Sustainable Growth through Green Productivity: A Case of Edible Oil Industry in India

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ABSTRACT

The economic policies highlighting only productivity and economic growth, without addressing environment, have resulted into adverse and irreversible environmental impacts. A combined approach called Green Productivity signifies a new paradigm on socio-economic development aimed at the pursuit of economic and productivity growth while protecting the environment, simultaneously. A study was undertaken with the support from Asian Productivity Organisation (APO) for application of GP in soyabean sector in India in view of low productivity and environmental pollution. Soyabean sector plays a vital role in strengthening Indian economy in terms of export potential and employment, and rapid growth is expected in this sector in India. The study was carried out at Rama Phosphate Ltd., Indore (M.P.) processing soy having 400 TPD Solvent Extraction Plant and 100 TPD oil refinery.

The field studies included various areas such as water, wastewater, energy, steam, emissions to air, loss of oil during extraction as well as refining and various housekeeping measures. Based on the information gathered during the review and detailed study, concentration diagram and eco-maps were prepared to identify major problem areas like oil loss in DOC and refinery, hexane loss in SEP, energy loss, and inadequate steam generation. Each problem area was subjected to intensive cause-effect analysis using Ishikawa diagrams. Subsequently, 38 GP options were identified for implementation resulting into reduction in oil content in DOC, hexane loss, increase in SEP capacity, increase in power generation and saving in steam cost and coal.

By applying the concept of Green Productivity, M/s. Rama Phosphate Ltd., Indore has not only gained financially but also increased the overall productivity by 20% and met the regulatory requirements. The company reduced the hexane losses by 13% and oil losses in de-oiled cake (DOC) by 20%. The boiler efficiency of the existing boiler increased from 60% to 80%. Apart from these benefits, the company received ISO 14001 certificate, the first in edible oil sector in India, by the end of the project.

1. INTRODUCTION

As a result of the liberalization of the industrial policy in India, a number of multi-national companies are being established in the country. This open economy has created a competitive atmosphere among the industries not only at the national level but also at the international level. Developing countries like India are characterized by a large number of small and medium enterprises (SMEs) supporting the activities of large-scale industries. With the varied nature of these industries, they are resource intensive and generate more waste resulting in lower overall productivity. Many approaches have been adopted in various countries to minimize the generation of waste and protect the environment. The Environmental Protection Authority of USA, the United Nations Environment

Programme (UNEP) and the United Nations Industrial Development Organization (UNIDO) have popularized the concept of pollution prevention and cleaner production which emphasizes on the pollution reduction at source along with improving the efficiency of the production processes. In the recent past, the emphasis has been laid on resource conservation and pollution control together in order to sustain development. Since the Earth Summit in Rio de Janeiro in 1992, sustainable development has been a key term for overall socio-economic development without creating negative impacts on the environment. The need for resource conservation, efficient use of resources and environmental friendly corporate policies and behavior has now been recognized worldwide.

The concept of productivity is known to the industries since long. Japan has introduced the concept of Quality Circle (QC) and Total Quality Management (TQM). All these concepts have been applied by the industries in a piece meal basis. Of late, the International Standards Organization (ISO) has introduced standards for the improvement of environmental performance (ISO 14001) and the shop floor environment (ISO 18000). With the growing awareness of the consumer and government level, there is a need to integrate all these concepts to remain in the competitive era, particularly for the SMEs in India.

With the improvement in the quality of life, the demand for goods and services has also increased leading to more production to cater to the ever increasing demand. As a result, more resources are being extracted to meet the demand. This has not only improved the quality of life, but also affected the environment. It depletes the natural resource on one hand and degrades the environmental quality on the other hand by dumping the generated pollutants into natural bodies. It may pose serious risk to the environment and health while using and discharging of toxic and hazardous substances. Economic policies highlighting only productivity and economic growth, without addressing the environment, may cause an adverse effect and irreversible damage to the environment.

It has been recognized that efforts to increase productivity alone would come to a stand still if no efforts are made to improve or at least protect the environment simultaneously by all parties concerned. Today, the biggest challenge we are facing is to integrate environmental protection along with productivity enhancement. This is also required to withstand in the ever increasing global competition. While productivity provides the framework for continuous improvement, environmental protection provides the foundation for sustainable development. Green productivity signifies a new paradigm on socio-economic development aimed at the pursuit of economic and productivity growth while protecting the environment, simultaneously.

This paper describes a case study employing green productivity strategy as a tool to enable an edible oil industry to identify problem areas in productivity and environment and make improvements aiming at sustainable growth. The paper focuses on the approach/methodology adopted and the outcome of the study. It also provides comprehension of the concept of green productivity and its application.

2. GREEN PRODUCTIVITY STRATEGY AND METHODOLOGY

While selecting green productivity strategy in carrying out the study, it was emphasized that appropriate productivity and environmental management tools, techniques and technologies were applied to reduce the adverse environmental impacts of organization's activities, goods and services while enhancing its productivity. The focus was kept on three distinguishing characteristics of GP, i.e., productivity improvement, environmental compliance, and integrated approach.

Productivity improvement: Productivity improvement is one side of the GP coin. The Kaizen approach of continuous improvement forms the basis. This has to accompany environmental protection. The concept of continuous improvement achieved by adopting the tenets of the PDCA (Plan, Do, Check and

Act) cycle is aimed at ensuring not only productivity improvement unlike in classical productivity improvement programs but also environmental improvement. This is a dynamic and iterative process.

Environmental compliance: The heart of GP is environmental protection, the first step for which is compliance. It is today one of the most challenging tasks facing the industry, which can be achieved through the practice of GP by pollution prevention and source reduction. The residues should be viewed as a resource, which can be a raw material in another process, or valuable products which can be recovered. Whatever the remainder, it will be required to be managed using end-of-pipe treatment measures. While achieving environmental compliance, it is the unique characteristic of GP that productivity will also improve. These practices may lead to a situation beyond compliance with the ultimate aim of ensuring quality of life.

Integrated approach: One of the strengths of GP is its worker involvement and integrated team-based approach. Its team-based approach extends to improve working environment, worker health and safety, non-discrimination and related social welfare issues. The approach adopted is methodology-based and involves multi-stakeholder participation. This enables a step-by-step approach, systematic generation of options and solutions, and contribution by all the members in an organization to the GP process [1].

The central element of GP methodology is the examination and re-evaluation of both production processes and products to reduce their environmental impacts and highlight ways to improve productivity and product quality. Implementation of these options leads on to another cycle of review and so promotes continuous improvement. GP methodology revolves around the PDCA cycle. The GP methodology as illustrated in Fig. 1 entails six principal steps.

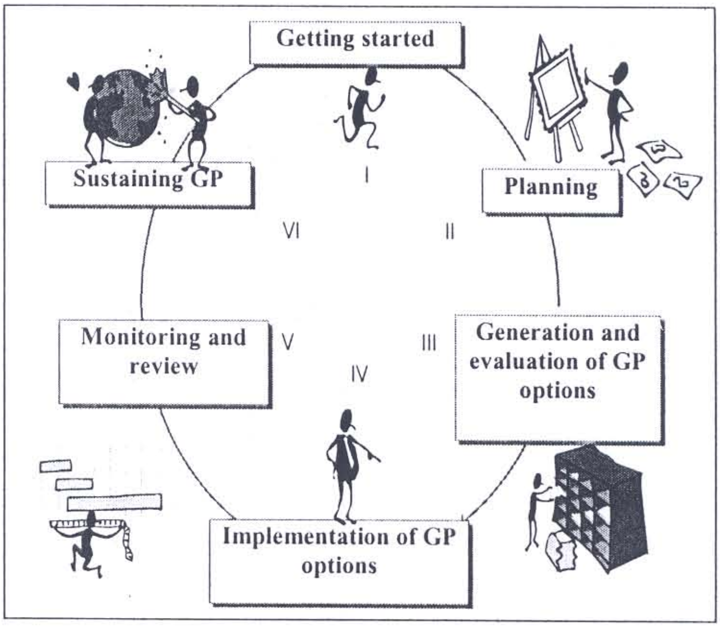

Fig. 1 Green productivity (GP) methodology

3. IMPLEMENTATION OF GP IN SOY PROCESSING INDUSTRY: A CASE OF M/s. RAMA PHOSPHATE LTD., INDORE (M.P.)

India is the fourth largest oilseed producing country in the world, next to the U.S.A., China and Brazil, harvesting about 25 million tons of oilseeds as against the world production of 250 million tons per year [2]. Although India is a major producer of oilseeds, per capita oil consumption in India is only

10.6 kg/year as compared to 12.5 kg/year in China, 20.8 kg/year in Japan, 21.3 kg/year in Brazil and 48 kg/year in the U.S.A.

The major oilseeds produced in India are soybean, groundnut, cottonseed, rapeseed, sunflower, linseed, caster seed and palm kernels. The oilseeds are grown in an area of nearly 27 million hectares across the country. Soybean is the third largest oilseed crop in India next to groundnut and mustard [3]. About 75% of soybean is produced in Madhya Pradesh alone and the rest in Maharashtra and Rajasthan. Though India is the fifth largest soybean producer in the world, its share in the world's production is only 3%. While soybean cultivation has grown from 0.003 to about 6 million hectares and the processing capacity of the industry from 3.28 to 15 million tons/year, the productivity and the efficiency have remained low as compared to other major soybean processing countries. Notwithstanding the remarkable growth exhibited by the soybean sector, it is passing through crisis for the last 4 to 5 years.

In India, the yield of soybean is only 0.95 tons/hectare as compared to the U.S.A. of 2.5 tons/hectare [4], which is quite low. Likewise the productivity of soy oil industries is also low compared to other countries. The average residual oil content in de-oiled cake in India is 1.18% whereas the same is 0.5% in Japan. The average specific hexane consumption is about 4.93 liters per ton of seeds processed compared to 1 to 1.5 liters per ton in Japan. The various influencing factors, i.e., technology, capacity, manpower, machinery, raw material, process, and operation and maintenance practices vary from industry to industry. The consumption of input materials (e.g., hexane, steam, electricity, and water) per unit output is very high which primarily leads to low productivity on the one hand and environmental pollution on the other hand.

Due to low productivity of soybean farm and industries, the cost of production is very high. The high cost of production makes Indian soy oil and other soy products costly in comparison to imported soy oil. In the era of economic liberalization and globalization of trades, such a situation is not conducive for survival and growth of Indian soy oil industries. Urgent steps are necessary to enhance the productivity of the Indian soy oil industries. The challenge is not only to enhance productivity but also to improve environmental performance of the soy oil industries in order to ensure its sustainability. How to meet this challenge? The obvious answer is Green Productivity (GP) – a strategy for enhancing productivity and environmental performance for overall socio-economic development. In the industrial sector, GP brings down the production cost and improves the environment by way of optimizing input materials and reducing wastage of resources. Cost-effectiveness, profitability, competitiveness and improved working environment are central goals of GP.

The concept of GP was applied to M/s. Rama Phosphate Ltd., Indore (M.P.) processing soy having 400 TPD solvent extraction plant and 100 TPD oil refinery. Before the start of the study, a GP team comprising of plant personnel from various departments along with NPC officials was formed. The GP team started with undertaking an initial review of the production processes including utilities for the purpose of preparing process flow diagrams, material balance and to identify various waste generating areas as well as areas having adverse environmental impacts. The initial review was followed by detailed field studies to quantify to the extent possible, the various waste streams and pollution load generated.

The field studies included various areas such as water, wastewater, energy, steam, emissions to air, loss of oil during extraction as well as refining and also various housekeeping measures. Based on the information gathered during review and detail study, concentration diagram and eco-maps were prepared to identify major waste streams and problem areas. The sample eco-map and concentration diagram is given in Fig. 2. The eco-map diagram depicts various sections having adverse environmental impacts and helps assess overall environmental situation in the industry and set priorities for making improvements. The identified major waste streams/problem areas are given in Table 1.

3.1 Cause Effect Analysis of Waste Streams/Problem Areas

The detailed analysis was carried out to establish the causes and effects of the waste streams and problem areas. The Fish Bone Diagram (Ishikawa Diagram) was used for cause-effect analysis. The

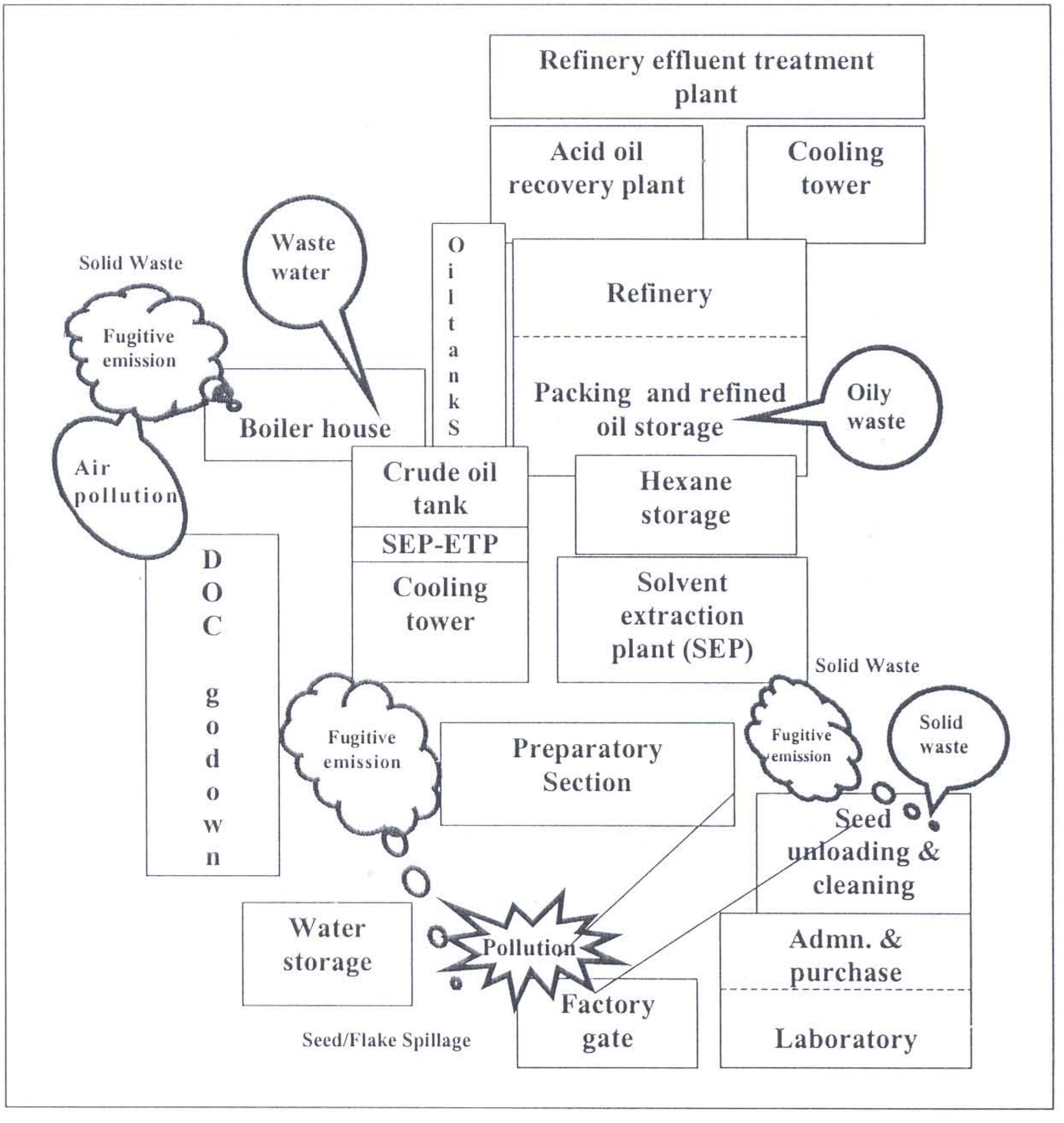

Fig. 2 Eco-mapping depicting environmental pollution

sample Fish Bone Diagram depicting causes for hexane loss is shown in Fig. 3. The detailed analysis of causes of waste streams/problem areas and their effects are presented in Table 2.

The major causes identified for the loss of oil and hexane are:

- Inadequate seed preparation in cracking and flaking due to defective rollers,
- Improper cooking of collates due to inadequate steam supply and generation,
- Inadequate hexane spray and extraction system.

3.2 Evolving and Implementing GP Options

In view of cause-effect analysis green productivity options were generated with an objective to minimize or eliminate the causes and associated impacts/effects of waste streams/problem areas. A total of 38 GP options were generated. The GP options evolved are classified into five groups based on the techniques, such as: (a) housekeeping improvement (36%), (b) material substitution (8%), (c) recycle/reuse (11%), (d) recovery (3%), and (e) technology (equipment) change (42%).

Table 1 Identified major waste streams/problem areas

Problem areas	Title
Problem area I	Oil loss in de-oiled cake (DOC). About 1% to 1.5% oil is lost in DOC due to poor extraction efficiency.
Problem area II	Oil loss in refinery. On an average 7% of oil is lost in refinery due to improper operational control.
Problem area III	Hexane loss in solvent extraction plant (SEP). The hexane is used as solvent for the extraction of oil. The hexane loss in SEP takes place due to carry over with DOC, crude oil, etc.
Problem area IV	Excessive wastewater generation and poor treatment. The waste waster is generated in refinery and oil recovery plant. The existing effluent treatment plant (ETP) is not capable to treat wastewater due to overload.
Problem area V	Energy loss. This was observed in the form of high electricity consumption in cooling towers, inadequate steam pressure resulting in high steam consumption in refinery section and heat losses from uninsulated steam lines.
Problem area VI	Inadequate steam generation. The existing stationary grate coal-fired water tube boilers operate at only 65% efficiency.
Problem area VII	Fugitive emissions in work environment in various sections.
Problem area VIII	Improper material handling and housekeeping practices.

The major GP options evolved and implemented by the management are:

- Repair of worn out rollers of the cracker and flaker;
- Insulation of the exposed steam lines, flanges and valves;
- Recalibration of water flow meters of refinery;
- Increase in the heating surface area by increasing the limpets in cooker;
- Installation of waste heat recovery (WHR) system from the flue gas;
- Commissioning of new higher capacity FBC boiler; and
- Replacement of aluminum impellers of cooling tower fan with FRP impellers.

3.3 Achievements of GP

The specific time bound targets were set corresponding to each feasible GP options. Also, a detailed action plan was drawn for each target. As of January 2002, out of 28 feasible GP options, 18 GP options have been implemented. The other GP options are under different stages of implementation. It is estimated that the total cost of implementing 18 GP options is about US$ 425,500 (Rs. 2 crore). This cost includes expenditure towards environmental management system documentation, logistics, housekeeping and ISO 14001 certification. It is estimated that this investment would be paid back within 12 to 15 months time. The highlight of implemented GP options is given in Table 3.

The overall productivity of the unit has increased by 20% in terms of:

- Reduced oil loss in DOC;
- Reduced oil loss in refinery section;
- Reduced hexane loss in SEP;
- Improved boiler efficiency;
- Reduced wastewater generation;
- Increased effluent treatment efficiency; and
- Improved work environment increasing workers' efficiency

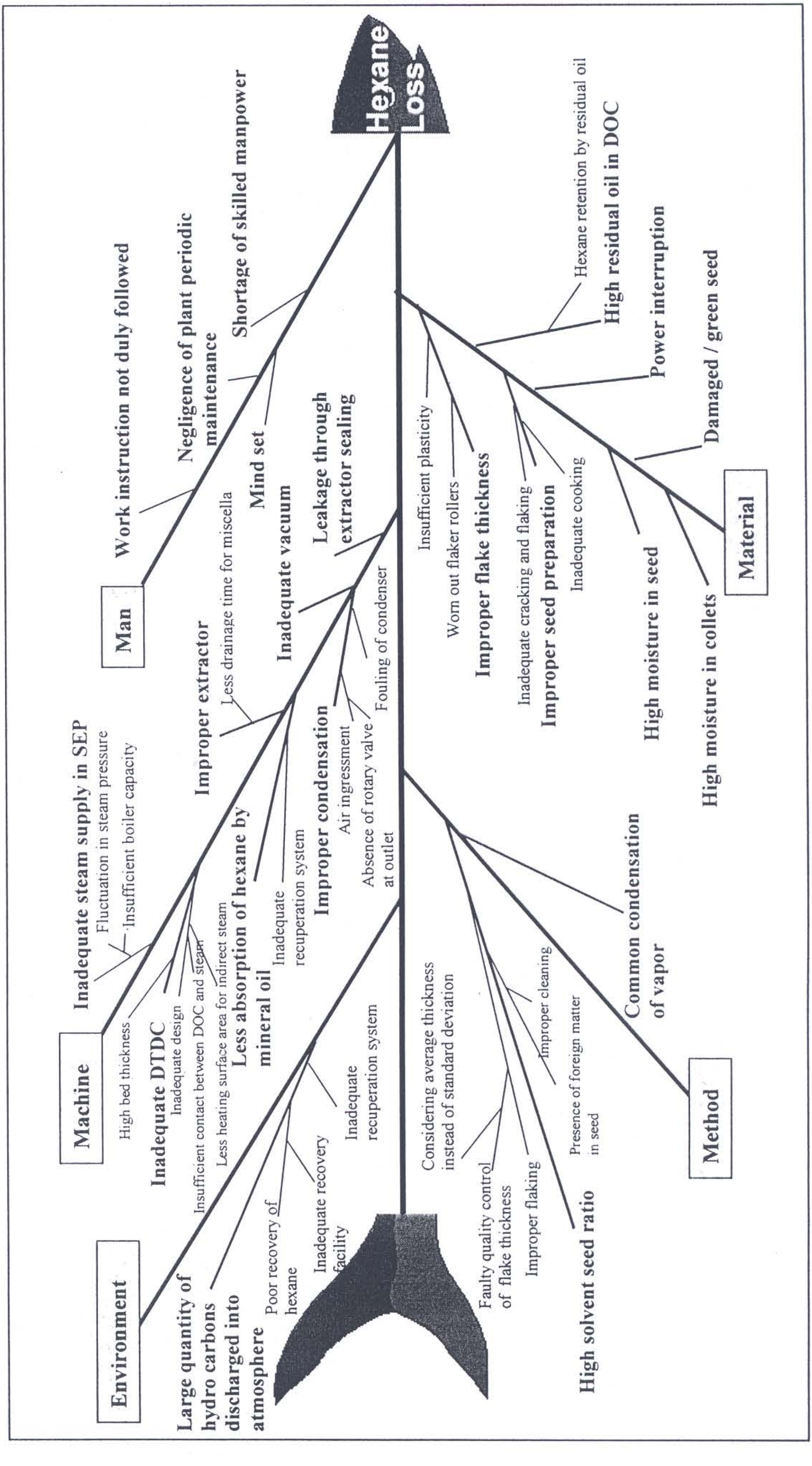

Fig. 3 Fishbone diagram depicting hexane loss

Table 2 Causes of problem areas and their effects

Problem Area	Causes	Effects
Oil loss in DOC	Less efficient cracking (non-graded seed, worn out roller, and presence of stone in seed)	Less efficient cracking leads to inefficient cooking, flaking and extraction subsequently
	Inadequate cooking (small cooker, and less heating surface)	Inadequate cooking leads to incomplete flaking and extraction subsequently
	Less efficient flaking (worn out roller, inadequate cracking and cooking)	As the thickness of the flake increases, oil content in DOC increases
	Less efficient extraction (low drainage time, improper hexane spray, inadequate cracking, cooking and flaking)	Poor extraction leads to high residual oil content in DOC
Oil loss in refinery	Excess water addition in hydration and neutralization (faulty flowmeter)	Excess water hydrolyses the oil and forms emulsion and concentration of soap stock reduces, leading to excess oil loss and generation of excess wastewater
	Absence of one washing separator	Gives rise to hydrated soluble gums in wastewater rendering it difficult to treat. Also, contribute to oil loss in refinery
	Possibilities of excess caustic addition in neutralization (no flowmeter, manual dosing)	- Oil loss due to saponification - Increased consumption of sulfuric acid for acid oil production
	Use of low grade bleaching earth	- Poor color removal efficiency - Color reversal problem - High oil carry over with spent earth
	Improper bleaching earth addition (addition of powder in place of slurry)	- Poor bleaching of oil - Loss of bleaching earth - Increase in cost of production
	Oil leakage from pump (worn out seal)	- Low yield of oil - High load to ETP
Hexane loss	Inadequate vacuum in (de-solventization-toasting-drying-cooling (DTDC) and distillation (inadequate steam, inadequate cooling and condenser)	- Leads to poor separation of hexane in the DTDC and distillation unit increasing the specific consumption of hexane - The quality of crude oil and DOC may further degrade due to high concentration of hexane
	Inadequate de-solventization in DTDC (inadequate steam, inadequate heating surface area)	- Leads to hexane carry over along with meal dryer air, resulting to hexane losses
	Inadequate drainage in extractor (inadequate drainage time, higher hexane concentration in wet DOC)	- Leads to additional hexane carry over with wet DOC
	Inadequate recuperation (inadequate absorption / release of hexane)	- Recovery of the uncondensed hexane is not completed
	Inadequate crude oil stripping (inadequate steam and vacuum, inadequate condenser size)	Poor oil stripping leads to hexane loss and also affects the quality of the crude oil

Table 2 *(continued)*

Problem Area	Causes	Effects
Excessive wastewater generation and poor treatment	High water consumption in short mix plant due to faulty flowmeter	Increase in the hydraulic and pollution load to ETP
	Discharge of seal cooling water to ETP	Increase in hydraulic load to ETP
	Non-availability of second washing separator in short-mix plant.	Leads to high pollution load to ETP
	Poor performance of the existing ETP	Non-compliance with effluent Discharge standard
Energy loss	High electricity consumption due to aluminium blade in cooling towers fans	Leads to 20% to 25% excess energy consumption compared to FRP impellers
	Higher cost of energy due to diesel as fuel in thermic fluid heater	Contributes to higher cost of product
	Supply of low pressure steam (7 kg/cm^2 against 10 kg/cm^2 required)	Results in excess steam consumption
	Heat losses from un-insulated steam lines, flanges and valves	Results in excess steam consumption
	Passing of steam traps leading to steam loss. No waste heat recovery system	Results in excess steam consumption. Energy loss with flue gas resulting in more coal consumption
Inadequate steam generation	Less efficient boilers	Less efficient boilers leads to high oil content in DOC and hexane loss in solvent extraction plant (SEP)
Emission in work environment	Inadequate dust extraction and air pollution control system (APCS) in the seed cleaning section	Leads to air pollution in the work environment
	Absence of air pollution control system (APCS) in the seed preparatory section	Leads to air pollution in the work environment
Improper material handling and housekeeping practices	Principle of industrial engineering and 5S not applied	Loss of man and machine hour, and loss of space resulting in overall loss of productivity

Table 3 Highlights of implemented GP options

Problem Areas	GP Options	Investment	Benefits
Oil loss in DOC (high residual oil content in DOC)	Replace worn-out roller of the cracker	Rs. 800,000 (US$ 17,024)	- Financial savings of Rs. 3,854,000 (US$ 82,000) per year as a result of 20% reduction in oil loss in DOC. (1.18% to 0.97%) - Pay back period less than 3 months
	Increase the heating surface area in the cooker by adding more steam pipes (limpets)		
	Repair worn-out roller of the flaker		
	Replace irreparable roller of the flaker		
	Improve the hexane spray system		
Oil loss in refinery	Recalibrate water flowmeter in short mix plant	Nil	- Financial saving of Rs. 84,000 (US$ 1,787) per year as a result of water saving of 14 m^3/day - Net saving
	Introduce preventive maintenance of pump gland seals		
Hexane loss in solvent extraction plant	Increase mineral oil flow rate in thermic fluid heater (TFH)	Rs. 195,000 (US$ 4,150) and in addition a part of cost of new FBC boiler is accounted	- Financial saving of Rs. 1,270,000 (US$ 27,000) per year as a result of reduction of hexane loss from 4.93 to 4.3 liters/ton of seed processed (13%) - Pay back period is less than 6 months.
	Increase heating surface area of plate heat exchanger (PHE)		
	Increase chilled water flow rate in vent condenser		
	Install separate condenser with steam ejector in stripper to increase vacuum		
Wastewater generation from refinery and its treatment	Reuse seal cooling water generated by short mix plant	Rs. 50,000 (US$ 1,064)	- Financial saving of Rs. 187,000 (US$ 3,979) per year as a result of water saving of 25 m^3/day - Payback period less than 3 months
Energy loss	Replace aluminium impellers of cooling tower fans by FRP impeller	Rs. 962,0000 (US $ 20,471)	- Financial savings of Rs. 2,422,000 (US$ 51,540) per year. - Payback period is less than 5 months
	Replace diesel fuel by coal in TFH		
	Replace 7 kg/cm^2 pressure steam nozzle by 10 kg/cm^2 pressure nozzle in de-odoriser		
Inadequate steam generation (due to less efficient boilers) leading to high oil and hexane loss	Install waste heat recovery (WHR) system in existing boiler	Rs. 150,000 (US$ 3,192)	- A gain of Rs. 264,000 (US$ 5,618) as a result of 128 ton coal saving per year - Reduction in GHG emission of 192 tons/year - Payback period less than 7 months
	Install FBC boiler of requisite capacity	Rs. 12,000,000 (US $255,360)	- A gross gain of Rs. 21,600,000 (US$ 459,648)* per year - Reduction in GHG emission of 2025 tons/year through reduction in coal consumption by 1350 tons/year - 60% to 80% increase in boiler efficiency - After depreciation, and interest on the principal amount the payback period is less than 15 months
Inadequate air pollution control device	Improve dust extraction capacity and efficiency of existing cyclone	Rs. 25,000 (US$ 532)	- Improved work environment - Increased labor productivity

* The gross gain is attributed to reduction in oil content in DOC, hexane loss, increase in SEP capacity, increase in power generation and saving in steam cost and coal.

The project helped unit to develop and establish environmental management system (EMS) meeting requirements of ISO 14001 standard. The certification audit has already been completed by M/s. SGS India Limited, the Certifying Agency and the unit has been awarded ISO 14001 certificate in May 2002.

4. CONCLUSIONS

By applying the concept of green productivity, M/s. Rama Phosphate Ltd., Indore has not only gained financially but also increased the overall productivity by 20% and met the regulatory requirements. The company implemented 18 out of 38 GP options by investing about US$ 425,000 with a payback period of just 15 months. In addition, the quality of oil was also improved. The company reduced the hexane losses by 13% and oil losses in de-oiled cake (DOC) by 20%.

The boiler efficiency of their existing boiler increased from 60% to 80% by installing waste heat recovery system and also saved in coal consumption. The coal consumption was further brought down by 1350 tons/year by installing more efficient FBC boiler, thus reducing greenhouse gases (GHG) emissions by 2025 tons/year.

Apart from these benefits, the company prepared themselves for environment management system (EMS) and received ISO 14001 certificate, the first in edible oil sector in India, by the end of the project.

5. REFERENCES

[1] Asian Productivity Organisation (APO). 2001. Green Productivity Training Manual (Draft). Tokyo: Asian Productivity Organisation, Japan.

[2] Hazara, C.R. 2001. Developmental Strategies for Soybean Production in India. Souvenir of India, Soy Forum, 17-18 March 2001, Indore, M.P., India.

[3] Hegde, D.M. 2001. Agro-ecoregion Specific Cropping Systems for Sustainable Soybean Production. Souvenir of India, Soy Forum, 17-18 March 2001, Indore, M.P., India.

[4] Hazara, C.R. 2001. Introductory remarks. In *Proceedings of India Soy Forum* 17-18 March 2001, Indore, M.P., India.

[5] Ministry of Agriculture. 1999. *Statistics at a Glance*. S.n.: Ministry of Agriculture, Government of India.

[6] Bailey's Industrial Oil and Fat Products, Edible Oil and Fat Products (Volumes 1 to 5). Hui, Y.H (ed).

[7] Sen, Thomas T. *Industrial Pollution Prevention*. S.n.: Springer.

[8] Snyder, Harry E. and Kwon, T.W. *Soyabean Utilisation*. New York: Von Nostrand Reinhold Company.

[9] SOPA Digest. The Soyabean Processors Association of India, Indore, India.

[10] 2002. NPC Project Report for Green Productivity Demonstration Project at M/s Rama Phosphate Limited, Indore, India.