Role of Green Sourcing in Green Productivity

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This paper focusses on the role of green sourcing in the process of GP. Raw materials or catalysts which are inputs to processes in industries contribute significantly in deciding the quantity and nature of wastes produced in the production processes. Green sourcing looks at the identification and selection of those input materials which bring about a substantial reduction in the pollution load, maintaining or improving the process efficiency. The examples and case studies presented in this paper indicate how, appropriate selection of the input materials have resulted in reducing waste generation potential, achieved energy or material conservation, eliminated hazard to the waste receiving bodies. Various issues on implementation of green sourcing have also been discussed.

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Green Productivity (GP) is essentially a matter of converting raw materials into products in the most efficient way, thus producing little or no wastes from the production processes. It is the latest integrated approach in handling wastes and pollutants in the industrial world. Before the idea of sustainable development became an integral part of every production system, environmental protection was carried out through the employment of end-of-pipe (EOP) technologies. Pollution control which means applying treatment techniques for generated wastes, was the traditional key to meeting waste-related legislation.

However, this reactive approach to waste management is hardly the best solution because EOP technologies simply transform wastes from one media to another, without really eliminating them. Secondly, more stringent regulations are forcing industries to upgrade treatment facilities, resulting in escalating costs added to production. Hence, environmental management strategies have shifted towards finding ways of preventing generation of wastes, whenever possible, such that a more integrated approach to reducing quantity and toxicity of waste is implemented in all aspects of the production processes.

Green Sourcing

Various techniques in GP have been developed so far and have received a positive response from the industrial sector with enterprises willingly adopting the new processes and consequently reaping the rewards of economic savings and environmental protection. The approaches to GP can take the following strategies as shown in Fig. 1. One is by raw material change. Selecting appropriate raw materials and/or catalysts in each production process so as to reduce the amount of waste or generate more easily biodegradable waste or less toxic waste is termed as green sourcing. Green sourcing can be applied by

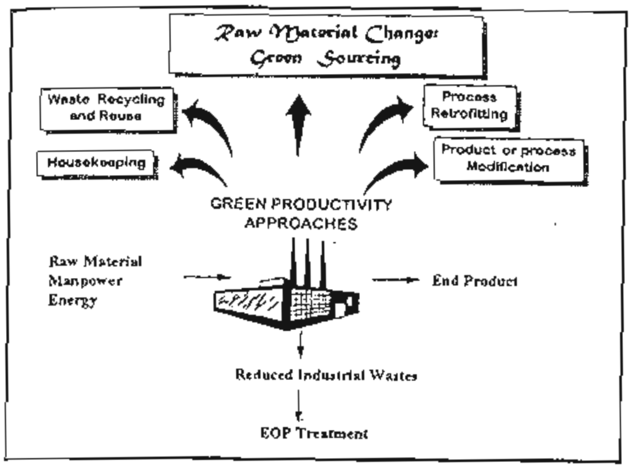

Fig. 1. Approaches to Green Productivity

selecting and substituting one raw material or a combination of two or more of them by more environmentally friendly substitutes in the production process which will result in any of the following:

- Reduction of waste amount in terms of weight, volume, organic content
- Change of hazardous wastes to non or less hazardous waste
- Lowering of capital investment in treatment systems needed to meet pollution discharge limits
- Contribution to the achievement of sustainable development.

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As a result of exploring ways of cleaner production through raw material substitution, many techniques have been discovered that are practically applicable to a number of production processes. Fig. 2 illustrates some general strategies in targeting green sourcing. With a deeper understanding of process chemistry, nature of raw materials used and their possible hazards to humans and the environment alike, an increasing number of environmentally less harmful substances have been found suitable in reducing, if not eliminating, pollution problems.

New catalysts that have been developed greatly improve conversion efficiencies and minimize the production of useless by-products. Impurities in the feed streams may reduce the activity and selectivity of catalysts or may even lead to reactions that yield unwanted by-products.

Some of the other techniques already applied in industry are the following (Schnitzer, 1996):

- Using pure oxygen instead of air, for oxidation reactions
- Using pigments, fluxes, solders, and biocides without heavy metal or other hazardous components
- Switching over to terpine or citric acid-based solvents from chlorinated or flammable ones
- Substituting organic by aqueous compounds; petrochemicals by biochemicals which are less volatile and contain less toxic components
- Utilizing wastes as raw materials, thereby conserving conventional raw materials.

Applications in Industry

Many industries have already benefitted from green sourcing. By reducing the hazardous impact of the whole production process, green sourcing lessens the liability of the industry in terms of occupational health and safety of its workers, possible clean-up costs in the future, and treatment and disposal of toxic wastes. Table 1 lists a number of techniques that have been successfully applied in specific industries.

Bleaching and dyeing industry: It is desirable to use raw materials that will cause less pollution. In this way, treatment of wastes coming from the industry will be less costly. In one bleaching and dyeing industry, material

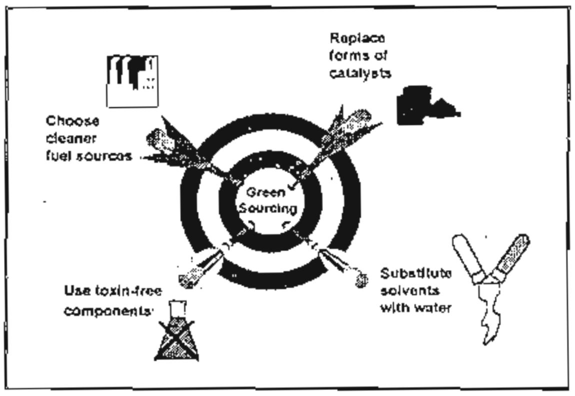

Fig. 2. General Strategies for Green Sourcing

Table 1: Techniques of Green Sourcing applied in Industry

Industry	Technique
Electroplating	Replace $Zn(CN)_2$ with $ZnCl_2$; Cr^{6+} with Cr^{3+}
Communications	Replace copper wires with optical fibers made of glass
Cleaning	Substitute halogenated hydrocarbons with water supported by detergents or ultrasonic
Textile and Dyeing	Replace starch with CMC as sizing agent Replace soaps with detergents as cleaning agent Replace coal tar dyes, azo dyes with triazine-based dyes
Wood processing	Replace creosol by pentachlorophenol, chromated copper arsenate and copper napthenate for impregnation of wood
Printing, Paints and Coatings	Replace solvent based ink by water based ink
Power generation	Replace coal by low-sulfur product; Use gas instead of oil or coal
Automobile	Replace coal by LPG, alcohol, low-olefinic gasoline
Chemical	Replace $AlCl_3$ by "Clayzic" or monmorillonites and zeolites-based as catalysts in Friedel Craft synthesis
Steel	Replace acid pickling of steel with peroxide treatment

substitution came in the form of carboxymethylcellulose (CMC) instead of starch as sizing agent, and soap instead of detergent as cleaning agent. Significant pollution reductions occurred as a result. Wastewater BOD was lowered by 48% and alkalinity by 65% (Tsang, 1987).

Fuel-grade ethanol production: A suitable substitute for transportation fuels is ethanol from biomass. In Greece, raisin and molasses are used as traditional raw materials for industrial production of fuel-grade ethanol. However, this process results in environmental problems such as liquid wastes with high biological charge, CO_2 produced from alcoholic fermentation, and CO_2 and SO_2 produced from combustion of solid fuels. When the raw material is substituted with sugar beets or straw, wastes produced have relatively lower temperature, zero biological charge, relatively small nitrogen concentration and absence of SO_2 in the gas wastes. Between sugar beets and straw (Koutinas, et al., 1984), the former is better because liquid wastes from using straw contain considerable pentozanes.

Surfactants industry: Surfactants or surface active agents such as alcohol sulfates, alcohol ethoxylates, or alcohol ethoxysulfates are used in consumer detergents. A life-cycle analysis on surfactants revealed that producing it from oleochemicals (based on palm oil, palm kernel oil, and tallow) resulted in the generation of higher amounts of atmospheric, waterborne, and industrial solid waste than surfactants derived from petroleum (Oude, 1993). However, because the oleochemical wastes differ in composition from the petrochemical wastes, extensive analysis of the safety and risks associated with individual waste components is required to support such a conclusion.

Pulp and paper industry: The production of pulp and paper produces bleaching effluent rich in hazardous chlorinated derivatives. By changing the bleaching agent from chlorine to ozone, oxygen and/or peroxide, several positive impacts were created. A total suppression of chlorine in the process was observed, hence effluents could be reused in a recovery boiler leading to the possibility of building a plant with a closed water circuit. Color in the effluent decreased by 97%, and malodorous discharges into the air from lower sulfide ratio of the pulp was reduced.

Steel Industry: In the treatment of steel, process chemicals such as HNO_3 and HF may be replaced by H_2O_2 and HF (Overcash, 1986). This material substitution reduced input requirements of HF by 36%. It also eliminated emissions of NO_x in the air and NO_3 in the liquid waste. Suspended solids in the effluent were also reduced by 54%.

Issues Faced in Implementing Green Sourcing

Industries and governments must play active cooperative roles: On a wider scale, green sourcing is an effective exercise when industries choose to utilize only renewable materials or those produced in a sustainable manner. For example, one furniture company labored to ensure that the raw materials for their teak-based products (Schmidheiny, 1992) are imported solely from a sustainable forest. By settling for nothing less than the most environmentally preferred materials, industries can create a global impact in protecting the environment and achieving sustainability. Likewise, through effective legislation, national governments can play a greater role in attaining green productivity through green sourcing. If the production of virgin raw materials was taxed instead of being subsidized, people will be more careful in using them more efficiently. Then, more efforts will be put into conserving

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or finding suitable substitutes for non-recyclable raw materials such as minerals, another key to attaining sustainability.

Involves high financial input: However, such noble pursuits in the quest for selecting the finest raw materials demand high monetary inputs. In this sense, green sourcing becomes mostly a privilege of rich nations which can afford to demand the best raw materials. Japan, for instance, has the financial capability to import fuel sources that can meet their stringent quality standards and can insist on coal with low sulfur content for their power plants. In contrast, countries like India and China are dependent on their own natural resources and resort to using coal with high sulfur content to provide for their energy needs. The quality of raw material obtained may not be optimum for the production process but because of lack of other options, Indian and Chinese industries are reliant on what their mines can produce. As a result, energy industries in Japan, unlike in India or China, can run more efficiently with minimum environmental hazards.

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Needs accompanying technological change: In many cases, green sourcing entails accompanying change in technology to adopt to the introduction of new raw materials. A dynamic understanding of process chemistry must be coupled with advances in technological research to aid implementation of green productivity opportunities. A case in point is the shift from gasoline-fueled cars to electric cars. The whole design of automobiles will have to be modified if the fuel source is changed. Certainly, such major transformation will have other serious implications on other aspects of the automobile industry.

Case Studies

Change in fuel source for energy production: Table 2 presents the emission factors obtained when different fuel sources are considered for industrial boilers. By changing from coal or wood to gas or oil-fired boilers, emissions of harmful gaseous pollutants have been significantly minimized. Table 3 gives the conversion efficiencies and emissions of air pollutants from various electricity-generating raw materials. Here with a change in raw material and a corresponding change in technology, emissions of environmentally-damaging gases such as NO_x, SO_2 and CO_2 have been reduced to a minimum.

Table 2: Emission Factors from Industrial Boilers

Raw Material	Emission Factors (kg/TJ energy input)		
	CO	CH_4	NO_x
Wood	1,504	15	115
Coal	93	2.4	329
Residual oil	15	2.9	161
Natural gas	17	1.4	67

Table 3: Conversion Efficiencies and Air Pollutants from Electricity Generation

Raw Material	Conversion Efficiency (%)	Emissions (g/k Wh)		
		NO_x	SO_2	CO_2
Pulverized Coal	36	1.29	17.2	884
Fluidized Coal	37	0.42	0.84	884
Phosphoric Acid Fuel Cell	36	0.04	0.00	509
Combined-cycle Gas Turbine	53	0.10	0.00	345

Change in type of refrigerant in chillers: The Montreal Protocol has called for the cessation of

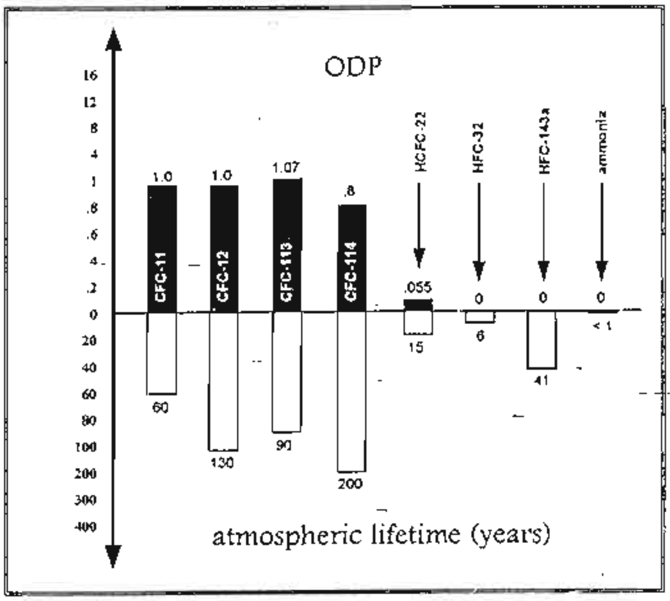

Fig. 3. Ozone Depletion Potential (ODP) and Atmospheric Lifetimes of Common Substances

manufacture of ozone depleting chemicals, including refrigerants, around the world. Some refrigerants, especially chloroflourocarbons (CFCs) contribute to the destruction of the ozone layer which is the protective layer of the earth's atmosphere. Two important factors that must be considered in choosing an alternative refrigerant (such as HFCs) are the refrigerant's atmospheric lifetime and the ozone depletion potential (ODP). Fig. 3 presents the differences in ODP and atmospheric lifetime of several refrigerants. This case shows that green sourcing for chillers has advantages that has worldwide impact.

Change in reducing agent in textile dyeing: The highly polluting Na_2S is the traditional reducing agent used in converting the original dye into its affinity form. This causes an increase in the sulfide content of the mill's effluent to undesirable levels and leads to complications in the conventional effluent treatment processes. A textile company in India found through research that hydrol, a by-product of the maize starch industry, can serve as an alternative reducing agent with corresponding improvement in the quality of the dyed product. The substitution even resulted in the reduction of sulfide concentration in the effluent to levels below the required standards. With less sulfide in the treatment plant, corrosion was minimized and the foul smell of sulfide in the work place was eliminated.

Conclusions

To achieve effective green productivity, conventional wisdom is the approach through waste or by-product recycling and reuse, process retrofitting, product modification or manpower modification. The contribution of the kind of raw materials used in the processes to the attainment of green productivity has, however been long overlooked.

With the successes of green sourcing achieved i various industries, it is obvious that there lies a grea potential in exploring strategies in changing raw materia for green productivity. Although this may entail length and expensive in-depth analysis of the process chemistr involved in production processes, experience has show that these efforts can have tremendous pay-offs.

As the concept of green productivity is integrate into each production process in industry, the role c green sourcing will continue to expand to include mor industrial systems, resulting in elimination of toxic sub stances, improved process safety and efficiency, prope management of raw materials, thereby leading to sus tainability of the environment.

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