# ASSESSMENT OF ENVIRONMENTAL AUDIT SYSTEM

## PAN-AFRICA STUDY

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# Introduction

The rapid growth of development interventions and their associated pollution potential needs to be coupled with a robust environmental governance system to regulate its impacts and ensure its sustainability. Environmental Impact Assessment (EIA) is considered the first step in this direction. EIA is an effective tool in predicting environmental impacts at an early stage of project and exploring means and techniques to reduce adverse impacts.

EIA is a legal instrument for decision-making. However, countries have varied systems in place with respect to the assessment process. In many countries, EIA is also used as a tool to monitor compliance of the commitments made at the inception of the project. The Centre for Science and Environment's (CSE's) 2022 report *Environmental Impact Assessment—Evaluation of Legislations in Countries of Africa and South Asia* highlighted this variance effectively. The report comprised assessment of EIA legislation for 11 countries on indicators of project categorization, information collection, compliance mechanism, information transparency and accreditation of EIA consultants. The assessment found inherent weaknesses in legislations of almost all countries. While some countries had comprehensive legislation, others attempted to cover all the aspects but omitted providing details of the required aspects. Though the study does not cover implementation status on the ground, these shortcomings clearly indicate poor implementation. EIA, although an efficient tool, is a preliminary step and does not guarantee the safeguarding of environment from the adverse impacts of the project. An EIA report identifies the negative impacts and suggests corrective measures, but the major challenge is monitoring the compliance of suggested measures.

Additionally, anticipated impacts also tend to differ in terms of severity and duration on the affected environment with the actual implementation of project and may require constant modifications in the suggested mitigation measures. A regular assessment during the operation of the project is important to keep a check on the rising impacts and lacunas in effectiveness of the proposed measures. This is where environmental audit (EA) plays a crucial role.

Environmental audit is a management tool that enables industries to evaluate its environmental performance and improve it on a regular basis, verify the implementation of environmental management tools proposed during the

Environmental Impact Assessment (EIA) and ensure effective compliance of governing environmental laws by an industry. It is not a one-time step but an ongoing activity that aims to identify and correct environmental issues that arise during the operation of a project and improve operating and environmental conditions in industries. Simply, it is a process to evaluate the balance of resources such as water, raw materials, fuel with the product generated and waste in terms of water, solid and gaseous emissions.

A thoroughly performed environmental audit allows industries to analyse the ambiguities in the implementation of management plans and take corrective measures. It also helps industries improve the process efficiency by optimizing the usage of resources, increasing production and thereby resulting in monetary benefits. An effective audit also needs historical data to make quantification and analysis representative in nature. To obtain this, the industries should have a self-audit mechanism whereby an industry itself monitors its own adherence to legal and environmental standards, keeps a record of the performance, and ensures compliance and effective utilization of resources. It is a monitoring system on a voluntary basis to implement a systematic approach to achieve the set environmental objectives and targets.

On the regulatory front, a comprehensive audit report can be helpful for regulatory purposes as it will help assess the compliance status of the industry and understand its environmental performance. Comparing data of two to three years can ascertain whether the performance of an industry is improving or declining. The data mentioned in the audit reports also helps regulators identify any issues pertaining to resource usage and associated environmental impacts. Overall, environmental audit can be used by regulators to take a cognitive approach towards the operating environment of industries and to incorporate new priorities in policies and practices. Considering the fast-growing development and increasing environmental impacts, conducting an environmental audit is no longer an option but a sound precaution and a proactive measure.

Although several benefits are associated with the process of EA, it also presents challenges. Many of these challenges stem from the fact that the process is still evolving in many developing countries. These countries have laws and regulations mandating the requirement of environmental audit, but the quality of data provided in the audit report might be debatable. And though the audit report might be comprehensive, in absence of the relevant information the whole audit exercise becomes futile.

This report aims to highlight crucial information required in an audit report and how that information can be used for regulating the industry. It discusses the EA process of eight African countries and attempts to understand the shortcomings as well as best practices followed by these countries. It also details the procedure to conduct an audit and methodology for reviewing audit reports.

# 1. Review of country-specific audit system

As stated, the audit system of eight countries are reviewed in this report. The countries included are Tanzania, Zambia, Zanzibar, Kenya, Nigeria, Rwanda, Ethiopia and Malawi.

The methodology adopted for this exercise involved reviewing of country-specific legislations governing audits in their country and environmental audit reports (see *Table 1: Country-specific legislation reviewed*). The legislation and reports for all countries are either obtained from the respective regulatory authorities or available in the public domain.

Since the presence of a strong law with legal binding is the prerequisite for proper implementation on ground, the first part of review aims to understand the requirements stated in the legislation. This involved examining what aspects are covered regarding audit in the law, how much detail provided for each aspect, whether supporting documents/formats are provided etc. Reviewing these pointers gives an understanding of applicability and detailing expected to be provided by the auditor in the audit report. The second part involves actual review of the audit

**Table 1: Country-specific legislation reviewed**

| Country | Legislation reviewed | Sector reviewed * |
|---|---|---|
| Ethiopia | Environmental Audit Guidelines in July 2022 | Textile |
| Kenya | Environmental (Impact Assessment and Audit) Regulations, 2003 | Dairy |
| Malawi | Environment Management Act, 2017 and National Environmental Policy, 2004 | Hotel |
| Nigeria | National Environmental (textile, wearing apparel, leather and footwear industry) Regulations 2009 | Tannery, Pharmaceutical |
| Rwanda | General Environmental Audit Guideline in 2009 and Environmental Monitoring and Audit Guideline (EM&AG) in 2014 | Cement |
| Tanzania | Environment Impact Assessment (EIA) and Audit Regulations, 2005 and its Amendment of 2018 | Sugar, cement |
| Zambia | Environmental Management Act No. 12 of 2011 as amended Act no. 8 of 2023 and Environmental Protection and Pollution Control (Environmental Impact Assessment) Statutory Instrument no. 28 of 1997 | Cement |
| Zanzibar | Environmental Management Act 2015 | Hotel |

* Name of the industry and details of the process are not mentioned in this report

reports submitted by the auditor to the Authority. The aim is to evaluate the actual implementation of legislation on the ground and identify the gaps.

The audit reports considered in this exercise are comprehensive audit reports done by third parties; compliance audits/inspection reports are not included. It is pertinent to mention that these reports are referred to to enable an understanding of the ground scenario of implementation and do not aims to target a particular industry or sector. A country-wise analysis of legislation and reports is presented in the following section.

## ETHIOPIA

The Federal Democratic Republic Ethiopia laid down Environmental Audit Guidelines in July 2022. The main objective of the guidelines is to provide an outline of the concept of environmental auditing.

The guideline, comprising seven chapters, covers different aspects related to environmental audit, including types of environmental audit, its components, objectives, legal consideration and environmental standards. Chapter V of the guideline elaborates the methodology of environmental auditing and lists the tools and techniques to be used. It also explains the format of writing an environmental audit report and the responsibility of the competent environmental agency and lead auditor.

The guideline has laid out the framework of the frequency of an audit. According to the guideline, the frequencies of the audit will depend upon the size and complexity of operations, potential environmental aspects and impacts and stage of development of the management system. For example, a high-risk operation or one where the management system is new requires the audit annually while in a low-risk operation industry a full audit may be undertaken every three years. The guideline clarifies that an audit can also be conducted based on the need from the public or regulatory agency.

The guideline has a detailed criteria for environmental auditor registration and qualification, including competency of environmental auditors and experts, their roles and responsibilities, experience and expertise. The only gap that could be found is lack of stress on proper laboratory staff, either internal or outsourced.

The major highlight of the guideline is the link provided for supporting documents at the end. The documents includes audit review, compliance checklist, format for action plan etc., which plays an important role in improving the quality of audit report. The supporting documents have asked many relevant questions which the auditor may fail to notice or report. For example, *Are appropriate waste management practices being followed? Is industrial wastewater discharged into a septic tank? Is hazardous waste collected and stored in properly constructed, undamaged and closed containers? Are only authorized discharges to surface water or controlled water being made?* These are basic and important questions which an auditor should consider while doing the audit. EPA, Ethiopia need to be complimented for taking extra efforts to ensure quality audits are conducted in the country.

## Textile industry

The audit report of a textile industry has been reviewed. The industry is located in the outskirts of Addis Ababa. The operation comprises knitting, spinning, dyeing and blanket production. The main products from the industry are yarn and garments.

The audit performed followed the complete protocol as mentioned in the report. However, the content of audit report shows a different scenario. The report seems to be prepared on the basis of inspection of the plant. The report is devoid of any data except for total number of employees, number of men and women and number of shifts with working hours.

Two samples of discharged effluent were collected from the source of the discharge. One sample was from the blanket house while the other sample was from dyeing house. The laboratory result shows that the sample from blanket section is less polluted than dying house. The results have been compared with effluent standards of Uganda and except for pH; total dissolved solids, BOD, COD, total suspended solids, phosphates as $PO_4$ , and chloride were above acceptable limits. The industry does not have any comprehensive effluent treatment plant. The audit report have asked the industry to install treatment facility to minimize the pollution load that is discharged to the nearby river.

It is surprising how the industry is allowed to operate without a requisite treatment facility. The report seems to be more an inspection report than an environmental audit going by the way the audit report has been compiled.

## KENYA

The Environmental (Impact Assessment and Audit) Regulations, 2003 details the protocol for environmental audit in Kenya. According to Section 31 (1), an environmental audit study shall be undertaken on development activities that are likely to have adverse environmental impacts. It is applicable to projects commenced before these regulations came into force and to new projects undertaken after completion of an environmental impact assessment study report.

The regulation mandates conducting of the audit by qualified and an authorized environmental auditor or environmental inspector registered in accordance with Regulation 14. Section 31(5) mentions that the audit study should be conducted in accordance with the term of reference developed by the proponent in consultation with the authority. Such direction increases the work load of NEMA officials. It would be prudent if NEMA comes out with sectoral guidelines to avoid working on terms of reference before each audit exercise.

Regulation 34 (1b) highlights the frequency of the audit exercise. According to the regulation, the proponent shall take all practical measures to ensure the implementation of the environmental management plan by preparing an environmental audit report and submitting it to the Authority annually or as may be prescribed by the Authority.

## Dairy industry

CSE could get access to an audit report of an industry in the dairy sector which only aggregates milk, chills it and sells it. There is not much environmental impact from the industry except that it has significant water consumption and wastewater generation of high BOD and COD. However, in terms of wastewater treatment system, the industry has only a septic tank followed by a soak pit. CSE thinks that this arrangement cannot treat wastewater with high BOD and COD load. Additionally, the odour from the wastewater is also reported as a nuisance to the occupants of the premise.

The report does not provide any data on water consumption and wastewater generation, which is important information for a dairy industry to understand its impact on environment. The report also highlighted poor management of solid waste as it is being burnt and the smoke causes a nuisance to the neighbours.

The report randomly recommends installing rainwater harvesting without much justification regarding area availability, annual rainfall data and water requirement of the industry.

It was found that the auditors conducted a public participation exercise during the course of the audit, which is a good step. The concept of public participation during an audit needs to be understood and implemented by other developing countries. CSE could not find the provision for public participation in the regulation but auditors carried it out, which is a good initiative. The audit report of this particular dairy industry also brings focus to the issue on which type of industry should undertake audit exercise.

## MALAWI

Malawi does not have any separate regulation on environmental audit. The procedure for audit is included in the Environment Management Act, 2017. Section 31 (4) of the act, however, mentions the requirement for having regulations for environmental audit. It states '*The Minister may on the advice of the Authority make regulations for the effective administration of environmental audit*.' Section 32(1) also guides the authority to consider carrying out periodic environmental audits of projects for the purpose of enforcing the provision of this Act. It also sets the frequency of the audit as annual. The country also has a National Environmental Policy (NEP), 2004, which is an overarching framework instrument addressing the broad range of environmental problems in the country.

The National Environmental Policy, under the heading Environmental Impact Assessment, Audits and Monitoring has asked for '*environmental audits, including inspections, record-keeping and updating, and monitoring shall be required for activities as determined by the mitigation plans or otherwise*'. The policy has also mentioned development of sector-specific guidelines and standards for EIA's audits and environmental management plans. The information provided in both act and policy regarding environmental audit are general and does not include any specifics. In order to meet the benefits of environmental audit, the country needs to develop comprehensive regulation for EA to help auditors understand the aspects and details to be covered in the audit report.

### Hotel industry

CSE reviewed the environmental audit report of a hotel with 130 rooms. The audit was based on Terms of Reference (ToR) provided by the Malawi Environment Protection Authority. The ToR has asked for concise description of all raw materials used, final products, byproducts and waste generated by the facility, illustration diagram or pictures where possible, and detailed action plan for non-compliance issues, corrective activities, their cost, implementation, timeframe and mechanism for implementation.

The hotel industry has three main environmental issues—water, energy and waste—and the report omitted providing information on these aspects. As mentioned in the report, the hotel uses electricity sourced from a hydro project and from two backup generators. The report has not mentioned the units of electricity used and diesel consumption for generators; instead it has provided the monetary expenditure on the electricity used. It says that MK 15,000,000–18,000,000 worth of electricity per month and MK 2.5–2.7 million of diesel in a month are used. Similarly, for water consumption, the information provided is that 3,623 units of water equivalent to MK 12,000,000 is used in the facility.

Around the world, the acceptable way of providing information on energy consumption and water consumption is kWh/month and $m^3$/day respectively. Providing information in monetary terms is challenging to understand and not the appropriate way, and it needs to be reviewed by the Malawi Environmental Protection Authority (MEPA).

Regarding waste generation, the report says that the solid waste generated is collected and given to the city administration for disposal. In terms of quantification, the report only mentioned that 20 bins of 200 litres are filled every day. The report highlighted burning of garden trimmings and recommended compositing of waste. It mentions that 3,000 litres of wastewater generated per day is discharged into a sewer system, but the bifurcation of wastewater from different streams is not provided. Overall, the information provided in the report does not suffice for the requirement of audit since the performance of the facility cannot be determined due to absence of data.

## NIGERIA

Ministers of Environment under National Environmental Standards and Regulations Enforcement Agency (Establishment) Act 2007 have made several sector-specific regulations in Nigeria. CSE reviewed one of its regulations titled ‘National Environmental (Textile, Wearing Apparel, Leather and Footwear Industry) Regulations 2009’. The regulation is fairly comprehensive and covers several important aspects such as frequency of audit, polluter pays principle and chemical management. Section 2(b) of the Regulation has fixed the frequency of environmental audit reporting to three years. Section 5 of the Regulation highlights the polluter pay principle, where the facility will be responsible for the cost of damage, remediation or reclamation/restoration.

The Regulation details the procedure for safe procurement and storage of chemicals along with recordkeeping. It also provides a strict procedure for banned chemicals and allows them to be used with a permit from the Agency. The list of banned chemicals is provided in Schedule IX of the Regulation. The question that arises here is that when the chemicals are listed as banned how can they be allowed to be used even with permission. They should instead be listed as ‘restricted chemicals’ that need special permit for use.

Section 19(2) states, 'The facility shall be required to quantify and report source and emission data. It shall undertake emission reduction and implementation plan, which shall be reviewed every three years.' This is an essential aspect of the environmental audit report as an evidence of continual improvement in the performance. It is pertinent to mention that the regulation fails to cover the details of stack monitoring such as location of potholes and required parameters.

Section 15 of the Regulation emphasizes on meeting the effluent standards as provided in Schedule I of the Regulation. It prohibits discharge of effluent onto land, watercourse or into a waterbody unless the parameters of the effluent are under permissible limits. Another important aspect of the regulation is that it also details the location associated with type of sample such as grab/spot and composite, along with parameters required. The regulation has even gone one step ahead by specifying the geo-referencing of the sampling point. However, the regulation does not mention the requirement of effluent reduction as stated in air emissions. The effluent quantity and parameters monitored need to be mentioned. The same should be followed in the case of solid and hazardous waste, which is missing in the regulation.

Another highlight of the regulation is the way it details how self-regulation should be implemented and the kind of data to be collected. According to Section 36, the permittee needs to maintain information on production data, water consumption, discharge, emission monitoring, waste management records and accident reports. It is pertinent to mention that while audit guidelines of other African countries focus more on administrative aspects, Nigeria emphasizes on technical information that can be used in the decision-making process.

In an important addition, the Regulation has considered stringent measures on falsification of data. Not only is failing to comply with permit conditions an offence as per Section 45(1) of the Regulation, but so is furnishing falsifiable information under Section 46 of the Regulation. This is an important issue addressed by Nigeria in its Regulation, which needs to be appreciated.

### Tannery industry

CSE reviewed the audit report of a tannery unit to understand how far the guidelines have been followed. The unit has an installed capacity of 20,000 skins/day (wet blue).

The tannery industry is an effluent intensive unit along with significant quantities of waste. However, in the 84-page audit report, only five pages dealt with these aspects. The information as furnished in the audit report with respect to effluent generation in full capacity is 1,200,000 litres/day. Currently, the unit releases 250,000–300,000 litres of effluent daily. However, no information was provided on daily production that can be used for evaluation of the correctness of effluent generation.

The audit report highlighted that the unit has a primary treatment plant that is inadequate in treating the effluent to the level of compliance with the standard. This is supported in the effluent results, which show that BOD, TDS, TSS, chlorides, sulphide, oil and grease, turbidity, phenolic compounds and chloride are on the higher side of the effluent standards. This highlights the release of toxic chemicals in the wastewater discharged in the environment. However, it is difficult to understand how the chromium levels in the effluent were reported as nil, with no proper treatment method.

Huge quantities of solid waste are generated from the unit, comprising fleshing and solid residue from the liming which is made up of broken hair, plastic, paper, chemicals, oil and grease. Around 1,670 kg of waste is generated on a daily basis from the industry. The waste is reported to be dumped on the land outside the industry and is eventually transferred to the approved dumping site. The audit report highlights the possibility of groundwater contamination in the area due to unscientific disposal of waste, but no groundwater sample has been collected to understand the impact. It is also important to highlight that the audit report does not have any information on the amount of sludge generated from the primary treatment plant. It is an important aspect as it is toxic in nature due to usage of chromium and other chemicals in the process. The report does not spell out details on handling, storage and management of solid waste at site.

The audit report did not provide details of energy audit and material balance as mentioned in the introduction section. Overall, the report did not seem to follow the guidelines thoroughly as provided in the regulations. Focus has been given more on social and administrative issues, which are important, but equal emphasis should be given to environmental parameters as well.

## Pharmaceutical industry

Another audit report for a pharmaceutical unit which only procures raw material, packs and sells it was reviewed. It is difficult to understand why such non-polluting units are included to undergo the audit process.

The effluent, air quality and noise data are all under the norms. The unit also has a good effluent treatment plant consisting of neutralization followed by a bio-oxidation process. The unit's solid waste includes polyethylene, cartons, plastic cans, batteries, wood pellets, bottles and used raw material bags. The unit has taken the initiative for reuse and recycle of solid waste generated. Some of these materials are used in packaging/storage of imported and locally sourced raw materials while some are byproducts. Most of the waste is useful to third parties for other purposes and the rest is disposed of to the registered authority. The unit generates 50 kg of waste per week which is a small quantity. The audit report has not provided any information on sludge generated from the bio-oxidation plant and its disposal practice.

## RWANDA

The 2009 General Environmental Audit Guideline of the Rwanda Environmental Management Authority (REMA) was amended in 2014 as the Environmental Monitoring and Audit Guideline (EM&AG). The guideline describes the procedure to be followed while monitoring and/or conducting an audit of industrial projects. It was developed specifically for systematic documentation and conducting periodic evaluation of how activities and processes of ongoing industrial projects comply with the approved environmental management plan.

The guidelines detail what is expected in the report. Apart from assessing compliance with relevant statutory and regulatory requirements, it is also mandatory on the part of the industry to collect data on environmental, operational and social practices, and control procedures. They are also required to identify feasible, cost-effective mitigation and/or corrective measures for overall improvement of environmental and social management practices.

The environmental guideline has stressed on self-audits to be carried out by both internal and external auditors commissioned by the proponent. The auditor must have been registered with REMA. The guidelines also highlights that environmental auditing will be based on project description/design and baseline information generated during the EIA process. Existing projects that have not been subjected to EIA will be audited on the basis of information generated over a period of time.

The proactiveness of REMA could be understood by the fact it has final effluent quality standards based on the assimilative capacity of receiving environment. The guideline has also stressed on provision of wastewater treatment plants such as oxidation pond, sophisticated biological treatment or tertiary plant as per the need to reduce pollution load of final effluent.

It is appreciable to note that guidelines have asked details about the use of ozone-depleting substances as refrigerants. Another highlighted aspect of the guidelines is the provision of sector-specific checklists, which are beneficial for auditors while performing an audit. One of the limitations observed with the guidelines is it has not laid emphasis on the aspect of air pollution.

## Cement industry

A cement industry has a plant with a capacity of 600,000 tonnes of clinker production per annum. The plant is based on energy-efficient dry technology.

Upon commencement of the plant, the neighborhood village communities complained regarding dust and noise pollution and vibration from the industry resulting in cracks of their houses. In addition, complaints on flooding of some village homes due to storm water discharged and overflow from the storage tank were registered.

In response to instructions by the Ministry of Environment to address these complaints, the industry proposed an environmental audit (EA) to be performed for evaluation of issues and guided solutions against the complaints from the village communities.

According to the audit report, ambient air quality was monitored at nine locations, with GPS coordinates. However, no rationale for site selection was provided. Generally, the site selection should be done on basis of wind direction and sensitivity of the area. While analysing the data for air quality, the report mentioned only upward and downward wind direction.

The stack monitoring data from the kiln section shows that that the emissions were below the norms (50 mg/Nm$^3$). Since there were complaints about air pollution from the plant, the audit should have also included monitoring of other stacks attached to raw mill, clinker, cooler section and cement mill.

In order to understand the impact of storm water on the receiving medium, the quality of storm water was analysed. A pH value of 11.76 was found, which above the permissible limit of 8.5. Similarly, conductivity, TDS, TSS and COD were also found to be on the higher side. However, the BOD levels were found well below the permissible limit, which clearly identified that the contamination of storm water was because of plant operation and not domestic sewage. In terms of metal contamination also, the level of copper, cadmium and lead were found on the higher side. The audit report provides a good analysis on the probable reason for high values of parameters, which will help the industry to take corrective measures.

The audit report has highlighted some of the good practices of the industry which can be used for sectoral benchmark not only in Rwanda but also at the pan-Africa level. The industry currently uses locally available alternative fuels, such as peat, rice husks and palm kennel, to minimize the use of coal. The industry's target is to use 19 per cent of alternative fuels replacing coal but is currently at 13 per cent, which is a good initiative.

The recommendations given in the audit report are good but could be little bit more stringent to bring down dust levels significantly in the surrounding areas of the plant. The measures could be a completely covered yard for raw material and coal/fuel, 100 per cent covered conveyor belt, concrete road for movement of vehicles from mine to plant and regular ambient air quality and stack monitoring. Periodic data is also required to understand the impact of plant operation on the surroundings, especially when there is public complaint. One-time data collection or data of a few hours cannot define the environmental performance of the plant.

### TANZANIA

According to the Environment Impact Assessment (EIA) and Audit Regulations, 2005 and its Amendment of 2018, 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.

Part X of the Regulation details the objectives, principles, self-audit guidelines and content of audit reports. An environmental audit study is required to 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. The section also clarifies that 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. The content of the audit report is governed by the terms of reference developed by the proponent or a developer in consultation with the National Environmental Management Council (NEMC). Such direction increases the work load of NEMC officials. It would be prudent if NEMC comes out with sector-specific guidelines to avoid working on terms of reference before each audit exercise.

Under Section 49 of the Regulations, NEMC has been empowered to check the compliance status against the environmental parameters and verify self-auditing reports submitted by project proponents. Section 51 of the said Regulation emphasizes on the procedure of conducting an environmental audit. Apart from providing a monitoring plan, verification of records and infrastructure facility for environmental management, 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.

Section 53 of the Regulation also lays down the process for review of the audit report. It 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.

## Sugar industry

An audit report of a sugar industry has been reviewed. The industry has a production capacity of 82,000 metric tonnes per year of sugar and has a cogeneration plant of capacity 5 MW power output.

The sugar industry is a water-intensive unit. However, the audit report has no information with regard to the quantity or quality of wastewater. No water balance and water circuit network is provided to highlight the major water-consuming areas as well as source of wastewater in the industry. Additionally, no laboratory report with respect to quality of wastewater discharged is reported. The report highlights that wastewater from the industry is channelled into the on-site drainage system and then discharged into natural wetlands without mentioning the adequacy of the wastewater-treatment facility.

According to the audit report, solid waste from the industry is generated in the form of bagasse, filter cake, boiler ash, office trash and garbage. Bagasse is collected and stockpiled in the factory and used as a source of energy for heating boilers. 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 once again does not provide information on the quantity of waste generated from industry.

The report provides information on stack monitoring of bagasse-fired boilers for which data was collected for parameters like $CO_2$, CO, NO, NOx, $SO_2$. It is pertinent to mention that though particulate matter is a significant pollutant from boilers, no monitoring data for PM has been provided.

The review of the audit report concludes that the information provided by the developer is not sufficient. The report has more information in text and less in terms of data, thus making it difficult for regulators to understand the plant's environmental performance or to take any regulatory decisions. The availability of historic data is also insufficient in the audit report.

## Cement industry

The integrated cement plant has an installed capacity of 3 million tonnes per annum of Portland cement.

The audit report provides details about emissions from different stacks in the plant, but no data has been made available regarding emissions from the kiln, clinker cooler and power plant stack, which are major sources of emissions in a cement plant.

One chapter of the report has been dedicated to the project description and current operation, and has ample qualitative information but little quantitative information. For example, in one table, the information on mineralogy in terms of percentage of various chemicals has been addressed, but no description has been provided thus making it difficult to understand the purpose of the table.

Similarly, the information on mining equipment and mining manpower in the report is 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, exhausted, used for dumping of waste such as overburden and topsoil and land used for reclamation. Even the size of land allotted for mining of limestone is not mentioned in the report.

In addition, the report provides information on ground vibration from different sections of the plant and mine. It is difficult to understand the rationale for providing such information as 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, which do not cause much vibration. Although the data clearly shows that the vibration was low in comparison to the Occupational Safety and Health Administration (OSHA) Regulation, 2016, such information makes the report unnecessarily bulky.

## ZAMBIA

The principal law for environmental management in Zambia is the Environmental Management Act No. 12 of 2011 as amended Act No. 8 of 2023. Further, Zambia has the Regulations for Environmental Impact Assessment and Environmental Audits.

The provision under Section 30(2) e of the regulation includes requirements of environmental audit for 'categories of facilities and activities in respect of which the Agency may require environmental audits to be conducted and the submission of reports on the audits to the Agency'. The Section 30 (2) f of the regulations details about the contents of an environmental audit report.

Further, Regulation 28 (2) requires a developer to undertake an environmental audit of the project within a period of not less than 12 months and not more than 36 months after the completion of the project or the commencement of its operations, whichever is earlier.

The regulations require preparation of environmental audit report by at least two appropriately qualified persons from those who prepared the environmental impact statement, and where this is not possible, by persons whose names and qualification have been approved by the council for the purpose. The report needs to be submitted annually to the Agency.

The EIA Regulations also states about the penal provision against submission of false statement in an environmental audit report or failing to comply with the Regulations.

### Cement industry

CSE have reviewed the audit report of a cement company—an integrated cement plant which has both mine and cement manufacturing units and also has coal-fired thermal power plant.

It is surprising to observe the environmental audit report has no information on production capacity of the plant, limestone and coal consumption on daily or monthly basis. The report is not an actual audit report but only a compliance status of environmental management plan submitted in EIS. The report, however, does not provide rationale on the scores given on each parameter.

The audit report failed to provide appropriate information on type of storage provided for crushed limestone and coal, coverage of conveyor belts, number of transfer points with bag filter and air pollution-control equipment at the crusher. The report has detailed out less about coal-based power plant. Even the installed capacity of power plant and quantity of coal used is not mentioned in the report. The report has focused more on hazardous waste which is not a big issue in a cement plant.

The highlight of the audit report are the annexures, where details of effluent parameters, stack emissions, ambient air quality data and solid and hazardous waste management are provided. The report also has a scanned copy of self-monitored data, which is a good practice. The only issue observed is PM data from the kiln stack is as low as 1.1 mg/$Nm^3$, which is difficult to achieve.

Topsoil removal, its storage and stabilization is an important activity in a mining operation. It is therefore pertinent to understand how the industry manages the topsoil. The report only mentioned that the topsoil is stockpiled and no further information is provided on it.

One of the important observation in the audit report is inadequate storage of fly-ash in silo. The ash has been stockpiled behind the power plant, which is not a good practice as it cause air pollution. The report highlighted the good practice of managing $SO_2$ emission through the injection of limestone as an absorbent in the coal.

## ZANZIBAR

Sections 46 and 47 of Zanzibar Environmental Management Act 2015 mentioned how the Environmental Audit should be conducted in the country. It talks about which projects need to go for audit and focuses on the aspect that audit can only be carried out by the expert of firm recognized under this act. The country also has Environmental Assessment Regulations, 2019 which covers both EIA and audit process. According to these regulations, the expert or firm is required to submit the scoping report and draft Terms of Reference to the Authority before initiating the audit. It also mentions involvement of various experts and stakeholder in reviewing of the submitted audit report.

Further, in 2022 the Zanzibar Environmental Management Authority has also published the 'General Terms of Reference' for conducting an environmental audit in the country. According to these Terms of Reference (ToR), the process for conducting Environmental Impact Assessment needs to be used for conducting the Environmental Audit. The ToR have also provided scope of the work, which is similar to what is covered in the EIA report such as process description of existing activity, its location, size and components, baseline condition of the site, including relevant socioeconomic, biophysical, heritage and cultural aspects etc. The ToR have also listed what needs to be done in the public consultation process. The ToR is valid for three months, which can be extended by ZEMA on request. Overall, the ToR provides general guidelines on what to be included and how the audit needs to be done.

## Hotel industry

Audit reports of two resorts were reviewed, one with 24 rooms and other with 100 rooms.

There are three main environmental issues with resorts and hotels—water, energy and waste. However both the reports have failed to provide detailed quantification of data on the above said aspects.

Both the reports have provided some information on water consumption and wastewater discharge, but there is no water balance provided that can highlight sources and quantity of water consumption and wastewater generation. Both the reports have also stressed that no treated or untreated grey water is discharged into the sea and is reused for the purpose of gardening or irrigation. However, the report does not mention details about wastewater treatment from toilet flushing, which has more organic and faecal contamination. Moreover, no monitoring data on quality of treated wastewater is provided in the report.

Both the resorts are dependent on renewable energy, especially hydro to meet their power requirement and also have generators for emergency power. One of the reports provides the energy requirement from various sources while the other does not mention the amount of energy used from hydropower.

Similarly, both the reports have mentioned total quantity of solid waste generated but no attempt is made to provide information on bifurcation of the waste with respect to sources. The resorts dispose of their total waste through an officially registered company for collection which disposes of waste on a dumping site. The reports does not provide any recommendations on composting of waste such as leftover food, vegetable or fruit, which can be used as manure.

The salient feature of both the reports is they have gone for stakeholder—including local communities—engagement exercises for feedback and/or complaints.

## 1.1 Conclusion and recommendations

The review of the environmental audit's legislation and few audit reports clearly establishes that there are concerns with the way environmental audit is being conducted in African countries. Though the countries have made efforts to bring in a system through adequate legislations for quality audit reports, the implementation seems to be quite weak. For a few countries, the reports were more compliance reports than actual audits; for others the reports are more theoretical with lesser required data. The major inadequacies identified are as follows:

1. **Insufficient quantitative information:** Most of the reviewed audit reports provide detailed information about the industry manufacturing process, type of raw material used, power source and chemicals used, but only a little information is provided with regard to quantity. Some reports lack even basic data on production capacity, energy and water consumption and quantity of wastewater and solid waste generated. The objective of performing an environmental audit is do a detailed evaluation of an industrial operation in terms of resource utilization and waste generation. With the absence of the data, the whole audit process becomes ineffective.

2. **Lack of historical data:** None of the reports reviewed have historical data. Historical data is data of an industry's operation for the last two to three years, which helps in analysing whether the performance of an industry has improved or deteriorated which cannot be done with one-year data. It also helps to understand the effectiveness of proposed measures by the developer in previous audits.

3. **Incomplete monitoring information:** The audit reports have provided exhaustive information on protocol adopted to conduct monitoring and equipment used but failed to provide data from relevant locations. For example, the audit report of a cement industry has provided monitoring data from all the stacks except the main stack, which is attached to the kiln. This stack is the major source of emissions in a cement plant.

   Similarly, the audit reports do not provide monitoring reports for effluent (treated or untreated) discharged from an industry. A few reports have conducted ambient air monitoring in and around industry, but the rationale for site selection for the monitoring have not been provided. Performing monitoring at locations where the impact of a plant's operation is minimal does not serve the purpose.

4. **Weak enforcement:** While the review of audit reports shows inadequacy at the developer's and auditor's end, it also highlights negligence from the regulators front as well. Allowing operation of a textile and tannery industry without adequate treatment plant, dairy industry with only a septic tank for treating high BOD/COD effluent, and a hotel industry without waste compositing are a few examples observed highlighting weak enforcement.

5. **Non-polluting industries undergoing audit process:** A dairy industry which only buys milk, chills it and sells it had gone for an audit process. Similarly, a pharmaceutical industry which procures raw material and does packing has undergone auditing. These are non-polluting industries and can be exempted from the audit process.

## Recommendations

The robustness of legislations clearly highlights the countries' intention of managing environmental issues along with ensuring sustainable development. The aforementioned inadequacies are a result of poor implementation of law on the ground and require stringent enforcement by the regulatory authority. Additionally, a few amendments on the regulatory front will also help strengthen the whole audit system. Thus, CSE proposes the following recommendations:

1. **Strengthening of legislation:** As mentioned earlier, the countries have made efforts in reinforcing the legislation. However, in order to get the desired results in the form of good-quality reports, it is required to bring more clarity in the legislation. The legislation should clearly distinguish between compliance audit and comprehensive audit and mention the requirements separately for both. For comprehensive audits, the regulation/guideline should provide a tabular format in which data regarding the industry/facility should be filled by the auditor. This will provide a clear understanding to the auditor about what information needs to be collected and submitted in the audit report. The legislation should also mandate that the auditors provide environmental data for at least two years. This will enable the regulators to evaluate the performance of the industry and will serve as a data bank that can be used to take policy decisions.

2. **Listing of industries eligibility for Environmental Audit**: The non-polluting industries undergoing audit unnecessarily increases the responsibility of the reviewing authority. Therefore, countries need to develop an eligibility criteria for industries for audits. The rationale for listing can be based on the scale of operation, type of raw material used (use of hazardous chemicals),

type and quantity of fuel used, quantity and characteristics of wastewater and waste generated etc. Non-listed industries can be subjected to inspection by the regulatory authority.

3. **Development of sector-specific guidelines**: Countries such as Kenya, Tanzania and Malawi have a system of issuance of terms of reference before each audit report is prepared. It is again a cumbersome job for the regulatory authority and seems challenging considering limitation of manpower. On the other hand, Nigeria has developed separate regulations for different sectors, which includes requirements for both EIA and audit. Thus, countries may consider developing sector-specific terms of reference detailing all the requirements needed in the audit report for a particular type of industry. It will also set boundaries for an auditor and will result in precise audit reports.

4. **Development of industry-specific benchmarking**: The benchmarking is essential as it will help in various intra-industry comparison on different aspects within the sector. This comparison is essential in developing the national average with respect to resource consumption (raw material, water and fuel), wastewater and solid and hazardous waste generation per unit of product. The regulatory authority can also compare the national average with the international average and can push the industries to update their process. This will also make the industry cost-effective and competitive in the global market.

5. **Capacity-building programmes:** The review of audit reports indicates a lack of understanding among auditors in terms of information required in the audit report. In order to get good-quality reports, regular capacity building is required for both developers and auditors, making them aware about the benefits of comprehensive audits. Additionally, training programmes for reviewers should also be conducted to enhance their understanding on aspects to be reviewed in the report.

# 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. 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 2: Input and output matrix of environmental audit*).

**Table 2: Input and output matrix of environmental audit**

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

Source: Centre for Science and Environment, India

**Steps to conduct an environmental audit**

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

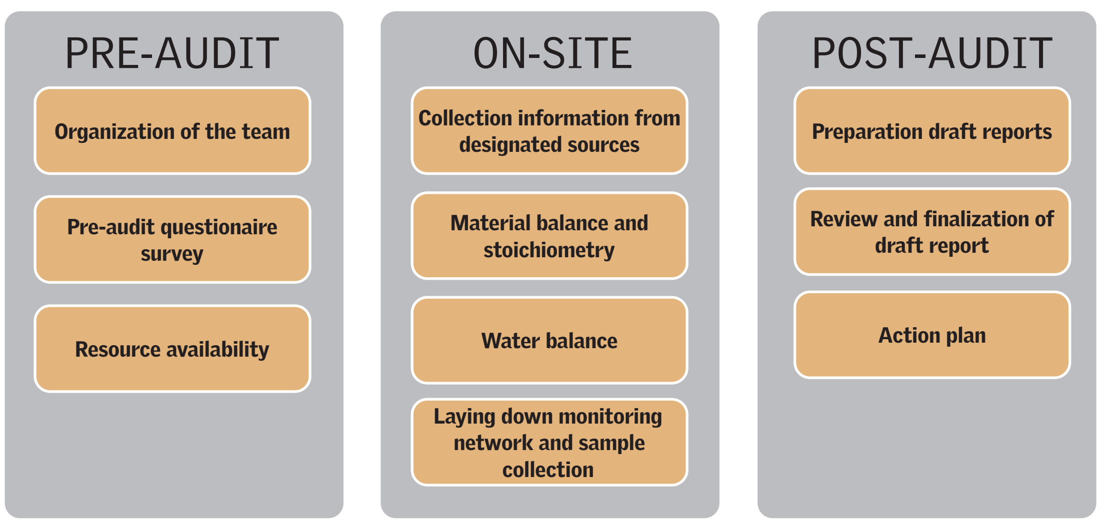
The pre-audit phase is a preparatory phase in which the audit team prepares the plan for conducting the environmental audit and identifies the sources of availability of information, structure of audit team and questionnaire.

The on-site audit phase is reconnaissance survey where site visits are conducted, samples are taken and evaluated and discussion on issues are performed.

The post-audit phase is when the environmental audit report and list of actions 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 of industry is also organized as they are the important stakeholders of the industry and should be considered as team members. The audit team should have a mix 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:

- *Overview and general information*
- *Site history and details*
- *Process review*
- *License permit*
- *Air, water and noise pollution*
- *Chemical handling and storage*
- *Solid and hazardous waste management*
- *Occupational health and safety*

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

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

The focus should be on following activities:

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

**b. Activities at the site**

The tasks involved during this step are as follows:

i. *Collection of information by interviews with cross sectional staff;*

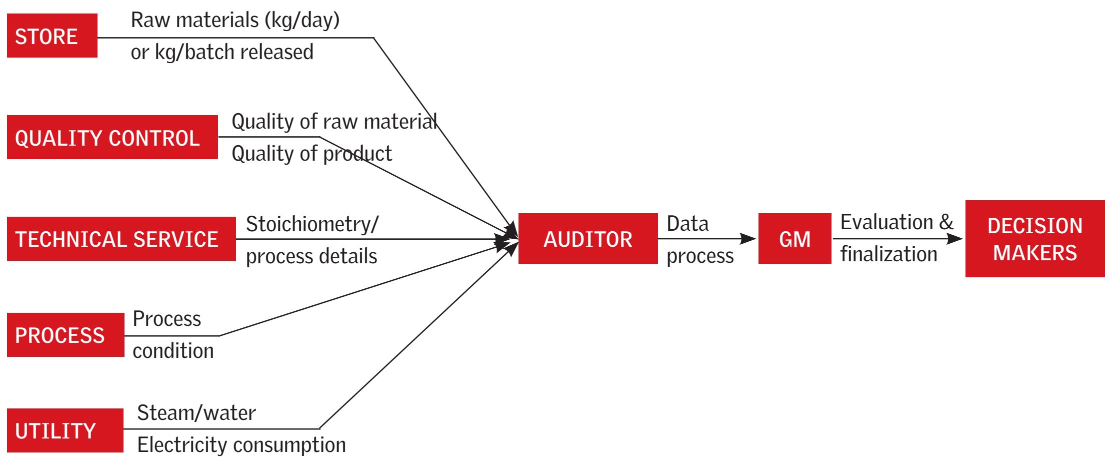
Information and data from different sections of the entity such as store, quality control, technical service, process and utility area are collected and shared with the auditor (see Figure 2: Information network for material balance). The data is synthesized and analysed by the auditor and submitted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

ii. *Verification of material balance, stoichiometry and water balance from* records of the industry;

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;

**Figure 2: Information network for material balance**




Source: Central Pollution Control Board, India

- 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.

*Water balance*

For performing the water balance study at the site, 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 waterdistribution network to derive a water balance.

*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.

*iii. Field inspection and laying down monitoring network for sample collection*

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

*iv. Closing meeting at site*

During the closing meeting draft report is being presented by the auditor to 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; and
- 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 material 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. 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.

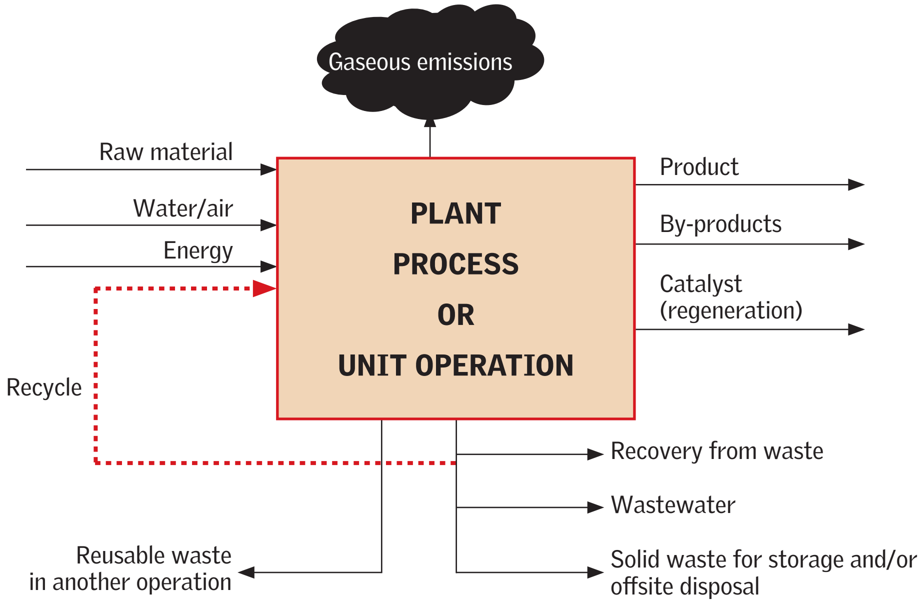
A good understanding of material balance calculations is essential in process design and fundamental to control processing, particularly in the control of yields of the products. The first material balance is determined in the exploratory stages of a new process; improved during pilot plant experiments 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, 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]*)

In order to understand material balance, an understanding of terms such as unit operation, unit process and type of industry is necessary. 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 each are unit operations which are connected to create the overall process.

Unit process is a step in which chemical changes take place to the material present in the reaction. This basically implies to a reaction between two or more chemical which results in another chemical. Some of the examples of unit process are oxidation, halogenation, sulphuration, nitration, etc.

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




Source: Centre for Science and Environment, India

## 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.

### *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. Examples of processing industries are milk processing, food processing and oil refineries. Examples of synthetic industries are breweries, cement industry etc.

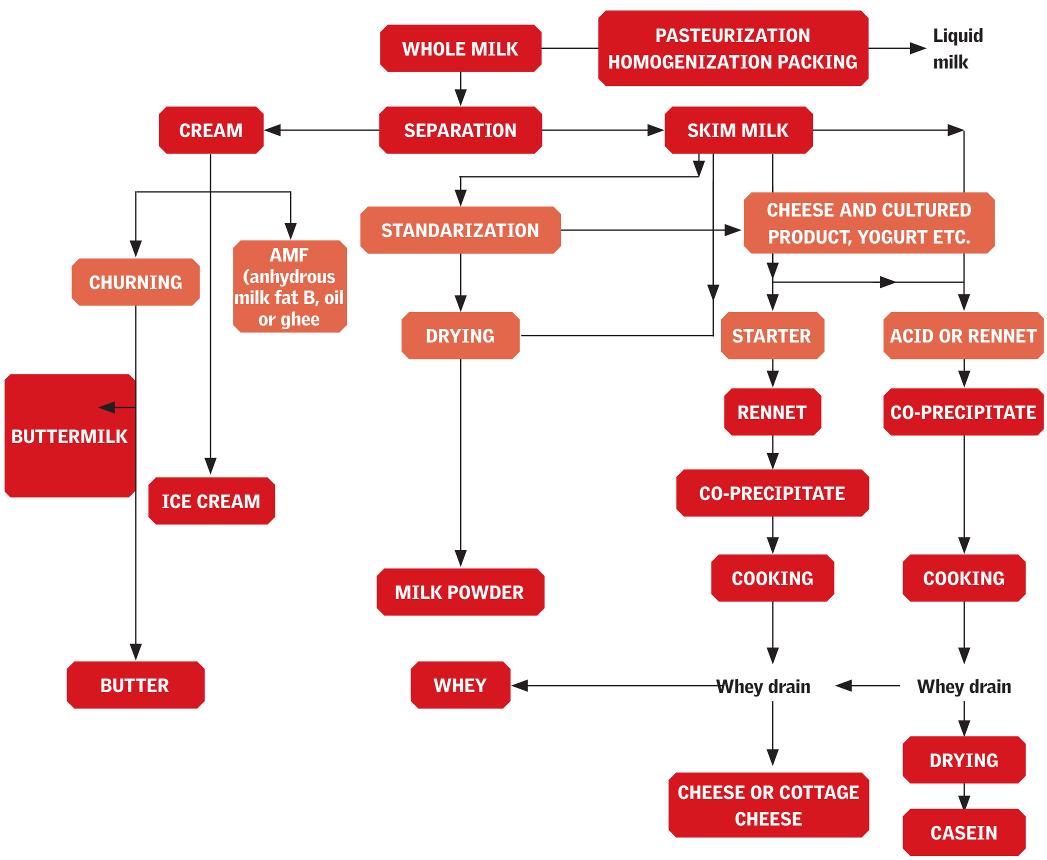
## 2.1.1 Approach for developing a material balance in the case of processing industry

The material balance for the processing industry should 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***

This is illustrated with the case of milk-processing industry, where from the whole milk which contains fats and solid non-fats (protein) is processed to form various products such as butter, cheese, ice cream etc. (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 buttermilk 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.

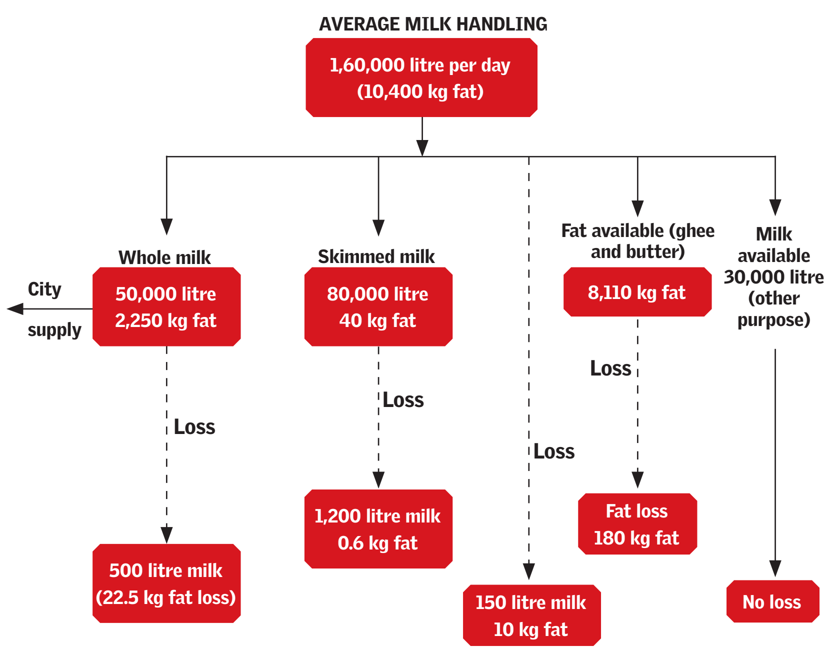
***Material loss in the process***

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**

This is explained with an example of dairy industry in figure 5.

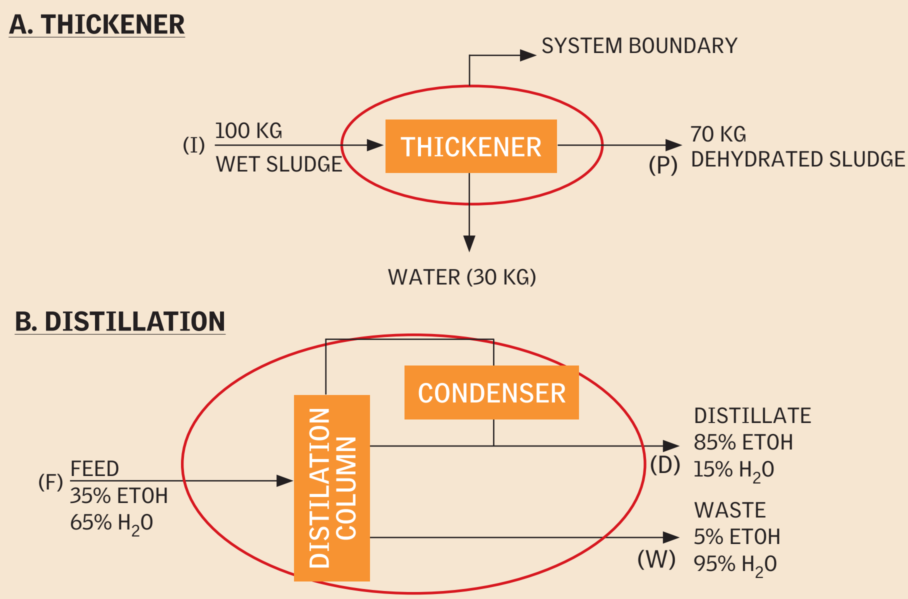
**Figure 5: Material balance of dairy industry**




Source: Centre for Science and Environment, India

**Material balance for processing industry with single-unit operations**

In thickening process, sludge— the input (100 kg)—is passed through the thickener and water (30 kg) is released as waste and dehydrated sludge (70 kg) as 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.




Source: Central Pollution Control Board, India

## 2.1.2 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. There are different cases of material balance in a synthetic industry. Ideally, there is 100 per cent conversion of raw material into products, i.e. **no loss means no pollutants**.

**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 losses in the form of solid, liquid, and gases pollutants to the environment*

Besides the limitation of the reaction mentioned in Case II, 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. The concept of material balance in synthetic industry is explained with an example of DDT (dichlorodiphenyltrichloroethane) manufacturing.

***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:

- 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) | → | $C_6H_5Cl$ (112.5) | + | HCl (36.5) | | |
| $2C_2H_6$ (92.1) | + | $4Cl_2$ (283.6) | → | $CCl_3CH(OH)OC_2H_5$ (193.5) | + | 5HCl (182.2) | | |
| $CCl_3CH(OH)OC_2H_5$ (193.5) | | | OLEUM → | $CCl_3CHO$ (147.5) | + | $C_2H_5OSO_3H$ (126) | | |
| $CCl_3CHO$ (147.5) | + | $2C_6H_5Cl$ (225) | → | $(C_6H_5Cl)_2CHCCl_3$ (354.5) DDT | + | H2SO$_{4}$-SO$_3$ | + | 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 highlights how product such as monochlorobenzene and by-products such as dichlorobenzene 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, but the excess benzene needs to be recovered.

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

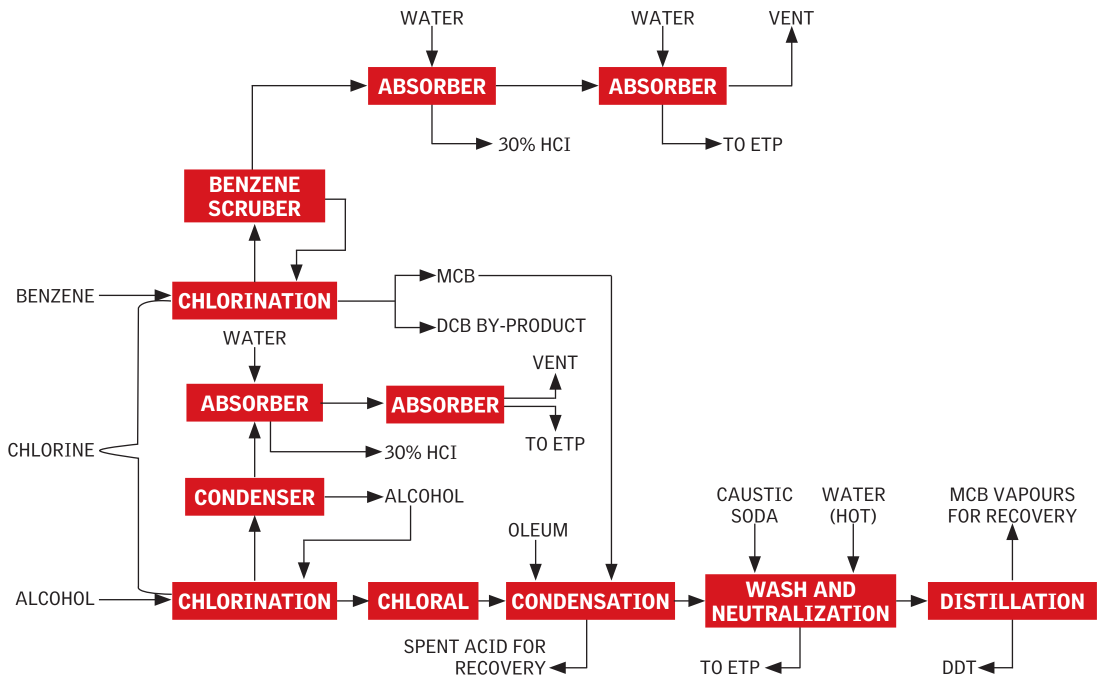
Excess consumption of ethanol needs to be optimized and it should be closed to the stoichiometric requirement and needs to be recovered.

**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

**Figure 6: Sequential diagram for manufacturing of DDT**




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, storage, changes and/or losses in a system. It helps to 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 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.

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 point of water withdrawal or treatment, through the distribution system, and into areas where it is used and finally discharged. A water audit 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 in visualizing what quantity of water is utilized in making a particular product, in identifying whether the product is sustainable or not in terms of water consumption, and identifying steps that can be taken accordingly 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 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 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 is conducting a water audit 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:

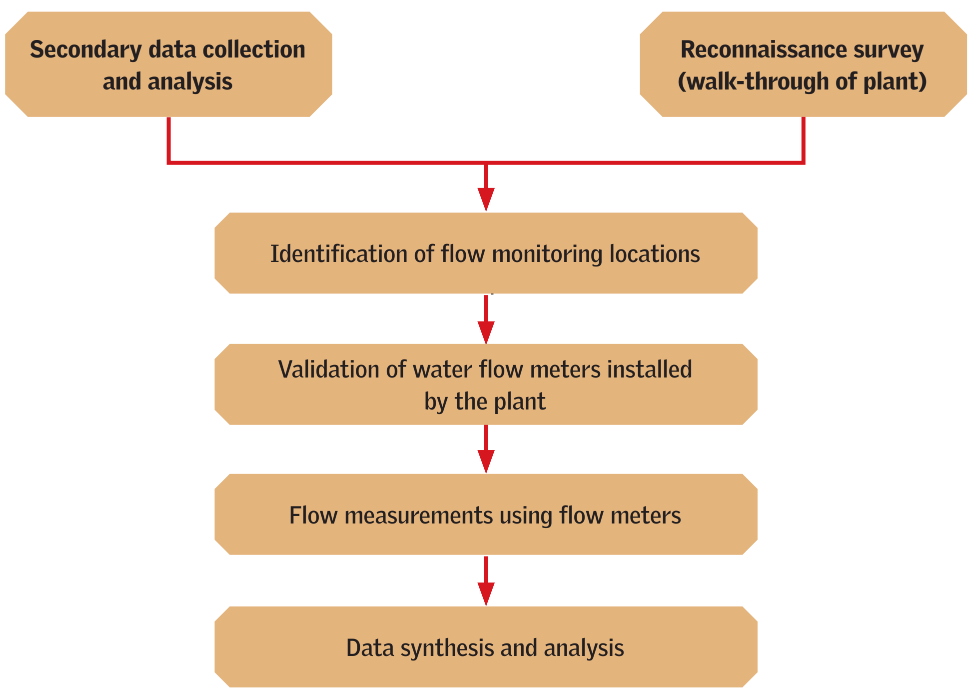
- Secondary data collection and its analysis: A detailed questionnaire is shared with the industry by the auditors and secondary data is collected. The flowmeter readings of flow meters located at various locations such as bore wells, process areas, utility areas, ETP and STP are taken. In addition, 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 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.

**Figure 7: Procedure for detailed water audit**




Source: Centre for Science and Environment, India

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.

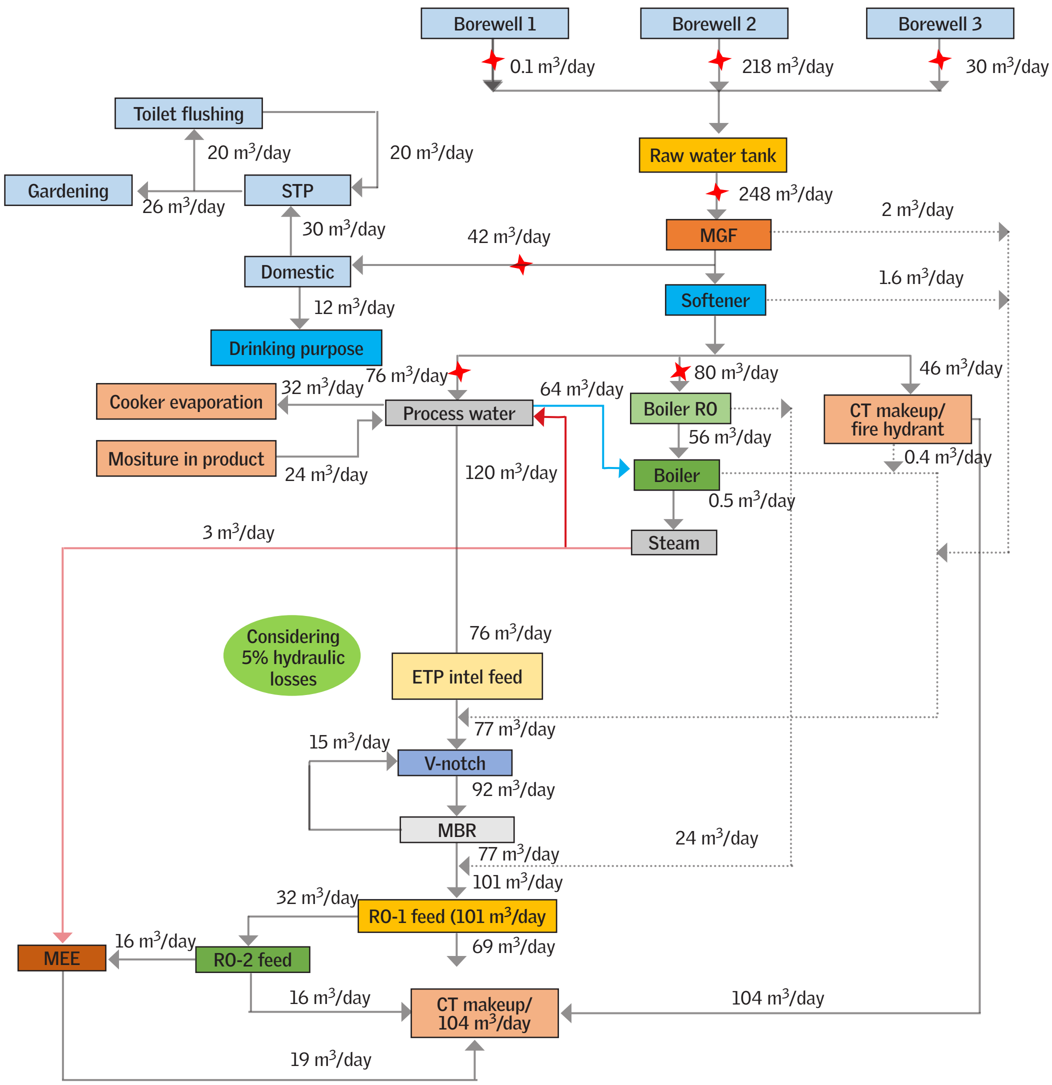
For conducting the water audit study, the data on borewell flowmeter readings and peizometer readings was collected from the plant personnel. Flow measurements were done using the ultrasonic flowmeters at the borewells, water treatment plant, inlet of raw water tank, and at other suitable locations where 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 m3/day of soft water and 104 m3/day of water (from MEE + RO) goes to the cooling tower as make-up, which is a major area of water consumption.

## Figure 8: Water balance diagram




Source: Centre for Science and Environment, India

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 a 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 identify and highlight the source of emissions, solid waste, and wastewater generation with respect to each unit operation/process along with sampling locations for monitoring. Additionally, performance assessment should be done for the installed pollution control devices (PCDs) and effluent treatment plant (ETP). The second step includes attempting to quantify the air pollutant emitted.

The case of pollution assessment has been highlighted in the figure 6, where the sequential diagram of DDT production has been shown.

***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 different type of emissions such as chlorine gas, alcohol vapour, HCl gas, dust and inert of DDT that are released from various sections such as MCB, CA house chlorinator, and grinding sections of a DDT unit.

It also suggests ways to control these 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. The wastewater generation profile highlights the collection and treatment facilities which are important components. The wastewater generation profile reflects the input (water use) and output (wastewater) and distribution of water. A monitoring network should be designed to allow identification of the specific source as well as the combined wastewater treatment facility network.

**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

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 and various other pollutants from wastewater and making the wastewater fit for discharge into waterbodies or on to the surface. Improving the performance of the effluent treatment plant helps in reducing the operating costs, compliance with discharge license conditions and minimizing environmental pollution.

For assessing the performance, various sampling locations at the effluent treatment plant, parameters to be monitored and frequency of monitoring is required (see *Table 5: Parameters to be tested and their frequency at ETP*).

**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 neutral-izsation | 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 |

Source: Centre for Science and Environment, India

Testing the wastewater quality at these locations 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 for ETP of DDT plant*).

***Hazardous waste management***

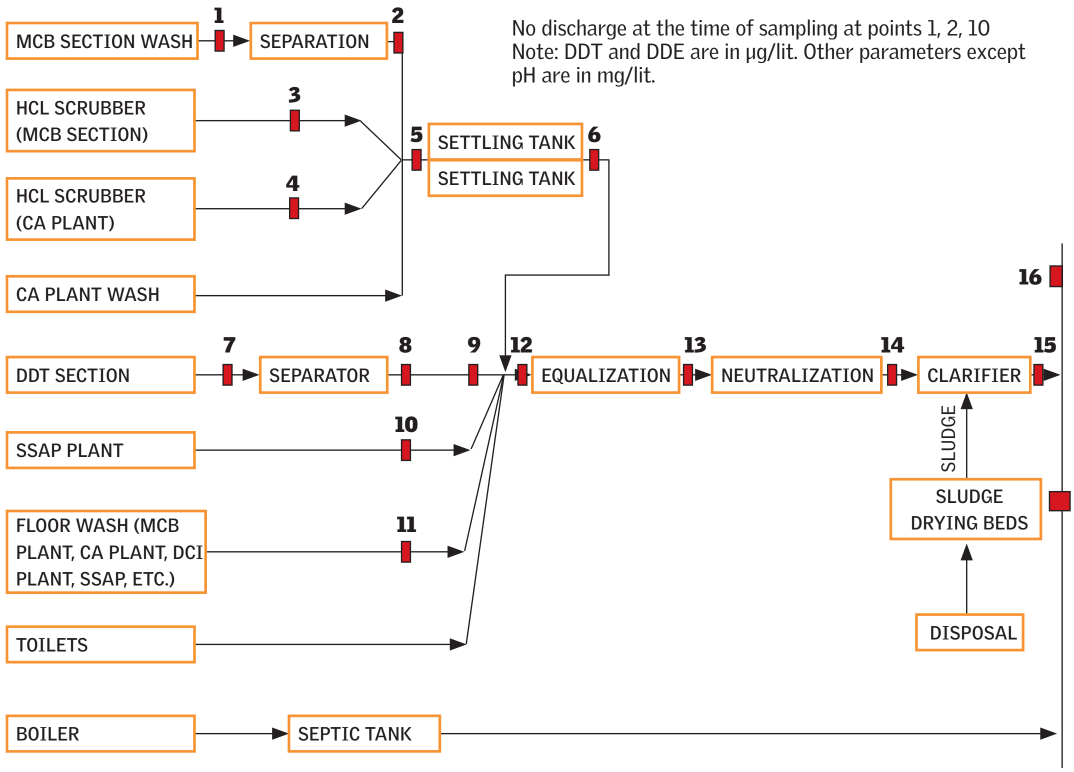
After the performance of the ETP is evaluated, the last component of pollution assessment strategy is the hazardous waste management system.

Hazardous waste is non-biodegradable, persistent in the environment and deleterious to human health or natural resources. It can be in the form of liquids, solids, 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.

### Figure 9: Spatial distribution of sampling location for ETP of DDT plant




Source: Central Pollution Control Board, India

In order to assess the performance of hazardous waste management, the information regarding sources and quantity of hazardous waste, type and categorization of waste with respect to incinerability, recyclability or environmentally safe disposal to secure landfill. The auditor should check the in situ storage and record keeping system. The audit team should also ensure that the recycler and the owner of common TSDF (treatment, storage and disposal facility) is authorized by a competent authority (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

Discussion in Chapter 2 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 data so that quantification can be statistically stabilized with an acceptable variation. Thus, industry must have a self-regulation mechanism to keep a record of their performance and effective utilization of resources.

Self-regulation is a process whereby members of an industries monitor their own adherence to legal, ethical and 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.

***Components of self-regulation***

The major components 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*)

***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 in environmental management (see *Figure 11: Industrial system and organization*).

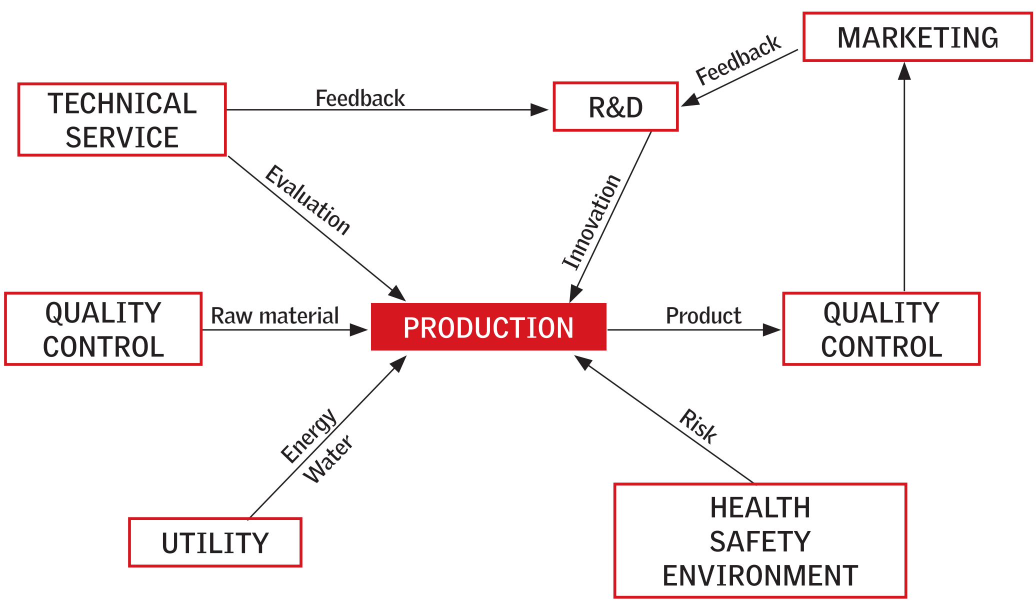
The contribution from major segments of the industries is as follows:

- 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.

### Figure 10: Components of self-regulation


Source: Centre for Science and Environment, India

### Figure 11: Industrial system and organization




Source: Central Pollution Control Board, India

- 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 as 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.

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.

***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.

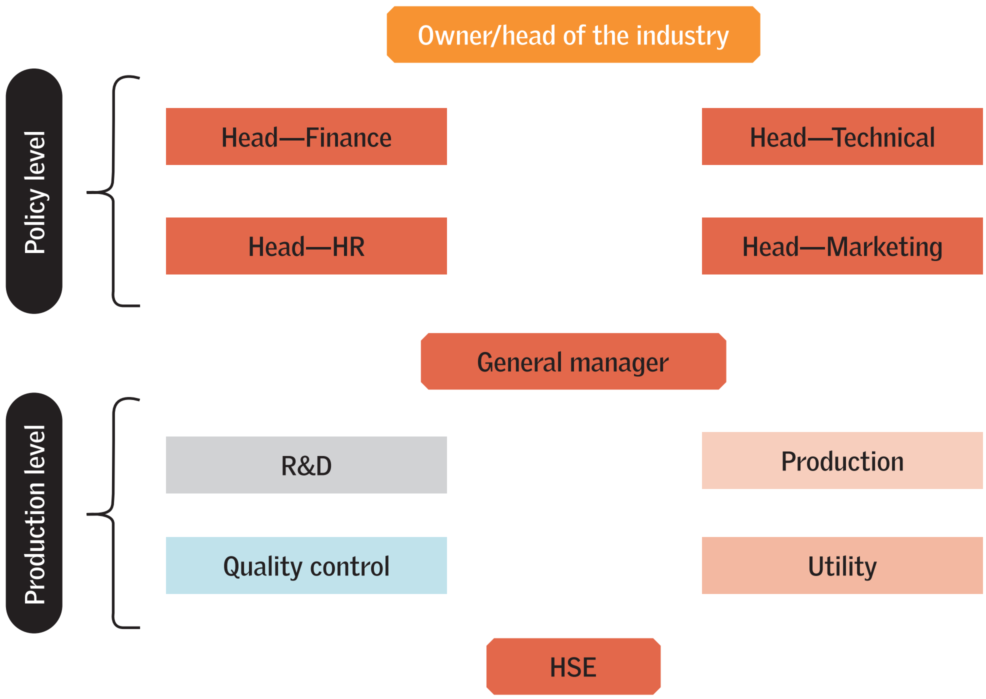
In an organization setup, owner/head directs at the policy level the head of various departments such as HR, technical, finance and marketing section, while at the production level, the General Manager directs the heads of various departments such as R&D, Quality Control, Production, Utility, and Health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

***c. Policy***

Internal policies should 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

**Figure 12: Organizational setup with two-tier system**




Source: Centre for Science and Environment, India

### *d. Creating a database*

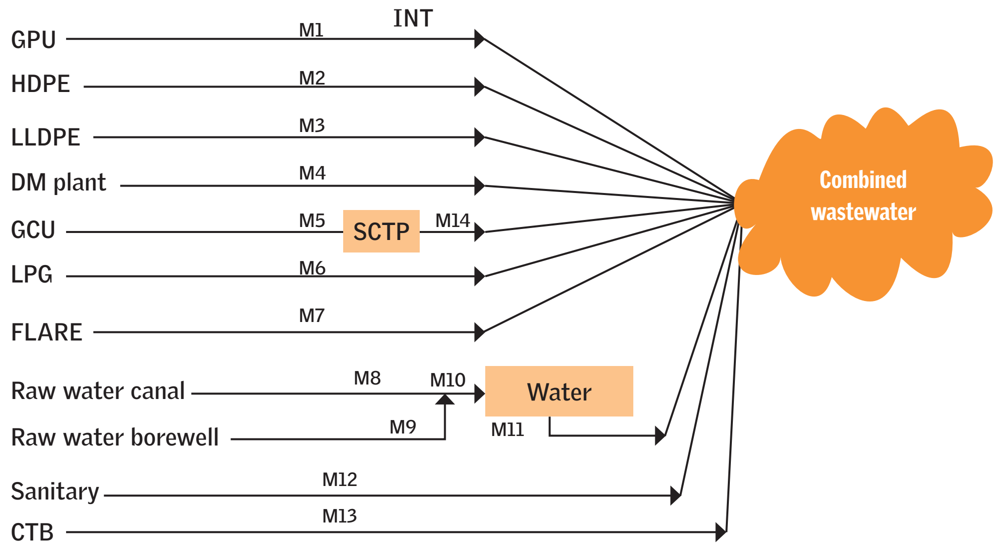
Creating a database has two major components:

*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 emissions, solid waste generation, or all of them. This needs systematic observation by way of a comprehensive monitoring programme.

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.

**Figure 13: Pollution load assessment in a petrochemical complex**




Source: Central Pollution Control Board, India

GPU: Gas process unit, HDPE: High density polyethylene, LLDPE: Linear low-density polyethylene
DM: Demineralization plant, GCU: Gas cracking unit, LPG: Liquified petroleum gas.

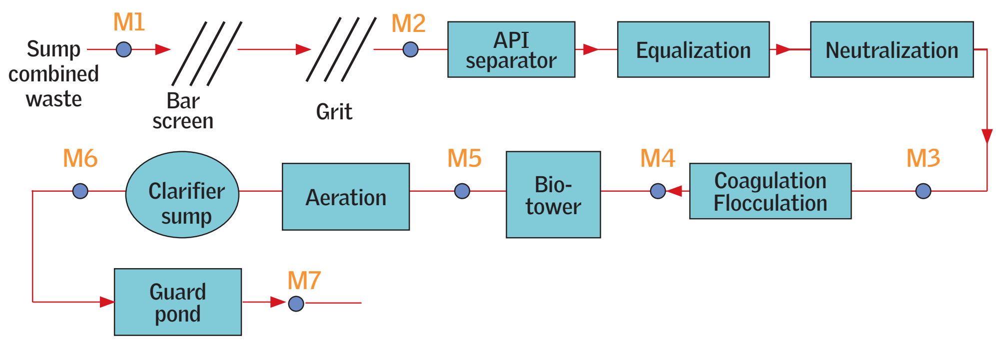
Each plant should have a monitoring station and the outcomes of the monitoring should be as follows:

- 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?

*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**




| | | | |
|---|---|---|---|
| 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

*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 the monitoring locations and the frequency of sampling and the parameters to be analysed.

Such detailed evaluation of pollution control devices is also applicable and should be done for 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 an industry comprising a series of activities for waste minimization, recovery, recycling and reuse approach. These activities are briefly described in the following:

*Waste minimization*

a. 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 wastewater and identify the possibilities of its recycling or recovery.
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*).

**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<br>• International conventions<br>• Legislations in exporting countries<br>• Sustainable development<br>• ISO standards |
| II | Management level | Implementation | • Duties and obligations under environmental legislation in the country<br>• Self-regulations and data management including reporting<br>• Conducting environmental audit, safety audit, ISO 14000 audit<br>• Development of SOP operate/laboratory analyst/helper |
| III | Worker level | Implementation | • Awareness on safety and environment<br>• SOP follow-up programme |

Source: Centre for Science and Environment, India

### *g. Transparency and report writing*

Reporting is useful for correction of operational practice of the entire factory operations and for internal purposes. A report should involve the investigation details and highlight the problem and the possible solutions. In addition to this, a report should be clear and lucid and should give 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 should review the report—it may comprise a single technical committee that does the entire review work of all industries in that country, but this may overburden 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 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 as members. 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 auditor 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 is as follows. The Principal Auditor is 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.

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.

**Table 8: Qualification and work experience required for audit team**

| S. no. | Designation | Qualification | Experience | Remarks |
|---|---|---|---|---|
| 1 | Principal auditor | Bachelors of Engineering<br>or<br>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<br>or<br>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 should 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 should be a part of infrastructure.

In addition, infrastructure for sampling of wastewater, stack monitoring kits, hazardous waste collection system are needed (see *Table 9: Checklist for availability of sampling apparatus and analytical facilities with the audit team*).

### 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- |
| | IIs 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 an 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 should 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 (see *Table 10: Checklist for review of status of registration*).

**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' are no, is the audit firm registered by another funding country or international organization such as the World Bank, African Development Bank, etc.? | | | |
| e) | If 'd' is yes, is the registration certification attached? | | | Accept report if 'e' is satisfied.<br>or<br>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. 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 (see *Table 11: Methodology adopted by auditor*). The auditor should also provide a concise environmental statement if required by the authority. The format for the environmental statement is provided in Annexure II.

**Table 11: Methodology adopted by auditor**

| S. no. | Period | Subject | Remarks |
|---|---|---|---|
| 1. | Pre- audit | • Questionnaire survey<br>• Pre-audit visit to assess the facilities available to team<br>• 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)<br>• Material balance<br>• Water balance<br>• Metering and monitoring | • Cross-checking of records<br>• Adequacy of monitoring programme |
| 3. | Post audit | • Draft report and discussion with the plant team<br>• Final report | • Comments on draft report |

Source: Centre for Science and Environment, India

## 4.3 Review of auditor's findings and observations

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

### *Review of auditor's observation w.r.t 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. The high contaminated zones include the wastewater treatment plant (ETP), storage of hazardous solid waste, and production area whereas, 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 (see *Table 12: Checklist for reviewing auditor's observations w.r.t. to layout and housekeeping in factory*).

**Table 12: Checklist for reviewing auditor's observations 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 auditor's observation w.r.t production figure*

The production figures need to be checked for at least two years with the production managers and technical service department. The auditors should 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 (see *Table 13: Checklist for reviewing auditor's observations w.r.t to production figures*).

### *Review of auditor's observation w.r.t. to raw material consumption*

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

### Table 13: Checklist for reviewing auditor's observations 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 for reviewing auditor's observations 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 require-ment? | | | 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?<br>i) IIs is due to impurities so that effective raw material is less?<br>ii) Is the production process condition not controlled properly?<br>iii) Is material handling not proper and resulting in spillage?<br>iv) Is the requirement as per the demand of the reaction?<br>v) Is there any off- specific product? | | | If yes, what is the recommendation given by the auditor?<br>More recovery of the raw material and recycling to the system |
| Any other reasons noted by the auditor? | | | If there are, the auditor should indicate it and maintain the list of raw materials. |

Source: Centre for Science and Environment, India

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 (see *Table 14: Checklist for reviewing auditor's observations w.r.t. raw material consumption*).

***Review of auditor's observations w.r.t. to water conservation and wastewater generation***

The auditor should 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 should 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 (see *Table 15: Checklist for reviewing auditor's observation with w.r.t. water conservation and wastewater generation*).

### Table 15: Checklist for reviewing auditor's observation 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 should 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 should 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 should 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 should 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 should 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 should confirm with the performance evaluation of treatment plant with unit opera-tion/process. |
| Is the entire treatment plant well maintained? | | | If no, auditor should identify areas of improvement and provide the recom-mendations 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

***Review of auditor's observation w.r.t. to solid waste (hazardous and non-hazardous waste generation)***

The auditor should prepare an inventory for both hazardous and non-hazardous waste and should 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 should ask the plant team to prepare it in an adequate manner and keep the records in an organised manner. The auditor should also ask the plant team for the safe disposal of waste in an environmentally sustainable manner and the audit report should 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 (see *Table 16: Checklist for reviewing auditor's observation w.r.t. solid waste*).

**Table 16: Checklist for reviewing auditor's observation 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?<br>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 auditor's observation w.r.t. to air pollutant***

To keep track of the air pollution, the auditor should 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 should 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 (see *Table 17: Checklist for reviewing auditor's observation w.r.t. to air pollutant*).

### Table 17: Checklist for reviewing auditor's observation 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 should 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 should 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 should suggest the SOP, frequency of monitoring as per the license condition for improvement of results.<br><br>If not, the auditor should 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:<br>Old and obsolete machinery?<br>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 $m^3$/tonne or $m^3$/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 demineralization (DM) plant? What is then average quantity of water treated in DM plant ($m^3$/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 $m^3$ |
| **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:<br>Gas—Is the supply regular? If not, mention the number of hours.<br>Biomass—Is it available for the entire year?<br>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<br>i) Electromagnetic<br>ii) Mechanical type<br>iii) Others, if any | | |
| Number of flow meters installed at different locations, | | |
| When were they last calibrated, mention the date<br>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<br>• **Surface water**<br>i) With treatment<br>ii) Without treatment<br><br>• **Groundwater**<br>i) With treatment<br>ii) Without treatment<br><br>• **Seawater**<br>i) With treatment<br>ii) Without treatment | | |

Note: 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<br>2. SS<br>3. BOD<br>4. COD | | | |
| Note: Add more parameters as per NEMC | | | | |
| Air | 1. PM<br>2. SOx<br>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<br>i.<br>ii. | | | | | | |
| From Pollution Control Device<br>i.<br>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<br>i.<br>ii. | | | | | | |
| From Pollution Control Device<br>i.<br>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.

Environmental audit (EA) is a management tool that enables industries to evaluate their environmental performance, verify the implementation of environmental management tools proposed during environmental impact assessment (EIA) and ensure effective compliance of governing environmental laws. A thoroughly performed EA allows industries to analyse ambiguities in the implementation of management plans and take corrective measures. It also helps industries improve the process efficiency by optimizing usage of resources and increasing production, thereby resulting in monetary benefits. On the regulatory front, a comprehensive audit report can be helpful for regulatory purposes as it will help in assessing the compliance status of an industry and understanding its environmental performance. It can also be used by regulators to take a cognitive approach towards the operating environment of industries and to incorporate new priorities in policies and practices.

Environmental audit faces many challenges. Countries have laws and regulations mandating its requirement, but the quality of data provided in audit reports may be debatable.

This report discusses the EA process of eight African countries and attempts to understand the shortcomings as well as best practices followed by these countries. It identifies insufficient data, lack of historical data and weak enforcement as the major issues with the audit reports and suggests recommendations to strengthen the audit system.

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