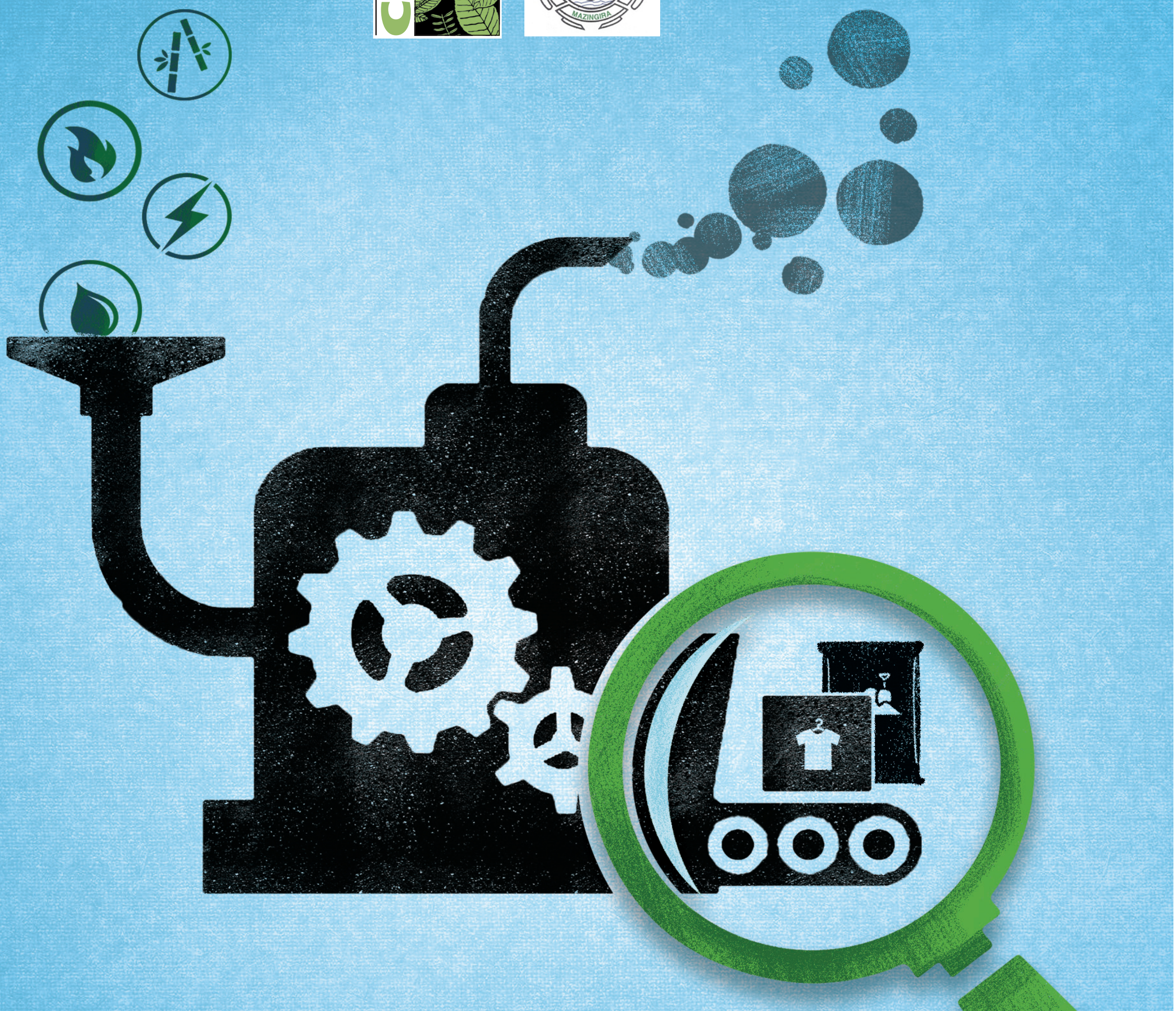

STRENGTHENING ENVIRONMENTAL AUDIT IN TANZANIA

Technical Manual

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Technical Manual

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The Centre for Science and Environment is grateful to the Swedish International Development Cooperation Agency (Sida) for their institutional support.

Citation: Nivit Kumar Yadav and Dr Samuel G. Mafwenga, 2023, *Strengthening Environmental Audit in Tanzania*, Centre for Science and Environment, New Delhi.

Published by
Centre for Science and Environment
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EIA	Environment Impact Assessment
NEMC	National Environmental Management Council
TANESCO	Tanzania Electricity Supply Company
GPS	Global Positioning System
PM	Particulate matter
IFC	International Finance Corporation
TZS	Tanzania Standards
CO_2	Carbon dioxide
CO	Carbon monoxide
NO	Nitrogen oxide
NOx	Oxides of nitrogen
SO_2	Sulphur dioxide
CaO	Calcium oxide
ESP	Electrostatic precipitator
OSHA	Occupational Safety and Health Administration
CSR	Corporate social responsibility
kwH	Kilowatt hour
APCD	Air pollution control device
DG	Diesel generator
ETP	Effluent treatment plant
CSE	Centre for Science and Environment
GJ/h	Gigajoule per hour
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
DDT	Dichlorodiphenyltrichloroethane
ROI	Return on investment
MGF	Multi-grade filter
CT	Cooling tower
STP	Sewage treatment plant
MBR	Membrane bioreactor
MEE	Multi-effective evaporator
RO	Reverse osmosis
COC	Cycles of concentration

TDS	Total dissolved solids
lpcd	Litre per capita per day
AHU	Air handling unit
MCB	Monochlorobenzene
SS	Suspended solids
HSE	Health Safety Environment
R&D	Research and development
HR	Human resource
GPU	Gas process unit
HDPE	High density polyethylene
LLDPE	Linear low-density polyethylene
DM	Demineralization plant
GCU	Gas cracking unit
LPG	Liquified petroleum gas
CETP	Common effluent treatment plant
DCS	Distributed Control System
PLC	Programmable logic controllers
SOP	Sequence of procedure
ISBL	Inside battery limit treatment
OSBL	Outside battery limit treatment
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
CTO	Consent to operate
RWH	Rainwater harvesting

Foreword

The National Environment Management Council (NEMC) is putting emphasis to ensure regulated communities comply with the environmental governing laws. In facilitating such a process, the Council has embarked in developing supporting tools including Guidelines, Terms of References (ToR) and Technical Manuals that can support the undertaking and implementation of the Environmental Impact Assessments and environmental audits. The developed tools are essential in facilitating the work done by the experts as well as review process undertaken by NEMC and other regulatory authorities. The development of such tools is to ensure processes such as EIA and Environmental Audits are systematic and that the prepared reports are useful in guiding informed decisions.

Environmental audit is a series of activities undertaken on the operations of a facility or an organization to evaluate its environmental performance. This is in recognition that the environment is an important parameter for consideration for any decision-making for the development of any organization and national environmental programmes as a whole. However, an effective way of addressing environmental issues of any facility is through systematic environmental management programmes, including undertaking of self environmental audits. These audits are considered as a methodological examination, involving analyses, tests and confirmations of a facility's procedures and practices with a goal of verifying whether they comply with environmental legal requirements.

The Council is aware of the requirements of the Environmental Management Act (EMA), 2004 and its Regulations with regard to the preparation of self monitoring/audit reports by the regulated community. According to Environment Impact Assessment and Audit Regulations, 2005 and its Amendment of 2018, which were made under Environmental Management Act Cap 191, the ongoing projects that have been issued an EIA certificate are required to undertake self-monitoring and preparing Annual Environmental Audit reports and submitting the same to the Council annually or as may be prescribed by the Council.

The Council has observed that the received self-audit reports are in different formats, they lack important information and in some situations they do not reflect the actual situation of the operating facility. Likewise, these reports do not cover adequately information included in the Environmental Management Plan developed during EIA.

This developed technical manual is intended to streamline processes associated with undertaking and review of environmental audits. The submitted self-audit reports need to be clear, capable of identifying and correcting non-complainces as well as supporting improvement programmes. Therefore, this manual is intended to strengthen environmental audits in Tanzania. In addition, it is intended to improve the quality of submitted audit reports and as well as help reviewers to efficiently and effectively review the submitted self-audit reports.

Apart from the technical manual being used by project proponents and experts in conducting self-audits, the document is also useful for the Council and other regulatory bodies in the review process of the submitted documents. It is important to note also that the documents are also useful for the Council in undertaking its audit studies that are stipulated in the Environmental Management Act, 2004. For instance, Section 18 (1) (a) of the Environmental Managment Act has mandated the Council to undertake environmental audits. Similarly, Section 101 (1) of the Act stipulates that the Council is required to undertake environmental audit in respect of any project or undertaking that is likely to have significnat impact on the environment.

It is against this background that the Council felt the need to prepare a technical guide that can facilitate standardizing self-environmental audit studies. This developed technical manual is an outcome of collaborative efforts between the Centre for Science and Environment (CSE) and NEMC. At this juncture I would like to extend my appreciation to CSE for technical support they have offered to NEMC in the development of this manual. Likewise, I would like to extend my appreciation to NEMC staff for the contribution they have given in the preparation of this document.

Thank you,

Eng. Dr. Samuel G. Mafwenga
Director General
National Environment Management Council (NEMC)

1. Need to strengthen environmental audit framework

According to the Environment Impact Assessment (EIA) and Audit Regulations, 2005 and its Amendment of 2018, which were made under Environmental Management Act (Cap. 191), the ongoing projects that have been issued EIA certificates are required to undertake self-monitoring and preparing an Annual Environmental Audit report and submit it to the Council annually or as may be prescribed by the Council.

Section 48–56 of Part X of the Regulation detail the objectives, principles, self-audit guidelines and content of audit reports. According to the Section 44, the main objective of the environmental audit is to determine how far activities of a project conform to the approved environmental and social management plan as stated in the EIA report. An environmental audit provides a mechanism for regulators to learn from experience, and to refine, design and implement procedures of a project or undertaking so as to mitigate adverse environmental impacts. It also provides regulatory bodies with a framework to ensure compliance with the Environmental and Social Management Plan, which is part of Environmental Impact Assessment. In a way, the audit scheme in Tanzania is forward-looking and aims to push projects towards improving their environmental performance.

An environmental audit study shall be undertaken for the projects specified in the Third Schedule of the Act and in the First Schedule of these Regulations. Additionally, ongoing projects which commenced prior to the enforcement of these regulations and new projects undertaken after completion of an environmental impact statement (expansion, change of product or change in manufacturing process) also need to undertake environmental audit studies.

Section 3 of the Part X defines who can undertake an environmental audit. An environmental audit shall be conducted by a qualified and authorized environmental auditor or environmental inspector who shall be an expert or a firm of experts registered in accordance with the Environmental Regulations (Registration of Environmental Experts), 2005.

The content of the audit report is governed by the terms of reference developed by the proponent or a developer in consultation with the Council. The Act also emphasizes that the environmental auditor shall ensure that an appraisal of all the project activities gives adequate consideration to environmental regulatory frameworks, environmental health and safety measures and sustainable use of natural resources.

Section 9 of Part X elaborates what an audit report should contain. The audit report should include the following:

a) The past and present impacts of the project;
b) The responsibility and proficiency of the operators of the project;
c) Existing internal control mechanisms to identify and mitigate activities with a negative environmental impact;
d) Existing internal control mechanisms to ensure the health and safety of workers; and
e) The existence of environmental awareness and sensitization measures, including environmental standards and regulations, law and policy for the managerial and operational personnel.

There is provision for a control audit under the Section 49 of the Act. Under this, the National Environmental Management Council (NEMC), Tanzania has been empowered to check the compliance status against the environmental parameters and verify self-auditing reports submitted by project proponents. This objective of a control audit is to verify the adequacy of the environmental plan in mitigating negative impacts of a project as evolved during environmental impact assessment process or after the initial audit.

The emphasis of Section 51 of the said Regulation is on the procedure of conducting an environmental audit. The steps of conducting the audit comprise questionnaire survey, site visit, sampling and analysis in the manner specified in the regulation. An auditor carries out the audit taking into consideration the relevant environmental laws, regulatory framework on health and safety, sustainable use of raw material and verification of compliance status as per the Environmental Management Plan. The audit report also encompasses a monitoring plan, verification of records and of infrastructure facility for environmental management. In addition, inspection of building premises, manufacturing facility, testing and transportation facilities within and outside the project areas as well as areas where goods are stored and disposed of is also carried out. Most importantly, the auditor needs to indicate the extent to which the environmental management plan corresponds to the planned arrangement and if implemented whether it achieves the stated objective. The auditor also needs to identify significant sources of air pollution, water pollution, land contamination and degradation along with a list of ongoing activities, with recommendations to improve the situation.

The Regulation also lay down the process for review of the audit report. Section 53 states that a cross-section advisory committee shall review the audit report with the purpose of establishing accuracy and coverage of key issues and make appropriate recommendations of remedial measures. If necessary, the said advisory committee may conduct an on-site visit and/or consult stakeholders to verify the content of audit report. During review, the proponent may be invited for clarification and further information.

A review of the Environmental Impact Assessment and Audit Regulations, 2005 shows that it has been framed with proper checks and balances. With regard to its implementation, however, a review of the audit reports was taken up to understand whether the report reflects the intention that is clearly mentioned in the Regulation.

1.1 Review of annual environmental audit report

1.1.1 Sugar industry in Tanzania

A private sugar industry in Tanzania produces brown sugar that is currently sold in the internal market only. The industry has a capacity to produce more than 82,000 metric tonne of sugar per year and plays a vital role in the economic progress of Tanzania by creating permanent and temporary or seasonal employment opportunities. Currently, the industry has more than 10,000 employees working in the factory for work such as plantation, administration and other supportive service-provider departments.

The maximum capacity of power output from the cogeneration plant is 5 MW, but depending on the process conditions current generation is less than or equivalent to 4 MW which is not sufficient for all uses at the factory. To supplement power demand at the factory, 10 MW is sourced from the Tanzania Electricity Supply Company (TANESCO), especially for factory operations, irrigation of sugarcane fields and domestic uses.

The process of sugar production depends on the availability of the essential raw material sugarcane. The industry harvests more than 800,000 tonne of sugarcane from its farms and outsource about 110,000 tonne of sugarcane from outgrowers as well. The industry owns about 14,000 hectare of cane farms. It intends to expand cane farms and enhance production to up to 170,000 metric tonne of sugar per annum by 2025.

Sugar production at the factory comprises the following steps:

a. Cane offloading
b. Handling and preparation
c. Extraction
d. Clarification
e. Evaporation
f. Crystallization
g. Mechanical separation
h. Drying and packaging

Highlights of Tanzania's sugar Industry audit report: data availability and quality of information provided

The review of the annual environmental audit report of the sugar factory concludes that the information provided by the entrepreneurs is not sufficient. The environmental audit report of the sugar factory in Tanzania has more information in text and less in terms of data, thus making it difficult to use it in guiding informed decisions. The information provided in the report is not sufficient for regulators to understand the plant's environmental performance or to take any regulatory decisions.

The availability of sufficient historic data is another issue with the audit report. For a few indicators, the information provided is only for one year, and cannot be analysed to indicate whether the performance of industry is improving or deteriorating. Further, wherever the information is provided, its relevance needs to be understood. For example, one section of the report talks about the location and accessibility with the GPS coordinates in tabular form followed by maps, but such information can be easily sourced from the EIA report.

The report has also highlighted the environmental policy of the factory. According to the report, the policy has tools for the environmental management of the factory. The policy, however, was not provided in the report.

Information available in the report

Production of sugar: 82,000 tonne of sugar/year
Sugarcane requirement: 4,500 tonne of cane per day
Water requirement: 150 m^3/hour
Wastewater discharge: No information
Wastewater treatment system: To natural wetlands through drainage system
Sewage treatment system: Septic tank and soak pits
Fugitive dust emission: Data of 17 sites provided
Stack emission: Data for bagasse-fired boiler

Information available for stack and fugitive emissions and noise levels

Ambient air quality was monitored at 17 places to understand the impact of fugitive dust emission on the surroundings. Information provided shows that Tanzania does not have a standard for $PM_{2.5}$. The National Environment Management Council (NEMC) needs to develop standards for the same. Only eight sites were complying with the $PM_{2.5}$ and PM_{10} dust concentration as per local standard (TZS845:2005) and International Finance Corporation (IFC), 2007. This also means there were many sites were not complying with the ambient air quality standards. Further, no reason for a specific site selection for the ambient air quality monitoring standards has been rationalized in the report. In addition, it is difficult to understand the reason for selecting locations such as oil-storage area, instrumental workshop, control room and mill-house control room, where probability of source for fugitive dust emission is low.

The report provides the information for the bagasse-fired boiler for which three days of stack monitoring was conducted. Data was collected for CO_2, CO, NO, NO_x, SO_2 and other parameters. Though the audit report highlights particulate matter as a significant pollutant, it seems that the industry has not conducted monitoring to collect PM data. **Such an approach makes the whole process of conducting the audit redundant (as it does not fulfil the desired objective).**

Data for noise level was collected from 17 sites. While the report says that only six sites have high noise levels, it also says that 13 sites out of 17 have level above 80 dB, which earmarks high noise levels.

Lack of adequate information on wastewater and solid waste

Wastewater

The audit report of the sugar industry has no information with regard to the quantity or quality of wastewater. A small paragraph, with no data on quantity of wastewater generated or quality of wastewater discharged, is provided in the report.

The report highlights that wastewater from the factory is channelled into the on-site drainage system and then discharged into natural wetlands, which indicates that the factory does not have an adequate wastewater treatment facility. The photograph on the front page of the report, however, shows a clarifier that is part of the wastewater treatment system, but no such information is provided in the report. This highlights that information on effluent treatment is missing from the report.

In addition, no laboratory report is attached with the environmental audit report, elaborating the quality of the wastewater discharged. Therefore, the lack of data on wastewater quantity or quality once again makes the process of audit redundant as the water consumption is very high in the factory which is around 150 m^3 per hour. There is also no water balance and water circuit network provided in the report highlighting the major water consuming areas in the factory.

Solid waste

According to the audit report, solid waste is produced from production process in the form of bagasse, filter cake, boiler ash and office trash and garbage. Bagasse is collected and stockpiled in the factory and used as a source of energy for heating boilers, which in turn generates electricity. Boiler ash and filter cake are transferred to sugarcane fields and used as manure. Office trash and garbage is collected and transported to the solid waste dumping site. However, the report does not comment on the total waste generated in terms of quantity.

The report talks about work on the new power generation system, which will be completed by 2025. No other information is, however provided with regard to the system, to provide an understanding of the type of fuel used, technology or type of pollution-control equipment they will install to reduce the cumulative impact of the existing plant and new plants.

1.1.2 Cement industry in Tanzania

The integrated cement plant in Tanazia has an installed capacity of 3 million tonne per annum of Portland cement. The major operations are mining, manufacturing, packaging and distribution of cement to the local market.

Highlights of the cement industry audit: text without data

The industry has included the operation of the mines and cement plant together in the environmental audit report. One chapter of the report has highlights about the project description and current operation and has ample qualitative information but little quantitative information, which is not of much use for regulatory purpose. For example, in one table, the information on mineralogy detailing the percentage of various chemicals has been addressed out of which only CaO is important, but no explanation of the table in the form of text has been offered in the report.

Similarly, the tables on mining equipment and on mining manpower in the report are irrelevant for any environmental regulator. The other section of the report talks about how reclamation of land might be affected by mining activity, but it has no information on total land that has been excavated, total land that has been exhausted, total land used for dumping of waste such as overburden and topsoil or land used for reclamation. The section mentions utilization of varied resources, but not in terms of data. Even the size of land allotted for mining of limestone is not mentioned in the report. The report has however provided information on ambient air quality in three sections of mine.

Information available in the report
Cement production: 3 million tonne per annum of Portland cement
Consumption of natural gas in power plant: No information
Consumption of coal in power plant: 250,000 tonne/month
Land allotted for mining: No information
Limestone excavated per annum: No information
Land exhausted: No information
Land reclaimed: No information
Land used for overburden storage: No information
Land used for topsoil storage: No information
Land used for water storage in mine: No information

Air pollution control devices installed on equipment or within process
- Crusher: No information
- Storage yard for crushed limestone: Covered
- Raw material hopper: Bag filter
- Kiln: Baghouse
- Clinker cooler: ESP
- Cement silo: No information
- Packaging plant: No information
- Percentage of conveyer belt covered: No information

Information available for cement plant
The section on utilities and auxiliary services of the report talks about the type of fuel used in the captive power plant. Natural gas is the main fuel and coal is used as an alternative fuel for the power plant. However, the section—and the report—do not provide any information on the quantity of natural gas used per month or year for regulators to make an assessment of its impact on air emission. Surprisingly, the report provides information on alternative fuel, i.e. coal.

Details about stack emission from different stacks in the plant have been highlighted in the report. Surprisingly, however, the information provided in table does not include emissions from the kiln or clinker cooler or power plant stack, which are major sources of emission in a cement plant.

In addition, there is also a table in the report that provides information on ground vibration from different sections of the plant and mine. It is difficult to understand the rationale for collecting information on ground vibration. The issue of vibration is reported where blasting is applied to extract limestone. However, in the case of this cement industry, mining is done using an excavator and rock breaker as and when required. Excavators or rock breaker do not cause much vibration and it is thus difficult to understand the purpose of conducting the vibration study in the mine and in the plants. Unsurprisingly, however, the data clearly shows that the vibration is low in comparison to the Occupational Safety and Health Administration (OSHA) Regulation, 2016.

The report has several sections elaborating waste management, environmental and social management plan, CSR-related activities, fire-hazard management, liquid-waste management and mitigation measures, but without any concrete data and relevant information. It is thus difficult to understand how regulators will use the report for the purpose of compliance.

1.1.3 Textile industry in Tanzania

The textile industry in Tanzania occupies an area of 18,600 square metre and has a production capacity of 10 lakh pairs of jeans per month, but during the environmental audit it was found that the factory was producing around 30 lakh pairs of jeans per month.

The report gives the highlights on the manufacturing process (with step-by-step mention of unit operations), source of water, solid waste generation and wastewater generation in the factory.

Information available in the report

- Production of jeans: 30 lakh pairs of jeans per month
- Electricity consumption: 314,646 kwH per month
- Wastewater generation: 300 m^3 per month from garment washing section, 672.2 m^3 excreta black water per month, 36 m^3 per month grey water from floor washing.
- Wastewater treatment system: Capacity of 1,500 m^3 per day
- Sewage treatment system: Via sewerage network goes to waste stabilization ponds
- Stack emission: Fabric waste as a fuel in boiler to produce steam energy

Water consumption pattern

The major water-consuming areas in the textile industry—for drinking and maintaining hygiene—is around 28,010 litre per day, for floor cleaning around 1,200 litre per day and for garment washing around 10,000 litre per day. But the table on pattern of water consumption in the report does not mention the source from where the water has been extracted. In addition, six units in the factory have water storage tanks of different capacities, viz. four 10,000-litre tanks and five 5,000-litre tanks. Thus, it can be inferred that the factory does not have a common water storage facility with large capacity. Further, there is neither a discussion about the water balance nor water circuit diagram or details of installation and location of flowmeters in the environmental audit report.

Energy supply and consumption pattern

The source of power for running the factory and other factory facilities is from the Tanzania Electric Supply Company Limited (TANESCO) and there are standby diesel-based generators to be used in case of emergencies. Six transformers are installed in the factory and the monthly consumption of electricity is around 314,646 kWh per month. A boiler is also installed in the factory and as per the audit report, it is not working—it uses fabric waste as fuel to produce steam energy used for garment drying as well as for heating water to wash garments.

The report does not make any mention about the capacity of the diesel-based generators and type of fuel, quantity used or kind of Air Pollution Control Device (APCD) installed. Efforts should be maintained to ensure that there is a continuous power supply and dependency on DG sets can be reduced. In addition, DG sets can be switched for cleaner fuels in the long run.

The boiler installed in the industry uses fabric waste as fuel to produce steam energy, which is not a good practice. In addition, the environmental audit report has no discussion about capacity of boiler, its running hours, amount of steam generated, condensate recovery, and the type of APCD installed.

Liquid waste generation

The report gives process-wise information regarding wastewater generated from, for instance, domestic area, floor washing and garment washing. It also highlights the mechanism of wastewater collection, treatment and disposal. But there is no treatment given to domestic and floor-washing water that is disposed of to sewer lines through which it goes to the municipal wastewater treatment plant.

The report mentions that industrial wastewater is treated in an effluent treatment plant (ETP) comprising a grit chamber, equalization tank, sedimentation tank, acid hydraulic tank, filtration, disinfection, and a recycled water pool where is finally collected. But the report does not highlight data on characteristics of wastewater, and information on performance evaluation of the ETP is also missing.

The report mentions that there are proper designs of drainage structures through which run-off water sets out to surface water, but there is no quantification of storm water. In addition, there are no details about water usage for firefighting and water usage in boilers.

Solid waste generation

The report highlights different types of waste along with its sources, quantity and management procedure. The types of waste discussed in the report are biodegradable domestic waste, office waste, packaging waste, fabric waste, short thread remainders and "other", which includes waste from first-aid rooms and medical waste. The report does not have a table on hazardous and non-hazardous industrial waste.

The report highlights that there are different storages for different waste, however all these wastes are dumped to the municipal facility. As per the report, industry do not re-use the fabric waste in the variety of applications and it is burnt into the onsite incinerator. The energy generated from incineration can be used in variety of operations such as garment washing, drying etc. In addition to this, the disposal mechanism of sludge generated from the ETP is also not properly addressed in the report.

Noise pollution

Noise pollution was measured at 10 locations, and some of the locations were found not to meet the standards. The data shared in the report is not well addressed with respect to frequency of measurement at regular intervals. The report does not suggest a noise monitoring network with adequate number of locations and frequency of measurement. The suggestion for employees to use ear plugs in noisy areas has been made. In addition, the report highlights that the factory has installed a generator in standby mode, but there is no discussion regarding enclosures to reduce the noise of the generator.

Air pollution

With respect to air pollution, the factory has monitored 10 locations with respect to formaldehyde, benzene, carbon monoxide, hydrogen sulphide, carbon monoxide for ambient air pollution and PM_{10} and $PM_{2.5}$ for ambient particulate emissions. The report has little clarity about the locations for measurement of these pollutants. For many parameters the report says that the location of measurement was within the unit, but the exact location has not been mentioned. The data shared in the report is not clear. At least a yearly average data is required, and the analysis can be done with fewer parameters and locations but with higher frequency.

Overall, the environmental audit report of the textile factory in Tanzania is lengthy but not context-specific. Further, the contents are not well organized. In the absence of proper format and manuals, a good and structured report cannot be produced.

The National Environment Management Council (NEMC), Tanzania could develop a format and manuals to make the environmental audit report more brief, precise and to the point.

1.2 Roadmap for annual audit reporting in Tanzania

Section 48, Part X of the Act states that the Minister has to prepare guidelines on the steps to be followed for conducting an environmental audit. This assumes significance in view of the different units submitting audit reports in detailed formats that could not be used for the regulators to understand the environmental performance of the unit or how to it plans to improve its performance.

Review of the audit reports of a few industries have also highlighted insufficient or improper reporting. It is in this regard, the National Environmental Management Council (NEMC) has requested the Centre for Science and Environment (CSE) to collaborate an prepare the audit manual that will strengthen the system. The data from the exercise can be used for policy decisions.

The following conclusion have been made after review of the audit report. CSE has tried to address them in the following chapters:

1. NEMC should come up with a technical manual detailing the format and information required in an environmental audit report.
2. NEMC should make water audit mandatory for water intensive industries.
3. NEMC should come up with self-audit guidelines for industries in order to ensure that industries collect relevant data which will assist the regulators during audit.
4. NEMC should have a committee of sector-specific experts who can technically review the audit reports and provide suggestions for improving the environmental performance of the industries.
5. NEMC should come up with a strategy to upload the audit reports on their website. The transparency will be helpful as it will involve public participation and feedback and will also help to gaze the performance of an industry in terms of public health.

2. Procedure for conducting an environmental audit

Environmental auditing is a process of checking the balance of resources such as raw material and water as input and yield (product), waste in terms of water, solid and gaseous emissions as an output. In simple words, it is a process to evaluate the loss of resources such as water and raw materials, and fuel usage and yield (product).

Environmental auditing is also intended to identify the status of environmental compliance and management system implementation gaps, along with related corrective actions.

The two major key components of an environmental audit are material balance and water balance. The methodology of environmental audit comprises procedures such as pollution assessment by analysing wastewater characteristics and quantity with respect to each unit process and/or unit operation as well as overall combined flow characteristics, preparation of emission profile from the process as well as from utilities such as boilers, diesel generator (DG) sets etc., performance evaluation of effluent treatment plant (ETPs) and air pollution control devices (APCDs). In addition, the assessment of the impact of environmental pollution to local areas, including concerned waterbodies and neighbourhood air sheds, should be included in the environmental audit.

The input and output matrix of an environmental audit gives a "pollution footprint" for an activity. In order to develop the input and the output matrix of an environmental audit, both qualitative and quantitative databases need to be addressed (see *Table 1: Input and output matrix of environmental audit*).

Table 1: Input and output matrix of environmental audit

Resource	Input	Output
Material balance	i. Quantity of materials consumed per unit of process or per month/year ii. Quantity of fuel consumed iii. Type of fuel consumed and its calorific value	i. Quantity of product produced per month/year ii. Quantity of material loss due to inefficiencies in per unit of production iii. Quantity of pollutants generated per day in the form of solid waste/emissions
Water balance	i. Source of water and its quality ii. Quantity of water consumption per unit of product iii. Quantity of water consumed for utilities, domestic, washing, and other purpose etc.	i. Quantity of wastewater generated per unit of product ii. Quality of wastewater

Steps to conduct an environmental audit

Environmental audit is a process that is generally done in three phases, viz. pre-audit, on-site audit and post-audit.

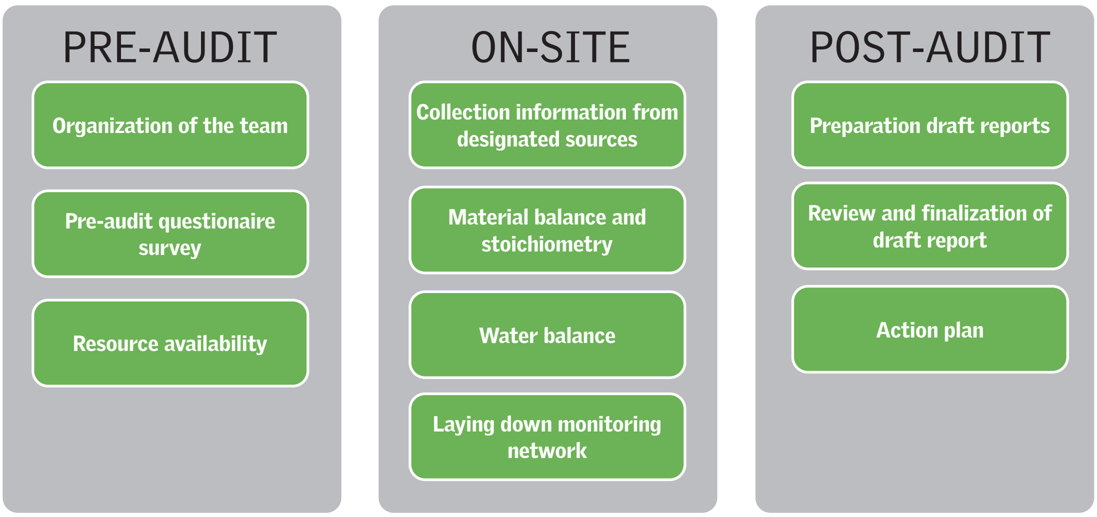
The pre-audit phase is a preparatory phase in which the audit team prepares the plan for conducting the environmental audit and identifies the sources of availability of information, structure of audit team and questionnaire.

The on-site audit phase is when actions are implemented on the ground, site visits are conducted, samples are taken, and evaluation, discussion on issues, and corrective actions are carried out.

The post-audit phase is when the environmental audit report and list of action items are prepared and required follow-up is done.

Each of these phases has several clearly defined objectives, and each objective is achieved through specific actions. These actions yield results in the form of outputs at the end of each phase.

Figure 1: Steps for conducting an environmental audit



Source: Central Pollution Control Board, India

a. Pre-audit activities

The purpose of this stage is to obtain preliminary information and to organize the entire audit process to be carried out. The audit team is also organized as they are the important stakeholders of the industry and shall be considered as team members. The audit team should have a mixture of skills, talents and perspectives.

The tasks involved in the pre-audit activities should be as follows:

i. *Development of questionnaire:* Through questionnaire survey, main areas of consideration are reviewed and identified.

   The questionnaire should be on following subjects:
   - o *Overview and general information*
   - o *Site history and details*
   - o *Process review*
   - o *License permit*
   - o *Air, water and noise pollution*
   - o *Chemical handling and storage*
   - o *Solid and hazardous waste management*
   - o *Occupational health and safety*

The detailed sample audit questionnaire has been attached as *Annexure I*

ii. *Resource availability:* In this process, the available resources are identified and the audit team is prepared and task is assigned to them.

   The focus should be on following activities:
   - *o* *Preparing an audit team with those who have a specialization and understanding of the subject;*
   - *o* *Organizing resources such as laboratory facility and other infrastructure;*
   - *o* *Developing visit programmes with deadlines; and*
   - *o* *Allocating specific tasks to team members.*

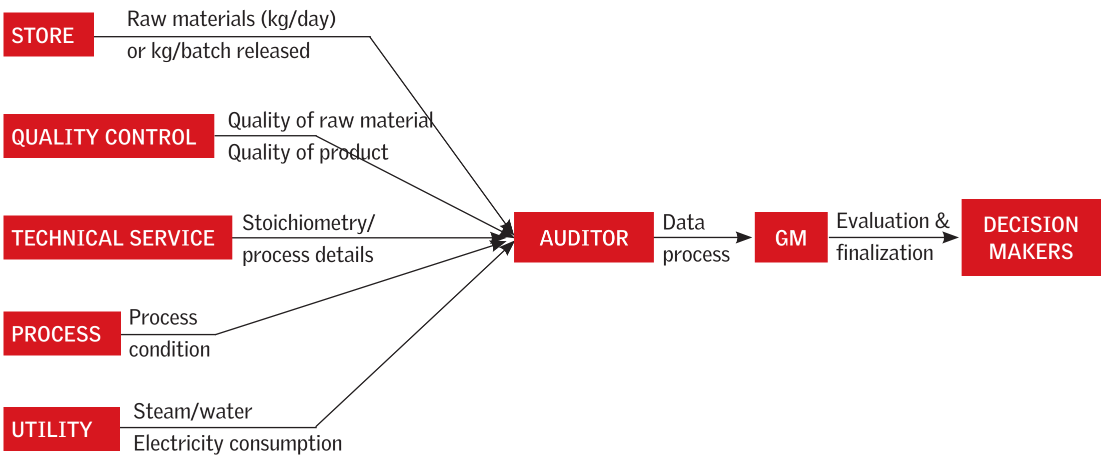
Information and data from different sections of the entity such as store, quality control, technical service, process and utility area are collected and shared with the auditor (see *Figure 2: Information network for material balance*). The data is synthesized and analysed by the auditor, and the auditor shares the information with higher officials such as the General Manager. The management evaluates and finalizes the recommendations given by the auditor.

b. Activities at the site

The tasks involved during the activities at the site are as follows:

i. *Collection of information by interviews with cross section of staff;*
ii. *Verification of material balance, stoichiometry and water balance from records of the industry; and*
iii. *Field inspection by laying down monitoring network.*
iv. *Material balance*

Figure 2: Information network for material balance



Source: Central Pollution Control Board, India

While doing the material balance study at the site, the following tasks should be done:

- Determine process inputs, record waste usage and of recycle and/or reuse;
- Determine process outputs; quantify products and/or by-products; account for wastewater, emission and solid and/or hazardous waste; and
- Incorporate data on process flow sheets, derive material balance.

v. Water balance

While doing the water balance study at the site, the following tasks should be done:

- Identify the sources of water, wastewater and location of flow meters;
- Conduct a walk-through survey, flow measurement, and draw a water distribution network; and
- Collect and synthesize the data, and incorporate the data on water distribution network to derive a water balance.

vi. Waste flow

While understanding the waste flow at the site, the following tasks should be done:

- Identify waste flow lines;
- Obtain details of pre-treatment and final treatment; and
- Obtain details of disposal.

vii. Monitoring and analysis

During the monitoring and analysis activity at the site, the following tasks should be done:

- Design monitoring network for samples of wastewater, solid waste, performance study of treatment facilities and the receiving environment;
- Identify parameters for analysis;
- Determine type and frequency of sampling;
- Analyse sample; and
- Data interpretation

viii. Closing meeting at site

During the closing meeting at the site, the following activities are done:

- Presentation of draft report and discussion with the management to discuss the findings

c. Post-audit activities

The activities after the visit to the site is completed are as follows:

i. Synthesis

- Evaluate performance and adequacy of the waste-treatment facilities;
- Identify the problems related to waste generation, treatment and disposal;
- Segregate waste and identify the waste reduction measures;
- Evaluate the technical and attitudinal capabilities of staff; and
- Formulate recommendations for the best practicable waste management.

ii. Final audit report preparation with recommendations

An audit report should address the following subjects:

- Status of the optimal use of resources such as water usage, raw material consumption, energy consumption and production;
- Performance of pollution control device with respect to air quality, status of air quality around the plant, wastewater treatment quality and ambient water quality in the receiving stream;
- Generation of hazardous waste and non-hazardous and its storage and transportation among the facilities.
- Resource recovery of valuable resources such as solvent metals and chemicals through proper employment of recovery, renovation, reuse, and recycling either within the factory or in other manufacturing process.
- Status of compliance with respect to various license conditions lay down by the concerned regulatory authorities risk reduction in terms of safety and conducting safety audit.

- Status of occupational health of the employee conducted
- Statistical presentation of data with respect to discharging effluent, emission or solid waste generation.

iii. Action plans with time frame for implementation
iv. Follow-up for the implementation of recommendations

2.1 Material balance

The material (mass) balance approach helps to identify the quantity of materials and losses associated with it, as they pass through processing operations. In simple words, it works on the principle of “conservation of mass” and determines the presence, fate and transport of contaminants in the environment.

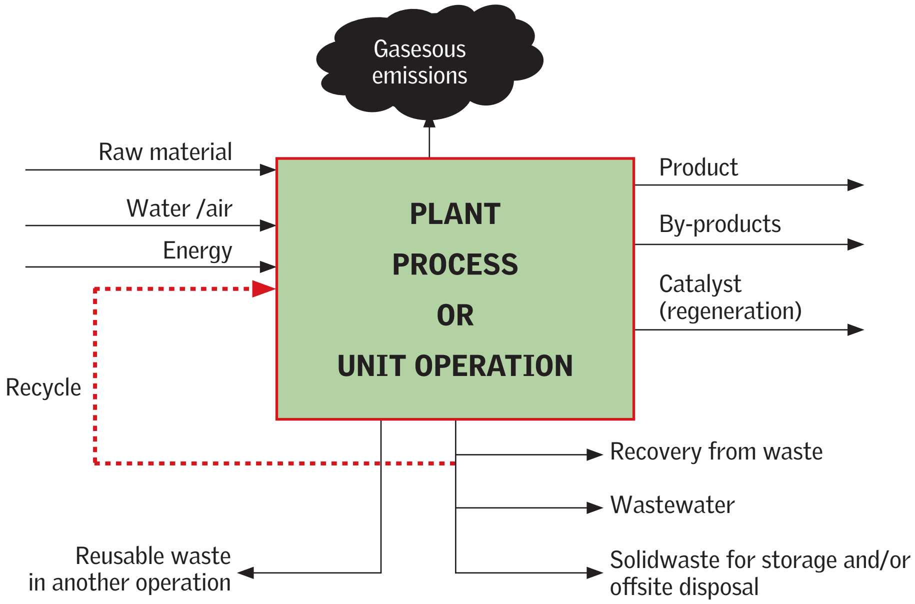
Material balance is an important aspect for any industry to maximize product yields and minimize costs. In order to prepare it, an understanding of unit processes and operations, and type of industrial process is necessary.

The approach for preparing a material balance is general in nature and should be made for all components that enter and leave a process, this exercise will help to establish a focus for waste reduction activities and provides a baseline for measuring performance of the system.

A good understanding of material balance calculations is essential in process design and fundamental to control processing, particularly in the control of yields of the products. The first material balance is determined in the exploratory stages of a new process; improved during pilot plant experiments when the process is being planned and tested; checked when the plant is commissioned; and then refined and maintained as a control instrument as production continues. When any changes occur in the process, the material balances need to be determined again.

Inputs such as raw materials, water, air and energy are used or consumed in the process or unit operation in any industry and the products, and byproducts such as gaseous emissions, wastewater and solid waste are generated. The waste which has a potential of reusing can recycled/reused again in the system or process (see *Figure 3: Material balance approach [unit operation/process wise]*)

Figure 3: Material balance approach (unit process- and operation-wise)



Source: Centre for Science and Environment, India

While developing of material balance may be simple or at times complicated, the basic approach is general. Cases vary from simpler systems such as individual unit operations to the more complicated situations that have various operations.

The increasing availability of computers and software programmes has meant that very complex mass balances can also be set up and manipulated quite readily and therefore used in everyday process management to maximise product yields and minimise costs.

In order to understand material balance, an understanding of terms such as unit operation, unit process and type of industry is necessary. Calculation of material balance needs unit operation and/or a unit-process-wise approach.

WHY IS MATERIAL BALANCE IMPORTANT?

Material balance is of paramount importance for industries for the following reasons:

1. It helps in preparing an inventory accounting system to identify and quantify material used in process, losses (material losses) and emissions, effluents and /or solid waste.
2. It is useful for monitoring improvements made in an ongoing project while evaluating cost–benefit.
3. It helps reduce the carbon footprint of the system in the long term and enhance sustainability aspects.

Unit operation is a basic step in a process which involves bringing a physical change such as separation, crystallization, evaporation, filtration, etc. A process may have many unit operations to obtain the desired product. For example, in the milk-processing industry, homogenization, pasteurization, chilling and packaging are each unit operations which are connected to create the overall process.

Unit process is a process in which chemical changes take place to the material present in the reaction and result in the chemical reaction known as the unit process. This basically consists of a reaction between two or more chemical which results in another chemical. Some of the chemical reactions involved in unit process are oxidation, halogenation, sulphuration, nitration, etc. are involved.

Not only knowledge of unit operation and unit process, but knowledge of type of industry is also required for preparing a material balance.

Types of industry

There are broadly two types of industries that need to be considered while preparing a material balance—one is the processing industry and the other one is the synthetic industry. The processing industry works on the concept of *"whole to part"—i.e.* from a single entity multiple products are formed—while the synthetic industry works on the concept of "*part to whole*", i.e. from the combination of different materials a new product is formed.

Processing industries are those in which processing of raw materials takes place through different stages of production (from whole to part). Examples of processing industries are milk processing, food processing and fruit processing industries and oil refineries. Material balance should consider aspects such as batch or continuous processing.

In synthetic industries, two or more materials are combined to form a new product (part to whole). Examples of synthetic industries are breweries, cement industry etc.

2.1.1 Case study of material balance in a coal-based sponge iron industry

Sponge iron is produced by direct reduction of iron ore in the presence of coal and air. In the last few years, sponge iron has emerged as an alternative raw material for steel making. The Indian government has recognized sponge iron as a vital sector for growth of Indian steel industries. With the increase in input cost of raw materials and decrease in selling price, however, the industry is struggling for survival.

The sector grapples with several problems such as lack of proper integration of heat energy, obsolete technology, non-optimal operation of equipment etc., making the manufacture of sponge iron less profitable. Thus there is ample scope to apply modern technology to this industry and make it more competitive by cutting down its internal losses.

A study was conducted in an Indian sponge iron plant, with a capacity of 500 tonnes per day. The main objective of the study was to reduce energy losses and find ways to increase efficiency in the plant through design modifications.

In order to estimate fuel requirement and to find kiln efficiency, a material and mass balance was made based on the data of the plant, and investigations were done. Components such as iron, gangue, carbon and ash are considered for mass balance as these are the main components of feed material, which is composed of iron ore, coal and dolomite (see *Table 2: Material balance of a coal-based sponge iron industry*).

Table 2: Material balance of a coal-based sponge iron industry

Material	Input	Kg/h	Output	Kg/h
Iron	Fe 0.63 30,000	18,900	Fe_M 18,900 x 0.835 Fe in FeO 18,900 x 0.09 Fe lost in dust 3159x0.424x112/160 as Fe_2O_3 Other losses by difference	15,781.5 1701 937.59 479.9
	Total	18,900		18,900
Gangue	From ore 30,000 x 0.0406	1218	In sponge iron 0.0462x189,000 Lost in flue dust	873.18 344.82
	Total	1218	-	1218
Carbon	F.E. coal 13,990 x 0.606 I.C. coal 7730 x 0.6221 Limestone 600 x 0.28 x 12/56 F.C. in F.E. coal C in F.E. coal V.M. F.C. in I.C. coal C in I.C. coal V.M.	84,77.94 48,08.833 36 5728.905 2749.035 3331.63 1477.203	C out in char 2900 x 0.285 C out in flue 3159 x 0.1348 dust C in sponge 18,900 x 0.0017 C consumed in reaction to form CO C burnt to CO_2 V.M.C. burnt to CO and CO_2 Unburnt V.M.C. C in CO_2 from limestone	826.5 425.83 32.13 5404.77 2371.3 967.478 3258.76 36
	Total	13,322.77		13,322.77
Coal ash	Ash in F.E. coal 13,990 x 0.2374 Ash in I.C. coal 7730 x 0.2129	3321.226 1645.717	Ash in char 2900 x 0.696 Ash in fly ash 3159 x 0.3594 Free ash to cooler	2018.4 1135.345 1813.2
	Total	4966.943		4966.943

Note: I.C.: injection coal, F.E.: feed end, V.M.C.: volatile matter carbon.

Source: Nishant R. Dey, Anil K, Prasad and Shravan K,. Singh, Energy Survey of the coal based sponge iron industry, 2015

Table 4 clearly shows that an appreciable portion of the energy is lost in the rotary kiln and a significant amount of heat is also lost with waste gas. The analysis also highlights that the large amount of coal is being utilized for preheating the feed material and air which otherwise could have been saved.

Key highlights of the study

After analysing the material, mass and energy balance, the thermal efficiency of the plant was calculated to be around 51.3 per cent, which seems low, but since the reduction reactions require such high temperatures, energy losses are inevitable.

Through a material balance study, it was found that 24.9 per cent less coal is required by the industry to produce sponge iron. The study also revealed that water requirement should be around 43 tonne per hour instead of 57 tonne per hour, and waste generation should be around 118.6 tonne per hour instead of 157.9 tonne per hour.

A material and energy balance around the kiln indicated that due to chemical reactions and combustion, heat generated inside the kiln is 272 gigajoule per hour (GJ/h), which is the total theoretical energy required for the kiln. However, actual energy consumption in a conventional plant in the kiln works out to 498 GJ/h. This value is 45.2 per cent more than the theoretical energy consumption.

The material balance study helped the coal-based sponge iron plant to find out the possible ways to reduce energy consumption, water consumption, and waste gas generation.

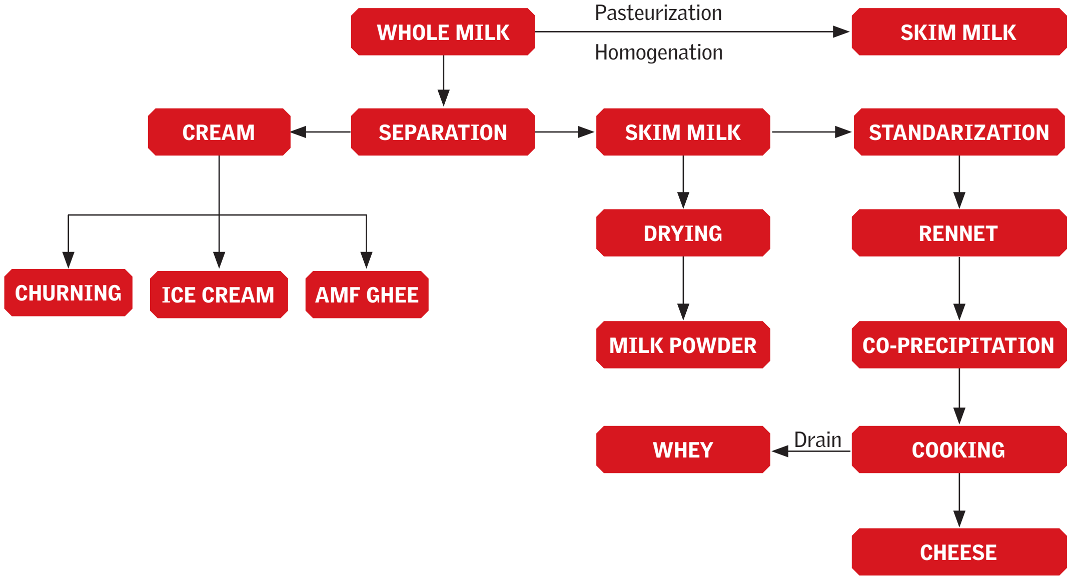
2.1.2 Approach for developing a material balance in the case of processing industry

The material balance for the processing industry shall be developed in two steps—the first is drawing a flow diagram with identification of the process as well as waste generation, and the second is highlighting the material loss in the process.

Identification of process and waste generation

In the case of the processing industry, the material balance can be prepared on the concept of "whole to part". This is illustrated with the case of milk-processing industry, where from the whole milk which contains fat and solid non fats (protein) (see *Figure 4: Flow chart of milk-processing industry*). Whole milk (full-fat milk) can be sold as it is after pasteurization and homogenization.

Figure 4: Flow chart of milk-processing industry



Note: AMF : Anhydrous milk fat
Source: Central Pollution Control Board, India

Whole milk can also be separated to get cream and skimmed milk. Churning of cream produces butter and butter milk and the cream can also be used to produce ice cream or anhydrous milk fat (ghee).

Skimmed milk contains more protein and less fat than whole milk. It is dried to get a milk powder. In addition, after standardization of skimmed milk, products such as cheese, cultured products and yogurt are produced. These cultured products are renneted, co-precipitated and cooked to form casein.

In the entire process of the milk-processing industry, whey comes in wastewater from the factory, with higher concentration of BOD, COD, and it needs to be collected and treated. Since the process is in batches, the reactor needs to be cleaned after every batch, thus generating the wastewater.

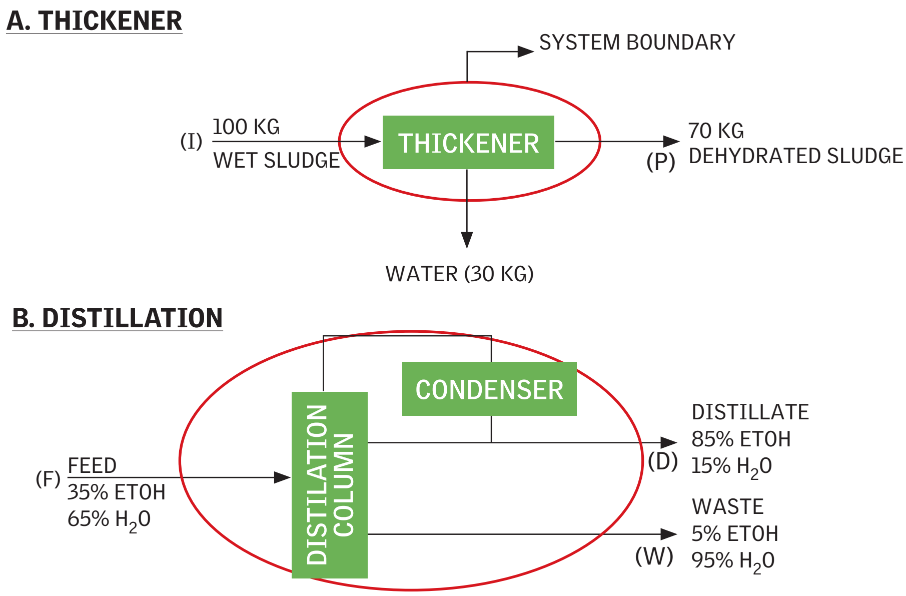
Material loss in the process

Material balance is an exercise which help us identify and quantify the losses in the system and can be understood from the following basic equation:

Input = Products + waste/losses + changes in stored materials

Figure 5 shows the material balance of a processing industry, where wet sludge—the input (100 kg)—is passed through the thickener and water (30 kg) is released

Figure 5: Material balance for processing industry with unit operations



Source: Central Pollution Control Board, India

as waste and dehydrated sludge (70 kg) is the product. In the case of distillation, feed (F) is fed to the distillation column and after it passes through the condenser, distillate is produced as the product and waste as the by-product of the process.

2.1.3 Approach for developing a material balance in synthetic industry

The steps in developing a material balance for a synthetic industry comprise writing the equation of the process, stoichiometric analysis, preparing the sequential flow diagram showing the wastewater generation, emission of gases and waste generation.

In the case of the synthetic industry, the study of material balance helps in determination of the quantity of raw material used and yield obtained. Ideally, there is 100 per cent conversion of raw material into products, i.e. **no loss means no pollutants**.

The different cases of material balance in a synthetic industry are as follows:

Case I: A + B = P

Where,

A and B are raw materials,

P is the product

If raw materials A and B are utilised 100 per cent to manufacture the product, it indicates that there is no loss of raw materials to products, which is practically not possible. Thus, it can be inferred that some losses are there.

Case II: **(A - X) + (B - Y) = (P - Z)**
Where
X, Y, and Z are the pollutant losses in the form of solid, liquid, and gases to the environment

Besides the limitation of the reaction mentioned in Case I, there are two factors that are responsible for generation of pollutants. These factors are impurities of raw material and limitation recovery of product.

Case III: **(A+ a) + (B + b) = (P - p)**

In this case, the raw materials are in excess as compared to the stoichiometric requirement. Such cases are predominant in synthetic organic chemical manufacturing industries such as pesticides, bulk drugs, basic organic chemicals etc., where a and b are excess raw material and p is unrecovered product.

In the case of the synthetic industry, the material balance is made on the concept of "part to whole", where the reactants in a reactor produce a new product. To understand the concept of material balance in the case of synthetic industry, a case of DDT (dichlorodiphenyltrichloroethane) manufacturing has been discussed in the following.

Writing the chemical equation and stoichiometric analysis
The following chemical reaction is the step-by-step production of DDT along with the stoichiometric requirement.

The production of DDT takes place in four stages, including:
- First is the formation of monochlorobenze through chlorination of benzene;
- In the second stage, chloralcholate is produced by reaction of ethanol taking place with chlorine;
- In the third stage, chloralcholate breaks downs in the presence of oleum to form chloral; and
- In the final stage, chloral reacts with monochlorobenze to produce DDT. This is clearly mentioned below in the reaction.

Once the stoichiometric balance is made, the presentation is made in form in the form of a sequential diagram to highlight the manufacturing process.

C_6H_6 (78.1)	+	Cl_2 (70.9)	$\longrightarrow$	C_6H_5Cl (112.5)	+	HCl (36.5)
$2C_2H_6$ (92.1)	+	$4Cl_2$ (283.6)	$\longrightarrow$	$CCl_3CH(OH)OC_2H_5$ (193.5)	+	$5HCl$ (182.2)
OLEUM $CCl_3CH(OH)OC_2H_5$ (193.5)			$\longrightarrow$	CCl_3CHO (147.5)	+	$C_2H_5OSO_3H$ (126)
CCl_3CHO (147.5)	+	$2C_6H_5Cl$ (225)	$\longrightarrow$	$H2SO_4$-SO_3 $(C_6H_5Cl)_2CHCCl_3$ (354.5) DDT	+	H2O (18)

Sequential flow diagram

The sequential diagram illustrates the sequence of process taking place one after the other, in general it highlights the interaction between one and the other process.

Figure 6 clearly highlights that how products such as monochlorobenzene and dichlorobenzene and by-products such as vapours, etc. are formed in a sequential manner.

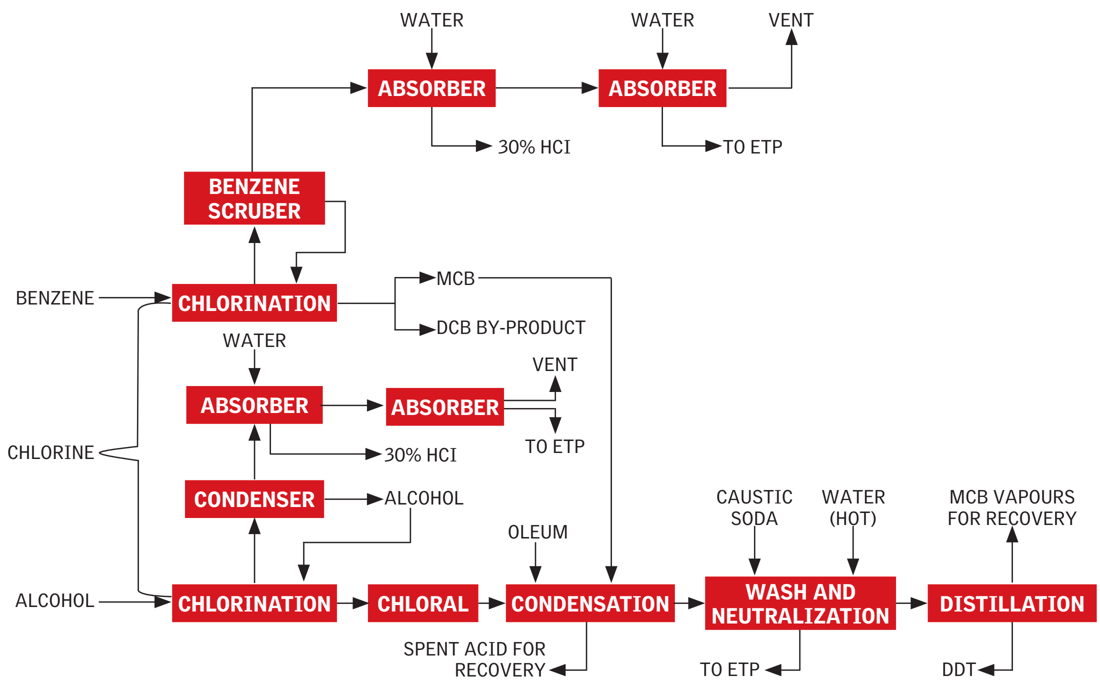
Based on the aforementioned chemical equations, the details of stoichiometric requirement are discussed in Table 3. The table highlights comparison of the raw material requirement at stoichiometric versus actuals, along with the excess percentage consumption.

From Table 3, it can be inferred that excess benzene is consumed in the formation of DDT (actual consumption is higher than the stoichiometric requirement). Excess of benzene is required to get monochlorobenzene, otherwise the chances of formation of dichloro-, trichlorobenzene cannot be avoided, and the excess benzene needs to be recovered.

Excess chlorine is used to form chloralcholate as a product and chlorine is released as HCl and needs to be recovered.

Excess consumption of ethanol needs to be optimized and it should be closed to the stoichiometric requirement and needs to be recovered.

Figure 6: Sequential diagram for manufacturing of DDT



Source: Central Pollution Control Board, India

Table 3: Raw material requirement: stoichiometric versus actual

Raw material	Stoichiometric requirement (kg)	Actual requirement (kg)	% extra consumption
Benzene	440.7	780.7	77.1
Chlorine	1,200.2	1,773.24	47.7
Ethanol	259.9	409.00	57.4
Oleum (20%)	-	1,580.58	-

Source: Central Pollution Control Board, India

2.2 Water balance

Water balance is an accounting exercise to keep track of inputs and outputs of water flow in a system. In order to prepare a water balance, the focus should be on inflows, outflows and storage, changes and/or losses in a system. It helps us identify the unknown component of the equation (leakages and losses) provided that other components of the equation are known with accuracy.

The main objective of making a water balance is to prepare a long-term sustainable water-management plan. Therefore, knowledge of consumption pattern of water in industry is necessary. Generally, the major water-consuming areas are the cooling water system, fire water tanks, demineralization plant, process water, service water and sanitary water.

Similarly, wastewater generated depends on the pattern of water consumption, and wastewater is generated from different sections of the manufacturing industry in the form of cooling tower blowdown, demineralization plant regeneration wastewater and boiler blowdown, wastewater from the process area, service area, storm water and sanitary wastewater, etc.

The basic equation of preparing a water balance is as follows:

Water inflow	=	**Water outflow**	+	**Losses**
(water going in a system)		(water leaving a system)		(losses in terms of leakages, etc.)

Water balance diagram
In order to prepare a water balance diagram, a water audit exercise must be done. Water audit is a systematic tool for obtaining a water balance by measuring flow of water from the site of water withdrawal or treatment, through the distribution system, and into areas where it is used and finally discharged. A water audit typically involves a more comprehensive, time-intensive, facility-wide effort to assess a facility's water use and efficiency-improvement opportunities.

A water balance diagram helps to visualize about what quantity of water is utilized in making a particular product and helps in identifying whether the product is sustainable or not in terms of water consumption, and steps can accordingly be taken to reduce the water footprint. Simply, it provides a solid framework for systematically acquiring, quality controlling and analysing water-related information and evidence.

A water balance diagram helps in the following ways:

1. **Gives visibility:** It gives us visibility in terms of achieving goals to reduce the specific water consumption, and helps in calculating the current and historical water use, water flows and pressures.
2. **Identifying water losses:** It help us to identify the leakages and unidentified water losses, suitability of existing fixtures, fittings and tap-ware, areas of non-compliance, operating hours.

3. **Evaluating alternative processes:** It provides assistance in evaluating the alternative processes and practices for water-saving measures and upgradation of technology.
4. **Preparing water audit report:** It helps in preparation of water audit report along with cost–benefit analysis including Return on Investment (ROI), highlighting the environmental benefits.

2.2.1 Why conducting a water audit is important?

A water audit is a fact-finding exercise and should become a regular exercise in industrial premises on the basis of the assumption that **what gets measured, gets managed.**

A water audit starts at the point where water enters the premises and goes up to the point where the wastewater is discharged, including all aspects of use. It critically examines existing treatment systems and practices and recommends changes to improve efficiency and reduce usage. This exercise can be conducted internally by the entity as well as externally by the third-party auditors.

With the help of this tool, quantitative and qualitative analysis of water consumption can be done, losses can be identified and options for water conservation by means of recycling and reuse of water can be explored.

Conducting a water audit is therefore important for the following reasons:
1. It serves as a framework for assessing a utility's water loss situation in a system.
2. It reveals the availability and/or reliability of data and level of understanding.
3. It provides direction and recommendations for improvements to reduce water losses, leakages, etc.
4. Improves knowledge and documentation of the distribution system and helps to generate data from various sections of the entity.
5. It serves as a tool for benchmarking, and the specific water consumption values can be compared with different entities of the same size and with the same process.
6. It helps prioritize important areas and direct investment of funds where water saving schemes can be implemented.
7. It helps to creates awareness about water-related problems or issues, and in the long term water security can be achieved.

Scope and methodology of water audit

The scope of work of a water audit conducted at any complex or industry broadly includes the following steps:

I. Assessment of water inventory

a. Study of water sources (size, capacity, quantity and quality);
b. Existing water distribution system, associated losses;
c. Water usage for process, utilities, domestic and other areas; and
d. Wastewater discharged points across the process.

II. Process mapping and development of water balance across the entire system

a. Identification of water consumption of each existing meter/sub-meter;
b. Quantification of water distribution network in each section; and
c. Mapping of raw water, process, recirculating water, cooling and domestic uses, recycling and effluents (size, capacity, quality and quantity).

III. Assessment of prevailing wastewater system

a. Segregation and collection of waste streams based on quality and quantity; and
b. Study of various treatment and disposal schemes.

IV. Suggestion for water conservation (based on 4R [recovery, renovation, recycling reuse]) with cost–benefit analysis and the required investment

a. Identification and recommendations of projects based on reduce, reuse and recycle on water conservation;
b. Return on Investment (ROI) and payback period calculations, discussion with vendors; and
c. Presentation and discussion with the plant team on audit findings.

Methodology for conducting a water audit

A water audit is conducted into two levels, level 1: Preliminary water survey, and level 2: Detailed water audit.

Preliminary water survey

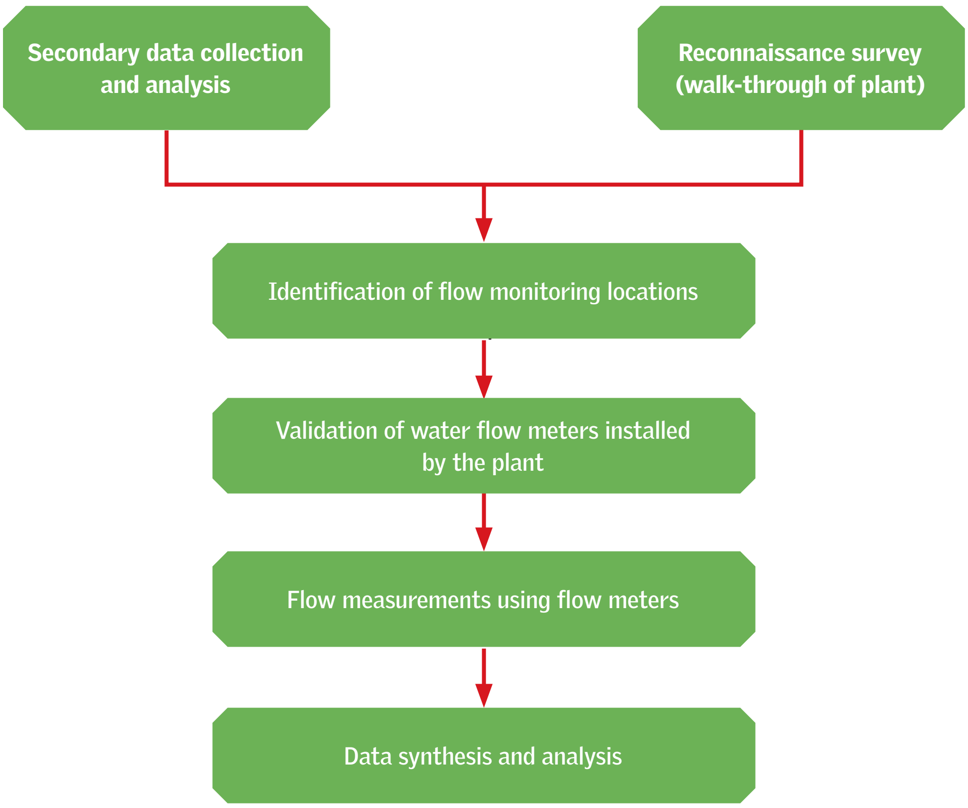
In the preliminary water survey, the visit is made to the industry and background information—such as total plant area, number of employees, brief of manufacturing process, sources of water supply, status of water metering, total freshwater consumption, wastewater generation, cost of raw water, capacity of effluent treatment plant and sewage treatment plant and the list of good initiatives taken by the plant to conserve water—is collected.

Detailed water audit

After the preliminary water survey, and once the basic information is received, a detailed water audit is conducted. The steps involved in this are:

- Secondary data collection and its analysis: A detailed questionnaire is shared with the industry by the auditors and secondary data is collected. The flowmeter readings of flow meters located at various locations such as bore wells, process areas, utility areas, ETP and STP are taken. In addition, information on cooling tower and boiler blowdown and other aspects is also collected.
- Reconnaissance survey: In the reconnaissance survey, a walkthrough of the plant premises is done to understand the water flow network and water distribution or water circuit diagram is prepared.
- Identification of flow meter location: After the reconnaissance survey, the location of flow meters installed at the plant premises are identified and the validity of the location evaluated.
- Validation and flow measurements of flow meters installed by the plant: The validation of installed flow meters should be done using an ultrasonic flow meter. It will help to understand the status of calibration of flow meters installed in the plant premises and help to identify the leakages as well as losses in the system.
- Data synthesis and analysis: After the flow measurement is conducted, and the plant meter reading with the reading of ultrasonic flow meters compared, the

Figure 7: Procedure for detailed water audit



deviation is calculated and data is synthesised and analysed and water balance is prepared highlighting the location of flow meters and the quantity of water used in differed areas.

The methodology for conducting a water audit comprises the following steps:

Step 1: Walk-through survey of the facility
This is done to understand the locations of various water supply sources, schematic layout of water supply pipeline networks, intake of raw water, process water use and water and wastewater treatment systems, etc.

The following activities are covered in this step:
- Understanding of existing water sourcing, storage and distribution facility;
- Assessing the water demand and water consumption areas/processes within the facility; and
- Preparation of detailed water circuit diagram based on water supply network.

Step 2: Secondary data collection through discussion with plant executives, past records, available technical literature/specifications
This entails collection of secondary data information covering aspects related to layout of the plant and different unit processes, source(s) of water, supply schematics and available instrumentation along with technical details related to supply (such as capacity of pumps); water supply network diagrams and operational capacities, etc. Additionally, the following data is collected for analysis:
- Historic water use and wastewater generation to analyse the trend in consumption and generation;
- Metered and unmetered supplies within the plant;
- Freshwater treatment scheme and cost—type, quantity and cost of chemicals used for treatment;
- Understanding of "base" flow and usage trend at the site;
- Past/old water bills of the plant; and
- Wastewater treatment scheme and cost of treatment—type, quantity and cost of chemicals used for treatment

Step 3: Site water audit planning (based on site operations and practices)
For planning the site visit, the preparation in advance should be done. Instruments such as flow meters should be charged and calibrated, plans and maps of the premises should be understood and the following activities should be done:
- Preparation of water flow measurement plan to quantify water use at various locations;

- Identification of wastewater flow measurement and sampling plan; and
- Use of instruments like ultrasonic water flow meter, stop watch, measuring cylinders, power analyser etc.

Step 4: Conducting detailed flow measurements and establishment of water balance and water consumption pattern

To conduct flow measurements, ultrasonic flow meters with flow transducers to measure the velocity and flow of water in pipelines are used. The thickness of pipes is also measured through a thickness gauge transducer. Based on the measured velocity, cross sectional area and pipe thickness values, the flow of water in the pipelines at various selected monitoring locations is estimated. The task/activities listed below should be done:

- Conducting field measurements to quantify water/wastewater streams;
- Power measurement of pumps/motors;
- Measurement of suction and discharge pressure at various pumps;
- Wastewater sampling and analysis;
- Preparation of water balance diagram;
- Establishing water consumption pattern;
- Evolving value added "cost of water" at various end-use locations; and
- Detection of potential leaks and water losses in the system.

Step 5: Water and wastewater quality characterization

The assessment of the water quality is done to characterize and understand the quality of water being used at different process locations as well as the quality of wastewater being discharged and to assess performance and efficacy of various systems, including the cycles of concentration (COC). Also, drinking water is assessed for its portability.

The samples are collected from drinking water, process water and wastewater locations. From each location, representative water samples are collected and transported to the laboratory with the desired preservatives and within the prescribed time preference for testing of different physiochemical and bacteriological parameters.

Relevant field tests, namely, pH, TDS, temperature, BOD, COD, oil and grease are carried out and recorded for each sample from the different plant-level sources.

Step 6: Data analysis and preparation of detailed water audit report

The final part of the water auditing is to analyse the collected data and prepare a holistic water audit report in a proper format highlight the key opportunities to conserve water with cost–benefit analysis and recommendation to reduce water leakages and losses.

The following activities should be done:
- Documentation of collected and analysed water balancing and measurement details; analysis of secondary data and field survey and measurements;
- Determining key opportunities for water use reduction, reuse and recycling with payback;
- Listing opportunities identified for water conservation based on cost–benefit analysis of each identified option; and
- Making recommendations to maximize water savings and minimize/eliminate water losses.

2.2.2 Case study of water audit

The water audit study was done in a gum and candy manufacturing unit in India and the plant had a consent to withdraw 335 m^3/day of freshwater from three bore wells available in the plant premises. But the plant was consuming approximately 248 m^3/day of water for plant operations, of which the entire demand was met from borewells.
The industrial wastewater generated in the plant was reused as make-up water to cooling towers. The plant is a zero-liquid unit (it has installed a two-stage stage RO followed by multi effective evaporators) while domestic sewage is 42 m^3/day, which is treated in the STP.

For conducting the water audit study, the data on borewell flowmeter readings and peizometer readings was collected from the plant personnel. Flow measurements were done using the ultrasonic flowmeters at the borewells, water treatment plant, inlet of raw water tank, and at other suitable locations where plant flow meters were available and were validated by the auditors. In addition, water quality testing was done for both fresh as well as wastewater.

Figure 8: Water balance diagram shows the location of flow meters and water consumption in different sections of the plant such as softeners, boilers and cooling towers for industrial purposes; drinking and gardening for domestic purposes; and wastewater generated from the effluent treatment plant (ETP) and the sewage treatment plant (STP).

Key findings of the water audit study

1. The water audit exercise showed that the domestic water consumption of the plant was high, around 42 litre per capita per day (lpcd) against the standard of 30 lpcd.

2. The condensate generated water from the air handling units (AHU) section is drained to the storm-water pond and then to the ETP. The quality of the AHU condensate is good.
3. Around 46 m^3/day of soft water and 104 m^3/day of water (from MEE + RO) goes to the cooling tower as make-up, which is a major area of water consumption.

After analysing the data and water balance, the auditors gave their recommendations to the industry to reduce domestic water consumption by installing water-saving devices. Direct use of air-handling units (AHU) condensate can be done in cooling tower make-up as it is of good quality and water-cooled chillers can be replaced with air-cooled chillers wherever possible.

Based on the above recommendations, around 45 per cent saving can be achieved in raw water/freshwater and in monetary terms Rs ~ 0.5 million/annum cost savings can be achieved.

2.3 Pollution assessment, performance evaluation of treatment system and waste management

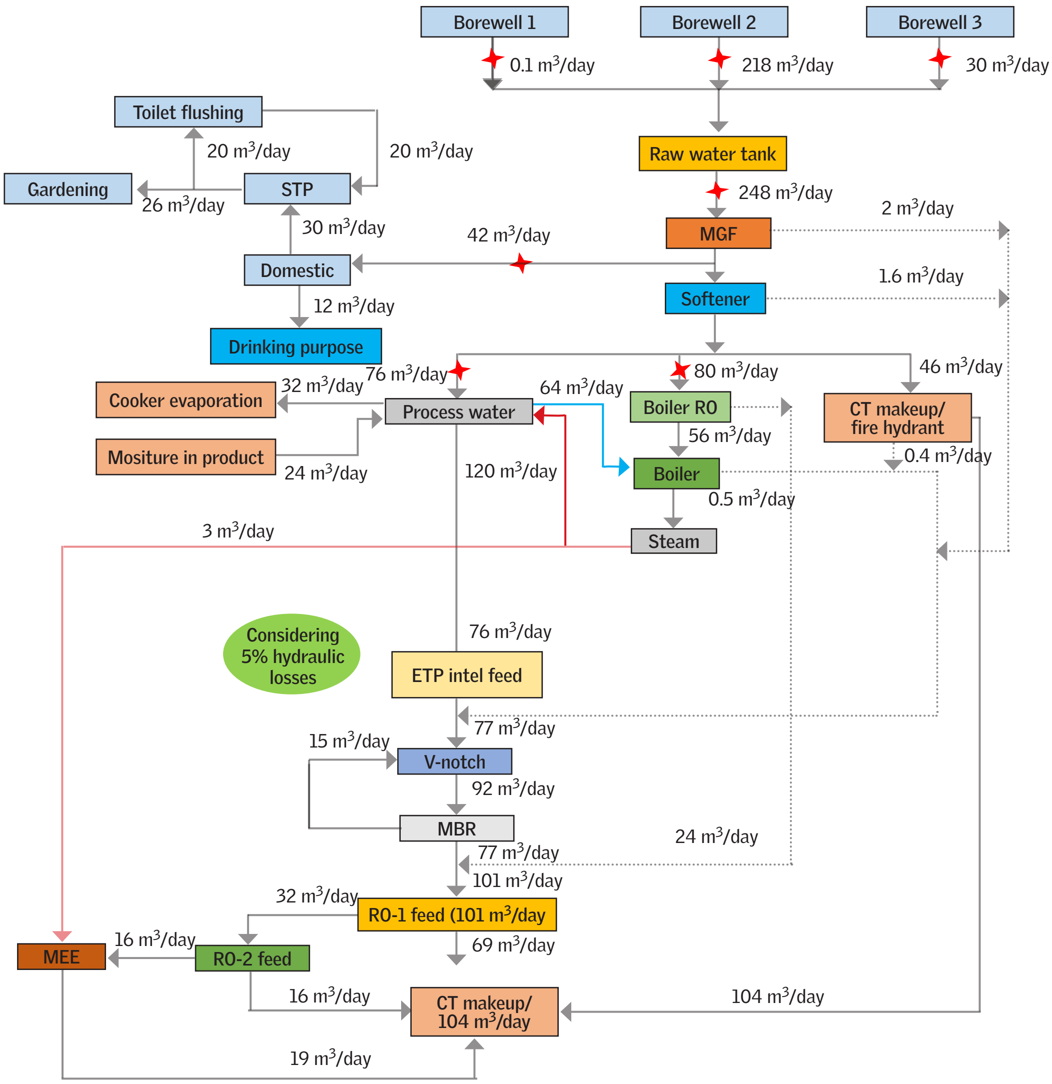
To assess the pollutants generated in the form of solid, liquid, and gaseous emissions due to excess use or unused raw materials and water, a pollution assessment and performance evaluation study is requisite. This exercise will not only focus on the material and water balance but will also help to reduce the burden on the environment.

Simply, if the pollutant is treated, it will be cost-prohibitive but if it is reduced it will be cost-effective and will ensure regulatory compliance, reduce environmental burden and increase optimization of resources.

In order to develop pollution assessment, performance evaluation of treatment system and waste management schemes, the first step is to develop a sequential diagram. The source of emissions, solid waste, and wastewater generation with respect to each unit operation/process and sampling locations should be identified and highlighted in the sequential diagram for monitoring. Additionally, assessment should be done for the installation of pollution control devices (PCDs) and effluent treatment plant (ETP) and its performance assessed.

The case of pollution assessment has been highlighted in the figure 8, where the sequential diagram of DDT production has been shown. In the second step, the emission sources and wastewater generation points are highlighted. In case of

Figure 8: Water balance diagram



Source: Centre for Science and Environment, India

emissions, the possible air pollutant and control system needs to be identified, followed by the third step, where attempt is made to quantify the air pollutants emitted.

Process emission—Type and control equipment

Table 4: Process emission—Type, source and control equipment summarizes the emission profile of a DDT plant. It shows that different source of emissions is released from various sections such as MCB, CA house chlorinator, and grinding sections of a DDT unit, and highlights the different types of emissions, such as

Table 4: Process emission—type, source and control equipment

Source of emissions	Type of emissions	Control equipment	Remarks
MCB (monochlorobenzene)	Emission vapour	Benzene scrubber	Chimney for monitoring emissions, with suitable chimney height, is to be provided.
	Chlorine gas	Water absorber to scrub HCl and produce 20 per cent acid as a by-product	-Do-
	HCl gas	Tail gas absorber where gas is further scrubbed with water	-Do-
CA house chlorinator	Alcohol vapour	Alcohol vapour to be removed using cooling water and brine	-Do-
	Chlorine gas	Water scrubber to absorb HCl gas and produce 30–35 per cent acid as a by product	-Do-
	HCl gas	Tail gas absorber, where gas is further scrubbed with water	-Do-
Grinding section	HCl gas, dust of DDT and inert	Dust extraction system with hoods, ducts, cyclone separator and a chimney height of 55 metre	-Do-

Source: Centre for Science and Environment, India

chlorine gas, alcohol vapour, HCl gas, dust and inert of DDT that are generated. It suggests ways to control the emissions with various air pollution control equipment such as scrubbers, gas absorbers, dust extraction system with hood etc. before they are released them into the environment.

Wastewater generation profile

After emissions, the next aspect for consideration is the wastewater generation profile. A monitoring network should be designed to allow identification of the specific source as well as the combined wastewater treatment facility network. The wastewater generation profile highlights the collection and treatment facilities—these facilities are the important components. The wastewater generation profile reflects the input (water use) and output (wastewater) and distribution of water.

The monitoring network design has the following three main components:

- Location of monitoring points
- Selection of parameters
- Frequency of sampling

Performance evaluation of ETP

After the wastewater generation profile is made, the performance of the effluent treatment plant (ETP) needs to be evaluated. The performance of the ETP shows its efficiency in removing the BOD, COD, phosphates and various other parameters from wastewater and making the wastewater fit for discharge into waterbodies or on to the surface.

By improving the performance of the effluent treatment plant, reduction in operating costs can be achieved as well as compliance with discharge consent conditions and minimizing environmental pollution.

In addition, ETP is required by industries for the following reasons:

a. To clean industry effluents and recycle it for further use;
b. To reduce the usage of fresh/potable water in industries;
c. To cut expenditure on water procurement;
d. To meet the standards for emissions or discharge of environmental pollutants from various industries set by the government and avoid hefty penalties; and
e. To safeguard environment against pollution and contribute in sustainable development

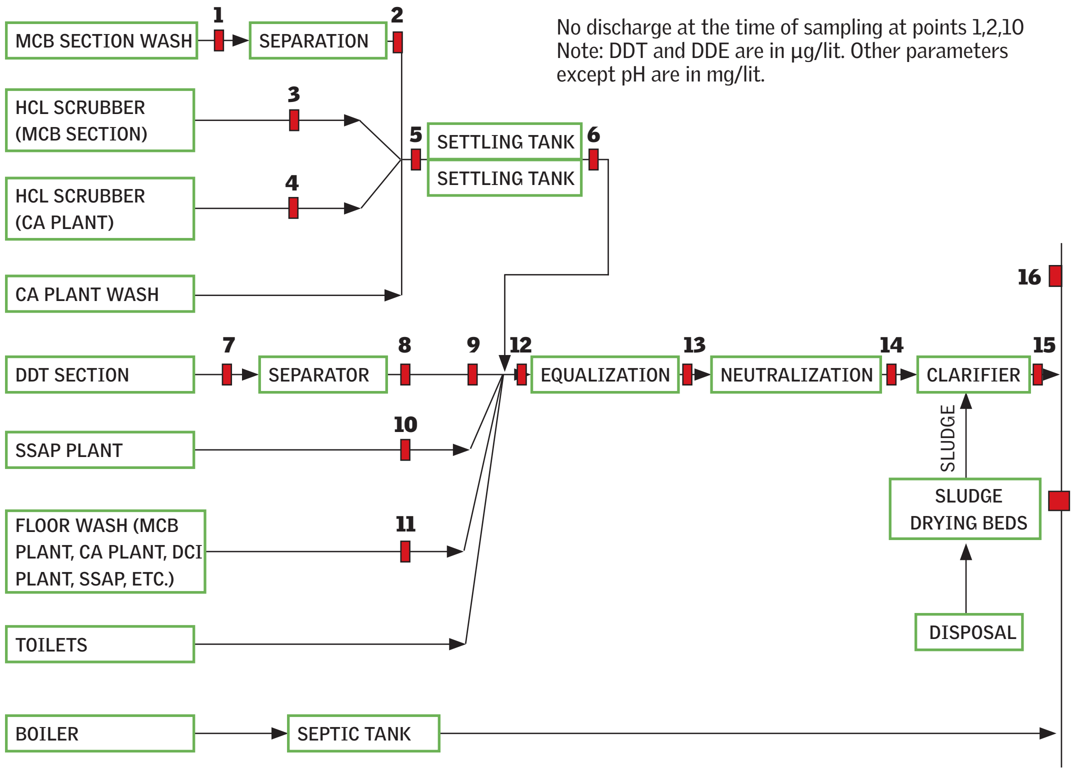
Table 5: Parameters to be tested and their frequency at ETP highlights the various sampling locations at the effluent treatment plant (ETP) such as before the equalization tank, after the equalization tank, after the neutralization tank, after clarification, downstream and upstream sections.

Table 5: Parameters to be tested and their frequency at ETP

S. no.	Sampling location	Parameter	Frequency
1	Before equalization tank (combined wastewater)	pH, SS, chloride, sulphate, COD, DDT, DDE	Once a day, eight hours composite sample
2	After equalization tank, before neutralizsation	pH, SS, COD, SO_4, chloride	Once a day, eight hours composite sample
3	After neutralization, before clarification	pH, SS, COD, SO_4, chloride	Once a day, eight hours composite sample
4	After clarification	pH, SS, chloride, sulphate, COD, DDT, DDE	Once a day, eight hours composite sample
5	Downstream	pH, SS, chloride, sulphate, COD, DDT, DDE	Grab sampling, once a week
6	Upstream	-Do-	Grab sampling, once a week

After testing the wastewater quality at these locations at a regular interval, will help to identify the performance of the ETP and comment can be made on the removal efficiencies (see *Figure 9: Spatial distribution of sampling location*).

Figure 9: Spatial distribution of sampling location



Source: Central Pollution Control Board, India

Hazardous waste management

After the performance of the ETP is evaluated, the last component of pollution assessment strategy is the hazardous waste management system.

Hazardous waste, simply, is non-biodegradable, persistent in the environment and deleterious to human health or natural resources. It can be in the form liquids, solids, gases, sludge, discarded commercial products (e.g., cleaning fluids or pesticides), or by-products of manufacturing processes. The management of hazardous waste includes collection, recycling, treatment, transportation, disposal and monitoring of wastes disposal sites.

In general, hazardous waste can be classified into following categories known as CRIT:

a) **Corrosive:** This type of waste eats away at other materials like metal;
b) **Reactive:** This type of waste violently reacts with elements like air or water;
c) **Ignitable:** Includes materials flammable at low temperatures; and
d) **Toxic:** Includes poisons with immediate, long-term and/or chronic health effects.

Hazardous waste generated from the DDT industry should be given special treatment and should be scientifically disposed of (see *Table 6: Management of hazardous waste*).

Table 6: Management of hazardous waste

Source	Characteristics	Special treatment	Disposal
ETP sludge	DDT, DDE	To be suggested by auditor	Stabilized with mixing agent and disposed in secured landfills
Used containers	-	-	Sent to supplier

Source: Central Pollution Control Board, India

3. Self-regulation—A tool for environmental audit

A study of the section on the procedure for conducting the environmental audit shows that industry should be an effective partner with the audit team in order to collect and share the requisite database and integrate with various departments. Further, effective audit also needs a historical database so that quantification can be statistically stabilized with an acceptable variation. Thus, industry must have a self-regulation mechanism to keep a record of the performance, ensure compliance and effective utilization of resources.

Self-regulation is a process whereby members of an industry monitor their own adherence to legal, ethical or safety standards instead of having an outside, independent agency such as a third-party entity or governmental regulator monitor and enforce those standards. It is a monitoring system on a voluntary basis and may ease compliance and ownership of standards.

Self-regulation must be done with the following objectives:

a. Industry should be an effective partner on pollution control with the help of a specialized audit team;
b. Bringing transparency to auditors at the time of audit as well as to the regulators and citizens. This will enhance the credibility of the industry in the market and in the eyes of citizens;
c. Overcoming limitations of the regulatory body enforcement in terms of manpower, infrastructure and finance; and
d. In the long term, it shall help to attain the overall objective of sustainable development.

Components of self-regulation

The major components of organization and policy of the process of self-regulation are as follows:

a. Integration of all components of environment management
b. Organization setup for self-regulation
c. Policy
d. Creating a database
e. Action plan
f. Training and awareness
g. Transparency and report writing (see *Figure 10: Components of self-regulation*)

Figure 10: Components of self-regulation

Source: Centre for Science and Environment, India

a. Integration of all components of environment management

An industrial system is composed of various segments with production as the central point. Generally, this component is mutually exclusive except for smooth operation of production. But at the same, it is necessary to integrate this component on environmental management (see *Figure 11: Industrial system and organization*).

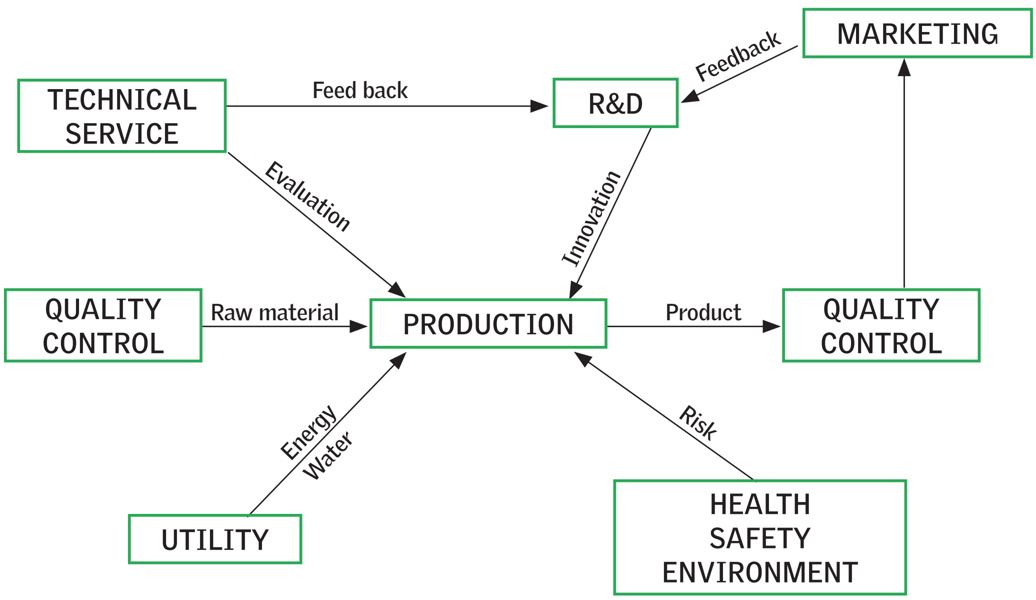
The contribution from major organs of the industries is as follows:

- Raw materials are fed to production system through approval of quality control. Here quality control indicates the impurities which in turn come out as waste in the form of solid waste, gaseous emissions or and wastewater.
- The utility is an important functionary which provides steam, energy and water to the plant and are a major participant for water and energy balance.
- The other important functionary is Health Safety Environment (HSE), which acts a monitor to ensure safe and green production by the industry. In addition, technical service is also an important component for material balance in the case of small- and medium-scale industries production manager itself acts a technical service.
- The marketing division may use environmental management as a *"credit"* point in their activities. It monitors response of a market with respect to quality of product as well as to *"goodwill"* factors on environment management.

- The research and development division should identify the recovery, innovation and recycling or reuse of valuable materials from wastewater, solid waste and from emitting materials.

In short, the functions of various organs of the industry need to be integrated and be in synchronization with each other to enable a green production system. This challenge can be overcome by an effective organogram of an industry.

Figure 11: Industrial system and organization



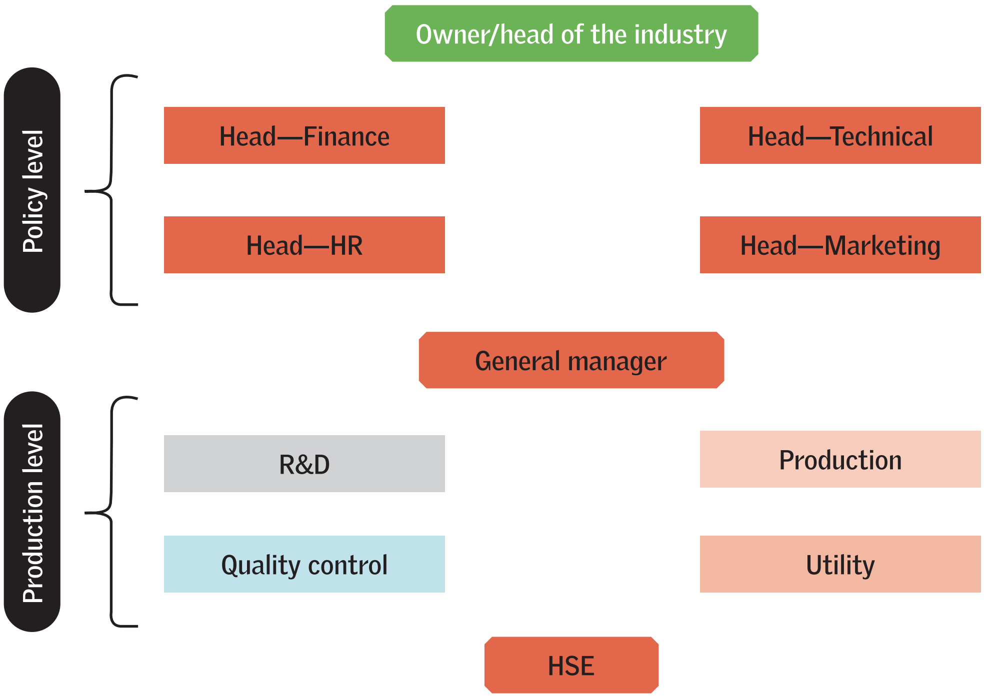
Source: Central Pollution Control Board, India

b. Organization setup for self-regulation

Generally, the industrial organogram is divided into two tiers, one at corporate or policy level and the other at the production level (factory level). The factory level is in the process of implementation and performance. But at both the levels, integration of various department is essential for effective environmental management with suitable work allocation.

In an organization setup, owner/head directs at the policy level the head of various departments such as HR, technical, finance and marketing section, while at the production level, the General Manager directs the heads of various departments such as R&D, Quality Control, Production, Utility, and Health Safety Environment (HSE) (see *Figure 12: Organizational setup with two-tier system*).

Figure 12: Organizational setup with two-tier system



Source: Centre for Science and Environment, India

c. Policy

Internal policies shall be developed with following objectives:

- To ensure pollution-control norms
- Conservation of resources
- Environmental impact assessment in operation phase
- Develop Environmental Management System
- Integration of all departments on Environmental Management

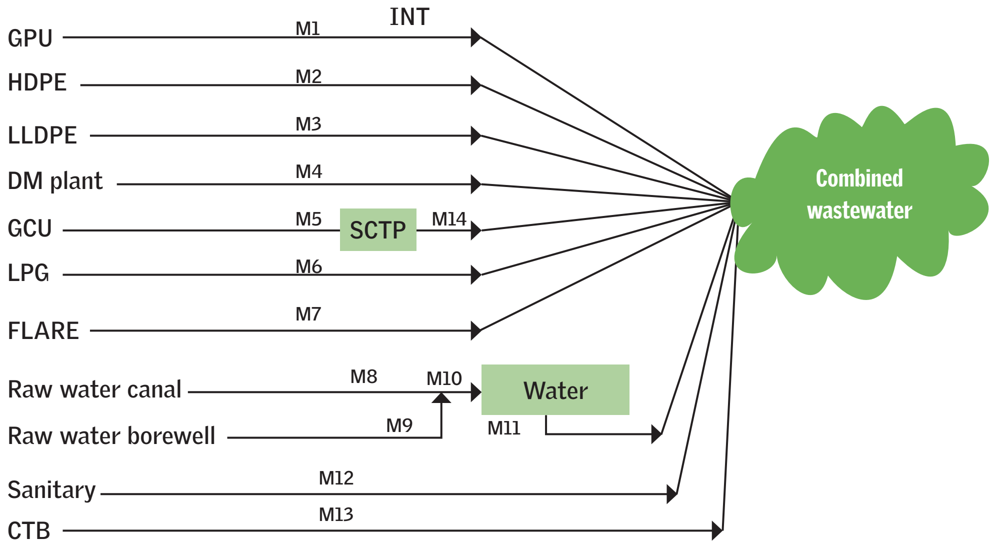
d. Creating a database

Creating a database creation has two major components as follows:

Pollution assessment—monitoring and data management

The mechanism for pollution assessment should be developed based on each unit operation/ process, which contributes either to wastewater generation, air pollutant emissions, solid waste generation, or all of them. This needs systematic observation by way of a comprehensive monitoring programme.

Figure 13: Pollution load assessment in a petrochemical complex



Source: Central Pollution Control Board, India

This can be understood from the example of a petroleum complex (gas cracking) (see *Figure 13: Pollution load assessment in a petrochemical complex*). In this gas cracking unit, there are various plants such as gas process unit (GPU), high density polyethylene plant (HDPE), linear low-density polyethylene (LLDPE), demineralization plant (DM), gas cracking unit (GCU), etc. Each plant generates wastewater with different pollution load. Monitoring should hence be done to assess the pollution load at the individual unit operation or process-wise as well as at the combined level.

Each plant has a monitoring station and the outcomes of the monitoring are as follows:

- How much wastewater is generated per unit of each product or per plant basis (in terms of BOD, COD, oil and grease)?
- How much wastewater is blown down from the cooling tower and boiler section on a per day basis and their characteristics in terms of TDS, hardness and silica, etc.?
- How much wastewater and waste load is generated in terms of BOD, COD, TDS, and oil and grease for sanitary purpose?
- How much water is consumed from the borewell and canal separately with load determination in terms of TSS, TDS and from each case heavy metals and chlorinated pesticides?

Monitoring is a programme for systematic observation in order to draw inferences (predictions) about the experiment or the phenomena for which it is designed. The systematic observation means a periodic observation with regular intervals or at regular frequency. "By observation" means measurement and the parameters that are to be measured shall be defined along with the location of sampling.

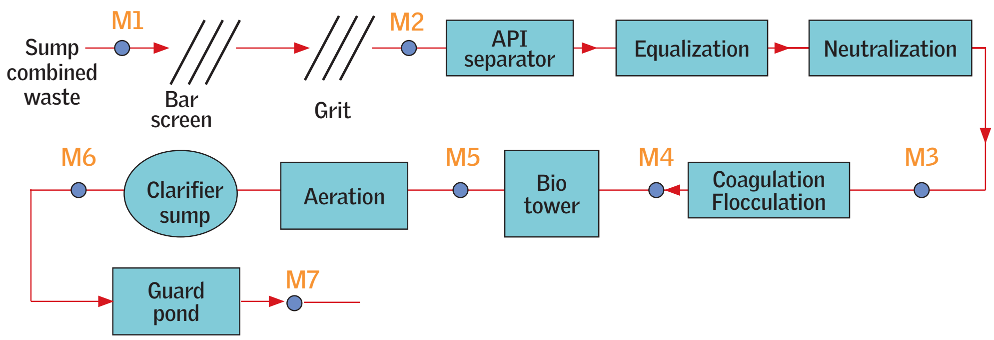
Such a plant-wise or unit operation/process-wise approach is also applicable to assess air pollutant load and solid waste generation.

Performance evaluation of pollution control devices

Performance evaluation is a productive tool to measure the efficacy of various devices installed for reducing or lowering pollution load. Simply, it is used to gauge whether devices installed are performing their task efficiently. Such evaluation paves the way for improvement and performance of the devices can be enhanced in the long term.

Figure 14: Monitoring network design for effluent treatment plant performance shows performance evaluation of common effluent treatment plant (CETP) in a petrochemical complex plant. It shows the line of treatment at the CETP along with

Figure 14: Monitoring network design for effluent treatment plant performance



M1	pH, BOD, COD, O&G, TSS (two-hour grab and 24 composite, every day)	M2	TSS (grab, once a week)
M3	pH, BOD, COD, O&G, TSS (grab, once a day)	M4	BOD, COD, O&G (once a day)
M5	BOD, COD, O&G (once a day)	M6	BOD, COD, O&G (once a day)
M7	pH, BOD, COD, O&G, TSS (two-hour grab and 25 composite, every day)	Aeration tank —DO, MLSS, MLVSS	

Source: Central Pollution Control Board, India the monitoring locations, along with the frequency of sampling and the parameters to be analysed.

Such detailed evaluation of pollution control devices is also applicable and should be done to reduce air pollution and solid waste.

e. Action plan

To enhance the material circularity and reduce the pollution load, an environmental auditor should develop an action plan in consultation with industries comprising a series of activities for waste minimization, recovery, recycling and reuse approach. These activities are briefly described in the following:

Waste minimization

a. Principles of waste minimization: control of raw material losses
b. Optimization of reactions and raw material use
c. Elimination of sources of leaks and spills
d. Installation of closed system
e. Equipment standardization
f. Installation of DCS (Distributed Control System) or PLC (Programmable logic controllers).

Recovery, recycle and reuse

a. The solvents used in the manufacture of various products can be recovered, recycled and/or reused. A similar thing can be done in the case of spent acids, catalyst, metals.
b. In most of the chemical reactions, there are more products formed than the required products. These unwanted products form wastes if left unrecovered. They can be recovered as valuable byproducts by employing suitable techniques such as condensation, distillation, absorption etc.
c. Condensate water can be collected and recycled and/or reused.
d. Wastewater from the floor-washing section can, at times, be collected, treated if necessary and recycled and/or reused.
e. Seal cooling water, vacuum pump water and cooling water can be recycled and reused in operations such as neutralization, washing etc.

Recycling and reuse of wastewater

a. From the investigation of material balance and unit operations of a particular process, it will be possible to characterize the waste and identify the possibilities of recycling or recovery of useful products. The process of identification of recoverable matter and recycling of wastewater can be made effective through an "environmental audit".

b. Treating some or all process wastewater to make it suitable for plant processes, cooling water makeup, floor washing etc.
c. Recirculating the same water within a unit operation several times before it becomes unfit.
d. Sequential use of effluent from one process with treatment, if necessary, as input into another.
e. Usage of wastewater from a process to a lesser duty usage where an inferior quality of water can suffice the purpose. For example, it can be used for coal ash quenching in boiler house, for making lime solution used for neutralization in ETP etc.
f. The concept of 4Rs—"Recycle, renovate, recharge, and reuse"—should be employed wherever possible.

In-plant control

a. Good housekeeping is the least expensive means to reduce the overall burden on treatment and disposal.
b. Loss of raw material, solvent and product can be restricted by installing monitoring devices.
c. The steam jet ejectors and barometric condensers can be replaced in some cases by vacuum pumps and surface condenser systems.
d. Waste segregation and treatment also form an important step in in-plant control of pollution.

f. Training and awareness

There should be a comprehensive training programme which addresses the officials at the corporate, management, factory and operator levels. It should also include laboratory analyst and helpers. The training and awareness programme help the employees to enhance their knowledge and understanding and make them aware about the norms, regulations, latest events and technologies, etc.

A three-tier training programme is suggested (see *Table 7: Internal training as a tool for self- regulation*).

g. Transparency and report writing

Reporting is useful for correction of operational practice of the entire factory operations, and is for internal purposes. A report should involve the investigation details and highlight the problem and shall highlight the possible solutions. In addition to this, a report should be clear and lucid and should give

Table 7: Internal training as a tool for self-regulation

Tier	Target group	Type of training	Subject
I	Corporate level	Perception building	• Environmental legislations in country • International conventions • Legislations in exporting countries • Sustainable development • ISO standards
II	Management level	Implementation	• Duties and obligations under environmental legislation in the country • Self-regulations and data management including reporting • Conducting environmental audit, safety audit, ISO 14000 audit • Development of SOP operate/laboratory analyst/helper
III	Worker level	Implementation	• Awareness on safety and environment • SOP follow-up programme

Source: Centre for Science and Environment, India

a key or central message. However, it demands a high degree of honesty and transparency. This report should produce:

a. Wastewater load from unit operations or process wise with respect to key parameters like BOD, COD, TDS etc.
b. Performance evaluation of inside battery limit treatment (ISBL) and outside battery limit treatment (OSBL);
c. Unit operation or process-wise emission load and performance of pollution control devices;
d. Solid waste generation, it storage and management system;
e. Identify the area of recycling and reuse of waste and wastewater; and
f. Identification of critical unit operation or process.

4. Procedure for review of environmental audit reports

The most important component of the environmental audit system is the review of quality of audit reports. If the reviewer of the audit report is satisfied, the report is accepted, otherwise the auditor is advised to resubmit the report with modifications as suggested or the report may be rejected due to its poor quality.

An environmental audit report needs to be reviewed after it is prepared. The regulatory authority will review the report—it may comprise a single technical committee that does the entire review work of industries of that country, but this may overburden for the committee. In such cases, the technical committee at the headquarters should review large-scale industries and the technical committee at the zonal/regional level should review small- and medium-scale industries.

In general, the technical committee may be headed by the principal environment organ of the government. For example, in the case of Tanzania, it will be the National Environment Management Council (NEMC) and representatives of important government organs such as the Ministry of Industry, Ministry of Mines, Ministry of Water, Ministry and Natural Resources and Tourism etc. as it deems fit. In addition, technical experts from outside the government may also be considered by the regulatory authority.

4.1 Review of environmental audit report

The areas covered under review of environmental audit report are the audit or audit team, status of registration of the audit team, methodology adopted by the auditor to conduct the audit, findings and observations of the auditor, summary report and recommendations to develop an action plan. The review methodology covers the checklist on the above-mentioned subjects and is stated in detail subsequently.

Composition of audit team

The audit team should consist of various members, such as principal auditor, associate auditor, chemist and field assistant. Each of these members play a vital role in the audit team and in conducting the audit on the field. These members should have adequate experience in their respective fields (see *Table 8: Qualification and work experience required for audit team*).

The role of the audit team has is as follows. The Principal Auditor is basically a coordinator of the team related to audit activities. He must have overall knowledge of the production system of unit operation/ process, and types of industries such as the processing and synthetic industries. He should also possess a knowledge on environmental management in industries.

The associate auditor should work in coordination with the principal auditor and should possess knowledge of production system of a few industries as well as of pollution control devices such as ETP, APCDs, and waste management facilities.

The chemist must have knowledge of sampling and analysis of pollutants related to water, air and waste.

Table 8: Qualification and work experience required for audit team

S. no.	Designation	Qualification	Experience	Remarks
1	Principal auditor	Bachelors of Engineering or Masters of Science	10 years out of which at least five years of experience should be in industry	Industrial and/or regulatory experience preferred
2	Associate auditor	Bachelors of Engineering or Masters of Science	Five years out of which three years of experience should be in industry	-
3	Chemist	Bachelor of Science in Chemistry	Five years of experience in analytical chemistry	Experience of working in reputed laboratory
4	Field attendant	Final school leaving certificate with science	Three years	School leaving certificate from a recognized board or agency by the government

Source: Centre for Science and Environment, India

Infrastructure required by the audit team

The audit team requires a proper infrastructure to facilitate the audit activities. The facilities shall consist an office, accommodation, relevant documents including basic books of industrial process, wastewater treatment collection and management, air pollution control and dispersal, and waste management system.

Besides this documentation related to legislations, international conventions the various guidelines laid down by the international agencies like UNEP, UNDP, World Bank on the same subject and by the regulatory authorities of highly industrialised countries etc. Should be a part of infrastructure.

In addition, infrastructure for sampling of wastewater, stack monitoring kits, hazardous waste collection system are needed.

Table 9: Checklist for availability of sampling apparatus and analytical facilities with the audit team

Subject	Questions	Yes	No	Remarks
Water pollution	Does the audit team have a flow meter to carry out measurements?			If it is not available, whether the audit team has made arrangement for the same with the recognised laboratory
	Does the audit team have a multimeter for in situ measurements of, for example, pH, temperature and conductivity?			-Do-
	Does the team have sampling devices for collecting the composite sample, oil and grease?			-Do-
	Is there any laboratory established by the audit team to check the relevant parameters such as pH, suspended solids, total dissolved solids, hardness, COD and BOD?			If there is no laboratory available, the audit team should arrange to use a recognized laboratory or plant facilities.
Air pollution	Does the audit team have stack monitoring kits?			If not, the audit team should arrange for them.
	Does the audit team have analytical facilities for criteria pollutants such as SOx, NOx and particulate matter?			If not, the audit team should arrange for the same with the recognized laboratory.
	Is there high-volume sampling facility for collection of samples for particulate matter and SOx?			If it is not available, the audit team should arrange for it with a recognised laboratory.

Source: Centre for Science and Environment, India

Registration status with the regulatory authority

The country should have a registration system for auditors where the auditor shall continue to meet the eligibility requirements and comply with the norms of the regulator authority.

The audit firm should be legally registered in the country; if it is not registered within the country, it should be registered in another country or registered by the international organizations such as the World Bank, Africa Development Bank, etc. The audit can also be conducted by reputed institutes in the country.

The registration certificate along with the audit report should be submitted to the reviewer. In the absence of the registration certificate, the reviewer can reject the audit report.

Table 10: Checklist for review of status of registration

S. no.	Components	Yes	No	Remarks
a.	Is there a system of registration of auditors by the country?			If not, a reputed institute, certified international agency or institute recognized by funding countries may be considered valid.
b.	If "a" is yes, is the said audit firm registered?			Accept report if "a" is yes
c.	If "a" is no, is the audit conducted by reputed institute?			Accept report if "c" is yes
d.	If "a" and "c" is no, is the audit firm registered by another funding country or international organization such as the World Bank, Africa Development Bank, etc.?			
e)	If "d" is yes, is the registration certification attached?			Accept report if "e" is satisfied. or If a, b, c, d, e is no, the report should be rejected

Source: Centre for Science and Environment, India

Previous record of audit team

The reviewer should also assess the previous audit reports prepared by the concerned audit team and should ask for information related to clients with whom the audit team has worked in the past.

4.2 Methodology adopted by auditor

The methodology adopted by the auditor is different for each phase of an environmental audit. For each phase, there are different tasks (see *Table 11: Methodology adopted by auditor*).

During the pre-audit period, activities such as the questionnaire survey, walk-through survey, and organization of audit team is done by the auditor.

Activities at the site include collection of data, preparation of water and material balance followed by metering and monitoring.

Table 11: Methodology adopted by auditor

S. no.	Period	Subject	Remarks
1.	Pre- audit	• Questionnaire survey • Pre-audit visit to assess the facilities available to team • Identifying the key person and organizing the audit on time	• Evaluate the adequacy of questionnaire survey
2.	Activities at site	• Collection and collation of information (review of records) • Material balance • Water balance • Metering and monitoring	• Cross checking of records • Adequacy of monitoring programme
3.	Post audit	• Draft report and discussion with the plant team • Final report	• Comments on draft report

Source: Centre for Science and Environment, India

After the audit is done, the draft report is prepared and discussed with the plant team and if there are any comments, they are addressed and incorporated in the final report.

Recommendation

In this process, the reviewer reviews and checks the composition and qualification of the environmental audit team and gives the recommendation whether the team or any individual is fit to conduct the audit and make the report.

If the audit team or any member in the team grossly violates the norms for qualification, the reviewer may reject the audit report.

Is a concise environment statement provided?

The reviewer checks whether a concise environment statement as required in the format of regulatory authority is provided. If it is not provided, the auditor will be asked to provide it. In addition, if they are any discrepancies in the environmental statement, the reviewer may ask the auditor to resubmit it (see *Annexure-II* for a specific example).

4.3 Review of auditor's findings and observations

The reviewer shall ask the auditor for the findings and observation of the audit report and shall review the compliance status on EIA licensing conditions as well as other environmental requirements as per governing laws. The key areas of report review shall consist of license conditions with respect to layout plan and housekeeping, observation of auditor with respect to production figure, raw material consumption, observation of auditor with respect to material balance, water conservation and wastewater generation, adequacy of water treatment plant and its performance, and solid waste (including hazardous waste management). The details are as follows.

Review of observation of auditor with regard to layout and housekeeping in factory

The layout of a factory should be well planned and designed with respect to high, medium, and low contaminated zones. In such cases, the high contaminated zones include the wastewater treatment plant (ETP), storage of hazardous solid waste, and production area. The medium contaminated zone includes quality control department, research and development laboratories, and product storage areas. The low contamination zones are administration buildings, control rooms, canteens, product storage. In addition to this, overall housekeeping of the factory should be well maintained.

Table 12: Checklist for review of observations of auditor w.r.t. to layout and housekeeping in factory

Questions	Yes	No	Remarks
Is the layout plan properly zoned with respect to low-, medium- or high-contaminated activity?			If not, what is the recommendation given by the auditor?
Is there any congestion and susceptible risk?			If there is, what is the recommendation given by the auditor?
Is the storage area properly ventilated, well-spaced and the raw material/products are kept properly stacked?			If there is, what is the recommendation given by the auditor?
Is the storm water properly laid down and well maintained?			If not, what is the recommendation given by the auditor?
Is there any spillage and leakage of the drain?			If there is, what is the recommendation given by the auditor?

Source: Centre for Science and Environment, India

Review of observation of auditor with regard to production figure

The production figures need to be checked for at least two years with the production managers and technical service department. The auditors shall also check the figures from the other agencies, for example the sales tax department, to keep track of the production data and material balance. This exercise will help the regulator to understand whether the production figures are as per the licence condition or not.

Review of observation of auditor w.r.t. to raw material consumption

The auditor shall prepare the material balance to keep track of utilization of raw

Table 13: Checklist for review of observations of auditor w.r.t to production figures

Questions	Yes	No	Remarks
Has the auditor checked the production figures with the production manager and technical service?			If not, the auditor is advised to check the figures.
Are the figures given by the plant team matched with the figures of other agencies like tax department?			If not, the auditor is advised to match the figures to keep a back track and submit the same to the review committee.
Is it as per licence condition?			If not, does the auditor provide the reason/s and are the reasons adequate?

Source: Centre for Science and Environment, India

Table 14: Checklist of review of observations of auditor w.r.t. raw material consumption

Question	Yes	No	Remarks
Did the auditor make the material balance?			If not, the auditor should prepare it
Has the auditor checked the raw material consumption with the log book of the storage (at least for two financial years)?			If not, a comparison should be done to keep track of inflow and outflow of materials
Is the raw material consumption high compared to the stoichiometric requirement?			If not, it should be compared with the stoichiometric requirement to keep a track of consumption of raw material
If it is, what are the reasons thereof? i) IIs is due to impurities so that effective raw material is less? ii) Is the production process condition not controlled properly? iii) Is material handling not proper and resulting in spillage? iv) Is the requirement as per the demand of the reaction? v) Is there any off- specific product?			If yes, what is the recommendation given by the auditor? More recovery of the raw material and recycling to the system
Any other reasons noted by the auditor?			If there are, the auditor shall indicate it and maintain the list of raw materials.

Source: Centre for Science and Environment, India

material and losses in the system. The auditor should also check the raw material consumption with the log book of the storage and compare the consumption with the stoichiometric requirement. This exercise will help regulators to understand about the raw material consumed in the process as well as the losses and the inflow and outflow of materials can be kept track of.

Review of observations of the auditor w.r.t. to water conservation and wastewater generation

The auditor shall prepare the water balance with the help of plant team and provide an accurate rationale behind the estimations and highlight the major water-consuming and wastewater-generating areas and shall check whether the quantity of wastewater is as per the license condition or not and it is discharged through a designated outlet.

In addition, the designated area for wastewater discharge should be identified and there should be combined wastewater treatment facilities. The water quality parameters should be within the permissible limit as per designated standards.

Table 15: Checklist of review of auditor with w.r.t. water conservation and wastewater generation

Question	Yes	No	Remarks
Did auditor make any water balance with the help of the utility or technical service?			If not, the reviewer should ask to prepare the water balance
If they did, was it measured or estimated?			If it is not measured, the auditor should advice the plant team to install flow meters at the relevant areas
If estimated, did they provide rationale for estimates?			The audit report should give the rationale for the estimations. If it is not provided, the auditor shall be asked to provide it.
Did the auditor indicate the area of loss of water, collection of condensate or water for recycling?			If not, auditor shall highlight such areas in the audit report
Is is the quantity of wastewater as per the license condition?			If the quantity of wastewater generation exceeds the license condition, the audit report shall reflect the reasons thereof.
If the quantity is as per license condition, it is measured at outlet with V-notch or flow meter			If it not measured, the review team shall ask the audit team to give the rationale behind the estimations.
Is there any designated outlet for discharge of wastewater?			If not, does the audit suggest about the construction of outlet with flow measurement?
Is the wastewater stream identified by industry w.r.t to characteristics in terms of TDS, BOD, and COD?			If it is not identified, the reviewer shall ask the audit team for appropriate reasoning.
Is there any in situ/ISBL (inside battery limit) treatment arrangement given?			If not, does the auditor has advised for the in situ treatment?
Is the combined wastewater treatment adequate?			If yes, auditor shall confirm with the performance evaluation of treatment plant with unit operation/process.
Is the entire treatment plant well maintained?			If no, auditor shall identify areas of improvement and provide the recommendations accordingly.
Do all the wastewater quality parameters comply with the standards?			If not, the auditor may identify those parameters by analysing themselves and suggest the adequate line of treatment for the same.

Source: Centre for Science and Environment, India

Table 16: Checklist of review of auditor w.r.t. solid waste

Question	Yes	No	Remarks
Is there inventorization for both hazardous and non-hazardous waste?			If there is, is it checked by auditor with comments thereof? If not, has the auditor advised the auditor to prepare the same?
Has the industry maintained a log book regarding waste generation?			If it has, is it checked by the auditor and recommendations given thereof? If not, the auditor should ask the plant team to prepare a logbook and keep the records.
Does the industry send the waste in an environmentally safe manner?			Is there any comment by the auditor for the same?
Has the audit report identified recyclable waste for effective recycling?			Has the auditor made any comment in this regard?
Are all the containers holding hazardous waste well-maintained and stored properly?			What is the observation of the auditor?

Source: Centre for Science and Environment, India

Review of observation of auditor w.r.t. to solid waste (hazardous and non-hazardous waste generation)

The auditor shall prepare an inventory for both hazardous and non-hazardous waste and shall compare the data with the industry's logbook w.r.t to storage, recycling or reuse, incineration, disposal of waste. If the logbook is not maintained properly, the auditor shall ask the plant team to prepare it in an adequate manner and keep the records in an organised manner. The auditor shall also ask the plant team for the safe disposal of waste in an environmentally sustainable manner and the audit report shall highlight the mechanism for recycling the different streams of waste.

In addition, the containers handling the hazardous waste should be well maintained and stored properly.

Review of observation of auditor w.r.t. to air pollutant

To keep track of the air pollution, the auditor shall ask the industry about the combustion processes taking place inside the plant and whether the pollutant is generated from it or not. The information related to type of fuel used, quantity, its composition and calorific value shall also be asked by the auditor.

In addition, the installation and performance of air pollution control devices (APCDs) and emissions from the process area should be highlighted in the audit report.

Table 17: Checklist of review of auditor w.r.t. to air pollutant

Questions	Yes	No	Remarks
Is the air pollutant generation through combustion?			If it is, in which part of the process/utility and what is the methodology to control the pollution from it?
What is the type of fuel used? What is its quantity and its calorific value?			The auditor shall identify whether the log book has been maintained appropriately or not.
Are there adequate air pollution control devices (APCDs)?			If not, has the auditor recommended that they be installed?
Is the performance of APCD is adequate?			If the performance is not adequate, the auditor shall recommend modification in the device if needed, or installation of an appropriate one.
Is there any performance of stack monitoring programme by the industry?			If there is, the auditor shall suggest the SOP, frequency of monitoring as per the license condition for improvement of results. If not, the auditor shall recommend for the stack monitoring as per the license condition.
If yes, were the results verified by auditor?			Does the auditor do the stack monitoring during the audit period and verify the observation with results of the industry?

Source: Centre for Science and Environment, India

Annexure I: Questionnaire for conducting an environmental audit in pre-audit phase

1. Overview and general information

a)	Name of the unit and complete address
b)	What are the main processes carried out on site?
c)	Total production capacity of the plant in terms of tonne per annum
d)	Number of people employed on site (temporary + permanent)
e)	What is the work schedule (number of shifts in a day and their hours)?
f)	Is a copy of the site layout plan available?
g)	Is a map of the surrounding area showing water bodies and residential area available?
h)	Are there any other units in the area having similar process?
i)	Are there any noticeable stains, discoloured dirt, concrete or flooring on the site?
j)	Is the location free of: Old and obsolete machinery? Additional unrestrained debris
k)	Is the site well-organized and in good working order?

2. Site history and details

a)	When was the facility established?
b)	Who owns the facility/industry?
c)	Who owns the land and what is the type of the land?
d)	Is the land ownership/lease document available?
e)	What is the total land area?
f)	What was the previous land use of that area (commercial, residential, industrial or agricultural)?
g)	Does the facility have any citations or complaints pending against it?
h)	Has there ever been any major accidents on-site?
i)	Does the facility have any outstanding loan repayments?
j)	What is the annual turnover of the facility?
k)	Does the facility have an insurance policy?

3. Process review

a)	Give a detailed description of the production process.
b)	What are the inputs required in the production process (preferably in the form of a list containing name, amount/quantity required and their price?
c)	What are the outputs produced (including pollutants) and their quantities?
d)	Provide a list of all the machinery and utilities used on-site along with their capacities number, energy consumption and time in use.
e)	How often is maintenance work carried out on-site?
f)	Does any recycling/reuse of material take place on-site?

4. License and permits

a)	Does the facility have a valid factory license? If not, has the facility applied for it? Is a copy of the application form available?
b)	Does the facility have a valid Consent to Operate (CTO) certificate? If not, has the facility applied for it? Is a copy of the application form available?
c)	Does the facility generate hazardous waste? If it does, does the facility have authorization for storage, handling and transportation of hazardous waste as per the Hazardous Waste (Management and Handling) Amendment Rules? If not, has the facility applied for it? Is a copy of the application available?

5. Air emissions

a)	What are the sources of stack and fugitive emissions in the facility?
b)	Has stack and ambient monitoring carried out?
c)	Does emissions meet standards specified in the CTO certificates?
d)	Are monitoring records/reports maintained?
e)	What are the air pollution control device that has been installed?
f)	What is the frequency of cleaning and maintaining the air pollution control device?
g)	Are site processes and operations free of significant fugitive air emissions?

6. Water consumption and wastewater generation

Freshwater	
a)	What is the source of freshwater? Is it metered or not?
b)	How many borewells are installed in the plant?
c)	How many flow meters are installed in the plant? What are their readings?
d)	Schematic of a raw water treatment plant and DM plant
e)	Latest groundwater quality test reports
f)	Specify average daily water consumption of the entire plant and in township/colony (m3/day):

g)	Has the plant studied the impact of its water consumption on respective surface water source and/or groundwater table?
h)	Break-up of average freshwater consumed for last two financial years?
i)	Specific water consumption values for last two financial years (in m3/tonne or m3/Mwh, etc.):
j)	Name of WTP unit/s (filtration unit/softening unit/reverse osmosis plant etc.) and its capacity and average quantity of water treated in filtration plant (m3/day)
k)	Chemicals used in water treatment plant with quantity and price:
l)	What is the capacity of the demineralisation (DM) plant? What is then average quantity of water treated in DM plant (m3/day)?
m)	Does the plant have rainwater harvesting (RWH) system? If it does, is it rooftop, paved or unpaved?
n)	Method of harvesting rainwater—Storage in artificial tanks/recharge into the pit/ trench/well
o)	Total rainwater harvesting potential of the plant:
p	Rainwater harvesting potential of the site developed by the plant:
q)	Total rainwater harvesting done by the plant:
r)	Frequency of monitoring of the groundwater quality and quantity (pre- and post- monsoon) and frequency of cleaning the rainwater harvesting catchment/storage system
s)	How is the harvested rainwater utilized by the plant?
t)	Key measures taken by the plant for water conservation in the past three years and water saving achieved in terms of m3
Wastewater	
a)	Schematic diagram of an Effluent Treatment Plant (ETP) and Sewage Treatment Plant (STP) along with their capacities
b)	Latest laboratory test reports of ETP and STP inlet/outlet streams
c)	Does the plant have separate ETP for its different products?
d)	Total effluent generated by plant (including all products) in last two financial years
e)	Total sewerage generated by plant and colony in last two financial years
f)	Provide the details of wastewater generation and recycling in the entire facility
g)	Does the plant monitor the impact of wastewater on the receiving waterbody/ land?
h)	What is the total number of outlets for effluent discharge from the plant?

7. Noise pollution

a)	Does the facility have a valid factory license? If not, has the facility applied for it? Is a copy of the application form available?
b)	Does the facility have a valid Consent to Operate (CTO) certificate? If not, has the facility applied for it? Is a copy of the application form available?
c)	Does the facility generate hazardous waste? If yes, does the facility have authorization for storage, handling, and transportation of hazardous waste as per the Hazardous Waste (Management and Handling) Amendment Rules? If not, has the facility applied for it? Is a copy of the application available?

8. Fuel consumption

a)	List the different type of fuel used in different areas of the plant
b)	Quantification of fuel used in each process and its calorific value
c)	Cost of different fuels used in the industry
d)	Is there any subsidy for any fuel?
e)	How is the industry storing the different types of fuel?
f)	If they are using: Gas—Is the supply regular? If not, mention the number of hours. Biomass—Is it available for the entire year? Coal—Are they using low ash coke or high coke and the supply is regular or not?

9. Chemical handling and storage

a)	What are the various types of chemicals stored on-site?
b)	Is a list of chemicals available?
c)	How are chemicals transported?
d)	What kind of containers are there for storing the chemicals?
e)	Are there any above or underground chemical storage tanks on-site?
f)	Are any of the chemicals toxic or harmful? How many of them are hazardous?
g)	Are all the chemicals labelled?
h)	Are the chemical containers' lid closed after use?
i)	Are records of chemicals and dyes usage maintained in the logbook?

10. Solid and hazardous waste management

a)	What kinds of solid waste are generated on-site?
b)	What is the quantity of solid waste generated?
c)	How is the solid waste disposed of?
d)	Is any of the waste reused or recycled?
e)	What are the sources of hazardous waste generation on-site?
f)	What is the quantity of hazardous waste generated?
g)	How is the hazardous waste disposed of?
h)	Are hazardous waste disposal records maintained?
i)	Are any of the hazardous wastes treated on-site?
k)	Where are the hazardous wastes stored before disposal?

11. Occupational health and safety

a)	Does the facility have a site emergency plan?
b)	If yes, then has this plan been documented?
c)	What are the recognized hazards in the facility?
d)	Are fire extinguishers available in the facility?
e)	What type of fire extinguisher is available?
f)	Are the fire extinguishers functional?
g)	Are facility personnel trained in its use?
h)	Is personal protective equipment (PPE) available for use?
i)	Do the workers use PPE?
j)	Are health check-ups for workers conducted?
k)	Do the workers know whom to contact in case of an emergency?
l)	Has any accident ever occurred on-site?

Annexure II: Specified format for audit statement

PART A

1. Name and address of the owner/occupier of the industry
2. Production capacity (with units)
3. Year of establishment
4. Date of last environmental audit submitted

PART B

5. Product type and generation

S. no.	Type of product	Quantity (tonne or in kilolitre)	
		Current audit report (Year)	Previous audit report (Year)

6. Water sourcing

Types of sources	Water consumption in KL	
	Current audit report (year)	Previous audit report (year)
Groundwater (borewell)		
Surface water (river, lake)		
Seawater		
Third-party water (tankers, others)		

7. Water consumption in m^3/day

Different water-consuming areas	Water consumption per unit of product/output	
	Current audit report (year)	Previous audit report (year)
Domestic		
Utility (cooling towers, boilers)		
Process		
Others		

8. Details of borewells

Details of borewells	Current audit report (year)	Previous audit report (year)
Number of borewells		
Depth and head of borewells		
Average running of borewells		
If using, groundwater, share water-quality monitoring report		
Number of piezometers installed for groundwater monitoring		

9. Details of flowmeters

Description	Current audit report (year)	Previous audit report (year)
Type of flowmeter installed i) Electromagnetic ii) Mechanical type iii) Others, if any		
Number of flow meters installed at different locations,		
When were they last calibrated, mention the date Share the calibration certificates for each meter.		

10. Wastewater generation

	Current year	Previous year
Total wastewater generated in KL		
Quantity of wastewater recycled or reused in KL		
Wastewater discharge point • **Surface water** i) With treatment ii) Without treatment • **Groundwater** i) With treatment ii) Without treatment • **Seawater** i) With treatment ii) Without treatment		

Notes: Please provide the diagram for the wastewater treatment scheme; If the plant is zero-liquid discharge, provide the scheme

11. Raw material consumption

Name of raw material	Consumption of raw material (in tonne or per tonne of product)	
	Current audit report (year) specify unit	Previous audit report (year) specify unit
1		
2		
3		

12. Fuel consumption

Name of fuel	Consumption of fuel (in tonne/litre/kg or per tonne of product)	
	Current audit report (year) specify unit	Previous audit report (year) specify unit
1		
2		
3		

13. Energy consumption

Energy consumption	Consumption of energy in kwH or per tonne of product)	
	Current audit report (year) specify unit	Previous audit report (year) specify unit
1		
2		
3		

PART C

14. Pollution discharge to environment/unit of output (parameters as specified in license condition issued)

Pollution	Parameter	Quantity of pollutants discharged (mass/day)	Concentration of pollutants	Prescribed standard
Water	1. pH 2. SS 3. BOD 4. COD			
Note: Add more parameters as per NEMC				
Air	1. PM 2. SOx 3. NOx			
Note: Add more parameters as per NEMC				

PART D

15. Details of hazardous waste (as specified under license condition)

Hazardous waste	Current financial report			Previous financial report		
	Quantity recycled	Quantity sold	Quantity disposed	Quantity recycled	Quantity sold	Quantity disposed
From process i. ii.						
From Pollution Control Device i. ii.						

PART E

16. Details of non-hazardous waste

Non-hazardous waste	Current financial report			Previous financial report		
	Quantity recycled	Quantity sold	Quantity disposed	Quantity recycled	Quantity sold	Quantity disposed
From process i. ii.						
From Pollution Control Device i. ii.						

PART F

17. Please describe qualitatively disposal practices adopted for these categories of waste.

PART G

18. Impact of pollution abatement measures taken on conservation of natural resources and benefit thereof.

PART H

19. Additional measures/investment proposal for environment protection abatement of pollution, prevention of pollution.

PART I

20. Indicate both qualitatively and quantitatively how the industry plans to reduce its pollution, reduce its natural resource consumption, and maximize its waste consumption as raw material/fuel. Specify the target and deadline.

The Environment Impact Assessment and Audit Regulations, 2005 of Tanzania detail the need to conduct environmental audits and self-regulation as provided for under the Environmental Management Act.

The Regulations cover various aspects such as qualifications of auditors and content of audit reports and lay down the process for review of audit reports and a system of checks and balances by setting procedures in place.

To understand the quality of reporting and whether reports reflect the intention mentioned in the Regulations, the Centre for Science and Environment (CSE) reviewed audit reports from different sectors in Tanzania. It recommends detailed structure for the reports, strengthening self-audit manuals and a committee of experts to review the reports. This technical manual includes procedures for conducting environmental audits and review of reports.

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