Study of EHS indicators for sustainability and its effectiveness for Cement Industries in India

A thesis submitted to the

University of Petroleum and Energy Studies

For the Award of

Doctor of Philosophy

In

Environment Health and Safety Engineering

By

Shraddha Mishra

Oct 2020

Supervisors

Dr. Nihal Anwar Siddiqui

Dr. Ashutosh Gautam

UPES

UNIVERSITY WITH A PURPOSE

Department of Health Safety & Environment Engineering

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Dedication

This thesis is dedicated to my beloved Grandparents who blessed me eternally. I also dedicate this work to my Parents who have always stood by me and encouraged me to accomplish my Ph.D. work successfully.

Oct 2020

DECLARATION

I declare that the thesis entitled “Study of EHS indicators for sustainability and its effectiveness for Cement Industries in India” has been prepared by me under the guidance of Dr. Nihal Anwar Siddiqui, Professor & Head, Department of Health Safety & Environment Engineering, University of Petroleum & Energy Studies, Dehradun, India and Dr. Ashutosh Gautam. HOD – Environment, India Glycol Ltd A-1, Industrial Area, Bazpur Road Kashipur- 244713, Uttarakhand. No part of this thesis has formed the basis for the award of any degree or fellowship previously.

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THESIS COMPLETION CERTIFICATE

This is to certify that the thesis on ***"Study of EHS indicators for sustainability and its effectiveness for Cement Industries in India"*** by **Shraddha Mishra** in partial completion of the requirements for the award of the degree of doctor of philosophy (in engineering) is an original work carried out by her under our joint supervision and guidance.

It is certified that the work has not been submitted anywhere else for the award of any other diploma or degree of this or any other university.

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ABSTRACT

In the current era infrastructure is the key to development specially for developing countries. Simultaneously Infrastructure development is quite relevant to Sustainable development goals. When we talk about infrastructure the key material for construction i.e. concrete comes to our mind as an essential building block. It is cement which is used to make concrete and when such material is integral to structure and societal development, it becomes important to analyze its detailed impact of environment health and safety considering the sustainable choice for sustainable infrastructure and sustainable societies.

Sustainable and strong infrastructure has a significant role in preventing pollution, preserving resources, safe material sourcing and social inclusiveness. Remarkably, cement as an infrastructure basic building material has a very strong impact across all aspects of sustainability – economic (profits), social (people) and environmental (Planet) performance. The climate change threat in the near future puts more emphasis to address challenge with environment health and safety.

Globally multiple issues got prime focus as a critical issue in terms of sustainability for the cement industry and these issues require need to be addressed immediately. These issues included aspects of Health, safety and environment, like reducing energy consumption, reducing carbon emissions and other airborne pollutants, improving employee health and safety promoting the efficient consumption of fuels and effective use of raw materials, optimizing resource conservation and abating impacts of operations at local level.

In India, the raw materials for cement production are majorly mined locally, crushed and checked for chemical composition and sent to kiln for further processing. All the steps from kiln to cement bag result in huge energy consumption, large carbon emission during processing along with emission of other pollutant especially particulate matters. Some other factors are also playing key role such as health and safety of cement factory workers and the communities residing around the manufacturing units. Environment health and safety (EHS) aspects are taken care by the manufacturing industries in India due to legal mandates and stringent requirements set and given at the time of environment Impact Assessment (EIA). Majority of the manufacturing units opt for the certification for environment and occupational health and safety but still there are some gaps which left unaddressed to achieve the overall sustainability of manufacturing process in terms of EHS.

This thesis studies and reviews the various environment health and safety indicators which are significant for sustainability of cement industries. EHS performance of cement industries in India have been reviewed critically to identify the sustainability criteria and various scenarios as per the existing practices adopted. Considering the

criteria and scenario, an index has been developed to evaluate the sustainability effectiveness basis the current performance. The index helps in evaluating the focus EHS areas for effective sustainability basis the comparative study of EHS indicators and sub indicators.

EHS and sustainability are reviewed to establish the fact that both are adopted for the same set of improvements. In order to achieve the sustainability and EHS performance improvement the sustainability index had been developed to assist in linking EHS management system and sustainability. It has been tested and worked as missing linkage between EHS and sustainability.

The study has showcased the linkage to embed sustainability in EHS management system for improving effectiveness of the system. It has evaluated the defined set of environment health and safety indicators and resulted in defining the precise gap in EHS performance against industry performance. The study has also found effective in ISO and OHSAS Audits for showcasing the change points in upgraded version of IS014001:2015 requirements and hence helping in increasing company’s revenue, improving brand image and also effectively managing business risks. Additionally, it also helps in strategic betterment of workplace culture which results in raising employee’s morale.

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Shraddha Mishra
Date-1st Oct 2020

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Abbreviation

Acronym	Full Form
AIDS	Acquired Immunodeficiency Syndrome
AIA	Aspect Impact Analysis
BBS	Behavior Based Safety
CO	Carbon Monoxide
CR	Consistency Ratio
EHS	Environment, Health and Safety
ERM	Enterprise Risk Management
FR	Frequency Rate
HCl	Hydrogen Chloride
IPCC	Intergovernmental Panel on Climate Change
PAT	Perform, Achieve and Trade
PBFS	Portland Blast Furnace Slag Cement
PCRA	Petroleum Conservation Research Association
PPC	Portland Pozzolana Cement
RPO	Renewable Purchase Obligation
SR	Severity Rate
TDF	Tire Derived Fuel
VRM	Vertical Roller Mills
MT	Million Tonnes
AAQ	Ambient Air Quality
AHP	Analytic Hierarchy Process
BRR	Business Responsibility Report
BS	Biological Sludge
CDP	Carbon Disclosure Project
CEA	Central Electricity Authority
CFD	Computational Fluid Dynamics
CM	Centimeters
CO2,	Carbon Dioxide
CSI	Cement Sustainability Initiative
CSR	Corporate Social Responsibility
EIA	Environmental Assessment
EMS	Environmental Management System
ESCerts	Energy Savings Certificates
ESG	Environmental, Social, And Governance

GDP	Gross Domestic Product
GHG	Greenhouse Gas Emission
GJ	Gigajoule
GRI	Global Reporting Initiative
GW	Gigawatt
HF	Hydrogen Fluoride
HIRA	Hazard Identification Risk Assessment
HIV	Human Immunodeficiency Virus
HPGR	High-Pressure Grinding Rollers
HSD	High Speed Diesel
IFC	International Finance Corporation
ISO	International Standards Organization
KG	Kilo Gram
KPI	Key Performance Indicators
LCA	Life Cycle Assessment
LTIFR	Lost Time Injury Frequency Rate
M3	Cubic Meter
MCDM	Multiple-Criteria Decision-Making
MW	Megawatt
NCV	Net Calorific Value
NGO	Non-Governmental Organizations
NOx	Oxides of Nitrogen
NVG	National Voluntary Guidelines
OECD	The Organisation For Economic Co-Operation and Development
OH	Occupational Health
OHSAS	Occupational Health and Safety Assessment Series
OHSMS	Health and Safety Management System
OPC	Ordinary Portland Cement
PM	Particulate Matter
PV	Photovoltaic
RDF	Refuse Derived Fuel
SASB	Sustainability Accounting Standards Board
SDG	Sustainable Development Goal
SEC	Specific Energy Consumption
SOx	Sulfur Oxide
t CO2	Tonnes Of Carbon Dioxide
TBL	Triple Bottom Line

TOC	Total Organic Compounds
UN	United Nations
UNGC	United Nations Global Compact
VFD	Variable Frequency Drives
VOC	Volatile Organic Compounds
WBCSD	World Business Council for Sustainable Development
WHRS	Waste Heat Recovery System
YOY	Year on Year

Chapter 1

1. INTRODUCTION:

Cement is a very significant construction material which is used for infrastructure development. At present, cement production is considered as a key factor to economic growth. As we know that economic growth is linked to infrastructure, so these days majority of developing countries are continuously focusing on infrastructure development which is directly associated with demand of cement resulting in huge increase cement production.

As a growing concern across globe climate change and resource conservation are among key environmental issues, it is the need of the hour to create systems to avoid risks and create net positive corporate impacts. Today, companies are looking for growth across geographies and at the same time also owning their responsibilities towards the environment and society. Stakeholders are expecting that companies should own their responsibilities to protect the environment and the planet by conserving resources for our future generations while making profits. Investors are increasingly demanding that businesses must focus on social and environmental responsibilities effectively. While evaluating sustainability of the organizations, stakeholders are not only focusing on the financials of the company but also the EHS and social performance are increasingly requested by stakeholders, such as NGOs, customers, suppliers and new recruits. In last decade, it has been observed that environmental awareness has improved significantly among all the stakeholders and all are looking at sustainable business models.

Sustainability has been explained in different literatures and frames with similar core. It can also be described as “being able to continue over a period of time with causing little or no damage to the environment and therefore able to continue for a long run.” Sustainability reporting has been explained by GRI Guidelines which talks about the practices of measuring the sustainability performance against defined performance indicators and disclosing sustainability data in the sustainability reports. It enables stakeholders to understand the organizations’ sustainability performance and its impacts. The Sustainability reporting is designed in such a manner that it shows the clear link between financial and non-financial performance of the company. Companies have started realizing the need of publishing the sustainability reports covering the environment, social and governance aspects of sustainability.

There are three pillars of Corporate sustainability which are also referred as 3 Ps: Profits/financial performance, People/Social performance, Planet/Environment performance. All the pillars are significant for sustainability of the organization. These can’t be ranked, however in terms of importance Environment is the most vital pillar, as human existence on this planet is highly dependent on environment conditions.

Organizations knows the importance of Environment performance as indirectly social performance is link to it.

Companies are required to participate actively and have to own the responsibility towards the environment as they using environment and its resources for making profits, whereas all humans need the environment for fulfilling their basic needs. It is need of the hour that natural resources like land, water and air should be utilized in such a manner that we are not overshooting the rate of replenishment so that we should not harm the needs of future generations. It is high time that corporates have to adopt methodologies that integrate environmental health and safety measures in providing business leaders with a useful decision-making tool to identify risk and opportunity.

With reference to sustainable development, there are some key issues related to the cement which are seeking attention at globally. Various stakeholder groups are increasingly raising their concerns about the effects of cement production activities like quarrying, energy consumption, CO2, NOx and SOx emissions, dust, noise, health and safety, pollution control etc. The cement industry is considered for largest air pollution and Greenhouse Gas emission (GHG) emission due to specific features of the production. It is also one of the largest users of natural resources, including limestone as raw material and fuel for producing heat and energy. Cement industry has many impacts on environment and health safety. Solving problems pertaining to environment health and safety requires industry to adopt concept of sustainable development.

To ensure the long-term business survival in global markets, cement manufacturing companies have adopted sustainability as a strategic lever. In the pursuit of sustainability Cement industries are working on the broad range of sustainability factors covering Environment, Social and Governance. This research specifically focuses on the EHS indicators for sustainability to address environment health and safety performance of the industry.

Although industries get certified to ISO 14001 for environment management system and OHSAS 18001 for health and safety Management System which helps in setting up the targets for industry to improve EHS performance. At the same time industry also needs an index to benchmark and set a target for sustainable EHS performance. This research focuses on developing a sustainability index for cement industry in sync with EHS indicators by integrating environment health and safety management system with sustainable development. This index takes input from Cement Company's EHS performance as well as compare the performance against the industry performance.

1.1 Title of thesis:

"Study of EHS indicators for sustainability and its effectiveness for Cement Industries in India"

1.2 Statement of the proposal:

1.2.1 Problem Statement

Cement is the key material needed for global infrastructure development and it will remain a key to economic growth. Due to huge demand in global market the cement industry is facing budding challenges in material conservation, saving energy resources, and reducing its emissions. Continually cement sector is endeavoring to reduce their environment footprint. In order to achieve the environment footprint reduction, industries are adopting state of the art technologies to curb adverse environmental impact.

This study is considering environment health and safety sustainability measures undertaken for reducing environment footprints and improving health and safety performance, including community project activities for sustainability.
Under ISO 14001 and OHSAS 18001 Environment Aspect and Impact & Hazard identification and Risk assessment are carried out for identifying the significant aspects for EHS to work upon. But this approach works within the boundaries of the company to improve the EHS performance. Considering the EHS indicators for sustainability, it is required to compare performance with industry benchmark. So, a study needs to be carried out to quantify & assess the impact of sustainability measures on environment health and safety performance and to provide an index to compare the EHS performance with industry bench bark to becoming sustainable.

1.2.2 Background

Today, the industrial operations are responsible for potential environmental threats and the quality of life around it. It is generally accepted that industrial operations influence the quality of the environment. Unsustainable use of natural resource is considered to be the main cause of environmental damage due to increasing emissions, effluent discharge, waste generation and GHG emissions. Additionally, the communities around operations are facing health problems due to industrial operations affecting the quality of their life.
In India, there are 188 large cement plant which together represents 97% of the total installed capacity in the country, while other 365 small plants come under 3%. Out of the total 188 large cement plants in India, 77 plants are located in Rajasthan, Tamil Nadu and Andra Pradesh. After China, the Indian cement industry is the 2nd largest in global cement production which is approx. 8% of the total cement production globally. It had a total capacity of about 347 million tonnes (MT) as of financial year 2012-13. The total cement production in the country was 366 MT in financial year 2014-15, which is further expected to reach 550 MT by 2020.

Today, sustainability has been considered as an integral part of business strategies in various industry operations. Sustainability has many definitions and interpretations. World Commission on Environment and Development (1987) has defined sustainability as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Basically, it can be explained as a process that aims for a better future and planet for generations to come. The “triple bottom line” approach coined by John Elkington (1994) describes three pillars of sustainability - environmental, economic and social. Industries are adopting sustainability concept for preservation of environment, resource planning, economic equality, and social justice. The implications of these actions are considered to ensure that environment sustainability for the generations to come.

Majorly companies are adopting sustainability practices to reduce environment related risk and maintaining competitive business environment. Therefore, a focused research on sustainability practices in cement sector and its impact on reduction of environment foot print will appraise the industry sector to understand the effectiveness of current practices and improvement areas for sustainable future.

The Cement sector plays vital role in the economic growth of the country. Cement is a cyclical commodity with a high correlation with Gross Domestic Product (GDP). Growing demand of cement is directly related to the environmental health and safety performance of the industry. Due to climate change, environmental performance has become an imperative globally.

The Government of India is strongly focusing on infrastructure development to boost economic growth and aiming for 100 smart cities. It has been planned to increase investment in infrastructure in 12th five-year plan. To meet the rise in demand, cement companies are expected to add 56 MT capacities over the next three years. The country’s per capita consumption stands at around 190 kg.

So, the cement manufacturing sustainability is greatly depending on environmental health and safety performance of the cement industry. World business council of sustainable development has identified critical environmental health and safety issues of cement industry, which are significant to climate change and business sustainability. It was observed in recent studies that the companies are working for sustainability are largely certified to ISO 14001 and OHSAS 18001. But companies are driving sustainability and EHS management system in parallel. These two systems need to be integrated to obtain better results. Therefore, this research focuses to study environmental health and safety indicators and its performance to understand their importance as stainability quantifiers.

1.2.3 Motivation/ Need of research

The researcher has worked on sustainability and EHS profile of cement industry. It has been observed that the linkage between EHS and Sustainable development is still needing to be worked upon. Companies are working for sustainability and EHS as well but as a different vertical which actually needs to be integrated. The current sustainability reporting practices and importance of the subject matter in coming future has motivated the researcher to do a research work in the field of sustainability, especially focusing on environmental health and safety factors.

1.3 Scope

The Scope of the research is environment, health, safety performance of cement manufacturing industries in India including Community Environment Health and Safety initiatives. Therefore, a comprehensive literature survey was undertaken to review EHS indicators for sustainability specific to cement industry.
In order to develop Sustainability Index, relevant EHS indicators for cement industry which comprises of - Water Consumption and Conservation, Energy Consumption and Conservation, Raw material consumption and recycling, GHG and other Emission reduction, Occupational Health and Safety, Community Environment Health and Safety initiatives for Water and Energy Resources conservation, Green Belt development & Community Healthcare sustainability reports were studied in detail. Several sustainability initiatives were studied in line with ISO and OHSAS target and objectives to analyze gap areas in assessing sustainability maturity level. In parallel the methods of developing sustainability index were reviewed to select the right approach to formulate the sustainability maturity index.

Sustainability index requires EHS performance year on year trend data. EHS performance data is compared with industry benchmark from several data sources and were analyzed to identify sustainability maturity level criteria. In summary it required inter-disciplinary research and data from many sources to understand the application of sustainability index to assess maturity level and effectiveness of measures.

1.4 Objectives

This study is focused on environmental health and safety indicators for sustainability including social initiatives. The objective of this study are as follows:

1. To study the key EHS indicators for sustainability and analyze their performance trend.

2. To make a comparative study of the impacts of key EHS indicators for sustainability based on measures adopted by the industries.

3. To identify emerging sustainability criteria and various scenarios in sustainability practices.

4. To develop a Sustainability Index to measure the sustainability effectiveness.

5. To implement selective indicators in the industry to validate the effectiveness of developed sustainability index.

1.5 Limitation

As sustainability is itself a huge subject and contains various parameters which are correlated and applicable to all industries irrespective of nature. Cement sector is one of the growing and highly energy intensive and polluting industries. So, this study is limited to environment health safety indicators.

CHAPTER 2

2. LITERATURE REVIEW:

A comprehensive literature survey was undertaken to understand work already done in the area of research. Research Papers, review papers, books on sustainability and cement company's sustainability reports were studied. Broadly the literature review for is broadly classified into following areas:

A) Environment, Health and Safety (EHS) impacts of cement manufacturing
B) Study of EHS indicators under various standards and sustainability framework
C) Linkage of EHS and Sustainable development

2.1 Overview of cement industries sustainability Measures

It is difficult to visualize a cutting-edge existence without concrete. Concrete is a critical development material utilized for lodging and foundation improvement and a key to monetary development. Concrete interest is straightforwardly related to financial development and many developing economies are taking a stab at quick foundation improvement which underlines the colossal development in concrete creation (WBCSD-2014). The concrete business assumes a significant part in improving expectation for everyday comforts everywhere on over the world by making direct work and giving different falling financial advantages to related enterprises. Notwithstanding its prevalence and gainfulness, the concrete business faces numerous difficulties because of ecological concerns and manageability issues (Potgieter Johannes H. 2012). The concrete business is a vitality concentrated and critical supporter of environmental change. The significant condition wellbeing and security issues related with concrete creation are emanations to air and vitality use. Concrete assembling requires colossal measure of non-inexhaustible assets like crude material and petroleum derivatives.

The findings of prior studies suggest that organizations pursuing ISO 14001 and OHSAS 18001 certification in response to pressure from stakeholders are focused on reputational risk. Although other underlying motives for the adoption of these certifications are performance improvements. But currently these performance improvements are not aligned to triple bottom line (TBL). The possible mechanism to enable the organization for sustainable development is that one should take into consideration the link between sustainability and EHS indicators.

Hazard Identification Risk Assessment (HIRA) and Aspect Impact Analysis (AIA) identify significant issues related to environment and non-tolerable risk under ISO 14001 and OHSAS. It also helps us identifying opportunities to improve environmental and safety performance. HIRA and AIA are restricted to identification of issues and identifying opportunities. There is no further matrix used for identifying the focus areas for sustainable performance under EHS indicators (Matjaž Maletic, Manja Podpečan, Damjan Maletic, (2015).

The absolute biggest organizations are revealing their reasonable execution in their sustainability reports. These reports are generally founded on the GRI structure, where the key parts of social and ecological exercises are secured. The World Business Council for Sustainable Development (WBCSD), the International Standards Organization (ISO), and the Global Reporting Initiative (GRI) were the key drivers for execution of sustainability rehearses in the industries. Despite the fact that there are various sustainability indicators which are assorted in nature and have been grown willfully with the end goal of supportable strategic policies (M.Z. Majdalani 2016).

GRI standard model talks about labour practices, decent work, human rights, product responsibility, society, energy and emissions, water and effluent, waste management and conservation mechanism etc. under Social and environment section. Which are further categorized to drill down the various sub indicators under each set of social and environment indicators. Whereas United Nations (UN) framework considers equity, health, education, security, population, atmosphere, land, ocean, fresh water and biodiversity under social and environment section. The Organization for Economic Co-operation and Development (OECD) has phrased its requirements of social and environment with defining input and output of operations, which includes water intensity, energy intensity, renewable energy proportion, GHG intensity etc.

Sustainability practices and Environment, word related wellbeing and safety (EHS) are the two united ideas which are likewise considered as fundamental components in maintaining an effective business with the capacity and competency to get by in the market (Center for Safety and Health Sustainability report-2013). There are several papers discussing the connection among sustainable development, economic performance, environment, people, supply chain, society, stakeholder engagement etc. but the role of occupational health, workplace safety, EHS focused community initiatives not widely considered for sustainable development (Amponsah-Tawiah, Kwesi.2013).

2.2 Inferences from literature survey

Table-1

Sr. No.	**Title**	**Author**	**Year**	**Key Findings**
1	Methods for sustainability assessment: Sustainability indicators	Robert Paehlke	2000 International	Indicators identified for measuring environmental sustainability- through the aggregation of indicators like water quality, habitat prevention, ecological health, air quality, resource protection and well-being indicators
2	Indian Cement Industry Forecast to 2012	RONCOS - online business research	2008	Homegrown interest for concrete is expanding at a quick pace in India and it has outperformed the financial development pace of the organization. Concrete Consumption in India is estimated to develop by over 22% by 2009-10. Lodging area is to be remained the biggest customer of concrete in coming years.
3	Handbook on a novel methodology for the Sustainability impact assessment of new technologies	Anne Gaasbeek Ellen Meijer	Nov 2009	a life-cycle based method for full sustainability assessment.
4	Sustainable cement production	Chembureau	Jan 2009, International	Focus on solution in terms of reducing reliance on fossil fuel along with commitment towards the bringing down of emissions.
5	Challenges in sustainable manufacturing	Arun N. Nambiar	Jan 2010 Indian	This Research has demonstrated that organizations that embrace supportable practices can accomplish expanded item quality, expanded piece of the pie and expanded benefits. In this work inspects a portion of the difficulties that organizations are confronting and the devices they can use to beat them as they leave upon this excursion.

6	Towards a lifecycle sustainability assessment	UNEP/SETAC lifecycle initiative	2011, International	Focuses on strategies and methods that can quantify manageability and permit LCA to help dynamic toward more practical item and cycle frameworks.
7	A Review of sustainability assessment and sustainability/environmental rating systems and credit weighting tools	Cesar A. Poveda	2011 International	examines a scope of crucial methodologies, just as explicit and incorporated procedures for supportability evaluation.
8	The Cement Sustainability Initiative	Institution of Chemical Engineers, UK	March 2011, International	Progress detail of cement manufacturing in terms of environment safety and its future challenges
9	Reduce Energy Consumption: Cement Production	Murray Patrick	2011	It tells the best way to lead fabricating vitality evaluation which can help in recognizing a wide scope of changes to help decrease utilization.
10	Measuring and reporting on sustainability performance in cement industry	Adrian Vaida	March 2011 Indian	The paper analyses the pathway the concrete business has sought after so as to improve its presentation in alleviating social and ecological effects, and report on the outcomes. In view of direct involvement in and firsthand information on the concrete business, the arrangement of elective exhibition pointers created by CSI is introduced and an equal is drawn between that set and the broadly useful markers created by GRI. The methodology taken by CSI to guarantee consistence of the quantitative information with acknowledged announcing standards, for example, exactness, dependability, and

				equivalence is likewise nitty gritty and remarked on.
11	Environmental impacts of cement production	Stajanca M., Estokova A,	2012	The discharges from concrete plants causing most prominent concern and which should be controlled are dust, carbon dioxide CO_2, nitrogen oxides (NO_x) and sulfur dioxide (SO_2). This examination audits the principle natural issues identified with the concrete creation. Assessment of concrete effect on condition is a significant cycle to be thought of and considered.
12	Lifecycle assessment of the use of alternative fuels in cement kilns: Case Study	M.Georgi opoulou	2012	The examination results additionally show that the replacement of ordinary petroleum derivatives by elective powers, for example, RDF (Refuse inferred fuel), TDF (Tire determined fuel) and BS (Biological slop) or a blend of them is bringing about less outflows and consequently natural effects. It is required to be noticed that the utilization of RDF has a favorable position when contrasted with the other elective energy options.
13	Categorization of indicators for sustainable manufacturing	Cheb. Joung, John Carrell, Prabir Sarkar& Shaw C. Feng1	March 2013 International	This paper presents a categorization of sustainability indicators, in view of common likeness, in five scopes of sustainability: ecological stewardship, financial development, social prosperity, innovative progression, and execution the board. At long last, the paper discloses how to utilize this pointer set to evaluate an organization's assembling activities.
14	Health risks for population living in the neighbourhood of a cement factory	Syed Sana Mehraj	2013, Indian	Details the wellbeing related hazards with the assembling of Portland concrete for the populace living in the area of a concrete and cement industry.

15	Water scarcity footprint for cement production	Maly Puerto	2013	This study evaluates the creation of concrete in Lafarge-Holcim processing plant situated in Nobsa, Colombia, water impression assessment.
16	Study of Occupational Health, Safety and Environmental Aspects in Major Cement Manufacturing Industry	Meenesh Kumari Tomar	2014	This study analyzes procedures to comprehend the strategies around wellbeing and security at work in the concrete plants. It has been recognized Gap identification between ideal circumstance and as is circumstance of Health, Safety and Environment in the business.
17	Step towards developing a sustainability performance measure within industrial networks	Samaneh Shokravi	2014	Impartial and reckonable measure incorporates the financial, social and natural parts of sustainability and shows the measure of damage that the gracefully system can cause to the earth and society for each dollar of benefit that it produces.
18	Energy auditing in cement industry: Case study	Morteza Gholipour Khajeh Masoud Iranmanes h	2014	In this study an analytic hierarchy process (AHP) has been examined for dynamic after a vitality review of energy performance.
19	The greenhouse gas emissions produced by cement production and its Impact on environment: A review of global cement processing	Najabat Ali,Abbas Jaffar	2015	Study shows that the cement manufacturing and its effect of emanations on nature are colossal. The concrete business is significant reason for an unnatural weather change and it remains at the third greatest mechanical wellspring of global warming. It is critical to investigate choices to limit a dangerous atmospheric deviation and climate related issues.

20	Impact of safety health environment on employee retention in pharmaceutical industry: mediating role of job satisfaction And Motivation	Saad Salman	2016	This study confirms that employee retention is a huge result of wellbeing condition. Also, the degrees of occupation fulfillment and worker inspiration similarly intervene the connection between security wellbeing condition and employee retention.
21	Corporate social responsibility in cement industry	Ashok Sharma, Anupam Jain	2017	This study estimates the commitment of Cement businesses towards CSR exercises according to New Companies Act, 2013. It has been discovered that the harmony between the financial advantages and social and ecological commitments should be relooked.
22	Proposal of a sustainable circular index for manufacturing companies	Susana Garrido Azevedo, Radu Godina & Joao Carlos de Oliveira Matias	2017	Research says that the corporate e sustainability has been assessed by joining financial, natural, and social pointers which are not sufficiently incorporated for directing sustainable choices.
23	Sustainable-ERP system: A preliminary study on sustainability indicators	M.S. Hasan, Z Ebrahim, W.H Wan Mahmood & M.N. Rahman	2017	It is basic for a manufacturing organization to implant the sustainability angles identified with the monetary, social, and condition into their exhibition pointers so as to be sustainable. Chosen indicators additionally need to be checked from businesses specialists. a few standards to be defined which can be utilized in examining information to finish the sustainability indicators.
24	Advanced manufacturing	Ankur Goyal,	2017	Research proposes that no single technique is sufficient to fulfil the need

	management system for environmental sustainability: A review of select literature	Rajat Agrawal		of environmental concerns, results enable industries to adopt right combination of techniques from a complete set of manufacturing techniques. There is no universal implementation strategy for all type of industries, it depends on industry specific approach to develop a bridge between engineering and management view.
25	Sustainability performance evaluation- Literature review &future directions	Gulcin Buyukozkan, Yagmur Karabulut	2018	This audit spurs specialists to make sustainability execution assessment systems to help evaluation and think about the level of sustainability, prompting more feasible strategic policies.
26	Indian cement industry on path of environment sustainability through innovation and resource optimization	Sandeep Kudtarkar	2018	This study talks about the sustainability reporting patterns of cement organizations and distinguishes the sustainability challenges and their effects and probable measures. It expresses that cement organizations need to zero in additional on vitality and water preservation, scant crude material and reusing and decrease in carbon emissions.
27	Multi-criteria Decision Analysis- framework for sustainable manufacturing in automotive industry	Stella Stoycheva, Dayton Marches, Cameron Paul	2018	In the event that various kinds of devices are remembered for the dynamic cycle close by MCDA, there is likelihood that successful sustainability choices can be taken, and advantage the business. It proposed that future works may build up the model by choosing unique or more explicit other options, utilizing scores and weightage framework upheld by industry research.
28	Organizational sustainability practices: A study of the	Alamo Alexandre da Silva Batista	2018	This paper examines sustainable practices performed by big corporates. The outcomes show that inclusion of the infra, work environment, HR and so

	firms listed by the corporate sustainability index	and Antonio Carlos de Francisco		on in vital arranging are basic to set targets and baselines for usage of sustainability rehearses.
29	Transportation sustainability index in dairy industry e fuzzy logic approach	Ilija Djekic, NadaSmigic, Ruzica Glavan	2018	The research paper gives an understanding on investigation of transportation sustainability execution by utilizing interlinked rationale to assess two dairy conveyance frameworks. It has recommended the said approach has capacity to be repeated to different areas.
30	A sustainability assessment framework for cement industry-case study	Kuldip Singh, Vikrant Bhakar, Abhijeet Digalwa	2018	This expounds the conversation on the current structures which shows that sustainability evaluation does not have an incorporated appraisal comprising item life cycle, assets, basic variables (item, cycle and strategy), KPIs and their interrelationship with sustainability measurements. It additionally grandstands the writing survey which infers that these strategies are utilized for association explicit conditions and managing restricted markers of manageability. This examination likewise talked about different kind of practices for maintainability evaluation and improvement. It likewise the proposes the future examination heading to build up a marker archive for sustainability appraisal of manufacturing segment.
31	"Developing a sustainability index for auritian manufacturing companies." *Ecological Indicators* 96	Beekaroo, Dickcha, Devkumar S. Callychurn, and Dinesh Kumar	2019	The results show that sustainability issues are on the priority agenda of most manufacturing companies. Sustainability issues, which are important but are not of prime concern because of the difficulty in assessing the impact of sustainability. It identifies this as a main hurdle towards the implementation of sustainable manufacturing practices in the

		Hurreeram .		companies. It demonstrates that there is a need for developing the appropriate metrics for sustainable practices for evaluation.
32	Safety and sustainability nexus:a review and appraisal	Waqas Nawaz, Patrick Linke, Muammer Koc	2019	It proposed the total range of safety regarding hierarchical prerequisites to feature the zones where enhancement can bring about more reasonable results. It can profit to analyst to set better sustainability and for industry it recommends enhancements for defining up the reasonable objectives.
33	An analysis compliance level of Global reporting initiatives in Indian scenario	M Shivalingegowda, Abhishek Nanjundas	2019	This study intends to analyze how cement companies of India are agreeing to Global reporting activities rules in revealing ESG boundaries. It results that the cement organizations of India are not appropriately uncovering area indicated principles of GRI especially identifying with ecological perspectives.
34	Energy environmental performance of Thai cement industry	Natanee Vorayosa, Nat Vorayosa, Tassawan Jaitiangb	2019	This examination paper subtleties the cement business development where the expansion of concrete creation will bring about CO2 outflow in excess of 3 billion ton yearly. Since the cement business assumes a significant part in financial, vitality and ecological frameworks of numerous nations including Thailand, to accomplish the reasonable advancement objective, it is states that it gets important to build up the marker that can be applied at organization level. These indicators ought to mirror the energy management as well as need to consolidate the natural exhibition just as identified with the monetary perspective.
35	Identification & evaluation of	Rohit Singh,	2019	This paper acknowledges sustainable manufacturing is a basic worldwide

	determinants of sustainable manufacturing: case of Indian cement manufacturing	Sachin Modgil, Amit Tiwari		concern due to emission levels. It has investigated that manufacturing businesses are taking a few measures to actualize it however the surviving writing is unpredictable in clarifying the for sustainability. This examination has utilized just thirteen indicators of sustainability. It infers that the pointers like water, infra, land, machines, innovations utilized and so forth for the cement creation, can likewise be considered in future investigations.
36	Sustainability assessment in Cuban cement sector: a methodological approach	S Sanchez, Y Cancio, IR Sanchez, JF Martirena, ER Rosa & G Habert	2019	The aftereffects of this investigation characterize that the financial, social and ecological assessments have the positive effects on low carbon cement. It recognizes that the fundamental effects are related with the decrease of emanations of ozone harming substances and particulate issue, which are connected with word related wellbeing. It likewise accentuation that the sparing of vitality that outcomes in the decrease of the expense of creation. It shows that it is expected to build up the way toward incorporating monetary, social and ecological markers. The consequences of this paper shows that the Life Cycle Sustainability Assessment is related with nature, wellbeing and security, which thus impacts the decrease of ailments, the vitality sparing that is converted into cost decrease.
37	Measuring industrial sustainability performance-empirical evidence from Italian and German	Andrea Trianni, Enrico Cagno, Alessandra Neri, Mickey Howard	2019	Here it distinguishes an examination gap area, regarding absence of proof on how manufacturing measure Sustainability execution, select pointer to their particular needs, and furthermore questions if the created Sustainability execution estimation frameworks really suit.

	manufacturing small and medium enterprises			Sustainability estimation is a significant issue and furthermore essential for setting Sustainability goals in the manufacturing industry. Regularly enterprises are ignorant of their importance and need maintainability execution estimation frameworks to adequately quantify execution. It expresses that it is earnest to consider UN maintainability advancement objectives which offers center to both natural and social issues as a lot of Sustainability pointers.
38	A holistic approach to corporate sustainability assessment- Incorporating sustainable development goals into sustainable manufacturing performance evaluation	Anastasiia Moldavs, Torgeir Welo	2019	This paper perceives the coordinated thought of the social, financial, and natural issues as a fundamental necessity of sustainability. It expresses that critical endeavors have been made to coordinated and address the parts of sustainability. It shows that number of inadequacies, difficulties, and gaps have been recognized regardless of the advancement in the field. It distinguishes the Corporate Sustainability Assessment as an instrument that immediate the association toward economical practices and adds to a worldwide Sustainable Development by detailing maintainability technique and recognize objectives and targets.

39	Rethinking the way of doing business- A reframe of management structures for developing corporate sustainability	Thais Vieir Nunhes, Merce Bernardo & Otavio Jose de Oliveira	2020	This paper reviews the financial, ecological and social regions for Sustainability. It expresses that there are no precise audits happened which are centered around the joint examination of viewpoints that make up the incorporated administration of condition and sustainability zones. It proposes to make a structure that unites the framework previously being utilized in organizations with sustainability execution to help and support the combination of sustainability in business measures. This also suggests that future investigations ought to incorporate the investigation of the central bases of economical administration and add new components together to make a comprehensive structure.
40	Fuzzy multi criteria approach for sustainable maintenance performance evaluation in cement industry	Elita Amrina, Insannul Kamil, Dhova Aridharma	2020	This paper identifies the new difficulties of Sustainable support for organizations which helps in executing a sustainable advancement approach. This exploration has set up an assessment model for reasonable upkeep execution in the concrete business with sixteen KPIs determined indicators of financial angle social viewpoint, and natural perspective. It expresses that Future investigations are needed to build up the supportable execution assessment instrument for the concrete business.

It has been identified in the detailed literature survey that the environment, health and safety indicators have key role to play in sustainability. It has been determined by the past studies that there is a need of comprehensive assessment for prioritizing the indicators for long term business sustainability. It gives insights that social indicators require same weightage as do the indicators mapped against nature focused aspects based on climate change scenario. Considering the efforts and progress made on achieving sustainability in last decade recognizes that EHS has been marked as a critical to sustainability goals. The way globally industries have set their targets to align their businesses to achieve the sustainable development goals, India has to go long way.

Specifically manufacturing sector has a major footprints and social impacts has to be steered responsibly to run sustainably. For cement industry it becomes imperative to focus on key indicators for sustainability considering in inherent nature of industry which is creating significant footprints in terms of climate change scenario. A change has been started towards the integrated reporting which shows the economic value creation in sync with sustainability performance of the organization. The identified key indicators have been assessed and selected for this research to improvise the sustainability approach to bridge the gap.

CHAPTER 3

3. OVERVIEW

3.1. Brief on Cement Manufacturing process and its EHS aspects

3.1.1 Cement Manufacturing process

India is the second-biggest manufacturer of cement globally and it is manufacturing 502 million tons of cement every year. China is the biggest manufacturer of cement, representing nearly 60% of worldwide production, trailed by India at 7%. There are 210 huge cement plants manufacturing 410 million tons of cement each year and 350 small cement plants delivering 92 million tons of cement for every year. While installed limit became quickly in the course of the last seven years (2010-17), cement manufacturing in the nation has seen a steadier increment, from 217 Mt (2010) to 280 Mt (2017). Hence, the cement businesses share a significant part in the Indian economy.

3.1.2 Mining & Crushing

The cement manufacturing begins with the mining of raw material. Limestone mines and coal mines are a significant source in providing the raw materials utilized in cement industry. Limestone the significant raw material utilized in the cement production which is found in the sedimentary stone. Limestone mining removes 203,224 million tons of limestone that is significantly utilized in cement production ventures. The main thought in vitality effectiveness is frequently to find cement plants near the wellspring of raw material. In any case the raw materials are provided to cement plants by rail and by truck. States like Andhra Pradesh, Karnataka, Madhya Pradesh, Rajasthan, Gujrat, Meghalaya, Telangana have a significant store of limestone. Another significant raw material is coal that is utilized as a vitality source in the cement production. Coal is utilized for warming the raw materials at 1450 degrees centigrade to transform into clinker. Limestone is quarried from open cast mines and afterward this limestone is squashed and is stacked in longitudinal reserves. Limestone is taken out askew from these reserves for granulating in raw mill plant. Coal is utilized as a fuel to heat the raw materials in the cement production process.

After the raw material is mined and shipped to the cement factories, the initial step is to take care of it through the crushers, which separates it into pieces, roughly 10 centimeters (cm) in size.

3.1.3 Mixing of raw material

After crushing into pieces, the limestone is then processed together and creates a mixture which is called as raw meal. This raw meal is then granulated in Pre homogenization cycle by which raw materials are blended to acquire the concoction synthesis required for the end utilization of a given type of cement. Small quantities of additional materials, for example, iron metal, bauxite, shale, mud or sand might be expected to give additional iron oxide, alumina and silica to adjust the compound arrangement of the crude blend to the cycle and item prerequisites of cement production. To guarantee high cement quality, the composition of the raw materials and raw meal is continuously checked and controlled. Two sorts of blending method are there to produce cement - Dry cycle and Wet cycle.

In dry cycle the finely crushed material is put away in hopper post screening. Then these powdered minerals are blended in expected extent to get dry raw blend which is then put away in silos and kept prepared to be sent into rotary kiln. Presently the raw materials are blended in explicit extents with the goal that the normal synthesis of the last item is looked after appropriately. In the Wet cycle the raw materials are initially squashed and made into powdered structure and put away in silos. The clay is then washed in washing factories to eliminate impurities found in earth. The powdered limestone and water cleaned clay are sent to stream in the channels and move to pounding factories where they are totally blended and the glue is shaped, i.e., known as slurry.

3.1.4 Preheating

To improve the productivity of the cycle it is needed to pre-heat the raw meal before it enters the furnace, which animates quicker substance responses. A pre-heater is a progression of vertical cyclones through which the raw meal is passed, coming into contact with twirling hot gases moving the other way. These hot gases are exhaust gases delivered from the kilns, which helps in vitality effectiveness by utilizing heat created by one creation cycle to give vitality to another cycle. Contingent upon the dampness substance of the crude material, an oven may have up to six phases of cyclones with higher temperatures acquired through heat recovery.

3.1.5 Coal grinding and Fuel preparation for kiln

Coal is grounded into fine powder to empower it to feed into the kiln as a fuel, to produce the necessary heat for calcination.

3.1.6 Precalcination Process

Calcination is the deterioration of limestone to lime. The necessary reactions, which likewise need heat vitality inputs, are invigorated at two focuses in the cement manufacturing cycle: inside the "precalciner", a burning chamber at the base of the pre-heater over the furnace, and inside the Kiln. This is the primary purpose of the manufacturing cycle at which outflows are delivered: the chemical disintegration of limestone normally represents 60% to 65% of absolute emissions. The fuel burning expected to create heat in the precalciner likewise delivers emissions, representing about 65% of the rest of absolute emissions.

3.1.7 Clinkerisation Process

The fine powder of limestone is heated at a very high temperature, approx. at 1450 degrees Celsius for clinkerisation. Coal is being used to heat this fine powder at high-temperature in clinkerisation process. The burning of limestone process is undertaken in the rotary kilns, in which at 1-3rpm the raw materials is being rotated at its longitudinal axis. These rotating kilns are fabricated of steel pipes having with the diameter of approx. 2.5-7.0 meter and the length varies from 90-300meter. The internal section of the kiln is lined with intractable bricks. The kiln is reinforced on the columns of concrete and fixed on roller bearing in slight inclined situation. The raw mix is inserted from the upper end into the kiln. Fuel is fired right into the kiln as the kiln rotates, along with rotation the material slides and shifted towards the flame, in gradually hotter zones of the kiln.

As of now there are two types of kilns are in use. Older version which was quite ineffective were “wet” kilns which makes raw materials into a slurry before processing, whereas dry kilns make raw ingredients in powder form and utilize about 25% lesser energy in comparison to wet kilns. Powdered coal and sometimes oil and hot gases are being used to heat the kiln. The kiln is placed inclined and it rotates very slowly, the material fed from upper end starts moving towards lower end at the rate of approx. 15m/hr.
Water in the mixture/ slurry is evaporated at approx. 400 degree Celsius in the upper part of kiln and this zone is called Drying Zone. Calcination zone, which is the central part where the temperature is about 1000-degree Celsius, where decomposition of lime stone happens by converting the limestone/ calcium carbonate into lime/ calcium oxide and carbon dioxide and this reaction is called calcination. The residual material is left in the form of small lumps which are called nodules, it generates after the CO_2 is separated. The clinkering zone of the kiln which is the lower part have temperature approx. 1500-1700 degree Celsius, where the calcium oxide reacts with the other raw materials and lime and clay are forming calcium aluminates and calcium silicates. This aluminates and silicates of calcium mixed together to form pellets which are known as clinkers. The size of the clinker varies from 5-10mm in size. The clinker which comes from the burning zone are quite hot. Air is admitted to bring down the temperature of clinkers, in counter current direction inside the base of the rotary kiln. The air-cooled clinkers are accumulated in small trolleys.

$CaCO_3 = CaO + CO_2$
$2CaO + SiO_2 = Ca_2SiO_4$
$3CaO + SiO_2 = Ca_3SiO_5$
$3CaO + Al_2O_3 = Ca_3Al_2O_6$
$4CaO + Al_2O_3 + Fe_2O_3 = Ca_4Al_2Fe_2O_{10}$

3.1.8 Grinding of Clinkers

A regular cement plant has clinker storerooms between clinker production and the plant parts that handle mixing as well as granulating. The last phase of cement manufacturing is that of grinding the clinker and the other crude materials in ball mills. Generally, cement plants utilized "ball mills" for grinding. Today, more productive advances – including roller presses and vertical mills – are utilized in numerous cutting-edge plants. More extensive arrangement could additionally improve productivity of the business in general. The cooled clinkers are gotten from the cooling dish and sent into mills. The clinkers are granulated finely into powder in ball factory or ball mills. Powdered gypsum is included around 2-5% as impeding operator during conclusive crushing to help the setting time, stockpiling, and usefulness of the concrete. It frames a fine dark powder and the last acquired item is called cement.

3.1.9 Storage and packaging

The crushed cement is kept in silos, from which it is transported either in bags and dispatched in the market for sale and purchased. The Portland cement is also used for ready mix plants and precast, where it is blended with aggregates and water to make concrete.

3.2 Study of various sustainability and EHS frameworks and standards for identification of EHS indicators

3.2.1 Cement sustainability initiatives (CSI)

For cement industry the most commonly used indicators for sustainable manufacturing are referred from the cement sustainability initiatives (CSI) under World Business Council for Sustainable Development (WBCSD). CSI guidelines include parameters like GHG emissions and other emissions, co-processing of fuels and materials, safety and water consumption in cement manufacturing. Energy consumption has been recognized as one of the key sources of CO2emissions in the cement manufacturing. It also defines emissions of dust, NOx, SO2, VOC, heavy metals and dioxins/ furans, water withdrawal, discharge and consumption, improvement in water balancing, work-related fatalities and injuries etc. as the Key Performance Indicators (KPIs).

Table-2

Sr. No.	Indicator Category	Key performance indicators (KPIs) developed by CSI
1	Energy and Emissions	Total CO_2 emissions (million tonnes/year)
2		Emissions from electricity purchased (million tonnes/year)
3		Specific heat consumption for clinker production (MJ/t-clinker)
4		Alternative fuel rate (Percent of thermal energy consumption) of kiln
5		Biomass fuel rate (percent of thermal energy consumption) of kiln
6	Health and safety	Number of fatalities for directly employed
7		Number of lost-time injuries
		Clean workplace, Hygiene
8	Water	Amount of withdrawal
9		Amount of discharge
10	Biodiversity	Number of sites wherever biodiversity issues are well captured
11	Waste	Waste reduction
12	Community wellbeing	Local investment

3.2.2 Global Reporting Initiative (GRI)

In addition, there are number of indicators projected by Global Reporting Initiative (GRI) which emphasis on the organization’s important ESG aspects like economic, environmental and social impacts.

Table-3

Sr. No.	Indicator Category	Key performance indicators (KPIs) developed by GRI
1	Materials	Materials used by weight or volume for production
2		% of materials used that are recycled input materials
3	Energy	Energy consumption within the organization
4		Energy consumption outside the organization
5		Reduction in energy consumption
6	Water	Water withdrawal by source
7		Water sources getting significantly affected by withdrawal
8		% and total volume of water recycled and reused
9	Biodiversity	Significant impacts on biodiversity by the industrial activities, products, and services
10	Emissions	Direct greenhouse gas (GHG) emissions
11		Indirect greenhouse gas (GHG) emissions
12		Reduction of greenhouse gas (GHG) emissions
13		Nox, Sox, and other emissions
14	Effluents and Waste	Water discharge by quality and destination
15		Total weight of waste by type and disposal method
16	Supplier Environmental Assessment	% of new suppliers that were screened using environmental criteria
17	Occupational Health and Safety	Type of injury and rates of injury, occupational diseases, lost mandays,
18		Percentage of total workforce represented in formal joint management–worker health and safety committees
19	Local Communities	Percentage of operations with implemented local community engagement, impact assessments, and development programs

3.2.3 International Finance Corporation (IFC)

International Finance Corporation (IFC) has customized the requirement basis EHS issues related with cement business. It comprises the issues as mentioned in the below table:

Table-4

Sr. No.	Indicator Category	Key performance indicators (KPIs) developed by IFC
	Environment	Energy use- Consumption and conservation measures
		Greenhouse gases (GHGs)
		Air emissions- PM, Sox NOx, Heavy metals
		Wastewater
		Solid wastes
	Health and Safety	Dust and Physical hazards
		Heat
		Noise and vibrations
		Radiation and Chemical hazards
		Other industrial hygiene issues.
		Accident and Fatality Rates
	Community Health and Safety	Community health and safety impacts

Organization for Economic Co-operation and Development (OECD) works upon agendas like Education, work and labour practices, employment, and other social concerns including energy and environment. Under environmental areas OECD works on four sectors which comprise Environmental assessments, Climate change and biodiversity, health and safety indicators and viewpoints, Dissociating environmental burdens from economic growth environment.

3.2.4 sustainable development goal (SDG)

UN Global Compact (UNGC) is another voluntary initiative to drive global sustainability principles and to take actions to support UN goals for sustainability which are also known as sustainable development goal (SDG). The SDGs offer an opportunity to work jointly to fight discrimination and inequality, alleviate extreme poverty and protect our earth.

Table-5

Sr. No.	Indicator Category	Key performance indicators (KPIs) as per SDG
1	Environment	Life on land
2		Climate actions
3		Affordable clean energy
4	Health & Safety	Good health and wellbeing
5	Community Health and Safety	Clean water sanitation
6		Sustainable cities and communities

The Sustainability Accounting Standards Board (SASB) is an independent nonprofit organization which has established this exhaustive list of sustainability matters which describes material impacts of those matters. Environment aspects comprises impacts due to business operations, on the environment over the use of nonrenewable resources, use of natural resources for production (e.g., water usage, raw material consumption, impact on ecologies, and biodiversity) and creating damages through emissions and discharges into air, land, and water that may dangerously affect natural resources. CDP, which was previously called the Carbon Disclosure Project, drives the global disclosure system which allows companies to quantify and manage their impacts on environment by focusing on carbon emission trend and water usage trend.

3.2.5 Environmental Management System (EMS) and Occupational Health and safety management system (OHSMS)

Apart from sustainability frameworks, Environmental Management System (EMS) and Occupational Health and safety management system are structured systems which supports an organization to recognize the environmental and OH&S impacts resulting from its business activities. Under EMS standard talks about Prevention of pollution, which considers all the environment aspects (Air, water, Noise, land, emission, waste etc.) with respect to all the activities, product and services of the company. Whereas OH&S system covers Hazard identification and risk assessment process which evaluates all the activities, product and services of the company against Health and safety performance. It requires to form control procedures and management systems for improved EHS performance.

Table-6

Sr. No.	Indicator Category	Key performance indicators (KPIs) as per ISO 14001 and OHSAS 18001
1	Environment	Complying with relevant EHS regulations and other requirements
2		Preventing and minimizing pollution, incidents and accidents
3		Replacing or reducing the use of materials that are hazardous
4		Conserving material and energy usage through efficient use of resources
5		EHS communication
6		Suppliers and contractors t EHS performance
7	Health and Safety	Competence, Training, and Awareness
8		Emergency Preparedness, and Response
9		Incident reduction
10		Working conditions- Illumination, Hygiene, ergonomics

The Global Responsibility Initiative's Sustainability framework is an internationally accepted Reporting Standards (GRI Standards) for sustainability reporting. Global Responsibility Initiative (GRI) US based non-profit organizations which was established in Boston and it was known as "The Coalition for Environmentally Responsible Economies" abbreviated as CERES and the "Tellus Institute". GRI is established with an approach of creating guidelines for combined reporting of financial information of business and its related environmental, social and corporate governance performance. GRI supports businesses and governments internationally to identify and communicate their impact and actions on significant sustainability issues such as governance, climate change issues, human rights and social well-being of communities etc. GRI provides an arena to create and connect the social, environmental and economic benefits for all the businesses.

In year 2000, GRI initiated the first version of global standards for comprehensive sustainability reporting. Gradually it evolved in form of G1, G2 and G3 guidelines, later in May 2013 GRI G4 was launched. After that, in October 2016, GRI has released the current guidelines on Sustainability Reporting which is called as GRI Standard. Companies who are publishing their sustainability reports in accordance with GRI are obligatory to follow the GRI Standard guidelines. The disclosures under the GRI standards are divided into 2 parts- General Standard Disclosures and Specific Standard Disclosures.

GRI reporting also offers sector specific reporting framework which has all the detailed requirements on cement, however similar opportunity is not offered by BRR. It comes under GRI G4-reporting guidelines formulated for construction and real estate sector. Here the scope of the research is limited to cement industries in India. The implementation of these standards to report non-financial information by the companies specifies the organizational efforts in the direction of sustainable development. GRI standards are also being used by the Indian business because it helps them to fulfill with mandated BRR requirements as per the SEBI. In recent studies it has been found that the majority of cement companies in India are not appropriately disclosing sector specified standards of GRI mainly relating to environmental aspects.

3.2.6 Business responsibility Report (BRR)

In 2012 Ministry of Corporate Affairs published and instructing to publish the National Voluntary Guidelines. Business Responsibility Report by top 100 listed companies in SEBI. It was further applied to topmost 500 companies and has also highlighted that these companies should voluntarily implement combined reporting for disclosure on economic and non-economic parameters. The Environmental, Social and Economic factors are being represented by these nine principles of BRR. National Voluntary Guidelines (NVG) and SEBI (The Securities and Exchange Board of India) have specified the practices and purposes to be achieved by implementing these principles. All companies instructed to make a Business Responsibility Report, require to comply with these defined nine principles and disclose responses to each question formulated under nine principles. SEBI has also defined the reporting template for BR Reporting. These nine principles of Business Responsibility are as follows:

Principle-1: Ethics, Transparency and Accountability- It details that businesses should conduct and direct themselves with Ethics, Transparency and Accountability

Principle-2: Product Life-Cycle Sustainability: It details that businesses should offer goods and services that are harmless and contribute to sustainability throughout life cycle

Principle-3: Employees' Well-being: It details that businesses should promote the wellbeing of all employees

Principle-4: Stakeholder Engagement: It details that businesses should respect the interests of, and be reactive towards all stakeholders, especially those who are underprivileged, susceptible and disregarded

Principle-5: Human Rights: It details that businesses should respect and endorse human rights

Principle-6: Environment: It details that businesses should be responsible for taking conservation efforts to reinstate the environment.

Principle-7: Public Advocacy: It details that businesses should behave in responsible manner while influencing public and regulatory policy.

Principle-8: Inclusive Growth: It details that businesses should promote inclusive growth and unbiased development

Principle- 9: Customer Value: It details that businesses should behave responsible manner while engaging and providing value to customers and end consumers.

In India Business Responsibility Reporting is not as evolved and broad when it is equated with the global reporting guidelines. Majority of Indian companies require to expand their sustainability practices to be in line with international combined reporting framework on sustainability reporting. Various Principles which are related to environment, health and safety under BRR requirements are referred in this research. GRI guidelines are more exhaustive as compared to the BRR in terms of the content and detailed format.

The existing set of standards and frameworks have been discussed on environment, safety and health parameters. Environment has been discussed in terms of energy, emissions, water and waste, whereas safety and health has been covered for employees and communities. Correlation is indicative for environment and health and safety parameters. Supply chain segment has also been talked about at various levels. Biodiversity is also found to be a key parameter which is falling under various models.

3.3 EHS Indicators for Sustainability

A detailed literature review has been carried out in an attempt to determine indicators frequently used in sustainable manufacturing assessment.

List of key EHS Indicators for Sustainability

For identifying the various framework and standards diverse range of EHS topics were identified which are considered for sustainability. It is correspondingly very significant to recognize EHS aspects of cement manufacturing process.

Cement is referred as glue as it is the key ingredient in making concrete. The material is the foundation of infrastructure development which is utilized to make shelters for billions of people around the world. It fortifies our buildings in natural disaster and helps in building our lifeline structures for transport, healthcare, education, industry and energy. It combines with water to bind crushed stone and gravel called as aggregates and sand. Cement has significant value in our day-to-day life through numerous varied applications and practices because of its resourcefulness, strength, and robustness to build structures like schools, hospitals, roads, tunnels, bridges, runways, dams, marine structures, industrial plants and housing projects etc. When a material turns out to be as fundamental to the structure and extremely used then it becomes very imperative to evaluate its health safety and environmental impacts to realize the sustainability aspect in long run.

When sustainability is examined the following aspects need to be addressed like Energy and water required to produce the material, CO2 and other emissions resulting from the material's manufacture, impact of product on health and safety while manufacturing, lifecycle of the material and its probable reuse and recycle opportunities etc.

In 1824 Portland cement was patented by British bricklayer Joseph Aspdin which is now captures around more than 95% of the cement market. It is made from calcium carbonate (mainly from locally quarried limestone or chalk), silicon, aluminum, and iron from clay, sand, and a variety of other materials. Portland cement is composed mainly of calcium silicate minerals. The other raw material mixed are clinker, the primary component of Portland cement, Lime Limestone, shells, chalk, Silica Sand, fly ash, Alumina Clay, shale, fly ash, Iron oxide Iron ores.

Manufacturing the portland cement is energy intensive process and releases huge amounts of carbon dioxide (CO2) as well as many other pollutants. Cement sector is one of the eight reported energy intensive sectors. The world's approximately 5% of the anthropogenic CO2 emissions comes from the manufacturing of portland cement worldwide. In cement manufacturing approx. half of the carbon dioxide emits from burning of coal and other carbon-laden fuels which are used as a heat source in kilns and approx. half of its carbon releases from calcining limestone, which emits CO2 due to the chemical reaction involved in the process. The production of cement includes the consumption of huge amounts of raw materials, energy and heat. Cement production results in exhausting natural resources and the release of a substantial number of gaseous emissions in the environment. The manufacturing process is very multifaceted, involving a large number of raw materials, wet and dry kiln pyro processing techniques, preheating, recirculation and fuel sources like coal, HSD, natural gas, waste tires, industrial hazardous wastes, petroleum coke etc.

In India there is a massive demand of cement post the government of India has initiated the smart cities projects and related schemes to boost infrastructure development, highway constructions, housing societies etc. to enhance the Indian economy. Another key demand driver is the real estate sector and it consumes approx. 65% of the total consumption in India.

In recent years the concern has increased over the impact of anthropogenic carbon emissions on the global climate due to growing awareness on global warming. The cement manufacturing industry is under radar of government agencies due to its hostile environmental and health impacts and being energy intensive and attributed with the large volumes of CO2 emissions. Consumption of raw materials and huge energy use and emissions to air are the main environmental issues associated with cement production.

In cement manufacturing there is no as such impact on water resource as waste water discharge is usually restricted to surface run off and cooling water only and causes no significant influence to water pollution. The storage and handling of fuels are a possible source of pollution of soil and groundwater. The key pollutants emitted to air are dust, carbon oxides nitrogen oxides (NOx) and sulphur dioxide (SO2). While cement handling, storage, operation of kiln, clinker coolers etc. are the main sources for air emissions in a cement industry. Particulate Matter emissions (PM) has greatest effects on health of workers of cement and lime manufacturing. Particulate Matter emissions created from crushing and grinding of raw materials and also in handling and storage of solid fuels. The type and quantity of air pollution be subject to different parameters like the raw materials and fuels used and the type of manufacturing process implemented. In the cement industry the most frequently used fuel is pulverized coal (Black coal and lignite) and petroleum coke (Pet-coke). Coal and pet-coke produce higher emissions of greenhouse gases in comparison to fuel oil and natural gas. In cement manufacturing approx. 40%-50% of total production costs are from electric energy and fuel.

Below is the broad category of the key EHS indicators for sustainability have been filtered out for the research purpose basis coverage in multiple frameworks and aspects involved in manufacturing process.

Environment:

• Energy Consumption and Conservation:
• GHG and other Air Emissions
• Water Consumption and Conservation
• Raw material consumption and recycling

Occupational Health and Safety:

- Occupational Health
- Workplace Safety

Social Environment Health and Safety

- Community project - Water conservation, forestry and basic amenities
- Community project-Green Belt development
- Community Healthcare

CHAPTER 4

4. RESEARCH METHODOLOGY

4.1 Theoretical framework

The research has adopted a multi methods strategy by combining quantitative and qualitative approaches for data collection and analysis. Based on the focus area of the research, methodology has kept aligned with the internationally accepted GHG protocol, ISO &OHSAS guidelines and GRI guidelines for analyzing environmental health and safety indicators for sustainability.

Study is quantitative and qualitative analysis of EHS performance indicators and CSR projects undertaken by cement industry. For the assessment of the EHS and CSR trend and impacts, a step-by-step approach is adopted for calculating environmental occupational health and safety performance and community initiatives for selected indicators as follows:

Environment:

- GHG and other Air Emissions
- Energy Consumption and Conservation
- Water Consumption and Conservation
- Raw material consumption and recycling

Occupational Health and Safety:

- Occupational Health
- Workplace Safety

Social Environment Health and Safety:

- Community project - Water conservation, forestry and basic amenities
- Community Project-Green Belt development
- Community Healthcare

4.2 Sampling and Source of Data

To analyze the performance trend of EHS indicators for cement companies, the sample companies were selected. While selecting the samples it was considered that mix of companies to be considered basis old and new plants, large and small capacity of production. Total 5 Indian cement companies were studied to understand the performance trend of EHS indicators for sustainable development. These companies have multiple plants across India which are mostly certified to ISO 14001 and ISO 18001 for environment management system and occupational health and safety. These companies are reporting as per various standards as GRI, ISO, UNGC, WBCSD etc. which includes numbers of indicators for sustainability. Out of several indicators of sustainability few are relevant to EHS. For research purpose, the identified set of EHS indicators data was collected form the sample companies. The production for each of the company varies year to year which is summarized below in the below table.

Table-7

Company	A	B	C	D	E
	Production				
unit	mllion tonnes	mllion tonnes	mllion tonnes	mllion tonnes	mllion tonnes
2012-13	42.59	23.13	22.31	12.33	5.68
2013-14	43.6	24.24	22.31	14.2	5.34
2014-15	43.88	23.84	21.54	16.2	5.3
2015-16	35.51	23.18	12.06	18.50	5.3
2016-17	33.99	26.56	11.92	19.42	5.72

The cement industries located in India are selected for this study. The sample companies for the study are given as follows which includes ACC Ltd, JK cement, Ambuja Cement Ltd, Shree Cement Ltd and Ultra Tech Ltd. Total 5 cement company's EHS and social initiatives performance have been studied for the selected set of sustainability parameter for three financial year (2013-14, 2014-15, 2015-16) data. These are selected from top 10 largest cement companies based on their production size in India. Four years' sustainability performance from 2014 to 2017 are taken for the research purpose. Various data and information on the given parameters of sustainability for the study were collected from the website of the companies, public disclosures, mandatory reports and submissions. As the data has been used from actual performance of industry for research purpose. So, the names of the companies have been kept confidential while analyzing performance and the selected sample companies have been coded as follows:

1. Cement Industry-A, 2. Cement Industry-B, 3. Cement Industry-C, 4. Cement Industry-D, 5. Cement Industry-E (Names have not been disclosed due to confidentiality reasons). (Refer Appendix I)

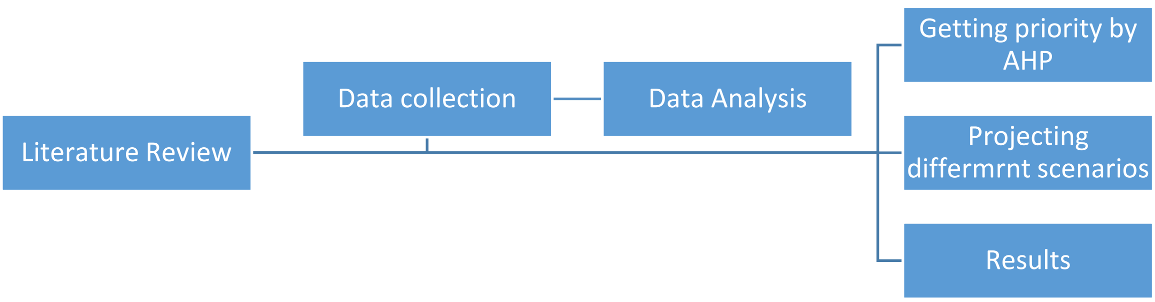
The source of the data referred from the following:

Data collected directly from the industries on environment health and safety indicators for sustainability including Community initiatives. World Business Council for Sustainable Development (WBCSD) - Cement Sustainability Initiative published Reports, Corporate Sustainability Reports published by the cement industries and Environment Compliance reports and other available documents submitted to government agencies or published in form of any report, article etc.

4.3 Statistical tools

The various statistical tools such as different comparison charts such as line diagram, bar chart, pie charts & Excel spread sheets and AHP Software have been used.

Fuel Consumption data used for calculating energy consumption patterns and resulting CO2 emissions in different cement industries. Net calorific value (NCV) sourced from Petroleum Conservation Research Association (PCRA) for energy consumption calculations. Emission factors for fuel sourced from Intergovernmental Panel on Climate Change (IPCC) and Emission factors for purchased Electricity sourced from Central Electricity Authority (CEA) user guide ver. 06. Global reporting initiative calculation guidance have been followed for calculating the performance trend of EHS indicators.



4.4 Research framework

The research is broadly organized as follows:

Overview of EHS performance of cement industry and trend Analysis

Collection of data on Environment health and safety & Community initiatives for sustainability.

Outlining sustainability emerging criteria and various scenarios in sustainability practices for rating.

Development of Sustainability Index for measuring sustainability effectiveness and maturity level.

4.5 EHS Indicators for Sustainability and their performance trend

Environment:

Energy Consumption and Conservation:

For the construction industry cement is one of the key crucial material. Cement production is an energy intensive process, and largely dependent on the primary energy sources (direct energy- fuels like coal, pet coke, diesel etc.) and secondary energy sources (Indirect Energy- grid electricity). The major direct demand of fuels in cement industry is towards operating the pre-heater and kiln facilities. The 90 percent of the cement manufacturing energy is consumed in kiln process and rest 10 percent is used up in almost equal quantities by activities associated to fuel and raw materials preparation, crushing of clinker and the amalgamation of materials to make the finished cement product.

The cement industry heavily depends on fossil fuels which are carbon-intensive. Coal (including Lignite, Petcock), Furnace Oil, Agro Waste and High-Speed Diesel (HSD) are the major primary fuels used across cement manufacturing units in India. To burn raw mix, coal and petroleum coke products are generally used as primary fuel. During start-up of the kiln HSD is generally used whereas to reduce the consumption, coal, tire fuels, municipal solid waste, liquid waste and other alternative energy sources are also being used.

During raw material extraction, grinding, finished grinding and packaging, electricity is mainly needed. Electricity is also used for conveyors, compressors, fans in different production stages. The trend shows that direct energy consumption has been increasing year on year (although there is dip in 2015-16, which is due to one of the sample company's some of the plant was not operational for 3 months). Whereas the purchased electricity (grid electricity) has been reducing from 2014-15 to 2016-17. At the same time Renewable energy share has been increased tenfold in 2016-17 in comparison to 2013-14.

Figure-1

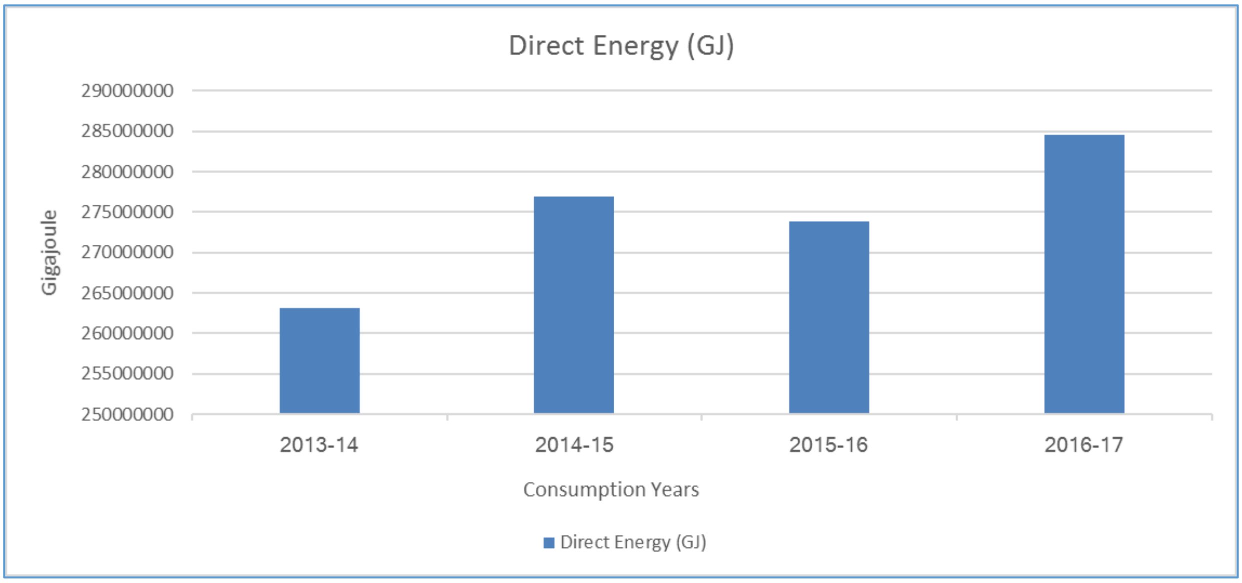


Figure-2

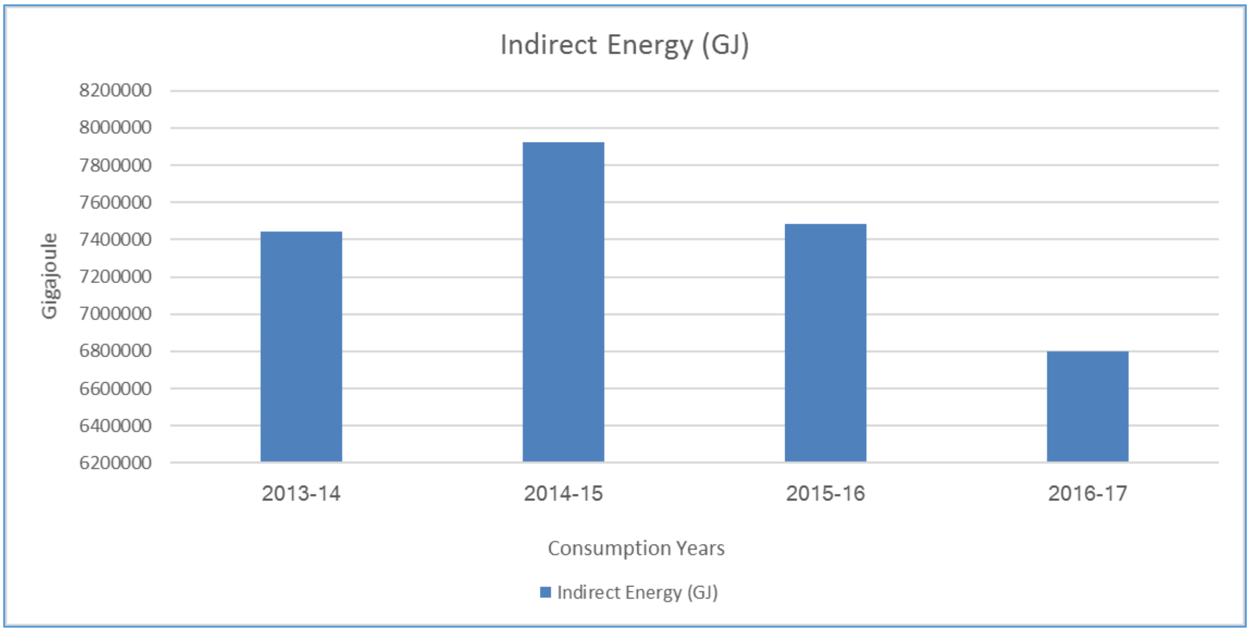
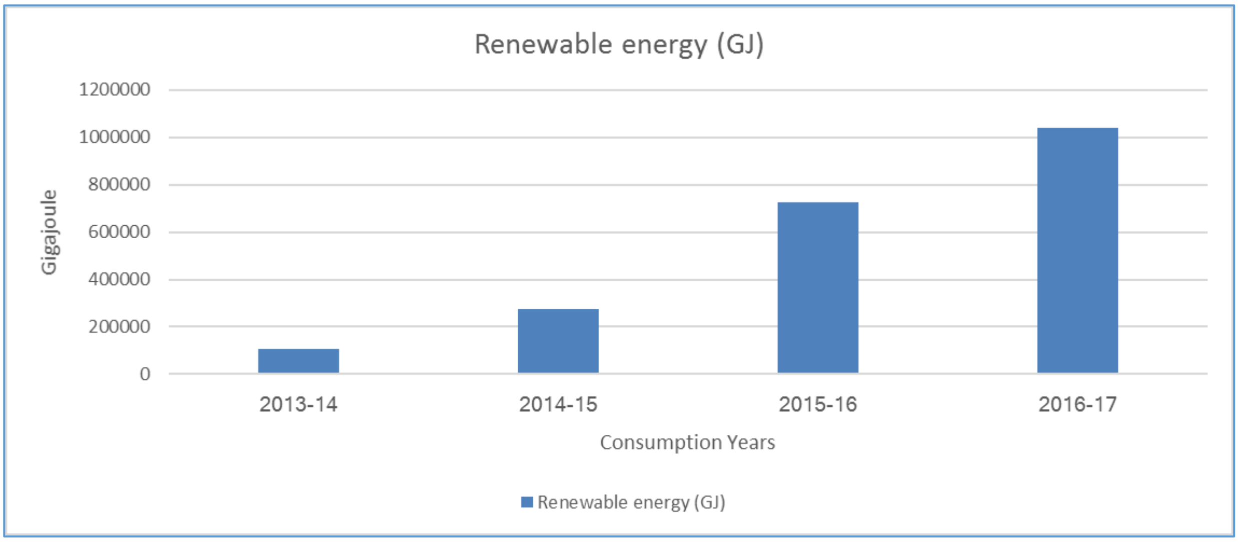


Figure-3



GHG and other Air Emissions:

Sources of CO_2 and GHG emissions in the manufacturing of cement are limestone calcinations, fuel combustion and from use of electric power. Approx. 50 to 60% CO_2 emissions from cement production are produced during the breakdown of limestone and other calcareous material used to produce clinker. Carbon dioxide is released during the production of clinker, in which calcium carbonate ($CaCO_3$) is fired in a rotary kiln to initiate a sequence of complex chemical reactions. It is quite difficult to reduce the emissions generating from clinker production which involves calcination of lime that reaction releases CO_2 over chemical decomposition. For calcination, the required thermal energy is provided by coal/lignite.

To initiate and maintain the high temperatures in the kiln approx. 40% of CO_2 emissions are created by burning the fossil fuels. In comparison to total energy consumption very minimal CO_2 emissions are accounted from transportation and other operations related activities. The trend shows that GHG emission from direct source (Fuel consumption and calcination process) is increasing and GHG emission from indirect source (purchased electricity) is decreasing. GHG emission from direct and indirect source are directly proportionate to the direct and indirect energy consumption.

Figure-4

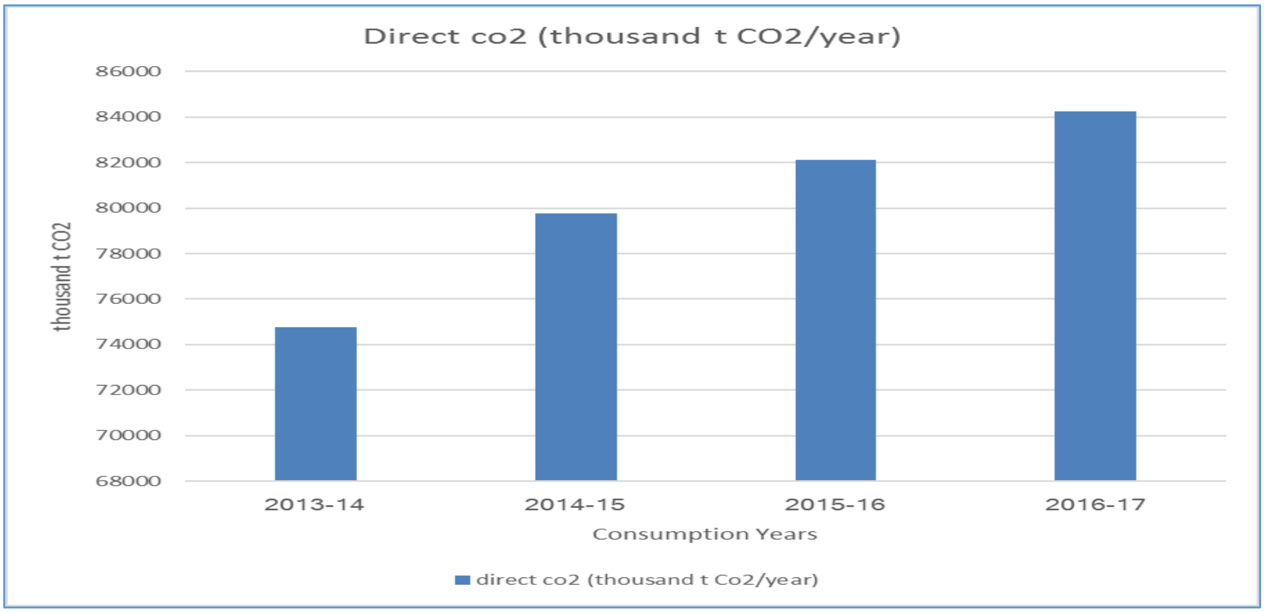
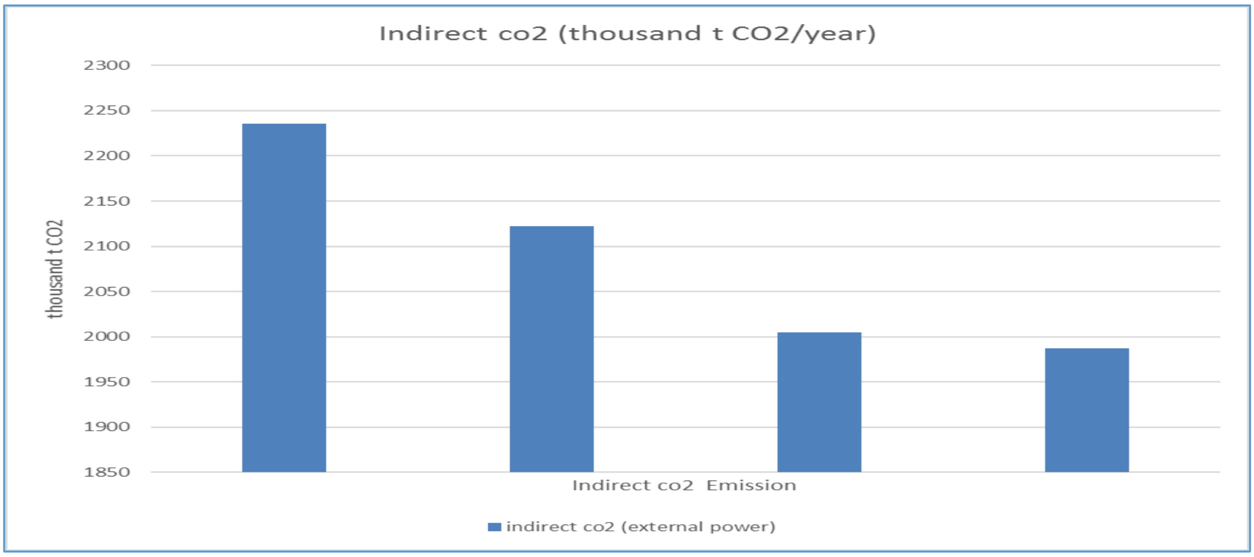


Figure-5



Water Consumption and Conservation

Freshwater is a limited resource, and a critical component for survival of human being. Over the past few years, around the globe, companies have started focusing on world's supply of fresh water for sustaining life and have also recognized it as a human right to have access to safe drinking water and sanitation. In India the major cement production plants are located in dry and arid regions where there is scarcity of water like Rajasthan, Gujarat, and Andhra Pradesh etc. As availability of fresh water is continuously becoming decreasing there is urgent demand of reduction in cement Industry. The water withdrawal sources for cement industries are surface or river water, ground water, purchased water, rain harvested water and recycled water. The trend shows that water withdrawal has been decreasing although there is bit fluctuation in pattern. Companies are continuously focusing on water efficiency with adopting dry process of cement manufacturing to reduce the water demand for production. Considering the water recycling again the trend shows that recycling needs to be focused. Although Indian cement industries are actively working on rain water harvesting projects to be become water positive but still water consumption remains the area of improvement.

Figure-6

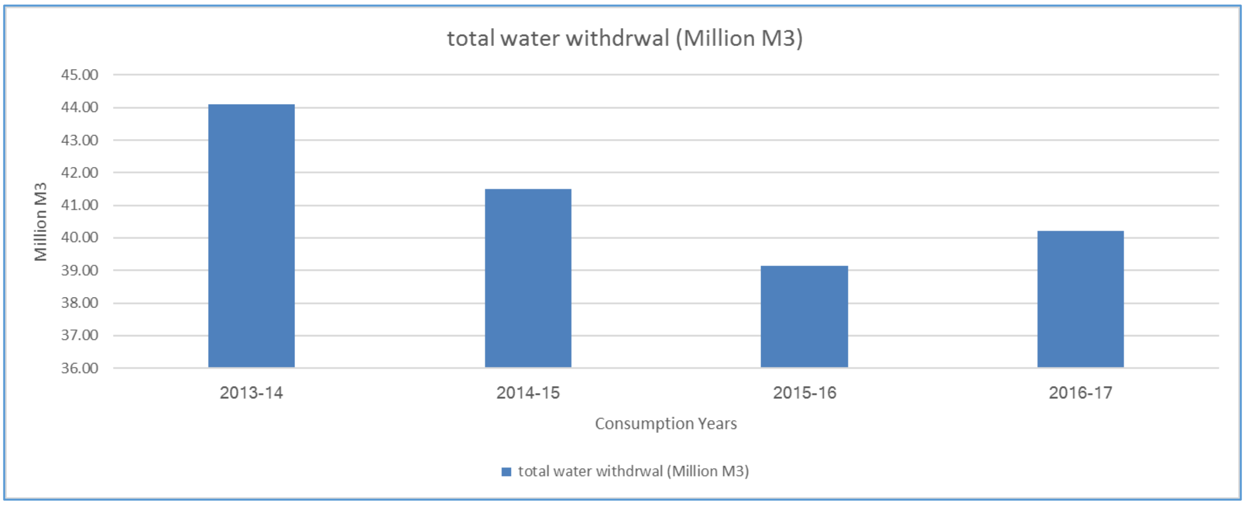
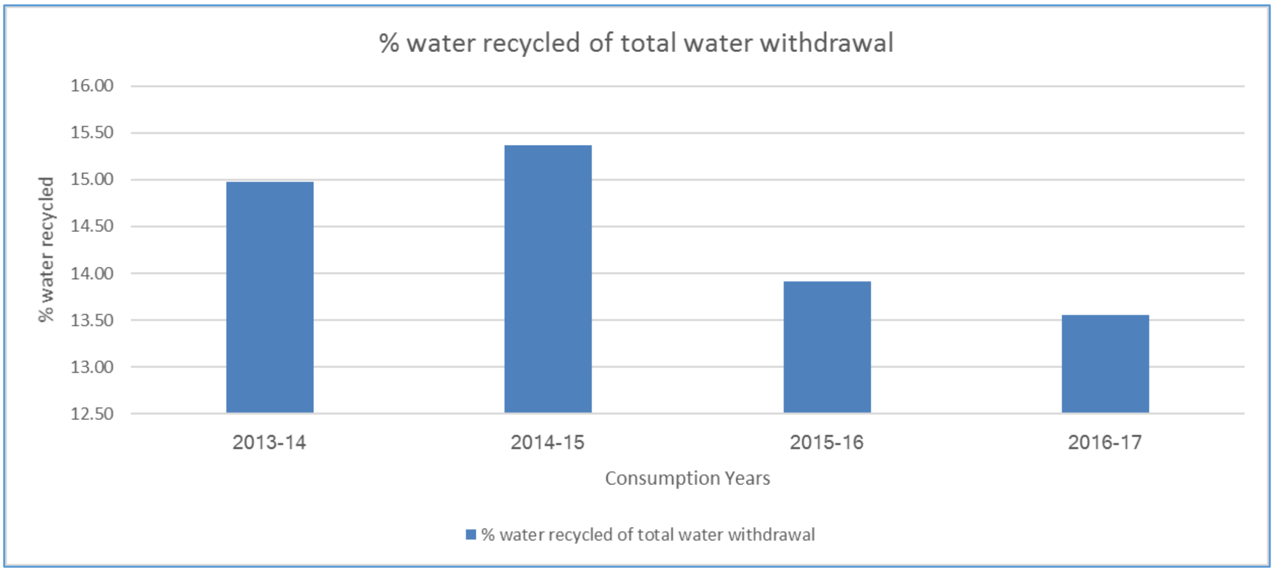


Figure-7



Raw material consumption and recycling:

Raw material consumption is increasing year on year as the industry is growing. At the same time usage of recycled material has also been increased. Alternative materials like use of fly ash, manufactured chemical gypsum, slag and other industrial waste are being used which help in conserving natural raw materials used for the cement production.

Figure-8

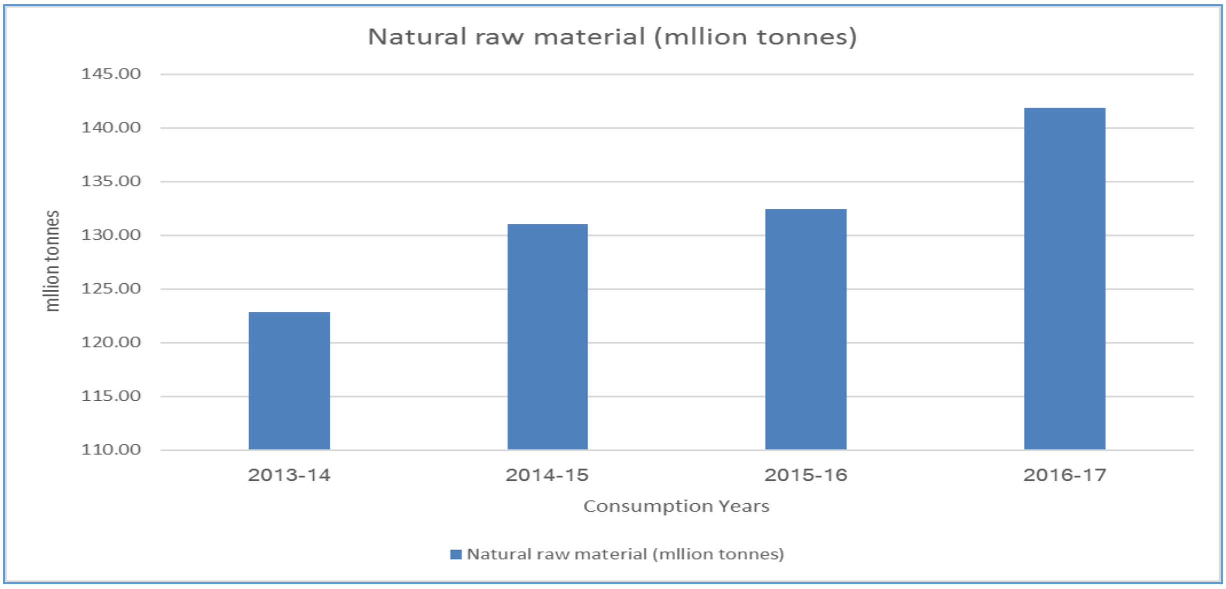
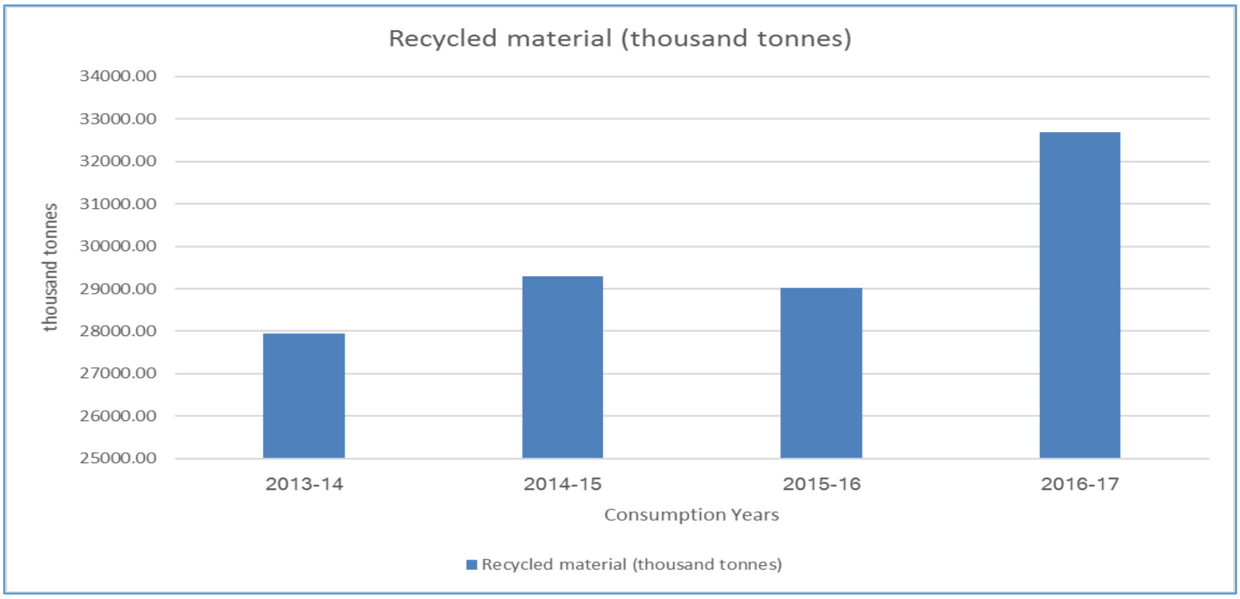


Figure-9

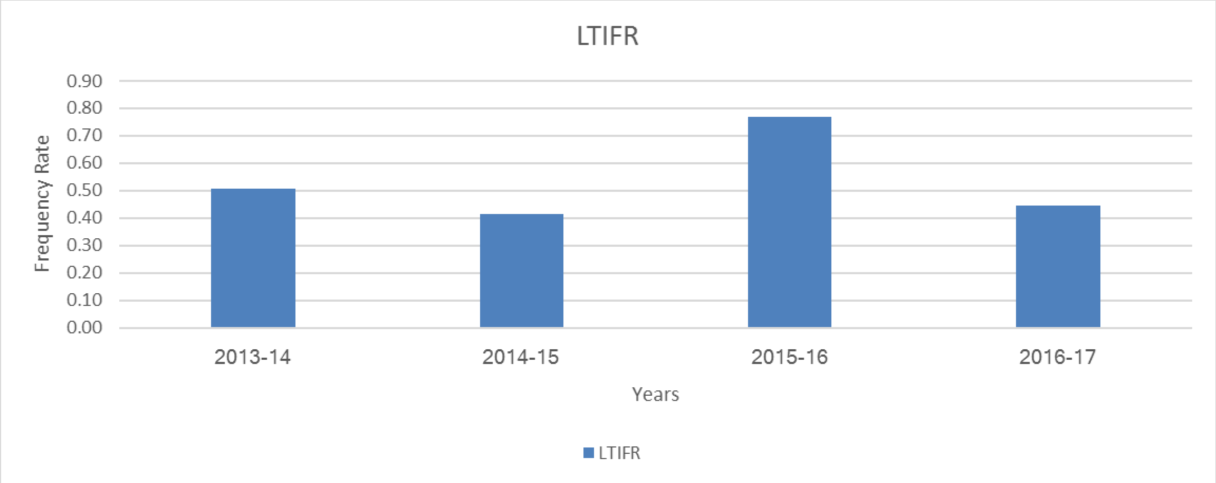


Occupational Health and Safety

Workplace Safety:

Ensuring safe and healthy working conditions for employees and contractors is a key issue for the cement industry in India. The fatality and injury rate in the cement industry is higher than any other industry sector (WBCSD report 2013). Studies have shown that in India the inherent safety culture is still missing. It is extremely important that the hazards in the operations and maintenance activities should be focused and the management should take responsibility to provide safe workplace for all the employees considering the huge number people working in the cement industry in India both direct and indirect.

Figure-10



Occupational Health:

Majorly plants are certified for occupational health and safety management system (OHSAS 18001) to ensure a better system in place for continuous improved health and safety performance. Following are the various programs undertaken by companies over years to improve the workplace safety.

- Nos. of safety training programs for employees and contact workers
- Nos. of Defensive Driving training programs conducted for truck drivers
- Nos. of Joint Safety Audits conducted
- Mock Drill conducted during the quarter
- Rewards, recognitions and instant prizes to encourage safe practices
- Proper use of personal protective equipment
- Medical check-ups for all the employees
- Programs on behavior-based safety

Social Environment Health and Safety

Community project - Water conservation, forestry and basic amenities:

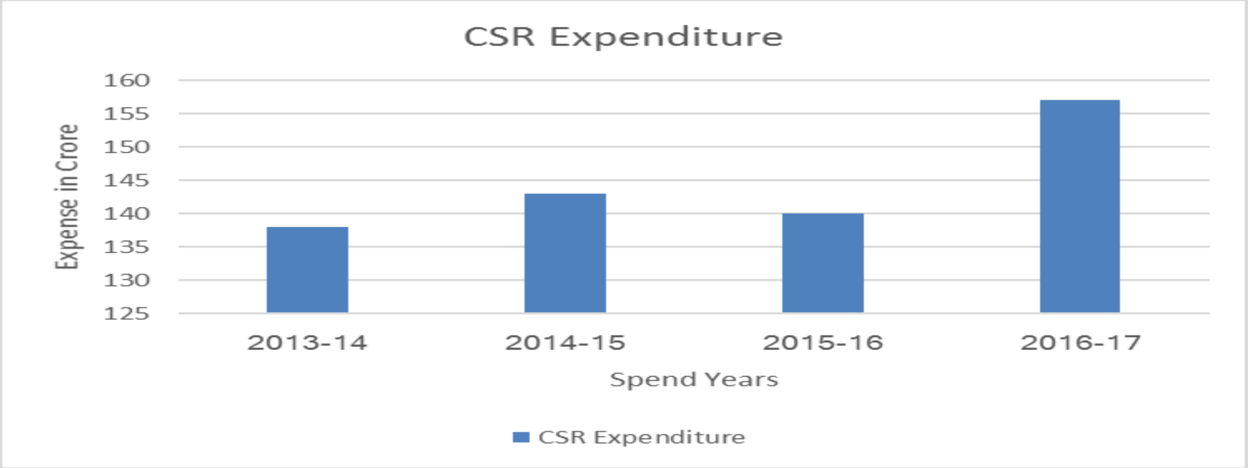
Below environment sustainability linked projects have been acknowledged under CSR activity which comprises following:

- Conservation of Natural Resource & use of Non-conventional Energy Programs
- Bio gas related Programs
- Solar energy projects and other energy conservation programs
- Plantation and tree drives

- Roadside plantation drives for developing green belts
- Soil conservation and land improvement projects for supporting local farmers
- Water conservation and rain water harvesting projects
- Developing pasture land and orchards for community
- For mass tree plantation saplings distribution
- Constructing water harvesting structures for benefiting communities.
- Roof top RWH for ground water recharge.

The CSR spend data trend shows that approximately seven percent of the total CSR spend is utilized for environment sustainability projects by Indian cement industries. The expenditure trend for environment sustainability projects shows year on year increase towards safeguarding environment for the society.

Figure-11



Community Project-Green Belt development

Plantation drives in nearby community areas beyond legal mandates for organizations for developing green belts.

Community Healthcare

Under Community heal care Indian companies have undertaken many initiatives which are listed below:

- Immunization programs
- Health care for visually impaired, and differently abled
- Free Medical camps
- Rye checkup camps
- Blood donation camps

4.6 Comparative study of the impacts of key EHS indicators for sustainability based on measures adopted by the industries.

Environment:

• Energy Consumption and Conservation:

Figure-12

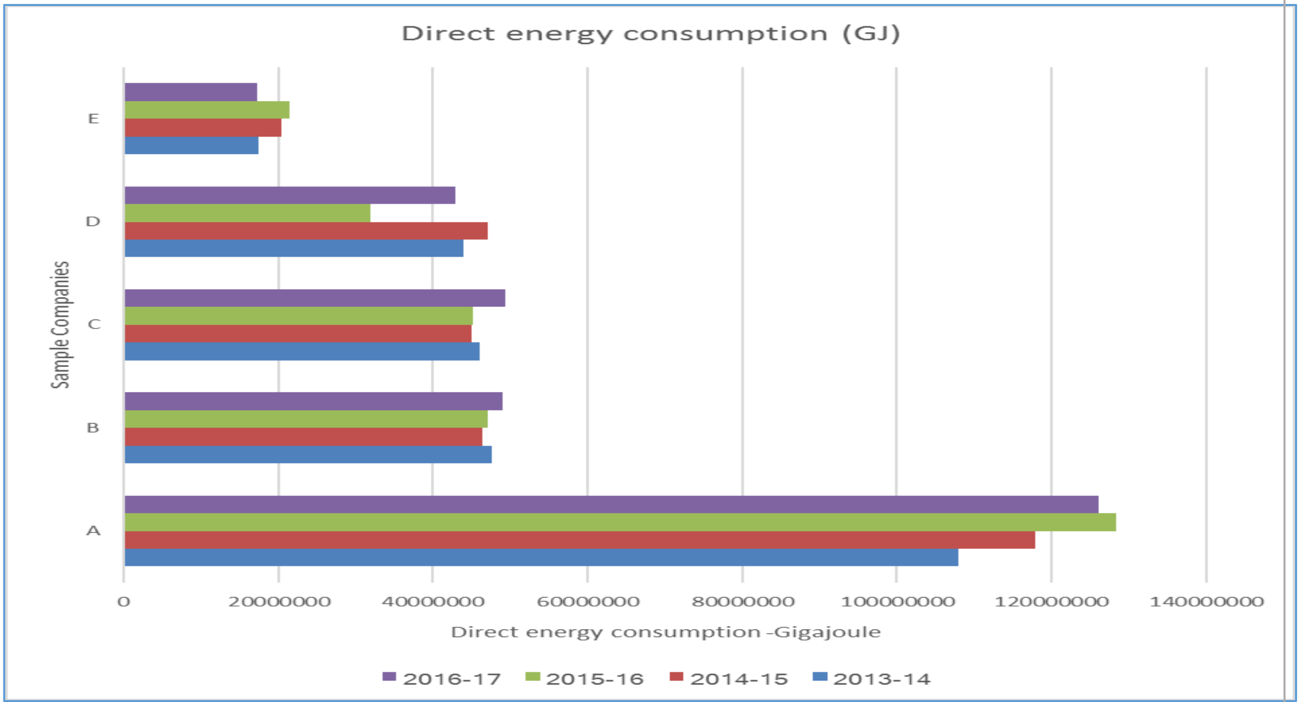


Figure-13

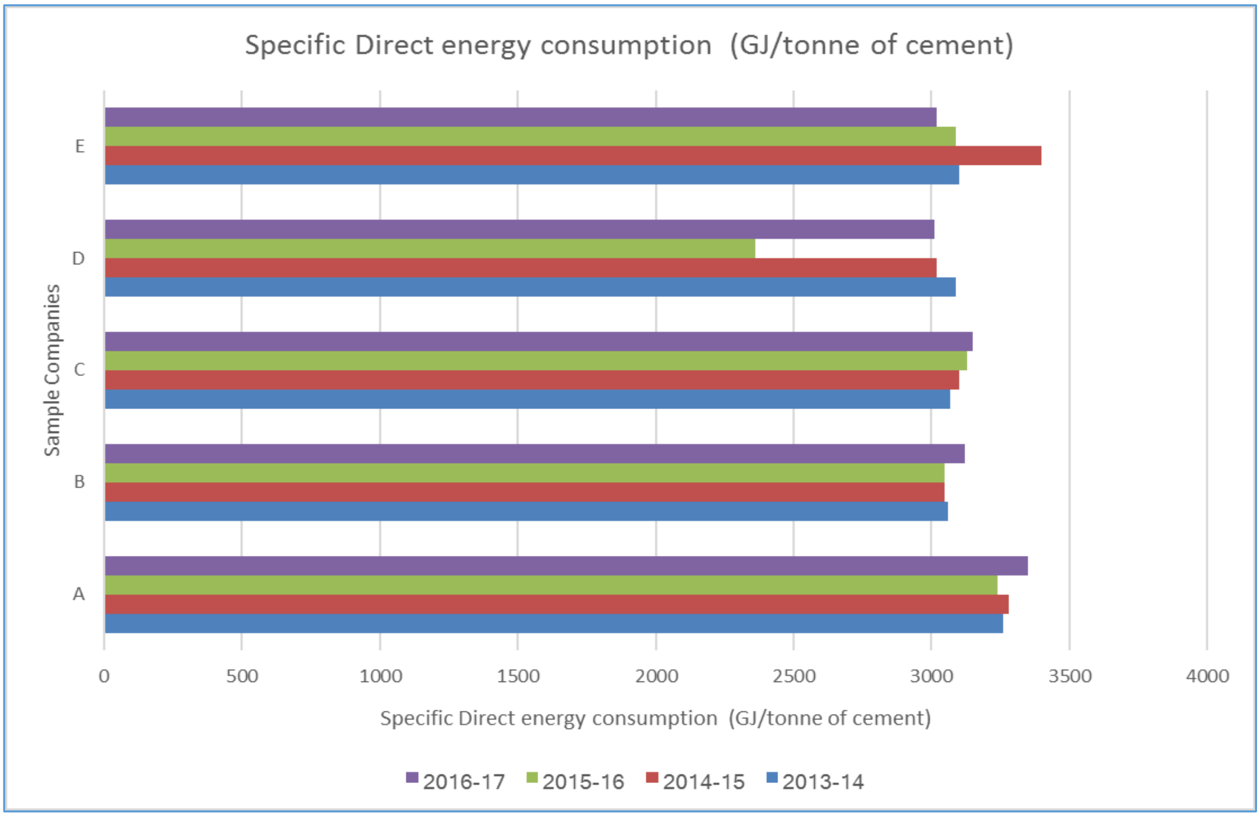


Figure-14

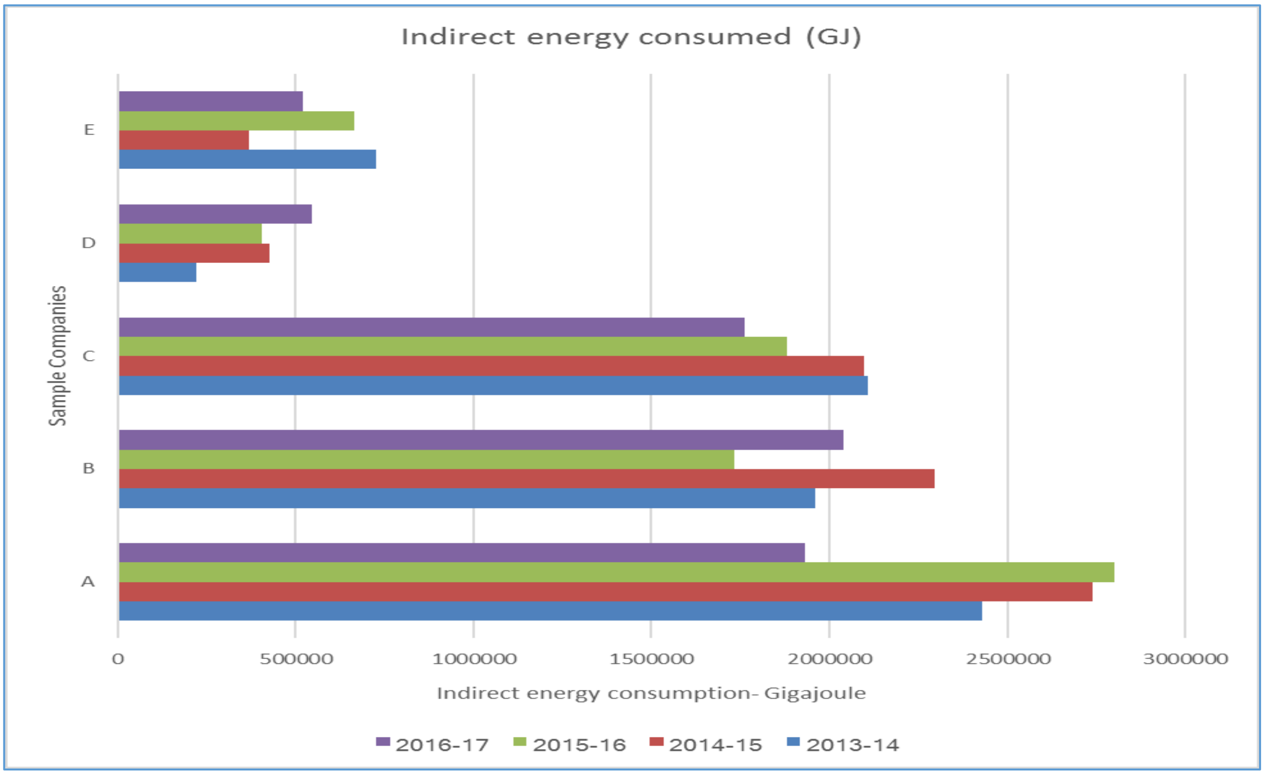
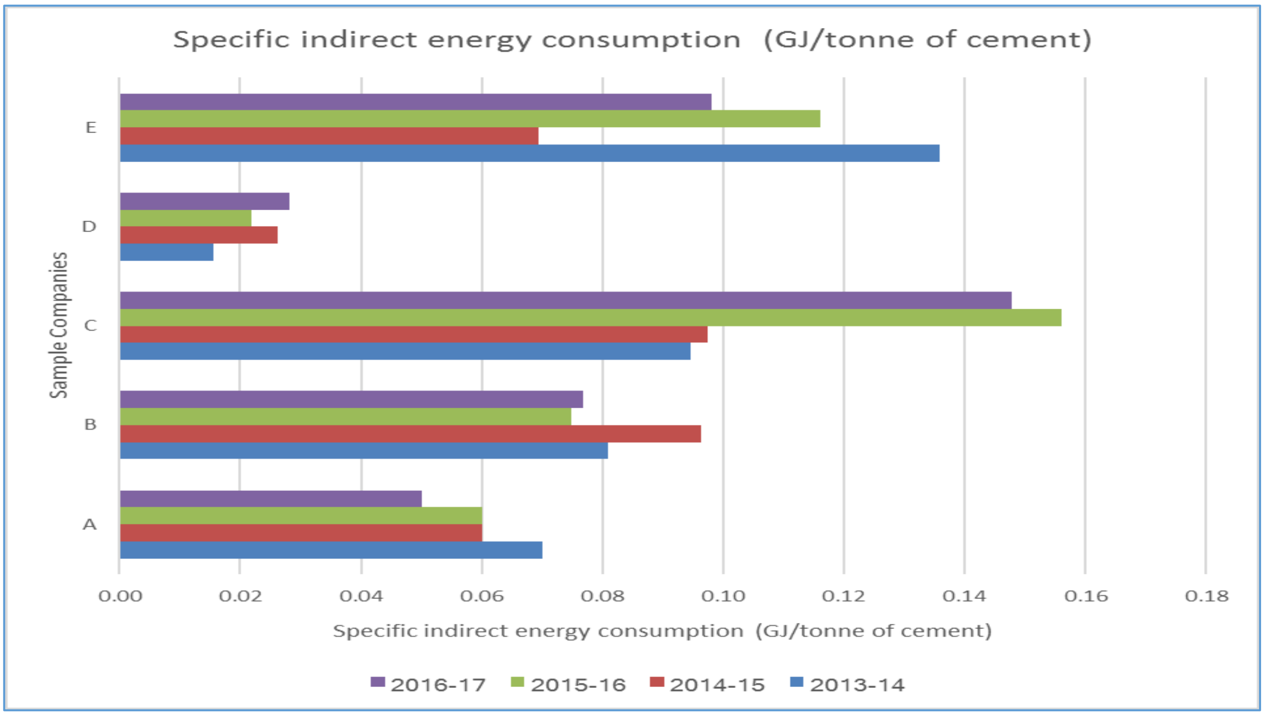


Figure-15



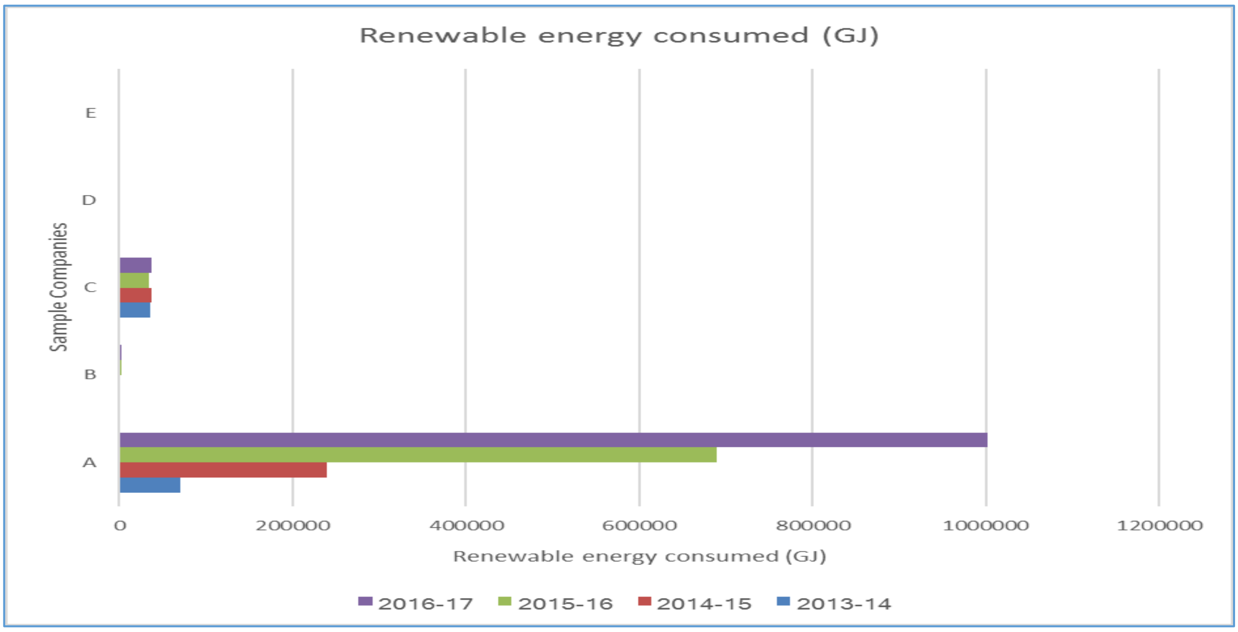
The following initiatives have been adopted by the companies to reduce energy consumption and resource efficiency- High efficiency clinker coolers, Waste Heat recovery projects, Co-processing, Material preprocessing for improved alternative fuel use, Oxy-fuel combustion technology, for material crushing installing pre-grinder with Ball Mill, heat recovery system to recover Kiln surface heat etc.

Companies can identify a wide range of opportunities by conducting an energy assessment which can help reduce consumption of energy and to instrument the energy management program. Energy audits and assessments can benefit in determining the energy savings opportunities, defining key system of measurement and planning of all required resources in place keeping the holistic energy usage patterns and trends throughout the entire organization. In this process all consumption sources of energy, starting from an industrial process to other building systems operations are considered. Production equipment monitoring also make available the details about assets consuming energy. Identified useful data across equipment and processes help in analyzing analyze that data and implementing the program for energy conservations.

It can help in identifying power system irregularities and controls example the cost of a power outage etc. by gathering and studying power quality information. It comprises the study of power quality monitoring procedures, displays, records, patterns and setting alerts on power quality parameters, such as- Harmonics, Voltage drops and other events that can cause impairment to plant equipment and can cause problems of power factor.

In industry majorly the electricity is used by different type of motor-driven systems. Energy usage is being reduced significantly by cement companies by implementing intelligent motor controller technologies, example- variable frequency drives (VFDs). In the Kiln cycle the conventional damper control frameworks which were utilizing a fixed amount of energy to run at full limit regardless the plant creating item and was resulting in energy wastage. Usage of variable frequency drives (VFDs) has automated the kiln head exhaust fan, coal mill exhaust fan, electric fan, high-temperature fan, and kiln tail exhaust fans speed control and now the system only uses the necessary amount of energy to produce the essential volume of airflow. The industry is continuously working on finding and evolving various technical measures to reduce energy consumption. (Refer Appendix II)

Figure-16



India has capacity of 20 GW installed base for renewable energy and this makes a place for our country among the top five countries in the world who are using renewable energy. Wind power is one of main renewable energy source In India which is being used in industries. Additionally, all biomass fuels can also be used in cement industry. Biomass fuels are being used to have uniform heating value by cleaning, preparing, drying and homogenized. Solar energy is also an important source of renewable energy though it is used less because Solar PVs are quite costly and needs large area for installation. Solar thermal energy has also been experimented to heat limestone while supporting different chemical reaction creating no carbon dioxide as by product.

GHG and other Air Emissions

Figure-17

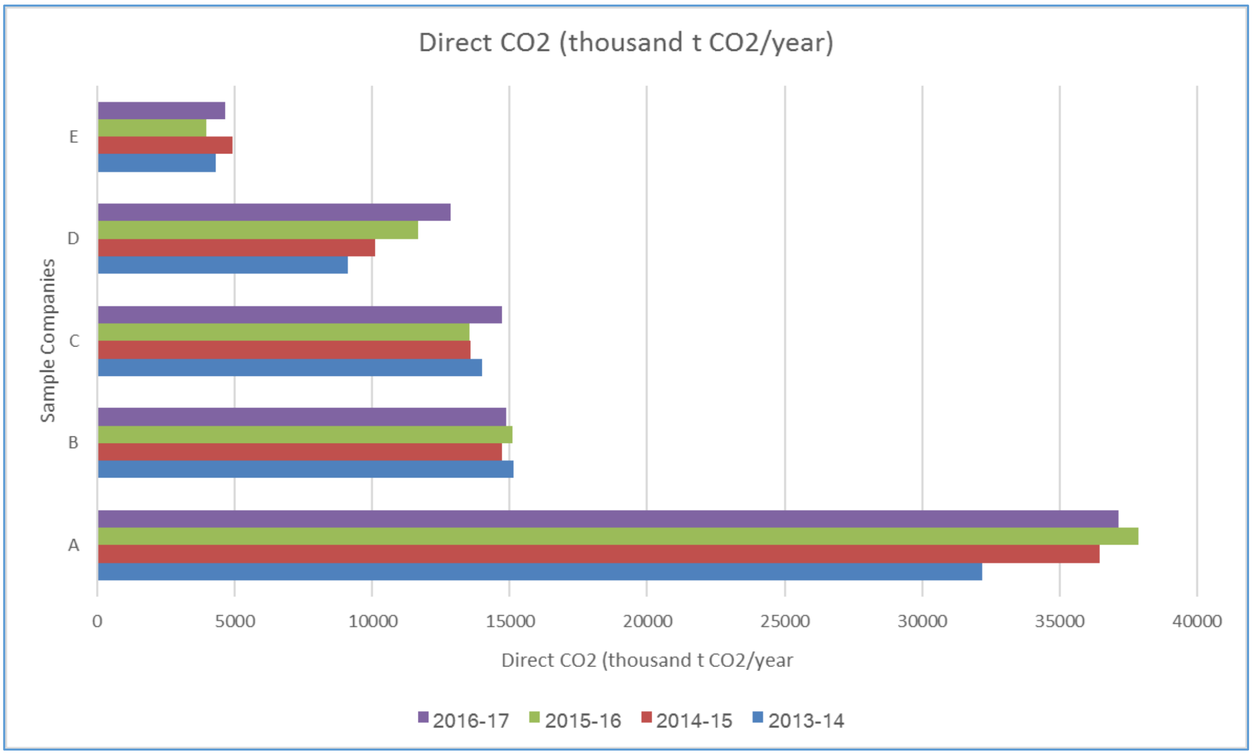


Figure-18

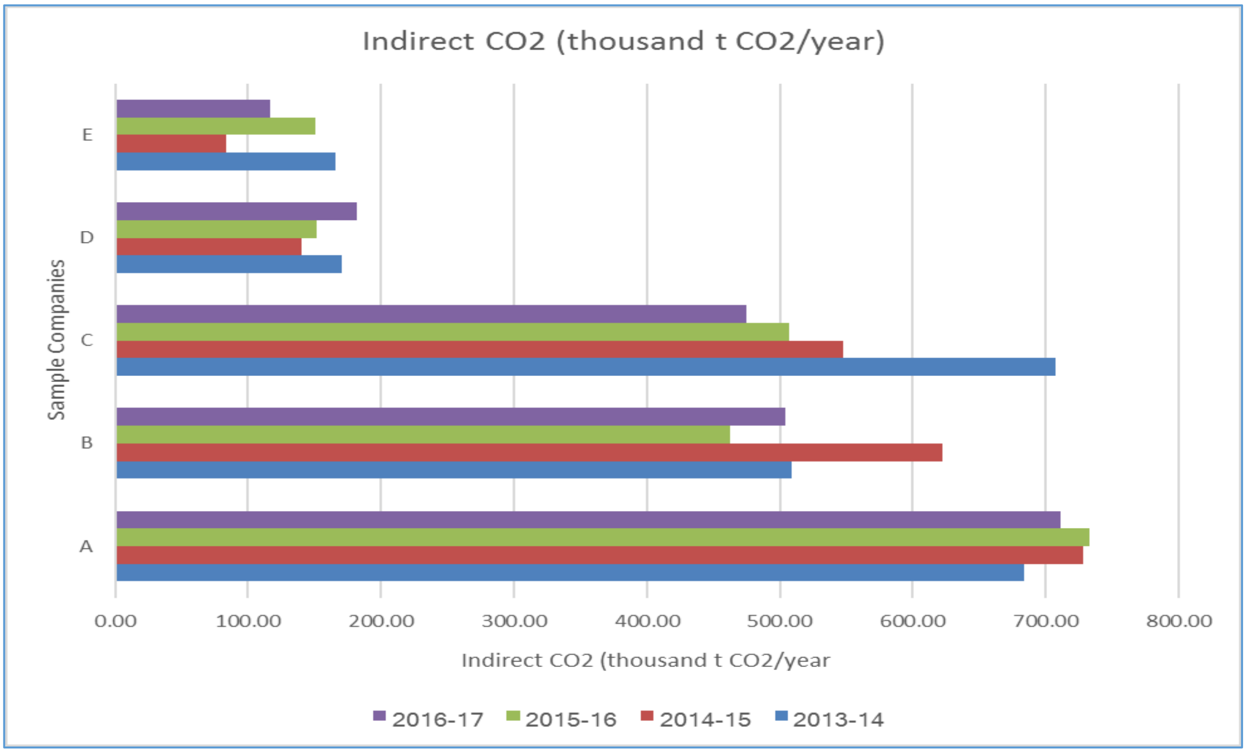
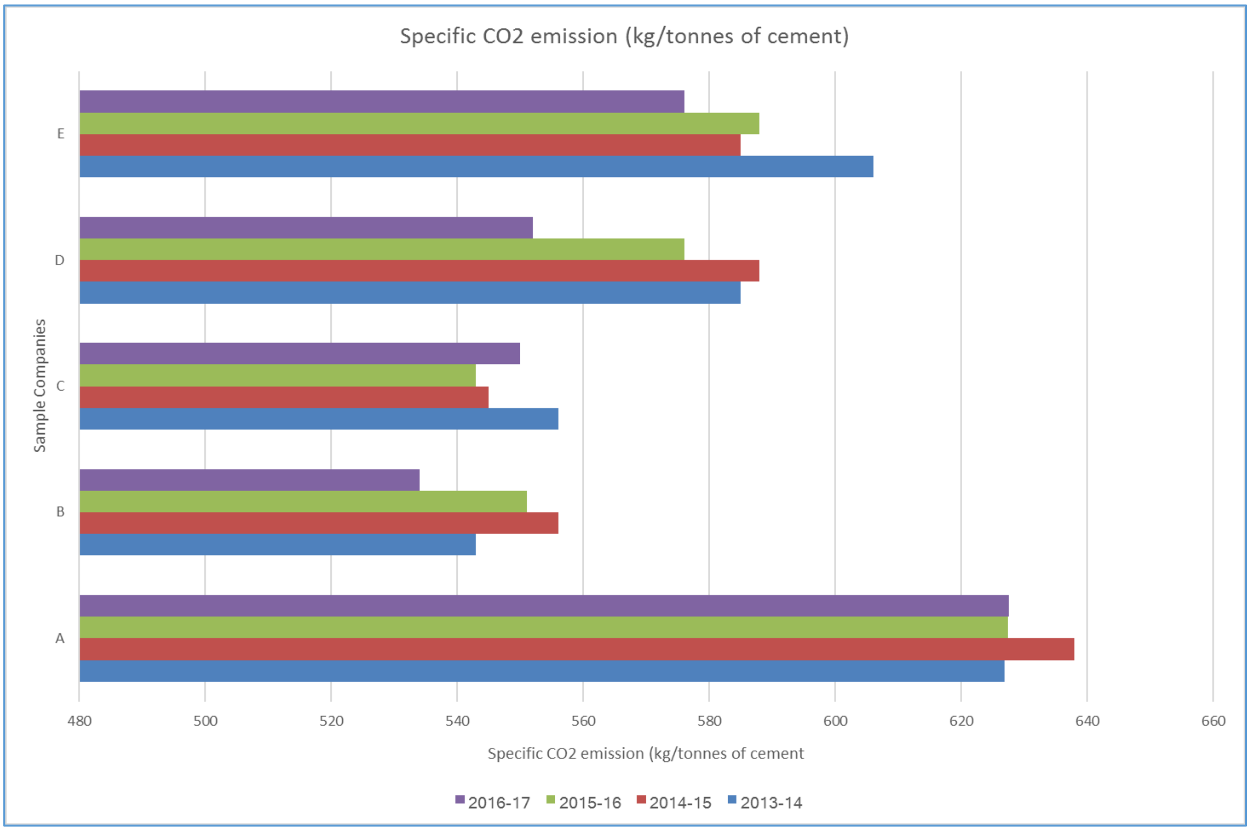


Figure-19



The cement manufacturing emissions from various production processes are contaminating the quality of air and creating environmental pollution. Carbon emissions are an important environmental issue for the cement industry. Carbon dioxide is one of several greenhouse gases that are triggering global warming by trapping the Sun's radiant energy in our atmosphere, called as greenhouse effect.

Around half of the emissions from cement manufacturing process arise from the reaction where calcium carbonate is fired and dissociated to calcium oxide and emits carbon dioxide, resulting as CO2 release and it cannot be eradicated by shifting fuel or increasing productivity. Other than energy-related emissions, which comes from clinker production and results in CO2 emissions would be difficult to restrict as these emissions are an integral part of the decarbonization process for clinker formulation. Additional 40% of carbon emissions come from burning of fossil fuels in the kilns at the high temperatures for calcination process. Operating mining equipment for taking out the raw materials and transportation of the raw materials to the cement plant and other manufacturing process emit comparatively small quantities of CO2. Rest ten percent of emissions come from fuels required for transporting the raw materials. There are many aspects which impacts the emissions like type of fuel used and equipment efficiency.

Water Consumption and Conservation

Figure-20

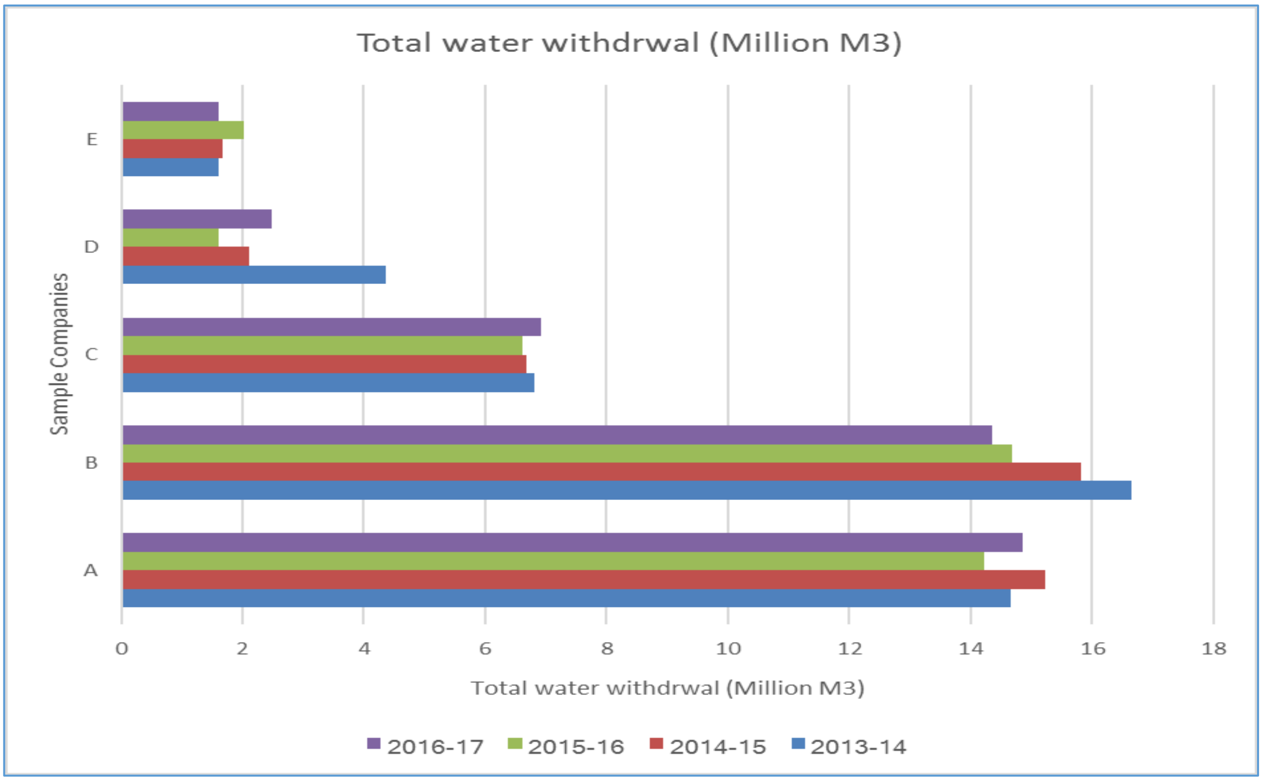


Figure-21

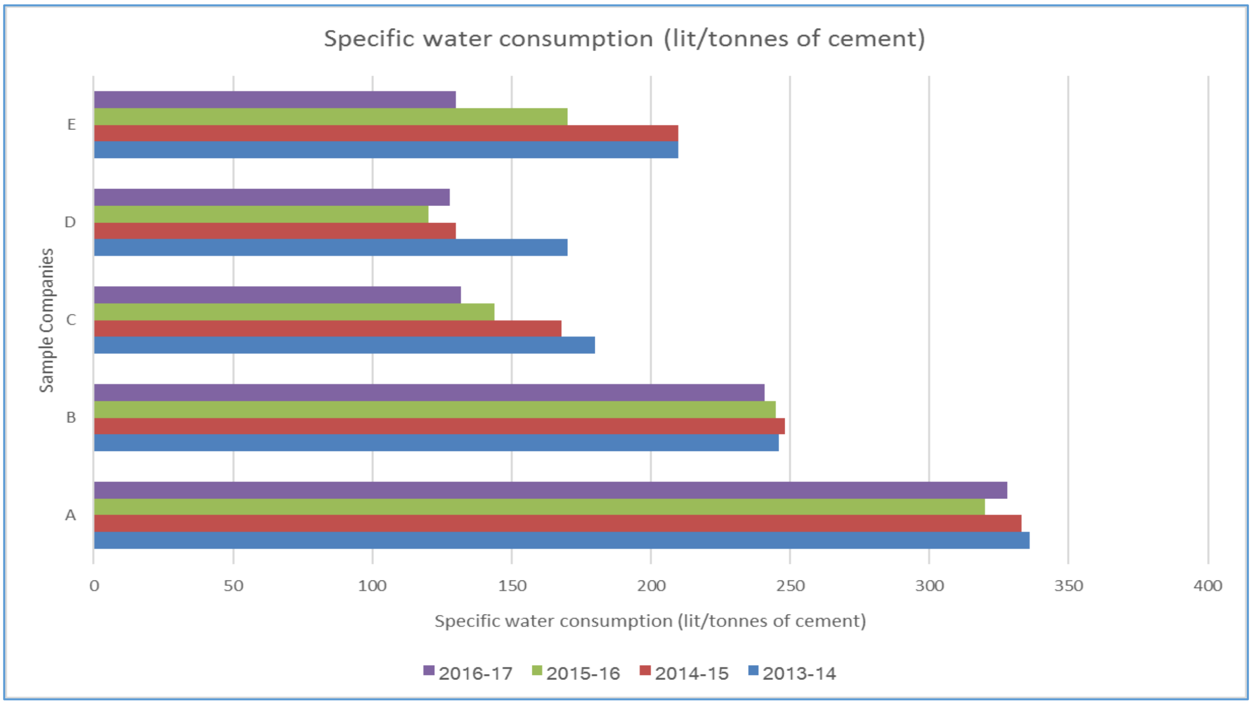
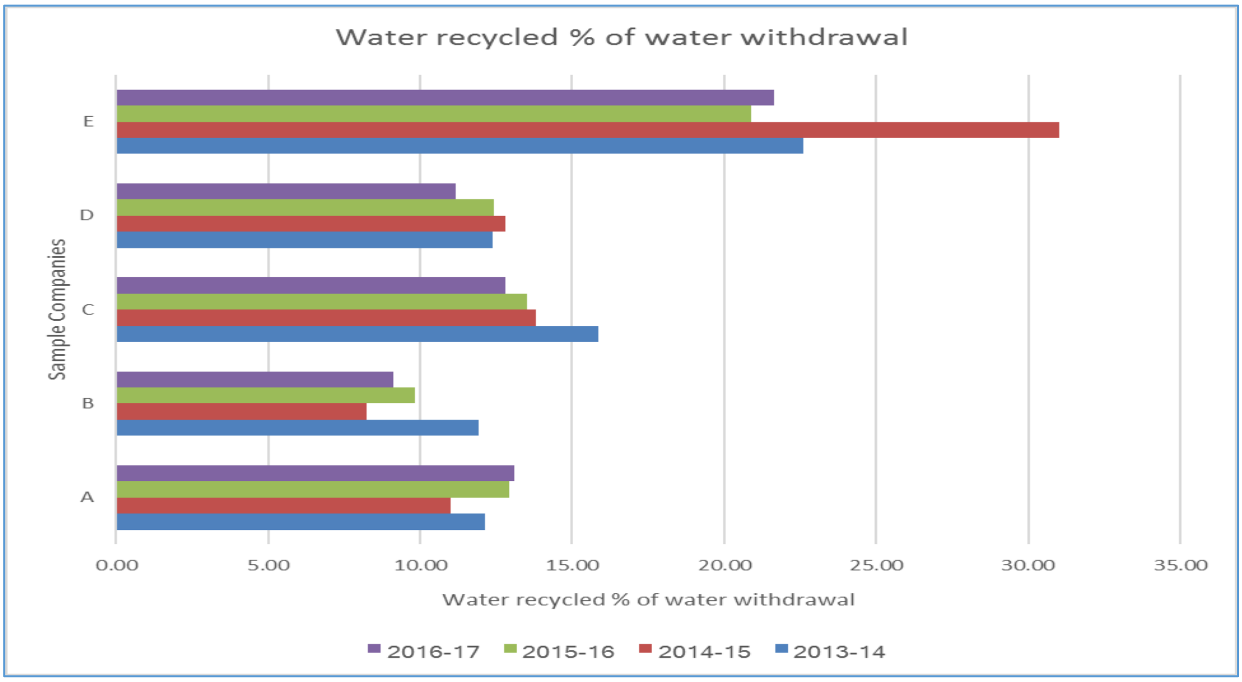


Figure-22



The major cement production clusters of India are located in dry and arid regions like Rajasthan, Chandrapur, and Andhra Pradesh etc. which are facing water scarcity. As availability of fresh water is scarce, Indian Cement Industry is committed to reduce its water impacts and enhancing water management. Cement Industry has been making efforts to improve water efficiency.

The water footprint assessment studies have shown that total specific water consumption for Indian Cement Industry (including plant operations, captive power plant, colony and mines operation) varies and average consumption is approx. 0.21 m^3/tonne of cement for dry process-based cement plants. The average specific water consumption for plant operations comes out to be 0.14 m^3/tonne of cement for dry process-based cement plants and 0.92 m^3/tonne of equivalent OPC for wet process-based cement plant.

Raw material consumption and recycling

Figure-23

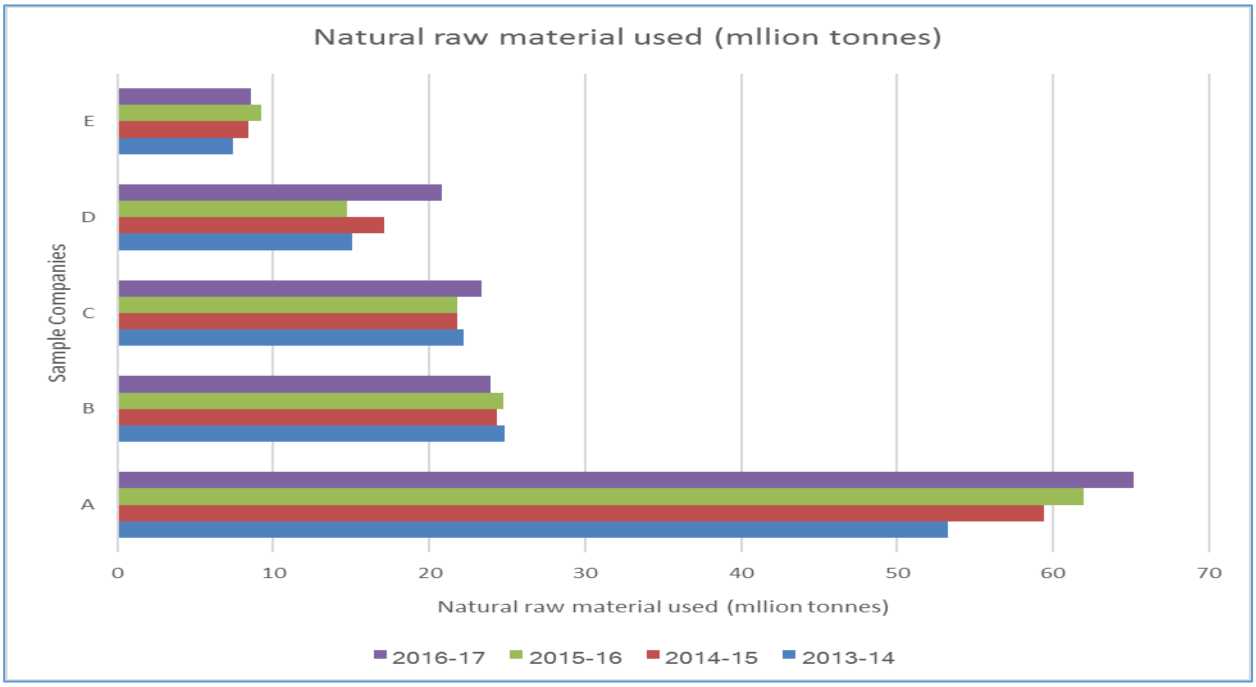
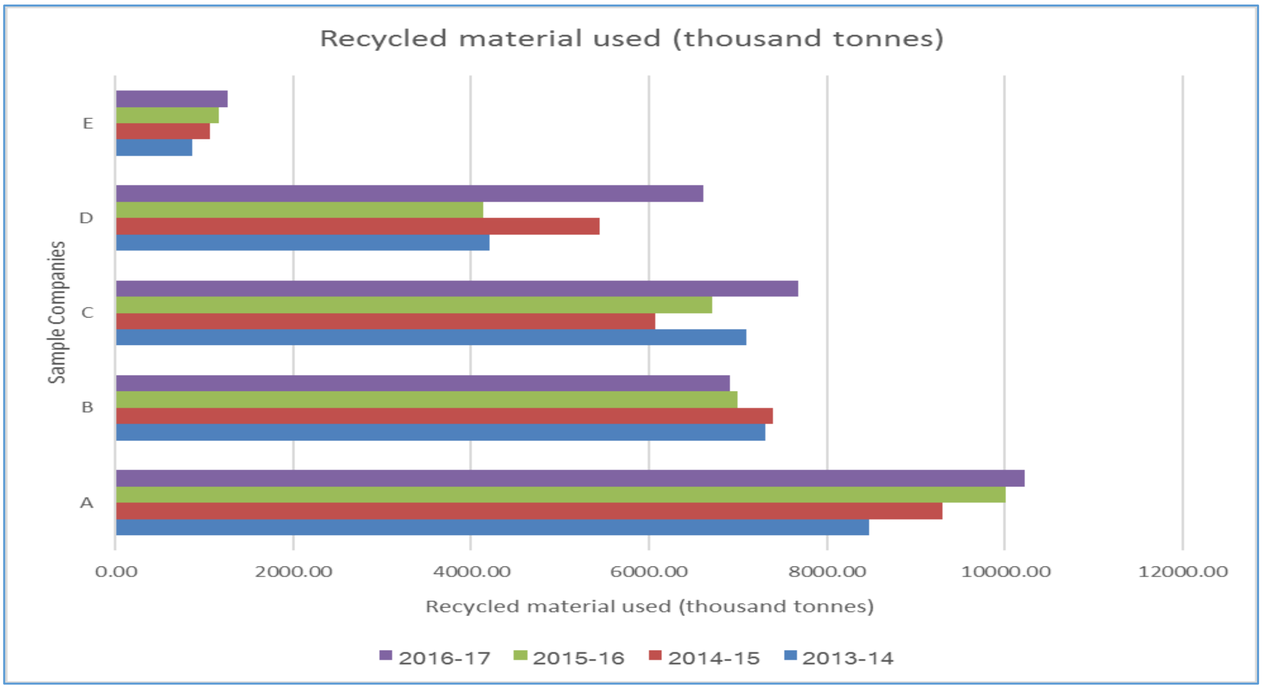


Figure-24

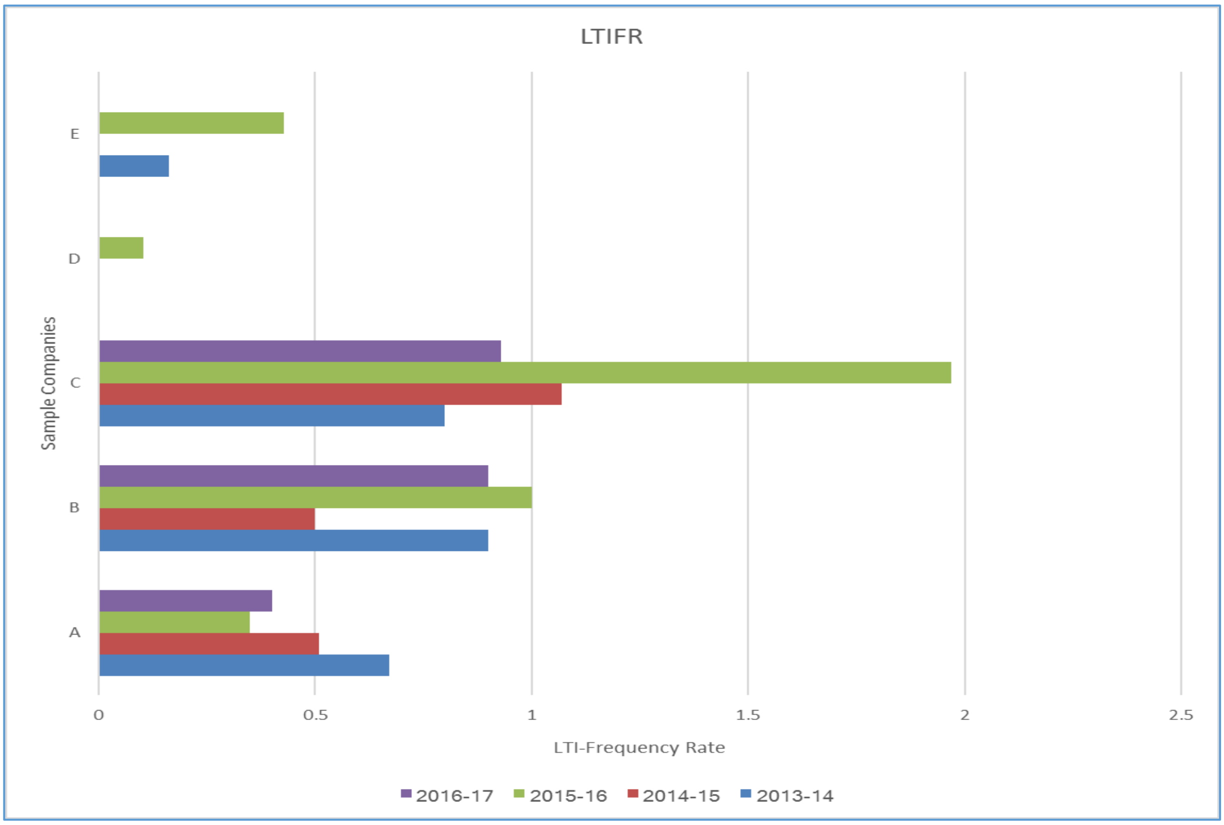


The cement industries are providing an advantage to society by using waste as alternative fuels and raw materials which was earlier incinerated or sent to landfills. At the same time, it is also reducing the use of fossil fuels for cement manufacturing. Cement companies are experimenting to use alternative raw material in co- processing mode with industrial and municipal solid waste and bio-waste like tyres, plastic, wood chips, rice husk etc.

Occupational Health and Safety

Workplace Safety:

Figure-25



Safety is an utmost propriety issue for all the companies across sectors. All companies are working to safeguard their employees, contractors and third parties who all re associated with their operations. In safety performance "Lost time incident frequency rate" denotes to the number of employees lost time injuries in hours per 1,000,000 manhours of directly employed full-time employee. One of the company's safety trend shows that its LTIFR for was 0.82 in 2011-2012, and then consistent drop was observed year by year. One of the company's trend shows that its LTIFR was 0.4 which has increased year on year. The safety LTIFR trend is very fluctuating in 3 of the sample companies.

Despite many efforts taken by the management some of the cement plants have recorded a few incidents in the selected years. Every incident is analyzed in detail by Incident Investigation Teams and all corrective measures are applied to prevent similar occurrences in the future.

Occupational Health

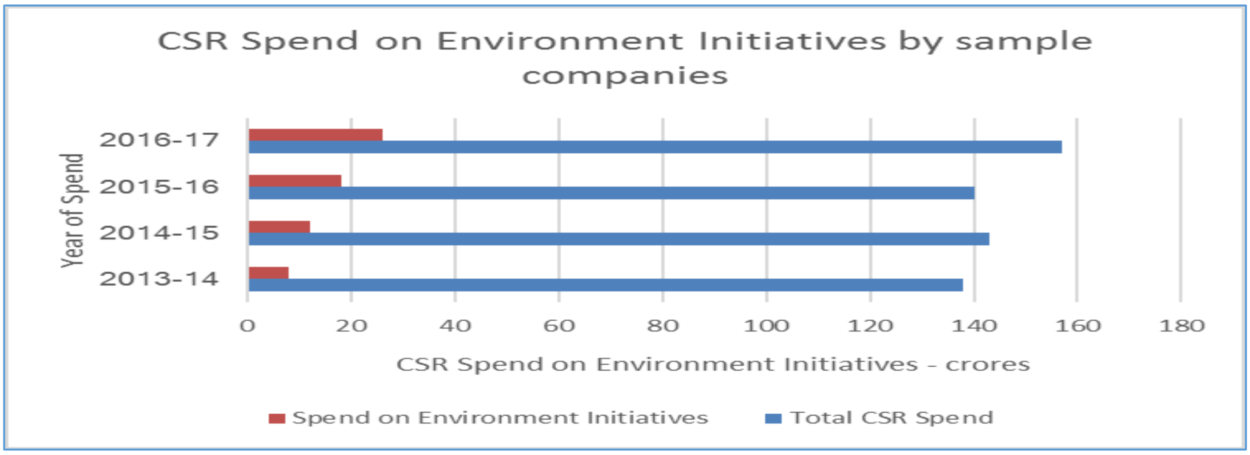
For cement industry it is top most priority to ensure healthy and safe working environment for employees and contractors. Thousands of workers associated with cement industry are exposed to cement every day without knowing its harmful effect on their health. A huge number of cement industry labors are not attentive of the occupational hazards they face while working in cement plant. Many illnesses are quite prevailing in workers due to their exposure to fine dust, fuels, enormous heat, heavy burdens, shift work etc. Workers in the cement remain exposed to such deadly substance, which remains hidden initially but can impact in long term.

In the cement industry the threat of respiratory problems and skin/dermal disease is a main concern. With technological advancement companies have significantly decreased the direct exposure to dust and wet cement, still threat to skin disease is very high. Workers within the cement manufacturing industry and people residing in nearby areas are most in risk due to cement dust. It has been researched extensively that cement has harmful constituents that creates dermal diseases due to its corrosive effects because of ingredients such as lime which is alkaline in nature. Similar to chromium, cement has the ability to cause of allergic sensitization which can lead to dermatitis.

The majority of the cement manufacturing units do facilitate their workers with protective equipment like gloves, boots and helmets. However, the available protective equipment does not satisfy the needs of protection, comfort and cost as well. (Refer Appendix III)

Social Environment Health and Safety

Figure-26



The cement manufacturing uses huge amount of natural resources and leaves a substantial ecological impression and yet these ventures are additionally contributing towards the societies and environment condition in India. The CSR initiatives which have been taken by the cement companies are associated with multiple community wellbeing, environment conservation, basic infrastructure progress, health and cleanliness, education etc. Environment sustainability projects have shown the positive drift with CSR funds allocation for such projects but the effect of these projects has not yet been measured. While numerous environmental factors and aspects are measured and reported in BRR and corporate sustainability reports in terms of initiatives undertaken for environment protection such as energy management and related emission decrease and others.

Most of the major cement companies in India are having their own Society/Foundation through which they are implementing CSR activities. The cement companies are determined to uplift the local community wherever they are operating. Majority of the companies have well-structured development programs for children education and women empowerment around their operation sites. Education, health, greenbelt & infrastructure development are four prime areas where the four cement companies are focusing. These social initiatives and actions are more on health care and family welfare programs, basic infrastructure progress, education, environment, social wellbeing, and sustainable living. (Refer Appendix IV)

Cement manufacturing companies are undertaking social initiatives as suggested under the Environment Clearance obligation under Environment Impact assessment which comprises compliance to the environmental conservation measures and protection of environment. Activities such as measures for wellbeing of public residing nearby the project area are also ordered to carry out under eco development activities. As per the Company's Act obligation initiatives and projects have been undertaken which comprises Health care initiatives, access to safe drinking water for nearby people, providing support to farmers for agriculture upliftment, promoting educational initiatives including customer awareness, employment programs and skill development trainings, Women upliftment and capacity building, providing basic facilities, safety and medical amenities to aged individuals, Tree plantation drives, environment protection of including Biogas, Solar, tree plantation, Watershed management and Water Resources preservation, animal wellbeing, Support to community and other activities coordination with the CSR policy, sports Promotions, rural infrastructure development etc. Environment sustainability related plans have been recognized as per CSR activity which comprises:

Community project - Water conservation, forestry and basic amenities

- Water harvesting structures construction in villages for benefiting communities.
- Harvesting the rainwater from the roof tops and to recharge the ground water

- Undertaking water conservation projects and harvesting rain water
- Supporting farmers in soil conservation t projects and land improvement,
- Programs linked to preservation of Natural Resource
- Providing Support to programs associated with organic farming.
- Solar energy associated and other energy preservation projects

Community project-Green Belt development

- Developing pasture land and orchards for community
- Saplings supply for mass tree plantation in nearby villages,
- Promoting tree plantation drives
- Developing green belt along roadside

Community Healthcare

Some Cement Plants have focused on providing medical facilities to the villages in its vicinity. They have conducted mega medical camps with specialist doctors and free treatment and medicine distribution in the villages. In Some of the companies. a Medical Centre inside the Plant are open to all villagers during the day with an ambulance moving around the clock. Patients recommended for surgery in the medical camps have been sponsored for treatment in the hospitals. The companies have organized medical camps, immunization programs, sanitization programs.

CHAPTER 5

5. EMERGING SUSTAINABILITY CRITERIA AND VARIOUS SCENARIOS IN SUSTAINABILITY PRACTICES

Sample cement companies' data have been studied for the identified key EHS indicators for sustainability. Performance trend of each of the indicators was analyzed and comparative assessment was done to determine how the performance demonstrate the sustainability year on year. The measures adopted for the sustainability were also studied to understand the emerging criteria and scenarios for sustainability practices.

5.1 Sustainability criteria concept

In the field of health safety and environment for the sustainable development it stresses for defining the sustainability criteria for each EHS indicator. The availability of sustainability criteria supports in articulating action plans for sustainability in the long viewpoint.

The basis for defining sustainability criteria is the concept of sustainable development and EHS performance role in sustainability. In 1987, first time the term ''Sustainable development'' was described by the Brundtland Commission as 'development that fulfills the requirements of the present generation without compromising the capacity of upcoming generations to fulfill their own requirements'. An all-encompassing concept of the sustainable development is founded on the three-pillar method-environmental, social, and economic dimensions for sustainable growth. The environmental dimension addresses all the basics which are affecting the ecological and climate processes and talks about the feasibility of natural environmental systems for existence of human race. While the social segment encompasses all the basics related to human resources practices like employee focused policies, human rights issues, health and safety of all employees and stakeholders, supply chain sustainability etc. Economic dimension has been covering the different outlook for directing business with inclusive progress. It evaluates the business economic performance in synchronization with the facets of distribution revenues for inclusive progress by including local people in business.

The studies have emphasized that sustainability criteria can be of a qualitative or measurable nature as the social dimensions, it is complex to evaluate the measures. It has also focused on the fact that sustainability criteria are not always stationary, they often require constant assessment and adjustment time to time. It has highlighted that sustainability criteria can assists in sensing unjustifiable tendencies and effects, thus recognizing unsustainable methods. Sustainability criteria can establish a boundary for each component of indicator ex. the usage of natural resources and can also offer direction for future activities. [Goldschmidt].

This research has been highlighted on the environment and social dimension with reference to health & safety and societal initiatives. The organized criteria are articulated for EHS Indicators for sustainability seeing the cement industry processes.

5.2 Identifying sustainability criteria under the EHS Indicator and sub indicators

Environment:

Energy Consumption and Conservation:

The cement production entails very enormous quantity of energy. For cement manufacturing conventional fuel and electricity are highly demanded. Energy cost portions around forty percent of total production expenses happen in manufacturing of one tonne of cement. Electrical energy is essentially required while extraction of raw material, raw material crushing, clinker crushing and packaging. Electricity is also used on Conveyors, compressors, fans and pumps operation for production of cement. Depending on size and design of plant, raw materials characteristic and content of moisture in it, fuel's specific caloric values, output of kiln, type of clinker and other such factors are the deciding factors for specific energy consumption which varies case to case. Majorly Indian cement plants are operating the dry process cycle for cement which requires nine percent less power than the conventional wet process for cement manufacturing.

PAT

The Indian cement industry is producing numerous types of cement such as Ordinary Portland Cement also called as OPC, Portland Pozzolana Cement or PPC, Portland Blast Furnace Slag Cement abbreviated as PBFS etc. Under the National Action Plan on Climate Change, the National Mission for Enhanced Energy Efficiency is one of the eight national missions which have been adopted for combating climate chance. In lieu of this Bureau of Energy Efficiency initiated the PAT scheme, The Perform, Achieve and Trade by the under the Ministry of Power. It provides an opportunity to the business to improve its energy efficiency and energy consumption reduction which is resulting in long term financial profits with exchange of Energy Savings Certificates (ESCerts). PAT is formulated as a governing tool to decrease specific energy consumption (SEC) in energy exhaustive industries. It is related to a market-based mechanism which augments cost efficiency by certifying the additional energy savings achieved, which could be used for trading of ESCerts. Under National mission for energy efficiency the main focus is on PAT scheme. It is mandatory to achieve specific energy efficiency improvements targets for the highly energy exhaustive businesses which are additionally incentivized for achieving better energy efficiency advances. Those industries who overachieves their targets are being issued Energy Savings Certificate (ESCerts) for the units beyond the given target. It is mandatory to purchase ESCerts for compliance for those companies which do not achieve their target as obligatory. They can also be liable or to be penalized for not meeting the PAT requirements. Power exchanges are the platform for trading of ESCerts.

Waste heat recovery system (WHRS)

In WHRS system installations, it has been observed in last seven years till 2017 that there is triple upsurge, from 110 Megawatt in 2010 to 344 Megawatt in 2017. In installed capacity, there is a surge of more than 230 Megawatt. Rising costs of coal and grid electricity, have been played a major role in opting WHRS to reduce energy in cement manufacturing. In India, the WHRS contributes to long-term energy security in India and it offers several benefits to Indian cement plants, such as neutralizing emissions of greenhouse gas and achieving targets as defined under PAT scheme.

To increase the overall efficiency of a plant is one of the most cost-effective ways is WHRS and during production it is reducing fuel requirement and at the same time it reduces GHG emissions. Studies shows that co-generation of energy using waste heat recovery method meets approx. one fourth percent of total cement plant power requirements. In coming future, it has been projected that there is the potential to generate 800 Megawatt through co-generation of power using WHR. The significant limitation in choosing WHRS installation is the requirement of huge investment. It has been explored to get the WHRS under the Renewable Purchase Obligation (RPO) scheme as a policy initiative, which will give it a significant speed to meet the requirements.

In last few years it has been observed that cement sector has given key focus to improvement initiatives related to electrical and fuel energy-efficiency. Industries have completed numerous improvements in cement plant in preheaters and kilns. Initiatives like upgradation in feeding systems for alternative fuel, waste heat recovery from cement kiln, installation of energy-efficient blowers in kiln and coal feeding systems, heating raw meal at the pre-mixing stage of fuel with improved heat transfer which has also reduced Nox. Other modifications are also being undertaken to increases Specific Energy Consumption. The main improvements done are the installation of high-efficiency fans and Variable frequency drives (VFD), undertaking grinding by use high-pressure grinding rollers in the place of vertical roller mills for cement crushing.

In Cement manufacturing, emission has been lowered by using alternative fuels resources like biomass or municipal waste in place of coal. Use of alternative fuels and raw material have reduced the demand for fossil fuels like coal and pet coke requirement for cement production. Alternative fuels are also adding value by reducing CO2 emissions at plant level.

- ISO 50001/SS 564 management system certification
- Energy consumption pattern- Direct Energy (fuel) (YOY)
- Energy consumption pattern- Indirect Energy (grid electricity) (YOY)
- Energy consumption pattern for supply chain/ employee commute not under direct control of company (YOY)
- Company conducts Environment and Energy Audit
- Energy Efficiency Initiatives

- Alternate fuels Usage as a percentage of total energy (YOY)
- Renewable energy usage as a percentage of total energy (in a given year)
- PAT implementation and status
- Renewable purchase obligation status

GHG and other Air Emissions

Cement is produced from a blend of natural minerals - calcium for the most part from limestone or calcium carbonate, silicon, iron, aluminum and modest quantities of different input materials. These all-crude materials are warmed in a huge oven called kiln to over 1500° C to change over the crude materials into clinker. Clinker is the primary segment in many sorts of cements which is when ground and blended in with 4% to 5% gypsum, it responds with water and solidifies. Organizations have begun manufacturing mixed cement that consolidate other industrial by products that have cementitious properties, accordingly decreasing the part of Portland clinker in the cement which brings about lesser emissions along with replacing clinker with other materials. These other waste materials like fly ash from the iron and steel industry, waste from coal stations, and characteristic volcanic materials and so on can be utilized to substitute clinker in cement, along these lines diminishing the volumes of clinker utilized.
There has been a gradual uptick in the percentage of blended cements in its cement mix specially in Indian cement industry. This improvement has significantly influenced the reductions on energy consumption and CO2 emissions. For reduction of CO2 emission, the alternative fuels usage and raw materials usage has been proven an important lever in cement production. Unwanted waste material for society such as end of life tyres which are discarded, waste oil coming out of other industries which cannot be further recycled. Sewage sludge and municipal waste has been used in the cement kiln, which works at quite high temperature with an elongated residence time. It provides an impactful change which is environment friendly.

There are some other emissions like air emissions and noise arise throughout the cement manufacturing process. Varieties of other air emissions are also happening from the process of cement manufacture, including other process stages like the storage and handling of raw materials which results in emission of particulate matter. Other emission is also happening such as oxides of nitrogen and other nitrogen compounds, sulphur dioxide and other sulphur compounds dust, total organic compounds including volatile organic compounds (VOC), metals and their compounds, hydrogen fluoride, hydrogen chloride, carbon monoxide (CO) etc. Kiln is the main process which is responsible for huge while production of cement. The chief ingredients from a cement kiln escape gas are nitrogen from the ignition air, CO2 from calcination of CaCO3 and burning of fuel, water vapor from the burning process.

- Company reporting Emissions in CDP/ as per ISO 14064
- Direct Emission Pattern
- Indirect emission pattern

- Emission pattern for supply chain/ employee commute not under direct control of company
- Commitment to reduce CHG emissions with timelines.
- AAQ -PM, Sox, Nox
- Availability of latest technologies
- emission offset programs

Water Consumption and Conservation

There is a huge pressure on natural water resources with increasing population, growing industrial and agricultural activities. Pollution and climate change impacts are merging and resulting in extreme stress on water resources. Across globe, freshwater is becoming scares and inadequate to feed the population. Approx. seventy percent of earth's surface is enclosed with water, out of which only approx. three percent is fresh water and hardly one percent is usable for humankind since the most of the fresh water is ice-covered in glaciers and polar ice caps. Water is a scarce resource, and an essential component for survival of human being. Potable freshwater availability is a critical for sake of social and environmental factors. Industries and human activities consume huge quantity of water and also pollute the water bodies. It is need of the hour to reduce both consumption and wastage of water which is an important aspect of water management system. The importance of water issue is discussed globally in various international fora. Majority of the countries have reached to that level where they are facing water scarcity challenges and have identified as water stressed. Such regions are left with limited water reserve to feed the population to meet their water demands.

Total water footprint of cement manufacturing is quite less in comparison other sectors. Cement production needs water at a numeral of phases during the manufacturing process. It is required for cooling, wet scrubbers, for preparing slurry in the cement manufacturing with wet process, though the wet process has been phased out with time. Cement plants which are still on the wet process required huge water for producing per tonne of cement to feed slurry in the kiln. In the wet process up to 600 litres water is being consumed for per tonne of clinker production. Now a days the advanced dry processes have been practiced which is more water efficient and has significantly reduced in water feeding for cement business.

In cement manufacturing generally, the recycled waste water is being used for cooling purpose in the process. Wastewater generated in some operations have high pH and high suspended solids, which is treated in waste water treatment plants and later used for cooling and horticulture.

- ISO 14001 management system certification
- Fresh water consumption pattern (YOY)
- Ground water resource extraction pattern (YOY)
- Water Metering and management

- Waste Water Treatment and Reuse (reused percentage of fresh water consumption)
- Water Quality of effluent water
- Zero discharge plants
- Rainwater Harvesting (YOY)
- Ground water recharge

Raw material consumption and recycling

The conservation of natural resources is important part of sustainable business practice. Companies have started putting more stress on their Research and development activities to search for cost effective and efficient raw material and alternate fuel. Replacement of raw materials with the use of wastes in the clinker making has reduced the huge amount of virgin raw material usage. Such practices have improved the resource conservation by using alternative fuels and raw materials for the cement manufacturing. In recent years it has been observed that the availability of alternative resources has been augmented with various industry by products.

Limestone, petcoke, gypsum, coal, slag and fly ash, iron ore, bauxite, etc. are the key input material for cement manufacturing. Mostly cement plants in India are located close vicinity of limestone mines, which helps in reducing the transportation cost as well as related energy and emissions. The major fuel sourced are coal and petcoke from domestic market, which also plays an important role in sustainable procurement practices. Materials transportation is important aspect in material sourcing.

- Use of recycled materials as % recycled material of total Raw material used
- Sustainable procurement Initiatives

Occupational Health and Safety

The cement industry has hazardous manufacturing processes which also involves number of worker's at large scale. Due to this reason health and safety is a priority issue for the cement industry for its stakeholders like employees, contractors and those who are living in plant vicinity. During various processes exposure happens to cement dust and working near high temperatures areas like kiln and other which can cause contact with allergic materials etc. can be demarcated as hazards linked with health. Under Safety potential hazards are falling objects, working near hot surface causing burns, working at height, slip/trips/falls and transportation accidents can be defined as hazards associated with workers safety. Ensuring a health and safety culture in workplaces is a critical aspect for sustainability. For Sustainable health and safety practices it is required to carry out risk assessment regularly and efficiently.

Occupational Health

- OHSAS 18001 management system Certification
- Health and wellness programs in 1 year
- Health and safety programs- Hygiene, ergonomics

Workplace Safety

Trade union representatives are determined to strengthen their focus on OHS issues, to form and improve OHS committees, strengthen the capacity of union members, involve workers in OHS training. In recent times, almost all fatal accidents in the Indian cement industry have involved workers. Road accidents are also a key reason of numbers of fatalities in the cement industry. In cement manufacturing a large number of occupational illnesses including musculoskeletal, respiratory, skin and circulatory diseases, are often not even recognized as occupational diseases, resulting in a lack of appropriate medical treatment and compensation for victims. Union representatives continually working to enhance the union representation and regularization of workers. They are committed to put more effort into organizing and supporting to workers and improving participation of women and youth worker in EHS committees.

If safety performance of other sectors of manufacturing industry done with cement industry, it shows that the cement industry is lagging behind. It is high time for cement industry to raise safety bars urgently to ensure a sustainable industry model that fulfills the social and employment potentials. With the development of upgraded work practices and its intrinsic risks, it has resulted in critical requirement of raising awareness, sharing information, providing safety trainings to workers and motivate them to adopt and follow health and safety procedures at work.

- Frequency Rate (FR) – Number of recordable incidents per 1 million man-hours worked divided by year, should be less than the national average
- Severity rate (SR) – Number of man days lost per 1million man-hours worked/ divided by year, should be less than the national average
- Loss time injury rate
- Program on Behavior based safety
- EHS Trainings
- Safe work place initiatives to boost employee morale
- EHS committee and meetings

Social Environment Health and Safety

For Social aspects which are linked to EHS includes following actions - alleviation of extreme hunger and poverty, decrease in child mortality and mental health enhancement, positive events for education, vocational skill training programs for women empowerment and gender balance. Investing on the initiatives like eradication of malaria disease, spread awareness on HIV infection, AIDS, and other diseases etc. which would be considered for CSR under the health care and hygiene. Projects which are associated to sustainability of our natural environment have also been considered as CSR which may comprise ecological equilibrium, natural resource preservation, safeguarding flora and fauna, animal welfare, promoting agroforestry along with maintaining good ambient air quality, safe water and fertile soil. In addition to the aforesaid activities, the development and safety of national heritage, backing sports and contribution for Prime Minister's National Relief Fund or other development program for socio-economic upliftment by the governments which are concentrating on procedures for reducing social and economic disparities in vulnerable groups.

- Community project - Water conservation, forestry and basic amenities
- Community project-Green Belt development
- Community Healthcare

5.3 Defining sustainable practices scenarios

Now a days at company level Enterprise risk management (ERM) has been frequently been used for issues identification which are significant from business perspective. Although when it is about EHS still companies are currently using aspect Impact assessment (AIA) and Hazard identification and risk assessment (HIRA) for key EHS issues identification. Usually, AIA and HIRA are done at plant level and the actions are taken on identified opportunities and significant issues, where actions are taken for improvements. Targets taken under the identified issues are not prioritized and benchmarked with industry practices and also not assessed for sustainable performance. The study has attempted to identify the scenarios for sustainable practices basis the performance of the selected companies. (Refer Appendix VI)

Environment:

Energy Consumption and Conservation:

- ISO 50001/SS 564 management system certification- Status of certification of plants for energy management system
- Energy consumption pattern- Direct Energy (fuel) (YOY)- Specific direct energy consumption should show decreasing trend year on year with respect to industry standard
- Energy consumption pattern- Indirect Energy (grid electricity) (YOY)- Specific indirect energy consumption should show decreasing trend year on year with respect to industry standard

- Energy consumption pattern for supply chain/ employee commute not under direct control of company (YOY)- Pattern of energy consumption under scope 3 which talk about employee commuting and logistics and supply chain carbon footprint. Footprinting should show decreasing trend year on year with respect to industry standard.
- Company conducts Environment and Energy Audit- status of energy audits undertaken by company to understand the opportunities for energy conservation.
- Energy Efficiency Initiatives- Results of energy efficiency projects in terms of energy conservation
- Alternate fuels Usage as a percentage of total energy (YOY)- Pattern of Alternate fuel usage with respect to best industry practice
- Renewable energy usage as a percentage of total energy (in a given year)- percentage of energy consumed from renewable resource with respect to industry practice
- PAT implementation and status- Results of PAT with respect to industry performance
- Renewable purchase obligation status- Results of RPO with respect to industry performance

GHG and other Air Emissions

- Company reporting Emissions in CDP/ as per ISO 14064- Reporting status to CDP
- Direct Emission Pattern- Specific direct emission reduction should show decreasing trend year on year with respect to industry standard
- Indirect emission pattern- Specific indirect emission reduction should show decreasing trend year on year with respect to industry standard
- Emission pattern for supply chain/ employee commute not under direct control of company- Pattern of emission reduction under scope 3 which talk about employee commuting and logistics and supply chain
- Commitment to reduce CHG emissions with timelines. - targets achieved for emission reduction
- AAQ -PM, Sox, Nox- permissible limits and results achieved with respect to legal mandates and beyond.
- Availability of latest technologies- investment on latest technology for emission reduction
- emission offset programs- Status of emission offset projects and results with respect to industry practice.

Water Consumption and Conservation

- ISO 14001 management system certification- Status of certification of plants for environment management system and Fresh water consumption pattern (YOY) specific water reduction
- Ground water resource extraction pattern (YOY)- specific water reduction with respect to industry practices
- Water Metering and management- Initiatives undertaken for water management and results achieved in water savings
- Waste Water Treatment and Reuse (reused percentage of fresh water consumption)- Percentage of water recycling and reuse with respect to industry practice.
- Water Quality of effluent water- permissible limits and results achieved with respect to legal mandates and beyond.
- Zero discharge plants- Status and results in actual
- Rainwater Harvesting (YOY)- To understand the potential with respect to industry practices basis projects undertaken internally and externally.
- Ground water recharge- Yearly water recharge basis location of plant and potential.

Raw material consumption and recycling

- Use of recycled materials as a percentage of total Raw material used- percentage of use of recycled material
- Sustainable procurement Initiatives- various initiatives undertaken for sustainable procurement and green supply chain basis best industry practices

Occupational Health and Safety

Occupational Health

- OHSAS 18001 management system Certification Status of certification of plants for Occupational health and safety management system and Fresh water consumption pattern (YOY) specific water reduction
- Health and wellness programs in 1 year- No and type of programs undertaken and its impact on LTIFR
- Health and safety programs- Hygiene, ergonomics- No and type of programs undertaken

Workplace Safety

- Frequency Rate (FR) – Number of recordable incidents per 1 million man-hours worked divided by year, should be less than the national average- impact of programs undertaken and LTIFR
- Severity rate (SR) – Number of man days lost per 1million man-hours worked divided by year, should be less than the national average- impact of programs undertaken and SR
- Loss time injury rate- Year on year performance
- Program on Behavior based safety- Status of BBS incorporation in safety systems
- EHS Trainings- Year on year training on EHS and impact on incident numbers
- Safe work place initiatives to boost employee morale- Initiatives undertaken which are inclusive in nature and affects employee engagement
- EHS committee and meetings- Status of committee meetings and its effectiveness

Social Environment Health and Safety

Cement manufacturing have significant impressions on the natural environment and nearby communities in plant vicinity. Limestone mines which are operated for years more than five decades are long-lasting resources. Throughout the lifecycle of production of cement creates impact on environment, counting dust, noise and other aspects, must be accurately managed. The soil removal for mining activities and fluctuations done in landscape can have influences on local ecologies and water tables.

- Community project - Water conservation, forestry and basic amenities- No. and type of programs undertaken and investment done
- Community project-Green Belt development- No. and type of programs undertaken and investment done
- Community Healthcare- No. and type of programs undertaken and investment done

5.4 Developing a Sustainability Index

5.4.1 Prioritizing EHS indicators and sub indicators for defining Sustainability maturity Level

While making a well-integrated system for EHS and sustainability, it is foremost step to prioritize issues basis sustainability focus criteria performance benchmark. It enables the system to prioritize the issues and setting up targets for sustainable development.

Various models have been developed for sustainability prioritization like LCA, MCDM, Equilibrium models & AHP. Individually every model has some strengths and shortcomings, LCAs is the most commonly used tool for conducting environmental assessments, and they generally not contain social aspect of sustainability. Equilibrium models and MCDM have been used to maintain equilibrium in environmental and financial criteria but these models have various trouble points in managing the criteria, which are generally qualitative. To realize the potential of sustainability indicator, very less research has been carried out by diverse researchers using Multiple Criteria Decision Making (MCDM). However Analytic Hierarchy Process (AHP) is being used for a decision-making process to obtain a solution which is based on semi-quantitative criteria and have some corresponding weights.

AHP has been extensively studies and being used for decision marking for complex scenarios. In 1980, Thomas Saaty introduced the Analytic Hierarchy Process (AHP) which has been proved as an effective tool for making complex decision making. AHP has resulting in number of benefits as it permits for multiple criteria to be assessed with the scope of the conclusion problem, it permitted both quantitative and qualitative criteria for decision problem, it meet the requirements of the influence of the decision maker in decision-making process.

For each assessment criterion AHP makes a weight according to the decision maker's pairwise evaluations of the criteria. Higher weight means the corresponding criterion has more importance. Each option according to the decision maker's pairwise comparisons, AHP allocates some score basis the options created on that criterion. It is considered that the higher score means the improved the performance of the option with respect to the measured criterion. Lastly, the AHP alliances the criteria weights and the scores, thus defining a resulting ranking.

AHP comprise multiple stakeholders' interests for a multi-criteria decision analysis model. This thought of multiple stakeholders is echoed in the pairwise evaluations of the environmental, social, and financial criteria to the overall sustainability topics that create the final mathematical significances results of the distinct scenarios.

AHP comprise of many stages which are as follows.

Table-8 Set of Indicator prepared for this Study

Objective	Sub-Objectives	Criteria
Identify Emerging sustainability criteria	Environment criteria	Water Consumption and Conservation
		Energy Consumption and Conservation
		Raw material consumption and recycling
		GHG and other Emission reduction
	Occupational Health and Safety	Occupational Health
		Workplace Safety
	Social Environment Health and Safety	Community project-Water and Energy Resources conservation
		Community project-Green Belt development
		Community project-Community Healthcare

Table-9 Pair-wise comparison scale for AHP preferences

Numerical Rating Verbal judgment of preferences
AHP Scale: 1- Equal Importance, 3- Moderate importance, 5- Strong importance, 7- Very strong importance, 9- Extreme importance (2,4,6,8 values in-between).

To attain improved results in the sustainable growth, AHP supports in ranking indicators and focus on the given areas. In this study a cohesive decision-making approach created on Analytical Hierarchy Process (AHP) for evaluation of sustainability actions for cement industry is presented which includes of picking evaluation criteria, data collection and assessment of industry sustainability practices using the Sustainability Index and impact assessment of the current practices. (Refer Appendix V)

Priorities
These are the resulting weights for the criteria based on your pairwise comparisons

Table-10 Indicators Priority List

Category		Priority	Rank
1	Environment criteria	59.4%	1
2	Occupational Health and Safety	24.9%	2
3	Community EHS Practices initiative	15.7%	3

Number of comparisons = 3
Consistency Ratio CR = 5.6%

Priorities For environment indicators

These are the resulting weights for the criteria based on your pairwise comparisons

Table-11 Environment indicators priority list

Category		Priority	Rank
1	Water Consumption and Conservation	23.9%	3
2	Energy Consumption and Conservation	28.1%	2
3	Raw material consumption and recycling	14.0%	4
4	GHG and other Emission reduction	34.0%	1

Number of comparisons = 6
Consistency Ratio CR = 2.2%

Priorities Occupational Health and Safety

These are the resulting weights for the criteria based on your pairwise comparisons

Table-12 Occupational Health and Safety indicators priority list

Category		Priority	Rank
1	Occupational Health	66.7%	1
2	Occupational safety	33.3%	2

Number of comparisons = 1
Consistency Ratio CR = 0.0%

Priorities community EHS Projects

These are the resulting weights for the criteria based on your pairwise comparisons

Table-13 Community EHS Projects indicators priority list

Category		Priority	Rank
1	Community project-Water and Energy Resources	52.8%	1
2	Community project-Green Belt development	14.0%	3
3	Community project-Community Healthcare	33.3%	2

Number of comparisons = 3
Consistency Ratio CR = 5.6%

5.4.2 Formulating Sustainability Index using EHS indicator rating and criteria for assessing sustainability effectiveness

Sustainability has progressed slightly instead just gauging carbon emissions, which means it needs management of numerous factors which can affect water use and water source, human health including factory workers and nearby communities.

Companies sustainability performance in line with social, environmental and economic responsibilities can then be plotted to quantify their sustainability effectiveness and recognize areas of development.

With time sustainability concept has become important and companies need to monitor, track and compare their actions to progress their sustainable practices year on year. Sustainability Index is a valuable tool for decision-making process that supports the company to become constantly sustainable. Though process behind a sustainability index is to combined the comparative information about the sustainability aspects of several decisions, strategies, and methods, and then offer an easy-to-understand "grading" system to swiftly determine the most sustainable choices. It is a modified sustainability index which will benefit to offer a platform for assessing decisions that will upsurge the sustainable value of the organization based on EHS performance.

In the given EHS Sustainability index rating methodology is based on cement production impacts on environment health and safety, performance trend and information transparency. Globally accepted sustainability scenarios are identified which are used to define the sustainability performance. The research has mapped the EHS indicators that are considered in the sustainability scoring.

Rating system counts the performance in terms of specific consumption of resources per unit of production that are categorized as high sustainability performance, moderate performance and evolving sustainable performance. An example of evolving sustainable performance is a higher specific consumption than the current Indian industry standard while a high sustainability performance is lesser or equal to specific consumption than the current Indian industry standard. Other information is also factor in additional such as year on year performance and available information on adoption of advanced measures for improvement to assign the indicator ratings. Some of the ratings are done basis qualitative criteria especially for social indicators.
The objective is to develop the Sustainability index focusing on EHS measures available to assess company's sustainability performance that will help the company to understand how the company's sustainability efforts are aligned to sustainable business requirements.

5.4.3 Validation of the effectiveness of developed sustainability index

To check the effectiveness of the sustainability index, it was introduced in the company in line with the requirement of ISO 14001:2015. The revised version of environment management system talks about inclusion of stakeholder engagement and sustainability. The index was developed for integration of EHS and sustainability concept for sustainable business. The issues identified by ISO and OHSAS were lacking in the stakeholder engagement and sustainability incorporation in the system. The identified issue from ISO and OHAS were mapped on index and the stakeholder engagement was done to prioritize the issues and Peer benchmark was also used as an element for assessing the sustainable performance for the identified issues.

Considering the requirement of ISO 14001:2015, it was used for ISO transition from 2006 version to 2015 version. It was found well in structured manner for including stakeholder engagement and sustainability. The index was tested for one of the sample company and the identified issues were prioritized and target was taken accordingly which resulted in improved performance trend.

The developed index has been provided in the tables below to which was used by the companies for validation.

Table-14 Sustainability Index format

	EHS Indicators	EHS Sub indicator	Sr No.	Key Criteria	1	0.5	0.1	0.05	Matuarity level rating	weights	criteria rating
					Highly Sustainable	Moderately Sustainable	Evolving towards sustainable	Unsustainable			
Identify Emerging sustainability criteria	Environment	Water Consumption and Conservation	1	ISO 14001 management system certification	certified	under certification	Plan for certification	no certification		0.239	0
			2	Fresh water consumption pattern (YOY)	Consmp. less than 10%-20%	Consmp. less than 5%-10%	Consmp. less than 5%	No change in consumption patte		0.239	0.000
			3	Ground water resource extraction pattern (YOY)	extact. less than 10%-20%	extact. less than 5%-10%	extact. less than 5%	No change in consumption patte		0.239	0.000
			4	Water Metering and management	Well managed program	Initiated program	Plan for water manage	No program		0.239	0.000
			5	Waste Water Treatment and Recycle (recycle percentage of	recycle more than 30%	recycle more than 20%	recycle more than 10%	No recycling		0.239	0.000
			6	Water Quality of effluent water	Quality improved beyond re	Quality meets regulatory li	Tries to meet regulator	regulatory requirements not met		0.239	0.000
			7	Zero discharge plants	100% zero discharge	Initiated program	Plan for zero discharge	No possibility		0.239	0.000
			8	Rainwater Harvesting (YOY)	Harvested more than 10%	Harvested more than 5%	Harvested more than 1	No rain water harvesting system		0.239	0.000
			9	Ground water recharge	Qunatified and audited	Quantified but not audited	Initiated program	No data available		0.239	0.000
Identify Emerging sustainability criteria	Environment	Energy Consumption and Conservation	1	ISO 50001 management system certification	certified	under certification	Plan for certification	no certification		0.281	0
			2	Energy consumption pattern- Direct Energy (fuel) (YOY)	Direct Energy consmp reduc	Direct Energy consmp redu	Direct Energy consmp d	Direct Energy consmp increasing		0.281	0
			3	Energy consumption pattern- Indirect Energy (grid electricity) (YOY)	Indirect Energy consmp red	Indirect Energy consmp re	Indirect Energy consmp	Indirect Energy consmp increasi		0.281	0
			4	Energy consumption pattern for supplychain/ employee commute not under direct control of company (YOY)	Monitored and actions take	Monitored but no action ta	To be Monitored	No Monitoring		0.281	0
			5	Company conducts Environment and Energy Audit	once a year	Once in 2 -3 years	Plan for energy audits	Never conducted		0.281	0
			6	Energy Efficiency Initiatives	Well structured program	Initiatives undertaken	Initiated program	No program		0.281	0
			7	Alternate fuels Usage as a percentage of total energy (YOY)	AF used best in industry	AF use started	AF to be used	No AF used		0.281	0
			8	Renewable energy usage (YOY)	RE used more than 50%	RE used up to 50%	RE use started	No RE used		0.281	0
			9	PAT implemetation and status	Achieved and traded	Achieved but not traded	achieved	Not achieved		0.281	0
			10	Renewable purchase obligation status	Set up inhouse RE plants to	Complied beyond target	Complied as per target	Not Complied		0.281	0

Identify Emerging sustainability criteria	Environment	**Raw material Consumption and recycling**	1	Use of recycled materials (percentage YOY)	Recyled mat. used more th	Recyled mat. used up to 5	Recyled mat. use starte	No recycling		0.14	0
			2	Sustainable procurement Initiatives	Well managed program vali	sustaibale procurement is	Initiated program	No program		0.14	0
		GHG and other Emission reduction	1	Company reporting Emissions in CDP/ as per ISO 14064	Disclosed with A rating	Disclosed with less than A	Disclosed without ratin	No disclosure		0.34	0
			2	Direct Emission Pattern	Direct Emission reduced mo	Direct Emission reduced m	Direct Emission consist	Direct Emission increasing		0.34	0
			3	Indirect emission pattern	Indirect Emission reduced n	Indirect Emission reduced	Indirect Emission consi	Indirect Emission increasing		0.34	0
			4	Emission pattern for supplychain/ employee commute not under direct control of company	usage >25%	10-25%	0%-10%	0%		0.34	0
			5	Commitment to reduce GHG emissions with timelines.	Monitored and audited	Monitored inhouse	To be Monitored	No Monitoring		0.34	0
			6	AAQ -PM, Sox, Nox	AAQ improved beyond regu	AAQ meets regulatory limi	Tries to meet AAQ regu	not meeting regulatorty requirer		0.34	0
			7	Availability of latest technologies	State of Art technology ado	technology upgaradationir	technology upgaradati	no tech. upgradation		0.34	0
			8	emission offset programs	Well structured program an	emission offset program ir	Initiated program	No program		0.34	0
Identify Emerging sustainability criteria	Occupational Health and Safety	**Occupational Health**	1	OHSAS 18001 management system Certification	certified	under certification	Plan for certification	no certification		0.667	0
			2	Health and wellness programs in 1 year	1 or more program per mon	1 or more program per qtr	1 program per Six Mont	No program		0.667	0
			3	Health and safety programs- Hygiene, ergonomics	1 or more program per mon	1 or more program per qtr	1 program per Six Mont	No program		0.667	0
		Workplace Safety	1	Frequency Rate (FR) – Number of recordable incidents per 1 million man-hours worked/year (less than theindustry average)	Zero FR	FR above 25% of the indus	FR above 50% of the in	highest in industry		0.333	0
			2	Loss time injury	zero fatal incident in last tw	Minor Incident but no fatal	Minor incident and sig	fatal incident last two years		0.333	0
			3	Program on Behaviour based safety	1 or more program per mon	1 or more program per qtr	1 program per Six Mont	No program initiated yet		0.333	0
			4	EHS Trainings	1 or more program per mon	1 or more program per qtr	1 program per Six Mont	No program initiated yet		0.333	0
			5	Safe work place inititives to boost employee morale	Well managed program and	program undertaken but n	Initiated program	No program initiated yet		0.333	0
			6	EHS committiee and meetings	Formal committee meeting	Informal meetings happen	Initiated program	No program initiated yet		0.333	0

Identify Emerging sustainability criteria	Community EHS Practices/ initiative	Environment Initiatives- Water conservation and forestry	1	Projects on providing basic amentities	Results monitored and quar	Results monitored and qua	Results monitored but	No program initiated yet	0.528	0
			2	Projects on promoting sustainable agriculture and forestry	Results monitored and quar	Results monitored and qua	Results monitored but	No program initiated yet	0.528	0
			3	Access to improved drinking water source	Results monitored and quar	Results monitored and qua	Results monitored but	No program initiated yet	0.528	0
			4	Projects on watershed protection	Results monitored and quar	Results monitored and qua	Results monitored but	No program initiated yet	0.528	0
		Community project-Green Belt	5	Projects on Biodiversity	Results monitored and quar	Results monitored and qua	Results monitored but	No program initiated yet	0.14	0
			6	Projects to improve forest cover	Results monitored and quar	Results monitored and qua	Results monitored but	No program initiated yet	0.14	0
		Community project-	7	Community wellness program	Results monitored and quar	Results monitored and qua	Results monitored but	No program initiated yet	0.33	0

CHAPTER 6

6. RESULT AND DISCUSSION

Companies have started advancing towards Sustainability and adopting sustainable practices. Companies are attempting to lessen their energy consumption, carbon footprints, water conservation and total effect on environment. Plants have started adding certified integrated management programs, including energy management to ISO 50001 along with environmental management ISO 14001 and OHSAS 18001 safety management programs. It was found that Cement plants adopting approach towards integrated system with ISO 9001, ISO 14001, OHSAS 18001 and ISO 50001 have resulted in successful improvements on sustainability. Basis the study done on sample plants selected for this study have been analyzed for their performance basis the measures adopted and results achieved for better integration of EHS for sustainability. Refer appendix VII and VIII for details on prioritized and selected indicators and their performance trend over a year. The performance has been validated basis the audits qualified and management feedback shared by third party agencies.

6.1 Water Performance analysis

Most of the cement plants in India are situated in dry and arid regions and requires water for manufacturing processes. So, cement plants have realized the requirements of water management projects to meet the demand by other sources and reducing ground water or surface water consumption. Potential of rain water harvesting has been implemented inside the plant and as well as in nearby communities to restore the ground water reserve and to improve the water availability. Rainwater harvesting systems have also been installed in business complexes, on the roof of hospitals, schools and mine and plant offices around manufacturing plants. At plant level installation of water meters on water withdrawal points, water discharges points and the chief water feeding points have been done to capture meaningful information about water performance and hot spots are identified for corrections to make the efficient water use. Reuse, recycling of waste water and zero discharge approach have been adopted towards water management. Recycling process wastewater and reducing the consumption of fresh water have been now used as standard operating procedures at manufacturing plants.

Recycling of waste water, rain water-harvesting, recharging of ground water by constructing check dams are also some of the typical structures implemented by the cement manufacturing plants.

6.2 Energy Performance analysis

Companies have three focus areas: Energy efficiency, Waste Heat Recovery and use of renewable energy. Waste heat recovery (WHR) has been identified as strategic part of all upcoming cement plants of top cement companies to install all new kilns with a WHR arrangement. In few of cement kilns are equipped with Waste Heat Recovery (WHR) arrangements. There is acceptable scope in current dry process of cement manufacturing to produce energy from waste heat. It has been projected by some researches that one fourth of the energy required by a cement plant can be supplied by installing WHRS in the current systems.

Under energy efficiency initiatives implemented by cement companies are as follows like use of alternative fuels such as Carbon Black and Agro Waste. Other operational modifications &improvements are done to reduce Thermal Energy of Kiln by Installing the Variable Frequency Drives etc.

Electrical energy also called indirect energy source is presently produced mostly by burning fossil fuels like coal and oil which is used for manufacturing cement. To reduce the grid energy consumptions in some percentage, most of the cement companies have started generating power through solar panels and wind mills, bio mass energy. Wind and solar energy sources cannot be considered free of carbon as their infra involves some emissions, whereas only biomass fuels are carbon neutral. Companies are incessantly discovering several possibilities in order to produce renewable energy. The energy from solar plants is mainly used to provide electricity in townships established by cement giants. Energy savings achieved by the cement plants has a significant influence on lessening GHG emissions.

The cement industries are promoting the use of waste as fossil fuels. Number of cement plants have developed ground-breaking procedures for waste utilization in cement production as an alternative material such as rice husk, waste tyres chips, crop waste and saw dust as a source of fuel. One of the cement company has signed an agreement with municipal corporation to set up waste processing plant which can alter MSW to Refuse Derived Fuel (RDF). This confirms protection of natural resources and productive usage of industrial waste.

To reduce energy in scope 3 which is transport not owned or controlled by the cement manufactures are another focus area. Companies have ensured to maximize the source of raw materials from sites adjoining to cement plants. It is helping in improving the cost and environmental effect of transportation. For deliveries of clinker to other grinding plants owned or other, they have started deliveries by truck and railway transport. More focus id given on railways to make it more efficient.

6.3 Emission Performance analysis

Due to inherent release of significant amount of carbon dioxide to the atmosphere, as CO2 is released from limestone, the basic raw material of cement during in the process of calcination. Combustion of fuel fired in the kiln and electricity use for other plant operations are another source of emission. Blended cements release less CO2 as compared to Ordinary Portland Cement per ton of cement. The quantum of Co2 release is directly proportional to the quantum of fuel fired and the quantum of carbon in it, which means to reduce emissions the heat requirement has to be reduced or to use fuels with less carbon or those that are carbon neutral. Alternate fuels have been found to be used successfully in kilns. There are great opportunities available for using wastes of other industries and agriculture waste that have some calorific value which can be used as secondary fuels in kilns. Municipal and industrial waste as substitutes for coal as well as using materials being waste from other industries (fly ash, slag, rea-gypsum, etc.) to substitute for natural materials.

There are some technological changes required like certain modifications and additions in the existing fuel preparation and firing systems in order to use secondary fuels along with basic fossil fuels. It also requires capital investment for technological change, which need careful planning and top management approvals.

So, more focus is given to number of other key initiatives like- reducing the clinker-to-cement ratio. Governments can encourage investment and innovation through RD&D funding and by adopting mandatory CO2 emissions reduction policies.

Process optimization can bring down power consumed per ton of cement which in turn it will also reduce the Co2 emission as well as Particulate matters. manufactured and it also reduce consumption of other resources like water, cooling air, compressed air and manpower. In many Cement plants air pollution control equipment like ESP have been converted to pulse jet type of bag filter or a hybrid of ESP and bag filter combination to achieve the collection efficiency desired and also to comply with the emission norms.

There is huge potential in reducing Scope 3 emissions, which are indirect emissions from the production of purchased materials and fuels (such as clinker) which are used for cement manufacturing and then Fuel used for transport of finished product to market. Fuel used for employees for their transportation, transport-related activities in vehicles which are not owned or controlled by the cement companies, electricity-related activities (e.g., transmission and distribution losses) which are not covered in Scope 2, outsourced activities, waste disposal, etc. can also be explored for formulating emission reduction strategies.

6.4 Recycle material Performance analysis

Few Companies are putting more stress on their Research and development activities to search for cost effective and efficient raw material and alternate fuel. One of the sample company of studies under this research is using slag and Fly Ash to make superior blended cements. Cement companies are using fly ash and slurries as substitute for raw material to reduce its carbon footprints as well its production cost. Cement companies are experimenting with industrial and municipal solid waste and bio-waste like tyres, plastic, wood chips, rice husk etc.to be used as alternative raw material in cement manufacturing.

Large volume but low toxicity by-products or wastes are suitable for raw material alternatives. The following are few examples with the elements that each material contributes to the raw mix: Blast furnace slag, Bottom ash, Water treatment sludges, fly ash, Foundry sand, Petroleum contaminated soil, Refractory brick, lignite fly ash, crushed concrete fines etc. These Industrial wastes have potential for use in building materials as raw materials for clinker production.

6.5 Health and Safety Performance analysis

Safety

Behavior-based safety (BBS) has been evolved as one of the best tools for managing occupational risks and prevention of workplace injuries which is found not used effectively at cement industry. The research outcome assesses the efficiency of behavior-based safety implementation in cement plant. The efficiency of BBS assessed by comparing the accident and first aid cases recorded before and after implementation of BBS. The result demonstrates that BBS can help in minimizing the accidents in workplace, especially which happens due to manual interventions and negligence. BBS can be applied for improving the safety of workers.

Health

It has been resulted that the health and safety related cases in cement manufacturing industry can be reduced by maintaining safe working conditions and enforcing safety procedures focusing on training of employee on use of personal protective equipment. Exposure to cement dust can cause irritation in eyes, nose, throat and the upper respiratory system related disease which can lead to lung injuries including silicosis and lung cancer. Skin contact may result in cracking of skin to severe skin. With the support of top management and co-operation of workers as well as active participation of supervisory staff can help in achieving the positive results. Use of earmuff or ear plug where the noise level is more than or equal to 90dB (A), ensuring use of disposable coveralls, ensuring use of face masks or dust masks with instructing and providing training to workers on proper use of the equipment.

6.6 Community EHS Performance analysis

The result shows that companies took initiative to boost agricultural and horticultural activities to help farmers to make them achieve a rich harvest from their farms. Training programs were conducted for farmers to enable them to understand the modern agricultural practices. They were also helped in soil testing, providing quality seeds etc. and farmers were benefitted by these steps. Water conservation projects were also undertaken at community level which helped in improving harvest and developing pasture land area in the community. The projects were implemented to restore the ecological balance by conserving and developing watershed areas. These diverse agro-based activities improved soil fertility and reduced soil erosion and helped farmers in providing sustainable livelihoods. The local drainage system and seasonal nullahs around the mining areas were examined and check dams and canals were constructed to divert the water to recharge the local aquifer, which resulted in higher agriculture yield for the villagers. In the CSR reports it was found that community had given good feedback on the Agri projects. Cement companies are also keeping the environment green by planting trees and taking up schemes for afforestation in nearby areas even nearby cities as well.

The formulated index has been adopted under sustainability program at plant level to identify the gap areas for that particular unit. Base line study has been carried out to identify the current status of various initiatives undertaken under the purview of environment health and safety including the social aspects. Basis the indexing priority topics were defined for the selected plants and measures were planned and executed for the given year and performance monitoring was done to check the effectiveness and its impact. It has been identified that the improvements have been observed and been highlighted during audits.

Specifically, environment performance indicators were showing quick results as its qualification process is quite exhaustive and has also been captured under objective and targets for the environment management system. Even health and safety has also shown improved performance in terms of less injuries and recorded occupational health issues over a year in comparison to historical trend. Though the social aspects were found bit challenging to quantify but intangible positive changes have been accounted and validated through feedback responses. (Refer appendix VII and VIII)

This indexing has been used by the plants and has also been qualified as one of the approaches adopted for stakeholder inclusion under environment health and safety management system new requirements. The new set of requirements for stakeholder engagement and identification of their need and expectations have been incorporated while rating the indicators and to arrive the key material topics for improvements.

CHAPTER 7

7. SUMMARY AND CONCLUSIONS

The researches and various studies have identified that closely connected EHS and sustainability programs are very helpful. Well integrated program on EHS and sustainability give opportunity of scrutinize relevant issues which may result in legal implications due to regulatory non compliances. Hence such programs help in increasing company's revenue, improving brand image and also effectively managing business risks. Additionally, it also helps in strategic betterment of workplace culture which results in raising employee's morale.

- Earlier no linkage process was available to embed sustainability in EHS management system.
- It helped in mapping EHS management system improvement areas with sustainability by using the index.
- It resulted in defining the precise gap in EHS performance against industry performance.
- It can be used in ISO and OHSAS Audits for showcasing the change points in upgraded version of IS014001:2015 requirements and it was well accepted and found effective.
- Environmental and social metrics are key performance indicators for company's sustainability performance. There is a significant linkage between EHS and Sustainability but still both are drive separately.
- Integration of EHS and sustainability management programs will create comprehensive and extensive framework for the companies focusing on sustainable development encompassing social and environment indicators.
- Well integrated program on EHS and sustainability give opportunity of scrutinize relevant issues which may result in legal implications due to regulatory non compliances.

Environmental and social metrics are key performance indicators for company's sustainability performance. There is a significant linkage between EHS and Sustainability but still both are drive separately. Integration of EHS and sustainability management programs will create comprehensive and extensive framework for the companies focusing on sustainable development encompassing social and environment indicators. The evaluation can be done through index which is comprises of set of indicators that plays major role in decision making for company's sustainability performance and future actions. The requirement of linkage between EHS and the sustainable development is now crystal clear which should be addressed by their integration in the form of EHS sustainability index.

Using the developed index Sustainability maturity level for two of the sample companies are assessed and the ratings were given basis their performance and resulted level has been identified.

Table-15

Sample Cement Companies	EHS Index for Sustainablity	
	EHS Indicator Rating for sustainabaility	Sustainability maturity Level
	0.05	Unsustainable
	0.1	Evolving towards sustainable
	0.5	Moderately Sustainable
	1	Highly Sustainable
Company-E- Plant-1	0.20	Towards Moderately sustainable
Company-C-Plant-2	0.28	Towards Moderately sustainable

7.1 Main contribution from the research

This research has helped in developing the sustainability index which can be used as key linkage between Sustainability and EHS management system. As the EHS and sustainability were practiced separately irrespective of the fact that both are adopted for the same set of improvements. It can be used in integration of ISO 14001 and OHSAS 18001 with sustainability for improved and sustainable performance results.

EHS and sustainability were practiced separately irrespective of the fact that both are adopted for the same set of improvements. In order to address this problem and the sustainability index developed to assist in linking EHS and sustainability. It worked as missing linkage between EHS and sustainability. It is helpful in decision making for company’s sustainability performance and future actions.

CHAPTER 8

8. SCOPE OF FUTURE WORK

This research scope was kept limited to Cement manufacturing plants and its relevant environment, health and safety aspects. Though other areas which comes under cradle to grave like Mining, Supply chain involved in distribution of final product to market, end use and then end of life of the product, can also be studied to evaluate the focus sustainability indicators for each segment of this industry. Not only for cement industry but this can be replicated to any kind of industry by customizing the industry benchmark as per the required industry sector.

Other untouched areas of environment health and safety like Mining aspects, Waste Management, Noise, Contaminated Land, safety aspects of emergency preparedness and response, disease prevention, other social EHS indicators can be added for future studies to evaluate the microlevel of EHS indicators which can bring improvements in overall manufacturing process.

The criteria and scenarios are dynamic in nature which need to be incorporated in existing EHS management system design. As the cement industries are investing in R& D to explore opportunities to design green cement plants in future which will be designed to conserve natural resources of all kinds and that will contribute in possible extent to reduce the release of the greenhouse gases (GHG) to the atmosphere without compromising on the quality of cement produced.

Companies are working on Carbon Capture concept which aims at reducing the GHG emissions by physically collecting CO2 emitted and storing it and making it available to other industries that have use for it. Green building concept is also a growing criterion for manufacturing plants. Cement companies are designing and constructing cement plant as per green buildings requirements to make maximum use of natural light, ventilation, etc.

Now construction and demolition waste has been given focus and greeting more organized than before. It is also going to add value in cement manufacturing initiatives wherein raw material replacement can be done by using construction and demolition waste (CDW). The use of such waste material in cement plants will offer an opportunity for using it as recycled products and avoids consumption of natural raw materials (limestone, marls and clays) traditionally used for cement production.

With digitization of world and more user-friendly interphase, E–training for workers and contractors will become easier than before. After completing training on E platforms, it will be possible to take test and give certificates. More awareness can be created by such modes to reduce injury and incidents by upgrading safety skills of workers. Similarly, new studies and researches will keep happening and can be added in the scenarios to evaluate the need of the hour.

Another aspect for comprehensive coverage environment social and governance indicators can be added for future studies to enhance the scope of such indexes which can help in achieving the sustainable development goals. As well as benchmarking and materiality assessment can be aligned and assessed for integrated approach for sustainability.

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APPENDIX

I. Sample Cement Companies details

The top 5 cement companies account for the more than 40% of the total production. Total installed capacity of 502.03 million tonnes as of June 2018 [Indian Bureau of mines].

Table-16 Sample Cement Companies details

Table-17 Production details

Company	A	B	C	D	E
	Production				
unit	mllion tonnes	mllion tonnes	mllion tonnes	mllion tonnes	mllion tonnes
2012-13	42.59	23.13	22.31	12.33	5.68
2013-14	43.6	24.24	22.31	14.2	5.34
2014-15	43.88	23.84	21.54	16.2	5.3
2015-16	35.51	23.18	12.06	18.50	5.3
2016-17	33.99	26.56	11.92	19.42	5.72

Table-18

To study the key EHS indicators for sustainability and analyze their performance trend.
Environment
• Energy Consumption and Conservation
• GHG and other Emission reduction
• Water Consumption and Conservation
• Raw material consumption and recycling
Occupational Health and Safety
• Occupational Health •Workplace Safety

Community Environment Health and Safety
•Water and Energy Resources conservation • Green Belt development •Community Healthcare

II. Environmental Data Collection

Energy Consumption:

Direct Energy- Total fuel consumption within the organization from non-renewable sources, in joules or multiples, and including fuel types used.

Indirect Energy- It is the total energy by electricity purchased and used by the organization.

Renewable Energy- Total fuel consumption within the organization from renewable sources, in joules or multiples, and including fuel types used.

Table-19

Direct energy consumption (GJ)					
	A	B	C	D	E
2013-14	107980000	47584000	46119000	43910000	17504081
2014-15	117920000	46371000	45085000	47090000	20490127
2015-16	128310000	47159000	45101100	31880000	21465838
2016-17	126060000	48950000	49298900	43000000	17274409

Table-20

Renewable energy consumed (GJ)					
	A	B	C	D	E
2013-14	69850	117.11	36360.00	0.00	0.00
2014-15	238880	133.75	37440.00	0.00	0.00
2015-16	688860	1990.30	34920.00	0.00	275.53
2016-17	1001580	2039.44	37440.00	0.00	286.39

Table-21

Indirect Energy Consumed (GJ)					
	A	B	C	D	E
2013-14	2429000	1959124	2109000	220000	725663
2014-15	2738000	2295706	2098000	426000	367544
2015-16	2799000	1733846	1882000	405000	663892
2016-17	1930800	2040131	1761000	545000	520090

Table-22

Specific Direct energy consumption (GJ/tonne of cement)					
	A	B	C	D	E
2013-14	3260	3060	3070	3090	3100.00
2014-15	3280	3050	3100	3020	3400.00
2015-16	3240	3050	3130	2360	3090.00
2016-17	3350	3120	3150	3010	3020.00

Table-23

Specific indirect energy consumption (GJ/tonne of cement)					
	A	B	C	D	E
2013-14	0.07	0.08	0.09	0.015	0.14
2014-15	0.06	0.10	0.10	0.026	0.07
2015-16	0.06	0.07	0.16	0.022	0.12
2016-17	0.05	0.08	0.15	0.03	0.10

Emission

Direct Emission- Direct GHG emissions also called Scope 1 emissions include the CO2 emissions from the fuel consumption reported as direct energy source consumption.

Indirect Emission- Indirect GHG emissions also called Scope 2 emissions include, the CO2 emissions from the purchased electricity consumed by an organization which is reported as indirect energy source.

Table-24

Direct CO2 (thousand t CO2/year)					
	A	B	C	D	E
2013-14	32203	15144	13997	9100	4302.22
2014-15	36437	14706	13586	10100	4936.02
2015-16	37860	15098	13544	11651	3964.55
2016-17	37136	14856	14712	12869	4666.72

Table-25

Indirect CO2 (thousand t CO2/year)					
	A	B	C	D	E
2013-14	684.00	508.81	707.36	170.00	165.29
2014-15	728.00	622.88	547.81	140.00	83.72
2015-16	733.00	462.36	507.08	151.35	150.66
2016-17	711.00	504.04	474.48	181.57	116.40

Table-26

Specific CO2 emission (kg/tonnes of cement)					
	A	B	C	D	E
2013-14	626.88	543	556	585	606.00
2014-15	637.98	556	545	588	585.00
2015-16	627.37	551	543	576	588.00
2016-17	627.52	534	550	552	576.00

Water – Total water consumption by plant is comprises of following categories:

Groundwater

Surface Water

Third Party Purchase

Harvested Water

water recycled and reused

Table-27

Total water withdrawal (Million M3)					
	A	B	C	D	E
2013-14	14.67	16.66	6.81	4.37	1.60
2014-15	15.23	15.81	6.69	2.11	1.67
2015-16	14.22	14.69	6.62	1.60	2.01
2016-17	14.85	14.35	6.91	2.49	1.60

Table-28

water recycled % of water withdrawal					
	A	B	C	D	E
2013-14	12.13	11.91	15.88	12.40	22.59
2014-15	10.99	8.25	13.80	12.80	31.02
2015-16	12.92	9.84	13.50	12.42	20.90
2016-17	13.10	9.10	12.80	11.17	21.63

Table-29

Specific water consumption (lit/tonnes of cement)					
	A	B	C	D	E
2013-14	336	246	180	170	210
2014-15	333	248	168	130	210
2015-16	320	245	144	120	170
2016-17	328	241	132	128	130

Raw Material- These are important raw materials used in the manufacturing of cement like Lime stone, gypsum, silica and alumina.

Recycled Material- Waste materials like fly ash, gypsum used as raw material to replace naturally occurring limestone.

Table-30

Natural raw material used (Million Tonnes)					
	A	B	C	D	E
2013-14	53.26	24.85	22.24	15.03	7.44
2014-15	59.44	24.33	21.81	17.09	8.41
2015-16	61.94	24.75	21.76	14.75	9.26
2016-17	65.19	23.93	23.37	20.80	8.55

Table-31

Recycled material used (thousand tonnes)					
	A	B	C	D	E
2013-14	8470.00	7310.00	7097.65	4210.00	864.60
2014-15	9304.92	7400.00	6076.89	5444.00	1066.91
2015-16	10005.25	7000.00	6708.93	4140.00	1168.55
2016-17	10220.00	6910.00	7678.37	6616.00	1256.64

III. Health and safety Data Consideration

Occupational health and Safety- It is about healthy and safe working conditions for employees and contractors in cement companies. Lost Time Injury (LTI) is a work-related injury causing the absence of one or more working days (or shifts), counting from the day after the injury, before the person returns to normal or restricted work. LTIFR Lost Time Injury frequency rate Number of LTIs in a year per million hours worked.

Table-32

LTIFR					
	A	B	C	D	E
2013-14	0.67	0.90	0.80	0.00	0.16
2014-15	0.51	0.50	1.07	0.00	0.00
2015-16	0.35	1.00	1.97	0.10	0.43
2016-17	0.4	0.90	0.93	0.00	0.00

IV Social EHS Data Consideration

These are initiatives undertaken under umbrella of CSR projects which are focused on community improvement and poverty alleviation. Here focus has been given on projects related to environment health and safety aspects considered for nearby community areas which includes projects on improving green areas, water management, providing support to healthcare of people residing near plant areas.

Table-33 Social EHS Projects details A, B, C, D, E

	Company A									
year	Biodiversity (plants / sapling planted) Nos	survival %	Community Healthcare	Environmental protection	Projects on providing basic amenities	Projects on promoting sustainable agriculture and forestry	Access to improved drinking water source	Projects on water shed protection	Community wellness program	Projects to improve forest cover
2012-13	279316	84.86			Yes	No	No	No	Yes	Yes
2013-14	311663	86.26	Immunization programmed with a thrust on polio	Soil and Water conservation	Yes	No	No	No	Yes	Yes
2014-15	240556	85.81	eradication, Health care for visually impaired, and differently abled	Watershed development	Yes	No	yes	No	Yes	Yes
2015-16	171312	83.17	Community Healthcare	Argo Forestry	Yes	Yes	yes	Yes	Yes	Yes

2016-17	283873	78.15		Environmental protection	Yes	Yes	yes	Yes	Yes	Yes

Company	B									
year	Biodiversity (plants / sapling planted) Nos	survival %	Community Health care	Environmental protection	Projects on providing basic amenities	Projects on promoting sustainable agriculture and forestry	Access to improved drinking water source	Projects on watershed protection	Community wellness program	Projects to improve forest cover
2012-13			Health care for differently abled		Yes	No	No	No	Yes	No
2013-14			Community Health care	Argo Forestry	Yes	No	No	No	Yes	No
2014-15				Soil and Water conservation	Yes	No	No	Yes	Yes	No
2015-16				Watershed development	Yes	Yes	yes	Yes	Yes	No
2016-17	140000	80			Yes	Yes	yes	Yes	Yes	Yes

Company	C									
year	Biodiversity (plants / sapling planted) Nos	survival %	Community Health care	Environmental protection	Projects on providing basic amenities	Projects on promoting sustainable agriculture and forestry	Access to improved drinking water source	Projects on water shed protection	Community wellness program	Projects to improve forest cover
2012-13			Health care for differently abled		Yes	No	No	No	Yes	No
2013-14			Community Health care	Agro Forestry	Yes	No	No	No	Yes	No
2014-15				Soil and Water conservation	Yes	No	No	Yes	Yes	No
2015-16	160000			Watershed development	Yes	Yes	yes	Yes	Yes	yes
2016-17	280000				Yes	Yes	yes	Yes	Yes	Yes

Company	D									
year	Biodiversity (plants / sapling planted) Nos	survival %	Community Health care	Environmental protection	Projects on providing basic amenities	Projects on promoting sustainable agriculture and forestry	Access to improved drinking water source	Projects on water shed protection	Community wellness program	Projects to improve forest cover
2012-13			Health care for women		Yes	No	No	No	Yes	No
2013-14			Community Health camps	Agro Forestry	Yes	No	No	No	Yes	No
2014-15	27000	85		Soil and Water conservation	Yes	Yes	No	Yes	Yes	Yes
2015-16	50000	89		Watershed development	Yes	Yes	yes	Yes	Yes	Yes
2016-17	188000	89			Yes	Yes	yes	Yes	Yes	Yes

Company	E									
year	Biodiversity (plants / sapling planted) Nos	survival %	Community Health care	Environmental protection	Projects on providing basic amenities	Projects on promoting sustainable agriculture and forestry	Access to improved drinking water source	Projects on water shed protection	Community wellness program	Projects to improve forest cover
2012-13					No	No	No	No	Yes	No
2013-14					Yes	No	No	No	Yes	No
2014-15			Medical check-ups Camp	afforestation and plantation drives	Yes	No	No	Yes	Yes	No
2015-16	24,000		Eye Camp, Medical check-ups Camp, blood donation camps	Water harvesting structures	Yes	Yes	yes	Yes	Yes	Yes
2016-17	10000		Medical check-ups Camp, blood donation camps	751 saplings	Yes	Yes	yes	Yes	Yes	Yes

V. EHS Indicator prioritization

Table-34 EHS Indicator, Sub indicators and criteria

Core EHS Indicator	Sub-Indicators	Criteria
Identify Emerging sustainability criteria	Environment criteria	Water Consumption and Conservation
		Energy Consumption and Conservation
		Raw material consumption and recycling
		GHG and other Emission reduction
	Occupational Health and Safety	Occupational Health
		Workplace Safety
	Community EHS Practices initiative	Community project-Water and Energy Resources conservation
		Community project-Green Belt development
		Community project-Community Healthcare

Numerical Rating Verbal judgment of preferences
AHP Scale: 1- Equal Importance, 3- Moderate importance, 5- Strong importance, 7- Very strong importance, 9- Extreme importance (2,4,6,8 values in-between).

	Category	Priority	Rank
1	Environment criteria	59.40%	1
2	Occupational Health and Safety	24.90%	2
3	Community EHS Practices initiative	15.70%	3

Number of comparisons = 3

Consistency Ratio CR = 5.6%

	Category	Priority	Rank
1	Water Consumption and Conservation	23.90%	3
2	Energy Consumption and Conservation	28.10%	2
3	Raw material consumption and recycling	14.00%	4
4	GHG and other Emission reduction	34.00%	1

Number of comparisons = 6

Consistency Ratio CR = 2.2%

	Category	Priority	Rank
1	Occupational Health	66.70%	1
2	Occupational safety	33.30%	2

Number of comparisons = 1

Consistency Ratio CR = 0.0%

	Category	Priority	Rank
1	Community project-Water and Energy Resources	52.80%	1
2	Community project-Green Belt development	14.00%	3
3	Community project-Community Healthcare	33.30%	2

Number of comparisons = 3

Consistency Ratio CR = 5.6%

VI. EHS Key criteria table

The structured Key criteria are developed for EHS Indicators for sustainability considering the cement industry operations. Table gives a completed set of questionnaires considering all the emerging criteria identified in objective 3 and the responses are based on the data studied under objective 1 and 2. Weights are derived from AHP (analytical hierarchy process) method using the software. The data is plotted in the index for calculating the mutuality level and effectiveness of the sample cement injuries under study:

Table-35 EHS Key criteria table

Identify Emerging sustainability criteria	**EHS Indicators**	EHS Sub indicators	Sr No.	Key Criteria
	Environment	Water Consumption and Conservation	**1**	ISO 14001 management system certification
			2	Fresh water consumption pattern (YOY)
			3	Ground water resource extraction pattern (YOY)
			4	Water Metering and management
			5	Waste Water Treatment and Recycle (recycle percentage of fresh water consumption) YOY
			6	Water Quality of effluent water
			7	Zero discharge plants
			8	Rainwater Harvesting (YOY)
			9	Ground water recharge

1	**0.5**	**0.1**	**0.05**
Highly Sustainable	**Moderately Sustainable**	**Evolving towards sustainable**	**Unsustainable**
certified	under certification	Plan for certification	no certification
Consmp. less than 10%-20%	Consmp. less than 5%-10%	Consmp. less than 5%	No change in consumption pattern
extact. less than 10%-20%	extact. less than 5%-10%	extact. less than 5%	No change in consumption pattern
Well managed program	Initiated program	Plan for water management	No program
recycle more than 30%	recycle more than 20%	recycle more than 10%	No recycling
Quality improved beyond regulatory limits	Quality meets regulatory limits	Tries to meet regulatory limits	regulatory requirements not met
100% zero discharge	Initiated program	Plan for zero discharge	No possibility
Harvested more than 10%	Harvested more than 5%	Harvested more than 1%	No rain water harvesting system in place
Quantified and audited	Quantified but not audited	Initiated program	No data available

Environment	Energy Consumption and Conservation	**1**	ISO 50001 management system certification
		2	Energy consumption pattern- Direct Energy (fuel) (YOY)
		3	Energy consumption pattern- Indirect Energy (grid electricity) (YOY)
		4	Energy consumption pattern for supply chain/ employee commute not under direct control of company (YOY)
		5	Company conducts Environment and Energy Audit
		6	Energy Efficiency Initiatives
		7	Alternate fuels Usage as a percentage of total energy (YOY)
		8	Renewable energy usage (YOY)
		9	PAT implementation and status
		10	Renewable purchase obligation status

1	**0.5**	**0.1**	**0.05**
Highly Sustainable	**Moderately Sustainable**	**Evolving towards sustainable**	**Unsustainable**
certified	under certification	Plan for certification	no certification
Direct Energy consumption reduced more than 5%	Direct Energy consumption reduced more than 2%	Direct Energy consumption consistent	Direct Energy consumption increasing
Indirect Energy consumption reduced more than 10%	Indirect Energy consumption reduced more than 5%	Indirect Energy consumption consistent	Indirect Energy consumption increasing
Monitored and actions taken	Monitored but no action taken	To be Monitored	No Monitoring
once a year	Once in 2 -3 years	Plan for energy audits	Never conducted
Well-structured program	Initiatives undertaken	Initiated program	No program
AF used best in industry	AF use started	AF to be used	No AF used

RE used more than 50%	RE used up to 50%	RE use started	No RE used
Achieved and traded	Achieved but not traded	achieved	Not achieved
Set up inhouse RE plants to achieve targets	Complied beyond target	Complied as per target	Not Complied

Environment	Raw material Consumption and recycling	**1**	Use of recycled materials (percentage YOY)
		2	Sustainable procurement Initiatives
	GHG and other Emission reduction	**1**	Company reporting Emissions in CDP/ as per ISO 14064
		2	Direct Emission Pattern
		3	Indirect emission pattern
		4	Emission pattern for supply chain/ employee commute not under direct control of company
		5	Commitment to reduce GHG emissions with timelines.
		6	AAQ -PM, Sox, Nox
		7	Availability of latest technologies
		8	emission offset programs

1	**0.5**	**0.1**	0.05
Highly Sustainable	Moderately Sustainable	Evolving towards sustainable	Unsustainable
Recycled mat. used more than 50%	Recycled mat. used up to 50%	Recycled mat. use started	No recycling
Well managed program validated by third party	sustainable procurement is part of sourcing process	Initiated program	No program
Disclosed with A rating	Disclosed with less than A rating	Disclosed without ratings	No disclosure

Direct Emission reduced more than 5%	Direct Emission reduced more than 2%	Direct Emission consistent	Direct Emission increasing
Indirect Emission reduced more than 10%	Indirect Emission reduced more than 5%	Indirect Emission consistent	Indirect Emission increasing
usage >25%	10-25%	0%-10%	0%
Monitored and audited	Monitored inhouse	To be Monitored	No Monitoring
AAQ improved beyond regulatory limits	AAQ meets regulatory limits	Tries to meet AAQ regulatory limits	not meeting regulatory requirements
State of Art technology adopted	technology upgradation process	technology upgradation to be done	no tech. upgradation
Well-structured program and audited by third party	emission offset program in progress	Initiated program	No program
Occupational Health and Safety	Occupational Health	**1**	OHSAS 18001 management system Certification
		2	Health and wellness programs in 1 year
		3	Health and safety programs- Hygiene, ergonomics
	Workplace Safety	**1**	Frequency Rate (FR) – Number of recordable incidents per 1 million man-hours worked/year (less than the industry average)
		2	Loss time injury
		3	Program on Behaviour based safety
		4	EHS Trainings
		5	Safe work place initiatives to boost employee morale
		6	EHS committee and meetings

1	0.5	0.1	0.05
Highly Sustainable	**Moderately Sustainable**	**Evolving towards sustainable**	**Unsustainable**
certified	under certification	Plan for certification	no certification
1 or more program per month	1 or more program per qtr	1 program per Six Month/ year	No program
1 or more program per month	1 or more program per qtr	1 program per Six Month/ year	No program
Zero FR	FR above 25% of the industrial average	FR above 50% of the industrial average	highest in industry
zero fatal incident in last two years	Minor Incident but no fatal incident in last two years	Minor incident and significant first aid cases but no fatal incident in last 2 years	fatal incident last two years
1 or more program per month	1 or more program per qtr	1 program per Six Month/ year	No program initiated yet
1 or more program per month	1 or more program per qtr	1 program per Six Month/ year	No program initiated yet
Well managed program and employee engagement evident	program undertaken but no tracking done to evaluate employee engagement	Initiated program	No program initiated yet
Formal committee meetings happening	Informal meetings happening	Initiated program	No program initiated yet

Community EHS Practices/ initiative	Environment Initiatives- Water conservation and forestry and basic amenities	**1**	Projects on providing basic amenities
		2	Projects on promoting sustainable agriculture and forestry
		3	Access to improved drinking water source
		4	Projects on watershed protection
	Community project-Green Belt development	**5**	Projects on Biodiversity
		6	Projects to improve forest cover
	Community project- Community Healthcare	**7**	Community wellness program

1	**0.5**	**0.1**	**0.05**
Highly Sustainable	**Moderately Sustainable**	**Evolving towards sustainable**	**Unsustainable**
Results monitored and quantified	Results monitored and quantified but not audited	Results monitored but not quantified	No program initiated yet
Results monitored and quantified	Results monitored and quantified but not audited	Results monitored but not quantified	No program initiated yet
Results monitored and quantified	Results monitored and quantified but not audited	Results monitored but not quantified	No program initiated yet
Results monitored and quantified	Results monitored and quantified but not audited	Results monitored but not quantified	No program initiated yet
Results monitored and quantified	Results monitored and quantified but not audited	Results monitored but not quantified	No program initiated yet
Results monitored and quantified	Results monitored and quantified but not audited	Results monitored but not quantified	No program initiated yet
Results monitored and quantified	Results monitored and quantified but not audited	Results monitored but not quantified	No program initiated yet

VII. Index Implementation Plant-1 Rating for sustainability

Table-36 Plant-1 Rating for sustainability

EHS Indicators	EHS Sub indicators	Sr No.	Key Criteria	1	0.5	0.1	0.05	Maturity level rating	weights	criteria rating	sub-Indicator rating	EHS Indicator Rating for sustainability
				Highly Sustainable	**Moderately Sustainable**	**Evolving towards sustainable**	**Unsustainable**					
Environment	**Water Consumption and Conservation**	**1**	ISO 14001 management system certification	certified	under certification	no certification	no certification	1	0.23	0.23	0.12	0.10
		2	Fresh water consumption pattern (YOY)	Consmp. less than 10%-20%	Consmp. less than 5%-10%	Consmp. less than 5%	No change in consumption pattern	0.5	0.23	0.12		
		3	Ground water resource extraction pattern (YOY)	extact. less than 10%-20%	extact. less than 5%-10%	extact. less than 5%	No change in consumption pattern	0.5	0.23	0.12		
		4	Water Metering and management	Well managed program	Initiated program	No program	No program	0.5	0.23	0.12		
		5	Waste Water Treatment and Recycle	recycle more than 30%	recycle more than 20%	recycle more than 10%	No recycling	0.1	0.23	0.02		

			(recycle percentage of fresh water consumption) YOY									
		6	Water Quality of effluent water	Quality improved beyond regulatory limits	Quality meets regulatory limits	Tries to meet regulatory limits	regulatory requirements not met	0.5	0.23	0.12		
		7	Zero discharge plants	Yes	Initiated program	No	No possibility	0.1	0.23	0.02		
		8	Rainwater Harvesting (YOY)	Harvested more than 10%	Harvested more than 5%	Harvested more than 1%	No rain water harvesting system in place	0.5	0.23	0.12		
		9	Ground water recharge	Quantified	Initiated program	No data available	No data available	1	0.23	0.23		
	Energy Consumption and Conservation	**1**	ISO 50001 management system certification	certified	under certification	no certification	no certification	0.1	0.28	0.028	0.10	
		2	Energy consumption	Direct Energy	Direct Energy consumption	Direct Energy consu	Direct Energy consu	0.1	0.28	0.028		

			pattern - Direct Energy (fuel) (YOY)	consumption reduced more than 5%	reduced more than 2%	mption consistent	mption increasing					
		3	Energy consumption pattern - Indirect Energy (grid electricity) (YOY)	Indirect Energy consumption reduced more than 10%	Indirect Energy consumption reduced more than 5%	Indirect Energy consumption consistent	Indirect Energy consumption increasing	0.5	0.28	0.14		
		4	Energy consumption pattern for supply chain/ employee commute not under direct control of company (YOY)	Monitored	To be Monitored	No Monitoring	No Monitoring	0.5	0.28	0.14		
		5	Company conducts Environment	once a year	Once in 2-3 years	Never conducted	Never conducted	0.5	0.28	0.14		

			and Energy Audit									
		6	Energy Efficiency Initiatives	Well managed program	Initiated program	No program	No program	0.5	0.2	0.14		
		7	Alternate fuels Usage as a percentage of total energy (YOY)	AF used	AF to be used	No AF used	No AF used	0.5	0.2	0.14		
		8	Renewable energy usage (YOY)	RE used more than 50%	RE used up to 50%	RE use started	No RE used	0.5	0.2	0.14		
		9	PAT implementation and status	Achieved and traded	Achieved	Not achieved	Not achieved	0.1	0.28	0.02		
		10	Renewable purchase obligation status	Complied beyond target	Complied	Not Complied	Not Complied	0.5	0.28	0.14		
	Raw material Consumption and recycling	**1**	Use of recycled materials (percentage YOY)	Recycled mat. used more than 50%	Recycled mat. used up to 50%	Recycled mat. use started	No recycling	0.1	0.14	0.01	0.04	

		2	Sustainable procurement Initiatives	Well managed program	Initiated program	No program	No program	0.5	0.14	0.07		
	GHG and other Emission reduction	**1**	Company reporting Emissions in CDP/ as per ISO 14064	Disclosed with A rating	Disclosed with less than A rating	No disclosure	No disclosure	0.1	0.34	0.03	0.10	
		2	Direct Emission Pattern	Direct Emission reduced more than 5%	Direct Emission reduced more than 2%	Direct Emission consistent	Direct Emission increasing	0.1	0.34	0.034		
		3	Indirect emission pattern	Indirect Emission reduced more than 10%	Indirect Emission reduced more than 5%	Indirect Emission consistent	Indirect Emission increasing	0.5	0.34	0.17		
		4	Emission pattern for supply chain/ employee commute not under direct	usage >25 %	10-25%	0%-10%	0%	0.1	0.34	0.034		

			control of company									
		5	Commitment to reduce GHG emissions with timelines.	Monitored	To be Monitored	No Monitoring	No Monitoring	0.5	0.34	0.17		
		6	AAQ - PM, Sox, Nox	AAQ improved beyond regulatory limits	AAQ meets regulatory limits	Tries to meet AAQ regulatory limits	not meeting regulatory requirements	0.5	0.34	0.17		
		7	Availability of latest technologies	State of Art technology adopted	technology upgradation process	technology upgradation to be done	no tech. upgradation	0.5	0.34	0.17		
		8	emission offset programs	Well managed program	Initiated program	No program	No program	0.1	0.34	0.034		
Occupational Health and Safety	**Occupational Health**	**1**	OHSAS 18001 management system Certification	certified	under certification	no certification	no certification	1	0.66	0.66	0.44	0.33
		2	Health and wellness	1 or more program	1 program per Six	No program	No program	0.5	0.66	0.33		

			programs in 1 year	per month/ qtr	Month/ year							
		3	Health and safety programs- Hygiene, ergonomics	1 or more program per month/ qtr	1 program per Six Month/ year	No program	No program	0.5	0.66	0.33		
	Workplace Safety	**1**	Frequency Rate (FR) – Number of recordable incidents per 1 million man-hours worked/year (less than the industry average)	Zero FR	FR above 25% of the industrial average	FR above 50% of the industrial average	highest in industry	1	0.33	0.33	0.27	
		2	Loss time injury	zero fatal incident	Minor Incident but no fatal incident	fatal incident	fatal incident last two years	0.5	0.33	0.16		
		3	Program on Behaviour	Well managed	Initiated program	No program	No program	0.5	0.33	0.16		

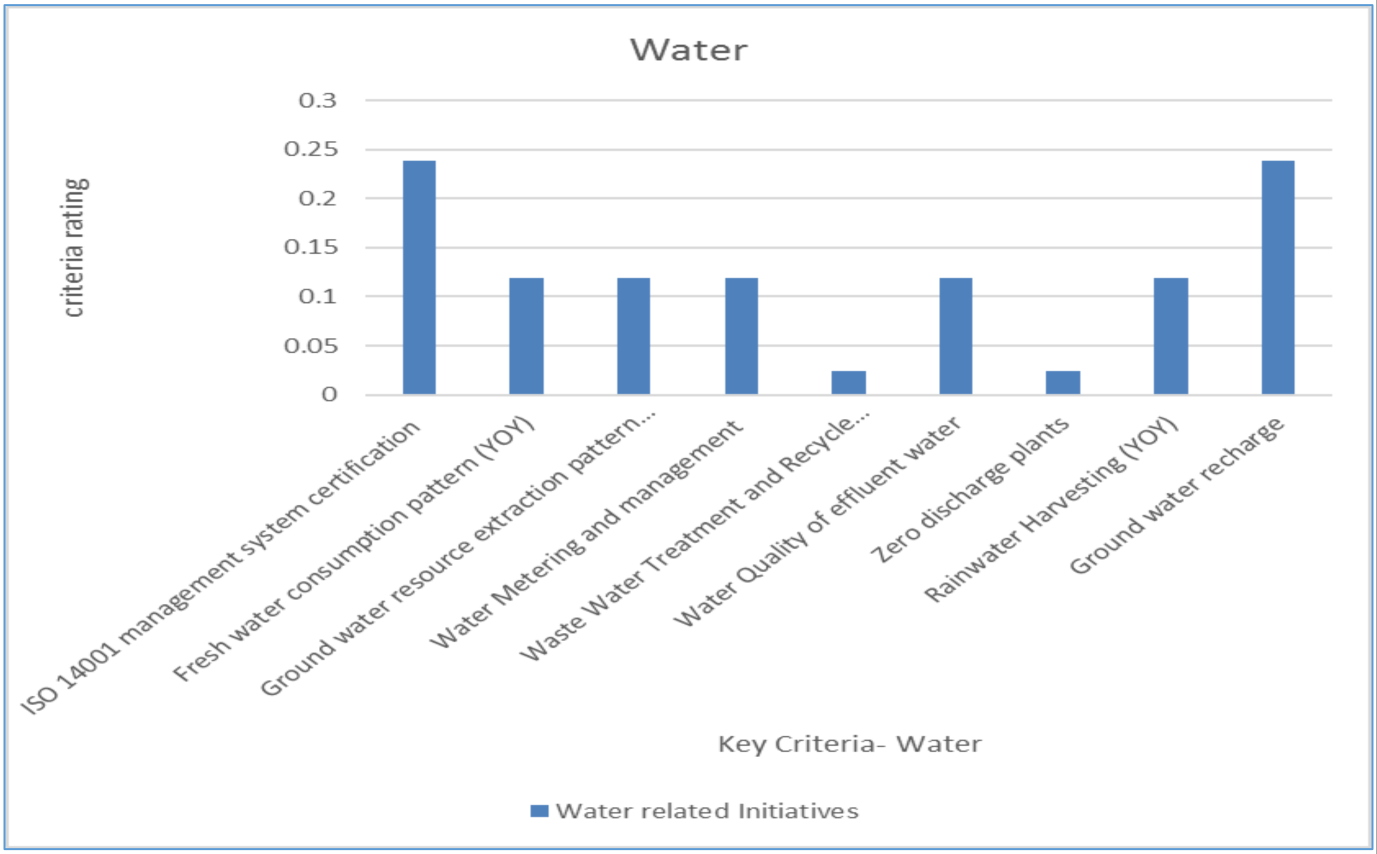
			based safety	program			initiated yet					
		4	EHS Trainings	Well managed program	Initiated program	No program	No program initiated yet	1	0.33	0.33		
		5	Safe work place initiatives to boost employee morale	Well managed program	Initiated program	No program	No program initiated yet	1	0.33	0.33		
		6	EHS committee and meetings	Well managed program	Initiated program	No program	No program initiated yet	1	0.33	0.33		
Community EHS Practices/ initiative	**Environment Initiatives- Water conservation and forestry and basic amenities**	**1**	Projects on providing basic amenities	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	0.5	0.52	0.26	0.18	0.18
		2	Projects on promoting sustainable agriculture and forestry	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	0.5	0.52	0.26		
		3	Access to improved drinking	Results monitored and	Results monitored but not quantified	No program	No program initiated yet	0.5	0.52	0.26		

			water source	quantified								
		4	Projects on watershed protection	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	0.1	0.52	0.05		
	Community project -Green Belt development	**5**	Projects on Biodiversity	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	0.5	0.14	0.07	0.07	
		6	Projects to improve forest cover	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	0.5	0.14	0.07		
	Community project - Community Health care	**7**	Community wellness program	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	1	0.33	0.33	0.33	

Plant-1 Target Vs Results

Water:

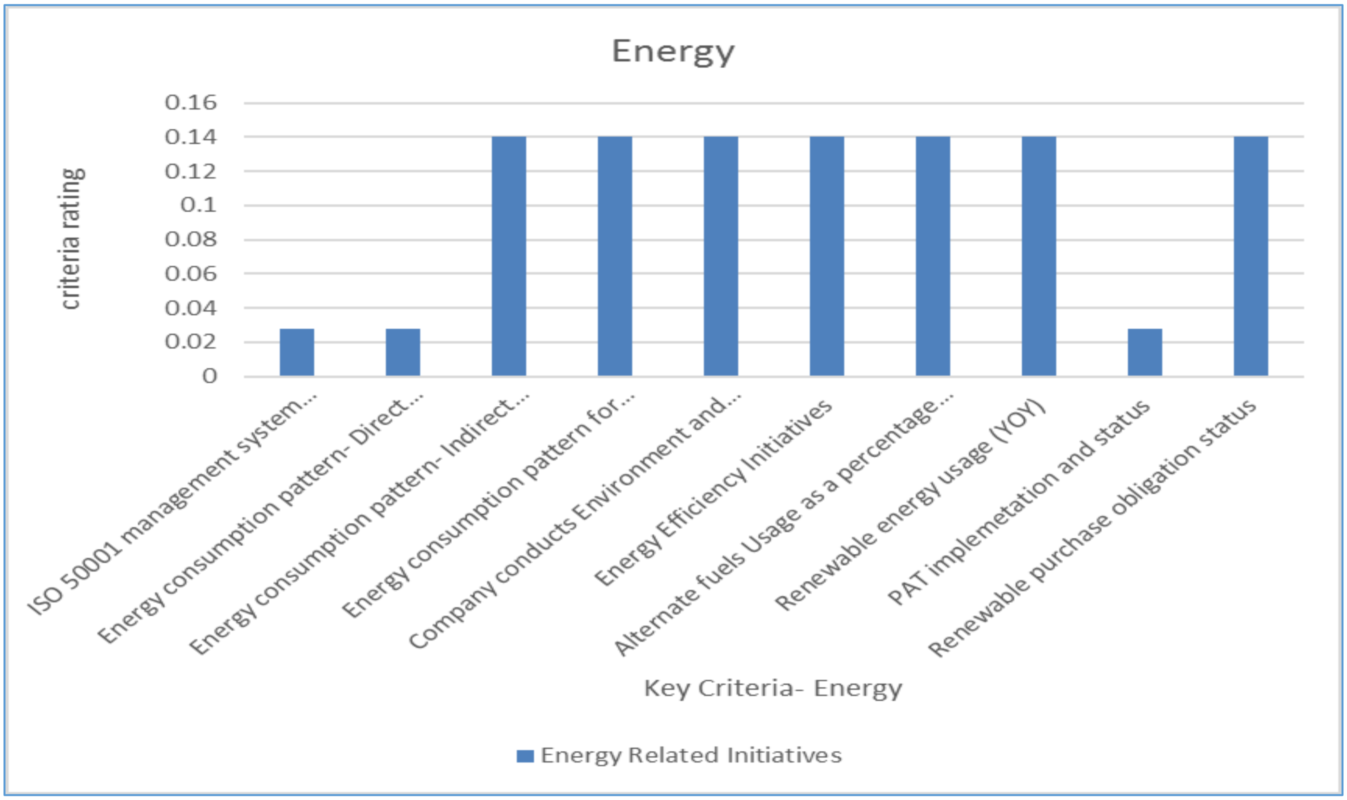
Figure-27 P-1 Water Sub Indicator rating



Target Suggested	Increase the usage of recycled water
Implementation Status	Yes
Results	Performance indicator was added in ISO EHSMS objective and targets Selection of indicator was qualified as stakeholder requirement captured. Implementation result shows 3% increase from base year

Energy:

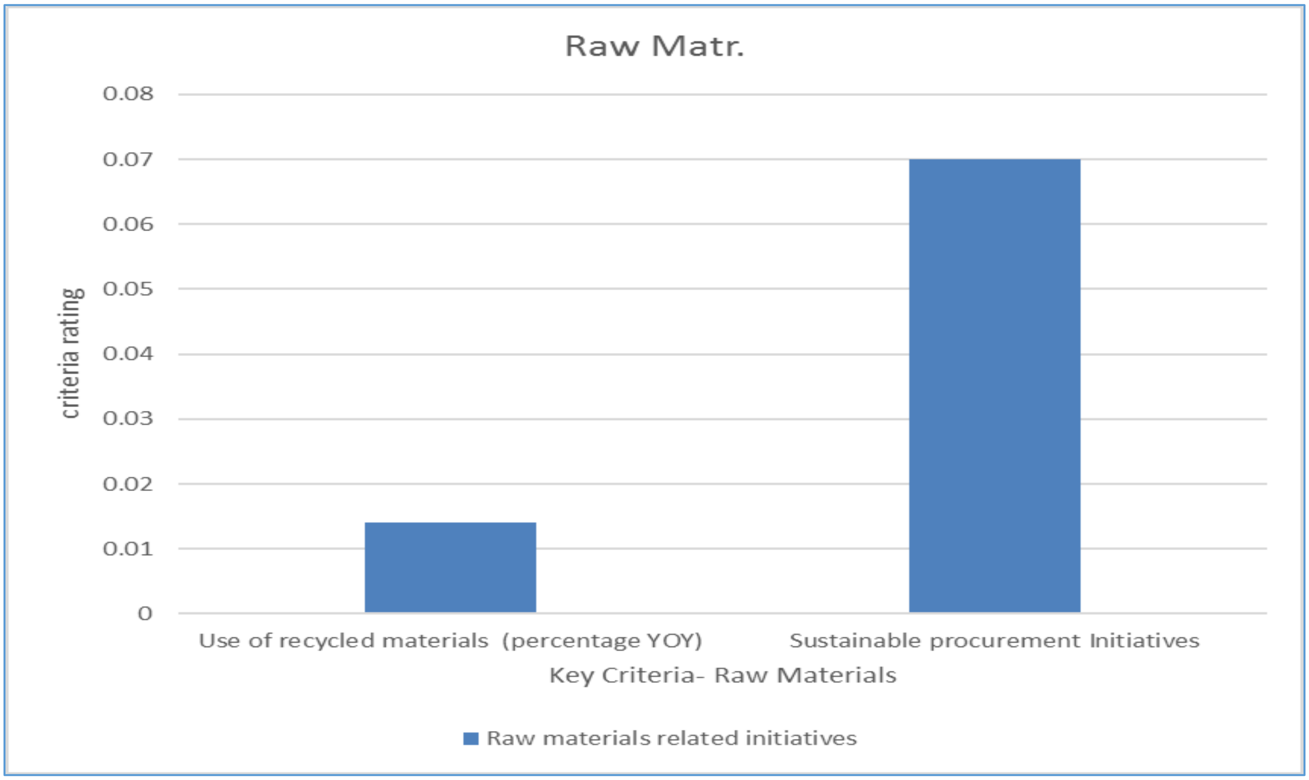
Figure-28 P-1 Energy Sub Indicator rating



Target Suggested	ISO 50001 certification of the unit
Implementation Status	Yes
Results	Performance indicator was identified as improvement project under EHS Selection of indicator was qualified as stakeholder requirement captured. Certification audit resulted in estimating additional 02 % decrease from base year.

Raw Material:

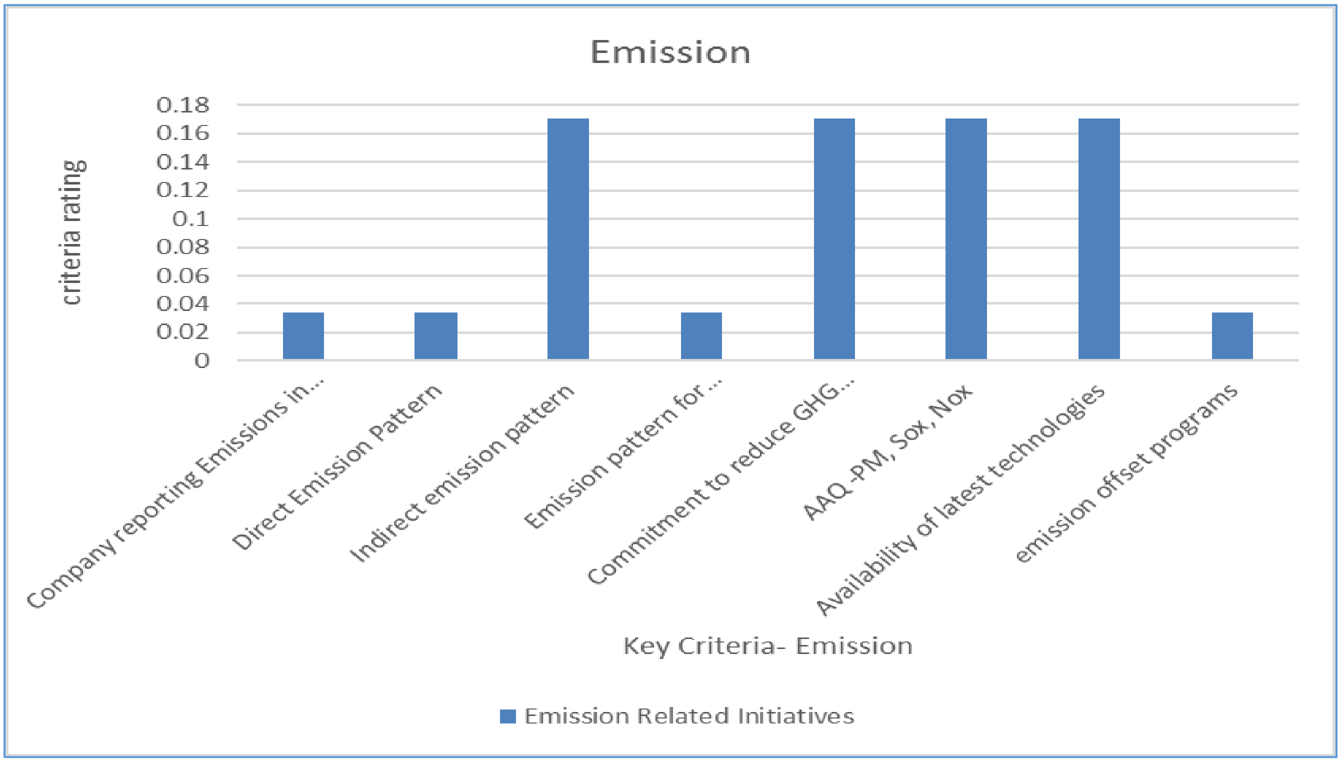
Figure-29 P-1 Raw Material Sub Indicator rating



Target Suggested	Increase the recycle material usage
Implementation Status	Yes
Results	6 % increase from base year

Emission:

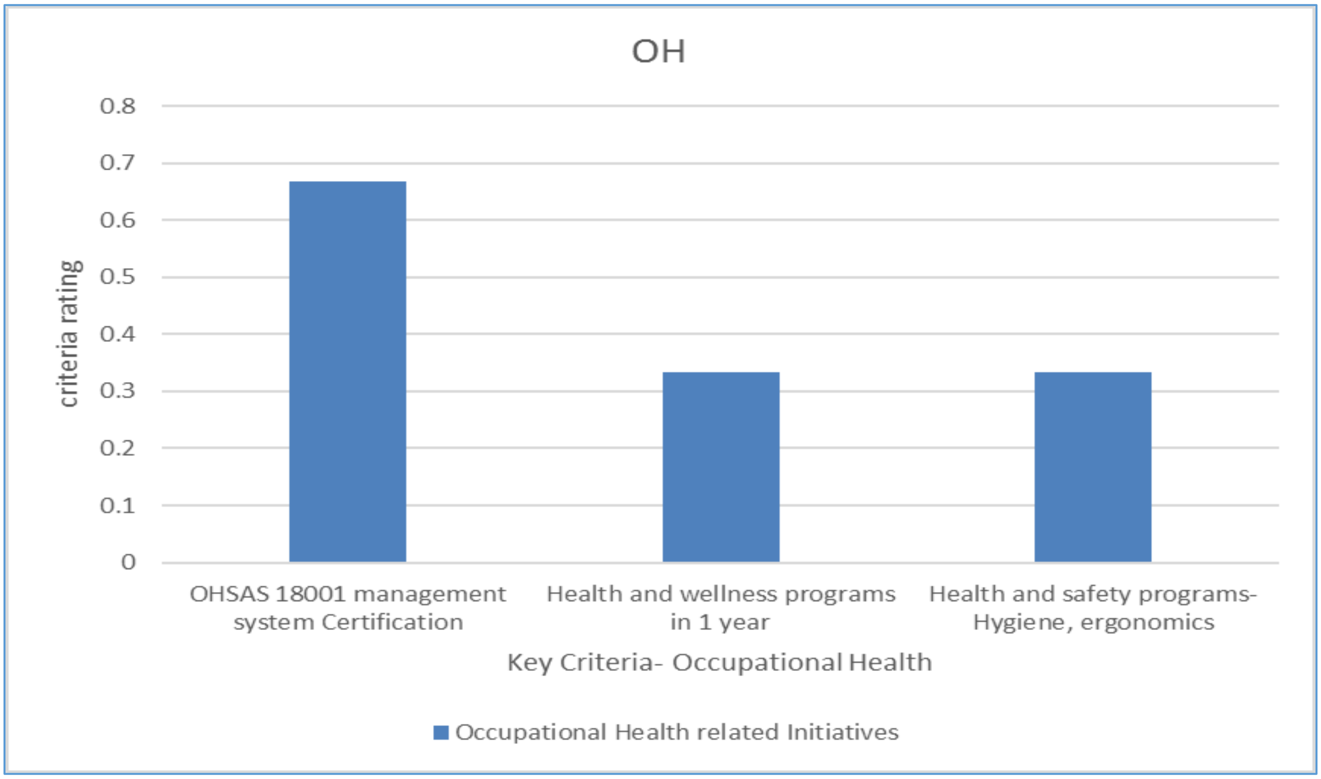
Figure-30 P-1 Emission Sub Indicator rating



Target Suggested	Decrease the emissions from direct energy source
Implementation Status	Not implemented
Results	Not shared

Occupational Health:

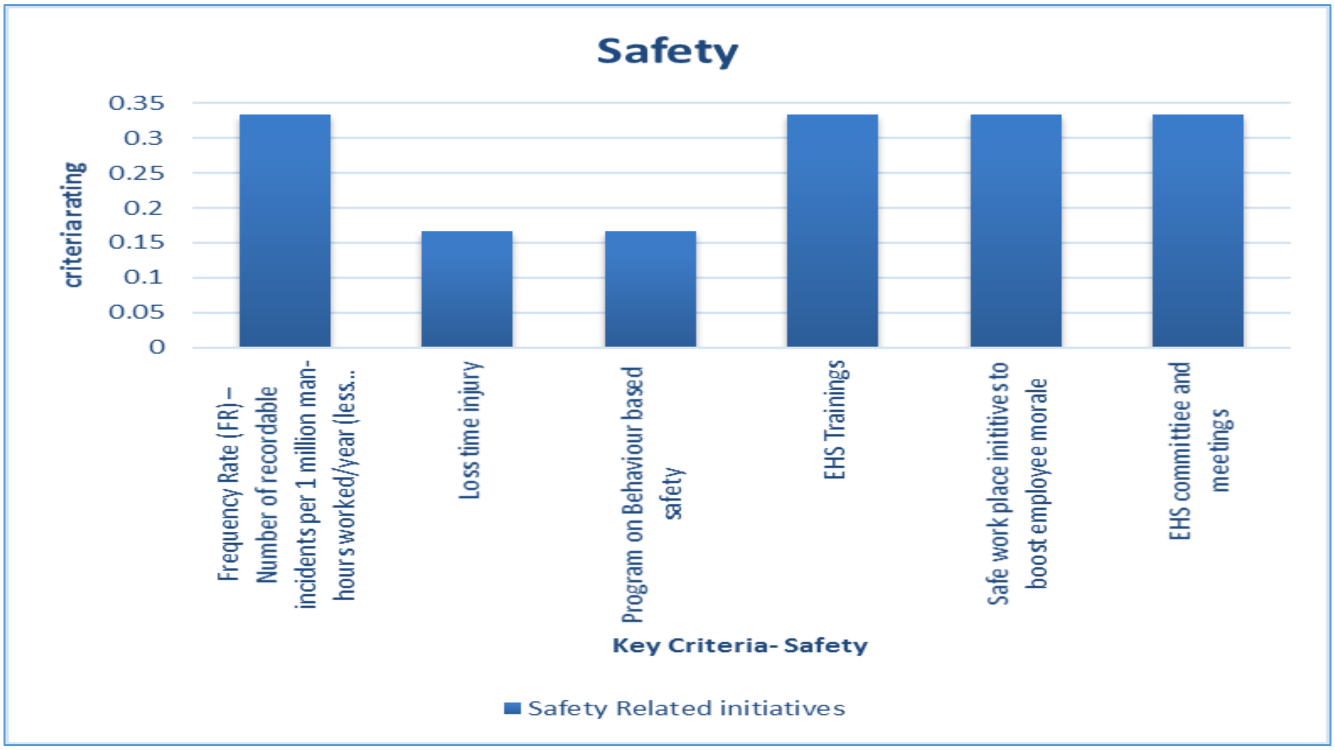
Figure-31 P-1 Occupational Health Sub Indicator rating



Target Suggested	Increase the trainings on hygiene by emphasizing use of PPEs
Implementation Status	Yes
Results	Performance indicator was added in OHSAS objective Selection of indicator was qualified as stakeholder requirement captured. PPE avoidance cases reduced as per the plant safety MIS reported

Safety:

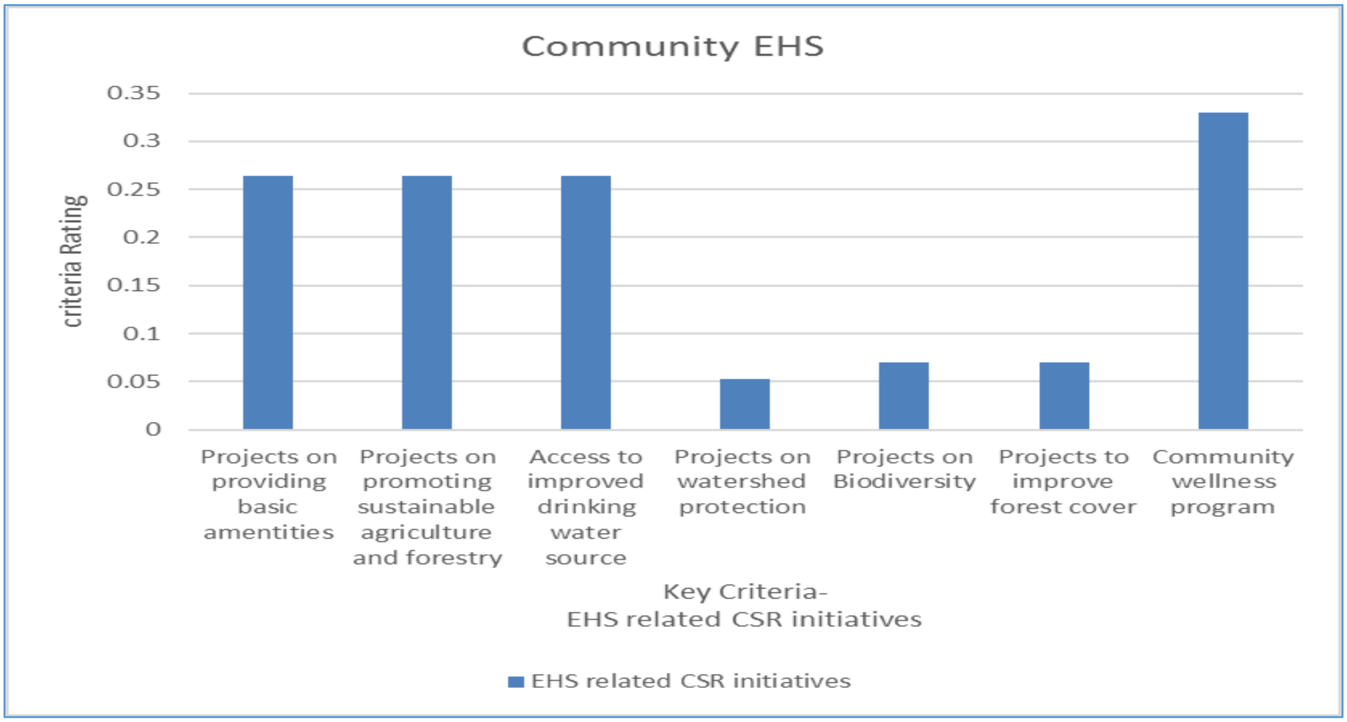
Figure-32 P-1 Safety Sub Indicator rating



Target Suggested	Increase the safety training by implementing BBS program
Implementation Status	BBS Program has been implemented and Avoiding PPE usage was one of the cases identified under behavioral List of top safety issues.
Results	Performance indicator was added in OHSAS objective Selection of indicator was qualified as stakeholder requirement captured. In cycle-1 of BBS- 17% Decrease in First aid cases observed due to avoidance of PPE use.

Community EHS:

Figure-33 P-1 Community EHS Sub Indicator rating



Target Suggested	Focus on water related program for community
Implementation Status	Yes
Results	Safe drinking water project was implemented by spending on water sanitization project. Improved Survey results were observed in CSR report.

VIII. Index Implementation Plant-2 Rating for sustainability

Table-37 Plant-2 Rating for sustainability

EHS Indicators	EHS Sub indicators	Sr No.	Key Criteria	**1**	**0.5**	**0.1**	**0.05**	Maturity level rating	weights	criteria rating	sub-Indicator rating	EHS Indicator Rating for sustainability
				Highly Sustainable	**Moderately Sustainable**	**Evolving towards sustainable**	**Unsustainable**					
Environment	**Water Consumption and Conservation**	**1**	ISO 14001 management system certification	certified	under certification	no certification	no certification	1	0.23	0.23	0.17	0.18
		2	Fresh water consumption pattern (YOY)	Consmp. less than 10%-20%	Consmp. less than 5%-10%	Consmp. less than 5%	No change in consumption pattern	0.5	0.23	0.12		
		3	Ground water resource extraction pattern (YOY)	extact. less than 10%-20%	extact. less than 5%-10%	extact. less than 5%	No change in consumption pattern	0.5	0.23	0.12		
		4	Water Metering and management	Well managed program	Initiated program	No program	No program	1	0.23	0.23		

		5	Waste Water Treatment and Recycle (recycle percentage of fresh water consumption) YOY	recycle more than 30%	recycle more than 20%	recycle more than 10%	No recycling	0.5	0.23	0.12		
		6	Water Quality of effluent water	Quality improved beyond regulatory limits	Quality meets regulatory limits	Tries to meet regulatory limits	regulatory requirements not met	0.5	0.23	0.12		
		7	Zero discharge plants	Yes	Initiated program	No	No possibility	1	0.23	0.23		
		8	Rainwater Harvesting (YOY)	Harvested more than 10%	Harvested more than 5%	Harvested more than 1%	No rain water harvesting system in place	0.5	0.23	0.12		
		9	Ground water recharge	Quantified	Initiated program	No data available	No data available	1	0.23	0.23		

	Energy Consumption and Conservation	**1**	ISO 50001/SS 564 management system certification	certified	under certification	no certification	no certification	0.5	0.28	0.14	0.17	
		2	Energy consumption pattern-Direct Energy (fuel) (YOY)	Direct Energy consumption reduced more than 5%	Direct Energy consumption reduced more than 2%	Direct Energy consumption consistent	Direct Energy consumption increasing	0.5	0.28	0.14		
		3	Energy consumption pattern-Indirect Energy (grid electricity) (YOY)	Indirect Energy consumption reduced more than 10%	Indirect Energy consumption reduced more than 5%	Indirect Energy consumption consistent	Indirect Energy consume increasing	1	0.28	0.28		
		4	Energy consumption pattern for supply	Monitored	To be Monitored	No Monitoring	No Monitoring	0.1	0.28	0.02		

			chain/ employee commute not under direct control of company (YOY)									
		5	Company conducts Environment and Energy Audit	once a year	Once in 2-3 years	Never conducted	Never conducted	1	0.28	0.28		
		6	Energy Efficiency Initiatives	Well managed program	Initiated program	No program	No program	1	0.28	0.28		
		7	Alternate fuels Usage as a percentage of total energy (YOY)	AF used	AF to be used	No AF used	No AF used	0.5	0.28	0.14		
		8	Renewable energ	RE used more	RE used	RE use	No RE used	0.5	0.28	0.14		

			y usage (YOY)	than 50%	up to 50%	started						
		9	PAT implementation and status	Achieved and traded	Achieved	Not achieved	Not achieved	0.5	0.28	0.14		
		10	Renewable purchase obligation status	Complied beyond target	Complied	Not Complied	Not Complied	0.5	0.28	0.14		
	Raw material Consumption and recycling	**1**	Use of recycled materials (percentage YOY)	Recycled mat. used more than 50%	Recycled mat. used up to 50%	Recycled mat. use started	No recycling	0.5	0.14	0.07	0.10	
		2	Sustainable procurement Initiatives	Well managed program	Initiated program	No program	No program	1	0.14	0.14		
	GHG and other Emission reduction	**1**	Company reporting Emissions in CDP/ as per ISO 14064	Disclosed with A rating	Disclosed with less than A rating	No disclosure	No disclosure	0.5	0.34	0.17	0.21	
		2	Direct Emission Pattern	Direct Emission reduc	Direct Emission reduc	Direct Emission	Direct Emission increasing	0.5	0.34	0.17		

				ed more than 5%	ed more than 2%	consistent						
		3	Indirect emission pattern	Indirect Emission reduced more than 10%	Indirect Emission reduced more than 5%	Indirect Emission consistent	Indirect Emission increasing	1	0.34	0.34		
		4	Emission pattern for supply chain/ employee commute not under direct control of company	usage >25 %	10-25%	0%-10%	0%	0.1	0.34	0.034		
		5	Commitment to reduce GHG emissions with timelines.	Monitored	To be Monitored	No Monitoring	No Monitoring	1	0.34	0.34		
		6	AAQ -PM, Sox, Nox	AAQ improved beyond regul	AAQ meets regulatory	Tries to meet AAQ regulatory	not meeting regulatory requir	0.5	0.34	0.17		

				atory limits	limits	limits	ements					
		7	Availability of latest technologies	State of Art technology adopted	technology upgradation process	technology upgradation to be done	no tech. upgradation	0.5	1	0.5		
		8	emission offset programs	Well managed program	Initiated program	No program	No program	0.1	0.34	0.03		
Occupational Health and Safety	**Occupational Health**	**1**	OHSAS 18001 management system Certification	certified	under certification	no certification	no certification	1	0.66	0.66	0.55	0.38
		2	Health and wellness programs in 1 year	1 or more program per month/ qtr	1 program per Six Month/ year	No program	No program	1	0.66	0.66		
		3	Health and safety programs- Hygiene, ergonomics	1 or more program per month/ qtr	1 program per Six Month/ year	No program	No program	0.5	0.66	0.33		
	Workplace Safety	**1**	Frequency Rate (FR) –	Zero FR	FR above 25%	FR above 50%	highest in industry	1	0.33	0.33	0.30	

			Number of recordable incidents per 1 million man-hours worked/year (less than the industry average)		of the industrial average	of the industrial average						
		2	Loss time injury	zero fatal incident	Minor Incident but no fatal incident	fatal incident	fatal incident last two years	1	0.33	0.33		
		3	Program on Behaviour based safety	Well managed program	Initiated program	No program	No program initiated yet	0.5	0.33	0.16		
		4	EHS Trainings	Well managed program	Initiated program	No program	No program initiated yet	1	0.33	0.33		
		5	Safe work place initiatives to boost	Well managed program	Initiated program	No program	No program initiated yet	1	0.33	0.33		

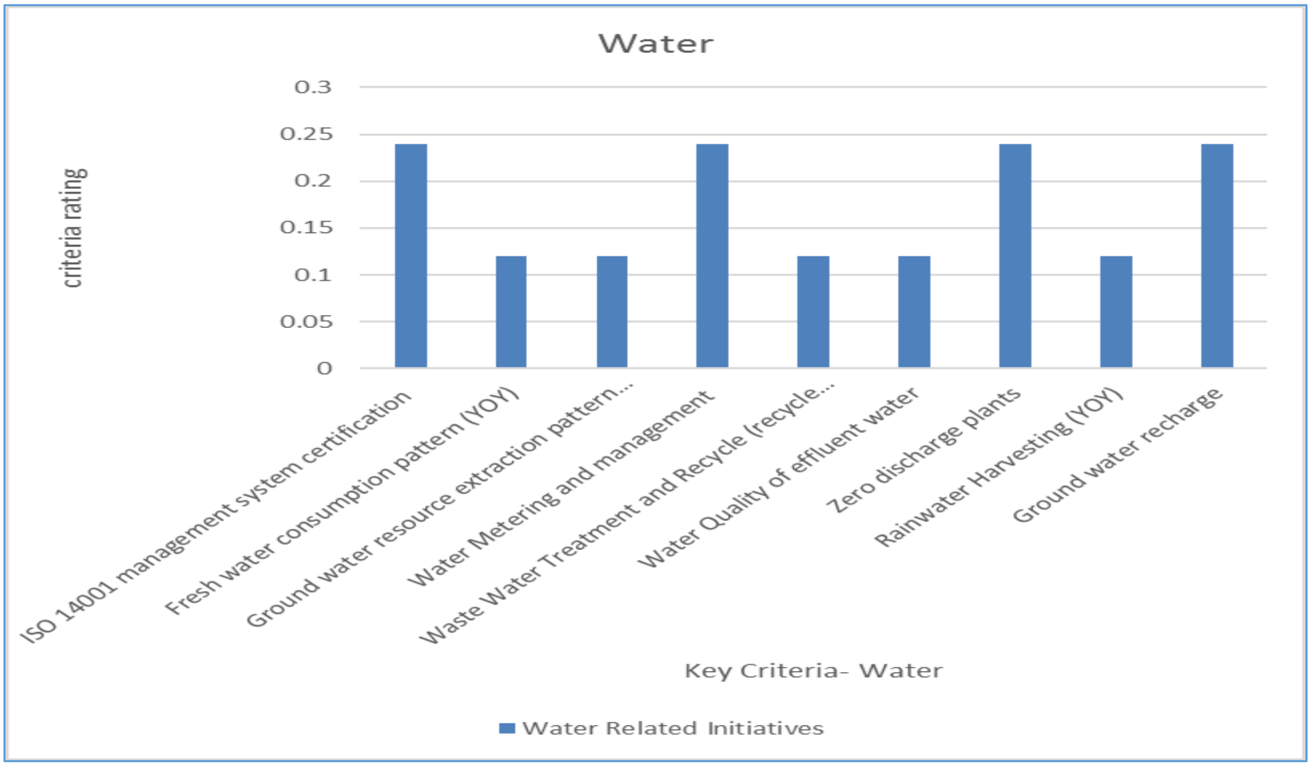
			employee morale									
		6	EHS committee and meetings	Well managed program	Initiated program	No program	No program initiated yet	1	0.33	0.33		
Community EHS Practices/ initiative	**Environment Initiatives- Water conservation and forestry and basic amenities**	**1**	Projects on providing basic amenities	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	0.5	0.52	0.26	0.29	0.27
		2	Projects on promoting sustainable agriculture and forestry	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	0.5	0.52	0.26		
		3	Access to improved drinking water source	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	1	0.52	0.52		
		4	Projects on watershed protection	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	0.5	0.52	0.26		

	Community project-Green Belt development	**5**	Projects on Biodiversity	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	1	0.14	0.14	0.14	
		6	Projects to improve forest cover	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	1	0.14	0.14		
	Community project-Community Healthcare	**7**	Community wellness program	Results monitored and quantified	Results monitored but not quantified	No program	No program initiated yet	1	0.33	0.33	0.33	

Plant-2 Target Vs Results

Water:

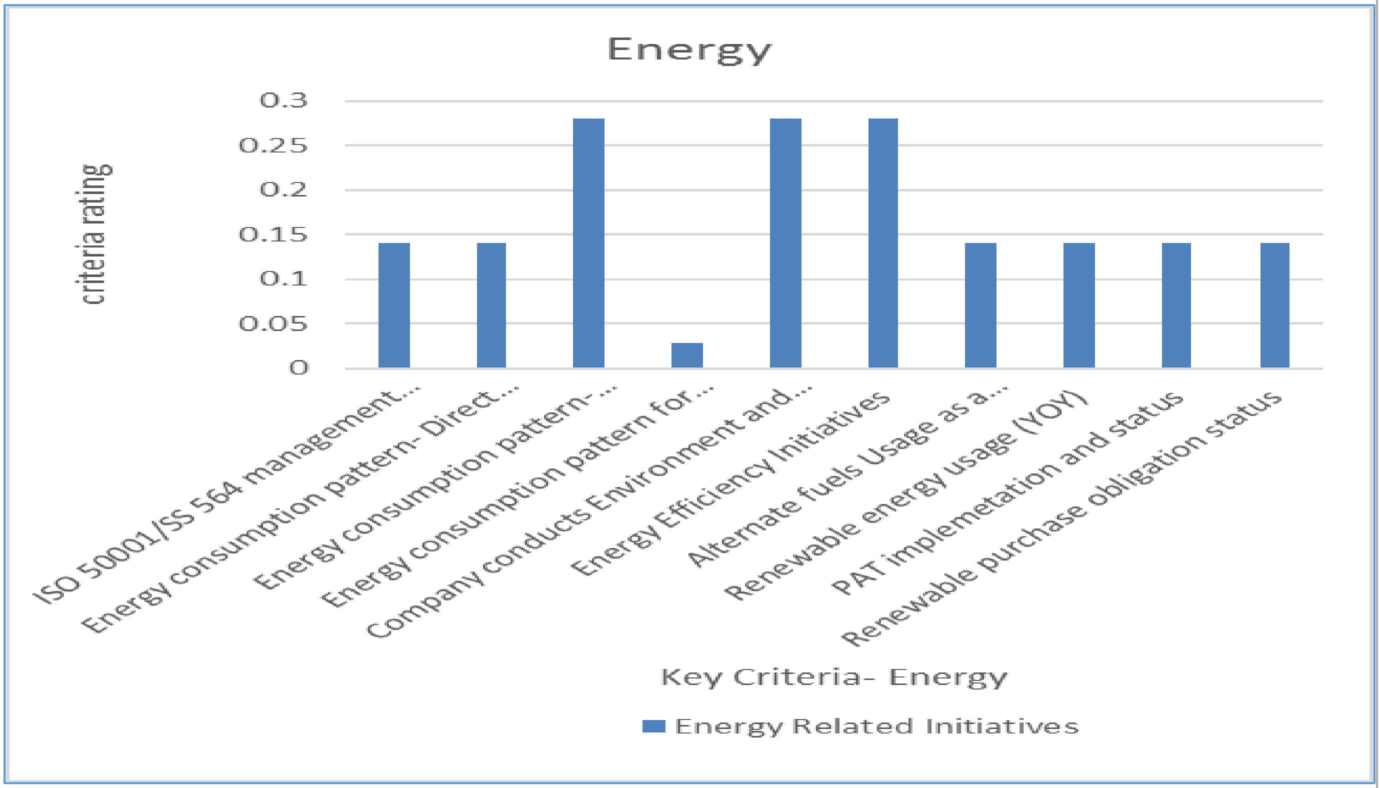
Figure-34 P-2 Water Sub Indicator rating



Target Suggested	Increase RWH by improvements in RWH design
Implementation Status	Yes
Results	Performance indicator was added in ISO EHSMS objective and targets Selection of indicator was qualified as stakeholder requirement captured. Implementation result shows 8% increase from base year

Energy:

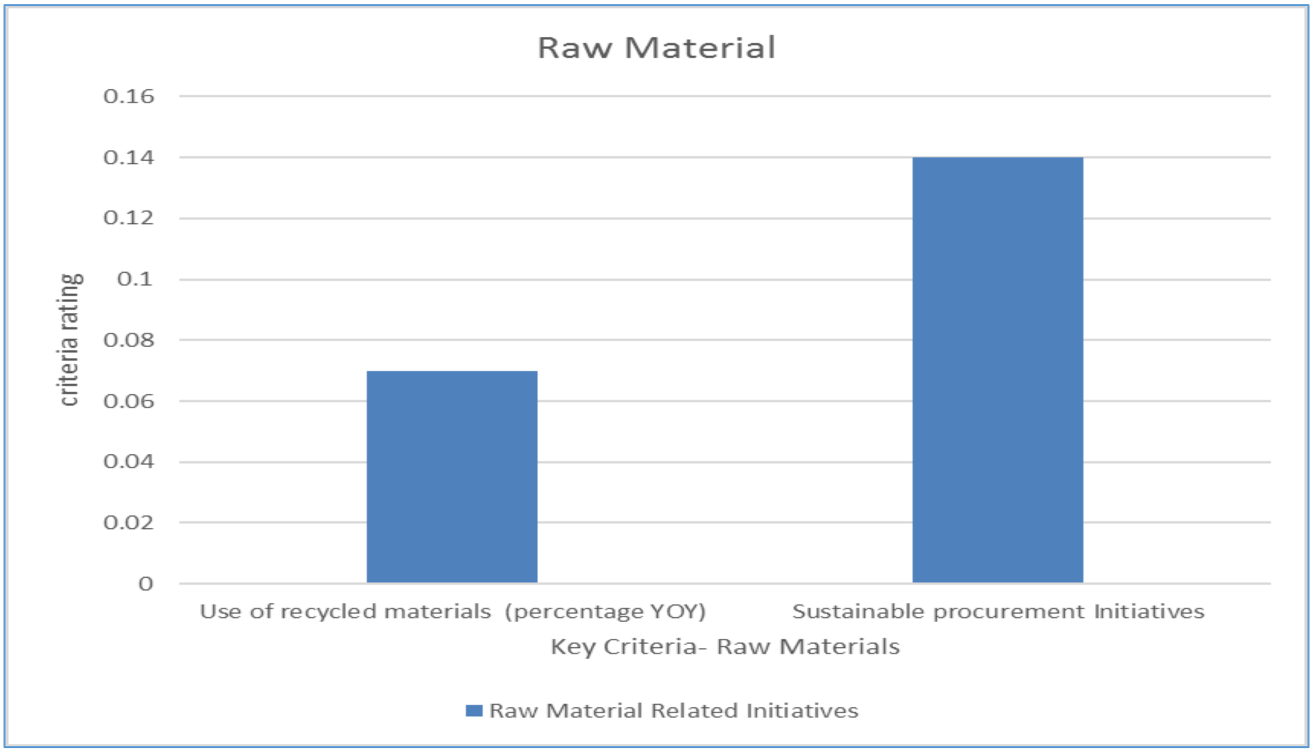
Figure-35 P-2 Energy Sub Indicator rating



Target Suggested	Scope 3 energy to be monitored and tracked to measure the potential reduction in future
Implementation Status	Tracking started and reduction target to be decided
Results	Performance indicator was identified as improvement project under EHSMS Monitoring started and it has been recognized as one of the effective initiatives under energy saving under supply chain category.

Raw Material:

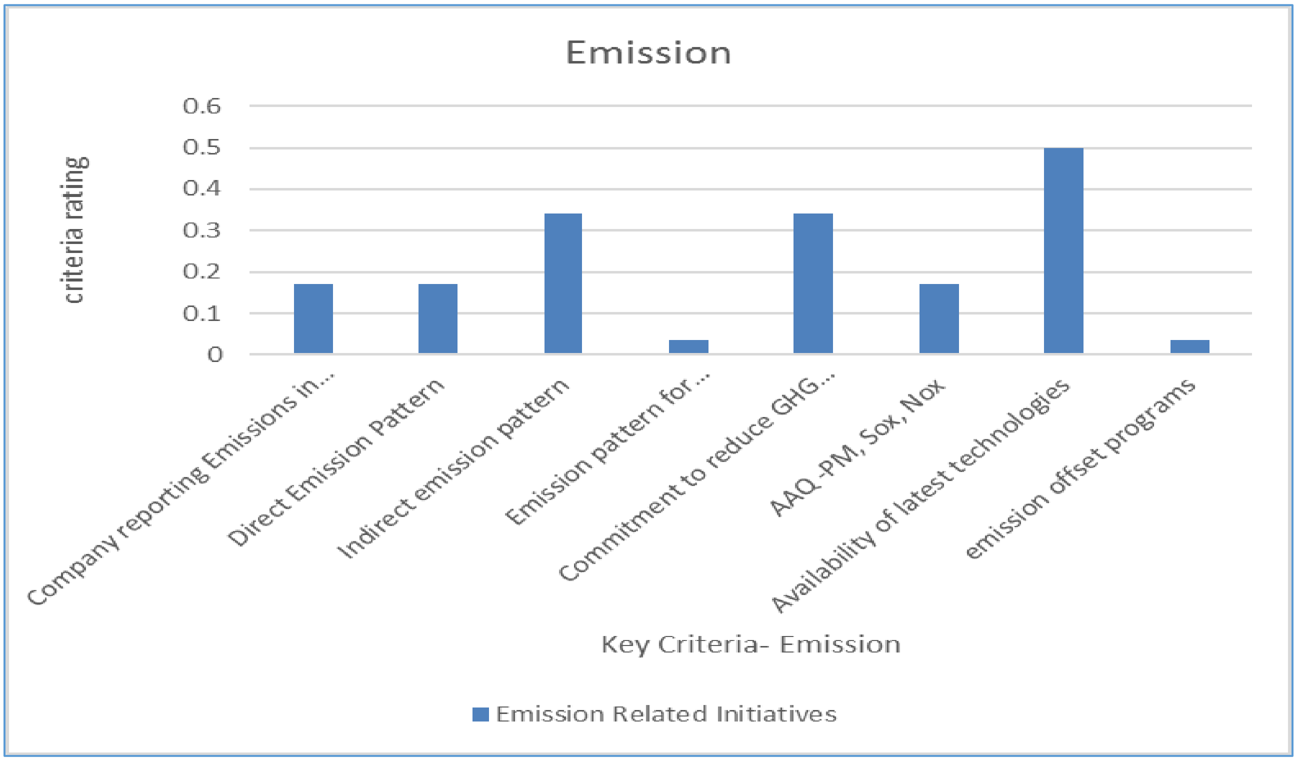
Figure-36 P-2 Raw Material Sub Indicator rating



Target Suggested	Increase the recycle material usage
Implementation Status	Yes
Results	6 % increase from base year Under ISO objective and target it has been identified as resource conservation potential area and targeted under sustainability target.

Emission:

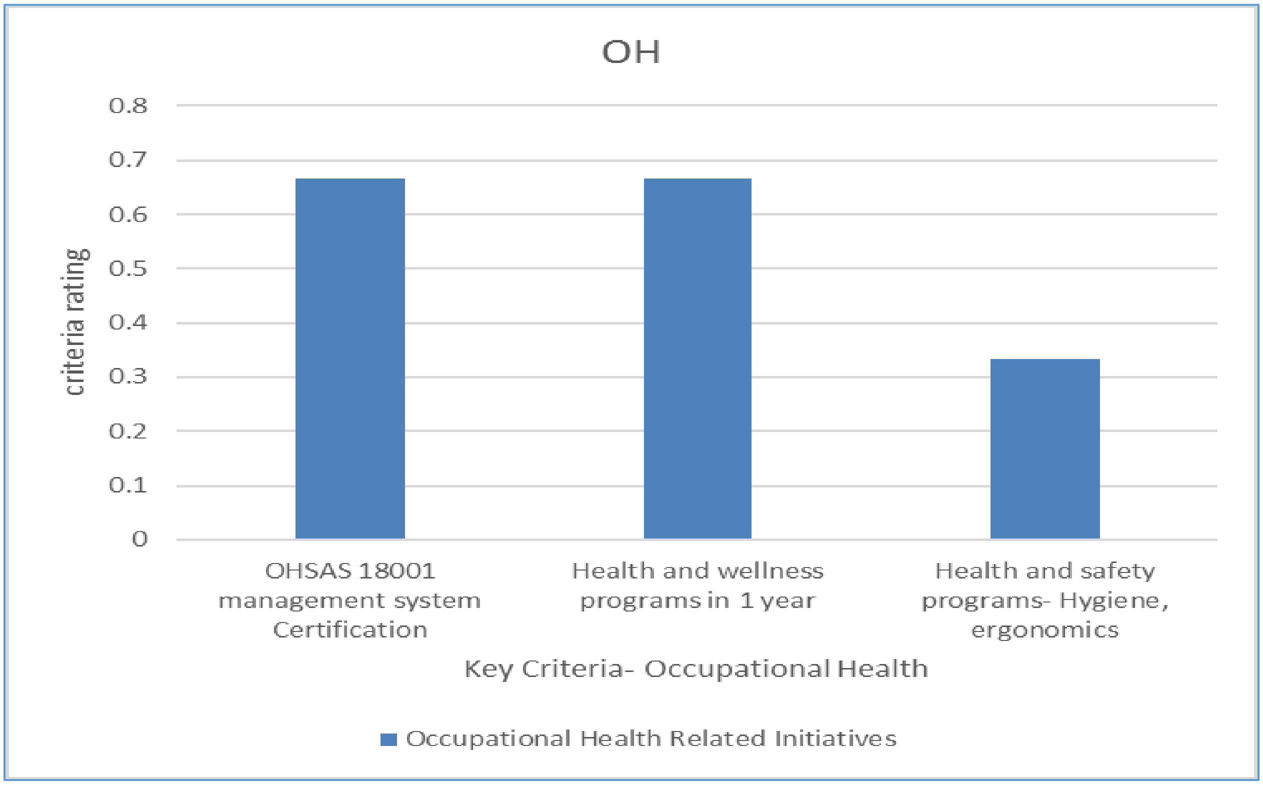
Figure-37 P-2 Emission Sub Indicator rating



Target Suggested	Decrease the emissions from direct energy source
Implementation Status	Not implemented
Results	Not shared

Occupational Health:

Figure-38 P-2 Occupational health Sub Indicator rating



Target Suggested	Increase the trainings on PPE usage for health safety
Implementation Status	Yes
Results	Trainings on Use of PPEs were focused and results shows that there is 28% improvement in Unsafe act reporting related to PPEs

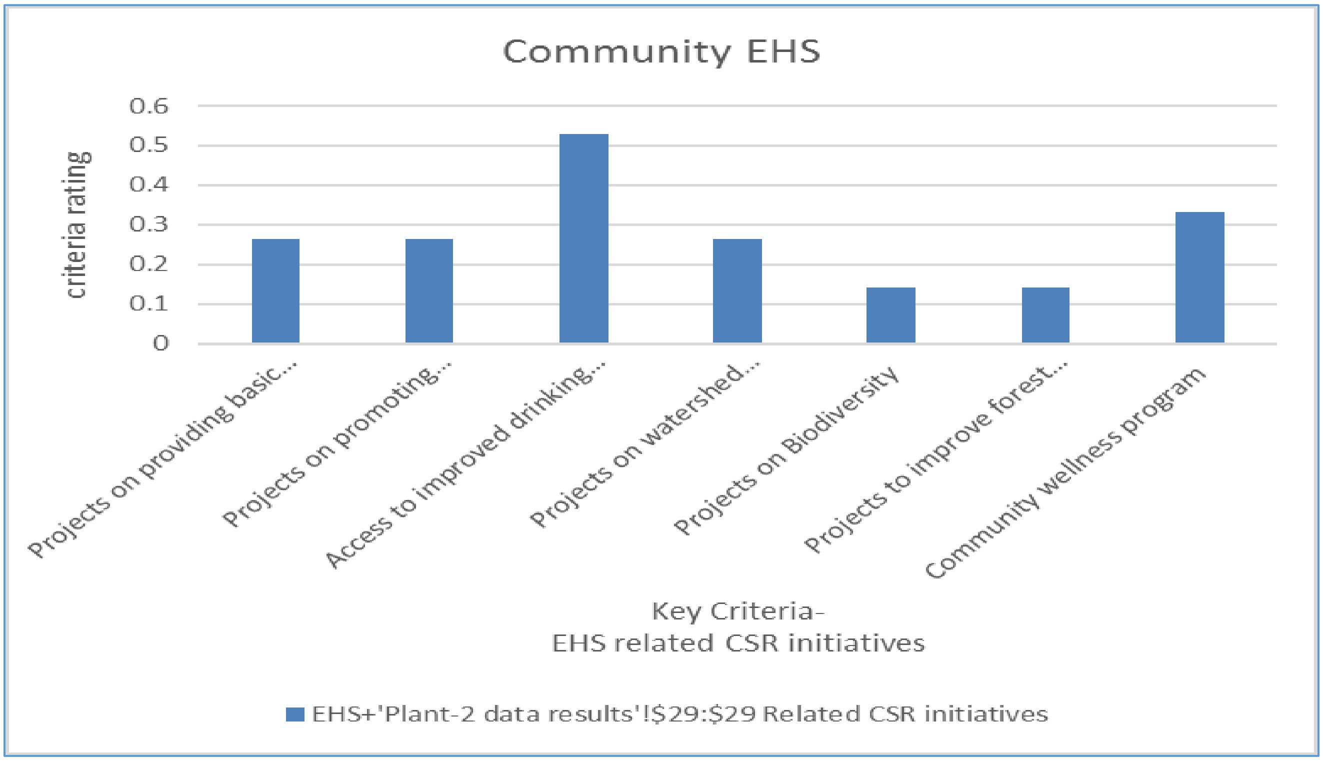
Safety:

Figure-39 P-2 Safety Sub Indicator rating

Target Suggested	Increase the safety training by implementing BBS program
Implementation Status	BBS Program has been implemented and Avoiding PPE usage was one of the cases identified under behavioral List of top safety issues.
Results	Performance indicator was added in OHSAS objective Selection of indicator was qualified as stakeholder requirement captured. In cycle-1 of BBS- 26% Decrease in First aid cases observed due to avoidance of PPE use.

Community EHS Projects

Figure-40 P-2 Community EHS Sub Indicator rating



Target Suggested	Focus on green belt projects for community
Implementation Status	Yes, project for green belt in nearby city on road dividers were implemented
Results	Number of trees planted under the green belt project was increased from base year. This was one of the projects for urban area near plant under world environment day occasion. In terms of spending, 46 % of spending was increased on green belt development project from base year.

IX. Summary of EHS Index- Maturity Rating

Table-36 Maturity Rating

Sample Cement Companies	**EHS Index for Sustainability**	
	EHS Indicator Rating for sustainability	**Sustainability maturity Level**
	0.05	Unsustainable
	0.1	Evolving towards sustainable
	0.5	Moderately Sustainable
	1	Highly Sustainable
Company-E- Plant-1	0.20	Towards Moderately sustainable
Company-C-Plant-2	0.28	Towards Moderately sustainable

X. PUBLISHED PAPER

9.1 Published Papers

- Mishra, Shraddha, and N. A. Siddiqui. "A review on environmental and health impacts of cement manufacturing emissions." International journal of geology, agriculture and environmental sciences 2.3 (2014): 26-31.

- Mishra S., Siddiqui N.A. (2018) A Review of CSR Activities Under Companies Act 2013 and Enterprise Social Commitment Under Environment Clearance for Major Cement Industries in India. In: Siddiqui N., Tauseef S., Bansal K. (eds) Advances in Health and Environment Safety. Springer Transactions in Civil and Environmental Engineering. Springer, Singapore

- Mishra, S., Siddiqui N.A. & Ashutosh Gautam (2019). Emerging Environment Health and Safety Indicators and Criteria to Establish sustainability Index for Cement Industry, International Journal of Scientific & Technology Research Volume 8, Issue 09, September 2019

Emerging Environment Health And Safety Indicators And Criteria To Establishsustainability Index For Cement Industry

Shraddha Mishra, Nehal Anwar Siddiqui Health, AshutoshGautam

Abstract: Numerous researches have determined sustainability criteria for assessmentof sustainability performance considering economic, environment and social indicators. To define sustainable EHS practices, industry must identify the criteria for sustainability to make choice and prioritizing the focus areas. For improving Environment health and safety (EHS) performance, it is required to emphasizecriteria specific to EHS with consideration to nature of industry.The aim of this paper is to present an approach for identifying emerging sustainability criteria for environment, health and safety & community initiatives and proposing sustainability index for evaluating sustainability effectiveness. By studyingin-depth EHS indicatorsspecific to cement industry, indicators have been divided in sub indicators and totalForty-six (46) criteria were established for study.Analytic Hierarchy Process (AHP) tool was employed to derive weights for prioritizing identified sustainability criteria for developing Sustainability This work is an attempt to establish a linkage between sustainability and environment health and safety and indicate the requirement of integration of environmental management system, Occupational health and elements of sustainability and social responsibility.

Index Key Words : Cement Sustainability; EHS indicators;Environment Indicators for Cement Sustainability;Sustainable EHS practices; Sustainability criteria; Sustainability index

1. INTRODUCTION

In the last decade sustainability has emerged as an imperative for business across the globe considering the 3 Ps (Planet, people and profit). To survive in market the organizations must demonstrate the equilibrium in climate change, resource availability, impact of businesses on people, supply chain and making profits at the same time. Under the umbrella of Sustainability Environment, health and safety are the important aspects in gauging organization's business sustainability. Initially, most emphasis was placed on the environmental topics such energy consumption, pollution from emissions, water usage and biodiversity. However, in recent years, with the development in Environment health and safety standards other aspects have also been undertaken: renewable energy, health and safety, community related EHS impacts etc. while considering sustainability [1]. Sustainable development and Environment, occupational health and safety (EHS) are the two allied concepts which are also considered as essential elements in running a successful business with the ability and competency to survive in the market [2]. There are several papers discussing the connection among sustainable development, economic performance, environment, people, supply chain, society, stakeholder engagement etc. but the role of occupational health, workplace safety, EHS focused community initiatives not widely considered for sustainable development. For this research the broad category of Environment, health & Safety and Community EHS initiatives have been divided into sub indicators which are as follows:

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- *Dr. AshutoshGautam, Jt. GM, India Glycol Ltd*

Consumption and conservation of Water and energy, conservation of raw material and recycling, GHG and other emissions, occupational health and occupational safety, Community projects on water and energy, green belt development and community health care. These sub indicators were ranged into set of criteria [12], [15].

2. METHOD USED FOR BUILDING SUSTAINABILITY INDEX FOR EVALUATING SUSTAINABILITY PERFORMANCE

The main procedures for building a sustainability index include selecting appropriate sustainability indicators, weighting the selected indicators, and aggregating those indicators into a composite index [3]. The set of sustainability criteria identified under the EHS Indicator and sub indicators by studying the emerging global sustainability practices though research papers [6],[7],[9], industry practices and available relevant literature [10],[17],[18].

3. IDENTIFICATION OF EHS INDICATORS AND CRITERIA FOR SUSTAINABILITY

Now a days organizations have started using environmental and social indicators to determine the performance of business activities. Some of the largest companies are reporting their sustainable performance in their sustainability reports. These reports are largely based on the GRI framework, where the key aspects of social and environmental activities are covered. The World Business Councilfor Sustainable Development (WBCSD), the International Standards Organization (ISO), and the Global Reporting Initiative (GRI) were the key drivers for implementation of sustainability practices in industries [20], [21]. Although there are numerous sustainability indicators which are diverse in nature and have been developed voluntarily for the purpose of sustainable business practices [20]. For cement industry the most commonly used indicators for sustainable manufacturing is referred from the cement sustainability initiatives (CSI) under World Business

Council for Sustainable Development (WBCSD). CSI guidelines include parameters like GHG emissions and other emissions from cement manufacturing, co-processing of fuels and materials, safety and water consumption. Energy consumption has been identified as one of the key drivers for CO2emissions in the cement sector. It also defines emissions of dust, NOx, SO2, VOC, heavy metals and dioxins/ furans, water withdrawal, discharge and consumption, improvement in water balancing, work-related fatalities and injuries etc. as the Key Performance Indicators (KPIs).Besides, there are number of indicators proposed by Global Reporting Initiative (GRI) which focus on the organization's significant economic, environmental and social impacts. It talks about labour practices, decent work, human rights, product responsibility, society, energy, water, emission, waste, effluent, conservation mechanism etc. under Social and environment section. UN Global Compact is another voluntary initiative to implement universal sustainability principles to take steps to support UN goals for sustainability which are also known as sustainable development goal (SDG). UN framework considers equity, health, education, security, population, atmosphere, land, ocean, fresh water and biodiversity under social and environment section.Apart from sustainability frameworks, Environmental Management System (EMS) and Occupational Health and safety management system are structured systems which helps an organization to identify the environmental and OH&S impacts resulting from its business activities [22]. Under EMS standard talks about Prevention of pollution, which considers all the environment aspects (Air, water, Noise, land, emission, waste etc.) with respect to all the activities, product and services of the company. Whereas OH&S system covers Hazard identification and risk assessment process which evaluates all the activities, product and services of the company against Health and safety performance. It requires to form control procedures and management systems for improved EHS performance [23], [24]. The list of criteria is given in the table which was used for developing the index for evaluating the sustainability maturity and effectiveness.

EHS Sub indicators	Sr No.	Key Criteria
Water Consumption and Conservation	1	ISO 14001 management system certification
	2	Fresh water consumption pattern (YOY)
	3	Ground water resource extraction pattern (YOY)
	4	Water Metering and management
	5	Waste Water Treatment and Reuse (reused percentage of fresh water consumption)
	6	Water Quality of effluent water
	7	Zero discharge plants
	8	Rainwater Harvesting (YOY)
	9	Ground water recharge
Energy Consumption and Conservation	10	ISO 50001/SS 564 management system certification
	11	Energy consumption pattern- Direct Energy (fuel) (YOY)
	12	Energy consumption pattern- Indirect Energy (grid electricity) (YOY)
	13	Energy consumption pattern for supply chain/ employee commute not under direct control of company (YOY)
	14	Company conducts Environment and Energy Audit
	15	Energy Efficiency Initiatives
	16	Alternate fuels Usage as a percentage of total energy (YOY)
	17	Renewable energy usage as a percentage of total energy (in a given year)
	18	PAT implementation and status
	19	Renewable purchase obligation status
Raw material Consumption and recycling	20	Use of recycled materials as a percentage of total Raw material used
	21	Sustainable procurement Initiatives
	22	Company reporting Emissions in CDP/ as per ISO 14064
	23	Direct Emission Pattern
	24	Indirect emission pattern
	25	Emission pattern for supply chain/ employee commute not under direct control of company
GHG and other Emission reduction	26	Commitment to reduce CHG emissions with timelines.
	27	AAQ -PM, Sox, Nox
	28	Availability of latest technologies
	29	emission offset programs
Occupational Health	30	OHSAS 18001 management system Certification
	31	Health and wellness programs in 1 year
	32	Health and safety programs- Hygiene, ergonomics
Workplace Safety	33	Frequency Rate (FR) – Number of recordable incidents per 1 million man-hours worked/year less than the national average
	34	Severity rate (SR) – Number of man days lost per 1million man-hours worked/year - less than the national average
	35	Loss time injury rate
	36	Program on Behavior based safety
	37	EHS Trainings
	38	Safe work place initiatives to boost employee morale
	39	EHS committee and meetings
Community project-Water and Energy Resources conservation	40	Projects on providing basic amenities
	41	Projects on promoting sustainable agriculture and forestry
	42	Access to improved drinking

		water source
	43	Projects on watershed protection
Community project-Green Belt development	44	Projects on Biodiversity
	45	Projects to improve forest cover
Community project-Community Healthcare	46	Community wellness program

Table-A [5,8,11.13]

4. Determining the Importance of Indicators and Sub Indicators Using the AHP Approach

Indicators were divided in sub indicators to study the detailed criteria of each sub indicator for defining sustainability [14]. After defining the sub indicators, the weights of importance of the parameters are determined. Often the weights are determined basis the shared opinion of stakeholders the interest party [19]. The group usually consists of stakeholders who are impacting or getting impacted by the industrial operations. Here, the three aspects of EHS were compared by using AHP considering the global trend on reporting on sustainability. The analytic hierarchy process (AHP) is frequently used to determine the shared opinion of the group as one of the most frequently used methods for multiple-criteria decision-making. AHP allows to make decisions concerning complex content by simplifying the natural decision-making basis pairwise comparisons between parameters. To obtain weights for sub indicators, a survey was carried out through online mode, in which a link of questionnaire was shared with industry people. The questionnaire comprised of pairwise comparisons of the sub indicators. Basis received Reponses the AHP online module was used to allocate the response in pairwise comparisons which used the scale of 1-9. Tables below show the list of sub indicators used for comparison. Pair-wise comparison scale and Numerical Rating for AHP preferences were as follows: 1- Equal Importance, 3- Moderate importance, 5- Strong importance, 7- Very strong importance, 9- Extreme importance (2,4,6,8 values in-between) [4]. Once responses are allocated, it is necessary to check that they are consistent. Since the numeric values are derived from the subjective preferences of stakeholders which results in some inconsistencies in the final matrix of judgment. AHP calculates a consistency ratio (CR) and compares the consistency index (CI) of the matrix in question and the consistency index of a random-like matrix (RI) which is expected to be highly inconsistent [3]. AHP defines the consistency ratio as CR where CR = CI/RI. A consistency ratio (CR) of 10% or less is acceptable to continue the AHP analysis [4]. If the consistency ratio is greater than 10% it is necessary to revise the judgments. Although here the AHP calculation has been done using the AHU software [16]. The results of indicator and sub indicator weights allocation using the AHP method are shown in the given below.

	Category	Priority	Rank
1	Environment	59.4%	1
2	Occupational Health and Safety	24.9%	2
3	Community EHS Practices and initiative	15.7%	3

Number of comparisons = 3, Consistency Ratio CR = 5.6%
Priorities for Environment Sub indicators: Following are the resulting weights based on pairwise comparisons

	Category	Priority	Rank
1	Water Consumption and Conservation	23.9%	3
2	Energy Consumption and Conservation	28.1%	2
3	Raw material consumption and recycling	14.0%	4
4	GHG and other Emission reduction	34.0%	1

Number of comparisons = 6, Consistency Ratio CR = 2.2%
Priorities for Occupational Health and Safety Sub indicators: Following are the resulting weights based on pairwise comparisons

	Category	Priority	Rank
1	Occupational Health	66.7%	1
2	Occupational safety	33.3%	2

Number of comparisons = 1, Consistency Ratio CR = 0.0%
Priorities for community Projects and initiatives Sub indicators: Following are the resulting weights based on pairwise comparisons

	Category	Priority	Rank
1	Community project-Water and Energy Resources	52.8%	1
2	Community project-Green Belt development	14.0%	3
3	Community project-Community Healthcare	33.3%	2

Number of comparisons = 3, Consistency Ratio CR = 5.6

5. RESULTS AND DISCUSSION

The results demonstrate the greatest importance to the quality of the environment (user aspect), whose weight is 59.4% followed by health and safety and community projects and initiatives with weight of 24.9 and 15.7 % respectively. For the sub indicators of environment GHG and other emissions scored highest priority (34%) followed by energy consumption and conservation (28.1), water consumption and conservation (23.9) and the lowest weight for raw material consumption and recycling (14%). In Occupational health and safety occupational health scored 66.7% and safety 33.3%. Under Community projects and initiatives, the water and energy scored the highest (52.8%) followed by community health care (33.3%) and green belt development (14%). Although the sub indicator scored lowest does not mean that they are the least important. In fact, it interprets that the lowest scored sub indicators have least impact on stakeholders in comparison to the highest scored sub indicators with the current practices and approaches towards EHS. The resulted index was presented in the form as shown in the table B.

SUMMARY AND CONCLUSIONS

The sustainability maturity rating for the given criteria and the allocated weightage of indicator and sub indicator establishes the index which helps in evaluating sustainability effectiveness. The maturity ratings and weights were multiplied to identify EHS indicator rating for sustainability and defining overall effectiveness. Sustainability maturity ratings were defined with three stages- Highly sustainable, moderately sustainable, evolving towards sustainable. The study has established a significant linkage between EHS and Sustainability. Integration of EHS and sustainability management programs have created comprehensive and extensive framework for the cement companies focusing on sustainable development encompassing social and environment indicators.

EHS Index for Sustainability

EHS Indicator Rating for sustainability	Sustainability maturity Level	Sustainability Effectiveness
50 - 59	Evolving towards sustainable	low
60 - 74	Moderately Sustainable	Medium
75 - 100	Highly Sustainable	High

The sustainability performance evaluation can be d through index which comprises set of EHS indicators. ratings resulting from the established index plays major in decision making for company's sustainak performance and future actions. There is future scop work in this research as the similar index can established for other industries by setting criteria specifi the nature of industry.

Table-B

	EHS Indicators	EHS Sub indicators	Sr No.	Key Criteria	1	0.5	0.1	Matuarity level rating	weights
					Highly Sustainable	Moderately Sustainable	Evolving towards sustainable		
Identify Emerging sustainability criteria	Environment	Water Consumption and Conservation	1	ISO 14001 management system certification	certified	under certification	no certification		0.239
			2	Fresh water consumption pattern (YOY)	Consmp. less than 10%-20%	Consmp. less than 5%-10%	Consmp. less than 5%		0.239
			3	Ground water resource extraction pattern (YOY)	extact. less than 10%-20%	extact. less than 5%-10%	extact. less than 5%		0.239
			4	Water Metering and management	Well managed program	Initiated program	No program		0.239
			5	Waste Water Treatment and Recycle (recycle percentage of fresh water consumption)YOY	recycle more than 30%	recycle more than 20%	recycle more than 10%		0.239
			6	Water Quality of effluent water	Quality improved beyond regulatory limits	Quality meets regulatory limits	Tries to meet regulatory limits		0.239
			7	Zero discharge plants	Yes	Initiated program	No		0.239
			8	Rainwater Harvesting (YOY)	Harvested more than 10%	Harvested more than 5%	Harvested more than 1%		0.239
			9	Ground water recharge	Qunatified	Initiated program	No data available		0.239
Identify Emerging sustainability criteria	Environment	Energy Consumption and Conservation	1	ISO 50001 management system certification	certified	under certification	no certification		0.281
			2	Energy consumption pattern- Direct Energy (fuel) (YOY)	Direct Energy consmp reduced more than 5%	Direct Energy consmp reduced more than 2%	Direct Energy consmp consistant		0.281
			3	Energy consumption pattern- Indirect Energy (grid electricity) (YOY)	Indirect Energy consmp reduced more than 10%	Indirect Energy consmp reduced more than 5%	Indirect Energy consmp consistant		0.281
			4	Energy consumption pattern for supplychain/ employee commute not under direct control of company (YOY)	Monitored	To be Monitored	No Monitoring		0.281
			5	Company conducts Environment and Energy Audit	once a year	Once in 2-3 years	Never conducted		0.281
			6	Energy Efficiency Initiatives	Well managed program	Initiated program	No program		0.281
			7	Alternate fuels Usage as a percentage of total energy (YOY)	AF used	AF to be used	No AF used		0.281
			8	Renewable energy usage (YOY)	RE used more than 50%	RE used up to 50%	RE use started		0.281
			9	PAT implemetation and status	Achieved and traded	Achieved	Not achieved		0.281
			10	Renewable purchase obligation status	Complied beyond target	Complied	Not Complied		0.281
Identify Emerging sustainability criteria	Environment	Raw material Consumption and recycling	1	Use of recycled materials (percentage YOY)	Recyled mat. used more than 50%	Recyled mat. used up to 50%	Recyled mat. use started		0.14
			2	Sustainable procurement Initiatives	Well managed program	Initiated program	No program		0.14
		GHG and other Emission reduction	1	Company reporting Emissions in CDP/ as per ISO 14064	Disclosed with A rating	Disclosed with less than A rating	No disclosure		0.34
			2	Direct Emission Pattern	Direct Emission reduced more than 5%	Direct Emission reduced more than 2%	Direct Emission consistant		0.34
			3	Indirect emission pattern	Indirect Emission reduced more than 10%	Indirect Emission reduced more than 5%	Indirect Emission consistant		0.34
			4	Emission pattern for supplychain/ employee commute not under direct control of company	usage >25%	10-25%	0%-10%		0.34
			5	Commitment to reduce GHG emissions with timelines.	Monitored	To be Monitored	No Monitoring		0.34
			6	AAQ -PM, Sox, Nox	AAQ improved beyond regulatory limits	AAQ meets regulatory limits	Tries to meet AAQ regulatory limits		0.34
			7	Availability of latest technologies	State of Art technology adopted	technology upgaradationin process	technology upgaradation to be done		0.34
			8	emission offset programs	Well managed program	Initiated program	No program		0.34

Identify Emerging sustainability criteria	Occupational Health and Safety	Occupational Health	1	OHSAS 18001 management system Certification	certified	under certification	no certification		0.667
			2	Health and wellness programs in 1 year	1 or more program per month/ qtr	1 program per Six Month/ year	No program		0.667
			3	Health and safety programs- Hygiene, ergonomics	1 or more program per month/ qtr	1 program per Six Month/ year	No program		0.667
		Workplace Safety	1	Frequency Rate (FR) – Number of recordable incidents per 1 million man-hours worked/year (less than theindustry average)	Zero FR	FR above 25% of the industrial average	FR above 50% of the industrial average		0.333
			2	Loss time injury	zero fatal incident	Minor Incident but no fatal incident	fatal incident		0.333
			3	Program on Behaviour based safety	Well managed program	Initiated program	No program		0.333
			4	EHS Trainings	Well managed program	Initiated program	No program		0.333
			5	Safe work place inititives to boost employee morale	Well managed program	Initiated program	No program		0.333
			6	EHS committiee and meetings	Well managed program	Initiated program	No program		0.333
Identify Emerging sustainability criteria	Community EHS Practices/ initiative	Environment Initiatives- Water conservation and forestry and basic amenities	1	Projects on providing basic amentities	Results monitored and quantified	Results monitored but not quantified	No program		0.528
			2	Projects on promoting sustainable agriculture and forestry	Results monitored and quantified	Results monitored but not quantified	No program		0.528
			3	Access to improved drinking water source	Results monitored and quantified	Results monitored but not quantified	No program		0.528
			4	Projects on watershed protection	Results monitored and quantified	Results monitored but not quantified	No program		0.528
		Community project-Green Belt development	5	Projects on Biodiversity	Results monitored and quantified	Results monitored but not quantified	No program		0.14
			6	Projects to improve forest cover	Results monitored and quantified	Results monitored but not quantified	No program		0.14
		Community project- Community Healthcare	7	Community wellness program	Results monitored and quantified	Results monitored but not quantified	No program		0.33

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A Review On Environmental and Health Impacts Of Cement Manufacturing Emissions

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Abstract: ***Climate change is considered as major environmental challenge for the world. Emissions from cement manufacturing are one of the major contributors in global warming and climate change. Cement manufacturing is a highly energy intensive process, which involves intensive fuel consumption for clinker making and resulting in emissions. Beside Fuel consumption, the calcining process is a major source of emissions such as NOx, SOx, CO2, particulate matters etc. In this paper, the role of cement industry is reviewed in causing impact on environment and health. It describes the cement production process and its emission sources followed by overview of emissions and their environmental and health impacts. Review study has focused on emission generation from clinker production and excluded the emissions due to indirect energy (electricity, transportation, supply chain etc.) used for cement operations. This review observed a comprehensive literature in term of peer reviewed journals, industry sector reports, websites etc on cement industry and associated emissions and health impacts.***

Keywords: Cement manufacturing, emissions, SO_2, NO_x, PMs, CO_2, environmental impact, health impacts, sustainability.

1. Introduction

It is impossible to envisage a modern life without cement. Cement is an extremely important construction material used for housing and infrastructure development and a key to economic growth. Cement demand is directly associated to economic growth and many growing economies are striving for rapid infrastructure development which underlines the tremendous growth in cement production **[1]**. The cement industry plays a major role in improving living standard all over the world by creating direct employment and providing multiple cascading economic benefits to associated industries. Despite its popularity and profitability, the cement industry faces many challenges due to environmental concerns and sustainability issues **[2]**.

The cement industry is an energy intensive and significant contributor to climate change. The major environment health and safety issues associated with cement production are emissions to air and energy use. Cement manufacturing requires huge amount of non renewable resources like raw material and fossil fuels. It is estimated that 5-6% of all carbon dioxide greenhouse gases generated by human activities originates from cement production **[2]**. Raw material and Energy consumption result in emissions to air which include dust and gases. The exhaust gases from a cement kiln contains are nitrogen oxides (NOx), carbon dioxide, water, oxygen and small quantities of dust, chlorides, fluorides, sulfur dioxide, carbon monoxide , and still smaller quantities of organic compounds and heavy metals **[3]**. Toxic metals and organic compounds are released when industrial waste is burnt in cement kiln. Other sources of dust emissions include the clinker cooler, crushers, grinders, and materials-handling equipment.

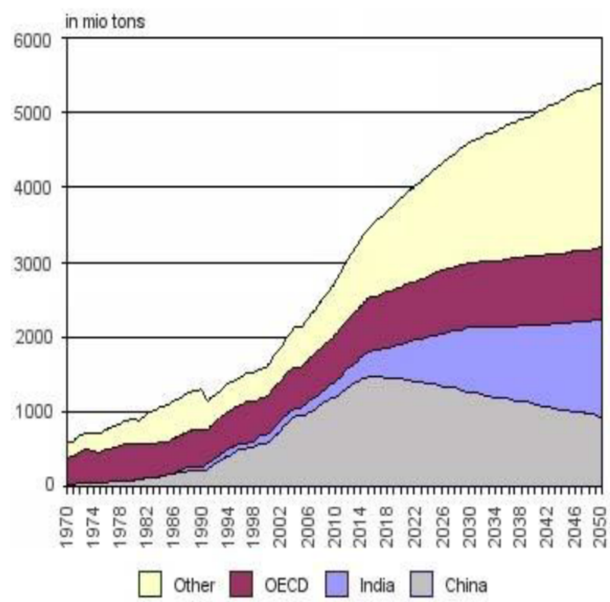

Figure 1: Global Cement Production 1970-2050 **(**Source: International Energy Agency (IEA)

These emissions are not only deteriorating air quality but also degrading human health. Emissions have local and global environment impact resulting in global warming, ozone depletion, acid rain, biodiversity loss, reduced crop productivity etc **[4]**. Scientific evidence indicates that air pollution from the combustion of fossil fuels causes a spectrum of health effects from allergy to death **[5]**. The results of several studies showed that these emissions are adversely affecting human health in a variety of ways, like itchy eyes, respiratory diseases like tuberculosis, chest discomfort, chronic bronchitis, asthma attacks, cardio-vascular diseases and even premature death **[6], [7]**.

2. Cement Manufacturing Process:

The main component of cement is clinker, which is produced from raw materials, such as limestone and clay. **[8]**. Limestone supplies $CaCO_3$ for the cement production. Silica, alumina, and iron are considered to be other raw materials. The lime stone used for cement manufacturing contains 75-90 % of $CaCo_3$ and remainder is $MgCo_3$ and impurities **[11]**. Raw material is extracted through mining and quarrying which follows drilling, blasting, excavating, handling, loading, hauling, crushing, screening, stockpiling, and storing **[10]**.

A specific composition of the raw materials are crushed and then milled into a raw meal for the quality and uniformity of cement. This raw meal is blended in blending silos and is then heated in the pre-heating system. This process dissociates carbonate to calcium oxide and carbon dioxide **[11]**. It can be accomplished by any of three processes: the dry process, the wet process, or the semidry process **[10]**. In a dry cement manufacturing process, dry raw mix contains less than 20% moisture by mass. However, in a wet process water is added to the raw mix to form slurry and then is transported to the kiln **[11]**.

Raw meal or blended raw materials are fed into the upper end of the pre-heater tower and then passed through the end of the rotary Kiln. A rotary kiln is a tube with a diameter up to about 6 m. which is installed at a horizontal angle of 3°–4° and rotates slowly with about one to four RPM **[9]**. The Kiln rotates and the ground raw material moves down toward the flame. As the temperature increases, the sequence of chemical and physical changes starts with reaction taking place between calcium oxide and other elements. This reaction will produce calcium silicates and aluminates at about 1500˚ C. The flame can be produced by fuel materials such as coal, petroleum coke, or by natural gas, oil, biomass, industrial waste and recycled materials. A series of chemical reactions will take place and the raw material will be melted and fused together to form a clinker. The clinker is discharged as red-hot at approximately 1500°C from the end of the kiln, which is passed through coolers, where the excess heat is recovered. Most commonly cooling of the clinker can be performed in a grate cooler, a tube (rotary) cooler, or a planetary cooler. It recovers up to 30% of kiln system heat and route it back to the pre-heater units **[9], [10], [11], [12]**.

In the final step, clinker is ground together with additives (e.g., fly ash, blast furnace slag, pozzolana, gypsum, and anhydrite) in a cement mill to control the properties of the cement. Combinations of milling techniques including ball mills, roller mills, or roller presses are often applied to ground clinker with additives in cement mill. The finished cement is being transferred via bucket elevators and conveyors to silo for storage **[9]**.

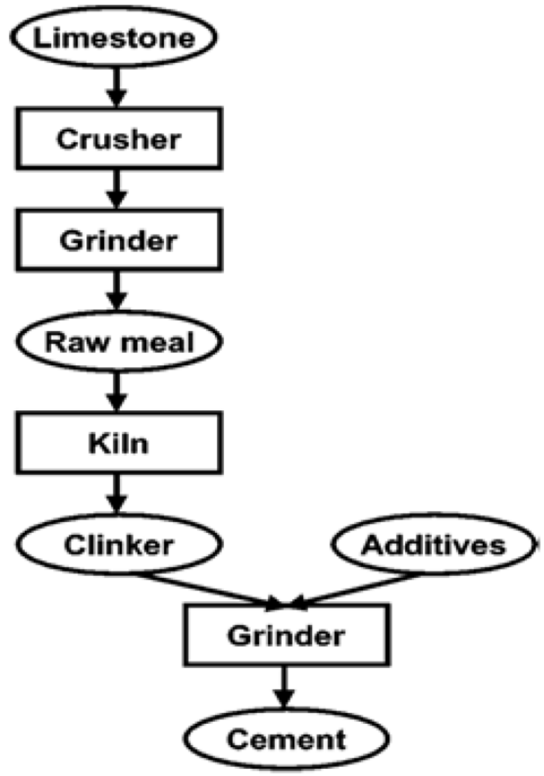

Figure 2: Cement Manufacturing Process

3. Emissions from cement manufacturing

The most significant environment health and safety issue of cement manufacturing is emission **[15]**. Cement industry is potential anthropogenic source of air pollution. It has estimated that cement production originates about 5% of global manmade CO_2 emissions **[13]**. The typical gaseous emissions to air from cement production include NOx, SOx, CO, CO_2, H_2S, VOCs, dioxins, furans and particulate matters **[14], [15], [16]**. These major pollutants can be classified in two categories- gaseous and particulates. Fuel combustion process is the source of gaseous emissions which include oxides of nitrogen, oxides of sulfur, oxides of carbon and volatile organic compounds and hydrogen sulfide. Quarrying, drilling, blasting, hauling, Cement mill, fuel preparation, packaging, road cleaning and stacks are sources of particulate matter in the form of dust and carbon particle **[14], [15], [16]**.

There are many other sources of emissions from cement manufacturing, such as emissions from transportation equipment used in the mining and transporting raw and finished material, fuel used for electricity production for operating other process in cement manufacturing **[23]**.
Types of fuel used in cement industries for few selected countries **[11]**

system and Pm less than 2.5 μm go on to the lungs and pass into the blood stream. It is determined that short term exposure to Particulate matters ($PM_{2.5}$) significantly increases the risk for cardiovascular and respiratory diseases. PM can also cause eye and throat irritation, bronchitis, lung damage, increased mortality rates, increased heart ailments **[5], [16], [21], [24], [25].** Some studies show that cement dust can cause respiratory and non respiratory diseases **[20]**.

Cement dust also affects plant productivity due to reduced chlorophyll content of the leaves which obstruct the photosynthesis process. It has adverse impact on agriculture in nearby areas.

VOCs, dioxins, heavy metals and other pollutants:

Other cement related emissions in trace quantity include VOCs, dioxins, furans, methane, heavy metals etc. The main source of VOC emission from cement kiln is organic matter present in raw material. Occurrence of VOCs is also associated with incomplete combustion. Heavy metal emission depends on content of these trace elements in fuel and raw material, which is naturally present in low concentration. In cement manufacturing dioxins are also formed in the combustion system when chlorine and organic compounds are present. Choice of raw material and fuel with low organic matter, with low content of volatile and semi-volatile heavy metals can reduce these emissions.

VOCs are precursor to ozone formation, which can also contaminate soil and ground water. It has been identified that VOCs can cause retardation of plant growth, chlorosis and necrosis in broad leaves plants. VOCs can cause potential health hazard like irritations in respiratory tract and eyes, headache, nausea, damage to liver, kidney and central nervous system. It is also known as potential carcinogen. Heavy metals and dioxins can also contaminate soil and water. Heavy metals can adversely affect plant functions and cell structure. Bioaccumulation of heavy metal can cause poising in aquatic and terrestrial life through biomagnifications. Heavy metals can cause damage to brain and nervous system, increased blood pressure, affect on gastrointestinal functions and reproduction. Dioxins and furans can also cause health impact like Skin rashes, liver damage, weight loss, reduction in immunity **[31]**.

6. Summary & Conclusion

It is well known fact that air pollution is hazardous to environment and human health. Due to infrastructure developmental activities cement industry is flourishing and resulting in the environmental deterioration and in turn degradation of the human health worldwide. The gaseous and particulate emissions from cement plants are degrading air quality and thus creating considerable environmental pollution especially air pollution **[32]**.

Recent studies and researches have listed the cement industry as one of the major contributor in global warming and climate change. Literature reviewed in this study shows the clear picture of dire consequences of emissions from cement manufacturing for rapid infrastructure growth and economic development. From this review it can be concluded that cement industry causes a tremendous harm to ecology and human health. The main environment and health concerns have identified are significant amount of fine dust and gaseous emissions. Gaseous emissions can have major impact on surroundings and ecology resulting in deteriorated environment. Workers and communities exposure to dust emission is associated with numerous health issues. For the sustainable development it is recommended to focus on effective emission control technology, energy efficiency, adoption of state of art technology and global synergy in environment friendly technologies.

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XI: CURRICULUM VITAE

Shraddha Mishra

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Experience Summary

Environment, Health and Safety professional with 10+ Years' of Experience in the core field of Environment, Health, Safety (EHS) and Sustainability with expertise in designing and implementing Environment Health Safety Management system for various industries as per ISO 14001 & OHSAS 18001/ISO45001, Environment and Safety Audits, Behavior Based Safety, Emergency preparedness and Mock drills, Sustainability reporting & CSR Reporting, Green House gas Accounting/ Carbon Footprinting, Water Foot-printing, Environment Legal Compliance, Environment Impact assessment. Have Assurance Audit Experience in Corporate Sustainability Reports/ Social Responsibility Report, Positive Water Balance.

Experience Profile

Organization : Genpact India Pvt Limited
From : Jun 2017 to till date
Profile : EHS & Sustainability Consultant
Job Responsibility:

- Maintaining EHS management system as per ISO 14001:2004 and OHSAS 18001:2007
- EHS audits- Project site safety audit/ facility safety audit/transport safety audits, vendor audits, infrastructure readiness audits, fire safety audits.
- Imparting Training on EHS, Emergency preparedness, BBS & Ergonomics, sustainability practices
- Leading Sustainability Reporting & Strategy development
- EHS & Sustainability Communication and Awareness Project
- EHS Legal Compliance review and assisting in return filing
- EHS Internal/external Audits
- Compliance to Business related EHS & Sustainability requirements
- Environment Footprinting projects

Organization : Subros Limited
From : Jun 2015 to Jun 2017
Profile : Manager- EHS
Job Responsibility:

- Maintaining EHS management system as per ISO 14001:2004 and OHSAS 18001:2007
- Conducting EHS audit/ Machine safety audit.
- Imparting Training on EHS, Emergency preparedness and sustainability practices
- Conducting EHS Committee meetings periodically
- Coordinating External Audits and ensuring closure of NCs
- Conducting Hazard Identification Risk Assessment, Environment Aspect Impact
- Formulating EHS control procedures
- Mock Drills on emergency preparedness response plan
- Incident investigation and Corrective and preventive Action implementation and monitoring
- Ensuring EHS legal and other compliances
- Customer EHS requirement and Green Supply chain compliances
- Coordinating with external EHS consultants and auditors
- Compliance to Corporate standards and practices related to Environment, Health and Safety
- Sustainability Indicators Tracking- GHG Emissions, water footprints, resource conservation, Health and Safety performance, CSR activities
- Implementing Behavior Based Safety (BBS)
- Compliance to Business related EHS requirements

Organization : Binani Industries Limited
From : Aug 2012 to Jan 2015
Profile : Manager- Sustainability Reporting
Project : Binani Cement Limited- Sustainability Reporting, Water Foot-printing
Project : Binani Zinc Limited- Sustainability Reporting

Project : Binani Industries Limited- Sustainability Reporting
Job Responsibility:

- Sustainability Policy formulation aligned with NVG, Company Bill 2012, UNGC 10 principle and MDG
- Sustainability Report writing as per GRI G 3.1 Guidelines
- Corporate Social Responsibility Reporting as per NVG Guidelines
- Coordinating with different departments at different plant locations for data collection

- Data Analysis and Trend Analysis
- Conducting sessions on Sustainability Reporting and CSR and alignment with ISO 14001 & OHSAS 18001, SA 8000
- Coordinating with third parties for Assurance on report, coordinating with designers for theme-based report designing

Organization : Deloitte Touche Tomatsu India Pvt Limited
From : April 2011 to July 2012
Profile : Sr. Analyst - Environment Health Safety and Sustainability

Project : **Design and Development of Environment Health Safety Management System** (Clients- Telecommunication, Banking Services)
Project : **Positive Water Balance Assurance Audit (**Clients- Beverage giant)
Project **: Sustainability/ Corporate Social Responsibility Assurance Audit (**Client- Oil and Gas, Glass Industry)
Project **: Environment and Social Due Diligence (**Client- Infrastructure Company)
Project **: Greenhouse Gas Accounting & Corporate Sustainability Reporting (**Client- Telecommunication)
Project : **Design and Development of Quality Management System (ISO 9001:2008) (**Clients- Infrastructure Company)
Project **: Environment Health & Safety Audit (Greening of supply chain) (**Client- Telecom vendor companies)

Job Responsibility:

- Design and Development of Safety Health and Environment Management System as per ISO 14001 and OHSAS 18001 for Telecom and banking industry.
- Conducted Safety Health Environment Audit.
- Prepared HIRA and Initial Environment Review
- Prepared Formats for GHG reporting and Corporate Social Responsibility Reporting
- Conducted Assurance audits for corporate social responsibility/ Sustainability Reporting
- Audited Beverage Plants for Water Balance
- Environment and Social Due Diligence
- Developed Quality Management Plan for telecom industry

Organization : Gammon India Limited
From : Mar 2009 to Mar 2011
Profile : Engineer- Safety Health Environment

Project **: DMRC Project Phase-II, New Delhi, Noida Corridor (Client: Delhi Metro rail Corporation)**

Project **: DDA Flyover Project (Client: Delhi Development Authority)**

Job Responsibility:

- Design, Development and Implementation of Site Safety Health and Environment plan
- Maintaining all SHE documents as per ISO 14001:2004 and OHSAS 18001:2007
- Conduct Monthly Environment Audit and Environment Monitoring.
- Conducting SHE Committee meetings periodically
- Prepared Hazard Identification Risk Assessment, Environment Aspect Impact and emergency preparedness plan for the project.
- To ensure compliance to statutory and corporate standards relating to Environment, Health and Safety

Achievements/ Responsibilities:

- Has done GRI certified training on Sustainability reporting
- Has done IS0 14046- Draft (Water foot-printing course) training
- Has done **ISO 14001:2004 and OHSAS 18001- Integrated Management system internal** auditor course.
- Has done certified Course of **First Aid.**
- Work as personnel in **Environment impact assessment of Dehradoon City,** done by University of Petroleum and Energy Studies.
- Has done training on **''SHE Policy and its implementation''**.
- Attended webinar and online training on BBS

Academic Qualification:

- **M.Tech. (Environment health and safety engineering)- (**2009) from University of Petroleum & Energy Studies, Dehradun
- **M.Sc. (Environment Science)-** (2007) from C.S.J.M University, Kanpur
- **B.Sc. (Chemistry and Zoology)-** (2005) from C.S.J.M University, Kanpur
- **Intermediate** (2002) from Uttar Pradesh Board, Allahabad
- **High School** (2002) from Uttar Pradesh Board, Allahabad

Internships Undertaken:

- 2 months summer internship at **Jaiprakash associates limited, Noida** as a part of **M. Tech (HSE)**. Project Work**: "Health Safety Environment Compliances at Jaypee Greens, Noida".**
- 4 months summer internship at **Industrial Toxicology Research Center, Lucknow** as a part of **M.Sc. (Environmental Science).** Project Work: **"Evaluation of Water Quality of Different District for Drinking Purpose".**

Computer Proficiency:

- **Applications : MSOffice (Word, Excel, Power Point, Project)**

Personal Profile:

Name	**: Shraddha Mishra**
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Date: 01.10.2020 — Signature

PLAGIARISM CERTIFICATE

1. We Dr N A Siddiqui (Internal Guide), Dr Ashutosh Gautam (Co Guide/ External Guide) certify that the Thesis titled Study of EHS indicators for sustainability and its effectiveness for Cement Industries in India submitted by Scholar Mr/ Ms Shraddha Mishra having SAP ID 500033597 has been run through a Plagiarism Check Software and the Plagiarism Percentage is reported to be 3 %.

2. Plagiarism Report generated by the Plagiarism Software is attached.

Signature of the Internal Guide

Signature of External Guide/ Co Guide

Signature of the Scholar

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Sources included in the report

SA	**Consolidated Chapters 30 Aug 2019 Ali(1).pdf** Document Consolidated Chapters 30 Aug 2019 Ali(1).pdf (D55400996)	8
W	URL: https://core.ac.uk/download/pdf/137246.pdf Fetched: 3/8/2020 11:48:59 PM	1
SA	**Thesis-Anusha Priya.docx** Document Thesis-Anusha Priya.docx (D54606970)	2
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SA	**05-01-2019 PhD Thesis Sandeep Bhatnagar.pdf** Document 05-01-2019 PhD Thesis Sandeep Bhatnagar.pdf (D46700793)	19
W	URL: https://www.titan-cement.com/wp-content/uploads/2018/04/Corporate-Social-Responsib ... Fetched: 12/1/2019 10:25:36 PM	2
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Whomever it may concern

PhD Work Completion cum Thesis submitted Certificate

This is to certify that this thesis entitled **"Study of EHS indicators for sustainability and its effectiveness for Cement Industries in India"** submitted to **University of Petroleum & Energy Studies, Dehradun** by – **Shraddha Mishra** for the degree of Doctor of Philosophy in Health Safety & Environmental Engineering, is the bonafide record of original work done by the candidate under our supervision. The work was planned, organized and executed in the Department of Health Safety Environment & Civil Engineering. This study has not previously formed the basis for the award of any degree, diploma, fellowship or any other similar title.

We further certify that the entire thesis represents the independent work of – **Shraddha Mishra (PhD candidate)** - and all the research work was undertaken by the candidate under our supervision and guidance.

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