.

3.2.8.1 Guidelines on Management Aspects

Before planning for any water quality monitoring programme ensure that adequate resources are available as prescribed.

- Ensure that everybody who is involved in monitoring is fully aware of the objectives, procedures, time schedule, quality assurance and importance of this programme.
- Ensure that people are motivated and working with full interest.
- Ensure that there is enough communication among all the groups involved in monitoring.
- All field data collected should be properly transferred to the laboratory people.
- Data should be transferred as soon as acquired through electronic mean (EDB).
- Adequate funds are available with the field staff and laboratory people to take care of emergency measures.
- Private transport facility should be available to the sampling team.
- There should be annual maintenance contract (AMC) for the repair and maintenance of laboratory equipment/instruments.
- There should be regular AQC exercises both internal and external and the results of these exercises are available to anybody.

3.3 Frequency of sampling for ambient water quality monitoring

The plan should describe the intended timing and frequency of monitoring. The frequency of monitoring would depend on the monitoring objective. The timing should consider the effect of temporal variations on water quality.

The sampling plan should describe how often sample will be taken and at what times of the year as water quality changes with the seasons.

Except as needed for special studies, it is not advisable to take samples when it is raining, within 24 hours after a heavy downpour or when the water level is at high stage. In these conditions, the water sample will not be representative.

In this case therefore it is advised to have two general water quality monitoring seasons in dry season and two in rainy season of each year. The sampling intervals should be placed upon realisation of other limiting factors (monitoring objective, accessibility of significant stations, laboratory capacities, distances between stations and laboratory (time), human and financial (budget) resources. After considering all the factors, optimizing monitoring programme is inevitable. Using the excel programme (appendix 6) it is easy to change variables in order to maximise utilisation of resources without compromising the monitoring objectives.

CHAPTER 4

EFFLUENT QUALITY MONITORING PROCEDURES

4.1 Introduction

This section on Effluent Quality Monitoring (EQM) addresses the requirements of the Environmental Management Act (EMA) of 2004 on compliance monitoring and self-monitoring by the industries. The chapter also is intended to guide the ministry of water (MoW) inspectors in monitoring the quality of effluent from industries and other establishments whose wastewater discharges are regulated by the government through MoW. It may also serve as reference for other users, such as the industries undertaking self-monitoring to ensure that their discharges meet the effluent quality standards. Effluent quality monitoring is undertaken by the Ministry of Water primarily to ensure compliance by the industries and commercial establishments with the TBS effluent standards. The MoW monitors the quality of effluent through the discharge permitting system even as the industries are encouraged to undertake self-monitoring of the quality of discharges.

The effluent or wastewater discharge is monitored for specific effluent quality parameters to ensure that the concentrations are within allowable limits. The monitoring results are used as basis for regulatory and control actions, e.g., issuance of discharge permits, issuance of notice of violation (NOV), or imposition of fines and penalties or computation of wastewater charges. The format of the effluent sampling report is attached in appendix 5.

The Ministry of Water in the year 2000 prepared “Effluent Treatment and Mitigation Measures” under Water Resources Management Review Programme. However, at that time, Tanzania had no robust legislations and standards with regard to wastewater management and environmental protection. Nevertheless, the document will be consulted especially at the circumstances where Tanzanian standards do not apply due to the fact that the document has adopted robust European standards.

4.2 Effluent Quality Monitoring Plan

A monitoring plan is a report that describes how the effluent will be monitored and how the effluent quality will be measured. A well designed monitoring plan will help ensure that the procedures for effluent sampling and other activities will conform to the objectives of monitoring.

Plans are designed according to the objectives of monitoring and take into account such factors as time, budget, equipment, human power, and implementation constraints. As effluent quality monitoring entails time and resources, the activities should be properly planned to optimize the use of resources.

4.2.1 Components of a Monitoring Plan

A monitoring plan typically includes the following components:

- Objectives of Monitoring
- Background Information
- Monitoring Stations
- Effluent Quality Parameters for Measurement
- Frequency of Monitoring
- Water Quality Sampling and Test Methods
- Quality Assurance and Quality Control Procedures

4.2.2 Preparation of Effluent Monitoring Plan

The efficacy of effluent monitoring is only as good as its preparation. Careful planning and coordination is critical to a successful monitoring program. At a minimum, the sampling team must know the location of the establishment, the distance from the laboratory to a sampling location, the number of discharge outlets, number and types of samples to collect the frequency of collection, source of supplies and equipment, and where the samples will be submitted. The following should be considered when preparing an effluent monitoring plan:

- Determine the objectives of the monitoring (treatment effectiveness, rectification, compliancy, trend assessment etc)
- Determine the location of the establishment, type of industry, and the type of WTP
- Determine the number and location of the discharge outlet and permit condition
- Determine the number of samples to be collected and the parameters to be analyzed Determine the sampling containers and field tests to be performed
- Determine the time it will take for the samples to reach the laboratory.

4.2.3 Selection of Sampling Stations

Selection of sampling stations depends on the purpose of effluent quality monitoring.

- If the discharger intends to meet the NWQS requirement, then sampling from the effluent streams of the wastewater treatment plant (WTP) will be sufficient.
- If the discharger intends to know the impact of the effluent discharged in the receiving water body then additional samples should be taken from the upstream of

a river system, at the discharge point and several at points downstream from the discharge point.

- However, if the discharger intends to evaluate the performance efficiency of the treatment units, samples should be collected from the influent stream of the WTP and from the effluent streams of each treatment unit.

4.2.4 Basic Considerations in Sampling

The basic considerations should be taken into account in the selection of the sampling location or station:

- The location must provide a sample that is representative of the final effluent discharged to receiving waters.
- It must be downstream of all treatment processes, including disinfection (chlorination/de-chlorination, ultraviolet light, etc.).
- The station should be such that the flow rate of the effluent can be measured or estimated.
- The station must be accessible. Safety of the person conducting effluent sampling must be considered in selecting the site. In this case people must wear appropriate Personal Protective Equipment (PPE). E.g. gloves, air/dust masks, gum boots, aprons, eye glasses.

4.2.5 Frequency of Sampling

The frequency of sampling depends on the variability of effluent flow rate and on the wastewater characteristics. Samples may be taken at longer intervals when variability is low and at shorter intervals when variability is high.

Sampling for significant parameters may be conducted on a monthly basis or as necessary or as indicated in the permit conditions.

However, effluent samples may be collected by the discharger as often as necessary based on the sampling schedule specified in its own effluent quality monitoring program to monitor the efficiency of its wastewater treatment plant.

4.2.6 Effluent Quality Sampling and Test Methods

The intended method of analysis should be indicated in the plan, including the methods for measurement of effluent discharge and should always be related to the objectives of monitoring.

Selection of test method should be coordinated with the laboratory as it will depend primarily on available equipment, reagents and apparatus. On the other hand, sampling procedures, containers and preservation techniques should conform to the selected laboratory method Appendix 2. For details on the test methods, Tanzania National Environmental Compendium by TBS shall be consulted.

4.2.7 Coordination with the Laboratory

Close coordination with the laboratory is extremely important in EQM. Coordination with the laboratory should be undertaken during the preparation of the monitoring plan. The laboratory should be informed of the following:

- The parameters proposed for analysis and the number of samples to be collected so that the laboratory could prepare appropriate containers, reagents, equipment and apparatus to be used in sampling.
- If there is intention to conduct on-site measurements or field testing so that the necessary field equipment can be prepared in advance.
- The estimated time the samples will be received at the laboratory.

A sample submittal form/chain of custody is to be provided by the laboratory during the conduct of effluent sampling.

4.3 Effluent sampling

Effluent sampling is taken for a variety of reasons such as to obtain (1) routine operating data and overall plant performance (2) data that can be used to implement proposed new programs, and (3) data needed for reporting regulatory compliance, which is the main purpose of this manual. To meet the goals of effluent sampling, the data collected must be:

- Representative: The data must represent the wastewater or environment being sampled.
- Reproducible: The data obtained must be reproducible by others following the same sampling and analytical protocols.
- Defensible: Documentation must be available to validate the sampling procedures. The data must have known degree of accuracy and precision.
- Useful: The data can be used to meet the objectives of the sampling plan.

4.3.1 Planning the Effluent Sampling

An effective effluent monitoring is only as good as its preparation. Careful planning and coordination is critical to a successful sampling program. Based on the monitoring plan, at a minimum, the sampling team must know the location of the establishment, the distance from the laboratory, sampling location, the number of discharge outlets, number and types of samples to collect, the frequency of collection, source of supplies and equipment, and where the samples will be submitted.

4.3.2 Sampling

The components that make up the wastewater effluent from a facility depend on the type of collection system used and may include:

- *Domestic (also called sanitary) wastewater*: Wastewater discharges generated from households (single residential structures) dwelling units specifically from toilets, kitchens, washing areas and other similar sanitary conveniences.
- *Commercial Wastewater:* All wastewater generated from trading or business establishments and/or any other related firms or companies, which include but not limited to restaurants, shopping malls, commercial laboratories, hospitals, markets, commercial condominiums, hotels, gasoline, stations, and other establishments.
- *Industrial wastewater:* All wastewaters from any producing, manufacturing, processing, trade or business or any other operations/activities from industrial establishments.
- *Infiltration/Inflow:* Water that enters the collection system through indirect and direct means.
- *Storm water:* Runoff resulting from rainfall.

Collection of effluent samples may be a relatively simple task to others. However, the issue in collecting effluent samples is how to get a sample which represents the quality and condition of the system being sampled. Often times, the sampling activity is where most errors are committed resulting in questionable laboratory test results.

The following should be considered when collecting effluent samples:

- Samples should be collected from a location that is representative of the facility's discharge (Ensure that the effluent system is separated from storm water drains).
- If the facility has more than one discharge point it may be necessary to collect samples from several locations in order to adequately characterize the facility's entire discharge. Convenience, accessibility, and safety should also be considered when selecting a sampling site.
- Sample should be collected from the centre of flow with the container facing upstream to avoid contamination.
- Samples should be collected in areas that are turbulent and well mixed and where the chance of solids settling is minimal. When sampling, the surface of the wastewater should not be skimmed nor should the channel bottom be dragged (ensure status-call prevails).
- Samples should not be collected from stagnant areas containing immiscible liquids or suspended solids.
- All wastewater samples obtained for analysis must be from a point in the effluent stream that is representative of the whole stream composition.

- The volume of sample taken must be sufficient to allow for analysis of all required parameters plus associated quality control samples (e.g. Field duplicate, laboratory replicate and spiked sample).

It is recommended that all automated and manual sampling devices and equipment, their containers and all tubing, valves and contact components be dedicated to a particular sampling site in order to minimize the possibility of contamination.

4.3.3 Effluent Sampling Procedure

Procedure in collecting effluent sample shall be as follows:
1) Based on preliminary survey in collaboration with proponent, locate the facility's outfall.
2) Prepare triplicate sample containers.
3) Label the containers accordingly. If no pre-printed label is available, label the samples, at a minimum indicating the sample ID, Date & Time of collection and the name of the Facility.
4) Put on proper personal protective equipment (PPE) such as gloves (for hand protection), hardhat (for head protection) and safety shoes or rubber boots.
5) Collect effluent sample following sample collection procedures mentioned in section 4.3.2.
6) Rinse the outside surface of the sample container with tap water before placing inside the cooler or ice chest to prevent contamination.
7) Conduct on-site measurement as necessary.
8) If the particular sample is for legal compliancy of enforcement a special attention should be given to the notice issued, number of samples collected at each station in respect to the intended analytical method, witnesses involved including local government personnel or complainer, relevant documentation, pictures, and qualifications of persons (analyst) involved.

4.3.4 Effluent Sampling in Typical Treatment Facilities

In the collection of effluent samples, another consideration relates to the type of treatment facility employed by the establishment. Depending on the nature of the wastes to be treated, treatment type may be generally classified as chemical and biological treatment.

i. Biological Treatment (Aerobic System-Activated Sludge, Trickling Filters and Anaerobic Systems) the effluent is normally taken from the discharge of the last treatment unit. For aerobic systems employing activated sludge process and trickling filter, the sample is collected from the outflow of the secondary sedimentation tank or final clarifier.
ii. Ponds/lagoons: The ponds or lagoons are normally provided with weirs where the flow rates can also be measured. Effluent samples can be taken from the outfall right after the weir or from its discharge outfall.

iii. Chemical treatment: The sample is collected from the discharge of the last sedimentation tank.

iv. Septic Tank: Effluent from the septic tanks is difficult to collect. Sampling station can either be from the outfall or from the ditches (before discharge to drainage). If septic tank effluent has no accessible sampling point or has no outfall (such as pipe is located underground), sample is collected at the effluent filter of the last chamber.

Comprehensive documentation of site specific source of pollution and possible impact related to water resources is attached in appendix 4.

APPENDICES

APPENDIX 1: SOURCES AND TYPE OF WATER POLLUTION

Table 2: Identification of sources and types of water resources pollution due to Agricultural activities

Type of economic activity	Activity	Source of water pollution	Indicative parameters
Agriculture	Land tillage	Sediments due to loose soil and grasses	• Turbidity • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at $100^{o}C$ • BOD_5 at $20^{o}C$ • Colour • Odour
	Application of pesticides	Organo chlorine pesticides (Cl^-)	• Chlorides (Cl^-)
		Pesticides other than Organo chlorines	• Phosphorus Total (as P) • Nitrates (NO^{3-})
	Fertilization	Phosphate fertilizers	• Phosphorus Total (P)
		Nitrate fertilizers	• Nitrates (NO^{3-})
		Organic manures	• Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at $100^{o}C$ • BOD_5 at $20^{o}C$ • Turbidity • Color • Odour • pH
	Irrigation	Salinity and hardness	• pH • Total Filterable Residue • Total Hardness ($CaC0_3$) • Calcium Ca • Magnesium Mg • Magnesium and Sodium sulphates [Mg^{2+} and Na^+ SO_4^{2-}] • Sulphate ($S0_4^{2-}$) • Chloride (Cl^-)
		Algae	• BOD_5 at $20^{o}C$
		Nitrogen Leaching to ground H_2O	• Nitrates (NO^{3-})
		Phosphorus leaching to ground water	• Phosphorus Total (P)
	Livestock keeping	Contamination/pathogens	• Total Coliform Organisms
	Release of waste water from aquaculture effluents	Contamination	• Total Coliform organisms

Table 3: Identification of sources and types of water resources pollution due to Mining activities

Type of economic activity	Activity	Source of water pollution	Indicative parameters
Mining	Exploration	Domestic waste from resident area	• Nitrates (NO^{3-}) • Phosphorus Total (P) • Total Coliform Organisms • BOD_5 at 20°C • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C • Oil and Grease (fatty matters and hydrocarbons), etc. • Total Kjeldahl Nitrogen (as N) • pH • Colour • Odour
		Soil excavation/trenching	• Turbidity • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C
		Drilling/Drilling fluids	• Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C • Turbidity • Diatomaceous Earth (DE) • Sodium (Na^+) • Chloride (Cl^-) • Potassium (K^+) • Calcium (Ca^+) • Bicarbonate (HCO_3^-) • pH
		Spillage and leakage of Fuel and lubricants from exploration equipment	• Oil and Grease (fatty matters and hydrocarbons)
	Construction (Roads, Houses, etc)	Spillage and leakage of Fuel and lubricants from construction equipment	• Oil and Grease (fatty matters and hydrocarbons) • Phenols
		Soil excavation	• Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C • Turbidity
	Mining	Spillage and leakage	• Oil and Grease (fatty matters and hydrocarbons),

Type of economic activity	Activity	Source of water pollution	Indicative parameters
		of Fuel and lubricants from mining equipment	etc.
		Ore stockpile/Waste rock dump	• Acid Mine Drainage (AMD) or Acid Rock Drainage (ARD) • Chemical Oxygen Demand (COD) • Sulphates (SO_4^{2-}) • Sulphides (S^-) • Chlorides (cl^-) • Fluorides (F^-) • pH
		• Heavy Metal	• Aluminium (Al) • Arsenic (As) • Barium (Ba) • Cadmium (Cd) • Chromium (total) • Chromium VI • Cobalt (Co) • Copper (Cu) • Iron (ferric and ferrous) • Lead (Pb) • Manganese (Mn) • Mercury (Hg) • Nickel (Ni) • Selenium (Se) • Silver (Ag) • Tin (Sn) • Vanadium • Zinc (Zn)
		Radioactive substances	• Deuterium (H^{2+}) • Tritium (H^{3+}) • (O_{18}^{2-}) • Uranium ($U^{23...+}$)
		Domestic waste from the resident area	• Nitrates (NO^{3-}) • Phosphorus Total (P) • Total Coliform Organisms • BOD_5 at $20^{o}C$ • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at $100^{o}C$ • Oil and Grease (fatty matters and hydrocarbons), etc. • Total Kjeldahl Nitrogen (as N) • pH • Colour • Odour

Type of economic activity	Activity	Source of water pollution	Indicative parameters
	Processing	Spillage and leakage of Fuel and lubricants from equipment	• Oil and Grease (fatty matters and hydrocarbons), etc. • Odour • Oil and Grease (fatty matters and hydrocarbons)
		Chemicals used during processing and extraction.	• Mercury • Sodium Cyanide • Polypropylene Glycol • Methyl Ether • Pottasium Amyl Xanthate • Carbon di-Thioic Acid • O-Pentyl Ester • Potassium Chloride • Sodium Carboxy-Methyl Cellulose • Sodium Chloride • Sodium Glycolate • Activated Carbon • Acryl amide Polymer • Sodium Di Iso-butyl di-thiophosphinate • Sodium Carbonate • Sodium Hydroxide • Magnesium Oxide • Silica • Crystalline Quartz • Calcium Oxide • Clay • Calcium Carbonate • Sodium metabisulphite • Temperature • Colour • pH • Borax (on trial)
	Other	Others	Others

Table 4: Identification of sources and types of water resources pollution due to Energy Sector activities

Type of economic activity	Activity	Source of water pollution	Indicative parameters
Energy	Exploration	Domestic waste from resident area	• Nitrates (NO^{3-}) • Phosphorus Total (P) • Total Coliform Organisms • BOD_5 at 20°C • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C • Oil and Grease (fatty matters and hydrocarbons), etc. • Total Kjeldahl Nitrogen (as N) • pH • Colour • Odour
		Soil excavation/trenching	• Turbidity • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C
		Drilling/Drilling fluids	• Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C • Turbidity • $CaCl_2$ (If NaCl Brine not used) • Bentonite API • Lime (Ca, Cao, $Ca(OH)_2$ • Citric Acid • Sodium (Na^+) • Chloride (Cl^-) • Potassium (K^+) • Calcium (Ca^+) • Bicarbonate (HCO_3^-) • pH
		Spillage and leakage of Fuel and lubricants from exploration equipment	• Oil and Grease (fatty matters and hydrocarbons)
		Spillage and/or percolation of Hydrocarbons from discovered reserve	• Oil and Grease (fatty matters and hydrocarbons) • Phenols
	Construction (Roads, Houses, etc)	Spillage and leakage of Fuel and lubricants from construction equipment	• Oil and Grease (fatty matters and hydrocarbons) • Phenols

Type of economic activity	Activity	Source of water pollution	Indicative parameters
		Soil excavation	• Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C • Turbidity
	Extraction	Domestic waste from the resident area	• Nitrates (NO^{3-}) • Phosphorus Total (P) • Total Coliform Organisms • BOD_5 at 20°C • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C • Oil and Grease (fatty matters and hydrocarbons), etc. • Total Kjeldahl Nitrogen (as N) • pH • Colour • Odour
		Spillage and leakage of Fuel and lubricants from used equipment	• Oil and Grease (fatty matters and hydrocarbons), etc.
		Radioactive substances	• Deuterium (H^{2+}) • Tritium (H^{3+}) • (O_{18}^{2-}) • Uranium ($U^{23...+}$) • Thorium Lead
		Spillage and/or percolation of Hydrocarbons from extracted reserve	• Oil and Grease (fatty matters and hydrocarbons
	Processing	Spillage and leakage of Fuel and lubricants from equipment	• Oil and Grease (fatty matters and hydrocarbons), etc. • Odour • Oil and Grease (fatty matters and hydrocarbons)
	Production	Domestic waste from the resident area	• Nitrates (NO^{3-}) • Phosphorus Total (P) • Total Coliform Organisms • BOD_5 at 20°C • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C • Oil and Grease (fatty matters and hydrocarbons), etc. • Total Kjeldahl Nitrogen (as N) • pH • Colour • Odour

Type of economic activity	Activity	Source of water pollution	Indicative parameters
		Soil excavation/trenching	• Turbidity • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100°C
		Spillage and leakage of Fuel and lubricants from equipment	• Oil and Grease (fatty matters and hydrocarbons), etc. • Odour • Oil and Grease (fatty matters and hydrocarbons)
	Others	Others	Others

Table 5: Identification of sources and types of water resources pollution due to Industrial activities

Type of economic activity	Activity	Source of water pollution	Indicative parameters
Textile	Weaving	Fibres	Suspended particle
		Dust	Turbidity
	Beaching	Calcium hypochlorite	Chlorine
		Sodium Hypochlorite	Chlorine
	Dyeing	Synthetic dye	Chromium
			Colour
			COD
			BOD_5
	Washing	Synthetic dye	Chromium
			Colour
			COD
Beverages	Washing	Bleaching	pH BOD5 COD
Brewing	Fermentations		pH BOD5 COD
Metal plating	Electrolysis	Metals	Cu
Milk processing			
Pulp &Paper industries	Pulping	Black liquor	

Type of economic activity	Activity	Source of water pollution	Indicative parameters
	Bleaching		
Fish processing			
Photo Processing			

Table 6: Identification of sources and types of water resources pollution due to Municipal activities

Type of economic activity	Activity	Source of water pollution	Indicative parameters
Public Services	Domestic/ Residential	Municipal solid wastes	Add BOD, COD and Turbidity
		Sewerage (Liquid waste)	Nutrients (N and P) and Faecal matters
	Institutions	Municipal solid wastes	Add BOD, COD and Turbidity
		Sewerage (liquid waste)	Nutrients (N and P) and Faecal matters
	Public services	Municipal solid wastes	Add BOD, COD and Turbidity
		Hazardous solid wastes (Hospitals)	Heavy metals and PH
		Hazardous liquid wastes (Hospitals)	Heavy metals and PH
		Sewerage (Liquid waste)	Nutrients (N and P) and Faecal matters

Table 7: Identification of sources and types of water resources pollution due to Transportation activities

Type of economic activity	Activity	Source of water pollution	Indicative parameters
Transport and Navigation	Emission	Exhaust deposition	Heavy metals
	Spillage	Petroleum materials	Add hydrocarbons
	Leakage	Liquid chemicals	Heavy metals
		Petroleum materials	Add hydrocarbons
	Waste Disposal	Liquid chemicals	Heavy metals
		Petroleum materials	Add hydrocarbons
		Liquid and solid chemicals	Heavy metals
		Solid waste generated by users	BOD5
		Solid waste generated by	COD

Type of economic activity	Activity	Source of water pollution	Indicative parameters
		users	Total coliform

Table 8: Identification of sources and types of water resources pollution due to Forestry activities

Type of economic activity	Activity	Source of water pollution	Indicative parameters
Forestry	Defoliation	Organic debris	• Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100^oC • BOD_5 at 20^oC • Turbidity • Colour • Odour
	Pesticides	Organo chlorine pesticides	• Chloride (Cl^-)
		Pesticides other than Organo chlorines	• Phosphorus Total (P) • Nitrates (NO^{3-})

Table 9: Identification of sources and types of water resources pollution due to Tourism activities

Type of economic activity	Activity	Source of water pollution	Indicative parameters
Wildlife and Tourism	Release of waste waters from swimming pools and aquarium	Effluent contaminants	• Total Coliform organisms • Faecal Coliform
	Chlorination in swimming pools and aquarium	Chlorine	• Chloride (Cl^-)
	Zoo establishment	Contamination/pathogens	• Total Coliform Organisms
	Ornamental planting	Organic matters	• Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) at 100^oC • BOD_5 at 20^oC • Colour • Odour

APPENDIX 2: WATER POLLUTION CONTROL MECHANISM

Table 10: Recommended Monitoring Mechanism in Agricultural, Forestry and Wildlife and Tourism economic activities

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
Turbidity	APHA Standard Methods: 2130 B. Nephelometric Method	300 NTU	Land use planning, runoff management, contour and terrace farming	MAFSC.
			Soil erosion should be prevented by reforestation and other methods	Farmers /PMO-RALG
			Treatment (physical, chemical, biological) before discharge	MAFSC /MoW
Total Suspended Solids (TSS)	EMDC1 1173: Part 1 - Gravimetric Method	100 mg/L	Land use planning, runoff management, contour and terrace farming	MAFSC/
Total Dissolved Solids (TDS) at 100°C			Land use planning, runoff management, contour and terrace farming	PMO-RALG Farmers
BOD_5 at 20°C	EMDC1 1173: Part 3 - Five-day BOD Method	30 mg/L	Algal growth should be prevented by draining swamps and pools around the intake or reservoir Treatment (physical, chemical, biological) before discharge)	MAFSC /MoW
Colour	IO 7887: 1994, Water quality - Examination and determination of colour - Section 3: Determination of true colour using optical instruments.	300 TCU	Algal growth should be prevented by draining swamps and pools around the intake or reservoir Treatment (physical, chemical, biological) before discharge	MAFSC MoW
Odour			Algal growth should be prevented by draining swamps and pools around the intake or reservoir Treatment (physical, chemical, biological) before supply for consumption	MoW

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
pH	TZS 94:1989 (Part 1) clause No.8 (see clause 2)	5.5 - 9.0	Treatment (physical, chemical, biological) before discharge for consumption	MAFSC /MoW
Chlorides (Cl)	GC ECD (ISO 6468: 1996, Water quality - Determination of certain organo-chlorine insecticides, polychlorinated biphenyls and chloro-benzenes - Gas Chromatographic method after Liquid-Liquid extraction)	0.0005 mg/l	Safe and Effective use of pesticides/Fertilizers Ban of POPs, promote IPM, Review of pesticides registration Avoid/abandon the use of halogenated pesticides	MAFSC
Phosphorus Total (as P)	EMDC1 1173: Part 6 - Colorimetric- Ascorbic Acid Method	6 mg/l	Safe and Effective use of pesticides, follow the pesticide code of conduct	MAFSC
Nitrates (NO^{3-})	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity.	20 mg/l	Safe and Effective use of Fertilizers follow the appropriate procedures.	MAFSC
Total Filterable Residue		500 -2000 mg/l	Appropriate irrigation drainage system	MAFSC
Total Hardness (CaC03)		500 - 600 mg/l	Water management for intake and outlet in irrigation schemes	MAFSC
Calcium (Ca)		75 - 300 mg/l	Water management for intake and outlet in irrigation schemes	MAFSC
Magnesium (Mg)		50 - 100 mg/l	Water management for intake and outlet in irrigation schemes	MAFSC
Magnesium & Sodium(SO_4		500 - 1000 mg/l	Water management for intake and outlet in irrigation schemes	MAFSC
Sulphate (S04)		200 - 600 mg/l	Water management for intake and outlet in irrigation schemes	MAFSC

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
Total Coliform Organisms	ISO 6222:1999, Microbiological methods	10,000counts/100mL	Good agricultural and Livestock keeping practices (GALP). Domestic livestock and other animals should be kept away from the intake (50m fencing)	MAFSC

Table 11: Recommended Monitoring Mechanism for Mining and Energy activities

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
Chlorides (cl^-)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	200 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Sulphides (S^-)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	1 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Nitrates (NO^{3-})	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	20 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Sulphates (SO_4^{2-})	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	500 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Fluorides (F^-)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	8 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Arsenic (As)	EMDC1 1173: Part 8 - Manual hydride Generation- Atomic	0.2 mg/L	Containment	Ministry of Energy and Minerals/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
	Absorption Spectrometry			
Barium (Ba)	EMDC1 1173: Part 7 - Direct Nitrous Oxide-Acetylene Flame Atomic Absorption Spectrometry	1.5 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Nickel (Ni)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	0.5 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Aluminium (Al)	EMDC1 1173: Part 7 - Direct Nitrous Oxide-Acetylene Flame Atomic Absorption Spectrometry	2.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Cadmium (Cd)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	0.1 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Chromium (total)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	1.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Chromium VI	EMDC1 1173: Part 9 - Colorimetric Method	0.1 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Cobalt (Co)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	1.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Iron (ferric and ferrous)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	5.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Copper (Cu)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	2.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Lead (Pb)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	0.1 mg/L	Containment	Ministry of Energy and Minerals/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
Mercury (Hg)	EMDC1 1173: Part 10 -Cold-Vapour Atomic Absorption Spectrometry	0.005 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Manganese (Mn)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	5.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Selenium (Se)	EMDC1 1173: Part 8 - Manual hydride Generation- Atomic Absorption Spectrometry	1.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Silver (Ag)	ISO 15586: 2003, Water quality - Determination of trace elements using atomic absorption spectrometer with graphite furnace	0.1 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Tin (Sn)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	2.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Vanadium	ISO 15586: 2003, Water quality - Determination of trace elements using atomic absorption spectrometer with graphite furnace	1.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Zinc (Zn)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	5.0 mg/L	Containment	Ministry of Energy and Minerals/ NEMC
Phosphorus Total (as P)	EMDC1 1173: Part 6 - Colorimetric- Ascorbic Acid Method	6 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Total Coliform Organisms	ISO 6222:1999, Microbiological methods	10,000 counts/100mL	• Wastewater Treatment Mechanism • Good Hygiene practices	Ministry of Energy and Minerals/ NEMC
Total Suspended Solids (TSS)	EMDC1 1173: Part 1 – Gravimetric Method	100 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
Total Dissolved Solids (TDS) at 100oC	Evaporation followed by Gravimetric Method		Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Organic Matter		mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Total Kjeldahl Nitrogen (as N)	EMDC1 1173: Part 5 - Kjeldahl Method	15 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Turbidity	APHA Standard Methods: 2130 B. Nephelometric Method	300 NTU	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Radioactive material	Gross alpha activity	0.1 Bq/l	Containment	Ministry of Energy and Minerals/ NEMC
Uranium ($U^{23...+}$)	Gross beta activity	0.1 Bq/l	Containment	Ministry of Energy and Minerals/ NEMC
Thorium ($Th^{.....+}$)			Containment	Ministry of Energy and Minerals/ NEMC
Oil and Grease (fatty matters and hydrocarbons)			• Containment • Decantation/Filtering Mechanism	Ministry of Energy and Minerals/ NEMC
Phenols	GC ECD (ISO 6468: 1996, Water quality Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes - Gas Chromatographic method after Liquid-Liquid	0.002 mg/L	• Containment • Decantation/Filtering Mechanism	Ministry of Energy and Minerals/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
	extraction			
Methyl Ether	GC ECD (ISO 6468: 1996, Water quality - Determination of certain organochlorine insecticides, polychlorinated biphenyls and chloro-benzenes - Gas Chromatographic method after Liquid-Liquid extraction)	0.05 mg/L		Ministry of Energy and Minerals/ NEMC
Temperature		20-35°C	Monitoring	Ministry of Energy and Minerals/ NEMC
pH	EMDC1 1173: Part 2 – Electrometric Method	6.5-8.5	• Monitoring • Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Colour	ISO 7887: 1994, Water quality - Examination and determination of color - Section 3: Determination of true color using optical instruments	300 TCU	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
Chemical Oxygen Demand (COD)	EMDC1 1173: Part 4 - Dichromate Digestion Method	60 mg/L	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC
BOD_5 at 20°C	1173: Part 3 - Five-day BOD Method	30 mg/L EMDC1	Wastewater Treatment Mechanism	Ministry of Energy and Minerals/ NEMC

Table 12: Recommended Monitoring Mechanism for Industrial activities

Indicative Parameter	Test Methods	Allowable limits	Control Mechanism	Responsible institution
BOD5 at 20 0C		30 mg/L	Wastewater Treatment Mechanism	OSHA/ NEMC
COD	EMDC1 1173: Part 4-Dichromate Digestion Method	60 mg/L	Wastewater Treatment Mechanism	OSHA/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control Mechanism	Responsible institution
Color	ISO 7887: 1994, Water quality - Examination and determination of colour - Section 3: Determination of true colour	300 TCU	Wastewater Treatment Mechanism	OSHA/ NEMC
pH	EMDC1 1173: Part 2- Electrometric Method	6.5-8.5	Wastewater Treatment Mechanism	OSHA/ NEMC
Temperature	See Annex A	20-35 ^{o}C	Wastewater Treatment Mechanism	OSHA/ NEMC
Total Suspended Solids (TSS)	EMDC1 1173: Part 1 – Gravimetric	100 mg/L	Wastewater Treatment Mechanism	OSHA/ NEMC
Turbidity	APHA Standard Methods:2130 B.Nephelometric Method	300 NTU	Wastewater Treatment Mechanism	OSHA/ NEMC
Aluminium (as Al)	EMDC1 1173: Part 7 -Direct Nitrous Oxide-Acetylene Flame Atomic Absorption Spectrometry	2.0 mg/L	Containment	OSHA/ NEMC
Arsenic (As)	EMDC1 1173: Part 8 - Manual hydride Generation- Atomic Absorption Spectrometry	0.2 mg/L	Containment	OSHA/ NEMC
Barium (Ba)	EMDC1 1173: Part 7 - Direct Nitrous Oxide-Acetylene Flame Atomic Absorption Spectrometry	1.5 mg/L	Containment	OSHA/ NEMC
Cadmium (Cd)	EMDC1 1173: Part 7 -Flame Atomic Absorption Spectrometry	0.1 mg/L	Containment	OSHA/ NEMC
Chromium (total)	EMDC1 1173: Part 7- Flame Atomic Absorption Spectrometry	1.0 mg/L	Containment	OSHA/ NEMC
Chromium VI	EMDC1 1173: Part 9 - Colorimetric Method	0.1 mg/L	Containment	OSHA/ NEMC
Chlorides (Cl-)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	200 mg/L	Containment	OSHA/ NEMC
Cobalt (Co) Flame Atomic	EMDC1 1173: Part 7- Absorption Spectrometry	1.0 mg/L	Containment	OSHA/ NEMC
Copper (Cu)	EMDC1 1173: Part 7 - Flame Atomic Absorption Spectrometry	2.0 mg/L	Containment	OSHA/ NEMC
Fluorides	APHA Standard Methods: 4110 B. Ion	8 mg/L	Containment	OSHA/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control Mechanism	Responsible institution
(F^-)	Chromatography with Chemical Suppression of Eluant Conductivity			
Iron	EMDC1 1173: Part 7 □ Flame Atomic Absorption Spectrometry	5.0 mg/L	Containment	OSHA/ NEMC
Lead (Pb)	EMDC1 1173: Part 7 □ Flame Atomic Absorption Spectrometry	0.1 mg/L	Containment	OSHA/ NEMC
Manganese	EMDC1 1173: Part 7 □ Flame Atomic Absorption Spectrometry	5.0 mg/L	Containment	OSHA/ NEMC
Mercury (Hg)	EMDC1 1173: Part 10 □ Cold-Vapor Atomic Absorption Spectrometry	0.005 mg/L	Containment	OSHA/ NEMC
Nickel (Ni)	EMDC1 1173: Part 7 □ Flame Atomic Absorption Spectrometry	0.5 mg/L	Containment	OSHA/ NEMC
Nitrates (NO_3^-)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	20 mg/L	Containment	OSHA/ NEMC
Phosphorus Total (asP) d	EMDC1 1173: Part 6 - Colorimetric-Ascorbic Acid Metho	6 mg/L	Wastewater Treatment Mechanism	OSHA/ NEMC
Selenium (Se)	EMDC1 1173: Part 8 - Manual hydride Generation- Atomic Absorption Spectrometry	1.0 mg/L	Containment	OSHA/ NEMC
Silver (Ag)	ISO 15586: 2003, Water quality - Determination of trace elements using atomic absorption spectrometer with graphite furnace	0.1 mg/L	Containment	OSHA/ NEMC
Sulphate (SO_4^{2-})	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	500 mg/L	Wastewater Treatment Mechanism	OSHA/ NEMC
Sulphides (S^-)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity	1 mg/L	Wastewater Treatment Mechanism	OSHA/ NEMC
Tin (Sn)	EMDC1 1173: Part 7- Flame Atomic Absorption	2.0 mg/L	Containment	OSHA/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control Mechanism	Responsible institution
	Spectrometry			
Total Kjeldahl Nitrogen (as N)	EMDC1 1173: Part 5- Kjeldahl Method	15 mg/L	Wastewater Treatment Mechanism	OSHA/ NEMC
Vanadium	ISO 15586: 2003, Water quality- Determination of trace elements using atomic absorption spectrometer with graphite furnace	1.0 mg/L	Containment	OSHA/ NEMC
Zinc (Zn)	EMDC1 1173: Part 7- Flame Atomic Absorption Spectrometry	5.0 mg/L	Containment	OSHA/ NEMC
1, 1, 2 - Trichloroethane	GC ECD (ISO 10301: 1997, Water Quality- Determination of highly volatile halogenated hydrocarbons -Gas Chromatographic methods.)	0.06 mg/L	Containment	OSHA/ NEMC
1,1,1 - Trichloroethane chromatographic methods.	GC ECD (ISO 10301: 1997, Water quality • Determination of highly volatile halogenated hydrocarbons Gas	3.0 mg/L	Containment	OSHA/ NEMC
1,2 - Dichloroethylene	GC ECD (ISO 10301: 1997, Water quality • Determination of highly volatile halogenated hydrocarbons • Gas chromatographic methods.)	0.2 mg/L	Containment	OSHA/ NEMC
1,2 - Dichloromethane	GC ECD (ISO 10301: 1997, Water quality • Determination of highly volatile halogenated hydrocarbons - Gas chromatographic methods.)	0.04 mg/L	Containment	OSHA/ NEMC
1,3 - Dichloropro	GC ECD (ISO 10301: 1997, Water quality	0.2 mg/L	Containment	OSHA/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control Mechanism	Responsible institution
pene	• Determination of highly volatile halogenated hydrocarbons - Gas chromatographic methods.)			
Alkyl benzene sulfonate (ABS)	ISO 7875 • 1: 1996, Determination of surfactants • Pat 1: Determination of anionic surfactants by measurement of the methylene blue index (MBAS)	0.5 mg/L	Containment	OSHA/ NEMC
Aromatic nitrogen containing compounds (e.g., aromatic amines)	APHA Standard Methods 6410: Liquid extraction GC/MS method	0.001 mg/L	Containment	OSHA/ NEMC
cis-1, 2 - Dichloroethylene	GC ECD (ISO 10301: 1997, Water quality • Determination of highly volatile halogenated hydrocarbons - Gas chromatographic methods)	0.4 mg/L	Containment	OSHA/ NEMC
Dichloromethane	GC ECD (ISO 10301: 1997, Water quality • Determination of highly volatile halogenated hydrocarbons - Gas chromatographic methods)	0.2 mg/L	Containment	OSHA/ NEMC
Oil and Grease (fatty maters and hydrocarbons)	APHA Standard methods 5520	10 mg/L	Containment	OSHA/ NEMC
Other aromatic and/or aliphatic hydrocarbons	GC ECD (ISO 6468: 1996, Water quality • Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzens	0.05 mg/L	Containment	OSHA/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control Mechanism	Responsible institution
not used as pesticides	• Gas Chromatographic method after Liquid-Liquid extraction)			
Pesticides other than organochlorines	GC ECD (ISO 6468: 1996, Water quality • Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzens • Gas Chromatographic method after Liquid-Liquid extraction)	0.01 mg/L	Containment	OSHA/ NEMC
Phenols	GC ECD (ISO 6468: 1996, Water Quality • Determination of certain organochlorine insecticides, polychlorinated biphenyls and Chlorobenzenes • Gas Chromatographic method after Liquid-Liquid extraction	0.002 mg/L	Containment	OSHA/ NEMC
Tetrachloroethylene	GC ECD (ISO 10301: 1997, Water quality . □ Determination of highly volatile halogenated hydrocarbons □ Gas Chromatographic methods.)	0.1 mg/L	Containment	OSHA/ NEMC
Tetra chloromethane	GC ECD (ISO 10301: 1997, Water quality □ Determination of highly volatile halogenated hydrocarbons □ Gas chromatographic methods.)	0.02 mg/L	Containment	OSHA/ NEMC
Trichloroethylene	GC ECD (ISO 10301: 1997, Water quality □ Determination of highly volatile halogenated hydrocarbons Gas chromatographic methods.)	0.3 mg/L	Containment	OSHA/ NEMC
Total Coliform Organisms	ISO 6222:1999, Microbiological methods	10,000 counts/100mL	Containment	OSHA/ NEMC

Indicative Parameter	Test Methods	Allowable limits	Control Mechanism	Responsible institution
Chlorides Cl	TZS 94: 1989 Part 3	1000	Containment	
Hexavalent chromium Cr	TZS 94:1980, Part 1 Clause 8	5.5-9.0 mg/L	Containment	OSHA/ NEMC

Table 13: Recommended Monitoring Mechanism in Municipal and Transport activities

Indicative Parameter	Test Methods	Allowable limits	Control mechanism	Responsible institution
Total Coliform	ISO 6222:1999, Microbiological Methods	10,000counts/100mL	Wastewater treatment plant/ Facilities and proper sanitation	Local Government authorities
BOD_5	EMDC1 1173: Part 3- Five-day BOD Method	30 mg/L	Waste treatment plant/ Facilities	Local Government authorities
COD	EMDC1 1173: Part 4- Dichromate Digestion Method	60 mg/L	Waste treatment plant/ Facilities	Local Government authorities
Turbidity	APHA Standard Methods: 2130 B. Nephelometric Method	300 NTU	Wastewater treatment plant/ Facilities	Local Government authorities
pH	EMDC1 1173: Part 2- Electrometric Method	6.5-8.5	Wastewater treatment plant/ Facilities	Local Government authorities
Phosphorous Total (as P)	EMDC1 1173: Part 6- Colorimetric- Ascorbic Acid Method	6 mg/L	Wastewater treatment plant/ Facilities	Local Government authorities
Nitrogen (as NO_3^-)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression	20 mg/L	Wastewater treatment plant/ Facilities	Local Government authorities

Indicative Parameter	**Test Methods**	**Allowable limits**	**Control mechanism**	**Responsible institution**
	of Effluent Conductivity			
TSS	EMDC1 1173: Part 1-Gravimetric Method	100 mg/L	Wastewater treatment plant/ Facilities	Local Government authorities
Hydrocarbons	APHA Standard methods 5520	10 mg/L	Containment and awareness	Local Government authorities
Heavy metals (as Pb)	EMDC1 1173: Part 7- Flame Atomic Absorption Spectrometry	0.1 mg/L	Containment and awareness	Local Government authorities
Total Coliform	ISO 6222:1999, Microbiological Methods	10,000counts/100mL	Provision of proper sanitation	Tanroads
BOD_5	EMDC1 1173: Part 3- Five-day BOD Method	30 mg/L	Provision of proper sanitation	Tanroads
COD	EMDC1 1173: Part 4- Dichromate Digestion Method	60 mg/L	Provision of proper sanitation	Tanroads

APPENDIX 3: WATER QUALITY PARAMETERS

Table 14: Water Quality Parameters

Parameter	Environmental impact	Natural range/Remarks
Temperature	Variations during day and season Affect physical, chemical and biological processes in the water Influence solubility of gases	0-30
Colour	Determine the depth to which light is transmitted. and thereby the rate of photosynthesis	< 5- 300 PtU/ll Should be measured within 2 hours of collection
Odour	Produced by phytoplankton and aquatic plants and by biodegradation of organic matter	Subjective variability
Residue and total suspended solids (TSS)	Determine the depth to which light is transmitted. and thereby the rate of photosynthesis	Based on gravimetric after filtration, evaporation, drying and ignition
Suspended matter, turbidity and transparency	Turbidity and transparency varies seasonally according to biological activities and rainfall	Turbidity may be used as a continuous, indirect measurements for TSS 1-1000 NTU. Field measurement
Conductivity	Relates to the concentration of TSS and major ions	10 - 1000 µS/cm, May be exceeded in polluted water or in those receiving large quantities of land run-off. Used for establishing a pollution zone. Continuously measured and recorded
pH	pH influences many biological and chemical process pH is controlled by the balance carbon dioxide, carbonate and bicarbonate ions and other natural acids the natural acid-base balance may be affected by industrial discharges and atmospheric acid precipitation	6,0-8,5 To be determined in situ or immediately after sampling. Continuous measurement and recording/field measurements pH is temperature dependent
Acidity and alkalinity	Defines the buffer capacity Alkalinity is taken as an indicator of carbonate, bicarbonate and hydroxide. but may include other basic compounds	

Parameter	Environmental impact	Natural range/Remarks
Redox potential (Eh)		- 500mV-+700 mV Difficult to obtain reliable results in situ or immediate after sampling
Dissolved oxygen (DO)	Varies with temperature, the photosynthetic activity, atmospheric pressure, etc. Seasonal and 24 hours variations waste discharges of organic matter and nutrients reduce DO down to zero (anaerobic conditions) Concentration< 5 mg/l adversely affect the functioning and survival of biological communities, > 2 mg/l lead to death of most fish	15 (0^oC) - 8(25^oC) mg/l at sea level Unpolluted water generally~10 mg/l
Carbon dioxide	Highly soluble in water. Produces by respiration of aquatic biota CO_2 and HCO_3- can be incorporated into organic carbon	
Hardness	Depends on the presence of dissolved calcium and magnesium salts	Wide range
Chlorophyll	Indirect measure of algal bio-mass and an indication of the trophic status Important for management of drinking water supply	< 2.5µg/l at low levels of nutrients 5-140 µg/l at high levels of nutrients
Nitrogen compounds Nitrogen is essential for living organisms as constituents of proteins Undergoes biological and non-biological transformations as a part of the nitrogen cycle		
Ammonia	Arising from natural breakdown of nitrogenous material Natural seasonal variations Discharged by some industrial processes and by municipal wastewater Toxic to aquatic life at high concentration	Total ammonia: NH_3 +NH_4 in equilibrium. The equilibrium is dependent on temperature < 0.2 to 2-3mg/l
Nitrate and nitrite (included in most basic water quality surveys and multipurpose or background	Natural sources of nitrate is igneous rocks, land drainage and plant and animal debris Gives a general indication of the nutrient status and level of organic pollution	NO_3: 0.1 mg/l natural levels Influenced by man: 1-5 mg/l, may be up to 200 mg/l NO_2: 0.001-1 mg/l

Parameter	**Environmental impact**	**Natural range/Remarks**
monitoring programmes	(NO_3/NO_2)	
Organic nitrogen	Subject to seasonal variations as formed by phyto-plankton and bacteria and cycled within the food chain	Increase level indicate pollution Determined by Kjeldahl method, that gives total N
	Phosphorous compounds	
An essential component of the biological cycle and often included in most basic water quality surveys or background monitoring programmes	Essential nutrient for living organisms Limiting parameter for algal growth in freshwater Control primary productivity Increased level the principal cause for eutrophication Equilibrium between different forms of P is dependent of pH Natural sources: the weathering of phosphorous rocks and decomposition of organic matter Considerable seasonal variations	Natural surface water: 0.005-0.02 mg/l PO_4 - P Knowledge of PO_4 in drinking water is essential to control rates of algal growth
	Organic matter	
Total organic carbon (TOC)	Organic carbon arises from living materials A useful indication of pollution	Surface water: TOC generally < 10 mg/l
Chemical oxygen demand (COD)	Measure for organic matter susceptible to oxidation by strong oxidating agent, i.e. dichromate or permanganate	20 - 200 mg/l O_2 depending on degree of pollution
Biological oxygen demand (BOD)	Measure of biodegradable organic matter in 5 or 7 days Interpretation must be done with great care due to chemical and biological interference	Unpolluted water: < 2 mg/l O_2 Treated sewage : 20-100 mg/l O_2
Humic and fulvic acid	Chlorination may give chloro-organics Humic substances affect the toxicity and mobility of heavy metals Humus is formed by chemical and biological degradation of vegetative residues	
	Major ions	
Sodium (Na)	Sodium is one of the most abundant elements on earth	1-10^5 mg/l Measured for drinking water

Parameter	Environmental impact	Natural range/Remarks
	An essential element for living organisms	and agricultural purposes
Potassium (K)	Found in low concentrations as rocks containing K are relatively resistant to weathering	< 10 mg/l
Calcium (Ca)	Readily dissolved from Ca- rich minerals An essential element for all organisms Contribute to the hardness of the water	< 15 mg/l
Magnesium (Mg)	Contribute to the hardness of the water Arises from weathering of rocks containing ferro-magnesium minerals An essential element for all organisms	1 - > 100 mg/l
Carbonates (CO_3^{2-}) bicarbonates (HCO_3^-)	Influences the hardness and alkalinity Arises from the atmosphere and from weathering of rocks	
Chloride (Cl)	Arises from atmospheric deposition of oceanic aerosols, weathering of some rocks Seasonal variations due to slalting of roads during winter Associated with sewage and used as an indication of faecal contamination	< 10 mg/l
Sulphate (SO_4^{2-})	Arises from atmospheric deposition of oceanic aerosols, leaching of sulphur compounds from sedimentary rocks	2-80mg/l
Other inorganic variables		
Sulphide (S^{2-})	Arises from decomposition of sulphurous minerals and from anaerobic bacteria decay of organic substances rapidly oxidised to sulphur and sulphates at aerobic conditions Toxic and strong odour	
Silica	Widespread and always present in dissolved, suspended and colloidal states Essential element for certain aquatic plants - taken up by growth and released by decomposition and decay. Therefore seasonal variations	1-30 mg/l
Fluoride (F)	Originates from weathering of fluoride-containing minerals High concentration is toxic to human Slight increase prevent dental caries; at	0.05-100 mg/l

Parameter	**Environmental impact**	**Natural range/Remarks**
	higher concentrations (> 2 mg/l) mottling of teeth occur	
Boron	Arises from weathering of rocks, soil leaching, volcanic actions and other natural processes Boron may be used for increasing the crop yield	0.1-3 mg/l
Cyanide	Toxic to humans	Enters freshwater by industrial discharges (electroplating)

APPENDIX 4: SITE SPECIFIC POLLUTION CONTROL CHECKLIST

CATEGORY 1: MANUFACTURING INDUSTRIES		
Class	**Steps in Manufacturing/Source**	**Possible Environmental aspects**
Metal smelting/ forging	Receiving raw materials e.g. scraps, pig iron, sponge iron, oil and chemicals	• Verify types and origin • Check for dust production, emission, collection methods (management), • Check for solid waste production, collection, and disposal methods • Check for Leakage and spillage, • Check for handling and storage of raw materials,
	Preparation of raw material - Sorting and separation - Compressing and baling	• Check for dust, solid waste and spillage/leakages
	Processing - Smelting kiln - Moulding (Ingot) - Furnace - Rolling - Cooling	• Check for oil spillage
Plastics and Foam	Receiving raw materials e.g. Virgin and recyclable materials, chemicals and other additives	• Verify types and origin • Check for raw materials handling and storage • Check for solid waste, dust and spillages
	Preparation -Sorting of plastics -Washing and cleaning of recyclable plastics -Cutting and grinding	• Check for waste water management.
	Processing - Melting - Moulding	• Check for Spillages management

CATEGORY 1: MANUFACTURING INDUSTRIES		
Motor vehicle assemblage	Fabrication and body building -Spray painting -Welding	• Check for management of paints, liquid wastes, and spillage
Wood industry - Pulp and paper - Fibre board - Furniture and joinery - Preserved wood	Preparation - Debarking and washing - Chipping	• Check for solid waste, liquid waste, dust, noise, vibrations, spillages and leakages management,
	Processing - Cooking (using boiler) - Preservations	• Check for management of waste • leakages
Textile Industry	Receiving raw materials e.g. cotton, chemicals and dyes and fuel	• Check for management of spillage
	Preparation -Sorting	• Check for spillage management
	Processing	• Check for management of wastewater and spillage
Cement and lime factories	Raw materials	• Check for management of spillages
	Preparation	• Check for management of spillages
	Processing	• Check for management of spillages
Tanneries	Raw materials	• Check for management of spillages
	Preparation	• Check for management of spillages
	Processing	• Check for management of spillages, liquid waste, and sludge
	Finishing	• Check for effluent from treatment plant
Soap	Raw materials	• Check for handling and storage of chemicals

CATEGORY 1: MANUFACTURING INDUSTRIES		
	Preparation	- Check for spillage and leakage - Check for liquid waste - Check for drainage system
	Processing	- Check for spillages - Check for management of liquid waste - Check for drainage and Effluent treatment plant
Printing Industry	Receiving raw materials e.g. chemicals and dyes, papers and fuel	- Check for methods of handling and storage of spillage

CATEGORY 2: FOOD PROCCESING AND SALES		
Grain handling and Milling	Receiving of raw materials	- Check for management of pesticides
	Preparation Sorting	- Check for management of liquid waste
	Processing Finishing/package	- Check for spillage
Milk and milk products	Receiving raw materials	- Check for spillage and leakages - Check for drainage
	Preparation	- Check for management of liquid wastes
	Processing -Pasteurization -Skimming	- Check for spillage and leakages,
	Packing	Check for management of liquid waste
Edible oil	Raw materials	- Check for management liquid wastes, leakages and spillages
	Preparation	- Check for spillage and leakage - Check for management of liquid waste,
	Processing	- Check for management of liquid waste - Check for drainage and Effluent of treatment plant

	Finishing/packing	Check for liquid waste
Sugar industry	Raw materials	• Check for spillages
	Preparation	• Check for dust, spillages, noise, solid waste, liquid waste, odour/offensive smell.
	Processing	• Check for effluent from treatment plant
	Packaging and storage	• Check for liquid waste and noise
Canning industry (fish, meat, vegetable and fruits)	Preparation	Check for liquid waste
	Processing	Check for liquid waste
	Packing	Check for liquid waste
Slaughter House/abattoir	Receiving	Check for liquid waste
	Processing	• Check for liquid waste • Check for drainage system • Check for effluent from treatment plant
Beverages industries	Receiving raw materials	• Check for spillages
	Preparation	• Check for Liquid waste, spillages,
	Processing	• Check for liquid waste spillages • Check for effluent from treatment plant
	Bottling or canning	• Check for solid waste, liquid waste, heat and noise
	Preparations Cleaning bottles	• Check for Liquid waste (detergents)
	Processing	• Check for liquid waste
	Finishing/Packing	• Check for liquid waste

CATEGORY 3: POWER GENERATION		
Thermal	Receiving of raw materials e.g. crude oil, coal, gas, biomass, chemicals	• Check for spillages and leakage
	Preparation - Fuel treatment - Sedimentation (settling)	• Check for waste oil, spillages and leakages • Check for sludge and chemicals

	Generation - Boiler - Turbine - Generator	- Check handling effluent
	Transmission lines	Check for leachate, leaking transformers, activities done along the transmission lines
Hydropower	Receiving of raw materials	Check for handling and storage, spillages
	Processing -Dam -Reservoir -Penstock -Turbine	Check for oil spillage and wastewater
	Transmission lines	Check for leachate, leaking transformers, activities done along the transmission lines

CATEGORY 4: EXTRACTIVE INDUSTRIES		
Mining/ quarrying	Excavation and drilling Extracting fossil fuel Refining	Check for waste water
	Grinding and crushing	Check for spillages, leakages and wastewater
	Refinery/separation	Check for heavy metal

CATEGORY 5: RESEARCH AND QUALITY CONTROL LABORATORIES		
Laboratory		
	Laboratory activities	- Check for handling and segregation of wastes, emissions, sewerage system, handling and disposal of expired chemicals - Check for handling of microbiological substances and radiation materials - Check for handling of liquid and hazardous waste

CATEGORY 6: CONSTRUCTION INDUSTRIES		
Building	Site clearance	- Check for liquid waste

constructions, surface works, tunnelling and demolition	Construction activities	• Check for liquid waste • Check for surface drainage interference

CATEGORY 7: TRANSPORT SECTOR		
Vessels	Marine vessels, Aircraft, Train, Motor vehicle	• Verify types and date of manufactured • Check for spillage, emissions, solid and liquid waste noise • Check for ballast water, sanitation • Check for vessels condition
Terminals	Harbour, Airport, Railway station, Bus station	• Check for solid waste and liquid waste disposals emissions and noise
Routes	Roads, Railway, Air, Water, Pipelines	
Petrol Station and Depots		• Check for location • Check for surface drainage • Check for the height of vent pipes • Check for leakage and drainage • Verify fire control
Maintenance	Workshops, Garage, Hangers, Filling stations and car wash	• Check for solid and liquid waste, oil and greases, leakage, emissions and housekeeping

CATEGORY 8: AGRICULTURE SECTOR		
Farms	Irrigation Systems, Buildings, Grain mills, Healthcare services, Social Services	Check for agricultural activities near water sources, deforestation, water rights, leakages of agrochemicals Check for pesticides application, infrastructures, drainage systems, Check for chemicals Check for solid and solid waste disposal Check for aerial application of pesticides

		Check for reuse/recycling of effluent/sewage
Animal farms and aquaculture	Animal houses and layout	Check for liquid waste Check for veterinary chemical Check for sewerage and drainage

CATEGORY 9: HEALTH CARE FACILITIES		
Hospitals, Health centres and Dispensaries	Outpatient and Impatient Department	• Check for liquid waste • Check for incinerator and type. • Check for disposal of disinfectants and leakages, sterilization unit, - waste sorting/segregation at source; treatment of clinical waste.
	Diagnostics facilities	• check for disposal of radioactive material, spillages and emissions
	Theatre	Check waste handling and disposal, coded receptacles for anatomical waste, sharps placenta etc.
	Laboratory	Check handling of chemicals and reagents; disposal of specimen / solid and liquid waste, drainage systems
	Mortuary	Check for disinfectants, capacity of cold rooms, housekeeping, drainage systems, protective gears Check for crematorium
	Laundry services	Check for waste management, disinfection of laundry material
	Catering services	Check for solid and liquid waste
	X-ray department	Check for handling and disposal of radioactive waste
	Internal and external compounds	Check for transfer stations for waste, aesthetic.
	Pharmacy	Check for handling and disposal of solid & liquid waste and expired drugs.

CATEGORY10: HUMAN SETTLMENT		
Community	Housing	Check for planned / unplanned settlements, solid and liquid waste, on-site sanitation and sewerage system
	Waste generation	Check for waste handling and disposal, sewerage systems Check for storm water drainage, receptacles for waste, dump sites, and transfer stations. Check for underground water quality
	Social / public services	Check for noise, solid and liquid waste,
	Economic activities	Check for urban agriculture and animal husbandry, garages, saw mills

APPENDIX 5: EFFLUENT SAMPLING REPORT

A. Basic Information

1. Name of Establishment:
2. Office Address:
3. Plant Address:
4. Contact Person/Position Title:
5. Purpose of Effluent Sampling:

( ) To assess water pollution source installation
( ) To conduct sampling in connection with its application for
Discharge Permit ( ) New ( ) Renewal
( ) To investigate pollution complaint
( ) To check status of commitment to___________

B. General Information

1. Nature of Business
2. Type of Industry/Code:
3. Year Established:
4. Name of CEO:
Phone No: _________ E-mail: _________
5. Name of PCO: _________ Accreditation No: ___
Phone No: _________ E-mail: ___________

6. with Discharge Permit:
( ) Yes Permit No.______ Date Issued: ____Expiry:______
( ) No

C. Plant Manufacturing Information

1. Raw Materials/Finished Products list

Raw Materials	**Quantity**	**Finished products**	**Quantity**
1.		1.	
2.		2.	
3.		3.	

2. Type of operation
( ) Batch
( ) Continuous
3. Status of operation during sampling

( ) Not operating
Why? ________________________________
( ) Below rated capacity Production output____________________
( ) Normal Rated Capacity__________________________

D. Water Supply/Wastewater Generation

1. Source of water
   ( ) Deep well
      ( ) MWSS
      ( ) District Town Water Supply
      ( ) Surface water (lake, river,)
      ( ) Any other
2. Water Inventory

	Vol. Water used	Vol. Wastewater generated
Process	_____	______
Washing/Cleaning	_____	______
Cooling	_____	______
Domestic	_____	______
Others	_____	______

Total water consumption: ______
Total volume of wastewater Generated: ______
Water reused or recycled for irrigation and other agricultural purposes ______

3. Quality of Abstracted/raw Water:

Date of Analysis: _____
pH _____
TSS _____
Petroleum Oil _____
BOD_5 _____
Heavy metal _____

E. Information on Water Pollution

1. Is the Factory operating with WTP ( ) Yes ( ) No

2. If there is WTP:

Type of WTP ( ) Chemical
( ) Biological

Date Installed: ________
Design capacity: ________
Cost of WTP: ________
Maintenance Cost: ______
Discharge point: ________ No. of discharge points: ___
Receiving water body: ________ Water Classification: ____
Latest Analysis of water body (Date): _______________

	Upstream	Downstream
PH	_____	_________
TSS	_____	_________
BOD	_____	_________

Flow metering device used: ( ) V-weir ( ) Flow meter
Influent: ______
Effluent ______

3. Components of WTP:

3-1 Primary treatment
( ) Screening
( ) Primary sedimentation tank
( ) Grit Removal
( ) Oil/water separator
( ) Equalization tank

3-2: Biological Treatment
( ) Activated Sludge
( ) Anaerobic Digestion
( ) Trickling Filter
( ) Oxidation/Stabilization pond
( ) Sequencing Batch Reactor
( ) Others

3-3: Chemical Treatment
( ) pH adjustment
( ) Disinfection
( ) Oxidation/reduction

( ) Flocculation/coagulation
( ) Others

3-4 Condition of the WTP
( ) properly maintained
( ) inadequately maintained
( ) poor maintenance

4. If WTP is under construction or undergoing rehabilitation

4-1 System or units under construction or being modified

____

4-2 Estimated completion

____

4-3 Treatment units utilized to treat wastewater

____

F. Field Data:

a. Date and Time of Sampling:_________________
b. Sampling Station Identification: _______________
c. Type of Sample: _________________________
d. Flow rate: ______________________________

G. Evaluation of Results:

Analyses	Results	Effluent Standard	Remarks
pH			
Temperature			
TSS			
COD			
Chlorine			
TC			
Others			

H. Findings and Observations:

____
____
____

I. Remarks and Recommendation:

____

____
____
____

Date: ________________________________
Prepared By: ________________________________
(Position)
Reviewed By:

____
For, Director of Water Laboratories

APPENDIX 6 Budget analysis for water quality monitoring programme

WATER QUALITY MONITORING BURGET ANALYSIS

LOCATION	FREQUENCY	DISTANCE KM.	COMULATIVE KM	PARAMITER	LAB.U.CHARGES	NO. STAFF	NIGHT	RATES /NIGHT	LAB COST	FUEL COST	PERDIEM	TOTAL
NO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
FUCTION												
T - A	2	140	140	DO	10,000	3	1	80000	20000	65,000	480,000	565,000
	2			PH	4,000	3			8000	-	-	8,000
	2			ALKALINITY	8,000	3			16000	-	-	16,000
	2			EC	6,000	3			12000	-	-	12,000
	2			TDS	10,000	3			20000	-	-	20,000
	2			T.Colifom	8,000	3			16000		-	16,000
	2										-	
A-B	2	120	260	DO	10,000	3			20000	55,714	-	75,714
	2			PH	4,000	3			8000	-	-	8,000
	2			ALKALINITY	8,000	3			16000	-	-	16,000
	2			EC	6,000	3			12000	-	-	12,000
	2			TDS	10,000	3			20000	-	-	20,000
	2			T.Colifom	8,000	3			16000		-	16,000
											-	
B-C	2	155	415	DO	10,000	3	1	80000	20000	71,964	480,000	571,964
	2			PH	4,000	3			8000	-	-	8,000
	2			ALKALINITY	8,000	3			16000	-	-	16,000
	2			EC	6,000	3			12000	-	-	12,000

WATER QUALITY MONITORING BURGET ANALYSIS

	2			TDS	10,000	3			20000	-	-	20,000
	2			F.Colifom	8,000	3			16000		-	16,000
											-	
C-D	4	134	549	BOD	10,000	3			40000	62,214	-	102,214
	4			TDS	10,000	3			40000	-	-	40,000
	4			NO3	8,000	3			32000	-	-	32,000
	4			Pb	15,000	3			60000	-	-	60,000
	4			Mn	8,000	3			32000	-	-	32,000
	4			T.Colifom	8,000	3			32000		-	32,000
											-	
D-E	4	154	703	BOD	10,000	3			40000	71,500	-	111,500
	4			TDS	10,000	3			40000	-	-	40,000
	4			NO3	8,000	3			32000	-	-	32,000
	4			Pb	15,000	3			60000	-	-	60,000
	4			Mn	8,000	3			32000	-	-	32,000
	4			F.Colifom	8,000	3			32000		-	32,000
											-	
E-F	4	120	823	BOD	10,000	3			40000	55,714	-	95,714
	4			TDS	10,000	3			40000	-	-	40,000
	4			NO3	8,000	3			32000	-	-	32,000
	4			Pb	15,000	3			60000	-	-	60,000
	4			Mn	8,000	3			32000	-	-	32,000
	4			T.Colifom	8,000	3			32000		-	32,000
											-	

WATER QUALITY MONITORING BURGET ANALYSIS

F-G	4	138	961	BOD	10,000	3	1	80000	40000	64,071	960,000	1,064,071
	4			TDS	10,000	3			40000	-	-	40,000
	4			NO3	8,000	3			32000	-	-	32,000
	4			Pb	15,000	3			60000	-	-	60,000
	4			Mn	8,000	3			32000	-	-	32,000
	4			T.Colifom	8,000	3			32000		-	32,000
											-	
G-H	2	167	1128	DO	10,000	3			20000	77,536	-	97,536
	2			PH	4,000	3			8000	-	-	8,000
	2			ALKALINITY	8,000	3			16000	-	-	16,000
	2			EC	6,000	3			12000	-	-	12,000
	2			TDS	5,000	3			10000	-	-	10,000
	2			T.Colifom	8,000	3			16000		-	16,000
											-	
H-I	4	186	1314	BOD	10,000	3			40000	86,357	-	126,357
	4			TDS	5,000	3			20000	-	-	20,000
	4			NO3	8,000	3			32000	-	-	32,000
	4			Pb	6,000	3			24000	-	-	24,000
	4			Mn	10,000	3			40000	-	-	40,000
	4			T.Colifom	8,000	3			32000		-	32,000
											-	
I-J	4	139	1453	BOD	10,000	3			40000	64,536	-	104,536
	4			TDS	5,000	3			20000	-	-	20,000
	4			NO3	8,000	3			32000	-	-	32,000

WATER QUALITY MONITORING BURGET ANALYSIS

	4			Pb	15,000	3			60000	-	-	60,000
	4			Mn	8,000	3			32000	-	-	32,000
CLOSE ROUTE A		1	1454	T.Colifom	8,000				**1,674,000**	**674,607**	**1,920,000**	**4,268,607**
	ROUTE B											-
T - K	2	100	100	DO	10,000	3			20,000	46,429	-	66,429
	2			PH	4,000	3			8,000	-	-	8,000
	2			ALKALINITY	8,000	3			16,000	-	-	16,000
	2			EC	6,000	3			12,000	-	-	12,000
	2			TDS	5,000	3			10,000	-	-	10,000
	2			F.Colifom	8,000	3			16000		-	16,000
											-	
K-L	2	160	260	DO	10,000	3			20,000	74,286	-	94,286
	2			PH	4,000	3			8,000	-	-	8,000
	2			ALKALINITY	8,000	3			16,000	-	-	16,000
	2			EC	6,000	3			12,000	-	-	12,000
	2			TDS	5,000	3			10,000	-	-	10,000
	2			F.Colifom	8,000	3			16,000		-	16,000
											-	
L-M	2	150	410	DO	10,000	3	1	80000	20,000	69,643	480,000	569,643
	2			PH	4,000	3			8,000	-	-	8,000
	2			ALKALINITY	8,000	3			16,000	-	-	16,000
	2			EC	6,000	3			12,000	-	-	12,000
	2			TDS	5,000	3			10,000	-	-	10,000
	2			T.Colifom	8,000	3			16,000		-	16,000

WATER QUALITY MONITORING BURGET ANALYSIS

											-	
M-N	2	145	555	DO	10,000	3			20,000	67,321	-	87,321
	2			PH	4,000	3			8,000	-	-	8,000
	2			ALKALINITY	8,000	3			16,000	-	-	16,000
	2			EC	6,000	3			12,000	-	-	12,000
	2			TDS	5,000	3			10,000	-	-	10,000
	2			T.Colifom	8,000	3			16,000		-	16,000
											-	
N-O	4	153	708	BOD	10,000	3			40,000	71,036	-	111,036
	4			TDS	5,000	3			20,000	-	-	20,000
	4			NO3	8,000	3			32,000	-	-	32,000
	4			Pb	15,000	3			60,000	-	-	60,000
	4			Mn	8,000	3			32,000	-	-	32,000
	4			T.Colifom	8,000	3			32,000		-	32,000
											-	
O-P	4	158	866	BOD	10,000	3			40,000	73,357	-	113,357
	4			TDS	5,000	3			20,000	-	-	20,000
	4			NO3	8,000	3			32,000	-	-	32,000
	4			Pb	15,000	3			60,000	-	-	60,000
	4			Mn	8,000	3			32,000	-	-	32,000
	4			T.Colifom	8,000	3			32,000		-	32,000
											-	
P-Q	4	160	1026	BOD	10,000	3	1	80000	40,000	74,286	960,000	1,074,286
	4			TDS	5,000	3			20,000	-	-	20,000

WATER QUALITY MONITORING BURGET ANALYSIS												
	4			NO3	8,000	3			32,000	-	-	32,000
	4			Pb	15,000	3			60,000	-	-	60,000
	4			Mn	8,000	3			32,000	-	-	32,000
											-	
Q-R	4	145	1171	BOD	10,000	3			40,000	67,321	-	107,321
	4			TDS	5,000	3			20,000	-	-	20,000
	4			NO3	8,000	3			32,000	-	-	32,000
	4			Pb	15,000	3			60,000	-	-	60,000
	4			Mn	8,000	3			32,000	-	-	32,000
	4			T.Colifom	8,000	3			32,000		-	32,000
											-	
R-S	4	148	1319	BOD	10,000	3			40,000	68,714	-	108,714
	4			TDS	5,000	3			20,000	-	-	20,000
	4			NO3	8,000	3			32,000	-	-	32,000
	4			Pb	15,000	3			60,000	-	-	60,000
	4			Mn	8,000	3			32,000	-	-	32,000
											-	
S-T	4	120	1439	BOD	10,000	3			40,000	55,714	-	95,714
	4			TDS	5,000	3			20,000	-	-	20,000
	4			NO3	8,000	3			32,000	-	-	32,000
	4			Pb	15,000	3			60,000	-	-	60,000
	4			Mn	8,000	3			32,000	-	-	32,000
	4			T.Colifom	8,000	3			32,000		-	32,000
											-	

WATER QUALITY MONITORING BURGET ANALYSIS

T	4	130	1569	BOD	10,000	3			40,000	60,357	-	100,357
	4			TDS	5,000	3			20,000	-	-	20,000
	4			NO3	8,000	3			32,000	-	-	32,000
	4			Pb	15,000	3			60,000	-	-	60,000
	4			Mn	8,000	3	1	80000	32,000	-	960,000	992,000
	4			T.Colifom	8,000	3			32,000		-	32,000
CLOSE ROUTE B		0	1569						**1,744,000**	**728,464**	**2,400,000**	**4,872,464**
TOTAL OPERATION COST												**9,141,071**

GLOSARY OF TERMS

A metal: is a chemical element that is a good conductor of both electricity and heat and forms cations and ionic bonds with non-metals.

Abstracted Water: Water taken from any source (groundwater or surface water) either temporarily or permanently.

Acid Mine Drainage (AMD) or Acid Rock Drainage (ARD) pollution: is a natural process whereby sulphuric acid is produced when earth material containing sulphide minerals are exposed to air and water.

Auto Sampler: a device to collect samples automatically either in proportion to the wastewater flow or as equal volumes at equal time intervals.

Biochemical Oxygen Demand (BOD): Sometimes referred to as Biological Oxygen Demand (BOD). A measure of the amount of oxygen removed (respired) from aquatic environments by aerobic microorganisms either in the water column or in the sediments. The parameter BOD uses the maximum rate of O_2 consumption over a 5 day period in the dark at 20^0 C to estimate the total amount of "biodegradable" organic matter in the system.

Blank Sample: An uncontaminated sample of reagent water which is free of the target parameters and of any substance which may interfere with that analysis.

Chemical Oxygen Demand (COD): A measure of the oxygen-consuming capacity of inorganic mater present in water or wastewater. It is expressed as an amount of oxygen consumed from a chemical oxidant in a specific test. It does not differentiate between stable and unstable organic matter and thus does not necessarily correlate with biochemical oxygen demand.

Composite Sample: A combination of individual samples of water or wastewater taken at selected intervals, generally hourly for some specified period, to minimize the effect of the variability to the individual sample. Individual samples may have equal volume or may be roughly proportioned to the flow at the time of sampling.

Dissolved Oxygen (DO or O2): The concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per litre, parts per million, or percent of saturation. Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms and the prevention of offensive odours. DO levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life.

Dissolved Solids: the anhydrous residues of the dissolved constituents in water

Earth material: includes elements, minerals, compounds, ore, soils, rocks or any other natural occurring substance originating from the earth.

Effluent: These are discharges from known source which are passed into a body of water or land, or wastewater flowing out of a manufacturing plant, industrial plant including domestic, commercial and recreational facilities.

Erosion and Sedimentation pollution: is manifested when earth materials and mine/quarry dusts are exposed and subjected to biological, chemical or physical erosion resulting into substantial amounts of sediment susceptible to be carried into a water body.

Heavy metal pollution: occurs when earth materials containing heavy metal come in contact with water.

Heavy metal: includes arsenic, cadmium, cobalt, chromium, copper, mercury, gold manganese, magnesium, nickel, lead, tin, and thallium

Hydrocarbon: is a naturally occurring organic substance, gaseous, liquid or solid, consisting of hydrogen and carbon with or without other element(s), including crude oil.

Incident: includes any incident or accident in which a substance pollutes or has the potential to pollute or has a detrimental effect on water resources.

Industrial Waste: The liquid wastes from industrial process, as distinct from domestic or sanitary wastes.

Industrial Wastewater: This refers to any liquid waste resulting from any activity, process of industry, manufacturer or from the development, processing or recovery of any natural resources.

Infiltration: Extraneous water that enters the sewer system through leaking joints, cracks and breaks, or porous walls.

Inorganic Matter: Chemical Substances of mineral origin, or more correctly, not of basically carbon structure.

Mineral: is an element or a crystalline solid chemical substance naturally occurring, having characteristic chemical composition, highly ordered atomic structure, and specific physical properties that has been formed as a result of geological (biogeochemical) processes.

Mining processes: include all activities done during the extraction and processing of valuable minerals, radioactive or non radioactive substances, hydrocarbons, quarry material, removal of soil or other earth material from the earth, from an ore body, from a vein or coal seams.

Non–point source pollution: refers to diffuse contamination that does not originate from a single discrete source. NPS pollution is often the cumulative effect of small amounts of contaminants gathered from a large area.

Point source pollution: refers to contaminants that enter a waterway from a single, identifiable source, such as a pipe or ditch.

Pollutant substance: is any material, natural or artificial, used or produced in a course of undertaking mining processes or during any incident associated with mining processes.

Processing Chemicals Pollution: occurs when chemical agents used during mining processes leak or leach into a water body.

Sulphide: is a chemical or earth material containing sulphur element in a simple or in combination with other elements or substances.

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