CLEANER PRODUCTION: THE UMBRELLA FOR ENVIRONMENTAL GLOBALIZATION

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ABSTRACT

Rapid population growth, coupled with poverty, is firmly bonded to environmental degradation. Economic activities reinforced by globalization and current trends of consumption patterns threaten the availability of resources in the near future. Under such conditions, technological developments have the potential to reverse negative environmental changes. The idea of cleaner production playing the role of a controlling factor is multifaceted both from an economic point of view and the inherent advantage of environmental protection. Technological developments have been made, in the face of huge environmental challenges, that endeavor to change the structure of the economy to a more environmentally friendly one, spread more efficient and cleaner technologies, and provide information to increase awareness of the impact such technological changes can have on the environment. There are several system-specific alternatives for adopting and implementing the ethics of cleaner production, but each requires a set level of investment and return based on cost-benefit analysis. By adopting cleaner production, it is possible to make industrial growth more competitive, as well as making improvements to the environment.

I. INTRODUCTION

Globalization is a double-edged sword, capable of bringing environmental opportunities (for example, through increased access to markets, information, capacity sharing and cleaner technologies) but also environmental threats (such as increased consumption of natural resources and generation of waste; IIED, 2000). It has been observed that current production and consumption patterns are not sustainable, and to prevent the situation from worsening, the agenda for industrialization in the developed world should remove barriers to eco-efficiency such as overbearing economic concerns, inadequate technological and technical skills, cultural concerns, lack of information dissemination etc. Environmental problems associated with the growth in production and consumption are increasing. The earth’s ecosystems have witnessed increasing damage from air, water, and soil pollution, making life intolerable in many parts of the world. A 1996/97 ILO study states that unemployment has risen due to low rates of economic growth in industrialized
countries since 1973 and the incapability of developing nations to bounce back from the crisis of the 1980s (Hansenne, 1997). The late 20th century will go down in world history as a period of global impoverishment (Chossudovsky, 1998). These are indicators showing that global poverty and unemployment are meanwhile increasing in line with population growth.

These developments add to the sense of urgency to shift production and consumption patterns onto a sustainable path. One way to accomplish this is to implement a conceptual change from “pollution control” to “cleaner production” in Industrial Environmental Management. In agreement with the important shift from the reactive end-of-pipe approach to the proactive zero pollution approach, there is a strong need to enhance our understanding of the application of these concepts to achieve better and more efficient Environmental Management.

With the failure of the end-of-pipe approach to abate industrial pollution and its impacts, the focus shifted backward to industrial production and its processes. Increased research identified the potential to improve consumption of resources, processes and equipment used, production practices in general and many other facets of industrial production. Methodologies such as Environmental Audits were developed as tools to study and appraise the production and pollution linkages in industries. International standardization like ISO 14000 induced the globalization of these concepts so that Integrated Environmental Management could be achieved.

II. A BRIEF BACKGROUND

Before the advent of pollution control methodologies, production and consumption patterns had the format shown in Fig. 1 below.

![Fig. 1: Past Production Pattern](image_url)

As shown in Fig 1, there are no procedures that take into consideration the reduction or treatment of the generated wastes. This lead to increased waste production, growing environmental pollution and degradation, problems of disposal, and ultimately the associated health hazards on the living populace.
These emanated not only from increased production capacities due to rising needs, but also due to processes performing below the optimum.

With the discovery of the negative environmental impacts of this open-loop unchecked system came the birth of ‘Pollution Prevention’. The concept of pollution prevention introduced a new dimension into waste management practices. As opposed to the traditional method of waste generation, this concept brought in the elements of the hierarchy of pollution prevention; i.e. source reduction, reuse, treatment and disposal as shown in Fig. 2 (IISD, 1997).

![Fig. 2: The Hierarchy of Pollution Prevention](image)

In order to make waste management more sustainable, it should be moved up this hierarchy (Reduction-Reuse-Recycle-Recover-Treatment-Disposal) to a new hierarchy without disposal facilities approaching zero pollution referred to as Cleaner Production Hierarchy for Zero Pollution (CPHZP) (El-Haggar, 2000).

![Fig. 3: Preferred Industrial Practices](image)
The concept of industrial ecology is just a version of the system above. There are checks on the processes with the goal of optimizing their operational parameters. These parameters are system dependent and rely on the production pattern being practiced. The industry is to be taken as an ecosystem with the idea of minimizing or completely reusing wastes.

III. WHAT IS CLEANER PRODUCTION?

The United Nations Environment Programme (UNEP, 1989) defines Cleaner Production as:

*The continuous application of an integrated preventive environmental strategy to processes and products to reduce risks to humans and the environment.*

By considering production processes, Cleaner Production includes conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes before they leave a process. For services, it focuses on incorporating environmental concerns into designing and delivering services. In other words, it advocates the adoption of clean technologies as an alternative to end-of-pipe treatment technologies. The use of clean technologies in production minimizes waste through process upgrades and improvement, thus reducing reliance upon pollution control equipment. It involves replacing inefficient and pollution-intensive production processes with environmentally sound processes and conserving raw materials in production to minimize waste generation (HKPC, 2002).

Cleaner Production is as much about attitudes, approaches, and management as it is about technology. Every employee in the organization, including top management, can potentially affect the environment and must be committed to helping minimize environmental impact. The focus is on preventing or reducing environmental impacts rather than treating wastes and repairing environmental damage after the event. It is important to move away from the mindset that compliance with the regulations is good enough—because regulations often lag behind the rapid technological improvements in Cleaner Production and consequently do not reflect ‘best practice’. Cleaner Production should be seen as an integral element of applying best practice. In some circumstances, government regulation is in fact ‘minimum requirement’ rather than best practice (Environment Australia, 2000).

The increased generation of waste arises from inefficiencies, but with continuity in technological development this waste can be converted into a commercially valuable resource. The room for improvement in industrial processes always exists, and an evolutionary or continuous improvement approach is better appreciated than a revolutionary approach since people adapt better to gradual changes. This also serves as a signal of the commitment of an
organization to deal with waste issues as an integral part of its business approach. Most present production systems are entirely linear but cleaner production systems are cyclical; they try to imitate nature’s processes. Wastes are used as secondary materials so that fewer new materials and less energy and water are required.

IV. COST-BENEFIT RESULTS OF CLEANER PRODUCTION SCHEMES

Many businesses do not realize how much money they lose in wasted materials, energy and water, or through handling, storing and disposing of waste materials. Large and small businesses can save money by introducing cleaner production. Pollution Prevention, or “P2”, shifts the emphasis from controlling pollution once it has been created to preventing its creation in the first place. The origin of P2 can be traced to the US manufacturer 3M, which in 1975 instituted a program called “Pollution Prevention Pays” (“3P”) in an effort to eliminate pollution at source. Between 1975 and 1999, the scheme saved 3M an estimated $827 million and eliminated more than 800,000 tons of pollutants. (IISD, 1997). The following points illustrate aspects of industrial environmental accounting that make cleaner production worthwhile.

a) Leads to improved products and processes

A good example of this is the process improvement in the reduction of heat loss in the Lead Oxide Unit at Sagar Surgicals in Kanpur, India by the modification of the furnace insulating material to reduce heat loss by radiation from the furnace. Adequate heating made it possible to obtain the desired yield and quality of Lead Oxide (El-Haggar, 2002).

b) Saves on raw materials and energy, reducing production costs

The example highlighted above also lead to reduced consumption (and thus expense) of fuel and power. The batch process time was also reduced. The case study of Edfina Company for preserved food in Alexandria and Kaha in Egypt centers on water and energy conservation. Some of the energy saving measures include bare steam pipe insulation, leaking steam trap and valve replacement, boiler combustion efficiency improvement by assessing the fuel to air ratio necessary for complete combustion, and hence, minimal fuel consumption etc. Water saving measures include the use of hose nozzles, cooling tower installation etc. The cost benefit result of these modifications shows that the Edfina company saved over 1000 tons/year of Fuel from a total investment of over USD 50 000, with a payback period of one and half years yielding an annual savings of approximately USD 40,000. Water savings amounts to over 100,000 m$^3$ per annum from an investment of over USD 25,000, with a payback period of less than a year (SEAM Project, 1994-1999).
c) Increases competitiveness through the use of new and improved technologies and ideas.

The improvement in processes leading to improved products creates an environment for positive competition between firms producing similar products. This tends to give an overall quality improvement in these sectors. The Edfina Company in Alexandria, Egypt also introduced the Hazard Analysis and Critical Control Point (HACCP) for the fruit drinks bottling line. This was done by integrating HACCP with ISO 9000 under one management system. The result of this is evident in the exportation of frozen vegetables and fruit drinks to the United States and Europe. Environmental improvements include a reduction in water consumption, pollution loads and the volume of effluent discharges.

d) Reduces the need for more environmental regulation

Instances like the reduction of chemical oxygen demand in the textile industry, reduction of chemical usage in the printed circuit boards industry, the use of water-based adhesives instead of volatile solvents, monitoring of the oxides of Nitrogen (NOx) and Carbon (CO) in the cement industry, etc. have surpassed the goals of environmental control (El-Haggar, 2002).

d) Reduces risk from on- and off-site treatment, storage and disposal of toxic wastes

Any technique that leads to reduction in energy consumption, raw material usage, etc. reduces the waste and the level of treatment required for such wastes before disposal.

e) Improves the health and safety of employees

La Societe Tunisienne de l'Accumulateur NOUR in Tunisia manufactures lighting and ignition batteries. One of the recommendations from the pollution prevention assessment by USAID emphasized the covering of large piles of slag, dross and bag house dust that present major environmental problems and risks to workers through lead exposure (El-Haggar, 2002).

f) Improves staff morale, leading to better productivity

The instance above gives a signal to the workers that their health is of significant importance to the existence of the company. These in turn boosts morale and makes the workers comfortable spending time within the company premises. This leads to better productivity.
g) Improves a company's public image

A firm carrying out an environmental policy by incorporating the ethics of cleaner production is judged responsible in the society. Taking care of the environment is an indirect way of caring for the surrounding or neighboring society.

h) Reduces the cost of increasingly expensive end-of-pipe solutions

For instance, the reduction of sulphide in effluent from Sulphur Black Dyeing at Century Textiles and Industries Ltd. in India resulted in less corrosion in the treatment plant.

The costs of wastes and emissions, in addition to negative environmental and health impacts, can be avoided by applying Cleaner Production. Therefore, it is the most cost-effective way to operate processes. Adopting Cleaner Production can reap both environmental and economic benefits. The phobia for change coupled with an all-time interest in immediate returns on investment remains the most potent reason why some of these practices have not been implemented. Other constraints in adopting cleaner production include the concern over product quality i.e. manufacturers and customers must be convinced that the new process will produce equally high products, lack of knowledge of environmentally sound processes which are available, coupled with an unwillingness to adopt processes which are new and untried. (Asolekar, 1999). However, it should be noted that practicing cleaner production not only leads to regulation compliance but can take firms ahead of regulations, leading to higher return on investments.

V. THE TECHNIQUES OF CLEANER PRODUCTION

The general prevention methodologies for cleaner production can be succinctly explained using Fig. 4. Unfortunately, there exists no particular standard set of rules for implementing cleaner production because production processes are multidimensional and based on the nature of the business. However, there exists a set of basic techniques that may be applied to any existing industry or process for the development of Cleaner Production. In the case of future industries, these procedures can be used to design the foundation of the production process. These techniques call for a localization of cleaner production practices in every respective subsystem, and hence offers a comprehensive approach unique to any given subsystem. One argument that may ensue is that of process selection (i.e. making a process better or choosing a better process to begin with). The response to this can be ascribed to the type of process in question with reference to the level of commitment on the part of management toward the cause of cleaner production. As mentioned earlier, gradual changes are better appreciated than radical ones, especially if such changes have no appreciable differences in
implementation or operation. Some examples of the application of these techniques include:

![Diagram of General Prevention Techniques](image-url)

Fig. 4: General Prevention Techniques (El-Haggar, 2002)

**Good Housekeeping**

Repairing all leaking points, keeping taps firmly closed when not in use, cover vibratory screens always to avoid spills, blockage removal along conduction lines etc are some of the numerous housekeeping practices. In the case study of Oil and Fats recovery at the Tanta Oil and soap Company, Tanta, Egypt, the housekeeping practice carried out is that of preventive maintenance through the upgrade of the loading and unloading procedures. During the loading and unloading of oil, ghee and fatty matter from batch reactors and separators, significant levels of spillages and leakages were occurring. These losses were entirely eliminated as a result of issuing improved procedural instructions and by improving the supervision of transfer operations. This was implemented at no cost, but it resulted in an annual savings of over two hundred thousand Egyptian Pounds (over USD 40,000). (SEAM Project, 2002). Good
housekeeping practices improve safety, delay damage of equipment, reduces breakdowns, and increase efficiency. Preventive maintenance will also assist in discovering leaks and spills when they first occur.

Better Process Control

An optimization of cooking process e.g. the Wort boiler in beer production, refining at the highest possible pulp consistency in paper production, use of retention-aiding chemicals to maximize dye utilization in textiles. The use of Lithographic Alcohol Eliminator (LAE) instead of alcohol in Lithographic printing by DS Chemport resulted in an annual savings of over six thousand dollars in a given company A, and over fifteen thousand dollars in another company B (DS Chemport, 1997).

Equipment Modification

The installation of more efficient equipment or by modifying existing ones lead to better production systems. For example, steam ejectors with barometric condensers, known for the copious amount of waste stream they generate, could be replaced by vacuum pump and surface condenser systems. (Asolekar, 1999). The use of capacitor banks for power factor correction, using diaphragm pumps that minimize the emission of Volatile Organic Compounds in the printing process, provision of overflow tanks, the installation of high pressure pumps to aid fluid flow are some instances of modifications on the system, which lead to cost and energy saving benefits.

The reduction of milk losses at the Misr Company for Dairy and Food, Mansoura, Egypt was achieved with the installation of stainless steel control valves, which helped to minimize leakages along the lines, eliminated spillages on the floors, thereby improving hygiene and safety. Forty of such valves were installed in the system at a cost of sixty-four thousand Egyptian Pounds (over USD 13,000) leading to daily milk savings of about 350 Kg or 126 tons annually. (SEAM Project, 2002).

Technology Change

The use of alternative bleaching agents such as oxygen or ozone, the use of heat exchangers, the use of a Dissolve Air Flotation (DAF) system in addition to the Gravity Oil Separator (GOS) in Oil-water separation. At the Tanta Oil and Soap Company, Tanta, Egypt, large volumes of oil and ghee are being recovered by the installation of three GOS manufactured by the company. The GOS are installed on the oil washing line. The implementation cost over two hundred thousand Egyptian Pound (over USD 40,000), but with an equivalent amount in annual savings. A DAF unit installed to reduce the oil
content of the effluent cost over USD 50,000 with returns expected from the recovered oil reuse (SEAM Egypt, 2002).

The Edfina Company in Alexandria, Egypt also introduced the Hazard Analysis and Critical Control Point (HACCP) for the fruit drinks bottling line. This was done by integrating HACCP with ISO 9000 under one management system. The result of this is evident in the exportation of frozen vegetables and fruit drinks to the United States and Europe. Environmental improvements include an improvement in water consumption, pollution loads and the volume of effluent discharges.

Input Material Change

High quality raw material selection, the use of Poly-Aluminum Silica Sulphate instead of Alum, the use of malted barley and malted sorghum instead of malted barley alone, a change from chlorine bleaching to no-chlorine bleaching, and switching over from an organic based cleaning medium to a water based medium are examples of input material substitution. The Sila Edible Oil Company, Fayoum, Egypt originally uses solid caustic soda for the neutralization process, but this has now been substituted by a caustic soda solution, at a much lower cost i.e. from a cost of over two thousand Egyptian pounds per ton to just one thousand tons per ton. As a result, daily neutralization costs dropped by 47% (SEAM Project, 2002).

On-site Recycling

Instances of this include condensate recovery and reuse in boiler houses, debarking water reuse after screening in paper production, treated effluent water reuse in toilets and cleaning of sewer systems. Seeds delivered to the Sila Edible Oil Company are sieved to remove stones, gravel, hulls and broken seeds, constituting around 1% by volume and containing 25% oil. Originally, these were collected and sold for one hundred Egyptian Pounds as animal feed, but the process has now been modified so that they are collected and transferred to another preparation unit, where they are further processed. As a result, an extra 78 tons of oil and 595 tons of meal are produced annually, valued at an equivalent of over USD 80,000 (SEAM Project, 2002).

Useful By-Products

Also at the company above, fat is manually collected from the refinery effluent by scrapper, acidulated and then split. The wastewater is disposed of and the fatty matter transferred to soapstock storage tanks. Benefits of this measure are the recovery of product and reduced strength of wastewater. The annual savings is twice the cost of implementation. Other notable instances of this include the use of spent grain as an additive in animal feeds, the use of
concentrate kegs and containers for fluid storage, the use of black liquor from sulphite pulping in fertilizers etc.

Product Modification

A new approach to the conventional brewing profile was initiated in Nigeria in the mid eighties when the government banned the importation of malted barley. There came the introduction of a brewing profile using malted sorghum and maize grits at certain ratios for beer production. This is a form of material substitution, which ended up in producing a modified beer. Nigerian Breweries Plc was perceived by the public as a “listening” company interested in introducing varieties to its brands as demanded. Gasoline has undergone a lot of reformulations from the use of antiknock agents like Tetra Ethyl Lead (TEL), Methyl tert-Butyl Ether (MTBE), to Reformulated Gasoline (RFG) all in a bid to minimize the production of gases that constitute photochemical smog. Another instance of product modification includes paper production with lower brightness levels.

The list above is by no means exhaustive as these are just a few of the multifaceted aspects of each of the techniques highlighted. There are six basic steps involved in carrying out a Cleaner Production program.

Step 1: Getting Started

This is the preliminary stage where the commitment from management is required to implement the ideals of cleaner production. Staff support is also essential for efficient and effective implementation. Most cleaner production techniques are essentially based on attitude.

This step comprises three major items.

- The creation of a Cleaner Production team, usually consisting of three to five people including an expert on cleaner production, technical support staff with a proven wealth of experience on the production processes, a top management level representative, and an accounting representative.
- A flow chart of the process steps is developed as at the time of commencement. This is to include all practices and processes involved toward achieving the goal of producing the final product.
- An identification of the wasteful processes also takes place simultaneously.
Step 2: Analysis of Process Steps

The process flow chart developed above is critically analyzed at every stage for material and energy balance. This analysis involves an assignment of costs to waste streams while identifying the sources and causes of these wastes. Before Cleaner Production Programs are implemented, it is recommended that the areas of improvement or changes be identified. Areas of focus can include procedural change, raw material substitution, process modification and product change etc.

Step 3: Generating Cleaner Production Opportunities

The identified areas are then prioritized based on resources and management practices. The cleaner production opportunities ranging from better housekeeping to equipment modification are highlighted against each area of deficiency. This is followed by selecting workable opportunities as mentioned earlier.

Step 4: Selecting Cleaner Production Solutions

Based on the numerous options listed above for each identified area of deficiency, technical feasibility questions are answered to determine the best alternative from the available options with respect to cost-benefit analysis while putting environmental aspects into consideration as well. Some opportunities or alternatives may not offer the best benefit returns on investment but may improve environmental impact, and vice-versa. This is the stage where experience and technical expertise are required to reach an optimum compromise. At this stage, the optimum solutions are selected and the team then consults with the top management on their recommendations.

Step 5: Implementation

Staff responsibilities and functions should be clearly defined for the proposed Cleaner Production Programs. The management should ensure that staff is properly trained for implementing the programs. Management support, both technical and financial, should be maintained throughout the development of programs (HKPC, 2002). Results are monitored and evaluated to act as inputs for the next step of the program.

Step 6: Maintaining Cleaner Production

The progress and results of implementing the Cleaner Production Programs should be regularly monitored and reviewed (for instance, examining the waste generation level for a process compared to previous levels). The organization should assess whether the environmental performance has been
improved after implementing the Programs. Are there any measurable differences in product quality, staff performance, and productivity? What cost saving benefits have occurred as a result of Cleaner Production? Have all goals set at the beginning of the Program been achieved? This is where the cyclical nature of cleaner production implementation comes into play. In order to sustain it, the exercise is performed continually with a re-identification of the wasteful processes and an assessment and implementation of methods for optimizing the process.

VI. CONCLUSION

It can be seen from above that cleaner production involves three logical steps of source inventory, cause evaluation, and option generation (i.e. where and why are wastes and emissions generated, and can these causes be reduced if not eliminated). The techniques highlighted are not restricted to large companies, neither do they always require large funding sources nor an entirely new modern technology. This practice is not a one-time activity because it involves a cyclical application of know-how, improved technology and, overall, a continuous change in attitude. Many proven case studies indicate high financial benefits in addition to environmental protection. A very good example is the Sila Edible Oil Company at Fayoum in Egypt. (SEAM Project, 2002) The company implemented a range of waste and energy minimization opportunities like steam trap modifications, collection and recycling of spilt oil, reuse of fines from the Preparation unit etc. To date, this has involved a total investment of over six hundred thousand Egyptian Pounds (over USD 100,000) and resulting in an annual savings of over one and half million Egyptian Pounds (over USD 300,000).

The concept of cleaner production questions the need for a particular product, and looks at other ways to satisfy the demand. It is a slowing down of the rate at which we use resources, and a gradual shift from linear to more circular processes, similar to those found in nature. The eventual goal of clean production is to achieve a ‘closed loop’ operation in which all excess materials are recycled back into the process (IISD, 1997). With a generalization of the concerns for cleaner production, industrial ecology under the modern trend of globalization would be sustainable because of the consideration for the environment in all aspects of operations.
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