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# WASTE MANAGEMENT PARADIGM TOWARDS INDUSTRIAL ECOLOGY, CLEANER PRODUCTION AND SUSTAINABLE DEVELOPMENT – A MINI REVIEW

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***Abstract***

*In accomplish eco-friendly natural resource utilization, the concept such industrial ecology and cleaner production are proposed. The two terms are generally considered to have nearness and numerous likenesses. The time of advancement of environmental management in the late 1980s to the mid-1990s turned into the beginning of the two ideas. Recently the likenesses and contrasts between the two ideas are still bantered in connection to the multifaceted nature of the issues examined. Unfortunately, a few definitions and implementations had done as such far just spotlight on the economic and ecological perspectives just so there are other vital angles, for example, social viewpoints that are as yet immaculate. Environmental problem solving needed multi perspective approach including the concept of cleaner production or industrial ecology. Therefore, the new paradigm in cleaner production and industrial ecology request agreement with the idea of economic improvement through the thought of the three pillars (social, economic and environment) and in addition all-encompassing and exhaustive examination. The new approach is required to minimize the ecological effects, as well as to enhance individuals' expectations for everyday comforts through financial strengthening and social states of the network.*

***Key words*****:** *industrial ecology, cleaner production, sustainable development, waste management*

## INTRODUCTION

Industrial ecology and cleaner production are the proposed concepts to achieve eco-friendly natural resource management. Both terms are widely considered to have proximity and many similarities. [1] on [8] mentioned that the basic concept of industrial ecology was first expressed in the seminal paper 'Strategies for Manufacturing' published by American Scientific, as follows: *"Waste generated from an industrial process can serve as a raw material for other industries, thereby reducing the industry's impact on the environment*" [4].

In the meantime, cleaner production was firstly known as "Clean Technology" proposed by the Organization for Economic Cooperation and Development (OECD), as follows: *"A wide range of engineering technologies are undertaken with the aim of reducing and even directly from the source, the production of various disturbances, waste or pollution and to assist in the saving of raw materials, natural resources and energy"*.

Both concepts are born along with increasing awareness and desire to reduce the various environmental impacts caused by industrial economic system. The period of evolution of environmental management in the late 1980s to the mid-1990s became the beginning of both concepts (Figure 1).

Industrial ecology was first introduced in America (1989) and began to be applied in Japan (1990), while cleaner production originally known as clean technology (1987) was later changed to cleaner production in Paris (1989) and spawned in Europe by UNEP (United Nation Environment Program) in September 1990.

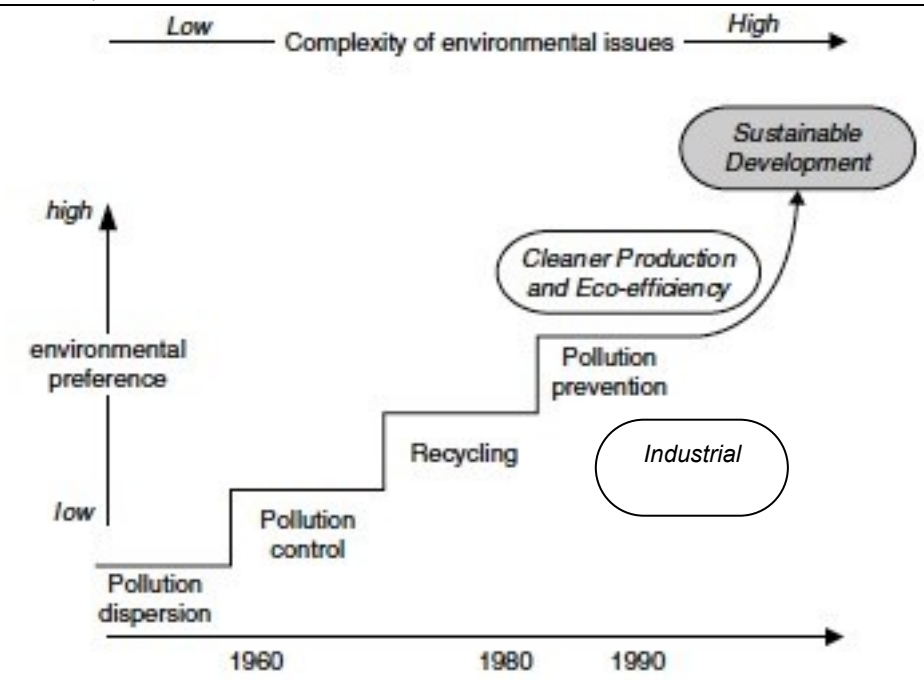


Fig. 1. Evolution of natural resource and environmental management paradigm [8]

## MATERIALS AND METHODS

This paper is based on a large information from literature in the field, mainly on key textbooks and published articles from various sources.

## RESULTS AND DISCUSSIONS

### *The Concept and Complexities of Industrial Ecology and Cleaner Production*

Until now the similarities and differences between the two concepts are still discussed regarding the complexities studied. [1] states that the cleaner production concept has more focus on improving process technology than on issues related to consumption patterns or even reuse of recycled and by-products. This is also in line with the statement of [12] in the book Environmental Management Accounting for Cleaner Productions which states that cleaner production aims to increase production and productivity of the company through the use of raw materials, water and energy more efficiently so as to reduce waste and any emissions directly from the source and contribute to product design more environmentally friendly and cost-efficient over the entire production cycle. Achieving these goals can be done through:

(i)Minimize the use of raw materials, optimize the reuse and recycling of various raw materials both harmful and harmless.
(ii)Use raw materials in the production process in a more efficient way, reducing the number of required inputs and the amount of unwanted output.
(iii)Minimize risk and improve human resources through employee safety and hygiene programs
(iv)Increase monetary return by minimizing energy consumption and reducing material and handling costs.

While the concept of industrial ecology is regarded as a way to focus attention on the use or reuse of waste generated by an industrial process as input for its derivative processes [1]. As revealed by [14], industrial ecology is a system used to manage the flow of energy or material to obtain high efficiency and produce less pollution.

Implementation of the concept of industrial ecology can be done by:
-Optimize the use of existing resources;
-Creating a closed material cycle and minimizing emissions;
-Dematerialization process; and
-Reduction and elimination of dependence on non-renewable energy sources [3].

Unfortunately, some definitions and implementation done so far only focus on the

economic and environmental aspects only so there are other important aspects such as social aspects that are still untouched. Both concepts involve preventing pollution in order to protect the environment and improve economic efficiency. Cleaner production focuses more on the waste reduction aspect, while industrial ecology emphasizes the recycling of an unavoidably produced waste [14].

The complexity of environmental issues will be closely related to many things, including the social aspect. Therefore, to solve environmental problems with an industrial ecological approach in the future will require:

(a)The exact meaning of the study scope and the aims to be accomplished by the industrial ecology,

(b)The sustainable development meaning in order to help accomplish the targets of industrial technology,

(c)The collaboration of different fields including the social field in order to acquire more data in the settlement of ecological issues,

(d)Development of new instruments in managing ecological issues, and

(e)Improving government policy implementation so as to strengthen industry incentives to reduce environmental burden [5].

The statement demands a holistic approach to solving environmental problems through an industrial ecological approach. The broader interpretation states industrial ecology as an integrated system between industry and environment that conceptualizes industrial systems as producers of products and waste and analyzes relationships between producers, consumers, other entities and the universe [11]. This is in line with [10] which states that industrial ecology has shifted the concept of "end of pipe" into a more comprehensive strategy through the development of environmentally friendly industries through a holistic approach. The first textbook of industrial ecology confirms that industrial ecology is a cautious and rational way of human beings in maintaining the desired carrying capacity, given the ever-evolving economic, cultural and technological evolutions.

The concept of industrial ecology is closely related to cleaner production and is even considered as complementary to the other. After some time the idea of cleaner production has additionally developed with a more thorough approach through the contribution of social perspectives. The advancement of cleaner production idea with the mix of social aspect approach helps to overcome the problem of field implementation, the repetition of the method and the process scales [2].

Comprehensive approach to cleaner production approach and industrial ecology concept are needed to solve environmental issues. This is because in a sustainable system of nature, matter and energy form a complex web where each other is interconnected. With the goal that when discarded, the energy and materials can be reused in the process or as crude materials in fabricate of new items. If the focus is further expanded on all material and energy cycles, this approach will involve subjects in various disciplines ranging from humanities, the social sciences to the natural sciences and technology [7].

### *Achieving Sustainable Development through Waste Recycling, Cleaner Production and Industrial Ecology*

The paradigm of solving environmental problems continues to evolve, from initially concentrating on pollution prevention to the present time concentrating on the idea of sustainable development (Fig. 1). The idea of cleaner production and industrial ecology are some approaches to solving environmental problems, which ultimately support the achievement of sustainable development [1]. Sustainable development demands the complexity of the issues studied and therefore is expected to further improve environmental performance as mentioned by World Commissions on Environment and Development/WCED (1987), the development to address the present issues without compromising the capacity of future generations to address their own needs.

Referring to these statements in other words, the decisions we take must consider the

potential impacts on society, the environment and the economy, while keeping in mind that our actions will impact elsewhere as well as in the future.

It is also important to note the importance of the three pillars expressed in OECD Insights: Sustainable Development that: *"The essence of sustainable development is the need to consider the "three pillars" collectively: society, economy and environment. Whatever the context the approach remains the same: people, habitats and economic systems are mutually interconnected*" [13].

Therefore, any decision making in the management of natural resources and the resolution of environmental problems should consider the three pillars, as follows:

(1)Social, there is equality of welfare, the satisfaction of different social services including wellbeing, education, gender equity, political responsibility and society participation.

(2)Economy, there is a guarantee of sustainable production of goods and services to maintain the level of management undertaken by the government by maintaining the balance of every sector including industry and agriculture.

(3)Environmental, stable resource guarantees, preventing over-exploitation of renewable natural resources and degradation of environmental functions. Includes maintenance of biodiversity, atmospheric stability and other undefined ecosystem functions as an economic resource [6].

It likewise applies to taking care of ecological issues through the execution of cleaner production and industrial ecology that should be possible through the material efficiency of production process. The concept of cleaner production and industrial ecology are conceived from the underlying idea of pollution prevention which then develops with different material efficiency approaches. The concept of material efficiency in cleaner production develops with waste minimization approach through optimization of production processes, while industrial ecology focuses on the waste recycling approach produced at the end of the production process [1]. However, [11] in the book The International Handbook On Environmental Technology Management states that recycling waste for raw materials of a production process is one of "preventative practices" in cleaner production. However, the waste management policy should include social, economic and environmental aspects to achieve sustainable development [9].

This recommends waste recycling is a method for tending to ecological issues through the implementation of cleaner production and industrial ecology. Figure 1 demonstrates that the improvement of the idea of cleaner production and industrial ecology is progressively prompting the idea of practical advancement that is always required to consider the three pillars. Therefore, in order to obtain a comprehensive environmental problem solving through waste recycling, the three pillars approaches that are social, economic and environmental are indispensable for the achievement of sustainable development.

## CONCLUSIONS

Waste is one of the environmental problems that try to solve through various pollution prevention approaches. Industrial ecology and cleaner production are the pollution prevention approaches that have been developed over the past two decades. Both concepts offer pollution prevention through material efficiency so that it is expected to reduce the amount of waste disposed into the environment.

The number of definitions and understanding of the two concepts causes the resolution of the pollution problem to be less specific and targeted. At first the idea of industrial ecology more offers the utilization of waste from a production process to fill in as crude materials for different enterprises. Then the cleaner production idea developed from clean technology focuses more on engineering and technology on the production process so that material efficiency can be made and the amount of waste produced is less. Initial concepts of both have a fundamental difference in which industrial ecology is more focused on the finish of the procedure (end of

pipe) while cleaner production focuses around the efficiency of the process itself.

Along with the expansion of sustainable development paradigm in solving environmental problems, the approach of these two concepts also developed. Sustainable development requires every solution of environmental problems to consider the three pillars (social, economic and environmental) holistically and comprehensively. Therefore, some new comprehension of industrial ecology and cleaner production request harmony with the idea of sustainable development through the thought of the three pillars as well as holistic and comprehensive study. The new demands are expected not only to eliminate the environmental impacts, but also to improve people's living standards through economic empowerment and social conditions of the community.

In addition, these developments further narrow the differences between industrial ecology and cleaner production. Even the distance between the two concepts by assuming that waste recycling done at the end of the process can also be categorized as a cleaner production concept because it is a "prevention practice" of pollution and material efficiency so that it can minimize waste generated. This statement further demonstrates the similarity of the two concepts that focus on preventing pollution through the efficiency of materials that can be done including at the end of the process such as waste recycling. Waste management through recycling is also required to be able to consider the three pillars so that a holistic and comprehensive environmental problem solving is expected to help achieve sustainable development.

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