ABSTRACT

Industrial revolution has provided humans with more access to transform nature that culminated in the environmental degradation. Today, industries to be competitive have to adopt newer approaches to tackle this situation along with other industrial challenges. To deal with environmental challenges, ISO 14001 - Environmental Management System (EMS) provides guidelines for pollution prevention and also suggests the continual improvement. Sustainable manufacturing suggests three pronged approach to address the problems related to economic, environment, and social. To meet ISO 14001 guidelines and to be sustainable, a strategy like Cleaner Production (CP) is required.

CP is a holistic approach that focuses on minimising resource use and avoiding the creation of pollutants, rather than trying to manage pollutants after they have been created. It involves rethinking products, processes and services to move towards sustainable development. The United Nations Environment Program (UNEP) has defined CP as the “continuous application of an integrated, preventative environmental strategy to processes, products and services to increase eco-efficiency and reduce risks to humans and the environment.” CP represents an immediate and urgent need for industry until a new generation of technologies and processes takes over from the present manufacturing systems.

CP aims at production processes to conserve raw materials and energy, eliminating toxic-raw materials, and reducing the quantity and toxicity of all emissions and wastes before they leave the process. It tends to reduce the environmental impact along the life cycle of a product, from raw materials extraction to its ultimate disposal and incorporates environmental concerns into designing and delivering services. It is about changing attitudes, responsible towards environmental management, and evaluating technology options. It can be especially beneficial to developing countries and those undergoing economic transition. It provides industries in these countries with an opportunity to leapfrog those more established industries elsewhere that are saddled with costly pollution control.

Literature review revealed that there are differences in the adoption of CP in various regions of the world that have different social, economic and political systems. In some
parts of the world already CP is adopted in the national policy and regulatory framework while in some other regions it is still at the infancy. Also there are situations in which CP has successfully been adopted in the absence of supporting structure. This indicates its intervention is still has got to be imbibed for which more understanding into the factors influencing its adoption and its benefits in different regions is essential. The concept of CP can be successfully implemented only if all the stakeholders participate actively in finding the ways to achieve it. Government policies must emphasise on; process optimization, pollution prevention rather than End-of-Pipe (EOP) solutions and necessary financial support. Sector-wise dissemination of information on CP techniques influences the institutions to take part in it. Apart from this, educating people, bringing attitudinal change, imparting training to all stakeholders would ease its implementation process.

The efforts made in boosting this strategy in India are significant but not profound. The UNIDO has been working in India on CP initiatives since early 1990s promoting training and consultancy in CP. A milestone was established when National Cleaner Production Center (NCPC) started working in 1995 hosted by the National Productivity Council (NPC). It assists industries including Micro, Small, and Medium sized Enterprises (MSMEs) in the implementation of viable CP options.

MSME is a crucial industrial group, and believed to account for more than 80% of companies in Asia, with diverse products and large workforce. They are characterized by the continued growth, rural orientation, and wider geographical dispersion on the one hand and on the other by their tendency to concentrate in the industrial clusters, low efficiency levels, growing sickness etc. The environmental impacts resulted from their brisk economic activities is remarkable and become increasingly serious as they produce a major portion of the total industrial waste. Due to the small scale of operation, these units rarely employ methods of treating waste due to lack of technical skill, space, finance and motivation. The incorrect notion that environmental protection always makes the production of goods more costly and is not affordable is deeply rooted in the industries, especially in MSMEs, in developing countries like India.

Agro-based industry is one of the oldest industries in the world. Being an agrarian economy it was natural that the process of industrialization in India gained momentum and impetus around this sector. Agro-based industries are not free from environmental
problems which are caused mainly due to the requirement of water and energy. Waste water and solid wastes are generated during their manufacturing processes, while air pollution occurs due to combustion processes. They also generate by-products along with final product. To summarize, the characteristics of agro-based industry is that they are resource and energy intensive and produces significant amount of by-products. Efficient management of the resources in agro-based industries would bring huge advantages. Considering the above aspects, it may be realized that there exists a significant scope to study the status of CP strategy in the Indian context. The overall objective of this study was to examine the opportunities and benefits of the CP in agro-based MSMEs with a cluster based approach. The overall goal was realized through the following specific objectives:

1. To study the production processes in the three selected agro based MSME clusters.
2. To understand energy consumption patterns and to estimate environmental impact of the prevailing production processes.
3. To assess the prevailing CP level (CPL) and to probe the factors influencing it.
4. To assess the CP performance and explore the potential for CP practices.
5. To identify, analyse and rank the drivers and barriers for CP initiatives.

The present study comprised three such agro-based MSME clusters in the state of Karnataka, India, viz., bakery, cashew processing and rice milling. Bakeries in Shimoga district, Cashew processing in the coastal districts of Dakshina Kannada and Udupi, and Gangavathi Rice- mill cluster of Koppal district were covered in this study.

The study relied on the survey of the selected industrial clusters to collect all relevant primary data required for the research. The unit profile and process particulars provide the information in terms of the size and year of establishment of the unit, human resource details like age, educational qualification of the owner and number of workers employed, technical details of the process, and resource consumption. Further, type of energy required, quantity of different forms of energy, processing capacity and actual processing carried out, waste water and solid waste generated, waste disposal, by-products use etc., were also obtained. Other details collected were about the state of policy and regulations, awareness and attitude of the owners, financial limitations, motivational factors regarding the environmental, and energy efficient technologies.
Apart from the primary data, the research study also employed the secondary data collected through published literature in journals, conferences; reports of acclaimed organisations like United Nations Industrial Development Organisation (UNIDO), United Nations Environmental Programme (UNEP), and Intergovernmental Panel on Climate Change (IPCC), internet, research reports and monographs, text books and magazines pertaining to the selected industries/clusters.

The first objective of the study was to understand process followed in the cluster. A pilot survey was carried out to design the structured questionnaire. The review of background of the clusters under reference and processing methods followed, revealed that all the units in the respective clusters were more or less similar on those counts thus ensuring homogeneous samples in the study. To understand the energy consumption pattern, thermal, electrical and manual energies were considered. Using the primary data collected from the MSME units in each of the three clusters, Specific Energy Consumption (SEC), and total energy used was determined and projection of energy requirement for the whole cluster was made. Thermal energy requirement was predominant in all the three clusters constituting 76%, 61.4% and 90% of total energy for bakery, cashew processing, and for rice-milling respectively. The estimated Specific Energy Consumption (SEC) showed 6.7 MJ, 3.73 MJ and 3.75 MJ per kg of raw material processed.

After studying energy consumption pattern and estimation of SEC, air pollution due to energy use was expressed in terms of generation of Green House Gases (GHGs) and other pollutants. GHG emissions were estimated using Intergovernmental Panel on Climate Change (IPCC) guidelines. From the results it was found that, SEC values and emissions of cashew processing and rice-mills were comparable as biomass constituted the major energy source. Bakery cluster deviated from the other two in utilising non-biomass energy source and proved to be highest energy consumer and also had highest Global Warming Potential (GWP) per unit of raw material processed.

To improve the CP status, the prevailing Cleaner Production Level (CPL) was essentially to be known. Thus, establishment of the present CPL was another crucial objective of the study. CPL has vagueness with respect to contribution from different aspects of the process thus making the task of evaluation cumbersome. To facilitate the measurement of almost an immeasurable entity a method using fuzzy logic was evolved. This approach
was simple but was applicable to a wide variety of processes mimicking human control logic, based on the vague data. Fuzzy logic toolbox in MATLAB (Version 7.8.0.347) environment was used to develop fuzzy inference system. Evaluation of CPL in an organisation depended on the prevailing processing practices which may give an idea about the status of its performance. The performance study of the CP in selected industrial clusters revealed that average CPL of the selected three industries was around 50%, and hence they had very good opportunities for further CP improvement. Among them, cashew processing cluster was relatively clean whereas bakery cluster had poor performance.

Despite all the units in the cluster adopting similar process technology, wide variation in CPL was observed. Consideration of only technical factors in fuzzy analysis might not substantiate the real reasons for the prevalent condition. Thus, it was decided to investigate the other factors which seem to be influencing CP indirectly. Some non-technology factors were identified on the basis of literature and discussion with experts. The factors identified were; Economic Factors (EF), Human Resource Factor (HRF), Technical Factor (TF), and Organizational & Behavioral Factor (OBF). Multiple Regression Analysis (MRA) was used to examine the influence of such factors on CPL. Statistical Package for Social Sciences (SPSS) version 13.0 was employed to carry out MRA. Multiple regression tests were conducted by treating CPL as dependent variable and the above non-technology factors as independent variables. Each factor was quantified with summated value of two variables associated with it. The results of MRA in the three clusters unfolded the important factors influencing the CPL. For the bakery cluster, it was established that TF and OBF were influencing CPL significantly, and for cashew processing HRF and OBF were contributors. Rice-mill cluster established EF, TF and HRF were the influencing factors of CPL but, OBF was not significantly affecting the CPL.

Another objective of the current research was the examination of potential for CP implementation. Benchmarking of MSME units in the cluster was adopted to bring out gaps in CP practices and improvement potential to accelerate the efforts to implement this strategy. For this purpose, Data Envelopment Analysis (DEA) approach was adopted to know how much of inputs can be decreased or outputs can be increased to make the inefficient units to perform on par with their efficient counter parts. MaxDEA Basic
version 6.0 software was employed to implement the DEA. The inputs and outputs were carefully included to ensure omitting undesirable outputs. The benchmarking result for bakery cluster revealed that the cluster was performing inefficiently; cashew processing cluster had huge opportunities in the area of energy conservation, renewable energy use, reuse and recycling of by-products. The rice-mill cluster reported 45% of the surveyed units were performing efficiently. The results of benchmarking of CP performance of agro-based industries unfolded the fact that huge potential existed for adopting the CP strategy amongst the three MSME clusters.

Effective implementation of CP was not widely seen due to the existence of many barriers despite a few drivers. So, it was thought that understanding the barriers and appreciating the drivers will benefit the MSMEs. The obstacles and motivators for CP implementation in the MSME clusters under reference were obtained through analysis of barriers and drivers. The perceptions and value judgements of entrepreneurs were involved in this approach. Barriers were identified in consultation with industrialists and the review of literature. The perception related to barriers was measured by Likert scale constructs. Then, exploratory Factor Analysis was carried out to bring out the underlying structure of the barriers. The principal component analysis (PCA) was used in the factor extraction using SPSS software version 13.0. The result revealed that barriers ranking were different for each of the individual clusters and the differences may be attributed to the variation in their nature of operation and prevailing business situations.

Significant drivers for CP implementation were identified using literature and discussion with the experts. The drivers were prioritized under a multi-criteria framework using Analytic Hierarchy Process (AHP). This analysis revealed, the stimulus for CP implementation is also different among the studied agro-based industrial clusters, clearly illustrating the different aspirations of the industrial entrepreneurs. To effectively infuse CP strategy, these pertinent drivers are to be understood to facilitate the industry to achieve their goals. Subsequently, the barriers and drivers obtained in agro-based industries as a whole were prioritized by assigning appropriate weights based on the rank-order centroid technique. The most important barrier as perceived by this industry sector was the 'availability of technological know-how and appropriate technology'. 'Bringing awareness and attitudinal change' was the other hurdle to be dealt with. Driver's prioritization in the studied industry found out that for agro-based industry sector,
'improved quality and productivity' was the prime driver followed by 'gaining financial benefit', and 'minimized environmental burden'.

On the whole, this thesis focussed on bringing out the opportunities and benefits of CP in the three agro-based MSMEs. It also identified the barriers and drivers and prioritized them. It is sincerely believed that assessment of CP status by this research in the three agro-based MSME clusters triggers concerned stakeholders to consider the CP strategy more rigorously and focus the efforts and resources to bust the barriers and boost the drivers to enhance CPL further. The findings made in the research are likely to assist in fine-tuning the MSME policy for agro-based industries, especially in clusters. In the long run, improved CPL contributes towards the sustainable development and growth of these agro-based MSME clusters.