A Dissertation Report

on

# ASSESMENT OF ENVIRONMENTAL PERFORMANCE MEASURES

# IN

# PROCESS SECTOR INDUSTRIES

**by**


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Department of Mechanical Engineering


Submitted

in partial fulfillment of the requirements

of the degree of

**Master of Technology**


**MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR**



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**JAIPUR – 302017 (RAJASTHAN), INDIA**

## CERTIFICATE

This is to certify that the dissertation entitled **"Assessment of Environmental Performance Measures in Process Sector Industries"** being submitted by **Sulabh Nalwaya (2012PMM5234)** is a bonafide work carried out by him under my supervision and guidance, and hence approved for submission to the **Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur** in partial fulfillment of the requirements for the award of the degree of **Master of Technology (M. Tech.) in Manufacturing System Engineering**. The matter embodied in this dissertation report has not been submitted anywhere else for award of any other degree or diploma.

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## CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled **"Assessment of Environmental Performance Measures in Process Sector Industries"** in partial fulfillment of the requirements for the award of the degree of **Master of Technology (M. Tech.)** in **Manufacturing System Engineering**, and submitted to the **Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur** is an authentic record of my own work carried out by me during a period of one year from July 2014 to June 2015 under the guidance and supervision of **Dr. G. S. Dangayach** of the Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the results of my own work and has not been submitted anywhere else for award of any other degree or diploma.

**Sulabh Nalwaya**
**(2012PMM5234)**

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

**Dr. G. S. Dangayach**
Supervisor

Place: Jaipur
Dated: June 2015

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**- Sulabh Nalwaya**

# ABSTRACT

Today, since environmental burden caused by ordinary organization’s activities is increasing, environmental efforts of business organizations, which account for a majority of economic activities, are extremely important. It is necessary to promote active and voluntary efforts of business organizations, such as efficient use of energy and resources, the reduction of waste, the reduction of environmental burden in production and distribution processes in a variety of business activities, as well as making efforts to prevent industrial pollution, with the viewpoint of the life-cycle of products and services.

Industries or organizations can minimize the pollution created by them, but first of all they should have the knowledge about the performance of their organizations or industries towards the environment. EPMs are the measures which show the performance of environment of an industry.

This research was aimed at assessment of environmental performance measures in process sector industries. The EPMs are categorized in four constructs namely air resources, water resources, land resources and material & energy resources. The main objective of this survey based study is to find out the critical factors from each construct for process sector industries. A database of 150 companies has been created and structured questionnaire was administered.

Based on the data collection from 62 companies, the analysis was done on the recorded data using SPSS 16.0. Descriptive statistics, correlation and t-test are applied to the recorded data and result was concluded.

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# LIST OF ABBREVIATION

| | | |
|---|---|---|
| AP | : | Acidification Potential |
| BOD | : | Biochemical Oxygen Demand |
| COD | : | Chemical Oxygen Demand |
| EAPS | : | Environmental Aspects in Product Standards |
| ECIs | : | Environmental Condition Indicators |
| EMA | : | Environmental Management Accounting |
| EMS | : | Environmental Management System |
| EPE | : | environmental Performance Evaluation |
| EPIs | : | Environmental Performance Indicators |
| EPMs | : | Environmental Performance Measures |
| HTP | : | Human Toxic Potential |
| MPIs | : | Management Performance Indicators |
| NMVOC | : | Non-Methane Volatile Organic Compounds |
| OPIs | : | Operational Performance Indicators |
| SPM | : | Suspended Particulate Matter |
| TSS | : | Total Suspended Particles |
| TTP | ; | Terrestrial Toxicity Potential |
| VOCs | : | Volatile Organic Compounds |

# CHAPTER 1
# INTRODUCTION

Environmental Performance Measures (EPMs) or Environmental Performance Indicators (EPIs) are the measures of environmental performance of an industry. EPMs or EPIs are the numeric values that show the performance of an organization in environmental aspect. In today's scenario, the environmental awareness becomes most important aspect from the customer, social and market point of view. The customers are aware towards the company's environmental performance, of the product they buy. The environmental awareness or the eco-efficient production is the key factor of a leading organization in the emerging market, as there are so many competitors in that field. As for the social point of view, it is the social responsibility of an industry or organization to prevent the environment by minimizing the pollution created by them.

Industries or organizations can minimize the pollution created by them, but first of all they should have the knowledge about the performance of their organizations or industries towards the environment.

There are certain regulations and penalties made by government, so that to make the industries environment conscious. ISO 14001 gives the Environmental Management System (EMS) to measure the environmental performance of the firm. As the pressure from government, public, neighbors, employees, environmental agencies increases, the company becomes aware to measure, documents and disclose the environmental performance.

There is no standard set of indicators that is applicable for all industry branches or companies. Rather, the composition of indicators may vary from region to region, company to company and time to time. One reason here fore can be found in the basic differences between the quantity and quality of a company's processes and products. Another reason is the lack of standard methods for measuring parameters and identifying priorities for specific environmental issues in different regions of the world. [Mohammad Jafar et. al., 2013]

## 1.1 RESEARCH BACKGROUND

Environmental consciousness becomes an essential part of any organization. There are so many reasons behind this like number of laws, penalties by Government to meet the environmental standards. EPIs help the organization to ensure its environmental objectives. A large literature is available on the use of EPIs and Environmental Management System (EMS), as a great research has been done on this subject. ISO 14001 and EU-EMAS regulations and certification promote environmental consciousness of the organization.

Jean-Franeois Henri and Mare Journeault (2007) have examined two aspects of performance indicators namely importance of measurement and use of indicators. Christine Jasch (1999) have compared ISO 14001 standard and EU-EMAS regulations for all type of organization and concluded which type of regulations suitable for which type of organization. Claudio Comoglio and Serena Botta (2011) have done an empirical research on ISO 14001 certified companies on the use of indicators and the role of environmental management system for environmental performance improvement perspective. Julie Doonam et al. (2002) have done an analysis on the role of higher-level management and employee’s education towards environmental performance of pulp and paper plant in Canada.

Sibylle Wursthorn et al. (2010) have discussed on a new approach of eco-efficiency in which economic environmental indicators are developed for monitoring eco-efficiency. PubaRao et al. (2005) have done an empirical research on environmental indicators for SMEs (Small and Medium Enterprises) in Philippines.

A large number of researches also done in process sector. Xin Ran (2000) has developed EPIs for textile process and product on the basis of the life cycle perspective. Greger Raolonjic and Polona Tominc (2006) have done a survey-based research for chemical, paper, metal and plastic industries to justify the importance of environmental management system. Marc Diebacker (2000) has prepared a pilot project for textile industry for environmental and social benchmarking in developing countries.

Ministry of environmental, Government of India has defined the standard emission to air, water and land. They also published the annual literature on environmental emission for individual industry category.

## 1.2 OBJECTIVE OF RESEARCH

The objective of this research is, doing the assessment of EPMs of process industries. Measures related to environmental pollution of process industries are listed from the literature, a questionnaire is prepared based on these listed EPMs, and then research methodology is applied on the result of survey.

The objectives of the research:

1. To examine the status of EPMs in process sector companies.
2. Find out the relation between all factors/elements under each construct.
3. Find out the critical factor/element within each construct.

## 1.3 PROCESS INDUSTRIES

Process industries are the industries where the production are continuous or batch type production. Process manufacturing is associated with formulas and manufacturing recipes, and differs from discrete manufacturing. Discrete manufacturing is associated with distinct items assembly like smart phone, airplanes, automobile, etc. In process manufacturing, the relevant factors are ingredients not parts, bulk materials rather than individual units, and formulas not bills of materials. In process industries there are no parts that required further assembly. We use formulas or formulation instead of bill of materials. In formulation, we find out the total amount (eg. pounds, gallons, liters) needed for production. Process manufacturing and discrete manufacturing are interrelated. For example injection moulding is a type of discrete manufacturing but plastic is process manufactured, which is used as a raw material in injection moulding.

In process manufacturing, the products are produced in bulk quantity. Once the product, is manufactured, cannot break to its constituent parts. For example, once it is produced, a soft drink cannot be broken down into its ingredients.

The process manufacturing includes the following industries:

1. Fabric & Textile manufacturing,
2. Tyre manufacturing,
3. Cement manufacturing,
4. Food & packaging,
5. Fertilizer manufacturing,
6. Pharmaceuticals,
7. Paper & paper products manufacturing,
8. Chemical manufacturing.

## 1.4 IMPORTANCE OF EPMs IN PROCESS INDUSTRIES

Process sector is a major part of whole manufacturing industries. Most products of daily uses and a variety of product, like medicines, paper, cement, textile, etc are manufactured in process sector. Process sector cover a large number of industries, which contributes in a greater portion of environmental pollution. So that it is very important to strictly follow the EMS by the process sector industries. EPMs are the backbone of the EMS, thus EPMs are important in process industries.

## 1.5 BRIFE INTRODUCTION TO THESIS CHAPTERS

**CHAPTER 1** introduces the current requirement of environmental conscious industries. This chapter describes the theme of the thesis. It includes research background of our topic "Assessment of Environmental Performance Measures in Process Industries". The objectives of the research are defined. This chapter also focuses on process industries and the importance of EPMs in process industries.

**CHAPTER 2** is named as Literature Review. The literature related to EPMs and its implementation in manufacturing industries including process sector is reviewed in this chapter under introduction to EPMs, importance of measurement of EPMs, classification of organization, environmental management system, ISO 14031 and measures or indicators.

**CHAPTER 3** is Research Methodology. This chapter describes the design of research methodology. Different steps in completing this research are described in this chapter. The research methodology has been completed in four steps, first is preparation of questionnaire, then database creation of process industries, data collection and analysis.

**CHAPTER 4** is Data Collection and Data Analysis. This chapter includes how data was collected and techniques for data analysis were applied. Reliability test, descriptive statistics, correlation and t-test were applied and results were tabulated in this chapter.

**CHAPTER 5** is Conclusion. The research work of thesis report is concluded in this chapter. The limitations of this study are also described.

# CHAPTER 2
# LITERATURE REVIEW

The literature on performance measurement suggests that organizations should focus more on environmental related or non-financial measures in their performance measurement systems. Organizations must use new performance measurement approaches such as the balanced score card and that measures should be aligned with contextual factors such as strategy and organizational structure. [Maurice Gosselin, 2005] Environmental indicators allow a firm to make measurements related to its environmental performance. In practical terms, environmental indicators also used as a benchmarking, measuring, and monitoring tool to track environmental performance. Within an Environmental Management System (EMS), environmental indicators can be used to check if a firm has met the targets, it is required to set for itself. It can also be used in firms that have not yet implemented an EMS. [Purba Rao, et. al., 2006]

## 2.1 EPMs DEFINATION

Environmental Performance Measures are the indicators that show the performance of the environment of an industry. EPMs are the numerical measures of environmental issues. EPIs represent numerical measures, financial or nonfinancial, that provide key information about environmental impact, regulatory compliance, stakeholder relations, and organizational systems. EPIs refer to the measurement of the interaction between the business and the environment. They represent the quantification of the effectiveness and efficiency of environmental action with a set of metrics. [Jean-Franc-ois Henri and Marc Journeault, 2008]

The new ISO 14001:2004 standard defines the environmental performance as ‘‘measurable results of an organization’s management of its environmental aspects’’. To help the organizations in the process of performance measurement, International Standard Organization (ISO) has developed the specific standard ISO 14031:00. Indicators are the main tools of this standard, and are defined as the ‘‘specific expression that provide information about an organization's environmental performance.'' Their main scope is to make measurement of the environmental performance easier for organizations. Unfortunately, the ''measurement'' of environmental performance remains one of the greatest difficulties for the organizations and for the certification/competent bodies. In particular, a factor, which is often neglected, is the uncertainty of measurements related to the indicators and indices. On the contrary, the uncertainty that affects raw data is a crucial issue, since an indicator can yield a reliable picture of the environmental aspects or performance only if it is based on good-quality data. [Eleonora Perotto, et. al., 2008] EPIs also define as analytical tools that allow one to compare various plants in a firm, or various firms in an industry, with each other and with respect to certain environmental characteristics. [Daniel Tyteca, 1996] EPIs or EPMs are also used as a benchmarking tool as they are used to compare various industries in a sector.

Environment performance measurement is a process of enhancing the environmental management system in order to achieve improvements in overall environmental performance consistent with the organization's environmental policy. ISO-14001 requires full compliance to environmental regulations but is not fix a minimum level of environmental performance for an organization, so ISO 14031 says that EPMs or EPIs are only provide the information about organization's environmental performance. [Claudio Comoglio, Serena Botta, 2012]

## 2.2 CLASSIFICATON OF EPMs

EPMs are classified in two categories namely

(1) Financial and Non-financial indicators,

(2) ISO 14031 classification

### 2.2.1 Financial & Non-financial Indicators

Financial measures are those who associated with the cost analysis and the profit of the firm, whereas non-financial measures are not linked with profit and gives the information about non-financial activities such as emission to air and water, etc.

financial measures are perceived as too historical and backward looking, lacking predictive ability to explain future performance, rewarding short-term or incorrect behavior, lacking actionability, lacking timely signals, being too aggregated and summarized to guide managerial action, reflecting functions instead of cross-functional processes, and providing inadequate guidance to evaluate intangible assets. In spite of their capacity to present results of decisions in a comparable measurement unit, to capture the cost of trade-offs between resources and the cost of spare capacity, and to support contractual relationships and capital markets, financial measures have been criticized for several reasons. Those criticisms have led to the emergence of non-financial measures. However, the link between improvement in non-financial measures and profits is unclear and sometimes impossible to assess directly. The ends and outputs are revealed by financial measures while the means and processes are reflected by nonfinancial measures. Hence, both types of information are useful for managers. EPIs generally integrate both financial and non-financial measures. [Jean-Franc-ois Henri and Marc Journeault, 2008]

### 2.2.2 ISO 14031 Classification

It is a sub category of ISO14001 concerns the evaluation of environmental performance. It proposes guidelines for the development of monitoring and measurement tools that evaluate the efficiency of an environmental system. This standard proposes three categories of EPIs:

**I. Environmental condition indicators (ECIs)** defined as specific expressions that provide information about the local, regional, national, or global condition of the environment. Those measures include

(i) Receptor indicators (e.g. ecotoxicity, biological oxygen demand, ect.)

(ii) Sustainability indicators (e.g. emissions of a substance per volume of production or per unit of value added), and

(iii) Proxy ECIs (i.e. indicators that express emissions and waste data in terms of their capacity to cause environmental damage).

**II. Operational performance indicators (OPIs)** provide information about the environmental performance of an organization’s operations. They include

(i) Input of materials, energy, and services,

(ii) Operation of facilities and equipment and logistics, and

(iii) Output of products, services, waste, and emissions.

**III. Management performance indicators (MPIs)** provide information about management's efforts to influence an organization's environmental performance. Four sub-categories are identified:

(i) Implementation of policies and programs,

(ii) Conformity of actions with requirements or expectations,

(iii) Community relations, and

(iv) Environment related financial performance. [Jean-Franc-ois Henri and Marc Journeault, 2008]

### 2.2.3 Classification According to Measurement, Use and Application

**1. Absolute indicators:** e.g. tons of raw material, emissions, taken from input–output analysis.

**2. Relative indicators:** where input figures are referenced to other variables such as production in tons, revenue, number of employees, office space in $m^2$; e.g. water per hectoliter beer, detergent per $m^2$.

**3. Indexed indicators:** where figures are expressed as a percentage with respect to a total, or as a percentage change to values of previous years etc.

**4. Aggregated depictions:** where figures of the same units are summed over more than one production step or product life cycle.

**5. Weighted evaluations:** which try to depict figures of varying importance by means of conversion factors. [Christine Jasch, 2000]

## 2.3 OBJECTIVES OF MEASUREMENT OF ENVIRONMENTAL PERFORMANCE

During the last decade, there has been an increasingly intensive interest in assessing, measuring and documenting the environmental performance. There is an increasing need for tools that would allow for proper and objective quantification or measurement of the performance of firms with respect to the environment. There are several objectives of the measurements, among the most important being the possibility to:

(i) Document continuous improvement according to ISO 14001;

(ii) Benchmark EP internally and externally for various stakeholders;

(iii) Document improvements of EP from investments in the production;

(iv) Prove compliance with emission permits, voluntary agreements etc. [B. von Bahr et. al., 2003]

Since environmental performance has to be quantified to be comparable, different kinds of indicators are used.

## 2.4 IMPORTANCE OF MEASUREMENT

### 2.4.1 Why EPMs are Important

(i) To allocate the organization’s limited resources to environmental problem solving.

(ii) EPMs supply the information for decision making while ensuring the attainment of the environmental objectives.

(iii) Organizations have to follow some regulations, laws and penalties related to environmental actions.

(iv) EPMs are effective tool for improving business practice and organizational performance. [Jean-Franc-ois Henri and Marc Journeault, 2008]

### 2.4.2 Importance of Measurement of EPMs

The importance of measurement of EPMs refers to the attention devoted by firms to the quantification of various environmental issues. Literature has identified four dimensions of environmental performance that EPIs should measure: internal, external, process, and result. On the basis of those four dimensions, the performance measures are classified into two major categories:

(i) financial and non-financial measures and

(ii) ISO 14031 guidelines. [Jean-Franc-ois Henri and Marc Journeault, 2008]

### 2.4.3 Use of EPMs

Little attention has been devoted in the management accounting literature on the different uses of performance indicators. Indeed, despite a considerable body of literature examining the generic use of various EPIs (i.e., global and undifferentiated use of indicators), the specific manner in which managers as control mechanisms, motivation tools, or communication devices use those indicators has been overlooked empirically.

As per accounting literature, four types of uses of EPMs are important, namely

(i) To monitor compliance with environmental policies and regulation,
(ii) To motivate continuous improvement,
(iii) To provide data for internal decision making, and
(iv) To provide data for external reporting. [Jean-Franc-ois Henri and Marc Journeault, 2008]

### 2.4.4 Purpose of EPMs

Environmental performance measures or indicators may have the following purposes:

(i) Comparison of environmental performance over time,
(ii) Derivation and pursuit of environmental targets,
(iii) Evaluation of environmental performance among companies (benchmarking),
(iv) Highlighting optimization potentials,
(v) Identification of market chances and cost reduction potentials,
(vi) Feedback instrument for information and motivation of the workforce.
(vii) Communicational tool for environmental reports,
(viii) Technical support for Environmental Management Systems (EMS). [Mohammad Jafar et. al., 2013]

Recognizes four desired attributes of environmental performance indicators:

(i) Suitable for an organization's environmental and social targets as well as to the information requirements of stakeholders

(ii) Comprehensible by non-scientists

(iii) Reliable

(iv) Comparable across different organizations and relevant benchmarks. [Mohammad Jafar et. al., 2013]

## 2.5 CLASSIFICATION OF ORGANISATION

According to environmental strategy, the organizations are classified into two categories, namely Active organization and Passive organization.

Active organizations have medium or high managerial involvement, partial or complete integration of the environment function, moderate or substantial employee involvement and training, and moderate or considerable resources allocated to the attainment of environmental objectives. Conversely, Passive organizations are described as having little or no managerial involvement, little or no environmental management and integration, little or no employee involvement and training, and few or no resources allocated to environmental performance.

More specifically, various elements can be used to determine whether an organization follows an active or passive environmental strategy based on components such as . controls on emissions and discharges, residue recycling, use of environmental arguments in marketing, environmental aspects in administrative work, periodical environmental audits, purchasing manuals with ecological guidelines, environmental seminars for executives, environmental training for firm’s employees, total quality program with environmental aspects, pollution damage insurance, environmental management manuals for internal use, environmental analysis of a product’s life cycle, participation in government-subsidized environmental programs, and sponsorship of environmental events.

Secondly, developed by the ISO, the ISO 14000 series of standards define and describe various aspects of environmental management. The ISO 14001 define a structured approach to setting and attaining environmental objectives and targets, and demonstrating that they have been achieved by management that is described as Environmental Management System (EMS). This set of standard encourage the organizations to follow a systematic environmental performance measure activity.[Jean-Franc-ois Henri and Marc Journeault, 2008]

## 2.6 ENVIRONMENTAL MANAGEMENT SYSTEM

The standard ISO 14001:04 defines the EMS ‘‘a part of an organization’s management system used to develop and implement its environmental policy and manage its environmental aspects’’, where the environmental aspects are ‘‘element of an organization’s activities or products or services that can interact with the environment’’. So, an Environmental Management System is a method of incorporating environmental care throughout the corporate structure. It is a useful tool to improve compliance with legislation, address stakeholder pressure, improve corporate image and raise awareness of environmental issues within the organization. An EMS is a continuous cycle of planning, implementing, reviewing and improving the processes and actions of the organization toward the continuous improvement of the global environmental performance. The EMS is based on ‘‘Plan, Do, Check, Act’’ model. [Eleonora Perotto et. al., 2008]

Environmental Management System (EMS) is a problem identification and problem-solving tool, based on the concept of continual improvement that can be implemented in an organization in many different ways, depending on the sector of activity and the needs perceived by management [Sibylle Wursthorn, et al., 2011]. The International Organization for Standardization (ISO 14001) and the European Commission Eco-Management and Audit Scheme have developed the standard for improving global environmental performance. [EleonoraPerotto et. al., 2008]

An Environmental Management System (EMS) helps the organization to reduce its environmental impacts and increase its operating efficiency. An Environmental Management System (EMS) is a framework that helps a company achieves its environmental goals through consistent control of its operations. The environmental performance of the company will be improved by this consistent control. The EMS itself does not dictate a level of environmental performance that must be achieved; each company's EMS is tailored to the company's business and goals. An EMS helps a company address its regulatory demands in a systematic and cost-effective manner. Health and safety practices for employees and the public can be improved by this proactive approach and also reduced the risk of non-compliance. The non-regulated issues, such as energy conservation and promotion of stronger operational control and employee stewardship can also be supported by the EMS.[Jean-Franc-ois Henri and Marc Journeault, 2008]

Basic Elements of an EMS:

- Analyzing the environmental impacts and legal requirements
- Setting environmental objectives and targets to reduce environmental impacts and comply with legal requirements
- Reviewing the company's environmental goals
- Monitoring and measuring progress in achieving the objectives
- Reviewing progress of the EMS and making improvements
- Establishing programs to meet these objectives and targets
- Ensuring employees' environmental awareness and competence.[Jean-Franc-ois Henri and Marc Journeault, 2008]

Environmental management system (EMS) refers to the management of an organization's environmental programs in a comprehensive, systematic, planned and documented manner. It includes the organizational structure, planning and resources for developing, implementing and maintaining policy for environmental protection. More formally, EMS is "a system and database which integrates procedures and processes for training of personnel, monitoring, summarizing, and reporting of specialized environmental performance information to internal and external stakeholders of a firm." To understand the EMS process, EMS is typically reported using International Organization for Standardization (ISO) 14001. An environmental management information system (EMIS) is an information technology solution for tracking environmental data for a company as part of their overall environmental management system.

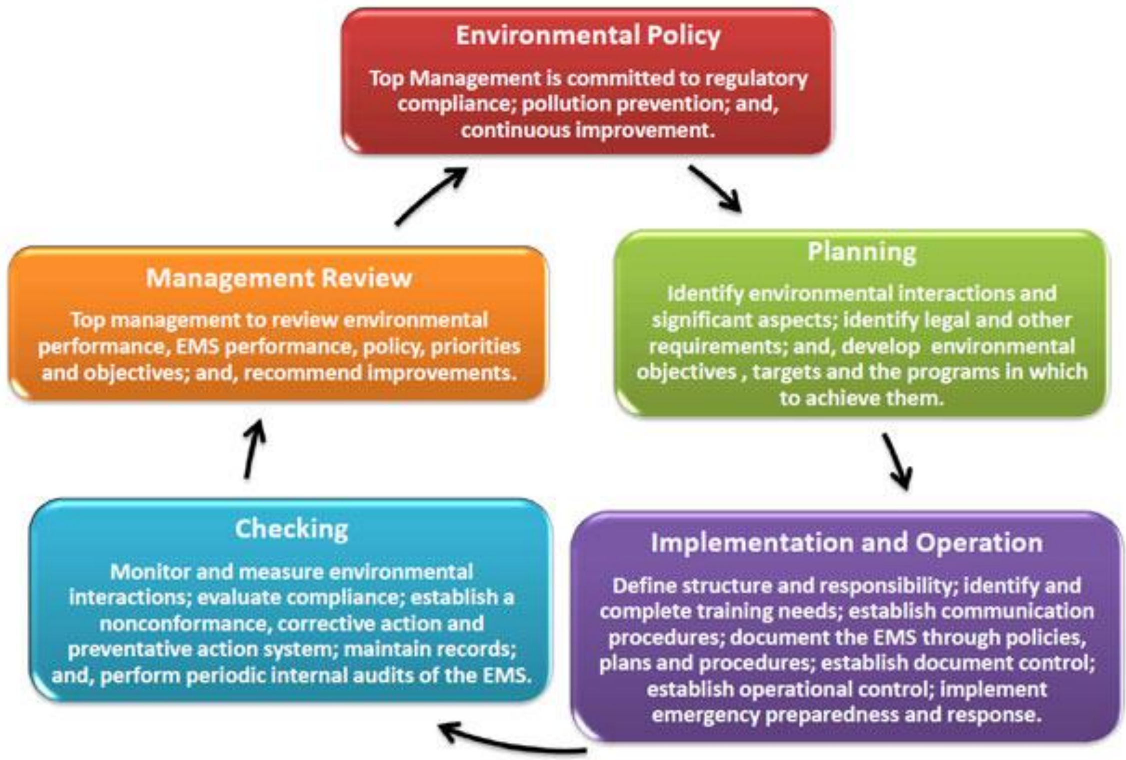


Fig.2.1 - Continuous Improvement Cycle

EPIs are one component of EMA (Environmental Management Accounting). EMA can be defined as the management of environmental and economic performance through the development and implementation of appropriate environmental-related accounting systems and practices.EMA typically involves lifecycle costing, full-cost accounting, benefits assessment, and strategic planning for environmental management and in some companies this may include reporting and auditing. It is considered that EMA is one component of EMS (Environmental Management System). [Jean-Franc-ois Henri and Marc Journeault, 2008]

### 2.6.1 Cost & Benefits of an EMS

| Potential Costs | Potential Benefits |
|---|---|
| **Internal**<br>• Staff (manager) time<br>• Other employee time<br><br>(Note: Internal labor costs represent the bulk of the EMS resources expended by most organizations)<br><br>**External**<br>• Potential consulting assistance<br>• Outside training of personnel | • Improved environmental performance<br>• Enhanced compliance<br>• Pollution prevention<br>• Resource conservation<br>• New customers/markets<br>• Increased efficiency/reduced costs<br>• Enhanced employee morale<br>• Enhanced image with public, regulators, lenders, investors<br>• Employee awareness of environmental issues and responsibilities |

### 2.6.2 EMS under ISO 14031

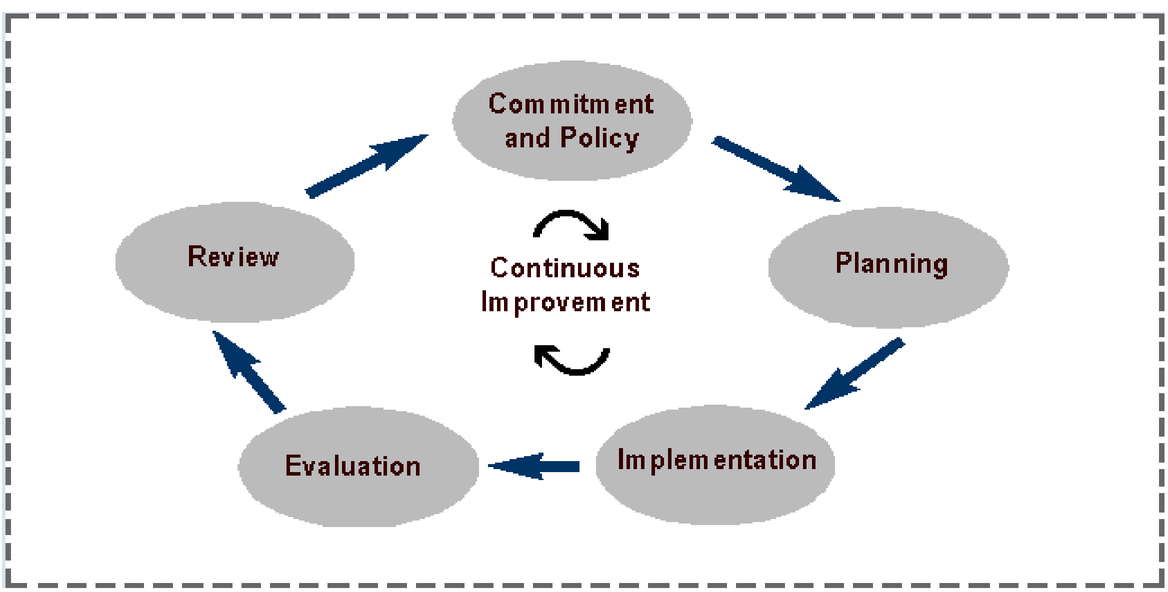


Fig.2.2 - The continuous improvement cycle

An EMS helps a company to continuously improve its environmental performance. The system follows a repeating cycle (see figure 2.2). First of all the company have to commits to an environmental policy, then uses this policy for preparing and establishing a plan, which sets objectives and targets for improving environmental performance. The next step is implementation. After that, the company evaluates its environmental performance to see whether the objectives and targets are being met. If targets are not being met, corrective action is taken. The top management reviews the result of evaluation to check whether the EMS is working. If there is a need to review the plan than the top management revisits the environmental policy and sets new targets in a revised plan. The company then implements the revised plan. The cycle repeats, and continuous improvement occurs.

The five main stages of an EMS, as defined by the ISO 14001 standard, are described below:

1. **Commitment and Policy** Top management commits to environmental improvement and establishes a company environmental policy. The policy is the foundation of the EMS.
2. **Planning** First of all the company identifies environmental aspects of its operations. Environmental aspects are those items that can have negative impacts on people and/or the environment such as air pollutants or hazardous waste such as air pollutants or hazardous waste. The company then determines the most significant aspect by choosing the criteria considered most important by the company. For example, a company may choose worker health and safety, environmental compliance, and cost as its criteria. A company sets objectives and targets after determining the significant environmental aspects. An objective is an overall environmental goal. A target is a detailed, quantified requirement that arises from the objectives. For an example the objective may be minimize use of chemical X but the target is reduce use of chemical X by 25% by September 1998.The final part of the planning stage is devising an action plan for meeting the targets. This includes designating responsibilities, establishing a schedule, and outlining clearly defined steps to meet the targets.

3. **Implementation** A company follows the action plan with the use of necessary resources (human, financial, etc.). An important component of the implementation phase is employee training and awareness for all employees. Other steps in the implementation stage include documentation, following operating procedures, and setting up internal and external communication lines.
4. **Evaluation** In the evaluation phase, the company monitors its operations to evaluate whether targets are being met. If not, the company takes corrective action.
5. **Review** The result of the evaluation is reviewed by top management to see whether the EMS is working. Management determines whether the original environmental policy is consistent with company values. The plan is then revised to optimize the effectiveness of the EMS. The review creates a loop of continuous improvement for a company.

## 2.7 ISO 14031

The ISO 14031: 1999 Environmental management - Environmental Performance Evaluation – Guidelines defines standard on the design and use of environmental performance evaluation, and guidelines on identification and selection of environmental performance indicators, for use by all organizations, regardless of type, size, location and complexity.

ISO 14031:2013 gives guidance on the design and use of environmental performance evaluation (EPE) within an organization. ISO 14031:2013 gives guidance on the design and use of environmental performance evaluation (EPE) within an organization. It is applicable to all type of organizations, every size, every location and complexity. ISO 14031:2013 does not establish environmental performance levels. The ISO 14031:2013 guidelines can be used to support an organization's in its own approach to EPE, including its commitments to compliance with legal and other requirements, the prevention of pollution, and continual improvement.

ISO 14031 standards is a subcategory of ISO 14001. It concerns the evaluation of environmental performance. ISO 14031 guidelines help in the development of monitoring and measurement tools of environmental system that evaluates the efficiency of an environmental system.

ISO 14031 standard proposes three categories of EPIs:

1. Environmental condition indicators (ECIs)
2. Operational performance indicators (OPIs)
3. Management performance indicators (MPIs)

**Environmental condition indicators (ECIs):** ECIs are the measures that provide information about the local, regional, national, or global condition of the environment. Those measures include (i)receptor indicators (e.g. ecotoxicity, biological oxygen demand, (ii) sustainability indicators (e.g. emissions of a substance per volume of production or per unit of value added), and (iii) proxy ECIs (i.e. indicators that express emissions and waste data in terms of their capacity to cause environmental damage).

**Operational performance indicators (OPIs):** OPIs are the measures of the environmental performance of an organization's operations. They include (i) input of materials, energy, and services, (ii) operation of facilities and equipment and logistics, and (iii) output of products, services, waste, and emissions.

**Management performance indicators (MPIs):** MPIs are the measures of management's efforts to influence an organization's environmental performance. The sub-categories of MPIs are(i) implementation of policies and programs, (ii) conformity of actions with requirements or expectations, (iii) community relations, and (iv) environment-related financial performance. [Jean-Franc-ois Henri and Marc Journeault, 2008]

### 2.7.1The ISO 14.000 series of standards for environmental management

A separate Technical Committee TC 207 under the International Standards Organization was established in 1993 to provide a worldwide methodology of tools for environmental management. The series was categories in various sub-committees (SCs) and workgroups, which included all aspects of environmental management.

The SCs includes the following items:

1. SC 1 Environmental Management Systems
2. SC 2 Environmental Auditing
3. SC 3 Environmental Labeling
4. SC 4 Environmental Performance Evaluation
5. SC 5 Life Cycle Assessment
6. SC 6 Environmental Management — Terms and Definitions
7. EAPS Guide for the Inclusion of Environmental Aspects in Product Standards

**SC 1**includes the specification standards ISO 14001 and the guide ISO 14004, the requirements for the establishment of environmental management systems. ISO 14001 is the only specification document within TC 207 which is confirmed by certification. All other standards are not required certification, they are only guidelines, which offer and simplify methodological steps for environmental management.

**SC 2** includes the environmental audit standards and guidelines, including various types of evaluations to identify environmental compliance and management system implementation gaps. There are two different types of environmental audits: compliance audits and management systems audits.

**SC 3**includes the guidelines to give environmental label to the product to confirm that the product is environmental friendly. ISO 14020 series define the environmental labeling.

**SC 4** includes the guidelines and standards of environmental performance evaluation. Environmental performance evaluation is the subset of environmental management. ISO 14031 standards is a subcategory of ISO 14001.

**SC 5** describes the life cycle assessment. It is a cradle to grave approach. It is a technique to assess the environmental impact with a product, process and service throughout its lifecycle.

The term and conditions of environmental management defined in **SC 6** categories. **SC4** has divided the areas of environmental performance evaluation into

(i) environmental management system

(ii) operational system (material and energy flows)

(iii) condition of the environment

### 2.7.2 Structure & principal of ISO14031
### [Guidance on Environmental Performance Evaluation (EPE)]

ISO 14031 describe the environmental performance evaluation as a regular recurring process. EPE also define the general requirement of performance measures. It contains the example related to each evaluation area. EPE is an operational process and based on input-output analysis of material flow.[Christine Jasch, 2000]

Fig. 2.3 shows the EPE model, which shapes like 'Plane-Do-Check-Act' management system model. The fig. 2.3 contains the outline of EPE process.. Data used for environmental performance indicators can be expressed as absolute or relative measurements and, depending on their use and application, can be aggregated and/or weighted. Indicators can be classified as follows:

- Absolute indicators; e.g. tons of emissions, raw material, taken from input–output analysis;
- Relative indicators, where input figures are referenced to other variables such as production in tons, number of employees, revenue, office space in m2; e.g. water per hectoliter beer, detergent per m2;
- Indexed indicators, where figures are expressed as a percentage with respect to a total, or as a percentage change to values of previous years etc.;

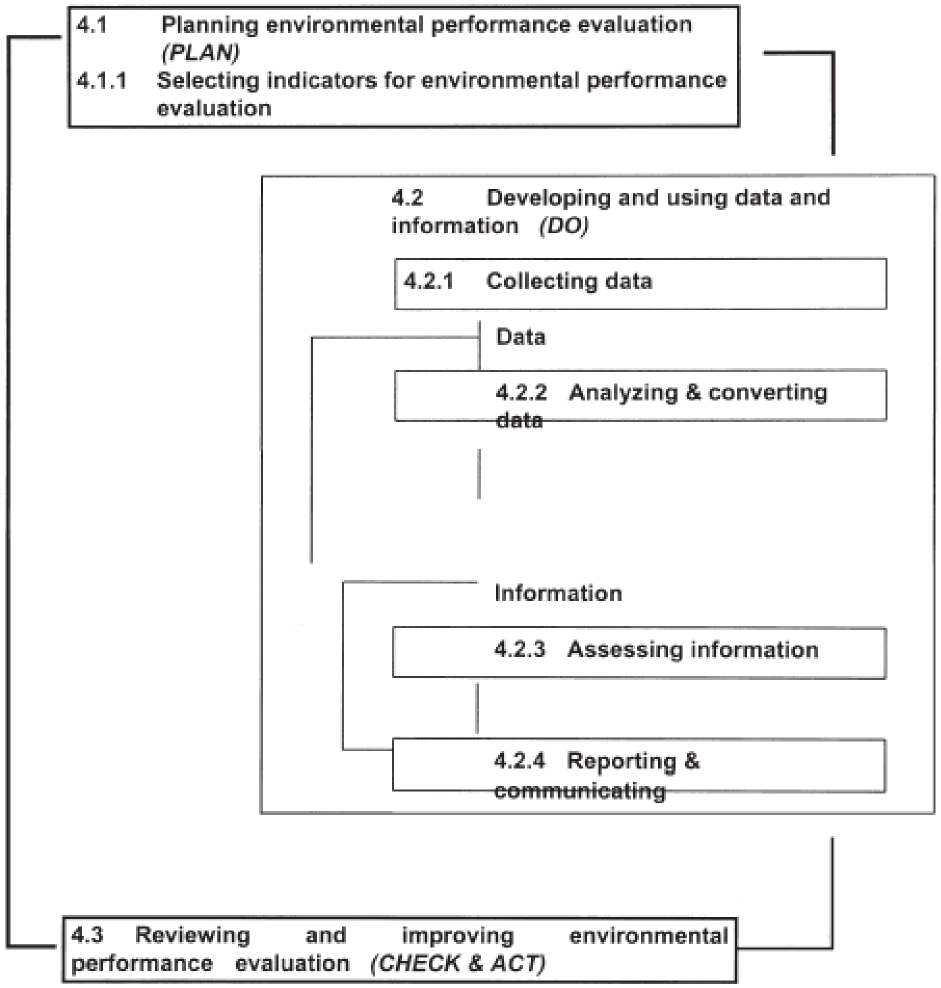


Fig.2.3 The EPE Process

- Aggregated depictions, where figures of the same units are summed over more than one production step or product life cycle;
- Weighted evaluations, which try to depict figures of varying importance by means of conversion factors. [Christine Jasch, 2000]

## 2.8 MEASURES / INDICATORS

We categories the environmental measures for all type of manufacturing industries including process industries into four resource groups:

- Air resources

- Water resources
- Land resources
- Material & Energy resources

### 2.8.1 Air resources

- Outputs of air emissions [Jean-Franc-ois Henri and Marc Journeault, 2008]
- $CO_2$ emission [A. Laurent et al. 2010]
- $NO_x$ emission [Daniel Tyteca, 1996]
- $SO_2$ emission [Daniel Tyteca, 1996]
- SPM emission [Mohammad Jafar et. al., 2013]
- CO emission [B.G. Hermann et. al., 2007]
- $CH_4$ emission [B.G. Hermann et. al., 2007]
- $N_2O$ emission [B.G. Hermann et. al., 2007]
- NMVOC emission [B.G. Hermann et. al., 2007]
- $PM_{10}$ emission [B.G. Hermann et. al., 2007]
- $NH_3$ emission [B.G. Hermann et. al., 2007]
- $CHCl_3$ emission [B.G. Hermann et. al., 2007]
- Control factor of $CO_2$ emission [Mohammad Jafar et. al., 2013]
- Control factor of $SO_2$emission [Mohammad Jafar et. al., 2013]
- Control factor of $NO_x$ emission [Mohammad Jafar et. al., 2013]
- Control factor of SPM emission [Mohammad Jafar et. al., 2013]
- Dust production [B. von Bahr et. al., 2003]
- Global warming potential(GWP) [Vesela Veleva et. al., 2001]
- Acidification potential (AP) [Vesela Veleva et. al., 2001]
- Amount of PBT used [Vesela Veleva et. al., 2001]
- Ozone creation potential (OCP) [A.C. Brent, J.K. Visser, 2005]
- Ozone depletion potential (ODP) [A.C. Brent, J.K. Visser, 2005]
- Human toxicity potential (HTP) [A.C. Brent, J.K. Visser, 2005]

### 2.8.2 Water resources

- Output of waste water [Jean-Franc-ois Henri, Marc Journeault, 2008]
- Water consumption ratio  [Purba Rao et. al., 2006]
- Water shade area [Eleonora Perotto et. al., 2008]
- Main water bodies (No.) [Eleonora Perotto et. al., 2008]
- Mean flow rate in main river [Eleonora Perotto et. al., 2008]
- Artificial water basins and capacity of reservoir [Eleonora Perotto et. al., 2008]
- Water supply source and abstraction [Eleonora Perotto et. al., 2008]
- Biochemical oxygen demand (BOD) [Daniel Tyteca, 1996]
- Total suspended solid (TSS) [Daniel Tyteca, 1996]
- pH concentration [Daniel Tyteca, 1996]
- Nitrates concentration [Daniel Tyteca, 1996]
- Phosphate concentration [Daniel Tyteca, 1996]
- Heavy metals concentration [Daniel Tyteca, 1996]
- Chemical oxygen demand (COD) [Mohammad Jafar et. al., 2013]
- River bank preservation area [Eleonora Perotto et. al., 2008]
- Indicator of congruity of preservation areas with the provincial master plan [Eleonora Perotto et. al., 2008]
- No. of works carried out on artificial reservoir on a yearly basis [Eleonora Perotto et. al., 2008]
- No. of abstraction and flow rate diversion [Eleonora Perotto et. al., 2008]
- Ecological state of the water body [Eleonora Perotto et. al., 2008]
- Ammonium nitrogen concentration [Eleonora Perotto et. al., 2008]
- Conformity to regulations for bathing and swimming [Eleonora Perotto et. al., 2008]
- E coil (Escherichia coli) [Eleonora Perotto et. al., 2008]
- Color [Xin Ren, 2000]
- Toxicity [Xin Ren, 2000]
- NaOH concentration [Xin Ren, 2000]
- Volatile organic compounds (VOCs) [Xin Ren, 2000]

- Absorbable organic halides (AOX) [B.G. Hermann et. al., 2007]
- Chloroform concentration ($CHCl_3$) [B.G. Hermann et. al., 2007]
- Polychlorinated phenols (PCP) [B.G. Hermann et. al., 2007]
- Eutrophication potential (EP) [A.C. Brent, J.K. Visser, 2005]
- Acidification potential (AP) [A.C. Brent, J.K. Visser, 2005]
- Human toxicity potential (HTP) [A.C. Brent, J.K. Visser, 2005]
- Aquatic toxicity potential (ATP) [A.C. Brent, J.K. Visser, 2005]

### 2.8.3 Land resources

- Acidification potential (AP) [A.C. Brent, J.K. Visser, 2005]
- Human toxicity potential (HTP) [A.C. Brent, J.K. Visser, 2005]
- Terrestrial toxicity potential (TTP) [A.C. Brent, J.K. Visser, 2005]
- Occupied land use (OLU) [A.C. Brent, J.K. Visser, 2005]
- Transformed land use (TLU) [A.C. Brent, J.K. Visser, 2005]

### 2.8.4 Material & Energy resources

- Mineral depletion (MD) [A.C. Brent, J.K. Visser, 2005]
- Energy depletion (ED) (kg/coal equivalent) [A.C. Brent, J.K. Visser, 2005]
- Material used [Vesela Veleva et. al., 2001]
- Energy consumption ratio [Purba Rao et. al., 2006]
- Percentage of energy from renewable [Vesela Veleva et. al., 2001]
- Energy cost ratio [Purba Rao et. al., 2006]
- Renewable energy ratio [Purba Rao et. al., 2006]
- Intensity of raw material consumption [Mohammad Jafar et. al., 2013]
- Intensity of electrical energy consumption [Mohammad Jafar et. al., 2013]
- Intensity of heat energy consumption [Mohammad Jafar et. al., 2013]
- Input of raw material [Jean-Franc-ois Henri, Marc Journeault, 2008]
- Input of auxiliary materials [Jean-Franc-ois Henri, Marc Journeault, 2008]

## 2.9 LIST OUT THE EPMs FOR PROCESS INDUSTRY

From the literature, we have find out 73 EPMs. We have classified these measures under four categories namely,

- Air resources
- Water resources
- Land resources
- Material & Energy resources

These measures are listed in section 2.5 Measures/Indicators. These measures are commonly used for all manufacturing industries, so we list out the measures related to process industries under same four construct. The list of the measures of process industries is given bellow.

Table 3.1 Determinants/Measures of EMS in Process Industries

| S. No. | Construct | Elements | Reference |
|---|---|---|---|
| 1 | **Air Resources** | Output of air | Jean-Franc-ois Henri and Marc Journeault, 2008 |
| | | $CO_2$ | A. Laurent et. al. 2010 |
| | | $SO_2$ | Daniel Tyteca, 1996 |
| | | $NO_x$ | Jaishree and T.I. Khan, 2014 |
| | | SPM | Mohammad Jafar et. al. 2013 |
| | | CO | Ravi Kumar Goyal et. al. 2014 |
| | | $N_2O$ | B.G. Hermann et. al. 2007 |
| | | NMVOC | B.G. Hermann et. al. 2007 |
| | | Dust | B. Von Bahr et. al. 2003 |

| | | | |
|---|---|---|---|
| | | Acidification Potential | Vesela Veleva et. al. 2001 |
| 2 | **Water Resources** | Output of waste water | Jean-Franc-ois Henri and Marc Journeault, 2008 |
| | | Water consumption ratio | Purba Rao et. al. 2006 |
| | | Water shade area | Eleonora Perotto et. al. 2008 |
| | | BOD | Jaishree and T.I. Khan, 2014 |
| | | TSS | Jaishree and T.I. Khan, 2014 |
| | | pH concentration | Jaishree and T.I. Khan, 2014 |
| | | Nitrate concentration | Daniel Tyteca, 1996 |
| | | Heavy metals concentration | Daniel Tyteca, 1996 |
| | | COD | Mohammad Jafar et. al. 2013 |
| | | Colour& toxicity | Xin Ren, 2000 |
| | | NaOH concentration | Xin Ren, 2000 |
| | | VOCs | Xin Ren, 2000 |
| 3 | **Land Resources** | Acidification potential | A.C. Brent, J.K. Visser, 2005 |
| | | HTP | A.C. Brent, J.K. Visser, 2005 |
| \ | | Hazardous waste generation | A.C. Brent, J.K. Visser, 2005 |
| | | TTP | A.C. Brent, J.K. Visser, 2005 |
| 4 | **Material & Energy Resources** | Resource depletion | A.C. Brent, J.K. Visser, 2005 |
| | | Energy depletion | A.C. Brent, J.K. Visser, 2005 |

| | | | |
|---|---|---|---|
| | | Energy consumption ratio | Purba Rao et. al. 2006 |
| | | Input of raw material | Jean-Franc-ois Henri and Marc Journeault, 2008 |

Table 3.2 Description of the Elements

| S. No. | Elements | Description |
|---|---|---|
| 1 | Output of air | Total air output including $CO_2$, NOx, $SO_2$, etc. |
| 2 | $CO_2$ | $CO_2$ are emitted when factories and machines burn fuels. |
| 3 | $SO_2$ | $SO_2$ are emitted from fossil fuel combustion. |
| 4 | $NO_x$ | $NO_x$ is a generic term for nitric oxide (NO) and nitrogen dioxide ($NO_2$). They are produced from the reaction of nitrogen and oxygen in the air during combustion, at high temperature. |
| 5 | SPM | Suspended Particulate Matter (SPM) are solid and liquid particulates like dust, smoke, soil particles, added to atmosphere. |
| 6 | CO | It is less dense than air and generated from generator exhaust. |
| 7 | $N_2O$ | Nitrous oxide arise from adipic acid production required for Nylon production during the oxidation of a ketone-alcohol mixture with nitric acid. |

| | | |
|---|---|---|
| 8 | NMVOC | Non-Methane Volatile Organic Compounds (NMVOC) are a collection of organic compounds that differ in their chemical composition but display similar behavior in the atmosphere. |
| 9 | Dust | Dust are generally produced in industries from raw material processing, exhaust, etc. |
| 10 | Acidification Potential (AP) | The AP measures the contribution of an emission substance to acidification. |
| 11 | Output of waste water | Total output of waste water containing $NH_3$, COD, BOD, etc. |
| 12 | Water consumption ratio | The ratio of total water consumed to total production or output. |
| 13 | Water shade area | It is an area of land that contains a common set of stream and river, in which the drain the water from industry. |
| 14 | BOD | Biochemical Oxygen Demand (BOD) is $NO_x$ measure of dissolved oxygen in a water body required for biological organisms. |
| 15 | TSS | Total Suspended Particles (TSS) is the particles larger than 2 microns in water body. |
| 16 | pH concentration | pH is the measure of the molar concentration of the Hydrogen ion in the solution or the measure of the acidity or basicity of the solution. |
| 17 | Nitrate concentration | It is nitrogen oxygen chemical unit which |

| | | |
|---|---|---|
| | | combine with various organic and inorganic compound. |
| 18 | Heavy metals concentration | Zinc (Zn), Copper (Cu), Nickel (Ni), Cadmium (Cd), Chromium (Cr) and Lead (Pb). |
| 19 | COD | Chemical Oxygen Demand (COD) is a measure of the capacity of water to consume Oxygen during the decomposition of organic matter and oxidation of inorganic chemical. |
| 20 | Color & toxicity | The color used in textile process and other synthetic process is toxic for nature. |
| 21 | NaOH concentration | Caustic soda concentration mainly from textile waste. |
| 22 | VOCs | Volatile Organic Compounds (VOCs) are organic compound, which volatilize or evaporate at atmospheric temperature. |
| 23 | Acidification potential | Due to acid gas acid rain is form which absorbed by plant, soil and surface water, increase the acidity of soil. |
| 24 | HTP | Human Toxic Potential (HTP) is caused by toxic waste exposed to land. |
| 25 | Hazardous waste generation | Waste like salt, color, chemicals that are harmful to land. |
| 26 | TTP | Terrestrial Toxicity Potential (TTP) is the measure of toxicity for terrestrial life. |

| | | |
|---|---|---|
| 27 | Resource depletion | The unconscious use of nonrenewable resources. |
| 28 | Energy depletion | The unconscious use of nonrenewable energy sources. |
| 29 | Energy consumption ratio | The ratio of energy consumed to total production or output. |
| 30 | Input of raw material | Total input of raw material. |

# CHAPTER 3

# RESEARCH METHODOLOGY

The research methodology is based on empirical data collected through a questionnaire survey. The survey methodology is used for study and focus of study is cross sectional. To measure the environmental performance of a firm or all firms related to one sector, firstly, we should have the data related to environmental issues. The environmental issues are the EPMs or EPIs. These factors are the measures of different environmental issues. Here we have chosen the process sector for research purpose, so find out the EPMs related to process sector. The commonly used technique for data collection is questionnaire technique. In this technique, a set of questions related to environmental issues in the form of EPMs is comprised. In this methodology, we have also used this questionnaire technique.

To measure environmental performance first a specific industrial sector (process sector) is selected and list out the EPMs. After this, a questionnaire is prepared and then survey is carried out on the basis of questionnaire. So basically there are five main steps in this methodology:

1. Prepare the questionnaire,
2. Creation of database of process industries,
3. Data collection and
4. Analysis of result.

## 3.1 PREPARE THE QUESTIONNAIRE

After finding the EPMs from literature, the EPMs related to process industries are listed in table 2.1 of section 2.9 of chapter 2. The different EPMs under the four construct are being investigated and described with the cause and effect on the environment, mentioned in table 2.2 of section 2.9 of chapter 2. A questionnaire is then prepared on the basis of these EPMs for the survey purpose.

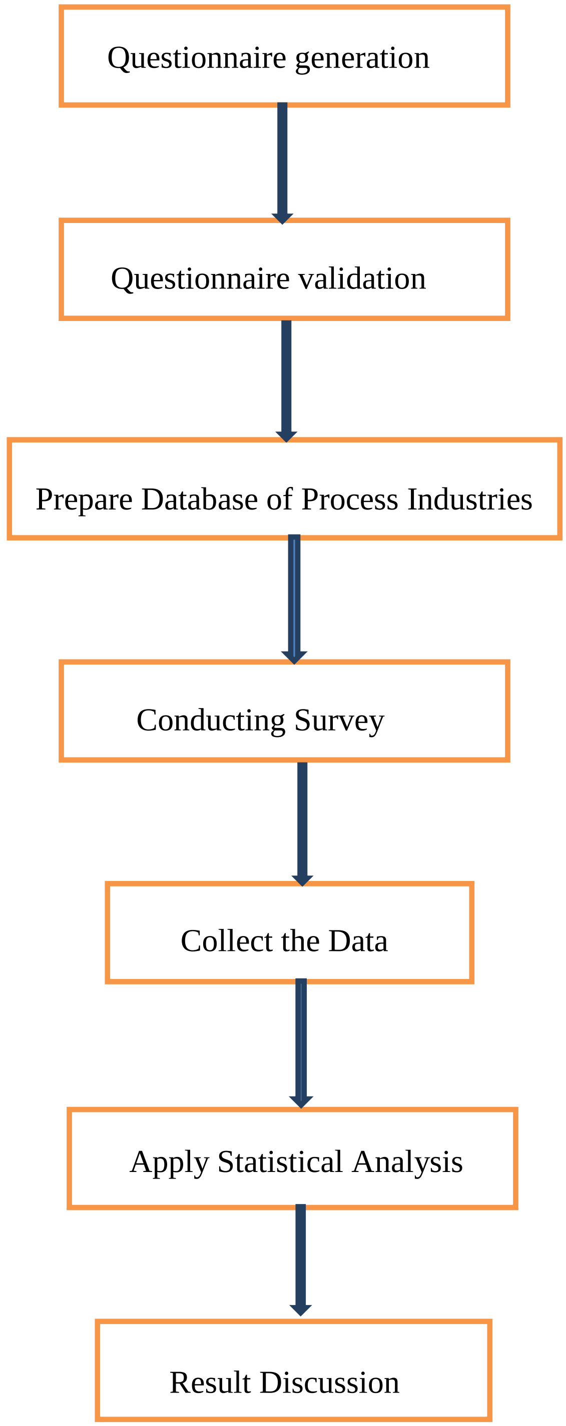


Fig 3.1 Various steps of Research Methodology

The questionnaire was prepared in two sections. Part 1 was comprised with the general information about the company and respondent person. The information was asking about the company are name of the company, number of employees, turnover, whether the company follow any EMS and any award related to environmental performance and the information asking about the person responding are name, designation and experience. Part 2 was prepared in four sections, under four constructs having different elements under each construct. The general question for each element is “is the emission/consumption level of each element of your plant around the standard emission/consumption limit?”.

A structured questionnaire has been developed on five point Likert scale for emission level. Annexure was given in the end of questionnaire, which contained key for responses and explained in brief the terminology used in the questionnaire to avoid unknown bias. Explanation of five points is as follow:

1 – Never

2 – Eventually

3 – Some time

4 – Maximum time

5 – Always

The validation of the questionnaire is required before conducting survey. To asses content validity a “dry run” was made and questionnaire were administrated to the CEOs, senior manager level and academician. Based on their feedback the present form has been evolved and final version of the questionnaire was sent to the related companies listed in database of process industries, so that to get the response of questionnaire.

## 3.2 CREATION OF DATABASE OF PROCESS INDUSTRIES

After conducting the dry run of the questionnaire, the content was validated. This final version of the questionnaire is ready for survey. Now we have prepared a database of the process industries of India mainly within and nearby Rajasthan. A database of 150 process industries has been extracted from north India region. The sample contains organization having at least 20 employee and 30 lakhs of annual turnover. This contains name of the organization, their location, main product and contact number or email id. The final version of the questionnaire was then sent to the contact person to get the response.

The process sector includes Fabric & Textile manufacturing, Tyre manufacturing, Cement manufacturing, Food & packaging, Fertilizer manufacturing, Pharmaceuticals, Paper & paper products manufacturing, Chemical manufacturing.

## 3.3 DATA COLLECTION

It consists of administration of questionnaire and respondent profile. The questionnaire was e-mailed to respondent and then they reminded through the phone. Questionnaire was also sent by post to the postal address of some company. They were also reminded by post and phone. A survey form was developed on Google form to conduct online survey. So the survey was done by online through e-mail and also on hardcopy by post.

In postal survey a covering letter, which described the object of the research and procedure for completing the questionnaire, was enclosed. A reminder through e-mail, phone and postal service was sent to non-respondent after three weeks.

The data was collected in the excel sheet for the analysis in SPSS 16.0.

## 3.4 ANLYSIS OF RESULT

After the data were collected, the analysis was done on the collected data. The data were entered in SPSS 16.0. SPSS is software, which is used for statistical analysis. First of all the inter-item analysis was done to check the consistency or reliability of the data. The reliability of the data was checked using reliability test, calculating Cronbach's alpha coefficient. After checking, the reliability further analysis was done.

We have three objectives so we have done the analysis in three steps. First we applied descriptive statistics to examine the status of EPMs. After that, we have applied correlation and one sample t-test. These statistical tools were applied individually for each construct. We have applied the correlation to find out the relation between different elements of each construct. And one sample t-test has applied to find out the critical elements of each construct on which company should focus to minimize the emission/consumption of that element.

# CHAPTER 4
# DATA COLLECTION AND ANALYSIS

The data, which was collected by the help of questionnaire, was analyzed in SPSS 16.0 software. First of all the reliability test was done on the data to check the internal consistency. It is assumed that the questionnaire filled would generate normal curve. Different tests like correlation and t-test were done to analyze the data.

## 4.1 DATA COLLECTION

For data collection, the questionnaire was sent to the sample organizations and records the responses. A random sample of 150 organizations was prepared with the contact detail. We have sent the e-mail to the listed organization. The questionnaire was prepared in Google form and the link was sent through the e-mail. After three week of communication, a reminder was sent to the non-respondent organization. They are also informed by phone call. Hard copy of the questionnaire was prepared with a covering letter. Covering letter includes the application for participation in survey and also guideline of filling the survey. Hard copy was also sent to the non-respondent organization and informed by phone call. Some responses were received through post in hard copy. After that non-respondent organizations were contacted and the questionnaire was filled through physical visit to the organizations.

22 responses were received through e-mail on Google form and 40 responses were received through physical visit. Total 62 responses were collected. The major problem in data collection faced in part I. The personal details and details of organization were not filled by all respondents. So this is the weak portion of our study. 37(59.67%) respondents were filled the part I as well as part II and 25(40.32%) respondents were not filled the part I.

Data were collected in the excel sheet. 62 responses were received out of 150, the response rate is 41.33%. With 2 to 5 year experience, 23(37.10%) respondent were of

GET, engineer, assistant manager level. With 6 to 10 year experience, 14(22.58%) respondent were of senior engineer, manager, executive engineer level. 25(40.32%) respondent were not gave the information related to experience.

## 4.2 DATAANALYSIS

After data collection through questionnaire data analysis was the next step in survey methodology. Data was analyzed by SPSS 16.0 software. SPSS stands for Statistical Package for Social Science. SPSS Statistics is a software package used for statistical analysis. It was acquired by IBM in 2009. SPSS is a widely used program for statistical analysis in social science. It is also used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations, data miners, and others.

Steps of data analysis:

1. Reliability analysis
2. Statistics of respondents
3. Descriptive statistics
4. Correlation
5. T-test

### 4.2.1 Reliability Analysis

Reliability of data was checked by inter-item analysis. Cronbach’s alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. A high value of alpha is often used as evidence that the items measure an underlying or latent construct. Inter-item analysis is used to check the scales/questions for internal consistency. Cronbach’s alpha is calculated for each scale as recommended for empirical research in operation management (Dangayach G.S. et. al., 2006; Gliem & Gliem, 2003). Table 4.1 shows Cronbach’s alpha value for each scale is above 0.5, which is considered adequate for exploratory research (Dangayach G.S. et al., 2006, Gliem & Gliem, 2003).

Table 4.1 Cronbach's Alpha for Scale Used

| S. No. | Scale | Cronbach's Alpha |
|---|---|---|
| 1 | Air Resources | .916 |
| 2 | Water Resources | .886 |
| 3 | Land Resources | .738 |
| 4 | Energy & Material Resources | .759 |

Table 4.2 Result of SPSS for Cronbach'sAlpha

**Reliability Statistics for Air**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .916 | .920 | 10 |

**Reliability Statistics for Water**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .886 | .898 | 12 |

**Reliability Statistics for Land**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .738 | .747 | 4 |

**Reliability Statistics for Material& Energy**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .759 | .772 | 4 |

### 4.2.2 Statistics of Respondents

After the reminders, phone calls, email and re-reminders, 62 filled responses were received out of 150, the response rate is 41.33%. Table 4.3 shows the average statistics of the respondents. The average experience of respondent person is 5 years within range 2 to 10 years, the average number of employees of respondent companies are 588 and average annual turnover of the respondent companies are 70.35 crore.

Table 4.3 Average Statistics of Respondent

| Parameter | Sample Average | Range |
|---|---|---|
| Experience | 5.05 years | [2 to 10] |
| Number of employees | 588 | [20 to 5000] |
| Annual turnover | 70.35 crore | [25 lakh to 600 crore] |

The questionnaire was constructed in two parts. Part I have question about general information of participants and firm, and part II is the main questionnaire related to EPMs. Part II has been filled by all 62 participants but part I has been filled by 37 participants only. It means 25 respondents have not filled the questionnaire completely. 40.32% respondents did not fill the part I, so the following statistics of respondents for general information is applied only 60% data. The statistics of the respondent company is shown, from table 4.4.1 to 4.4.5.

Table 4.4.1 shows the statistics of the respondent companies for questionnaire completion. This table of statistics is based on the data collected through part I of questionnaire. The table includes statistics of general information of respondent companies and person. As shown in table 37 respondents fill the questionnaire completely which is 59.68% of total response. The pie chart of questionnaire completion is also shown.

Table 4.4.1 Statistics of the Respondent Companies

| Questionnaire completion | Respondent Companies (in %) |
|---|---|
| 1. Completed | 37 (59.68%) |
| 2. Fill only part II | 25 (40.32%) |

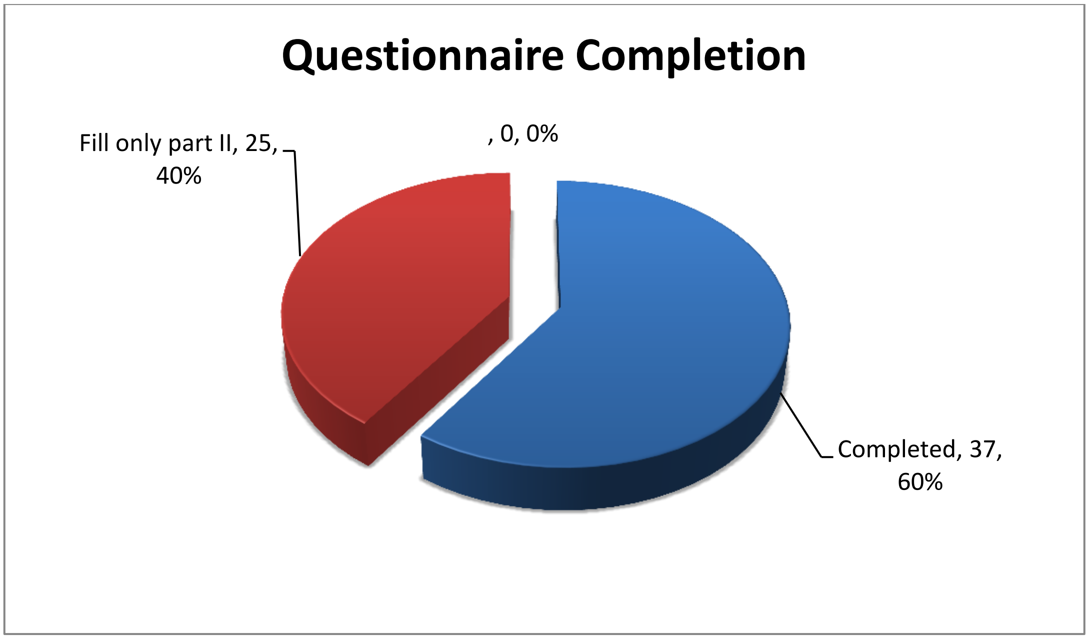


Fig. 4.1 Questionnaire completion

Figure 4.4.2 shows the statistics of the respondent person's experience. The 23 (37.1%) respondent persons were having 2 to 5 years' experience, 14 (22.58%) respondent persons were having 5 to 10 experience. 25 (40.32%) persons did not fill the part I. This statistics is also shown in pie chart in figure 4.2.

Table 4.4.2 Statistics of the Respondent Companies

| | |
|---|---|
| Profile of Responded (Years of experience) | |
| 1. 2 to 5 years | 23 (37.1%) |
| 2. 5 to 10 years | 14 (22.58%) |
| 3. Not mentioned | 25 (40.32%) |

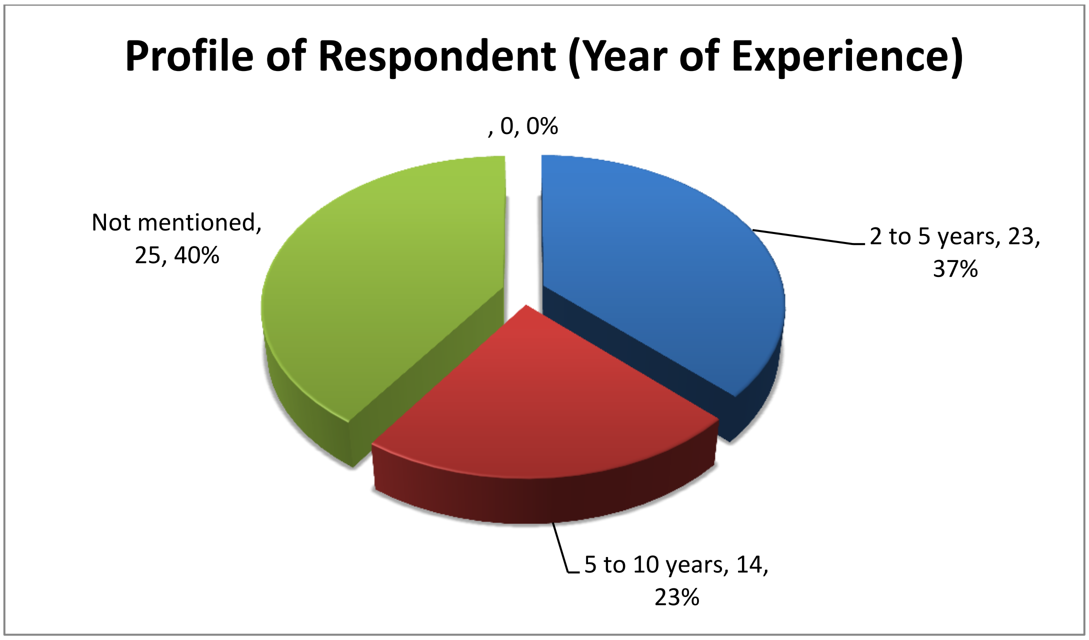


Fig. 4.2 Profile of respondents

The statistics of respondent companies (table 4.4.3) shows that 14 (22.58%) companies were having number of employees up to 50, 15 (24.19%) companies were having number of employees in the range of 50 to 250 and 8 (12.9%) companies have number of employees above 250. It is states that 22.58% small, 24.19% medium and 12.9% large scale industries participated in survey. The pie chart of this analysis is also shown in figure 4.3.

Table 4.4.3 Statistics of the Respondent Companies

| Number of employees | |
|---|---|
| 1. Up to 50 | 14 (22.58%) |
| 2. 50 to 250 | 15 (24.19%) |
| 3. Above 250 | 8 (12.9%) |
| 4. Not mentioned | 25 (40.32%) |

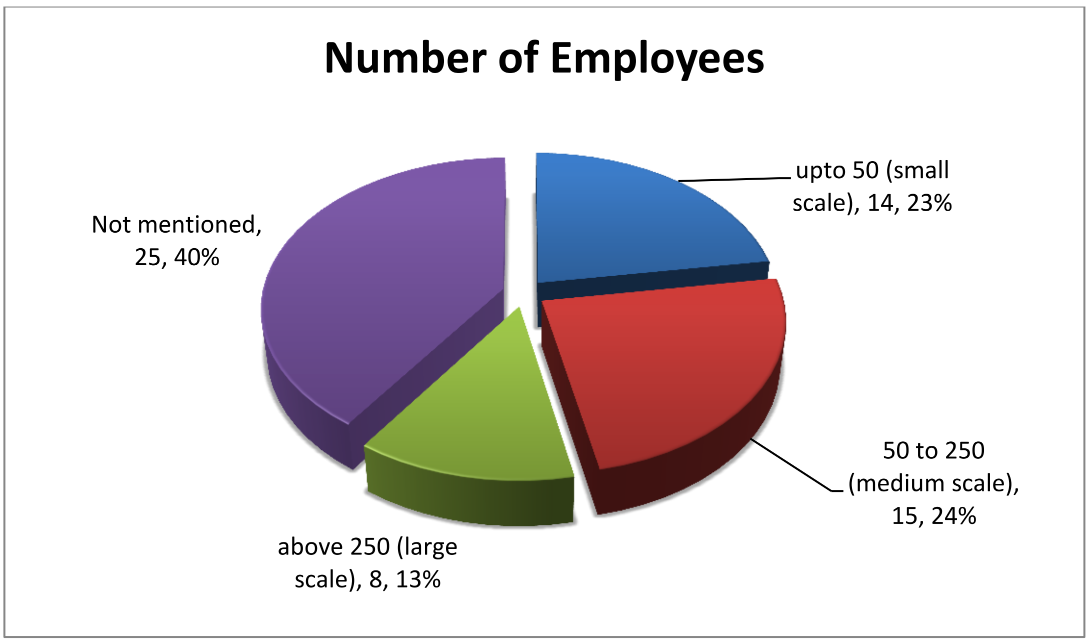


Fig 4.3 Number of employees

The table 4.4.4 shows that 13 (20.97%) respondent companies had annual turnover of between 25 lakh to 5 crore, annual turnover of 9 (14.52%) respondent companies had between 5 to 10crore and 15 (24.19 %) respondent companies had annual turnover above 10 crore. The pie chart for these values is shown in figure 4.4.

Table 4.4.4 Statistics of the Respondent Companies

| | |
|---|---|
| Annual Turnover | |
| 1. 25 lakh to 5 crore | 13 (20.97%) |
| 2. 5 crore to 10 crore | 9 (14.52%) |
| 3. Above 10 crore | 15 (24.19%) |
| 4. Not mentioned | 25 (40.32%) |

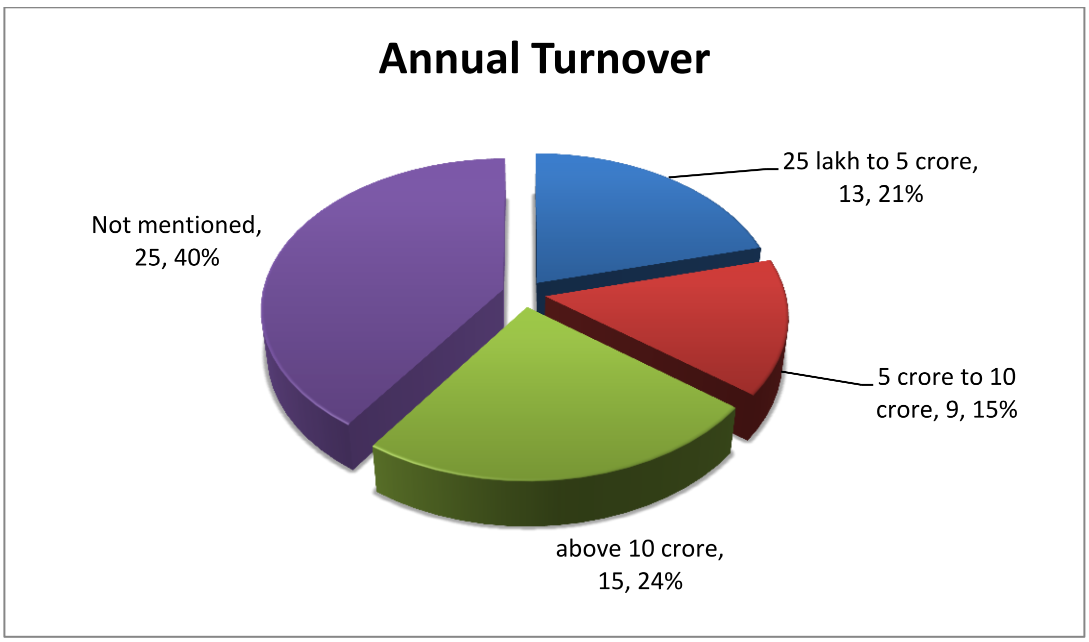


Fig. 4.4 Annual turnover

Whether the company follows the environmental management system of not, in the answer of this question it is found that 20.97% (13) companies of total respondents followed the EMS while 38.71% (24) companies did not follow the EMS and 40.32% (25) companies not fill the part I, shown in table 4.4.5. Figure 4.5 shows the pie chart distribution of these values.

Table 4.4.5 Statistics of the Respondent Companies

| | |
|---|---|
| EMS implementation | |
| 1. Follow EMS | 13 (20.97%) |
| 2. Not follow EMS | 24 (38.71%) |
| 3. Not mentioned | 25 (40.32%) |

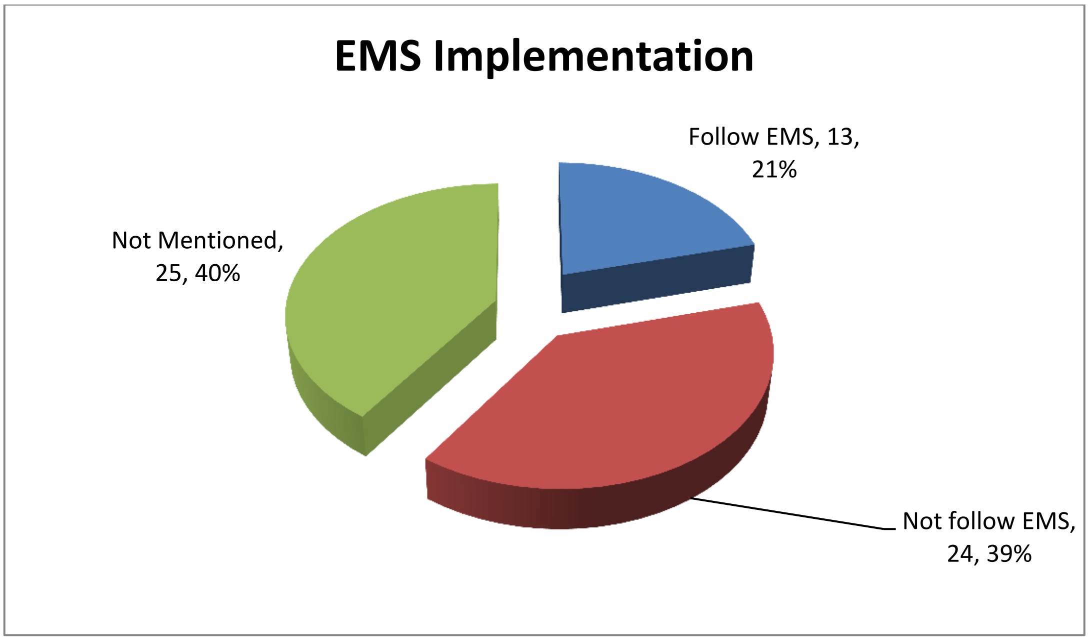


Fig. 4.5 EMS implementation

### 4.2.3Descriptive Statistics

After checking the consistency of the data through inter-item analysis it is found that the value of Cronbach's alpha is above .7, so the data are reliable. Now our first objective is "to examine the status of EPMs in process sector companies". To achieve this objective we applied the descriptive statistics to the recorded data. In descriptive statistics, mean and standard deviation were calculated using SPSS software for all elements under four construct. The result is tabulated from table 4.5 to table 4.8.

Table 4.5 Descriptive Statistics of Air Resources

| S. No. | Elements | Mean | Standard Deviation |
|---|---|---|---|
| 1 | Output of air emission | 3.82 | .859 |
| 2 | $CO_2$ | **3.00** | .992 |
| 3 | $SO_2$ | 3.47 | 1.183 |
| 4 | NOx | 4.15 | 1.038 |
| 5 | SPM | 3.94 | 1.129 |
| 6 | CO | 3.76 | 1.066 |
| 7 | $N_2O$ | 4.37 | .891 |
| 8 | NMVOC | *4.63* | .683 |
| 9 | Dust | 4.19 | 1.006 |
| 10 | Acidification Potential | *4.63* | .607 |

On five point Likert scale (Interval scale 1-5: 1 - Never and5 - Always)
N=62

Bold:Lowest Mean, Italics: Highest Mean

The table 4.5 shows the descriptive statistics of air resources. There are ten elements in air resources. The mean and standard deviation for all ten elements were calculated using SPSS 16.0. The lowest mean highlighted as bold and highest mean highlighted as italic format. The result shows that the companies should focus more on the emission of $CO_2$ (lowest mean 3.0). The process industries should try to minimize the $CO_2$emission. The highest mean is 4.63 for both NMVOC and acidification potential.
Both NMVOC and acidification potential are emitted in standard emission limit. The status of the EPMs is shown by the ranking of the measures according to mean values that shows the factors affecting the environment from more to less.

The factor most affect the environment is $CO_2$emission (minimum mean 3.0), after this $SO_2$ emission (3.47), then CO (3.76) and so on. $N_2O$ (4.37), NMVOC (4.63), acidification potential (4.63) are the factor that have emission within standard limit maximum time.

Table 4.6 Descriptive Statistics of Water Resources

| S. No. | Elements | Mean | Standard Deviation |
|---|---|---|---|
| 1 | Output of waste water | 4.02 | .896 |
| 2 | Water consumption ratio | 4.32 | .805 |
| 3 | Water shade area | *4.68* | .566 |
| 4 | BOD | **3.32** | 1.225 |
| 5 | TSS | 3.65 | 1.216 |
| 6 | pH concentration | 4.00 | 1.024 |
| 7 | Nitrate concentration | 4.60 | .613 |
| 8 | Heavy metals concentration | 4.60 | .664 |
| 9 | COD | 3.65 | 1.147 |
| 10 | Color & Toxicity | 3.98 | 1.123 |
| 11 | NaOH concentration | 4.61 | .583 |
| 12 | VOCs | 4.61 | .710 |

On five point Likert scale (Interval scale 1-5: 1 - Never and5 - Always)
N=62

Bold:Lowest Mean, Italics: Highest Mean

Table 4.6 shows the mean values of elements of water resources. The highest mean value is for water shade area (4.68) and minimum value is for BOD (3.32). Here the BOD is the factor which requires more attention to minimize the pollution. BOD (3.32), TSS (3.65) and COD (3.65) are the measures that sometime achieve the standard emission, most of the time level of the emission of these factors are higher than standard limit. The consumption of water shade area is in standard consumption limit maximum time. Similarly, VOCs (4.61), Nitrate concentration (4.60) and heavy metals concentration (4.60), emission of these factors also within standard limit maximum time.

Table 4.7 shows the mean values of elements of land resources. The lowest mean value is for acidification potential (3.82). This measure exceed the emission level maximum time. The highest value of mean is for hazardous waste generation (4.39). This measure attain the standard emission limit maximum time.

Table 4.7 Descriptive Statistics of Land Resources

| S. No. | Elements | Mean | Standard Deviation |
|---|---|---|---|
| 1 | Acidification Potential | **3.82** | .967 |
| 2 | HTP | 4.37 | .794 |
| 3 | Hazardous waste generation | *4.39* | 2.830 |
| 4 | TTP | 4.05 | .999 |

On five point Likert scale (Interval scale 1-5: 1 - Never and5 - Always)
N=62

Bold:Lowest Mean, Italics: Highest Mean

Table 4.8 shows mean values of material and energy resources. The lowest and highest mean values are for resource depletion (3.81) and energy consumption ratio (4.48) respectively. The consumption of the resource or resource depletion sometime achieves the standard limit and energy consumption ratio maximum time reach its standard limit.

Table 4.8 Descriptive Statistics of Material & Energy Resources

| S. No. | Elements | Mean | Standard Deviation |
|---|---|---|---|
| 1 | Resource depletion | **3.81** | .955 |
| 2 | Energy depletion | 3.92 | 1.013 |
| 3 | Energy consumption ratio | *4.48* | .646 |
| 4 | Input of raw material | 4.44 | .781 |

On five point Likert scale (Interval scale 1-5: 1 - Never and5 - Always)
N=62

Bold:Lowest Mean, Italics: Highest Mean

### 4.2.4 Correlation

After descriptive statistics, correlation was applied to the data through SPSS. Correlation is applied to find out the strength of relation between the elements of a construct.The correlation was applied to elements of all four construct separately. The result of correlation is tabulated from table 4.9 to 4.12.

Table 4.9 Pearson Correlation between elements of air resources

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Output of air | 1 | | | | | | | | | |
| $CO_2$ | 0.712** | 1 | | | | | | | | |
| $SO_2$ | 0.502** | **0.782**** | 1 | | | | | | | |
| NOx | 0.452** | 0.542** | 0.705** | 1 | | | | | | |
| SPM | 0.377** | 0.483** | 0.624** | 0.540** | 1 | | | | | |
| CO | 0.578** | 0.667** | 0.715** | 0.373** | 0.532** | 1 | | | | |
| $N_2O$ | 0.280* | 0.445** | 0.579** | 0.455** | 0.741** | 0.562** | 1 | | | |
| NMVOC | **0.277*** | 0.339** | 0.380** | 0.493** | 0.585** | 0.505** | 0.714** | 1 | | |
| Dust | 0.363** | 0.444** | 0.501** | 0.507** | 0.748** | 0.534** | 0.486** | 0.536** | 1 | |
| Acidification potential | 0.375** | 0.354** | 0.382** | 0.477** | 0.658** | 0.543** | 0.683** | 0.888** | 0.684** | 1 |
| | Output of air | $CO_2$ | $SO_2$ | NOx | SPM | CO | $N_2O$ | NMVOC | Dust | Acidification potential |

[illegible]

[illegible]

Table 4.9 shows the correlation between ten different environmental performance measures of air resources. Some measures are significantly correlated ($p \leq 0.05$) with other measures. From the values of correlations it is evident that $SO_2$ emission is strongly correlates with $CO_2$ emission (0.782), it is because $SO_2$ and $CO_2$ both are emitted from the combustion of fossil fuel. The correlation between output of air and NMVOC is very week (0.277), it is because non methane organic compound gives very less contribution in total output of air emission. The result of reliability analysis (Cronbach's alpha = 0.916) showed a high level of internal consistency among elements.

Table 4.10 Pearson Correlation between elements of water resources

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Output of waste water | 1 | | | | | | | | | | | |
| Water consumption ratio | 0.742** | 1 | | | | | | | | | | |
| Water shade area | 0.431** | 0.232 | 1 | | | | | | | | | |
| BOD | 0.324* | 0.109 | 0.365** | 1 | | | | | | | | |
| TSS | 0.472** | 0.169 | 0.403** | 0.672** | 1 | | | | | | | |
| pH concentration | 0.500** | 0.119 | 0.424** | 0.549** | 0.658** | 1 | | | | | | |
| Nitrate concentration | 0.400** | 0.069 | 0.658** | 0.373** | 0.509** | 0.627** | 1 | | | | | |
| Heavy metals concentration | 0.507** | 0.217 | 0.607** | 0.525** | 0.652** | 0.554** | 0.681** | 1 | | | | |
| COD | 0.213 | **-0.069** | 0.326** | **0.760**** | 0.390** | 0.586** | 0.400** | 0.326** | 1 | | | |
| Color & toxicity | 0.310* | **0.042** | 0.430** | 0.611** | 0.320* | 0.570** | 0.538** | 0.321* | 0.695** | 1 | | |
| NaOH concentration | 0.201 | 0.061 | 0.709** | 0.407** | 0.219 | 0.412** | 0.612** | 0.352** | 0.454** | 0.616** | 1 | |
| VOCs | 0.319* | 0.136 | 0.704** | 0.278* | 0.370** | 0.451** | 0.578** | 0.498** | 0.372** | 0.301* | 0.583** | 1 |
| | Output of waste water | Water consumption ratio | Water shade area | BOD | TSS | pH concentration | Nitrate concentration | Heavy metals concentration | COD | Color & toxicity | NaOH concentration | VOCs |

[illegible]
[illegible]

Table 4.10 shows the correlation matrix between twelve different EPMs of water resources. The matrix shows the strong correlation between COD and BOD (0.760). It is because both COD and BOD both are related to oxygen demand in water body. There is a very week correlation, seems like no relation between color & toxicity and water consumption ratio (0.042). It is because there is no direct relation between water consumption and emission of color & toxicity to water. There is a negative correlation (-0.069) shown in matrix between COD and water consumption ratio. The negative correlation shows that there is inverse relation between both the items. It is because there is no relation between chemical oxygen demand and consumption of water. Consumption of water and water shade area are the measures that have not much relation to other measures, according to the matrix. The result of reliability analysis (Cronbach's alpha = 0.886) showed a high level of internal consistency among elements.

Table 4.11 Pearson Correlation between elements of land resources

| | | | | |
|---|---|---|---|---|
| Acidification potential | 1 | | | |
| HTP | **0.642**$^{**}$ | 1 | | |
| Hazardous waste generation | 0.193 | 0.241 | 1 | |
| TTP | 0.077 | 0.432$^{**}$ | **0.040** | 1 |
| | Acidification potential | HTP | Hazardous waste generation | TTP |

** Significant at the 0.01 Level (2 – Tailed)

Table 4.11 shows the correlations between four environmental performance measures of land resources. There is highest correlation between human toxic potential and acidification potential (0.642), because acidification of land is closely related to human toxic potential. There is very week relation between terrestrial toxicity potential and hazardous waste generation (0.040). The measures of land resources are not having a good correlation between them. The result of reliability analysis (Cronbach's alpha = 0.738) showed an acceptable level of internal consistency among elements.

Table 4.12 Pearson Correlation between elements of material & energy resources

| | | | | |
|---|---|---|---|---|
| Resource depletion | 1 | | | |
| Energy depletion | **0.746**** | 1 | | |
| Energy consumption ratio | 0.420** | 0.386** | 1 | |
| Input of raw material | 0.334** | **0.149** | 0.712** | 1 |
| | Resource depletion | Energy depletion | Energy consumption ratio | Input of raw material |

** Significant at the 0.01 Level (2 – Tailed)

Table 4.12 shows the correlation matrix of EPMs of material and energy resources. Energy depletion and resource depletion have a strong correlation (0.746), as the energy is also a resource. Inputs of raw material and energy depletion have week correlation (0.149), as input of raw material does not depend on availability of energy. The result of reliability analysis (Cronbach's alpha = 0.759) showed an acceptable level of internal consistency among elements.

### 4.2.5 T-test

As per the third objective of thesis, after find out the correlation between EPMs of air, water, land and material & energy separately, we apply one sample t-test to EPMs of all four construct. One sample t-test is used for test of the sample mean. The one sample t-test is used to determine whether a sample comes from a population with a specific mean.

Here we want to find out the critical factor of each category so that we test the means against a hypothesized mean. If maximum time, the emission or consumption of each factor is within standard emission or consumption limit, then the environment would be protected. In our five point Likert scale, we have chosen value 4 for maximum time. So the null hypothesis would be “mean = 4”. The maximum t value shows that the mean of that element is near the test value 4.

T-test for each construct was performed on SPSS 16.0 and result was tabulated. The result of t-test is shown from table 4.13 to 4.17.

Table 4.13 One sample t-test for air resources

**One-Sample Test**

| | Test Value = 4 | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | |
| | t | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| Outputofair | -1.626 | 61 | 0.109 | -0.177 | -0.40 | 0.04 |
| $CO_2$ | **-7.939** | 61 | 0.000 | -1.000 | -1.25 | -0.75 |
| $SO_2$ | -3.541 | 61 | 0.001 | -0.532 | -0.83 | -0.23 |
| Nox | 1.101 | 61 | 0.275 | 0.145 | -0.12 | 0.41 |
| SPM | -0.450 | 61 | 0.654 | -0.065 | -0.35 | 0.22 |
| CO | -1.786 | 61 | 0.079 | -0.242 | -0.51 | 0.03 |
| $N_2O$ | 3.277 | 61 | 0.002 | 0.371 | 0.14 | 0.60 |
| NMVOC | 7.250 | 61 | 0.000 | 0.629 | 0.46 | 0.80 |
| Dust | 1.516 | 61 | 0.135 | 0.194 | -0.06 | 0.45 |
| AcidificationPotential | **8.161** | 61 | 0.000 | 0.629 | 0.47 | 0.78 |

Table 14.13 shows result of one sample t-test for air resources. The table shows the t value, degree of freedom and level of significance. The test was done at confidence level of 95%. Here negative t values shows in table 14.13. Negative t statistics shows that sample mean is smaller than hypothesized value. If the sample mean is greater than test value the t statistics will be positive.

Here in table 14.13 maximum t vale is for acidification potential (8.161) and NMVOC (7.250). The maximum t values show that emissions of these two factors are in standard emission limit for maximum time.T value is minimum for $CO_2$ (-7.939) and

$SO_2$ (-3.541) emission. T value is negative for these two factors, which shows that the sample means of both the factors are less than test value (4). The negative t value shows that both the measures $CO_2$ and $SO_2$ are the critical measures. The process industries should focus to minimize the emission of both the factors.

Table 4.14 One sample t-test for water resources

**One-Sample Test**

| | Test Value = 4 | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | |
| | t | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| Output of waste water | 0.142 | 61 | 0.888 | 0.016 | -0.21 | 0.24 |
| Water consumption ratio | 3.155 | 61 | 0.002 | 0.323 | 0.12 | 0.53 |
| Water shade area | **9.422** | 61 | 0.000 | 0.677 | 0.53 | 0.82 |
| BOD | **-4.354** | 61 | 0.000 | -0.677 | -0.99 | -0.37 |
| TSS | -2.298 | 61 | 0.025 | -0.355 | -0.66 | -0.05 |
| pH concentration | 0.000 | 61 | 1.000 | 0.000 | -0.26 | 0.26 |
| Nitrate concentration | 7.666 | 61 | 0.000 | 0.597 | 0.44 | 0.75 |
| Heavy metals concentration | 7.074 | 61 | 0.000 | 0.597 | 0.43 | 0.77 |
| COD | -2.437 | 61 | 0.018 | -0.355 | -0.65 | -0.06 |
| Color and toxicity | -0.113 | 61 | 0.910 | -0.016 | -0.30 | 0.27 |
| NaOH concentration | 8.283 | 61 | 0.000 | 0.613 | 0.46 | 0.76 |
| VOCs | 6.802 | 61 | 0.000 | 0.613 | 0.43 | 0.79 |

Table 4.14 shows the result of t-test for water resources. The maximum t value is for water shade area (9.422) and NaOH concentration (8.283). The maximum t value shows that both the consumption of water shade area and emission of NaOH in water bodies are within standard limit. The minimum t value is for BOD (-4.354) and COD (-2.437). Both the values are negative that shows the means of both measures are less

than 4. BOD and COD are the critical factor of water resources, which needs more attention, to protect the water pollution by process industries.

Table 4.15 One sample t-test for land resources

**One-Sample Test**

| | Test Value = 4 | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | |
| | T | Df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| Acidification potential | **-1.445** | 61 | 0.154 | -0.177 | -0.42 | 0.07 |
| HTP | **3.678** | 61 | 0.000 | 0.371 | 0.17 | 0.57 |
| Hazardous waste generation | 1.077 | 61 | 0.286 | 0.387 | -0.33 | 1.11 |
| TTP | 0.381 | 61 | 0.704 | 0.048 | -0.21 | 0.30 |

Table 4.15 shows the t-statistics for land resources. The maximum t value is 3.678 for HTP and minimum t value is -1.445 for acidification potential. The critical measure is acidification potential. Acidification potential is the measure, which remains in standard limit.

Table 4.16 One sample t-test for material & energy resources

**One-Sample Test**

| | Test Value = 4 | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | |
| | t | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| Recourse depletion | **-1.595** | 61 | 0.116 | -0.194 | -0.44 | 0.05 |
| Energy depletion | -0.627 | 61 | 0.533 | -0.081 | -0.34 | 0.18 |
| Energy consumption ratio | **5.895** | 61 | 0.000 | 0.484 | 0.32 | 0.65 |
| Input of raw material | 4.389 | 61 | 0.000 | 0.435 | 0.24 | 0.63 |

Table 4.16 shows the result of t-test for material and energy resources. The maximum t value is for energy consumption ratio (5.895), it means that energy consumption is within standard limit for maximum time. Minimum t value is for resources depletion (-1.595). Resource depletion is high and beyond the standard limit for maximum time. So resource consumption should be maintained in the standard limit. Energy depletion also attains negative value -0.627. So resource depletion and energy depletion both are the critical factors for material and energy resources.

# CHAPTER 5

# CONCLUSION

This study is conducted on the problem of assessment of EPMs in process sector industries. The study was successfully carried out. A large number of literatures were investigated related to EPMs and their implementation. The performance measures of environment were listed out from the literature, which are common for all manufacturing industries. The measures related to process sector are extracted from the EPMs list under four construct namely air resources, water resources, land resources and material & energy resources. A survey questionnaire was prepared on the basis of these EPMs of process sector. The survey was conducted and 62 responses were recorded.

We have decided three objectives of this study. The analysis was done on the recorded data on the basis of the three objectives. The analysis was carried out by SPSS 16.0. First, we applied descriptive statistics and discussed status of EPMs. Then correlations between different measures were calculated by correlation analysis. After this critical measure from each category was find out by applying one sample t-test.

It is concluded that the critical factor under air resources are $CO_2$ and $SO_2$, under water resources BOD and COD, under land resource acidification potential and under material & energy resources resource depletion and energy depletion. The process industries should follow environmental measurement system and focus on these critical EPMs.

There are following limitations in this study:

1. The study is industry specific; conducted only for process sector industries.
2. The study is area specific; the survey was carried out in the process industries of only north India.
3. The study is limited to environmental condition indicators and operational performance indicators only.

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## APPENDIX I
## QUESTIONNAIRE

**To,** **Date:**

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**Sub**: **Assessment of Environmental Performance Measures in Process Sector Industries**

**Sir,**

It is my pleasure to interact with you on the problem of assessment of Environmental Performance Measures in Process Sector Industries. In today's scenario environment is the most important subject as customer perspective and also as competitive point of view.

I am developing a theoretical framework of environment performance measurement system for process industries as a part of my M. Tech. Thesis. After critically examining the diverse streams of literature, 28 elements under 4 construct of performance measures are identified. In this context, I request you kindly to fill the attached questionnaire, which is one of the important components of my research work.

Your judicious response will assure substantial judgment in this exercise and help to carry out the same successfully. I will be happy to acknowledge the same.

Please make it convenient to spare your valuable time to fill in and return the attached questionnaire. The collected information will be kept confidential and utilized for research purpose only. I welcome your suggestions.

Thanking you.

Yours truly,

SULABH NALWAYA
IV SEM M.TECH.
M.N.I.T. JAIPUR
+91 9460608025

## PART I: GENERAL INFORMATION OF PARTICIPANTS AND FIRMS

**Requested response from Managers and above in the organization**

**Name of the Organization: ____________________________________**

**Name of the person responding: __________________________**

**Designation: _______________________________**

**Number of Years Experience: _____**

**E-Mail: _______________________**

**Number of Employees: __________**

**Turnover: ______________________**

**Does your company have some Environmental Performance Measurement System (EPMS)?**

**If Yes, Please mention the name of PMS:**

**Does your company have won any Awards for Environmental Practice?**

**If yes, please mention the name(s) of award(s):**

**PART II: Questionnaire: Determinants of EPMs in Process Industries**

**Rate the following elements under each construct from 1 to 5 with reference to the given question.**

Is the emission/consumption level of each elements of your plant around the standard emission/consumption limit?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Never | Eventually | Some time | Maximum time | Always |

**1. Air Resources**

| S. No. | Elements | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | Output of air emission | | | | | |
| 2 | $CO_2$ emission | | | | | |
| 3 | $SO_2$ emission | | | | | |
| 4 | Nox emission | | | | | |
| 5 | Suspended Particulate Matter (SPM) emission | | | | | |
| 6 | CO emission | | | | | |
| 7 | $N_2O$ emission | | | | | |
| 8 | Non Methane Volatile Organic Compounds (NMVOC) emission | | | | | |
| 9 | Dust production | | | | | |
| 10 | Acidification Potential | | | | | |

**2. Water Resources**

| S. No. | Elements | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | Output of waste water | | | | | |
| 2 | Water consumption ratio | | | | | |
| 3 | Water shade area | | | | | |
| 4 | Biochemical Oxygen Demand (BOD) | | | | | |
| 5 | Total Suspended Solid (TSS) | | | | | |
| 6 | pH concentration | | | | | |
| 7 | Nitrate concentration | | | | | |
| 8 | Heavy metals concentration | | | | | |
| 9 | Chemical Oxygen Demand (COD) | | | | | |
| 10 | Colour and toxicity | | | | | |
| 11 | NaOH concentration | | | | | |
| 12 | Volatile Organic Compounds (VOCs) | | | | | |

### 3. Land Resources

| S. No. | Elements | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | Acidification Potential | | | | | |
| 2 | Human Toxic Potential (HTP) | | | | | |
| 3 | Hazardous waste generation | | | | | |
| 4 | Terrestrial Toxicity Potential (TTP) | | | | | |

### 4. Material & Energy Resources

| S. No. | Elements | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | Resource depletion | | | | | |
| 2 | Energy depletion | | | | | |
| 3 | Energy consumption ratio | | | | | |
| 4 | Input of raw material | | | | | |

**APPENDIX II**

## Literature Review of the Research Papers

| S. No. | Title of Paper | Authors | Publication Year | Journal | Review |
|---|---|---|---|---|---|
| 1 | Green manufacturing performance measures: an empirical investigation from Indian manufacturing industries | Abhijeet K. Digalwar, Ashok R. Tagalpallewar and Vivek K. Sunnapwar | 2013 | MEASURING BUSINESS EXCELLENCE | The purpose of this paper to explore the performance measures for the green manufacturing practices in the Indian manufacturing industries. A questionnaire based survey is conducted to measure the environmental performance. |
| 2 | An environmental performance resource impact indicator for life cycle management in the manufacturing industry | A.C. Brent, J.K. Visser | 2003 | Journal of Cleaner Production | The paper discusses about sustainable production indicators and the process to implement the sustainable production measurement. |
| 3 | Carbon footprint as environmental performance indicator for the manufacturing industry | A. Laurent, S.I. Olsen, M.Z. Hauschild | 2010 | CIRP Annals - Manufacturing Technology | The carbon footprint (CFP) is investigated as the overall indicator of the environmental performance. The overall performance impact is investigated on the basis of life cycle assessment. |
| 4 | Assessing environmental performance by combining life cycle assessment, multi-criteria analysis and environmental performance indicators | B.G. Hermann, C. Kroeze, W. Jawjit | 2006 | Journal of Cleaner Production | The paper introduces a new tool for environmental performance measurement called COMPLIMENT. This tool combines life cycle assesment (LCA), multi-criteria analysis (MCA) and environmental performance indicators (EPIs). |
| 5 | Experiences of environmental performance evaluation in the cement industry. Data quality of environmental performance indicators as a limiting factor for Benchmarking and Rating | B. Von Bahr, O.J. Hanssen, M. Vold, G. Pott, E. Stoltenberg-Hansson, B. Steen | 2002 | Journal of Cleaner Production | The paper discusses about the data quality of performance indicators and describes how data quality relates with benchmarking and rating process by using hypothesis. |
| 6 | Environmental impact of cement production: detail of the different processes and cement plant variability evaluation | C. Chen, G. Habert, Y. Bouzidi, A. Jullien | 2010 | Journal of Cleaner Production | This study evaluates the environmental impact of the cement production and its variations between different cement plants, using Life Cycle Impact Assessment. For that purpose, details of the cement production processes are investigated in order to show the respective part of raw materials preparation and clinker production using environmental impacts calculated with CML01 indicators. |

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| 7 | Evaluating environmental performance using statistical process control techniques | Charles J. Corbett, Jeh-Nan Pan | 2001 | European Journal of Operational Research | The paper shows the basic five hypothesis of performance measurement from organization point of view. |
| 8 | Environmental performance evaluation and indicators | Christine Jasch | 1999 | Journal of Cleaner Production | This paper includes the detail of ISO 14031 on environmental performance evaluation, structure and its principles and link between ISO 14031 and EU-EMAS regulations. |
| 9 | The use of indicators and the role of environmental management systems for environmental performances improvement: a survey on ISO 14001 certified companies in the automotive sector | Claudio Comoglio, Serena Botta | 2011 | Journal of Cleaner Production | The paper describes the methodology of environmental measurement system (EMS) using the questionnaire technique and also find out the indicators of cost reduction. |
| 10 | Finding the connection: environmental management systems and environmental performance | Dagmara Nawrocka, Thomas Parker | 2008 | Journal of Cleaner Production | The paper is presents the study on the relation of environmental management system to environmental performance, the study focuses on how environmental management systems affect performance. |
| 11 | On the Measurement of the Environmental Performance of Firms— A Literature Review and a Productive Efficiency Perspective | Daniel Tyteca | 1996 | Journal of Environmental Management | The paper discusses about analysis of nature and cause of environmental inefficiency and relationship between environmental performance and the actual global effect of industrial activities on health and the environment. |
| 12 | Environmental indicators of textile products for ISO (Type III) environmental product declaration | Eija Nieminen-Kalliala | 2003 | AUTEX Research Journal | This paper examines the manufacturing processes of the selected textiles by using Life Cycle Inventory Analyses (LCI) of the Life Cycle Assessment (LCA) method, and also compares the data available with the criteria for different environmental labels. A proposal is presented for the formulation of technical environmental indicators of different types of textile products. |
| 13 | Environmental performance, indicators and measurement uncertainty in EMS context: a case study | Eleonora Perotto, Roberto Canziani, Renzo Marchesi, Paola Butelli | 2007 | Journal of Cleaner Production | This paper explains environmental performance, environmental performance indicators, environmental management system. The paper also defines various indicators related to water management, environmental quality and waste water discharge. |

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| 14 | The role of environmental management system on introduction of new technologies in the metal and chemical/paper/plastics industries | Gregor Radonjic, Polona Tominc | 2006 | Journal of Cleaner Production | The paper explains how the ISO 14001 certified companies use pollution prevention techniques and introduces a tool IPPC that is useful in promoting and adopting new cleaner technology. |
| 15 | Advanced Manufacturing Technology: A Way of Improving Technological Competitiveness | G. S. Dangayach, S. C. Pathak and A. D. Sharma | 2006 | International Journal of Global Business and Competitiveness | This paper includes an empirical study of process sector companies to use advanceed manufacturing technology in the environment of technologicalcompetitiveness. |
| 16 | Implementation of manufacturing strategy: A select study of Indian process companies | G. S. Dangayach & S. G. Deshmukh | 2001 | PRODUCTION PLANNING & CONTROL | This paper includes a survey based study of three process sector companies to implement the manufacturing strategy in terms of participants, complexity and degree of formalization. |
| 17 | Questionnaire for the development of Environmental Regulation Management System for Indian Manufacturing Industries | G Satish Pandian, N Jawahar, SP Nachiappan | 2013 | Management Arts | This paper discuss about the step by step procedure to design a questionnaire for development of Environmental Regulation Management System (ERMS) |
| 18 | POLICY AND PRACTICE Sustainable Development and its Indicators: Through a (Planner's) Glass Darkly | HELEN BRIASSOULIS | 2001 | Journal of Environmental Planning and Management | The paper evaluates the usefulness of indicators as decision support instruments in planning for sustainable development. It examines key concepts and critical issues in planning for sustainable development and reviews the development of indicators in the last two decades. It concludes that indicators are still a long way from making a substantial contribution to planning and proposes broad research directions to improve their contribution. |
| 19 | Environmental performance rating and disclosure: China's GreenWatch program | Hua Wang, Jun Bi, David Wheeler, Jinnan Wang, Dong Cao, Genfa Lu, Yuan Wang | 2004 | Journal of Environmental Management | In this paper authors describe a new incentive-based pollution control program, in which the environmental performance of firms is rated from best to worst using five colors—green, blue, yellow, red and black—and the ratings are disseminated to the public through the media. |
| 20 | Monitoring of Heavy Metal in Textile Waste Water of Sanganer, Jaipur (Rajasthan) | Jaishree and T.I. Khan | 2014 | International Journal of Scientific and Research Publications | This paper contains results of physico chemical analysis of waste water from textile sector.The value of heavy metals in waste water is calculated against standard values. |

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|---|---|---|---|---|---|
| 21 | Environmental performance indicators: An empirical study of Canadian manufacturing firms | Jean-Francois Henri, Marc Journeault | 2006 | Journal of Environmental Management | The aim of the paper is to examine the importance of measurement and use of environmental performance indicators (EPIs) within a manufacturing firm with the four characteristics of firm. |
| 22 | Calculating, Interpreting, and Reporting Cronbach’s Alpha Reliability Coefficient for Likert-Type Scales | Joseph A. Gliem, Rosemary R. Gliem | 2003 | Midwest Research to Practice Conference in | This paper explains how to calulate and interpreting the Cronbach's alpha coefficient for checking the reliability of data. |
| 23 | Environmental Performance of Canadian Pulp and Paper Plants: Why Some Do Well and Others Do Not ? | Julie Doonan, Paul Lanoie, Benoit Laplante | 2002 | Adult, Continuing, and Community Education | The paper highlights the pressure of Government, public, consumers, etc. to improve the environmental performance. It presents a conceptual model that relates the environmental performance with the source of pressure and Attitude of management. |
| 24 | Environmental Management System for the Textile industry: A case study | Mangala Joshi | 2001 | Indian Journal of Fiber & Textile Research | This paper discuss about the implementation of ISO 14000 series as an effective tool of EMS in textile sector |
| 25 | An empirical study of performance measurement in manufacturing firms | Maurice Gosselin | 2005 | International Journal of Productivity and Performance Management | The paper represents the implementation of life cycle approach (cradle-to-grave approach) to environmental impact analysis. |
| 26 | Environmental and Social Benchmarking for industrial processes in developing countries : a pilot project for the textile industry in India, Indonesia and Zimbabwe | Marc Diebacker | 2000 | Integrated Manufacturing System | This paper includes the benchmarking procedure of the United Nationn Industrial Development Organization (UNIDO) to industries of developing countries for environmental & social performance improvement. In this paper textile industries are selected for performance improvement. |
| 27 | Environmental sustainability assessment in the process industry: A case study of waste-to-energy plants in Spain, Resources | M. Margalloa, A. Dominguez-Ramosa, R. Aldacoa, A. Balab, P. Fullanab, A. Irabiena | 2014 | Conservation and Recycling | Environmental sustainability assessment in the process industry: A case study of waste-to-energy plants in Spain, Resources |

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|---|---|---|---|---|---|
| 28 | Advancing environmental evaluation in cement industry in Iran | Mohammad Jafar Ostad-Ahmad-Ghorabi, Mohsen Attari | 2012 | Journal of Cleaner Production | This paper discusses about how environmental evaluation of the cement industries can be facilitated and how to cure the major environmental issues related to cement industries. |
| 29 | Life cycle assessment of municipal solid waste management methods: Ankara case study | Ozeler D., Yetis U, Demirer G.N. | 2005 | Environment International | The goal of the paper is to determine the most environmentally friendly option of Municipal Solid Waste Management System to solid waste management. |
| 30 | Environmental indicators for small and medium enterprises in the Philippines: An empirical research | Purba Rao, Olivia la O' Castillo, Ponciano S. Intal Jr, Ather Sajid | 2005 | Journal of Cleaner Production | This paper defines various environmental indicators for small and medium enterprises and presents a research instrument based on questionnaire technique to evaluate the environmental performance. |
| 31 | Evaluation of occupational environment in two textile plants in northern India with specific reference to noise | Raman BEDI | 2006 | Industial Health | The study being reported here has been carried out in two textile plants located in Northern Indian state of Punjab. Equivalent sound pressure level L(eq) hasbeen measured in various sections of these plants with the help of a Class-I type digital sound level meter. The study thus demonstrates the presence of gross occupational noise exposure in both the plants and the author believes that occupational noise exposure and the related effects in India is a widespread problem. |
| 32 | Indian textile industry-Environmental issues | R B Chavan | 2001 | Indian Journal of Fibre & Textile Research | This paper presents an overview of Indian textile industry in terms of its structure, associated problems, its impact on environment, pollution control strategies, German ban on azo dyes, response of textile ministry to cope with the implementation of German ban, and otherenvironmental issues. |
| 33 | Evaluating and prioritizing of performance indices of environment using fuzzy TOPSIS | Rasoul Yarahmadi, Shima Sadoughi | 2012 | Indian Journal of Science and Technology | This paper aims to present a comprehensive approach for decision-makers to evaluate and prioritize environmental indices using a technique for order performance by similarity to an ideal solution (TOPSIS) as one of the most powerful and practical tools in multi attributed decision making (MADM) problems in the fuzzy environment. |

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| 34 | Risk assessment of groundwater of Sanganer industrial Area(Jaipur) on hematology of Swiss Albino Mice | Ravi Kumar Goyal, Kalpana Ojha, Subhashini Sharma, K.P. Sharma | 2014 | IOSR Journal of Environmental Science, Toxicology and Food Technology | In this paper Groundwater of Sanganer Industrial area is invetigated on the basis of Hematological parameters. Hematological values are widely used to determine systematic relationship and physiological adaptations including the assessment of general health conditions. |
| 35 | Greening of the textile and clothing industry, FIBRES & TEXTILE in Eastern Europe | Selin Hanife Eryuruk | 2012 | FIBRES & TEXTILES in Eastern Europe | This paper analyzed how green the textile and clothing industry is with respect to the product lifecycle, from raw material through the design, production and logistics up to disposal in order to point out important points and parameters for greening the industry. |
| 36 | Economic–environmental monitoring indicators for European countries:A disaggregated sector-based approach for monitoring eco-efficiency | Sibylle Wursthorn, Witold-Roger Poganietz, Liselotte Schebek | 2010 | Elsevier Ltd. | In this paper, authors represent an approach for analyzing the environmental economic performance of an economy at the level of disaggregated sectors. |
| 37 | Using Sustainable Production Indicators to Measure Progress in ISO 14001, EHS system and EPA Achievement Track | Vesela Veleva, Jack Bailey and Nicole Jurczyk | 2001 | international journal of corporate sustainability | This case study presents results from testing a new tool — indicators of sustainable production (ISPs). The authors demonstrate how the tool can be used to measure continual improvement and how it fits within the current system for reporting compliance to regulations; and performance under ISO 14001 (environmental management system standard), the environmental, health and safety (EHS) system, and EPA Achievement Track. |
| 38 | Environmental indicators for business: a review of the literature and standardisation methods | Xander Olsthoorn, Daniel Tyteca, Walter Wehrmeyer, Marcus Wagner | 2000 | Journal of Cleaner Production | This paper reviews the existing literature on environmental performance indicators as they relate to private sector organizations, followed by a basic classification of ways in which environmental data are being standardized for use in indicators. The paper concludes that environmental data, once normalized, should be used in a diversity of indicators that are tailored to the information needs of the data users |
| 39 | Development of environmental performance indicators for textile process and product | Xin Ren | 2000 | Journal of Cleaner Production | The paper represents the environmental performance indicators (EPIs) development methodology and various EPIs for textile industries. |

## APPENDIX III
## Database of the Process Industries

| S. No. | Name of the Organization | Location | Product |
|---|---|---|---|
| 1 | Ahuja Overseas | Jaipur | Textile |
| 2 | Jaipur Rugs Pvt. Ltd. | Jaipur | Textile |
| 3 | Arham Spinning Mills | Bhiwadi | Textile |
| 4 | Gopalas Textile Oversease | Jaipur | Textile |
| 5 | JCT Ltd. | Shriganganagar | Textile |
| 6 | Jagjanani Textile Ltd. | Jaipur | Textile |
| 7 | Radhika Textile | Jaipur | Textile |
| 8 | Jaipur Polyspin Ltd. | Ringas | Textile |
| 9 | Vanasthali Textile Industries Ltd. | Jaipur | Textile |
| 10 | Maharaja ShriUmed Mills Ltd. | Pali | Textile |
| 11 | Jai Amar Papers | Jaipur | Textile |
| 12 | NTC (DP & R) | Beawar | Textile |
| 13 | NTC (DP & R) | Bijaynagar | Textile |
| 14 | NTC (DP & R) | Udaipur | Textile |
| 15 | Ratan Textiles | Jaipur | Textile |
| 16 | Khatri Textile | Jaipur | Textile |
| 17 | Bombay Textile Industry | Jaipur | Textile |
| 18 | Bagru Textile | Jaipur | Textile |
| 19 | Orient Syntex | Bhiwadi | Textile |
| 20 | PrernaSyntex | Neemrana | Textile |
| 21 | Rajasthan Textile Mills | Bhawnimandi | Textile |
| 22 | PoojaSpintex Pvt. Ltd. | Bhilwara | Textile |
| 23 | Shree Rajasthan Syntex Ltd. | Udaipur | Textile |
| 24 | LagnamSpintexPvt.Ltd. | Bhilwara | Textile |
| 25 | BSL Ltd. | Bhilwara | Textile |
| 26 | Sanganeria Spinning Mills Ltd. | Neemrana | Textile |
| 27 | Swatantra Bharat Mills | Tonk | Textile |
| 28 | Tirupati Fibers & Ind. Ltd. | Abu Road | Textile |
| 29 | BanswaraSyntex Ltd. | Banswara | Textile |
| 30 | ShriBhagwati Textile Industries | Bhilwara | Textile |
| 31 | BhavalSunthytic (I) Ltd. | Udaipur | Textile |
| 32 | Bhilwara Spinners ltd. | Bhilwara | Textile |
| 33 | Nitin Spinners Ltd | Bhilwara | Textile |
| 34 | BTM Industries Ltd. | Bhilwara | Textile |
| 35 | R.V. Spiners Pvt. Ltd. | Bhilwara | Textile |

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|---|---|---|---|
| 36 | Super Syncotex (India) Ltd. | Bhilwara | Textile |
| 37 | Bhartiya Spinners Pvt. Ltd. | Bhilwara | Textile |
| 38 | A.K.Spintex Ltd. | Bhilwara | Textile |
| 39 | AnantSyntex Ltd. | Bhilwara | Textile |
| 40 | Rolexz Processors Pvt. Ltd. | Bhilwara | Textile |
| 41 | SpinfedGulabpura | Bhilwara | Textile |
| 42 | Shree Charbhuja Spinners | Bhilwara | Textile |
| 43 | Sulzer Processors Pvt. Ltd. | Bhilwara | Textile |
| 44 | Shipra Spinners Pvt. Ltd. | Bhilwara | Textile |
| 45 | Snagam India Ltd. | Bhilwara | Textile |
| 46 | Airjet Spinning | Bhilwara | Textile |
| 47 | Nitin Spinners Ltd. | Bhilwara | Textile |
| 48 | RSWM Ltd. | Bhilwara | Textile |
| 49 | Modern Woolens | Bhilwara | Textile |
| 50 | Suzuki Spinners | Bhilwara | Textile |
| 51 | PratibhaSyntex Ltd. | Bhilwara | Textile |
| 52 | GayatriSpiners | Bhilwara | Textile |
| 53 | Kanchan India Ltd. | Bhilwara | Textile |
| 54 | Star Cotspum Ltd. | Bhilwara | Textile |
| 55 | Sudiva Spinners Ltd. | Bhilwara | Textile |
| 56 | Sarvoday India Ltd | Bhilwara | Textile |
| 57 | Sangam Textile Ltd. | Bhilwara | Textile |
| 58 | Mayur Textile Ltd. | Bhilwara | Textile |
| 59 | Ajay Group of Companies | Bhilwara | Textile |
| 60 | Shree Cement Ltd | Beawar | Cement |
| 61 | J.K. Cement Works | Nimbahera | Cement |
| 62 | Wonder Cement Ltd | Nimbahera | Cement |
| 63 | Birla Cement Work | Chittorgarh | Cement |
| 64 | Lafarge India Pvt. Ltd. X | Chittorgarh | Cement |
| 65 | Nirma Cement Ltd | Pali | Cement |
| 66 | Vikram Cement Works | Nayagaon | Cement |
| 67 | Aditya Cement Works | Shambhupura | Cement |
| 68 | Lakheri Cement Works | Bundi | Cement |
| 69 | Tikaria Cement Works | Sultanpur | Cement |
| 70 | Ambuja Cements Ltd | Ambujanagar | Cement |
| 71 | Binani Cement Ltd | Pindwara | Cement |
| 72 | India Cements Ltd | Banswara | Cement |
| 73 | JK Lakshmi Cement Ltd | Sirohi | Cement |

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|---|---|---|---|
| 74 | Binani Cement Ltd | Sirohi | Cement |
| 75 | Binani Cement Ltd | Sikar | Cement |
| 76 | Sanghi Cement Ltd | Delhi | Cement |
| 77 | Shree Cement Ltd | Ras | Cement |
| 78 | Shree Cement Ltd | Suratgarh | Cement |
| 79 | Shree Cement Ltd | Roorkee | Cement |
| 80 | Shree Krishna Paper Mills & Industries Ltd. | Kotputli | Paper |
| 81 | The West Coast Paper Mills Ltd. | Dendeli | Paper |
| 82 | Malu Paper Mills Ltd. Nagpur | Nagpur | Paper |
| 83 | Deevya Shakti Paper Mills Pvt. Ltd. | Shadnager | Paper |
| 84 | Khanna paper mills ltd. Amritsar | Amritsar | Paper |
| 85 | JK Paper Ltd. | Surat | Paper |
| 86 | P.S. PaperMills Ltd. | Bhilwara | Paper |
| 87 | Murli Industries Ltd. | Nagpur | Paper |
| 88 | Jai Amar Papers | Jaipur | Paper |
| 89 | Umang Boards Pvt. Ltd. | Jaipur | Paper |
| 90 | BILT Papers | Bhilwara | Paper |
| 91 | Royal Paper Group | Jaipur | Paper |
| 92 | Avnai Group of Industries | Udaipur | Paper |
| 93 | Rajasthan Industries | Jaipur | Paper |
| 94 | Kalpana Handmade Papers | Jaipur | Paper |
| 95 | Astron Paper & Board Mill | Ahemdabad | Paper |
| 96 | Shree Gopinath Paper Mills Pvt. Ltd. | Surendranagar | Paper |
| 97 | SPM Paper Industries | Surat | Paper |
| 98 | Millenium Papers Pvt. Ltd. | Rajkot | Paper |
| 99 | Rama Pulp | Vapi | Paper |
| 100 | G.K. Dairy & Milk Products Pvt. Ltd. | New Delhi | Food |
| 101 | SMC Foods Ltd., Nanauta | Saharanpur | Food |
| 102 | SSP Pvt. Ltd. | Faridabad | Food |
| 103 | Mother Dairy | Ahemdabad | Food |
| 104 | Mahanand Dairy | Mumbai | Food |
| 105 | Umang Dairy (JK Organisation) | Ahemdabad | Food |
| 106 | Annkoot Agro Food | Jodhpur | Food |
| 107 | Saras Dairy | Jaipur | Food |
| 108 | Saras Dairy | Udaipur | Food |
| 109 | Saras Dairy | Bhilwar | Food |
| 110 | Vijay Harbal& Phytochemical | Jodhpur | Food |
| 111 | Ginger Food Product Pvt. Ltd. | Udaipur | Food |

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|---|---|---|---|
| 112 | Nimbus Foods Industries Ltd. | Ahemdabad | Food |
| 113 | Garima Milk Plant | Dholpur | Food |
| 114 | Satya Beverages and Distillers Ltd | Hisar | Food |
| 115 | Shree GopalVanaspati Limited | Hisar | Food |
| 116 | Britannia Industries Ltd. | Delhi | Food |
| 117 | Parle Biscuits Private Limited | Neemrana | Food |
| 118 | Mahashian Di Hatti Ltd | Delhi | Food |
| 119 | Haryana Milk Foods Ltd., | Kurkshetra | Food |
| 120 | Bohara Industries Ltd. | Udaipur | Furtilizer |
| 121 | Samarth Fertilizers & Chemicals Pvt. Ltd. | Udaipur | Furtilizer |
| 122 | Rama Phosphate Ltd. | Udaipur | Furtilizer |
| 123 | Liberty Phosphate Ltd. | Udaipur | Furtilizer |
| 124 | Sulux Phosphate Ltd. | Udaipur | Furtilizer |
| 125 | Phosphate India Pvt. Ltd. | Udaipur | Furtilizer |
| 126 | Patel Phosphate Ltd. | Udaipur | Furtilizer |
| 127 | NitinFertiliser Corporation | Kota | Furtilizer |
| 128 | Mount Natural Fertilizer Ltd. | Beawar | Furtilizer |
| 129 | Sigma Minrals Ltd. | Jodhpur | Furtilizer |
| 130 | Gujarat Narmada Valley Fertilizers Company Ltd. | Bharuch | Furtilizer |
| 131 | Gujarat State Fertilizer & Chemicals Limited | Fertilizernagar | Furtilizer |
| 132 | T J Agro Fertilizers Pvt. Ltd. | Navsari | Furtilizer |
| 133 | Sikko Industries Ltd. | Ahemdabad | Furtilizer |
| 134 | Basant Agro Tech (I) Ltd. | Neemuch | Furtilizer |
| 135 | BEC Fertilizers | Bilaspur | Furtilizer |
| 136 | Khaitan Chemicals &Fertilisers Ltd. | Nimbahera | Furtilizer |
| 137 | Khaitan Chemicals &Fertilisers Ltd. | Fatehpur | Furtilizer |
| 138 | Liberty Phosphate Ltd. | Kota | Furtilizer |
| 139 | Rama Phospates Limited | Indore | Furtilizer |
| 140 | Rajasthan Drugs & Pharmaceuticals Limited | Jaipur | Phrma |
| 141 | Admit Pharmaceuticals Pvt.Ltd. | Rajkot | Phrma |
| 142 | AVENTIS PASTEUR INDIA Ltd | Delhi | Phrma |
| 143 | Ajay biotech (I) ltd | Pune | Phrma |
| 144 | AlbenBiotec Pvt. Ltd. | Delhi | Phrma |
| 145 | Amol Pharmaceuticals | Jaipur | Phrma |
| 146 | Anla Pharmaceutics | Chandigarh | Phrma |
| 147 | J K Tyres | Kankroli | Tyre |
| 148 | Mewat Tire & Rubber Pvt Ltd | Alwar | Tyre |
| 149 | Balkrishna Industries Limited | Bhiwadi | Tyre |
| 150 | Tyre Technocrats (India) Pvt. Ltd. | Udaipur | Tyre |