Effective Environmental Management SystemReduces Greenhouse Gas Emissions

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***Abstract*-Nepal's contribution to global greenhouse gas emissions is almost negligible compared with that of other countries. However, the carpet industry is considered to be one of the polluting factors. This study focuses on the effectiveness of Environmental Management System (EMS) implementation in the carpet industry mainly in terms of reducing resource consumption and hence reducing greenhouse gas emission. Two focus group discussions were conducted, one before EMS implementation with 16 participants and the next after EMS implementation with 14 participants. Forty respondents (out of 100 workers) were randomly selected including the industry owner, top management personnel and other employees. Rice husk was found to be the major source of energy used for the production of dyed yarn before and after EMS implementation. The findings showed that the total greenhouse gas emission (GHG) from the industry after one year of EMS implementationwas reduced by 6.06% per ton of dyed woollen yarn. The reduction in GHG emissions isonly a small part of the benefits; overall there is local air pollution management and a global reduction in GHG emissions.**

Key words- Carpet industry, Emission, Greenhouse gas

I. INTRODUCTION

Industrial revolutions have always been accompanied by consequential damage to the environment [1]. However, the cessation of industry is not a viable solution economicallyor environmentally[2]. The reasons behind the negative impact of industry develop from a lack of knowledge and understanding about the environment [3]. So, to have sustainable industrial development with minimal environmental damage, the relations between industry and environment need to be more closely observed [4]. Hence, to deal with these problems in a timely and proper manner, EMS can provide improvements that are part of an organization’s management system.These improvements can be used to develop and implement its environmental policy and manage its environmental aspects [5].Furthermore, it is necessary for Nepalese industries to develop and implement those [6]as the increase in CO_2 concentration in the atmosphere thickens the ‘greenhouse blanket’, [7]adding to climate change with much of the heat being trapped in the earth’s atmosphere [8].

The Nepalese domestic sector accounts for more than 95% of energy consumption, and the transportation sector consumes most of the commercial fuel, i.e. petroleum products [9][10]. After the industrial revolution, mankind has been burning fossil fuels on a massive scale [11][12]. This energy is used to run vehicles, heat homes, conduct businesses, and power factories with little thought to the consequences[13][14]. Contributing electrical and thermal energy is an essential part of the manufacturing process, and using this energy accounts for a significant share of the manufacturing cost [15]. Energy demand is growing steadily while supply remains almostunchanged, thus raising the price of energy on a daily basis. On the other hand, the energy sources used for manufacturing industries are producing greenhouse gas[16]. In addition, industries manufacture carpets according to the needs of the customers at the national and international levels[17]. The demand is growing,[18]accounting for more energy consumption, leading to increased greenhouse gas emissions[19]and therefore, more adverse impacts on the climate.

According to Nepal Tourism, although different types of carpets are produced using indigenous wool, in recent years the Nepalese manufacturers have introduced modern designs and colours in line with present day market tastes [20].The traditional rectangular shapesof carpets has been replaced witha wide range of sizes and shapes including round, octagonal or even the personal preference of the customer.

Commercial carpet manufacturing began in Nepal with the exodus of Tibetan people in 1959. They contributed in the development of the carpet industry in Nepal through financial and technical support.But the garment and carpet industries, targeted for quality export production, have grown rapidly since the mid-1980s [21]. What started as a source of meagre income for Tibetan refugees gradually grew from local tourist sales into international commerce in European countries, particularly Switzerland.The chairman of Nepali Products Exporters reports that carpet has transformed into a more valuable, labour intensive commodity and continues to be the most important export in Nepal.

There are many profit-driven carpet companiesin Nepal [22]. The lack of awareness of the adverse impact to the environment, and in particular to the local people, makes the study of utmost importance[23]. There is very little research being done to determine the effectiveness of EMS implementation in Nepal.What is being studied is mainly in terms of reduction of resource consumption and maximizing outputs, andvery little in terms of the state of greenhouse gas emission from industries after EMS implementation. Contributing to the problem is the government'slack of attention to the issue of greenhouse gas emissions in the industries of Nepal. For these reasons research has been carried out to analyse the effectiveness of the implementation of EMS in the carpet industry [24], with reduction in energy consumption and greenhouse gasemissions thusmitigating climate change.

II. METHODOLOGY

ISO certified, Paramount Carpet Industry (PCI), Pvt., Ltd., was selected for the study because it is thought to be one of the top polluting industries in the city. Its annual production is about 450 to 500 tons of dyed woollen yarn. It is located at Gothatar-8, Kathmandu, Nepal. This company is one of the leading manufacturers and exporters of carpets with all products made according to the customer's specific requirements. Out of the staff of 100, including the owner, we interviewed 40 respondents through structured questionnaires. Two focus group discussions were conducted, one before EMS implementation with 16 participants and the other after EMS implementation with 14 participants. The participants in both focus group discussions included the company staff, local community representatives and the company owner.

At the first stage of data collection, visual inspection was done to understand the basic manufacturing process, major raw materials used, input-output processes, units of production, the utilities, etc.[25]. The questionnaires were given to the entrepreneurs and other concerned respondent's which included the company owner, management-level staff and workers [26]. The collected data were triangulated through the observation and key informants, and comparative analysis was done to determine the overall environmental performance before and after the implementation of EMS.

III. MATERIALS AND ENERGY

The major raw materials used for yarn dyeing in the industry are woollen yarn, dyestuffs,chemicals, water (the industry uses underground water by pumping from within the premises of the dyeing unit), and sand which is used in the burner with rice husk and coal for steam generation.The different sources of energy used in the industry are rice husks as the primary fuel for steam generation in the boiler, coal for steam generation in the boiler, diesel oil for generation during load shedding hours and also for complete combustion in the burner, Liquefied Petroleum Gas (LPG) for sample dyeing, and electricity for the dyeing unit (boiler, dyeing machines, yarn weighing machine and hydro extraction machine). The energy values for different raw materials were calculated from the calorific value of a substance for 1 Kg. The source for these values is UNFCC (United Nations Framework Convention on Climate Change). The value of1 Kg was then used to calculatethe total energy values of thematerials used. Again, we used the UNFCC data for calculating greenhouse gas emissions from different materials.We made use of greenhouse gas emissions data provided by UNFCC and then converted it into the total CO_2 equivalent per tonne of material.

The entire country of Nepal, including the carpet industry, uses hydro-electricity.It is known that the generation of thermal electricity emits greenhouse gases, but we have assumed hydro-electricity emits very little,and thealmost negligible secondary emissions that occursarea result of electricity use. The main staple food of Nepal is rice.The purpose of growing this crop is to produce food, not the husk for burning.However,the industry uses this material as it is readilyavailable and very cheap compared to other fuels. All bio-energy sources should be considered carbon neutral, and we have assumed CO_2 emitted from the combustion of fossils and biomass sources share the same physical characteristics and climate-forcing properties.As such, we believecarbon was extracted from the earth's crust, burned and then ended up as CO_2, increasing the overall concentration of greenhouse gasses in the atmosphere. One tonne of dyed woollen yarn was used as a functional unit for analysis because it was easy for us to do in large figures.

IV. RESULTS AND DISCUSSION

The implementation of EMS has shown energy savings, a reduction in the consumption of resources, and a reduction of GHG emissions. To find the effectiveness of EMS implementation and reduction of GHGs, the focus was mainly on resource consumption [27], energy consumption and production of dyed yarn. This enabled us to determine the amount of consumed materials used before and after EMS implementation. Data concerning energy consumption before and after EMS implementation enabledus to calculate the total amount of CO_2 emitted before and after EMS implementation. The quantity of production was also determined. The data are tabulated in Tables 1 to 7.

TABLE 1 OVERALL RESOURCE CONSUMPTION IN THE CARPET INDUSTRY

Materials Consumed	**Before EMS Implementation (2011)**	**After EMS Implementation (2012)**
Rice husk(tons)	637287	584485
Coal(Kg)	1865	1705
Diesel (litres)	11015	10365
Electricity(Kwh)	13869	13502

LPG(Kg)	170	160
Water (Litres)	15894000	14417000
Sand(Kg)	13650	12588
Dyes(Rs)	106909234	10112749
Chemicals(Rs)	4357091	4123107
Total production of dyed woollen yarn (tons)	486	575

Source: Paramount Industry

Note: US$1= NRs84 and the values above are expressed only for the carpet industry

It is clearly evident from the Table 1 that the consumption of materials was reduced,showing the effectiveness of EMS implementation and hence increasing the production of total dyed woollen yarn.There is huge reduction in rice husk, as well as coal, diesel, electricity, water, sand, dyes, and chemicals,with little reduction in LPG.These reductions are mainly due to the increased efficiency as a result of EMS implementation.Because of proper insulation of the machines, energy losses were significantly reduced, and insulation of the boiler and dyeing machines lowered resource consumption, and heat losses reduced energy consumption. Overall, there is increase in the efficiency of machines, thus reducing resource consumption in the carpet industry.

TABLE 2 ENERGY CONSUMPTION IN THE CARPET INDUSTRY

Energy Sources	**Energy Consumption in GJ (2011)**	**Energy Consumption in GJ (2012)**
Rice Husk	8005	7341.32
Coal	46.85	42.83
Diesel	417.8	393.15
LPG	8.4	7.8
Electricity	49.93	48.61
Total	8527.34	7834.25

Source: Paramount Industry,and UNFCC(United Nations Framework Convention on Climate Change) for obtaining the energy consumption in GJ.

Energy consumption in GJ charted in Table 2 shows lower energy consumption in 2012 compared tothe year 2011. This illustratesthat energy is being saved, thus showing effective EMS implementation. For example, the energy derived from rice husks in 2011 was 8005 GJ, and in the year following EMS implementation only 7341.32 GJ was required. The difference of 663.68 GJ is now being saved.

TABLE 3 COMPARISON OF MATERIAL CONSUMPTION BEFORE AND AFTER EMS IMPLEMENTATION

EnergySources	**Before EMS Implementation (2011)**	**After EMS Implementation (2012)**	
	Material Consumption/ton of DyedWoollenYarn	**Material Consumption/ton of Dyed Woollen Yarn**	**%Reduction in Material Consumption/ton of Dyed WoollenYarn**
Rice husk(ton)	1.31	1.23	6.11
Coal(ton)	0.0038	0.0036	5.26
Diesel(Kl)	0.0226	0.0218	3.54
Electricity(KWh)	28.51	28.44	0.24

Source: Field survey, 2012

The above data in Table 3revealed that there is a reduction in material consumption since EMS implementation [27]. Rice husk consumption per ton of dyed woollen yarn is reduced by 6.11%, coal consumption by 5.26%, and diesel consumption by 3.54%. These reductions of materials used are due to effective EMS implementation, which has achieved not only energy and material savings, but has also resulted in cost saving.

TABLE 4 COMPARISON OF RESOURCE CONSUMPTION BEFORE AND AFTER EMS IMPLEMENTATION

Energy Sources	**Before EMS Implementation (2011)**	**After EMS Implementation (2012)**	
	Consumption/ton of DyedWoollen Yarn	**Consumption/ton of Dyed Woollen Yarn**	**%Reduction in Resource Consumption/ton of Dyed Woollen Yarn**
Water (litters)	32667	30369	7.03
Sand (kg)	0.03	0.03	5.49
Dyes (Rs)	21973	21303	3.05
Chemicals (Rs)	8955	8685	3.01

Source: Field survey, 2012

Similarly, Table 4 shows reduction in consumption of resources including water, sand, dye, and chemicals [28]after EMS implementation. The water consumption per ton of dyed woollen yarn is reduced by 7.03%, sand by 5.49%, dyes by 3.05% and chemicals by 3.01%. And so the above data show that EMS is effective in achieving its goal set during EMS implementation in terms of reducing resource consumption in the dyeing unit of Paramount Carpet Industry.

Following EMS implementation, the effectiveness of introduced changes was observed. There was proper insulation of machines, which can typically reduce energy loss significantly and help ensure proper steam pressure inplant equipment [29]. Proper insulation of boiler, steam pipes and dyeing machines also tremendouslyreduces the amount of heat loss which occurs when steam leaks from pipes, boiler and dyeing machines [30]. The reduction in heat loss lowersenergy consumption required for steam generation. This reduction in energy consumption consequently reduces GHG emissions and as a result, helps to reduce climate change impacts at the local level [31].

TABLE 5 COMPARISON OF GHGS EMISSION BEFORE AND AFTER EMS IMPLEMENTATION

Fuel Type	Before EMS Implementation(2011)	After EMS Implementation(2012)	
	GHGs Emission in CO_2 Equivalent in ton/ton of Dyed Woollen Yarn. (Ton)	GHGs Emission in CO_2 Equivalent in ton/ton of Dyed Woollen Yarn. (Ton)	% Reduction in GHGs Emission in CO_2 Equivalent in ton/ton of Dyed Woollen Yarn.
Rice husk	1.91	1.80	5.76
Coal	0.0089	0.0083	6.74
Diesel	0.057	0.055	3.51
LPG	0.001	0.001	0
Total	1.98	1.86	6.06

Source: Field survey, 2012 and UNFCC (United Nations Framework Convention on Climate Change) for obtaining the greenhouse gas emission in CO_2 equivalent

The 4 tables, Table 1, 2, 3 and 4 show reduction in material and energy consumption,while Table 5 showsreduction in total GHG emission after one year of EMS implementation. The reduction of GHG emissions in 2012 after EMS implementation is 0.12 ton of CO_2 equivalent, which is 6.06% per ton of dyed woollen yarn.

TABLE 6 TOTAL GHGS EMISSION IN CO_2 EQUIVALENT

Fuel Type	Quantity		Total GHGs Emission in CO_2Equivalent in Ton (TCe)	
	(2011) (Ton)	(2012) (Ton)	(2011)	(2012)
Rice Husk	637	585	930	853
Coal	1.87	1.71	4.35	3.97
Diesel	11.02	10.37	27.98	26.32
LPG	0.17	0.17	0.53	0.53
Total	650.06	597.25	962.86	883.82

Source: Field survey, 2012

The above data in Table 6show that rice husk is the main source of GHG emission from the industry both before and after EMS implementation and contributes more than 96% of the total GHG emission. This is followed by diesel, which is used during load shedding hours and for complete combustion in the boiler burner, with around 3% of GHG emission. Coal and LPG together contribute less than 1% of the total GHG emission from the industry.

Before EMS implementation, the total GHG emission from the industry was 1.98 TCe per ton of dyed woollen yarn.After EMS implementation it was reduced to 1.86 TCe per ton of dyed woollen yarn. Good housekeeping and better process control were observed, preventing fuel and gas leakage, andresulting in chemical and dye savings [32].

TABLE 7 COMPARISON OF ECONOMIC STATUS BEFORE AND AFTER EMS IMPLEMENTATION

Energy Sources	Before EMS Implementation(2011)	After EMS implementation(2012)	
	Amount/ton of Dyed Woollen Yarn (RS)	Amount/ton of Dyed Woollen Yarn(RS)	Cost Savings/ton of Dyed Woollen Yarn (RS)
Rice husk	4585	4309	276
Coal	68.4	64.8	3.6
Diesel	1243	1199	44
Electricity	209.55	209.03	0.52
Sand	56	52	4

Dyes	21973	21303	670
Chemicals	8955	8685	270
Water	150.26	139.70	10.56

Source: Field survey, 2012

The above data show that with the implementation of EMS in the industry, cost savings have increased, by Rs. 1278, ie. $15.22($1=Rs. 84), demonstrating that EMS implementation in this industry can lead to environmental and economic benefits simultaneously. The ratio between an economic benefit and environmental impact is called eco-efficiency [33]and the relative change in this value is Rs 1278/0.12 ton of CO_2 equivalent.

After EMS implementation, there is reduction in GHG emission mainly because of technology changes, process monitoring and energy audits. Other benefits are resource and cost savings, increased organizational efficiency, and a better physical environment [34] [35]. Due to proper management of waste and greenery maintained within the company, positive impacts on the surrounding environment have occurred. This positive ambience also extends to visitors to the company.

Although PCI was successful in meeting its major objectives and targets set during EMS implementation, the bar could have been set much higher, mainly in terms of reducing energy consumption, thus reducing GHG emission which was found to be merely satisfactory, andnot as effective as other EMS-implemented companies. The major objective set by PCI during EMS implementation was to reduce energy consumption by 5% after one year and reduce air emissions by process monitoring, energy audits and technology changes. Although the companywas successful in achieving these objectives, reduction in resource consumption of around only 5% and reduction in GHG emission of 6.06% per ton of dyed woollen yarn cannot be considered significantly effective.Much more could be done to reduce emissions.

First, there is no blow-down heat recovery equipment in the boiler, which can reduce energy consumption significantly by recovering significant amounts of heat. Next, the industry lacks steam condensation closed systems which allows condensation(steam that has been condensed back into water either by a drop in temperate or an increase in pressure) to be returned in a closed pressurized loop to be re-boiled. Installation of such a system can improve boiler efficiency significantly, thus reducing the overall energy consumption required for steam generation.

Finally, there seems to be lack of awareness among the employees working in the industry regarding the adverse health effects of operating without the protective measures provided by the industry. With respect to this matter, the industry should make it mandatory for all employees to wear protective masks, goggles, gloves, head gear, and aprons (i.e. clothing) etc. Raising awareness of the adverse health effects of operating without such protective measures and providing required training would help to reduce overall energy consumption.

V. CONCLUSION

Analysis of primary data generated from PCI indicates that rice husk is the major source of energy used for the production of dyed yarn before and after EMS implementation. This fuel contributes more than 93% of the total energy consumption, followed by diesel with around 5%, which is used during load shedding hours. Coal, LPG and electricity each contribute less than 1% of energy. After EMS implementation rice husk consumption has been reduced by 6.11%; coal consumption by 5.26% diesel consumption by 3.54% water consumption by 7.03 % and sand consumption by 5.49%. Electricity consumption has also been reduced by 0.24% per ton of dyed woollen yarn, dye consumption by 3.05% and chemical consumption by 3.01%. The total GHGs emission has been reduced by 6.06% per ton of dyed woollen yarn within the first year of EMS implementation. Thus by implementing EMS, Paramount Carpet Industry was successful in achieving its goal. It is clear from the data and calculation that there is reduction in GHG emission, hence mitigating climate change. This can be an example for other industries to combat climate change nationally and globally.

To make EMS implementation truly effective in the industry in terms of reducing energy consumption and hence reducing GHG emissions.Advanced technological modifications can be considered, such as installation of blow down heat recovery equipment in the boiler, thus helping to recover more energy. Also, installation of steam condensationclosed systems to return condensationto the boiler by saving water consumption, along with increase in the height of the stack. Moreover, the Government of Nepal should promote EMS by appropriate subsidies or incentives. Reduction of greenhouse gas emissions through EMS in this industry is positive and this will have a direct impact for other polluting industries. Furthermore, it can be an example showing EMS to be a strong tool for reducing greenhouse gas emissions, and thus helping policymakers formulate rules with proper implication.

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