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Developing a Sustainable Landscape design Framework for the Municipal waste landfills, an ecological approach

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Abstract

Landfills cause environmental degradation through several factors i.e. GHG emissions including CH4 and CO2, leachate generation and contamination of soil and ground water, air pollution and threatening biodiversity and human life. Decomposition of organic matter in landfill occurs when water comes in contact with the buried waste, and leachate production and GHG emission are exacerbate by an increase in moisture level in landfills. While leachate generation causes vegetation damage, and surface and ground water contamination, GHG emission is leading to Ozone layer depletion and climate change process. In many aspects, achieving ecological or environmental sustainability is closely linked to the manner in which we deal with the landfills issues. Broad visions of what constitutes an ecologically sustainable system for waste treatment plant have been suggested. Ecological design is any form of design that minimizes environmentally destructive impacts through integrating itself with living processes and also explicitly addresses the design dimensions and the solutions for environmental problems. Ecological design is considered as effective adaptation to and integration with nature's processes. This paper firstly reviews the impacts of landfills on natural and built environment; then deals with investigation of the role of ecological design to reduce the effects of landfills and finally devises a framework for ecological planning and design provided with the strategies and policies for the landscape design of landfills.

Introduction

Rapid urban growth and population expansion especially in the second half of the 20thcentury accelerated the pressures on natural resources and energy, magnifying the impact we have on the health of the planet that supports us [2]. Meanwhile, Landfills may pose negative environmental impacts to air, land, and water, like GHG emissions, soil contaminations, and groundwater pollution [21]. Landscape pollution is known to produce toxins; chemical substances that cause any of a wide number of adverse effects in the living organisms. The effects may be acute and/or chronic, including changes in living tissues physiology, mutation and consequently sever diseases [11]. Over the past three decades ecological design has been applied to an increasingly diverse range of technologies and innovative solutions for the management of resources and energies.

Ecological technologies have been created for the food sector, waste management/conversion industries, architecture and landscape design; and also to the field of environmental protection and restoration [24]. By explicitly taking ecology as the basis of design, we can help vastly diminish the environmental impacts of everything we make and build [25]. Yet ecological design can be defined as any form of design that minimize the environmentally destructive impacts by integrating itself with living processes ,nature's own flows ,cycles, and patterns[8]. Theories of ecological design advocate principles and strategies to create sustainable landscapes [15][13][28][6]; hence, there are an increasing number of books devoted to technologies and strategies of ecological design [23][18][17][5].

The main purpose of this study thus, is to derive a framework for landscape planning and design of landfills through ecological approach.

Materials and Methods

Ecological design approach led to the comprehensive understanding the environmental layers and the study of the interaction between them to facilitate minimizing the environmental impact by the combination of biological processes through design framework [10]. This research has firstly, reviewed the impacts of landfills on their immediate and downstream natural and built environment. Then it deals with investigation of the role of ecological design in reducing the impacts of landfills; and finally develops a framework for landscape planning and design of landfills through ecological approach. A brief review of literature on the issue was undertaken to classify the major components of ecological design approach. Then influential factors on landfill location and impacts are discussed. Finally, the analyses of findings led to the identification of overlaying factors and elements and their interactions in the landfill landscape context to help the development of planning and design framework for such a landfill.

Findings and discussion

Municipal wastes may contain a wide range of materials that are potential pollutants, such as organic compounds or heavy metals [19]. Percolating rain water dissolves pollutants in the solid wastes forming a solution called leachate, which might percolate vertically through the soil into the groundwater or horizontally to open water bodies and pollute them eventually [1]. In many developed countries municipal solid wastes (MSW) are dumped in technically allocated and designed manageable landfills. In many developing countries, they are dumped in an uncontrolled manner without any precaution to deal with gas emissions and leachate generation, which pose a threat to the surrounding nature, wildlife, agriculture, and downstream settlements [20].

In the case of landfills, some major challenges to be tackled are including: a) Overcoming differential subsidence, b) Preventing gas emission, c) Preventing damage to the cap layer, and d) Slope stability. The following list presents the main engineering means, classified according to the problems they solve:

- Methods for overcoming differential subsidence: pile foundations [14], and mat foundation [7] for structures. In some cases, waste compaction enables loading the landfill with a light foundation [7] and light structure.
- Gas emission: engineered methods prevent the accumulation of gas in buildings and injury to plants. Methods for preventing the former include: passive venting of the gas through perforated pipes, and active venting using extraction wells and suspended floors that allow ventilation of the gas before it reaches the building space [16]. Methods for preventing the latter include applying a cap and using containers for planting, especially for trees[19]. Vegetative caps are also called ‘alternative covers’ or ‘evapotranspiration landfill covers’. A further advantage of vegetation coverd caps was rapid stabilization of the dumped wastes, decreased gas production after 5–20 years, and ease of access to the landfil site for alternative uses i.e. parkland, municipal building construction, and also cost effectiveness of landfill construction [12].
- Preventing damage to the cap by native or tolerant trees, therefore preventing rainwater penetration and leachate formation and increase. The methods include using a synthetic geo-textile in the cap, placing a thick layer of topsoil to contain the entire root system, and planting small trees to decrease the chances of wind overthrow. [4]
- Slope stability can be improved through retain wall [7],as well as various methods such as retaining walls and reinforced soil.[22] and using plants to keep slope stability.

Principles of ecological design are discussed by Sim Van der Ryn, Hart, Todd and Cuello. Van der Ryn, defines the related field of ecological design as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes" [28],

[9],[24],[3]. Accordingly Table 1 compares conventional and ecological design characteristics in relation to a number of relevant issues[28]. Five major factors/concerns are including: 1)Nature as whole complex, 2)Material and Energy issues, 3)Design considerations, 4) Economic and cultural considerations, and 5)Community Participation

Conclusions:

According to the comparative analysis of ecological design characteristics, an ecological design framework can be devised for the landfill sustainable landscape design. Firstly, the ecological design principles are identified in line with landfills needs. They are to include: 1) Design in according with existing site resources, 2)Relying on renewable energies, 3)The whole project consideration, 4)Solutions grow from place, 5) Integration of appropriate technology with natural infrastructure. Then policies and strategies are provided under each principle (Table2)[26][27]

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