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Mini Review

Cement factory design requirements based on industrial ecology

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ABSTRACT:

Industrial ecology is a hierarchy of production process which is designed for the material cycle accompanied with optimal raw material obtaining, production, consumption and final disposal aiming to minimize the environmental outcomes and waste. In an industrial process, making use of raw materials in process and changes on these materials along with waste disposal has different effects on the surrounding environment. These influences can directly be at first level on the region of environmental changes, microscale climate changes, lifecycle changes among organisms and plants as well as different soil, water, air pollutions and in the next level, indirect effects such as macroscale climate changes and local people's lifestyle changes etc. But, industrial ecology can be used in industrial development in order to design industrial cycles such that industrial activities have the least influence on surrounding environment. Present article aims to design the Golistan Payvand factory. During the process some solutions were derived in order to improve the cement factory wastes management as well as consistency between cement industry and natural basin.

Keywords:

Cement factory, Environmental design, Industrial ecology, Industrial process.

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INTRODUCTION

Industrial ecology is a new branch of ecology. It was developed in the recent century as industrial development and growth emerged and in general focuses on the fact that an environmental industrial site established isn't separated from its basin and plays the role of a system with internal-external relations with the basin itself (Allenby, 2009). Of course, irrespective of the environmental concept of industrial ecology, this concept is considered in economy too (Ayres, 2002). Industrial ecology involves studying the material and energy flow based on engineering systems and ecologic principles and attempts to determine correct flow of material and energy in industrial processes and to minimize environmental adverse effects (Chertow, 2003). The industrial ecology was first addressed by Frosch and Gallopoulos (1989) and addressed the inabilities of industrial system to act as natural ecosystems and why the outputs of an industry cannot be used as input of other industry and lead to environmental pollutions minimization; making efficient use of energy and material, reduce of wastes and problems due to their disposal (Despeisse *et al*., 2012). In defining the industrial ecology based on the natural systems rule, Chertow (2003) stated that the basis of industrial ecology is that an industrial system is not considered as an isolated system from the surrounding environment, but it is a part of it and is combined with the environment. This is a systemic approach that causes minimization of material and energy in the production cycle, end material in production, side components, raw production and final wastes. The parts in which desirable changes occur include energy sources and capital (Deutz and Lappolo, 2015). Industrial ecology is a systematic concept in which the production and manufacturing processes are designed such that the material cycle is accompanied with optimal raw material obtaining, production, consumption and final disposal aiming to minimize the environmental outcomes and waste. Before this approach, industrial systems were linear with inputs (sources, raw material, and energy) and outputs (products, wastes) (Frosch and Gallopoulos, 1989). The main assumption in industrial ecology is that the design and industrial process activity type are parameters highly affecting environment and nature. But, the types of industrial process are influenced by the surrounding environment and for this reason, it is necessary for industries in a basin to recognize their surrounding environment and take actions toward environmentally friendly activities to improve the environment health (Deutz and Ioppolo, 2015). Industrial ecology is indeed shared between human systems or society and environmental systems or ecosphere (Figure 1), namely anthroposphere or conosphere (Liao *et al*., 2012).

In fact, ecosphere includes all parts of life on earth such as (hydrosphere, atmosphere, lithosphere and iodosphere) (Moran *et al*., 2014). Industrial unit obtained the resources such as energy, material (raw mate-

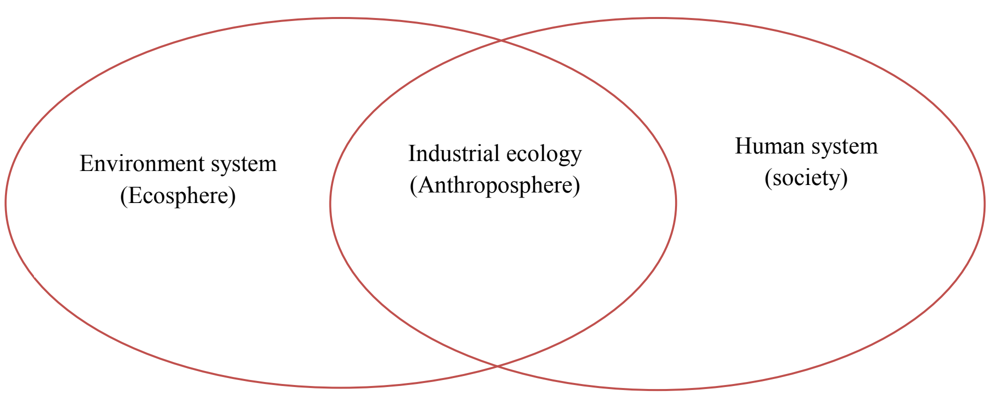


Figure 1. The intersection between society and ecosphere (Liao *et al*., 2012)

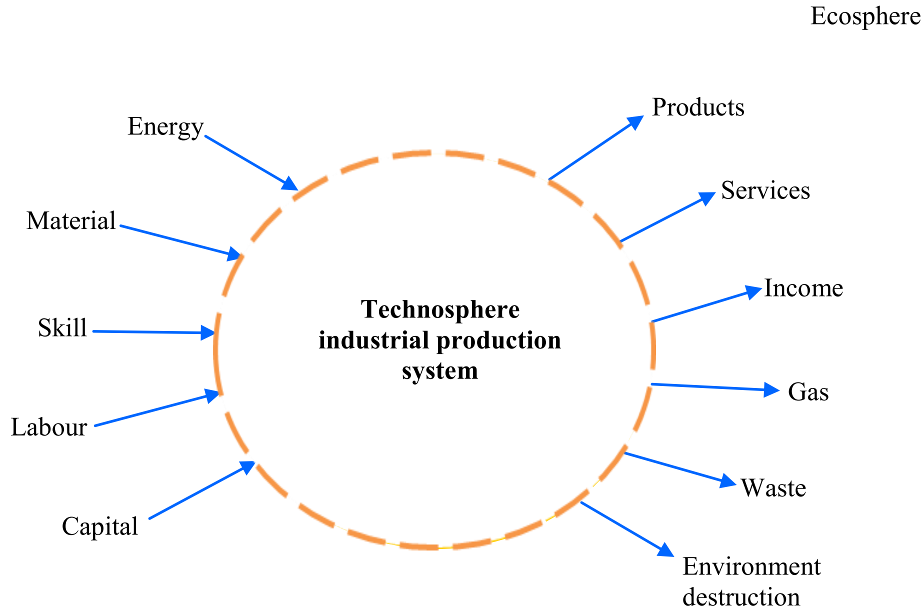


Figure 2. Relationship between ecosphere and technosphere (Muduli *et al.*, 2013)

rial, soil, water resource, atmosphere gases) and biologic energy along with labor, skill and capital from ecosphere and returns products, services, income, wastes, liquid, solid and gas to the environment (Figure 2).

Making use of raw material in process and changes on these materials directly affect at the first level region of environmental changes, microscale climate changes, lifecycle changes among organisms and plants as well as different soil, water, air pollutions and in next level, indirect effects such as macroscale climate changes and local people's lifestyle changes (Muduli *et al.*, 2013). Energy flows in ecosystems are generally unidirectional with input and output. The best way of minimizing environmental destruction, wastes and material and energy released is to employ industrial ecologic approach. In order to achieve this goal, industrial system has to leave linearity and become cyclic (Ramesh *et al.*, 2014).

Types of industrial system

There are several models or types for industrial systems:

- Linear model of material flow in ecosystem type I

This type of system is harmful for environment; since it only includes input/output (Figure 3) (Vardaka *et al.*, 1995).

- Semi-cyclic model of material in ecosystem type II

In this ecosystem, the system is infinitely cyclic in which the process is performed (Figure 4)

- Cyclic model of ecosystem type III.

This type of system is fully cyclic and is not harmful for environment (Figure 5).

In type I of industrial system, the resources are used infinitely; therefore, wastes released to the surrounding environment are infinite. As evaluated, this

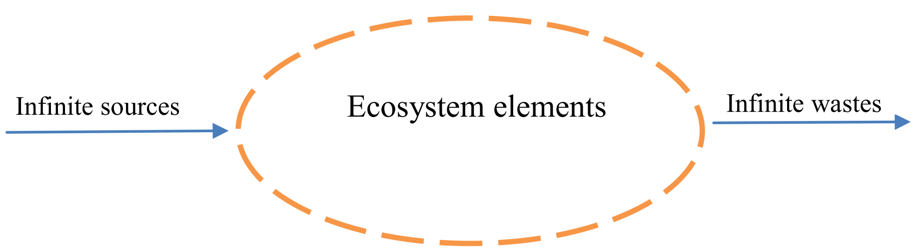


Figure 3. Ecosystem type I (Vardaka *et al.*, 1995)

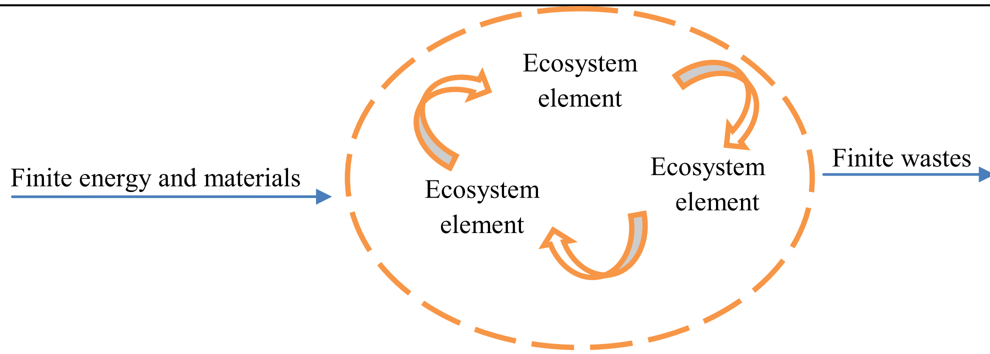


Figure 4. Ecosystem type II (Vardaka *et al*., 1995)

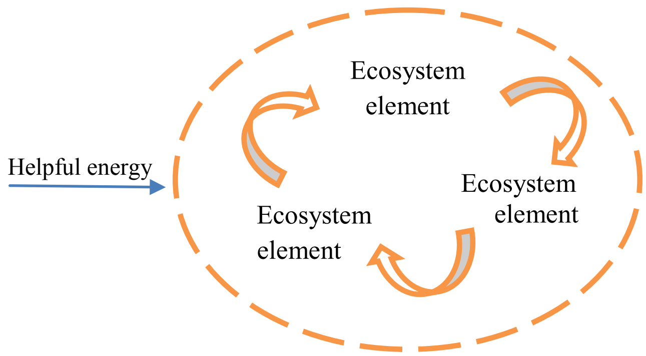
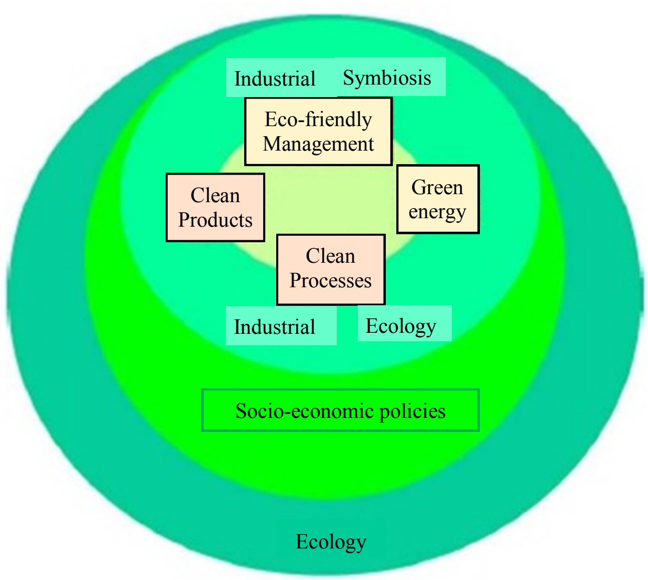


Figure 5. Ecosystem type III (Vardaka *et al*., 1995)

system mostly destructs the surrounding environment. In order to move from type I to types II and III needs cycle closure which leads to finite use of resources and finally, least waste outlet and lower level of environmental harms. The concepts such as efficiency, lower carbon, lower resources and more environmentally consistent materials are achieved (Vardaka *et al*., 1995).

Establishment of industrial ecology in the cement industry

In present article, a suitable model for establishing industrial ecology in cement industry is investigated. In this context, there are different findings of industrial



Sustainability

Figure 6. Green engineering in industrial ecology design (Diwekar, 2015)

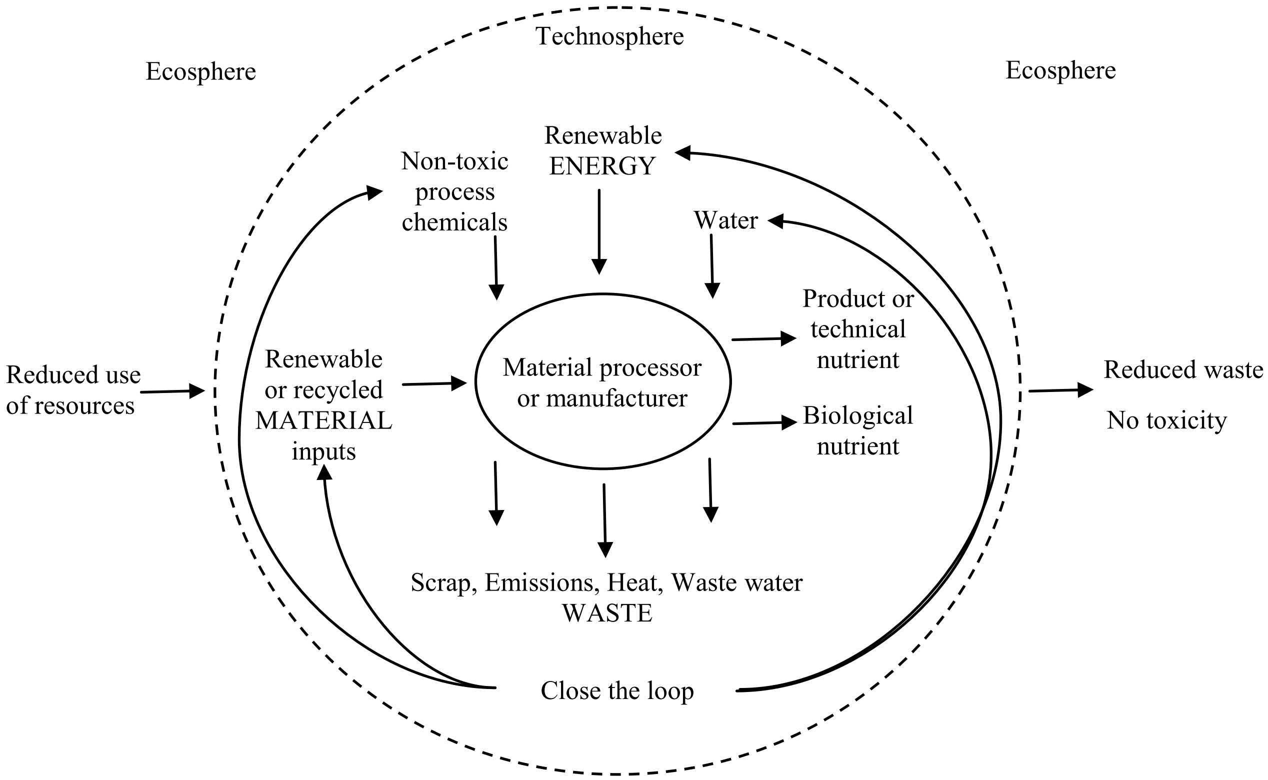


Figure 7. Changing linear system to cyclic one in industrial ecology (Despeisse *et al*., 2012)

ecology establishment on different industries evaluated and finally, a desirable model was provided for industrial ecology in the cement factory (Diwekar, 2015).

One of the main challenges in industrial concepts is environment in design which originates from uncertainty and defining more extensive criteria used in resources, environment and its economic influences worldwide. Nowadays, the sustainability is more than a concept and this operationalization and conceptualization influenced the concept's complexity. In Figure 6, a design process framework development is demonstrated for industrial environment which leads to social and economic sustainability at the center of this framework. Producing designed material with naturally friendly products is planned and managed during the clean processes along with green and environmentally friendly energies. Moreover, in order to develop industrial coexistence and industrial environment, there are policies coded with influencing environmental systems which in turn, leads to long-term sustainability. However, industrial systems are convinced to provide a metric for sustainability addressing the disciplinary nature of sustainability including human-ecosystem interaction (Diwekar, 2015).

There is an industrial activity observed according to the sustainable development requirements. In this model, the industrial activities indeed move in a direction to make more useful employment of resources as well as producing lower wastes. Among the important perspectives in this system is the co-operation between different internal elements in this system as a substantial goal. In this system, elements are interacting in line with minimizing the wastes resulted and reuse of obtained resources. In this article, two systems are observed. In the system demonstrated in Figure 6, the necessity of sustainable design and environment friendly products production were addressed. In system 2, the inputs and outputs of a system and how they are used were investigated. For this purpose, the systems were integrated in order to eliminate the deficiencies of each system

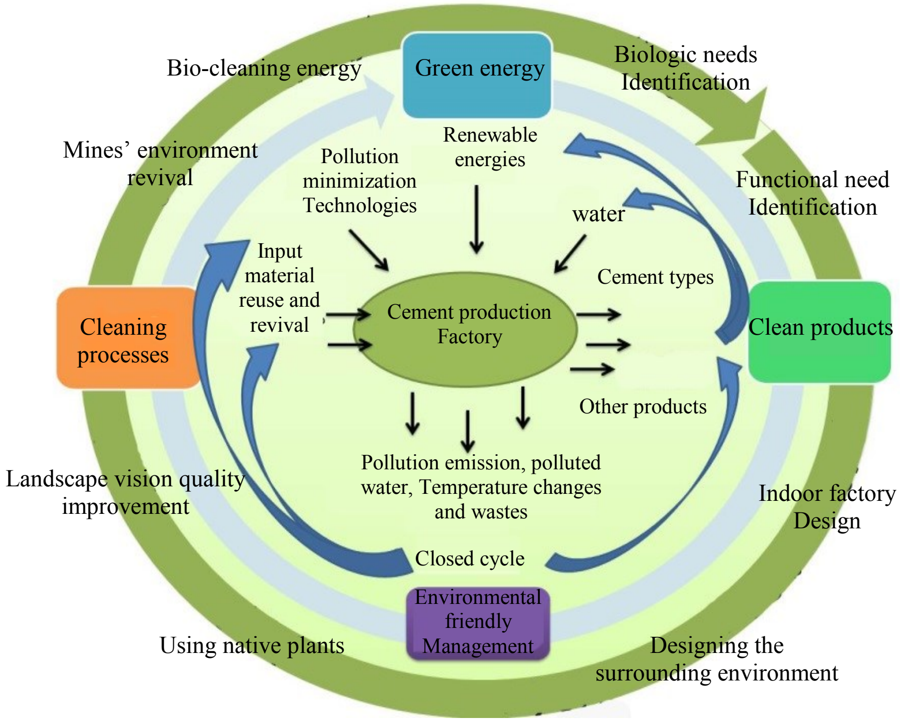


Figure 8. Integration of systems proposed in figures 6 and 7

(Despeisse *et al*., 2012) as shown in Figure 7.

Based on the model proposed in this Figure 8, the necessity of environmental design based on the present situation (Figure 8) is provided. In this system, the environmental design is the main basis of cement industry. According to inputs/outputs of this industry, the designed and implemented in each section of industry are checked for consistency with the environment and natural basis. In clearance processes green energies, environment friendly management and clean productions are main elements of the cement factory environment design. Moreover, reusing wastes resulted from first stage of cement production process, emission of pollutants with environmental requirements, making use of renewable energies etc. are other issues to be focused in the proposed system. Environmental design factors such as making use of botanic bio-clearance techniques for minimizing the contaminants resulted from the factory activities, revival of near mines environment, making use of internal factory environment design as well as near factory lands environmental design etc. in order to improve the cement factory landscape design could be adopted for elite purpose.

CONCLUSION

Cement industry is one of the most challenging industries worldwide. For this reason, preserving the surrounding environment of cement industry is significantly important. In releasing contaminants to the surrounding environment, cement factory activities lead to pay attention to the environmental design as a biologic solution in order to improve ecologic region condition as well as preventing the contaminants from emission to the environment, reduction or elimination of contaminants emitted to the environment. Environmental design isn't only a biological and harmless solution for eliminating contaminants resulted from cement factory activities, but also the low cost of actions taking in this procedure is a strength comparing to other non-biologic methods. Moreover, it is possible to make a relationship between cement industry and eco-parks' principles using the environmental design. That is, environmental design strategies can play the mediating role in between and achieve the industrial eco-parks' goals by minimizing the cement industry destructive effects. Using plants for bio-clearance in environmental design leads to ecologic conditions' improvement, biodiversity, social, environmental and sensual desirability enhancement in an industrial landscape. For this purpose, the following principles and solutions are proposed for environmental design planning of cement production complexes based on industrial eco-parks criteria.

RECOMMENDATIONS

Planning for energy and material flow

- Minimizing the use of resources by reducing raw material level as well as recycling dust and returning it to the raw material
- Enhancing the corridors in order to enter the air flow to region and extracting contaminants
- Replacing the fossil and nonrenewable fuels used in the cement industry with biologic and renewable fuels
- Collecting the industrial wastewater and groundwater management
- Minimizing wastes resulted from end products production and following that, reduction of wastes resulted from factory activity

Indoor and outdoor buildings environmental design:

- Revival of region ecologic conditions to the time before industry established in the region
- Planting different plants and suitable cultivation plan to the climate and environmental conditions
- Enhancement of green infrastructures and improvement of green nodes and corridors
- Improvement of visual conditions of landscape by cultivating different plants
- Making use of green techniques and walls in order to make more use of site space and to enhance green level
- Making use of plants bio-clearance in order to eliminate or minimize contaminants concentration resulted from the factory activity
- Improvement of green joints in order to improve region ecologic conditions
- Making use of different industries in outlet sequence of each industry to make easier use of outputs of a process as other process's input

Creating cultural identity

- Providing entertainment, welfare and cultural facilities for local society and employees
- Reviving the local values and providing the local society and employees with services
- Reviving region values to the first state before industry established there (Diwekar, 2015; Despeisse *et al*., 2012).

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