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Enhancing Cleaner Production Level in Rice - Mills: an Empirical Data Analysis

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Abstract:- **Cleaner Production (CP) strategy provides an opportunity to achieve economic, social and environmental sustainability. The current paper intends to examine factors influencing CP in a rice-mill cluster in the state of Karnataka. The prevailing CP level in the rice-mill cluster is estimated using fuzzy logic by considering three contributing criteria. Empirical data analysis revealed that, despite units in the cluster adopting a similar processing technology, considerable variation in their CP performance existed underlining a thorough probe. Accordingly some of the dimensions not considered in the fuzzy evaluation are identified and used to construct factors which are likely to influence the variation in CP level. Multiple Regression Analysis (MRA) is carried out by treating the factors as independent variables and CP level derived as dependent variable. Results revealed that in the studied rice-mill cluster 'technical', 'human resource' and 'economic', factors have significant influence on the CP level. The policy measures targeting enhancement of CP levels must focus on these factors for a sustainable growth of the rice-mill cluster in the long-run.**

Keywords:-- **Agro-Processing; Cleaner Production; Fuzzy Logic; Multiple Regression.**

I. INTRODUCTION

Cleaner Production (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 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 can be especially beneficial to developing countries and for those undergoing economic transition as most of the CP approaches are simple and inexpensive.

Apart from being a developing country, India is also an agrarian economy. It has many agro-based industries including rice mills. Most of these industries fall under Micro, Small and Medium Enterprises (MSMEs) group. MSMEs in this country are characterized by the continued growth, rural orientation, wider geographical dispersion, low efficiency levels, and growing sickness etc. Due to limited capital, they are generally started without the benefit of long-range project planning and feasibility studies. Rice mills 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 activities, and air pollution due to combustion processes. Also sizeable quantities of husk, bran, broken rice are produced as by-product during the processing of paddy. The by-products can be utilized as animal feed, energy source and produce useful and marketable products.

There are several works on the assessment of CP and factors influencing environmental initiatives in the context of MSME clusters. According to Dasgupta (1999) a comprehensive approach to address non-technical factors such as resource use efficiency, waste management, poor work practices, layout and house-keeping are essential. Balasubrahmanya and Balachandra (2002) have analysed energy consumption and environmental pollution of few SSI clusters in Karnataka. Fuzzy evaluation model is built by Telukdarie et al., (2006) to effectively evaluate CP condition for aviation enterprise. Howgrave-graham and Van Berkel (2007) developed semi-quantitative proxy indicators to estimate the level of CP assessment in small to medium-sized enterprises. A case study by Peng and Li (2012) on artificial intelligence based CP evaluation system uses a fuzzy logic operator based evaluation system. Basappaji and Nagesha (2014) developed a fuzzy logic based evaluation method for agro-based industries. Muhamad et al., (2014) opined that social responsiveness; legislation compliances and economic performance are the elements which have profound influence on the successful implementation of CP.

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To realize the benefits of CP in rice mills, it is essential to probe the factors which are influencing it, so that means of enhancing the level of CP can be found. In this work, initially fuzzy logic approach is used to estimate the CP status. Subsequently, Multiple Regression Analysis is carried out to explain the reasons for the prevailing level of CP with the help of different attributes potentially causing the variation in attainment of CP.

II. EVALUATION OF CP IN RICE MILLS

Rice milling is a process in which all stalks and other foreign material are removed from the rough rice (paddy) by a variety of specialized machinery. It involves cleaning, milling (to remove the husk), and polishing (to smoothen and brighten the rice) to get raw rice followed by grading and packing. On the other hand parboiled rice is produced using a steam pressure process prior to milling. By-products of rice milling are rice husk and rice bran. Rice husk is used as fuel for rice mill boilers and rice bran oil is extracted from bran. In this study, data from 40 rice-mills situated in Gangavathi, Karnataka State, South India are collected.

III. FUZZY LOGIC APPROACH

As vagueness exists in contributing factors to CP, its evaluation becomes difficult. In this situation fuzzy logic approach is considered as appropriate since it considers vague, ambiguous, imprecise, noisy, or missing input information. It effectively captures the contribution of various aspects. It allows characterizing the system behaviour and expresses different variable values linguistically and later it is translated to meaningful crisp quantity. The design of control algorithm using fuzzy rules describes the principles of the controller's regulation. This analysis is carried out on MATLAB numeric computing environment by using Mamdani's max-min inference method to model human expert knowledge. The fuzzy inference system comprises membership functions, fuzzy logic operators, and if-then rules. The membership function represents the degree of truth and a triangular membership functions are assigned in this work. The membership functions assigned converts the crisp data to a fuzzy data. The decision drawn by fuzzy inference system is derived from the set of rules framed. The fuzzy rules are developed by using fuzzy operators which are the subjects and verbs of fuzzy logic to frame if-then rules. Finally, the fuzzy output is defuzzified to get the crisp output of process, environmental and sustainable criteria. Centroid method of defuzzification is employed, because the values lie approximately in the centre and poses less ambiguity.

IV. IDENTIFICATION AND MEASUREMENT OF CONTRIBUTING FACTORS IN RICE MILLS

To assess the CP level in rice-mills, contributing criteria are identified. The contributing criteria considered are: evaluation of process efficiency, resulting environmental burden, and sustainability of the process.

The process efficiency is evaluated by three attributes namely, raw material conversion efficiency (RC), quantity of energy consumed (EC), and the amount of water consumed (WC). The burden on environment caused by the production activity is assessed by waste water generation (WWG), emission caused by combustion (GWP) and solid waste generated (SWD). The sustainability is measured by onsite recyclability (OR), dependence on renewable energy (REU) and employment generation potential (EGC).

The methodology of evaluation is to obtain a quantitative value for the level of CP of the rice-mill by aggregating the criteria contributing to it. To obtain the crisp value for the criteria, the values of attributes explained above are obtained from the process data by developing proxy indicators for them as outlined in the table 1.

Even though the quantitative values of attributes are available, it may not be appropriate to aggregate them directly for assessment because individual attributes vary independently and hence to capture their contribution fuzzy logic approach is adopted. To allow aggregation and to facilitate fuzzy computations, the values of attributes are derived from the data collected from the rice mills.

In fuzzy logic approach the crisp values are expressed in linguistic variables by assigning triangular membership function as low, medium and high to represent the range of values of each attribute. The crisp values of the attributes are normalized to bring them to a common scale i.e., between 0 and 1.

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Table 1. List of Proxy Indicators for Attributes

$$\text{Raw material conversion efficiency} = \frac{\text{Quantity of final product}}{\text{Quantity of raw material processed}} \times 100\ \%$$

$$\left\{\begin{matrix}\text{Quantity of}\\ \text{energy}\\ \text{consumed}\end{matrix}\right. = \frac{\sum [\text{Electrical energy} + \text{Thermal energy} + \text{Labour energy} + \text{Fossil fuel energy}]}{\text{Quantity of raw material processed}}\ \text{MJ/Kg}$$

$$\text{Amount of water consumed} = \frac{\text{Total water used}}{\text{Quantity of raw material processed}}\ \text{Liters/Kg}$$

$$\text{Waste water generated} = \frac{\text{Total quantity of waste water discharged}}{\text{Quantity of raw material processed}}\ \text{Liters/Kg}$$

$$\text{Solid waste generated ratio} = \frac{\text{Total solid waste generated}}{\text{Quantity of raw material processed}}$$

$$\text{Global warming potential} = \sum \frac{\text{Fuel used for processing}}{\text{unit raw material}} \times \{\text{Emission factor}\}\ \text{Kgs of } CO_2$$

$$\text{Onsite recyclability ratio} = \frac{\text{Quantity of generated biomass used}}{\text{Quantity of biomass generated}}$$

After obtaining quantitative values of the attributes, these values are aggregated to get the crisp values for the three criteria viz., process efficiency, environmental burden, and sustainability aspects of the process in the first level fuzzy evaluation. Later in the second level of fuzzy evaluation, five linguistic variables; very poor, poor, average, good and very good are assigned to obtain the crisp value for the overall CP level. The rule base to control fuzzy evaluation involves equal weightage to all attributes and criteria. The measured values of the attributes from rice mill cluster as proxy indicators are represented in table 2.

Table 2. Measured Values of Attributes – Rice Mill Sector

Unit No.	Process Criteria Attributes			Environmental Criteria Attributes			Sustainability Criteria Attributes		
	RC	EC MJ/kg	WC Litres /Kg	WWG Litres /kg	GWP Kgs of CO_2/Kg	SWD	OR	EGC Labour /kg	REU
1	0.75	2.95	1.04	0.57	3.69	0.25	0.92	0.91	1.70
2	0.66	4.44	1.07	0.54	3.90	0.88	1.19	0.91	0.90
3	0.65	4.59	1.08	0.53	3.89	0.83	1.63	0.95	1.10
4	0.60	4.00	0.96	0.58	3.84	0.27	1.15	0.93	3.40
5	0.60	3.71	0.95	0.46	3.80	0.83	1.02	0.91	0.90
6	0.67	3.37	0.84	0.39	3.76	0.53	0.90	0.90	1.20
7	0.69	4.33	1.43	0.52	3.87	0.82	1.24	0.93	0.90
8	0.68	3.73	1.38	0.55	3.80	0.86	1.10	0.90	1.10
9	0.58	2.73	1.36	0.64	3.69	0.86	0.73	0.86	0.90
10	0.60	3.32	1.12	0.60	3.75	0.22	0.93	0.90	3.10
11	0.61	3.67	1.17	0.55	3.79	0.47	1.00	0.92	1.50
12	0.70	3.08	1.50	0.67	3.72	0.50	0.96	0.92	1.40
13	0.60	2.98	1.00	0.44	3.75	0.71	0.75	0.82	1.20
14	0.58	3.71	1.43	0.58	3.80	0.28	1.40	0.91	2.90
15	0.58	2.44	1.25	0.63	3.65	1.00	0.64	0.89	0.60
16	0.67	4.74	1.21	0.55	3.94	0.31	1.30	0.92	3.00
17	0.59	4.07	1.25	0.71	3.84	0.27	1.35	0.93	3.40
18	0.70	5.12	0.87	0.40	3.99	0.21	1.32	0.92	3.40
19	0.65	4.71	1.00	0.44	3.94	0.20	1.12	0.90	2.50
20	0.43	4.10	1.38	0.66	3.85	0.35	1.00	0.92	2.40
21	0.69	4.80	1.08	0.35	3.95	0.15	1.45	0.91	2.80
22	0.59	3.20	1.37	0.69	3.76	0.12	0.92	0.85	4.80
23	0.25	3.74	1.25	0.58	3.80	0.28	1.17	0.90	2.00
24	0.23	4.41	1.00	0.40	3.89	0.24	1.37	0.92	2.00
25	0.65	4.15	1.29	0.58	3.87	0.16	0.97	0.89	2.20
26	0.22	3.86	1.46	0.84	3.81	0.50	0.95	0.93	1.40
27	0.45	3.58	1.20	0.56	3.79	0.94	1.00	0.90	0.50
28	0.70	3.87	0.70	0.30	3.83	0.21	1.74	0.91	1.00
29	0.56	4.88	0.80	0.48	3.95	0.06	1.16	0.83	1.60
30	0.49	2.60	1.41	0.79	3.67	0.43	0.64	0.88	0.20
31	0.60	3.58	0.80	0.30	3.79	0.75	0.88	0.91	0.60
32	0.60	4.46	0.88	0.35	3.90	0.94	1.42	0.91	0.20
33	0.56	5.67	1.18	0.45	4.03	1.07	1.95	0.95	0.90
34	0.65	5.00	0.80	0.45	3.95	0.55	1.75	0.94	0.30
35	0.65	5.38	0.72	0.32	4.02	0.47	1.54	0.93	0.50
36	0.63	4.49	1.00	0.32	3.90	0.38	1.20	0.90	0.70
37	0.65	3.29	1.15	0.50	3.74	0.85	0.90	0.92	0.20
38	0.56	3.87	1.12	0.56	3.84	0.36	0.72	0.87	0.50
39	0.52	3.05	0.86	0.58	3.72	0.33	0.94	0.89	0.80
40	0.64	3.94	0.40	0.18	3.83	0.42	1.06	0.91	0.60

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V. FACTORS INFLUENCING CP

From the literature it is observed that vital factors that influence CP in agro-based MSMEs are awareness & attitude, availability of clean technologies, and presence of good policy and regulations. Excluding the availability of clean technologies and presence of sound policies and regulations, the various aspects that are responsible for CP performance in agro-based industries include less resource consumption, which will enhance the environmental performance. Human factor is another important aspect that contributes to better organizational culture and promotes adoption of clean energy use, recycling and reusing wastes or by-products. As already discussed, status of CP of an enterprise has considered some of the quantifiable factors. The latent influence of other factors is also necessary to bring out clarity in understanding the phenomenon.

VI. A HYPOTHETICAL FRAME WORK OF INFLUENTIAL FACTORS

Evaluation of CP in the considered agro based cluster revealed that (i) there is wide variation in CP performance and (ii) units with higher CP levels are not performing to their fullest capability levels.

Hence, there is a potential for improvement in all the units of the cluster. Factors influencing CP are identified based on the available literature pertaining to agro-based industries and discussion with experts. The factors recognised are Technical Factor (TF), Economic Factor (EF), Organisational & Behavioural Factor (OBF) and Human Resource Factor (HRF). It is hypothesised that the variation in the CP level (CPL) may be explained by the combination of these factors. Each factor is made-up of pertinent variables and is illustrated in Fig. 1.

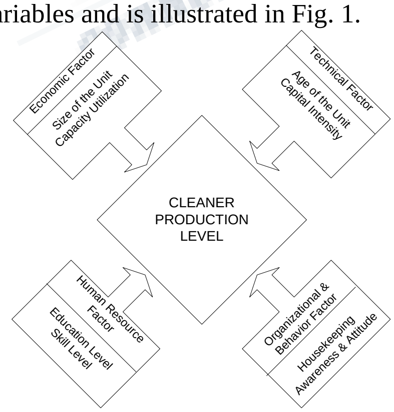

Fig. 1. Factors Influencing Cleaner Production

VII. MEASUREMENT AND MODELLING OF FACTORS INFLUENCING CP

The hypothesised factors illustrated in the above fig.1 are to be measured. Researcher administered questionnaire has fetched some of the information from the rice-mills regarding the age and location of the plant, size of the plant, and educational qualification of the owner etc. The skilled level of the workers is determined based on the location of the unit as urban localities ensure availability of skilled workforce. Attitude of the operators and their awareness about, CP in particular, and environment in general, are gauged on a five point Likert scale. The capacity utilisation data is derived from the ratio of actual processing level to rated processing capacity of the unit. In food processing, hygiene conditions and housekeeping aspects are very important. As measurement of these aspects is difficult, they are assessed qualitatively on the basis of conditions of plant layout, work practices, maintenance methods, cleanliness of the process etc., by researcher observation during the field visits. Automation in agro-based industries has evolved from labour intensive to capital intensive due to labour scarcity and development of technology. The intrusion level of machinery is assessed by the percentage of processes done using machinery. These factors are not used in the determination of CP levels as they have no direct relation with it. However, they are likely to have indirect influence on it, and hence it is intended to examine their influence on CP level. The required values of the variables for constructing the magnitude of influencing factors are thus derived either quantitatively or qualitatively. The details of scaling of the considered factors are explained in the next section.

The variables under each factor are intended to capture a particular dimension; the cumulative values of all the included variables are worked out to represent a factor. However, a variable is included under the factor, only if it meets the basic requirement of showing some significant association with the CP level. Subsequently, assuming a linear relationship between CP in MSMEs and the hypothesised factors, multiple regression models is developed in the form as shown in equations 1 and 2:

Overall CP = f {EF, TF, HRF, OBF} **- (1)**

OR

Overall CP = $(b_0 + b_1(EF)+b_2(TF)+b_3(HRF)+b_4(OBF)+u\}$ - (2)

Where
CP - Cleaner Production level of the unit
EF - Economic Factor score

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TF - Technical Factor score
HRF – Human Resource Factor score
OBF - Organisational & Behaviour Factor score
u - Random component
b_0 - Constant (intercept)
b_1, b_2, b_3 and b_4 - Coefficients of the above mentioned factors.

In Multiple Regression Analysis (MRA), CP level which was quantified through the fuzzy logic is considered as dependent variable and the four factors identified are treated as independent variables. In MRA, it is assumed that the dependent variable is a quantitative measure with normal distribution and equal variance for all combinations of independent variables. It is not necessary that the independent variables are normally distributed or even that they are quantitative measurements.

VIII. BUILDING FACTOR SCORES FROM VARIABLES

Factors considered in the stated hypothesis are cumulative values of the variables included in it.

These variables are assigned with values from 1 to 3 considering their central tendency and dispersion within the cluster. The idea is to express the variables on a common scale ranging from 1 to 3 with an assignment of equal weight-age. Score 3 indicates the most favourable situation, score 1 indicated the unfavourable situation, and Score 2 is intermediate between the two levels.

Table 3. Variable Grouping – Rice Mill Cluster

		Rice Mill Cluster Score		
Factor	**Variable**	**1**	**2**	**3**
Economic Factor	Plant Capacity Utilization	Below 30%	Between 30 - 50%	Above 50%
	Processing Capacity	Below 48000 Kgs/day	Between 48000-70000 Kgs/day	Above 70000 Kgs/day
Human Resource Factor	Owner's Education Level	School Education	Diploma/ Graduation	Professional/ Master's Degree
	Skill Level of the Worker	Rural	Semi Urban	Urban
& Behav	Awareness & Attitude	Less	Moderate	More
	House Keeping	Poor	Average	Good
Technical Factor	Age of the Unit	Below 8 Years	Between 8- 22 Years	Above 23 Years
	Capital Intensity	Low	Medium	High

The sampled units then are classified appropriately in any of these 3 groups under every variable. In the analysis any variable gets the place only when it shows significant correlation with CP level. As a result, there is no uniformity among the four factors in terms of number of variables used to arrive at their factor scores. Thus, in the regression analysis a factor score may range from 2 to 6 depending on actual number of variables it comprises. Table 3 lists out the variables grouping for the rice mill cluster.

IX. RESULTS AND DISCUSSION

a. Cleaner Production Status Assessment

The crisp value obtained from the fuzzy analysis of CP status of rice mill cluster is shown in the table 4. The results reveal that, sustainability criterion is far superior in this industrial sector due to high level of renewable energy use and on-site recyclable ability when compared to other two criteria. Due to the demand for high energy and water by the process, rice-mills are performing inferior in both process as well as environmental criteria. In this industry the opportunities exists for better CP performance through the judicial use of rice husk by adopting state of the art combustion technologies. Conservation of water is another important area to be focused for improvement as huge amount of water is discharged as effluent.

From the evaluation of CP level of rice mill cluster, the average performance in the cluster is estimated at 46%. It is also found that about 5% of the units in the cluster are good, 70% average, and 25% of them are below average. Thus, it is evident that there is variation in their performance even though the units in the cluster have adopted similar processing technologies and have similar operating conditions. This gives a clear indication that enhancement in CP level is possible. In order to achieve better CP levels, it is essential to understand the factors influencing it, so that ways and means of improving the situation could be found. In this backdrop, influencing factors are probed in the next section.

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Table 4. Crisp Values - Criteria and Overall CPL

Unit No.	Process Criteria	Environ-mental Criteria	Sustai-nability Criteria	Overall Cleaner Production Level
1	45.0	42.0	46.4	44.5
2	33.8	21.8	52.5	40.0
3	32.9	22.3	60.1	50.3
4	40.1	26.3	67.5	58.4
5	43.9	26.4	49.7	37.4
6	47.8	40.1	38.5	40.9
7	30.0	22.7	52.5	40.0
8	37.5	26.0	52.5	40.0
9	47.6	30.0	37.5	35.9
10	39.2	44.4	56.0	43.0
11	36.3	41.3	52.5	40.0
12	37.6	36.7	49.4	39.6
13	47.9	34.1	37.7	37.6
14	37.5	45.5	67.5	60.0
15	49.8	30.0	37.5	38.3
16	30.0	48.1	67.5	56.0
17	32.5	36.8	67.5	60.0
18	32.5	51.8	67.5	59.6
19	35.9	50.0	64.0	57.9
20	33.9	31.8	60.0	50.0
21	33.9	51.8	67.5	59.6
22	39.0	40.3	60.3	50.9
23	20.8	36.3	52.5	40.0
24	20.3	56.4	52.5	42.8
25	32.1	36.8	54.1	41.1
26	22.5	37.4	48.2	36.7
27	36.7	25.5	47.2	35.0
28	52.5	68.2	60.0	80.0
29	42.2	40.7	51.3	42.5
30	43.1	44.1	37.5	40.0
31	49.7	40.8	37.5	40.0
32	39.2	32.2	55.3	42.3
33	29.7	22.5	60.3	50.0
34	41.9	29.0	60.1	50.3
35	49.0	43.2	60.1	56.6
36	35.4	45.4	52.5	41.0
37	39.1	26.0	37.5	30.0
38	34.8	44.6	37.5	38.3
39	50.1	45.0	41.5	43.7
40	58.1	51.8	52.5	60.0
Ave-rage	**38.63**	**37.91**	**52.80**	**46.07**

b. Analysis of Influencing Factors

Following the grouping criteria in rice mills, values are assigned on a 1-3 scale under each variable, for all the sampled units. Then, correlation analysis is performed between each of the variables and CP level to ascertain their usefulness in explaining the variation in CP levels. To bring out influence of these factors on CP level, the following hypothesis is tested:

Null hypothesis: H_0: There is no relationship between the CP level and the considered four factors in the cluster (i.e. b1=b2=b3=b4=0).

Alternative hypothesis: H_1: There is a linear relationship between the considered four factors and CP in the cluster (i.e. b1, b2, b3, b4 $\neq$0).

The test conducted for rice-mill cluster revealed significant correlation between the attributes considered for the formation of factors and the respective independent variables. In the first run, all the coefficients have deviated from zero thus substantiating the rejection of null hypothesis. All factors have turned out to be statistically significant except OBF, and hence OBF is excluded from the MRA.

Table 5: Multiple Regression Results - Rice Mill (Dependent Variable: Overall CP level)

Factors	B	Stander-dized Coeffic-ients Beta	T	Adjusted R^2	F	N
Constant	**10.7**		**2.622**	**0.648**	**26.175**	**40**
EF	**3.61**	**0.359**	**3.487**			
HRF	**2.90**	**0.366**	**3.643**			
OBF	**---**	**---**	**---**			
TF	**3.09**	**0.773**	**4.002**			

The result of the MRA for rice-mill cluster is presented in the table 5. The result shows an adjusted R^2 value of 0.648 with statistically significant F value. Thus, a fairly good modelling of factors is obtained with the considered factors. While 'TF' has an outstanding influence on CP level, the 'HRF' and 'EF' are also vital with a marginal difference in the influence on CP level.

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X. CONCLUSIONS

It is felt that assessment of CP level and subsequent identification of influencing factors is a prerequisite for a CP enhancement strategy in an organisation effectively. The use of fuzzy logic provides a simple but robust approach for the assessment of CP level of a considered industry. The appraisal of the level of CP in the studied rice mill cluster indicates huge potential for improvement in process optimization and environmental performance. The study of factors influencing CP level in this industrial cluster ranked 'technological factor', 'human resource factor', and 'economic factor, in that order. Thus, CP performance can be enhanced by improving capacity utilization through appropriate capacity planning prior to establishment of a rice-mill. Furthermore, adoption of state of the art technology, improving skill level of workers etc., are the other factors which would of great help. By focusing on these key issues a sustainable growth and development of rice-mills in the cluster may be ensured in the long run.

REFERENCES

1. Dasgupta. N. 1999. Energy efficiency and environmental improvements in small scale industries: present initiatives in India are not working, Energy Policy, Vol 27, No. 13, pp 789-800.

2. Balasubrahmanya, M.H. and Balachandra, P. 2002. An exploratory study of environmental pollution by SSI sector in Karnataka, Research Project Report Submitted to Indira Gandhi Institute of Development Research, Mumbai.

3. Telukdarie, A., Brouckaert, Yinlun Haung. 2006. A case study on artificial intelligence based cleaner production evaluation system for surface treatment facilities. Journal of Cleaner production 14, pp 1622-1634.

4. Howgrave-graham, A. and Van Berkel, R. 2007. Assessment of cleaner production uptake : method development and trial with small businesses in Western Australia. Journal of Cleaner Production, 15 pp 787-797.

5. Peng, W. and Li C. 2012. Fuzzy-Soft Set in the field of cleaner production evaluation for aviation industry. Communications in Information Science and Management Engineering. Vol. 2 Iss. 12, pp. 39-43.

6. Basappaji,K.M. and Nagesha, N. 2014. Assessment of cleaner production level in agro based industries – a fuzzy logic approach. Energy Procedia, 54 pp 127-134.

7. Muhamad Zaki Yusup, Wan Hasrulnizzam Wan Mahmood, Mohd Rizal Salleh, Mohd Razali Muhamad. 2014. The influence factor for the successful implementation of cleaner production: a review" Journal Teknologi (Sciences & Engineering) 67:1, pp 89–97.