EMPOWERING STAKEHOLDERS TOWARDS BETTER WORKING CONDITIONS THROUGH GREEN FACTORIES: AN ACTION RESEARCH IN INDIA

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Abstract: The need of sustainable development is picking up pace, with one of the major concerns being to provide healthy environment for citizens to live and work. The Industrial sector has pursued its manufacturing operations without giving much attention to environmental and health issues. This has resulted in an impact on resources, human health and wellbeing. Thus in this context, Indian Green Building Council (IGBC) has developed green factory rating system which can help address issues like energy efficiency, conservation of natural, betterment of working conditions and enhanced productivity. Its adoption can be accelerated by generating awareness amongst stakeholders of manufacturing sector to voluntarily adopt green practices for their factory buildings. The research brings out the action oriented approach followed to generate awareness amongst stakeholders regarding the green factory rating system with special reference to Indoor Environment Quality (IEQ) technologies since it has major impact on the health and productivity of the workers. Also, newer technologies used for IEQ by operational green factories were also studied in detail.

Newer technologies employed by existing green factories, as revealed by the study were Building flush out, entryway systems, high efficiency filters and so forth. Taking these as a framework, a training programme was prepared to generate awareness. The training programme, dealt in imparting knowledge on various issues such as sustainable development, green built environment, green factory rating system etc. It consisted of modules assisted with comprehensive tools like presentations, videos, pamphlet, training manual and handouts. The training programme resulted in change in knowledge and perception of stakeholders which was statistically analyzed. This change helped them to understand and appreciate how their practices and preferences in their factory buildings can contribute to good working environment thereby leading to a holistic goal of sustainable development. Thus, such interventions can be taken up at a wider scale to motivate community stakeholders to adopt green building guidelines.

Keywords: Green Factory Rating System; Industrial sector; Indoor Environment Quality technologies; sustainable development; training program

INTRODUCTION

The concept of sustainability has been establishing a strong foothold in recent times, with efforts ranging from reducing air emissions from our industrial processes to lowering our energy consumption, and much more. There has been a significant increase in the interest and research activities related to the development and promotion of green building guidelines in the last decade [1]. There has been a rapid growth in the number of green building guidelines around world. More than 23, mostly developed countries, have implemented their green building guidelines and many other developing nations are in the process of framing these green building guidelines for their societies[2]. While buildings and development provide countless benefits to society, they also have significant environmental and health impacts. According to Whole Buildings Design Guide (WBDG) Sustainable Committee [3], "Industrial buildings construction and operation have extensive direct and indirect impacts on the environment. They use resources such as energy, water and raw materials, generate waste (occupant, construction and demolition) and emit potentially harmful atmospheric emissions". With rapid industrialization and urbanization in India, construction activities have increased manifold and

their impact on environment is being felt. In addition, society has become more aware of the negative effects of indoor environment on buildings [4, 5]

Booming economic activities in last 10-15 years in India has resulted in large scale building infrastructure activities. The introduction of green building guidelines to establish uniform standards for the application of sustainable practices and their acceptance has been a recent trend in the developing countries. With a great growth potential in the green building market, India is in need of rapid adoption strategies of green building guidelines [6]. The green building movement in the India has encouraged the creation of green building rating systems. IGBC was instituted in 2001 and LEED-India was introduced in 2007. LEED –India was developed by adapting LEED –USA to meet Indian conditions. Many countries, both developed and developing, have come up with their own rating systems. United States Green Building Council (USGBC) was among the first few who worked in this area of developing such systems and it came up with Leadership in Energy and Environmental Design (LEED) guidelines in 2000 [7].

Indian industrial sector is one of the most prominent sectors responsible for economic growth in India. The sector contributes one-fourth of total GDP and is successfully competing in the global marketplace and registering high growth [8]. At the same time, India's rapid economic and industrial growth is causing increasing severe environmental degradation, pollution problem. Nearly one third of the world's energy consumption and 36% of carbon dioxide (CO2) emissions are attributable to industries. In India, current GHG emissions from industry are estimated to be about 750 million tons CO2e [9, 10]. Also, occupational morbidity amongst industrial slums in India is seen to be very high. Occupational injuries and deaths in industries due to hazardous machinery, toxic chemicals, high rise construction, unprotected machinery, poisoning and burns form manufacture of chemicals, etc. have increased in both organised and unorganized sectors [11, 12]. Thus in light of these facts it becomes imperative to take initiatives to make a positive shift towards green and sustainable industrialization.

A green building is an outcome of a design which focuses on increasing the efficiency of resource use energy, water, and materials while reducing building impacts on human health and the environment during the building's lifecycle, through better siting, design, construction, operation, maintenance, and removal [13]. IGBC, in its endeavor to extend green building concepts to all building types envisioned a rating system for factory building in 2008. IGBC green factory building rating system is a voluntary and consensus based programme. Green concepts and techniques in the industry can help address national issues like energy efficiency, conservation of natural resources, handling of consumer waste, water efficiency and reduction in fossil fuel use in commuting. Most importantly, these concepts can enhance occupant health, happiness and wellbeing. The rating system is fundamentally designed to address national priorities which are as follows [14]. (1) **Energy Efficiency**: The factory building strives in reducing energy consumption through adoption of the latest trends and technologies in enhancing energy efficiency. (2) **Water Efficiency**: Effective water management strategies need to address the crisis. The green factory building rating encourages use of water in a self - sustainable manner through reduce, recycle and reuse strategies (3) **Handling of Waste:** Segregation of waste at source, diverting the material to the local recycling facilities and reuse of materials, thereby reducing waste dumped in the landfills are some of the strategies are undertaken in a green factory . (4) **Reduced Use of Fossil Fuels:** The green factories encourage the use of alternate fuels for transportation, public transportation, bio fuels for captive power generation, green power and onsite renewable energy generation. (5) **Reduced Dependency on Virgin Materials:** Green factory encompasses recycled & reused material and discourages the use of virgin wood thereby addressing environmental impacts associated with extraction and processing of virgin materials. (6) **Indoor Environment Quality and Occupational Health:** Green factory addresses issues related to occupational health such as avoiding the use of asbestos in construction, provision of breakout spaces etc.,

This initiative is beneficial for environment but it comes to a standstill when awareness amongst stakeholders is recognized to be low. There is an imminent need for acceleration of participation of owners, developers' architects and vendors in the nationwide green building movement [15]. An attitude of voluntary compliance has to be inculcated among stakeholders to ensure the high levels of commitment, cooperation and willing participation to bring about any meaningful change in their environment. Training programme was thus sought to be a tool for awareness and information sharing to empowering stakeholders for long-term sustainability

benefits through green factories. The work presented in this paper is meant to highlight the emergence of green factories in India. It focuses on exploring the potential impact of this system on workers with special reference to IEQ technologies and conducting an intervention through awareness program which was targeted to motivate stakeholders towards potential improvements in the working conditions in existing non-green factory buildings. This paper can be of immense utility for pioneer organizations promoting sustainability where in such interventions can be used to undertaken to generate awareness and promote the noble cause of sustainable development.

MATERIALS AND METHODS

The researcher identified two fully operational green factories as case studies (referred to as case 1 and case 2). Data for case profiling was collected using checklist and a questionnaire to elicit in-depth information of the project with special reference to IEQ technologies and the benefits derived from its implementation. The case profiling was taken as a framework to develop a need based training programme to be used as an intervention to generate awareness amongst managers of non-green factories regarding green factories. For intervention two non green factories located in Capital and National Capital Region were selected randomly. The sample selected from these factories comprised of all top and middle level manager who were deputed by the organization for training. Top managers were selected as they are the chief catalysts for implementation of strategic decisions in an organization. Middle managers apart from playing an important role in organizational decision making also look over the operations in the factories and serve as a link between workmen and top management.

Through intervention a change in knowledge and perception was targeted. The intervention was a training programme comprising of awareness raising training modules, which were assisted with comprehensive tools. It constituted three modules (awareness generation and motivation, green built environment, IGBC green factory rating system) each having 2-3 sessions. The delivery of training programme was framed into 3 elements introduction, content and recapitulation. The content was delivered using various tools like presentations and videos, session summary handouts, pamphlets, training manual. The awareness level of participants in training program was enhanced by building their knowledge and perception towards green factories. The knowledge level of participant was measured by administering a knowledge testing questionnaire both pre-training and post-training. Interview schedule, including a five point scale, was prepared to assess the perception of stakeholders towards green factories. Both these questionnaires were administered pre training and post-training. The tools tested the knowledge and perception of respondent sustainable development and global warming, green built environment, green rating systems. The difference between the result of the pre and post training would provide evidence to the knowledge and perception change brought about by the training.

By adopting a participatory approach for training program an effort was made to empower stakeholders so that they can effectively intervene and work towards betterment of work environment quality through adoption of green factory certification for their factory buildings. A tool for training evaluation was used to get feedback on the overall reaction of the managers to the training program. Tests were analyzed by applying two sample t-test and level of significance.

RESULTS AND DISCUSSION

Case Profiling

The selected buildings case 1 and case 2 had ventured in relatively new field of green manufacturing. Both buildings adhere to norms as given by IGBC green factory rating system and had applied for Gold rating of 80 and 70 respectively out of total 100 points. Table 1 shows a list of IEQ technologies installed by two factories

Both the factories used various technologies to maintain an optimum indoor environment. This contributed towards their ultimate goal of providing good work environment for the workers

Table 2 shows the potential impacts of green factories was accessed by understanding the perceived benefits accrued through implementation of IEQ credits as compared to their non green factories.

It was seen that both factories experienced 20-30% reduction in energy consumption, 10-15% reduction in employee absenteeism and incidence of sickness. They also perceived to have experienced an increment of 10-20% in productivity of workers. Thus, the workers perceived that working green factories had a positive impact on them.

Table 1: List of IEQ technologies installed in case 1 and case 2 Green factories

Indoor Environment Quality		Case 1	Case 2
Mandatory Requirement 1	Tobacco Smoke Control	• Smoking was prohibited inside the factory area. • Designated smoking room was maintained	• Negative pressure technology for smoking rooms • Signage - placed in building campus to educate occupants and visitors.
Mandatory Requirement 2	Minimum Fresh Air Requirements	• Sensors used to monitor the carbon dioxide level. • Use of high efficiency filters at main HVAC intakes	• Air conditioners system meets ASHRAE guideline of 30% more fresh air. • Carbon Dioxide Sensors level.
Mandatory Requirement 3	Avoid Use of Asbestos	No Asbestos is used in the building	No Asbestos is used in the building
IEQ Credit 1	Building Flush Out	—	The plant was flushed after construction in a 15 day period. To remove contaminants and clean indoor air
IEQ Credit 2	Day Lighting, 50%, 75%, 95%	• Light shelves and skylight use • 95% daylight penetrates through windows for at least 95% regularly occupied areas • All operational areas are	• Use of glass wool in the roof helps in using maximum daylight. • Lights are equipped with occupancy sensors
IEQ Credit 3	Low VOC Materials	Low emitting materials such as VOC sealant/ carpets/ composite woods/ paints	The plant uses fishing material such as paints and carpets with almost zero emissions of VOCs
IEQ Credit 4	Reduction of Workmen Fatigue (Break out spaces)	For staff modern canteen, games room and electric buses to transport have been provided	Canteen, sitting space, toilets, restrooms, locker facilities have been provided
IEQ Credit 5	Eco-friendly House-keeping Chemicals	• The use of chemically-reactive and toxic cleaning products is avoided • Audits - for maintenance of air conditioners, air ducts, vents • Training of workers, records are kept and programs are managed	—
IEQ Credit 6	Gymnasium	It is also provided in the factory building	

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Table 2: Perceived benefits from implementation of IEQ credit by case 1 and case 2.

Perceived benefits from implementation of IEQ credit	Percentage	
	Case 1	Case 2
Reduction in Energy Consumption	20-30%	20%
Reduction in Incidence of sickness	10-20%	15%
Increase in Employee productivity	10-20%	20%
Reduced Incidence of employee absenteeism	5-10%	15%

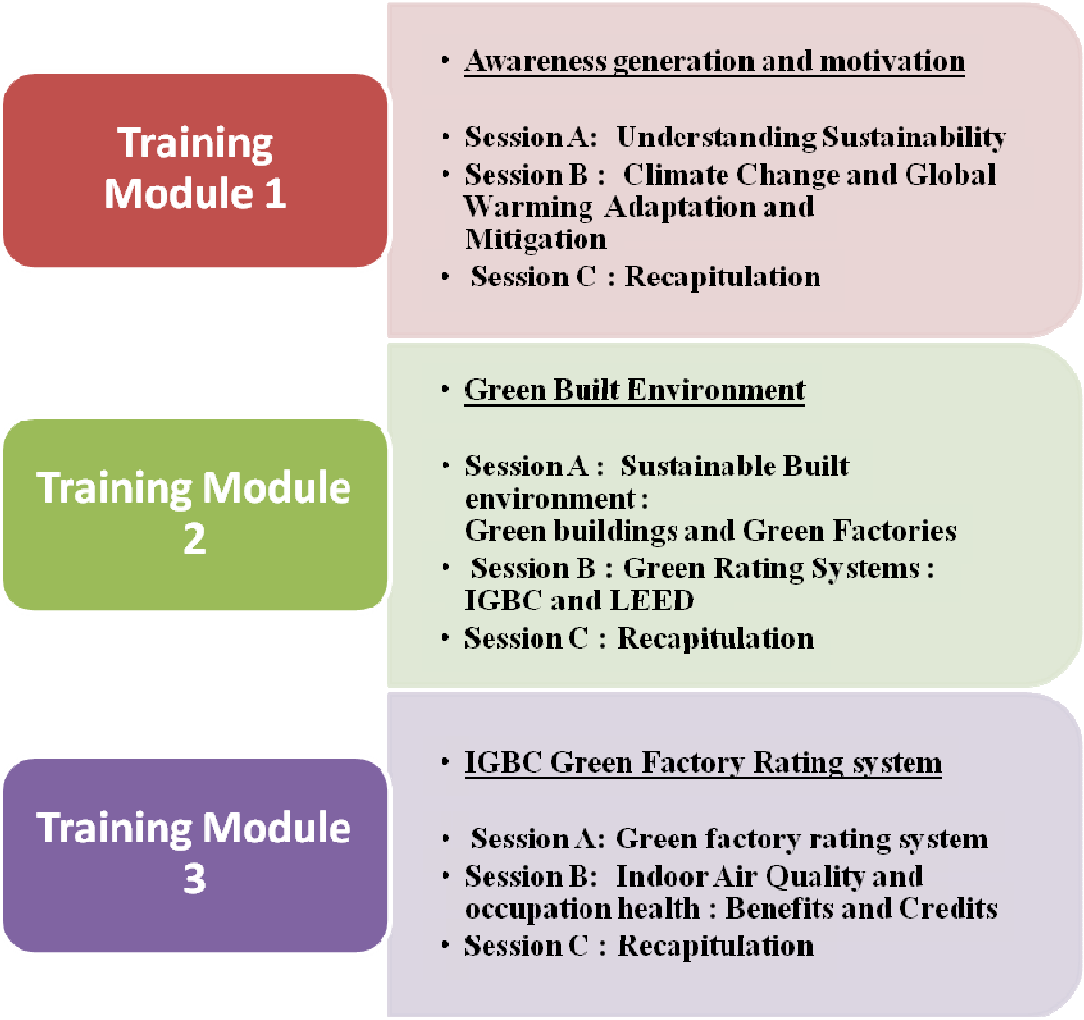


Figure 1: Content of training programme

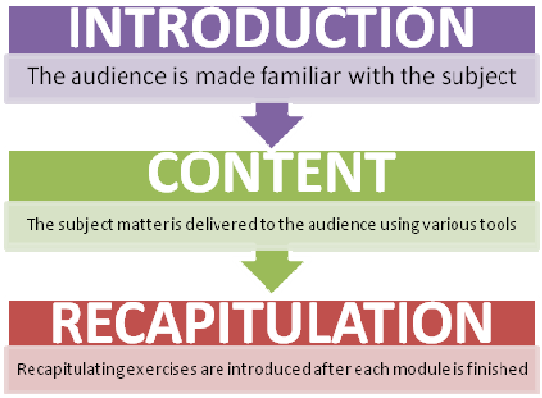
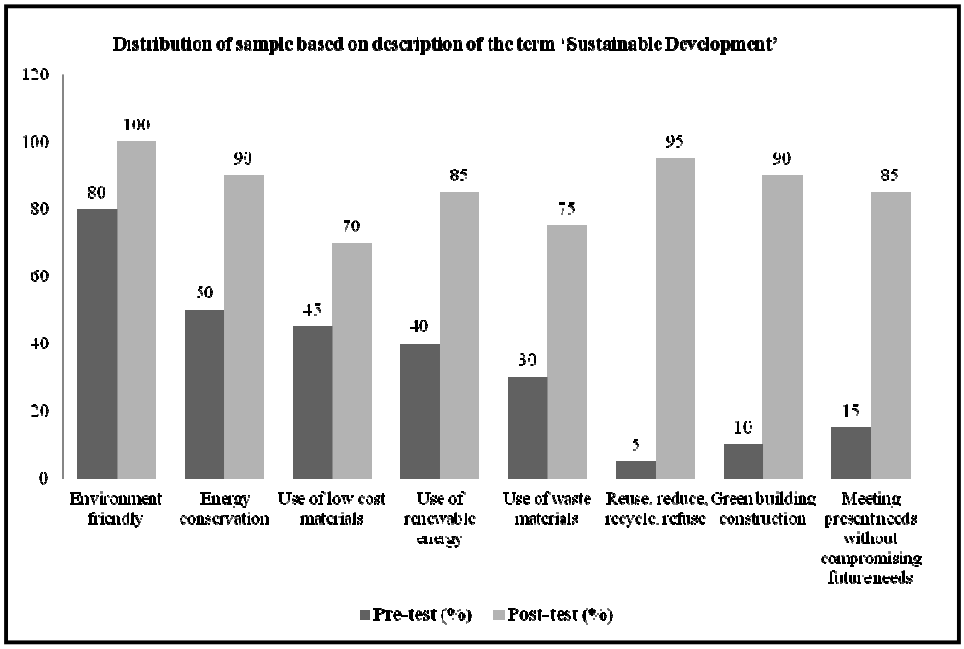


Figure 2: Elements of the Training Programme



Total percentage is greater than 100 as more than one response was obtained.
Figure 3: Distribution of sample based on description of the term 'Sustainable Development'

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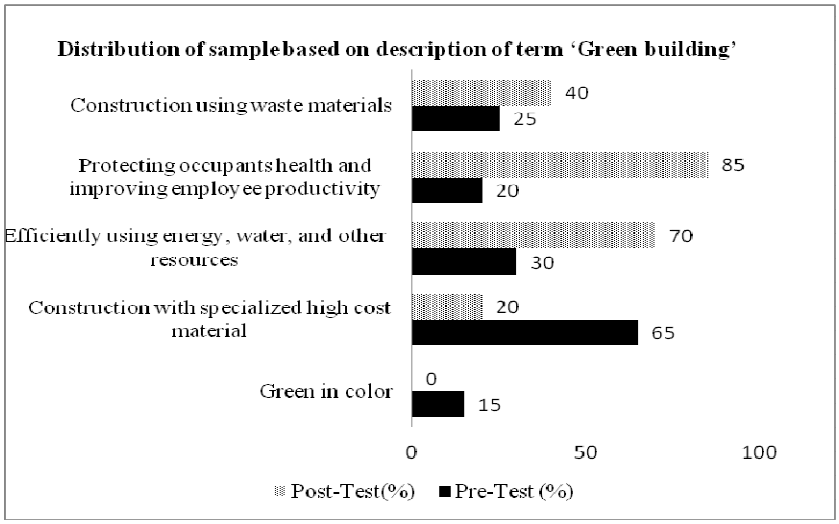

Total percentage is greater than 100 as more than one response was obtained.
Figure 4: Distribution of sample based on description of the term 'Green Buildings'

Table 3: Distribution of sample with regard the knowledge about features of green factory rating system

Features of green factory rating system	Pre-Test	Post-Test
Site Selection and Planning	0 (0)	7 (35)
Water Conservation	5 (25)	10 (50)
Energy Conservation	9 (45)	16 (80)
Material Conservation	3 (15)	12 (60)
Indoor Environment Quality	4 (20)	19 (95)
Innovation & Design Process	3 (15)	10 (50)

Total percentage is greater than 100 as more than one response was obtained

(Figure in parenthesis indicate percentages)

Training Programme

Intervention was a training programme, which consisted of awareness raising training modules, which was assisted with comprehensive tools. The training programme developed is discussed with respect to its content and delivery.

Content of training programme

To meet both the aims and objectives, and the differing levels of knowledge and expertise of the target audience, three modules have been formulated which each having 3 sessions as indicated by Figure 1

Delivery of training programme

The training program was framed into 3 elements as indicated by Figure 2

(1) Introduction – The respondents were made familiar with the subject matter though informal discussions and presentations. (2) Content – the subject matter was delivered using various tools which include (3) Presentations and videos (4) Session summary Handouts (5) Pamphlets (6) Training manual (7) Recapitulation – Recapitulation was recognized an essential part of training programme. It was administered with purpose to help respondents to recapitulate the content at the end of each session. For this, recapitulation exercises were developed for each session.

Intervention

The respondents were assessed for their knowledge and perception before and after training various issues: Sustainable development and global warming,

green built environment, green rating systems, green factory concept and IEQ

It was observed that respondents had fairly good idea of the term sustainable development but they not could not relate it to other options like green building movement, 4R's use of low cost materials. Respondents had fairly good idea of the issue of global warming as in pre-test, three fourth (75%) could identify its correct meaning. However, in post-test nearly all (90%) respondents chose the right option as indicated by Figure 3. Participants showed keen interest in understanding the role of manufacturing sector in global warming so that they can take suitable actions for mitigation and adaptation.

Figure 4 indicates that in pre-test 65% of responses were received for green buildings being associated with specialized high cost construction. Also, even though the respondents belonged to large manufacturing corporations, surprisingly 15% responses were received relating green buildings with a building which is green in color. However, these misconceptions were dealt in the training program, they were made aware of the fact that green buildings are high-performance building providing economic, human and community benefits as well as reduced environmental impacts. In post-test respondents were able to comprehend the same as majority of responses (85%) were obtained for option 4 (Protecting occupants health and improving employee productivity). Also, respondents could recognize the resource efficiency of green buildings since 70% responses were attained for option 3 (Efficiently using energy, water, and other resources) and 40% responses were received for waste materials for construction.

In pretest respondents could not comprehend the green factory concept. To bring about a change in knowledge many examples were cited from operational green factories, wherein a special emphasis was laid on IEQ credits employed. Participants were made familiar with IGBC green factory framework, which caters both to existing and new factories. Ensuring proper IEQ is one of the most pertinent component of the rating system, in pretest only 20% responses were received for this option whereas in post-test percentage responses increased to 95% as indicated by Table 1. During training for better understanding of these terminologies examples were drawn from operational green factories on how they have implemented these credits and benefits accrued through their implementation. Also, percentage of respondents that could identify green rating systems increased from 10% in pre-test to 100% in post-test.

A shift in the average scores from low to high indicated a perceptual change towards sustainable development and climate change. Pre-training respondents were seen to oblivious to the seriousness of climate change as they perceived it to be exaggerated. Post-test training their perception changed and they showed interest in knowing the contribution of manufacturing sector in climate change. They also showed a positive perception post-training towards sustainable development as they were interested in knowing how they can access workshops, seminar relating to these issues. One of the participants also pointed out that they needed a trainer in their organization for educate their workers towards sustainable development.

The knowledge towards IEQ technologies was seen to be quite low amongst respondents in pre-test. Respondents also were oblivious to the technologies like airflow and Air Changes per Hour (ACH) less than one fourth responded correctly. They were made aware of the adverse health effects of maintaining of not maintaining an optimum airflow and Air Changes Hour in a factory set up. In post-test 85% responded correctly for both. Respondents also lacked knowledge regarding the VOCs and break out spaces. They were acquainted with these two concepts and their importance by drawing examples from existing green factory set up where implantation of these credits has led to reduced incidence of sickness and greater satisfaction amongst workers.

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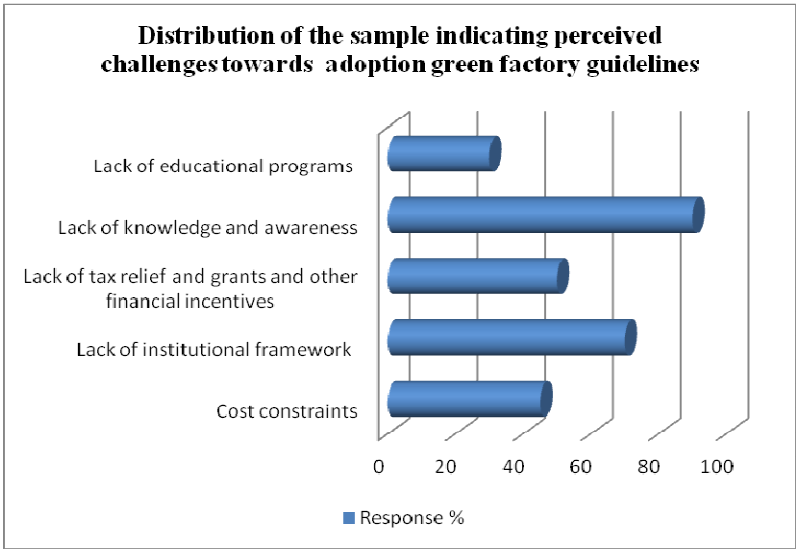

Total percentage is greater than 100 as more than one response was obtained

Figure 5: Distribution of the sample indicating perceived challenges towards adoption green factory guidelines

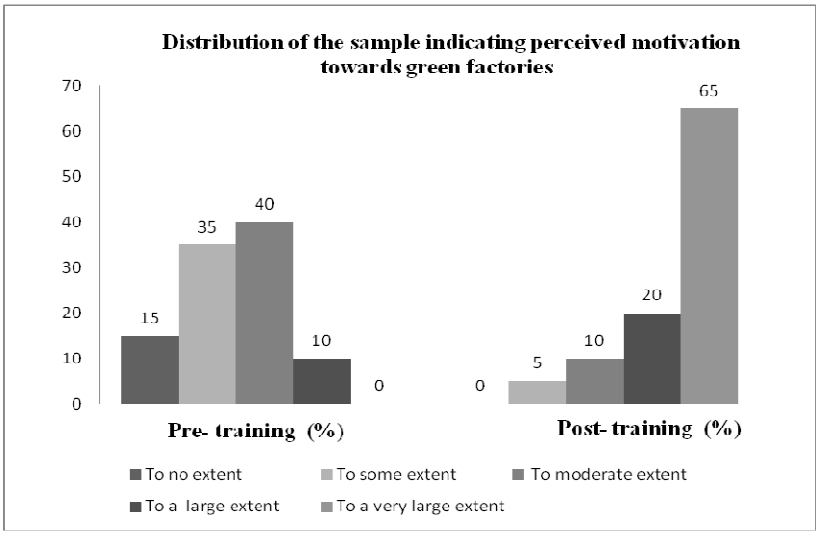

Figure 6: Distribution of the sample indicating perceived motivation towards green factories

construction and design that minimizes the total environmental impact while enhancing user comfort and productivity.

Respondents were asked to identify what they perceived to be major barrier towards adoption of green factory guidelines. Figure 5 Indicates towards a need of strong movement to build awareness towards green factories amongst stakeholders as maximum percentage of responses (90%) indicated towards the lack of knowledge and awareness as being the major barrier towards adoption of green factories. Hence this training module can be of immense utility for pioneer organization promoting sustainability where in such interventions and training strategies can be undertaken to generate awareness and promote the noble cause of sustainable development through adoption of green building practices.

The respondents also appreciated the efforts made by green factories – case 1 and case 2 were motivated to

adopt the certification by observing the benefits perceived by these two organizations. Percentage perception towards benefits of green factory rating system increased from 30% to 85% indicating the positive impact of training. Respondents, they realized their duty towards the protection of environment which can be seen as the first step towards the initiation of green movement. They expressed their willingness to various measures in protecting environment after training.

Figure 6 indicates the rise in motivation from pre training to post training. During pre-training only 10% were motivated to adopt the rating system. Post-training 65% of respondents were motivated to adopt the green factory guidelines. Respondents became aware of the benefits, technologies, and importance of all these aspects under green factory system and were thus ready to bring about a change in their existing environment by adoption of green factory certification system. This was evident from the fact that in post-training 90% of respondents expressed their willingness to adopt green factory rating system. Based on the responses obtained in knowledge and Perception test, scoring was done. Categories were created and scores were arranged under these categories to determine the number of respondents scoring high or low in pre-test and post-test. Figure 7-8 indicates a considerable amount of difference between the pre-test and the post-test scores of managers.

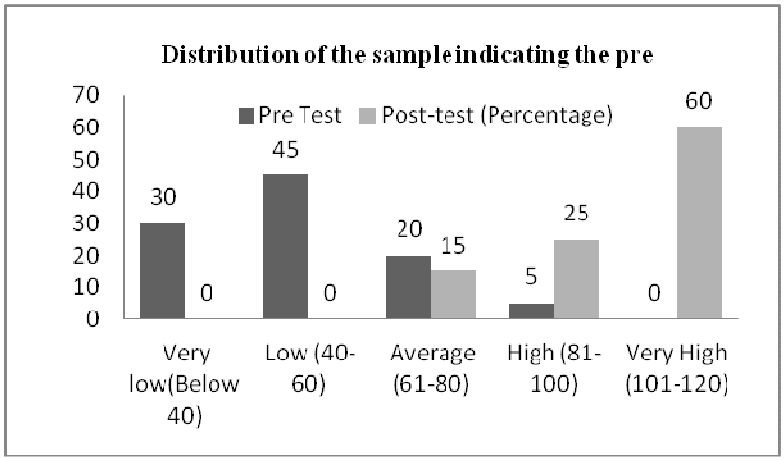

Figure 7: Distribution of the sample indicating pre and post training knowledge scores percentage

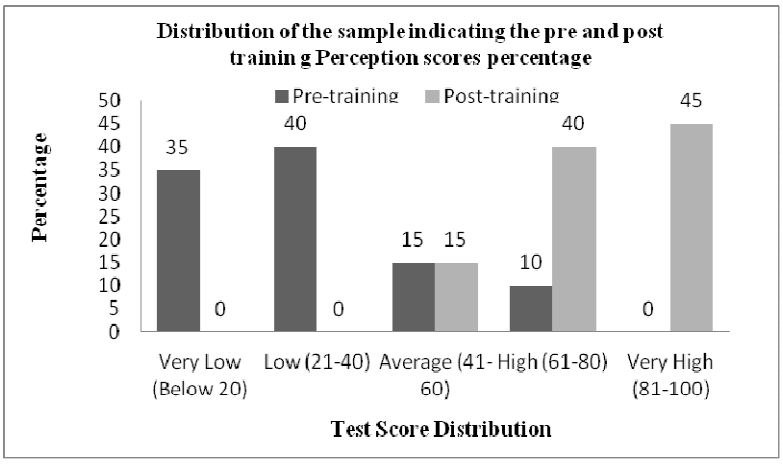

Figure 8: Distribution of the sample indicating pre and post training Perception scores percentage

Table 4: t-test for knowledge and perception scores

	Post test- Pre-test		
	Mean	t	level of significance
Knowledge	49.15	18.34	0.00
Perception	44.75	14.03	0.00

The paired t-test was calculated for knowledge and perception scores. The means of pre-test and post-test were found to be statistically significantly different as indicated by Table 4.Thus it was inferred that overall training did have an impact on knowledge level and perception of managers.

The training programme helped in increasing the knowledge and changing perception of stakeholders regarding sustainable development and related issues and also the benefits accrued from working in green environment. The training programme helped stakeholders to understand and appreciate how their practices and preferences in their factory buildings can contribute to good working environment thereby leading to a holistic goal of sustainable development.

CONCLUSION

The need of sustainable development is picking up pace, with one of the major concerns being to provide healthy environment for citizens to live and work. Industries being prominent drivers of economic growth in India have a growth rate of around 8-9% and contribute about 25% of the average annual GDP. However, rapid industrialization has led to massive pollution significant greenhouse gas emissions and degradation of the natural environment which has resulted in an impact on resources, human health and wellbeing. This indicates towards a rampant need for the development and adoption of green building rating systems in Industrial sector which will help in steering growth towards sustainable industrialization. To address this, IGBC has developed a new rating system for green factories and industrial structures.

The study was carried out in two buildings, both registered under IGBC green factories. These two buildings were developed as case studies. The managers and architects were interviewed to to gain an insight into the technologies that they implemented under IEQ category and the benefits derived from its implementation. The technologies employed by existing green factories, as revealed by the study were building flush out, entryway systems, high efficiency filters and so forth. The employees perceived to have experienced 20-30% reduction in energy consumption, 10-15% reduction in employee absenteeism and incidence of sickness along with increment of 10-20% in productivity of workers. Thus the workers perceived that working green factories had a positive impact on them Perception and awareness of stakeholders was studied regarding green movement which revealed the gaps in awareness. To fill these gaps a training program was structured, taking case profile of existing green factories as a guiding framework. The training program gave holistic overview towards green movement particularly green factory rating system eliciting in-depth information regarding with special reference to IEQ credits and the benefits accrued through its implementation. IEQ and occupational health in factory building directly impacts the human health and productivity of occupants [14]. It is one of the major concerns in providing safety and good working conditions in the industrial sector. Hence, IEQ credits were given importance so that managers can be motivated towards providing good work environment for their fellow workers through green factory adoption. The training was statistically tested using two sample t-test and it was found to be statistically significant in bringing about knowledge and perception change. Training program was instrumental in generating awareness and motivating employees, which was spelt by willingness of majority to adopt green factory rating system and take suitable sustainable initiatives for their factory buildings to provide a better work environment to the workers.

Thus, it was concluded that training program was fruitful in bringing about a knowledge and perception change towards green factory rating system. Such interventions can be taken up at a wider scale to motivate stakeholders to address the health concerns and productivity of workers along with other environmental concerns through adoption of green

factory guidelines. Training programmes can be used as a catalyst in accelerating this adoption. Moving forward towards the ultimate goal of sustainable industrialization, green factory rating system can be incorporated in policy framework to promote greater willingness on part of industries to adopt green practices for their factory buildings. Such interventions are fruitful for targeted beneficiaries and also civil society as a whole and can be used to have far reaching applications to address the issue of sustainability. To achieve the goal of sustainable industrialization globally, it is imperative that such rating systems for industrial buildings are developed and implemented by other leading rating systems like LEED (US), BREEAM (UK), CASBEE (Japan), Gold Star (Australia) and so forth. Future generations can be also empowered towards the goal of green industrialization by incorporating the knowledge regarding the same in school curriculum. This is in the view of the fact that future generations will take on the role of the industrialist, entrepreneur or the workforce in any organization. Hence the knowledge of green industrialization would help them in addressing sustainable development in more responsible manner.

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