

# Going toward Green Hospital by Sustainable Healthcare Waste Management: Segregation, Treatment and Safe Disposal

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## Abstract

Hospitals have always been the focal point of social systems identity. Thus, they act as the mirror of the community and should be responsible for it. Hospitals have been recognized as a significant source of contamination all around the world, therefore helping to endanger public health on an unintentional process. Although, the main mission of the hospital is to promote human health, it cannot be assumed as an island apart from its urban environment. "Green Hospital", as an approach to address environmental challenges and to meet communities need in health issues, has emerged recently as a try to improve the health, in line with its main mission. In this approach, all the environmental aspects of waste management are important and to be addressed. Hospitals' administrators can manage wastes disposal through composting, recycling and better supplying methods (downsizing packaging, using reusable products instead of disposables and using recycled products). This article is a review of the subject matter, in nature, using many library and online sources; it discusses about the need to move towards the green hospital approach, the ad-

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**ministration and leadership role in its establishment, the environmental impact of hospital operations and assessment of the effects, wastes management and control, and also the methods in wastes disposal and treatment.**

## Keywords

**Green Hospital, Wastes, Wastes Management**

## 1. Introduction

We are at a moment when the dual crises of public health and the environmental issues are emerging, and the place where these two destructive powers are intersecting. Since these two occur together, the cross flow of incoming diseases and deterioration of environmental conditions are becoming increasingly turbulent and changed to destructive forces which are departing the fabrics of our communities. Climate changes, chemical pollution and using unsustainable resource are intensifying diseases throughout the world. These growing problems in environmental health section have affected the healthcare systems very intensely, where the healthcare sector is contributing paradoxically in intensifying many environmental problems, at the same time, while forcing to deal with the related effects emerged. Healthcare sector, due to the application of products and technologies, resource consumption, waste production and its daily constructions and operations, is a significant source of pollution all around the world, and so helps the public health endangering process unintentionally [1]. Healthcare industry will influence the health of the environment by producing more than 2.4 million tons of waste annually [2]. While the hospitals responsibility is to treat the patients in their “wall”, they are also responsible for ensuring that their activities in the “wall” improve the health of our customers, employees and environment [3].

Waste disposal and collection of the special centers like hospitals and healthcare centers is of significant importance, due to the potential risks to human, animals, plants and the environment health [4]. Wastes generated during care activities have more potential risk of infection and injury than any other types [5]. Studies indicate that between 75 to 90 percent of the waste generated in the healthcare is with no risk in comparison with the wastes from houses. These wastes are mainly generated by the administrative and managerial functions of these centers and the (10 to 25 percent) are considered hazardous [6]. It seems that some of the production wastes of medical and clinical centers, which is called specific wastes or clinical wastes, have not been noticed and cared about significantly, especially in developing countries [7].

Many environmental issues in health sector directly associated with the waste production and disposal methods. Hospitals around the world are facing problems in the process of becoming a sustainable environment, and evidence indicates that developing countries are incurring more barriers in this field. One of the main barriers is the lack of necessary infrastructure in hospitals to handle hospital waste disposal. The definition of going green included waste reduction and energy and resource conservation [3]. As Florence Nightingale stated, environmental health is regarded as a key issue raised in the moving towards Green Hospital. Also as Satler said, in the view of Institute of medicine (IOM) specialists, environmental health is to get rid of diseases or injuries caused by toxic factors, agents and other environmental conditions, potentially important for human health [8].

Green hospital points to a hospital that see environment as part of their quality service. It includes characteristics such as strategic location, efficient use of water, energy and air pollution, the use of fine materials. It can produce other products, keep indoor quality, and provide good food and green environment as well. It has orientation for green products, non-toxic environment, green cleaning, and reduction of waste and provides a healing garden [9].

Green hospital has principles which are not yet well understood. Despite the establishment of Green Hospital in some of world countries, global efforts to tackle climate change and protect the environment, the current literature has been less paid to the green hospital. So this subject has significant potential for authors and researchers. Although research has been done separately for each of the dimensions, for example, a great deal of research has been done on green building, little research has been conducted with the green hospital terminology. Thus, this paper tries to open a window for the future research. Our focus in this study is on a model of green hospitals

and its association with one of the most important aspects of sustainable healthcare waste management.

## 2. Environmental Effects of Hospital

Hospital waste production and energy consumption affect environmental health and the health of every person in the affected area. While hospital owners are responsible for treatment within the confines of the hospital, they are also responsible for the hospitals' building, environmental performance, health promotion of customers, employees and their environment. They are also responsible to protect and maintain the environment friendly hospital among organization stakeholders [3]. **Figure 1** shows how pollution can increase the need for medical services, and this, in turn, can lead to the increased contamination [10].

## 3. Going toward Green Hospital

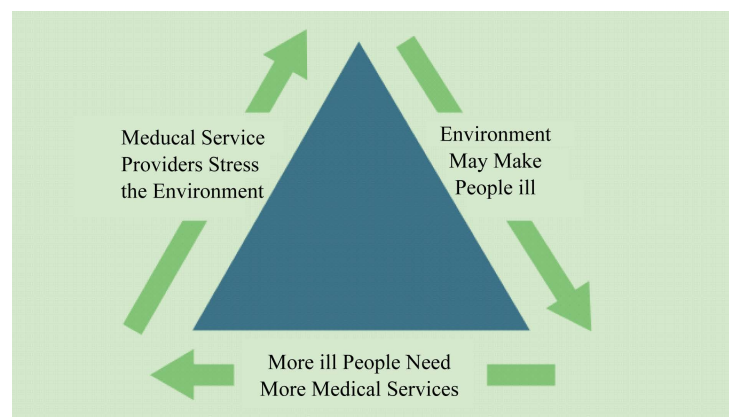
There is no universal standard that defines what a green hospital is or should be; however, this concept can be defined as follows:

Green Hospital is the one which is continuously upgrading public health by reducing environmental impacts and eventually by eliminating hospitals roles in disease burden. Green Hospital officially recognizes and confirms the relationship between human health and the environment, indicating that we could understand it only through governance, strategy and its operations. Green Hospitals connect local needs to environmental actions and primary prevention methods through active participation in community and environment health, justice in health and green economy.

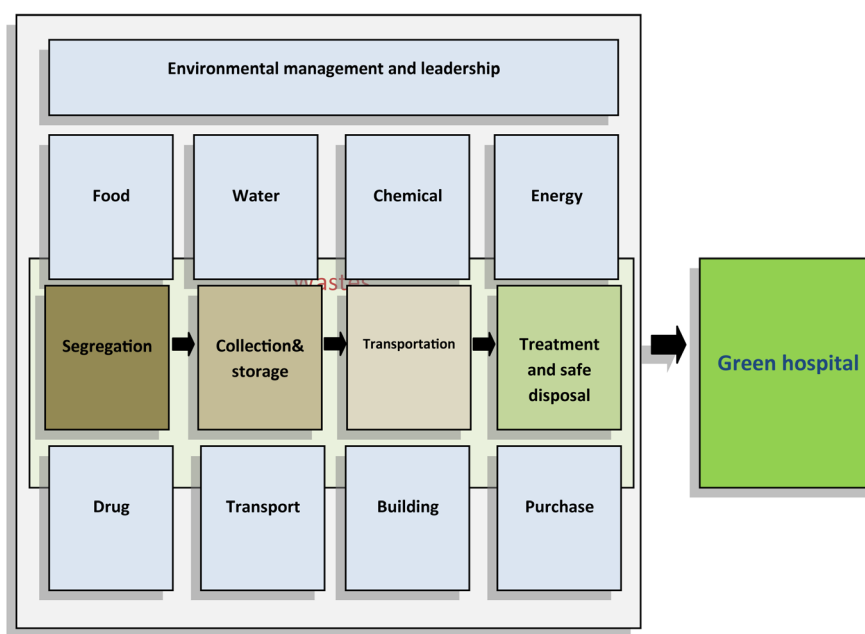
Although there is no specific model for green hospital in the world, many hospitals and health systems around the world have taken steps to reduce its environmental impacts, help to improve public health and also reducing the related costs, simultaneously. Moving towards green hospital includes wastes and energy reduction and also protecting the resources; besides, protecting the resources includes administrating the disposal of harming factors, recycling, reprocessing the reusable items and stuff and etc. and managing the products protection [1].

**Figure 2** shows a green hospital model focuses on the sustainable management of waste that we have given for easier understanding of their dimensions. To achieve Green Hospital goals, sustainable healthcare waste management plays a basic role, but this is not enough then we should pay attention to other aspects of its. For this purpose, we have introduced the following final model to be unaware of the other objectives of the Green Hospital. Obviously each of these dimensions in their turn requires further consideration. It is worth noting that we believed that environmental leadership and management has a special value and we begin our discussion from this dimension, then we will briefly mention the other dimensions as well. Later we will discuss the main dimension of Green Hospital—sustainable waste healthcare management in detail.

In order to promote the green hospital concept, leadership is essential at all levels. This means that leadership makes clear the key priorities of the organization and environmental health, safety and sustainability. This can be achieved through training, goal setting, accountability and incorporating these priorities in all relations and



**Figure 1.** Relationship environmental damage, increased illness and environmental impact of medical clinical services (source: [10]).



**Figure 2.** Going toward green hospital by sustainable healthcare waste management.

external communications. These actions and measures have to be done to make major changes in the organization's culture, which can be persuaded in a hospital, health system and/or MOH.

Nurses, physicians, hospitals, health systems and the health ministry are increasingly in the focus of the environmental problems and solutions. They are trying to save scarce financial resources, and play a leading role in support of the policies and procedures that will improve the general health of the environment. The leaders of the healthcare sector are seen as the symbol of a world view in health and sustainability, according to the Hippocratic oath telling "first of all, do not damage". Aside from working with hazardous chemicals having the safer alternatives, reducing the atmospheric effects of the hospital, or eliminating the exposure to healthcare wastes, these pioneers remind us that we cannot have healthy people on a sick planet, and thus hospital and healthcare sector will be in the front-line of global movement towards environment health [1].

In addition to environmental leadership and management, Green Hospital has various aspects with a lot of capacities to improve and with the implementation of standards and it may be possible to achieve the objectives of the Green Hospital. Chemicals are widely used in health centers is the most important aspect of green hospitals. By assessing of exposure to chemicals in health institutions, health sector can not only protect patients and their staff, but also can implement the safety management of chemicals actively. Hospitals in many countries consume significant amounts of fossil fuels energy [7]. They can reduce significant amounts of greenhouse gas emission and energy costs by applying alternative forms of clean and renewable energy [11].

Hospitals are strongly dependent on water for their various activities. Considering to climate change such as drought and shortage of water resources, it is recommended that all areas of water consumption must be evaluated to prevent water contamination and reduce water consumption. Healthcare systems can play an important role in reducing drug wastes by reducing prescribing excessive drugs, minimizing improper disposal of pharmaceutical wastes and banning free sale of drugs. Buildings in their current design are similar to boxes turn resources into wastes. The problem should be solved in the context of sustainability because of their immeasurable impact on the environment. Surely the only way forward is to design and build a green building or designing and creating performances that reduce negative effects on the environment [12].

Establishing a green and ethical purchasing policy including the purchase of environmentally friendly products can play a central role to the implementation of many green and healthy hospital goals [11]. Transportation is a major source of air pollution in the world that can cause significant health effects, especially in the urban areas The Health sector is a compact transportation industry. Consideration facilities Close to public transport infrastructure, telemedicine and so on can be proper strategies in this regards. Health care Centers are the largest

food consumer in many countries and can thus improve the level of health and sustainability through food choices. Modifying menus and hospital practices to support the purchase of healthy food through buying local products and organic products can help in achieving the goals of the Green Hospital [11].

#### 4. Sustainable Waste Management

World Health Center (WHO) has published the principles describing safe and sustainable management of healthcare wastes, as a necessity in public health issues, and also the procedure to achieve all the related measures to supply the needed financial resources [13]. Also governments all around the world have been called to take further actions in case of medical wastes through the World Health Assembly [14]. The UN Special Reporter on the Human Rights Commission has invited all the individuals and governments to “develop a comprehensive international legal framework to protect human health and the environment from the adverse effects of improper management in disposal of hazardous medical wastes” [15]. However, the healthcare waste management is still poorly funded and implemented, unfortunately, and the combined toxic and infectious effects of medical wastes, as environmental and public health threats, have not been noticed significantly. Recent related literature review concluded that more than half of the world’s population is at the risk of health effects of healthcare wastes [16].

Unlike many other hazardous wastes, currently there is no international convention that directly covers the management of medical wastes; therefore, the classification of these wastes varies from one country to another. However, the wastes are classified according to the risk of their transportation. Most medical wastes—about 75% to 85%—are similar to the normal municipal wastes, and are of low risk when burned. The next largest category is the infectious wastes, which are about 5% to 25% of the total wastes. Infectious waste can be generally categorized as infectious and sharp ones (1% of total wastes), the very infectious wastes, anatomical and pathological wastes (1%). Chemical and radioactive wastes, including medical, laboratory chemicals, cleaners, heavy metals such as mercury from broken thermometers and pesticides with a variety of health and environmental effects, from about 3% of the total medical wastes [10]. Hospitals sewage is removed from the list of medical wastes, but it is also worth considering. The effluent from sanitary facilities containing drug-resistant pathogens and chemicals with a great variety is more dangerous than domestic sewage [17].

Waste management technology should be affordable and consistent with the characteristics of the waste, the operation and maintenance of legal regulations. Waste minimization can be achieved by the following strategies: 1) As far as possible purchase items made from recycled glass and metals that can be disinfected and reused; 2) Sterilize reusable, strengthen sterilization procedures, quality assurance, control and validate cleaning, disinfecting for patient care, and reduce the number of pre-sterilized disposable items; 3) Adopt policies and procedures for the management of waste generated; 4) Establish effective policies in cooperation with the authorized manufacturer of plastics for recycling; 5) Use the steam sterilization method, preferred to chemical disinfection to prevent the generation of hazardous chemical wastes [18].

#### 5. Healthcare Waste Disposal and Treatment

If a proper management and control procedure is applied, healthcare waste should not have any adverse effects on human health and the environment. Medical wastes management is complex and success in such a big sector depends in large to the change of staff habits. In this context, it is necessary to reduce the production of wastes and provide a proper differentiation. With proper waste sorting and reducing, not only the disposal costs and environmental risks of them will be controlled and prevented, but also it enables a large proportion of non-medical wastes to be recycled, the reduction in the volume of raw materials, energy and the processing needed to replace the products that are used [1]. On the other hand, improper waste management which general and infectious wastes are mixed can lead to a bulk that has major potential for infection. Yet hospital waste can create the potential health risks, a secure and reliable infrastructure in many developing countries is not available [19].

Financial aids to healthcare sector could stop the generation of wastes and greenhouse gases through composting, recycling, better supplying methods (dawn packaging, usage of the reusable products instead of disposable ones and also using recycled stuff) and reduction in wastes transportation [1].

As mentioned earlier, between 75 and 90 percent of hospital wastes are common or no risk, and can safely be disposed in municipal landfills. The rest 10% to 25% of hospital wastes are infectious and hazardous that can cause the health risks [19]. To understand the management of medical waste, the healthcare manager have to

identify different types of waste generated and the potential human and environmental risks involved in the waste [3]. **Table 1** shows the types of waste generated in a hospital.

Similar to any type of waste management, safe disposal of hospital waste includes four key steps such as segregation, collection and storage, containment, transportation and safe disposal [19].

Waste segregation is different in hospitals. But wastes are stored on a temporary basis at the point of manufacture before collecting and treating [19]. Without source separation and recycling activities in place, hospitals have to dispose general wastes with infectious waste due to unplanned disposal costs. By having a clear plan, hospitals would handle their infectious waste and reduce generate additional costs [20]. Normally many hospitals in the world apply a three-colored containers system for separating waste: Yellow or sometimes red bags for infectious waste, black bag for general waste, and a container for sharps which are known as safety box, needles and other sharps can be thrown at it and dispose based on special instructions [19]. Among healthcare waste, sharps are a major concern for all health care workers alike, doctors, nurses, midwives, health care workers, recycler and community. It is possible to avoid sharp needle injuries during disposal or recovery that should be completely prevented [20].

Different technologies for healthcare waste treatment are available. Understanding the level and volume of waste before making decisions about these technologies is very crucial. Various categories of waste should be treated differently. Healthcare wastes Treatment technologies are often categorized into incineration and non-incineration technologies, particularly for infectious waste. Routine treatment technology for Healthcare wastes is incineration, where the waste was burned under controlled conditions [20].

A small portion of clinical wastes which are potentially toxic and are made of plastics as their main ingredient could be buried or recycled instead of being burned, since the burning will produce a large amount of greenhouse gases along with other toxic pollutants like dioxin and furan [21]. However, in recent years shortcomings of incineration largely perceived and more known to be incompatible with the environment. In fact, according to environmentalist waste incinerators only change shapes of waste, while their risks are remained. Basically, incinerator burns waste and emit ash and toxic and harmful gases into air [20].

Different types of non-incineration technologies are available that can be used to safely disinfect, bury and dispose wastes. Although autoclaves are typically used for sterilizing medical and surgical products, they are widely used as an antiseptic non-burning device. Using autoclaves is widely economical and also well understood and accepted by the healthcare systems [10]. But it seems that non-incineration technology to emit less pollution, affordable, reliable and prevent secondary pollution. The Most of non-incineration technologies produce hazardous solid residues which are not dangerous [20].

It is highly recommended to replace the burning and incineration method with other emission procedures, which should be undertaken by UN officials and through supplying the needed financial resources. WHO have recommended stopping the generation of dioxin and furan through using the new emission methods [21].

Some of the most commonly treatment and disposal methods used in infectious medical waste management include:

- Combustion (low-tech, medium, and high).
- Autoclaves and retorts.
- Microwave Disinfection Systems.
- Chemical disinfections.
- Controlled and healthy landfills [20].

Historically, incineration was used as an important disposal method. The burning has many benefits including the preventing infection and sterilizing the pathological or anatomical wastes, reducing the volume and recover-

**Table 1.** Types of wastes in hospital.

Solid waste	Biohazardous waste	Hazardous chemical waste	Medical waste
Waste commonly known as trash, garbage, or municipal solid waste These wastes are recycled or discarded in a sanitary landfill	Waste that is able to transmit infectious diseases These wastes are commonly known as infectious waste or red bag waste Considered sharps, cultures, human blood, human products, etc.	Waste that has potentially harmful characteristics These wastes are classified and managed through the Resource Conservation and Recovery Act (US EPA)	All waste that is generated at healthcare facilities ( <i>i.e.</i> , hospitals, clinics, physician offices, dental offices, blood banks, veterinary hospitals/clinics, and medical research facilities)

Source: Strashok, C., A. Dale, Y. Herbert, and R. Foon. "Greening Canadian hospitals" (2010).



ing the heat of waste. However, incineration may produce dioxins and furans known as hazardous air pollutants. Significant amounts of heavy metal waste can also be emitted in a form of steam or smoke, dust and ash due to burning [22].

Autoclave is a system works with heat and pressure. In this process water steam insert in the in the packages by creating a certain vacuum, the heat destroyed microorganisms and the excess steam are emptied. Microwave disinfection systems typically consist of three main types of equipments: 1) material handling equipments; 2) disinfection equipments; and 3) environmental control equipments. The steam produced from the waste water caused to destruction of pathogenic organisms in the waste by microwave energy [20]. Autoclave and microwave is considered as a positive alternative method to incineration. However, microwaving and autoclaving generally is not applicable for pathological, radiation, and chemotherapy wastes [22].

Chemical disinfectants are used in a variety of applications from preparation of a specific area of the body prior to injection to cleaning the surfaces in work areas. Chemical disinfection relies on specific properties of the chemical agent to disable the pathological organisms. A variety of chemicals can be used to achieve chemical disinfection, some of these chemicals include alcohols, acids, alkalis, phenols, halogens, heavy metal compounds, detergents (such as quaternary ammonium compounds) anti-metabolites and peroxide. Sodium hypochlorite (commonly known as bleach) is one of the most common solutions used for disinfection. However, due to the negative chlorine effects on health, and since it has been shown that chlorine is a precursor for the formation of dioxins in combustion, non-chlorine based disinfectants currently used. Sterilization can also be achieved using several chemicals in gaseous form. These compounds, such as formaldehyde and ethylene oxide, are highly toxic [20].

Landfill disposal methods which are used for the disposal or treatment of health care wastes in developing countries depends on the type of disposal facility is available. Facilities of open vet, so controlled and healthy Landfill and encapsulation are varied [20].

## 6. Wastes Management Criteria

Hospitals affect directly their patients and the environment health. Many environmental issues currently associated with health care are directly related to waste generation patterns and disposal methods [23]. Greening is behaviors or activities can promote environmental outcomes. Lausten has proposed specific ways to perioperative setting become more ecologically friendly. Three main categories he suggests are three Rs: reduce, recycle, and reuse [24].

An effective strategy in hospitals for seeking greener practices and reduces waste is to use environmentally preferred purchasing (EPP). It is defined as purchasing products or services which less damaging impact to the environment and human health environment [24]. Its recommended various solution to reduce waste including reducing or eliminating the use of some disposable such as overshoes except in chemotropic, using the empty packages of cleaners and antibacterial materials as a place to dispose needles and syringes, avoiding unnecessary packaging, helping to prevent peruse expiry of laboratory chemicals and etc. [10].

Hospitals can manage the process of equipments maintenance through using materials with small packages, reusable products instead of disposable ones and enhancing the wastes separation and categorization trainings [24]. Also, the lack of recycling programs increases the amount of wastes that are going to be incinerated or disposed in landfills [25] [26]. Sterilization is a method to reuse surgical instruments repeatedly. The sterilization methods and instruments are used to ensure preventing from potential infectious disease such as HIV or hepatitis and let user to reuse safely [24].

Another method for greening is recycling. Facility managers must decide about items which to be recycled, the place where be stored for pickup, the person who will remove these items, and the budget to remove the items. Recyclable materials must be collected in using sources (for example: stores, kitchens, laundries, pharmacies and workshops) and then to be delivered to the central storage area for transportation purposes [10].

## 7. Conclusion

Although the main mission of the hospital is to promote human health, it cannot be assumed as an island apart from its urban environment. This philosophy has a significant impact on the future hospital ideas and priorities: Promoting and advancing the health and well-being of all individuals and people wherever against the environment in a responsible manner. In the new philosophy, both structural aspects and structures of hospital should be

revised. One should walk towards the aim of transforming it into a climate friendly center that has a sustainable future for health care. Green hospital will be achieved through the strong commitment of medical health staff to assume the leadership of the health prevention measures and environmental protection in the future. Management of hospital waste consists of measures including avoidance, reuse, recycling and disposal that by doing the measures, steps are taken toward fulfilling one of the basic tenets of Green Hospital which is waste management. Obviously by taking these measures, in addition to saving the cost of services, we were also awarded the fulfillment of the hospital mission, “no harm to the patient, self and society and the environment”.

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