Multicultural Education

Volume 12, Issue 8, 2026

# A Systematic Review Management Principles And Methods Of Decontamination For Biomedical Waste And Comparison Between These Methods In Hospitals Of Kermanshah Province-Iran

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**Article Info**

***Article History***

Received:
May 01,2026

Accepted:
August 06,2026

***Keywords :***
Biomedical Waste, Biomedicalwaste Management, Biomedical Waste Treatment, On-Site, Off-Site

**DOI:**
10.5281/zenodo.21826295

**Abstract**

*Biomedical waste is defined as the kind of wastes produced by medical and biological centers and due to its dangerous effects, it cannot be decontaminated the same way as other types of waste. Biomedical waste management is an approach that prioritize reducing these effects and includes the processes of production, storage, maintenance, transportation, and decontamination. These methods must be effective on overcoming the challenges threatening people and nature, such as air and groundwater pollution or the spread of pathogens that could cause diseases and endanger different species. In this paper, the main features of the concept of biomedical wastes were primarily introduced and the difficulties and challenges of reckless management were then discussed. In the main part of this research, the problems in most of Kermanshah waste sites were evaluated in detail and finally, aneffective and optimal method to improve the control of biomedical waste management system was presented.*

## Introduction

Due to the differences between biomedical waste and home waste, such as infected and chemical materials in biomedical wastes, the same methods could not be applied for managing them.

Places that generate biomedical waste are hospitals, health care centers, dental centers, chemical laboratories, health clinics, and so on(Datta P et al.,2018),(Pasupathi P et al.,2011). Biomedical waste includes ordinary, infected, sharp, pharmaceutical, chemical, and cytotoxic wastes and the waste with heavy metals(Acharya A et al.,2014). Biomedical waste management involves the actions that improving the quality of annihilation of wastes and decreases the spread of insanitary particles and Infections, in the fieldof generation, accumulation, handling, storage, treatment, transport, and disposal (Bansal M et al.,2011). If biomedical waste management is not appropriately applied, it could lead to dangerous outcomes for the environment and spread of polluted particles results in the outbreak of several types of disease. Furthermore, these could pollute the underground water, endanger many species, and greatly harm the agriculture of the region and ultimately, the human life (Manzoor J & Sharma M, 2019),(Ambali AR, 2013).

Thus, prior to annihilating the biomedical waste, it is essential to omit the pathogens and harmful materials in biomedical waste. Biomedical waste treatment is the diverse procedure that makes biomedical wastes lose their hazardous material by sterilization them before they find their way to other form of safe wastes (Sarojini E et al., 2007). There are various ways to make the biomedical wastes safe, that the performance of each these, has advantages and drawbacks depending on the situation. However, before any treatment, it is necessary to have a complete management in the health centers that generate this type of waste because it could minimize the spread of pollution.

Careful execution of each step of biomedical management is of particular importance because it could improve the efficiency of the process. On the other hand, annihilation the biomedical wastes is carried out in two general ways (Hegde V et al., 2007) in the first method, biomedical management and treatment are done in the origin of production(on-site); in the second method, wastes are gathered in a place out of the center of generate and sterilization and annihilations are performed in a place other than the center (off-site). In the second way, it is possible to recycle the material and generate energy(SelvanChristyraj JR et al., 2021).

In this article, we discussed these two ways and compared the benefits and drawbacks of each one based on the research done for this subject. Furthermore, we explained the ways of treatment one by one and analyzed the adjustability of them through two ways of management mentioned above and the condition and possibilities of health centers.

**Method**

Data collection method in this study is based on field observations in a number of health centers in Kermanshah province such as hospitals and health clinics and interviews with relevant managers in Kermanshah University of Medical Sciences as the custodian of health in this province, infection control officials of hospitals and users of common waste decontamination systems in this city and also the study of regulations in the field of waste management in Iran. Finally, common methods in Kermanshah and in Iran in general were compared with biomedical management waste in developed countries.

## 3. Result

### 3.1 Biomedical wastes

Any waste with infected material and pathogens is called as biomedical waste. The main sources of this type of wastes are hospitals, health clinics, pharmaceutics centers, dental clinics, and laboratories. Infected wastes could be solid or liquid; for instance, syringes, blades, and needles that are in touch with blood or chemical materials, wasted blood, bondages, gloves, wasted hospital clothes, unused microbial culture medium (Babu BR et al., 2009).In the meantime, the sharp and keen wastes are of particular importance because if they are impregnated to blood or other infected materials and are not packed correctly after use, they could cause disease transmission due to injuries. Besides, the other form of these types of wastes is associated with several risk factors because they could easily spread in the environment.

Annihilation of these wastes is one of the main challenges due to their tendency to spread in the environment. Most of them are categorized in infectious and high-risk class and when not properly removed, they could be the main factor that endangers human and other species.

The main challenges in annihilation of biomedical wastes are their percentage of sterilization and the quality of packing for landfilling or burning (Rajor A et al., 2012). Better quality in sterilization of wastes lowers the possibility of outbreak of bacteria and microbes in the environment .Absolutely there is no possibility for perfect sterilization in any of methods, hence the factors of packing and landfilling are highly important. These factors, without management, could cause several problems, such as underground water pollution. On the other hand, although burning wastes could destroy all harmful elements of the wastes, it generates certain harmful poisonous gases (Manzoor J & Sharma M, 2019). On account of the above-mentioned reasons, burning and landfilling are not preferable methods in certain countries despite being easily available and cheap. In pioneer countries in the field of disposal biomedical waste, annihilation of biomedical waste is performed with new methods and strategies in which sanitation of the environment with an acceptable margin is guaranteed, for instance, utilizing ultra violet rays for sterling, called microwaves treatment, or plasma pyrolysis for removing the wastes.

Annihilation of biomedical wastes is introduced with more details, consequently. Moreover, making a proportional decision of annihilation wastes depends on plenty of elements, including sub-structures, possibilities, and potentials of the environmental and geographical condition, and without doubt, the cultural and social factors.

### 3.2 Biomedical waste management

As mentioned previously, the management of biomedical waste is performed through two general strategies: off-site and on-site. In off-site strategy, the wastes are accumulated in a place far from where they were generated. Afterwards, the process of sterilization and removing begins. Meanwhile, in on-site management, wastes are stored in a determined place in the health center which generated them and the mentioned processes are then launched. This way requires vast places in health centers to perform the steps of annihilation. In addition, patients and staff might be in touch with the harmful effects of biomedical waste. In smaller centers without enough space or equipment for annihilation, wastes are given to companies performing this. In off-site management, these problems do not rise; however, complete and perfect transportation system is needed to transmit the biomedical waste to the determined point in a safe way.

### 3.3 Generate and store

Biomedical wastes have to be kept in compartments with no leakage and no possibility for liquid waste to come out. Additionally, they must be able to resist against probable breaking as the result of displacement and transportation. These packs are usually determined with red sign as danger warning. Sharp and keen wastes are packed in their own compartments, which also is particular equipment that wastes as trash have to been packed into them according to the rules which prescribed, for instance, the packs that could vacuum the emitted gases (Deress T et al., 2018) Figure 1 represents the way of separating biomedical wastes in health center. Figure 2 shows the variety of the materials involved in biomedical wastes.

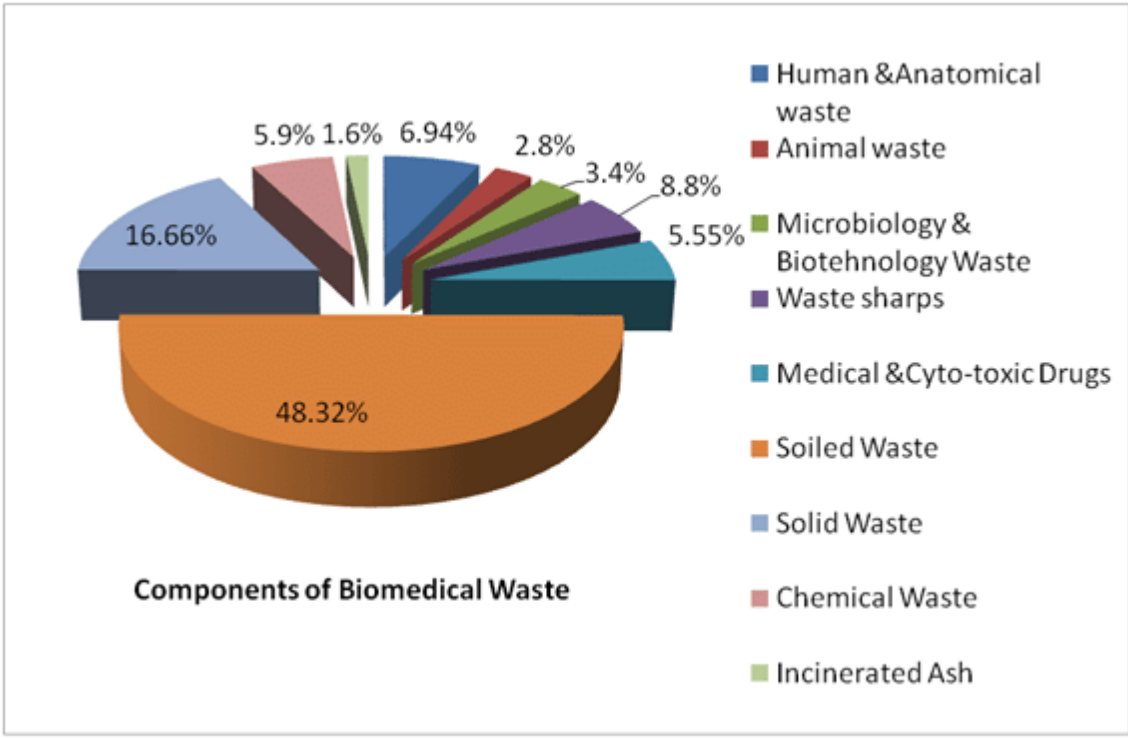


Figure 1. Separating biomedical waste in health centers

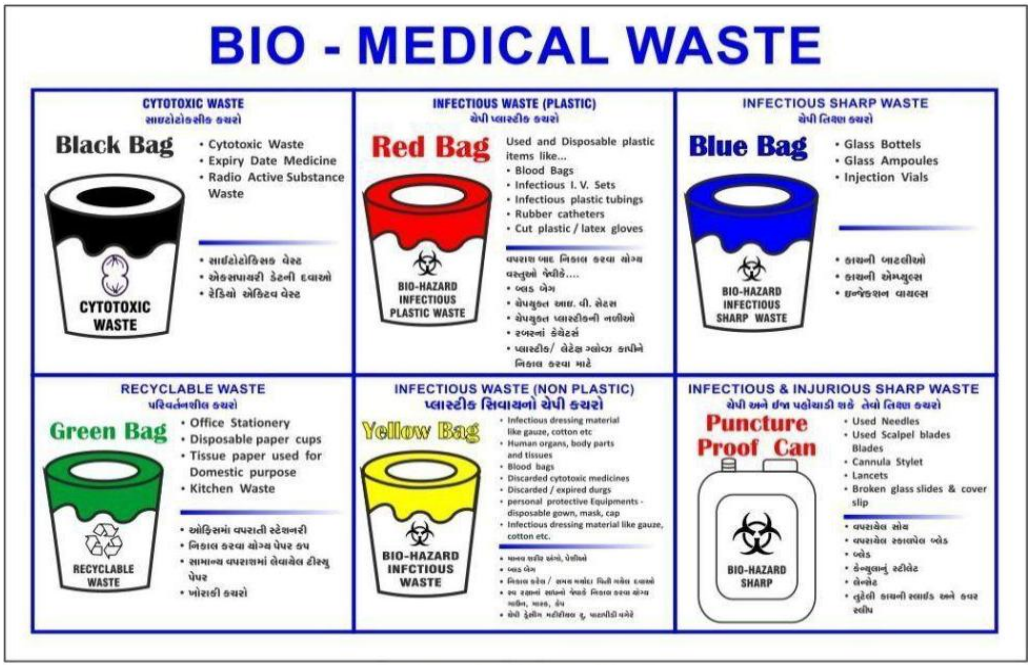


Figure 2. Variety of material involved in biomedical wastes

### 3.4 Storage

It is crucial to keep wastes in order not to transfer infection until the beginning of sterilization process and destroying bacteria and pathogens. In on-site management, these accomplishments for safe transportation are necessary. The time that biomedical wastes are kept do not have to be longer than a specific time because of the factors, such as infection leakage out of the packs (Mohamed NF).

### 3.5 Destroying infectious pollution of biomedical waste

In this part of the process, the main purpose is to minimize or omit the infectious pollution of biomedical wastes in a way that the wastes are safe and have no hazardous particles for the environment. Herein, some of the methods for safety of the biomedical waste was introduced, each of which could be useful according to their benefits and drawbacks.

**3.5.1 Burning the wastes**

Approximately all kinds of biomedical wastes could be burned. This causes the destruction of pathogens and could disable sharp equipment. On the other hand, burning some types of wastes, like those with materials with heavy metals and chemical wastes, leads in the release of some poisonous gases. Furthermore, burning has no effects on certain wastes like cytotoxic and radio activate ones. These two factors are known as the drawbacks of this strategy. Besides, releasing gases, like carbon dioxide, carbon mono oxide, and nitrogen mono oxide, as a result of burning has made this method inapplicable (Patan S &Mathur P, 2015). This drawbacks due to large amount of daily generated wastes (2.5 Kg per bed in a day(Katoch SS & Kumar V, 2008)) could be significant and is particularly important.

Another strategy in which biomedical waste is annihilated using heat is plasma pyrolysis (Nema SK &Ganeshprasad KS, 2002)which shown im Figure 3. This way has a basic difference with burning; the process in this way is launched without oxygen. Chemical changes in the molecule structure of materials result in the total elimination of wastes and certain changes in their nature. After the process is done, the mass and volume decrease by 85% and 90%, respectively. Despite the benefits of this strategy, due to the highly expensive equipment required in this way, it has not been launched in the centers.

(a) (b)

Figure 3. Burning machine (a); Plasma pyrolysis (b)Figure (3) depicts a sample of plasma pyrolysis and burning machine.

**3.5.2 Autoclave**

Autoclaving the waste is one of the non-incineration ways for sterilization the biomedical wastes. In this approach, using high pressure water vapor injected to the chamber containing biomedical waste, sterilization gets started. The vapor is injected in two ways: in a pressure of 1.2 Pa and 121℃ in 45 minutes or in a pressure of 1.5 Pa and 134℃ in 15 minutes. Both of them can destroy the most of bacteria and pathogens, but do not affect all the other kinds of biomedical wastes (Thakur Y &Katocha SS, 2012)In many cases, employing a combination of a shredder and autoclave could improve the efficiency of sterilization of wastes. Since shredding the waste as a result of shredder performance caused to outflow the steam of the waste composition and finally increase the steam volume in the sterile chamber. The shredder can be attached to the autoclave in three ways: pre-shredder, internal shredder, and post-shredder; each of them has some benefits and drawbacks.

**3.5.3 Microwave**

Using a microwave for destroying infections and pathogens has been reported to be more efficient than some non-incineration ways, such as autoclave. However, in a non-incineration method, it cannot do anything for other types of biomedical waste mentioned in the previous section.

This instrument demands expensive equipment and due to the samples used in some hospitals in Kermanshah, the cost of services and maintenance is always high.

The chamber containing wastes is filled with water vapor and then affect electromagnetic waves with the same frequency as the water molecules. Additionally, once resonance occurs, the increase in the temperature of the chamber and sterilizing begins (Dave PN & Joshi AK). Figure 4 illustrates the two types of autoclaves.

(a) (b)

Figure 4. Micro-wave system (a); Autoclave devices (b)

**3.5.4 Using chemical solution**

In this approach, using chemical solutions, such as bleach or sodium hydroxide, the infectious materials of polluted solutions are destroyed. The proportion of chemical solution with polluted solution is between 1% to 10%, which can be changed. Undoubtedly, this way has the least efficiency between the others due to its limited range of wastes, which can be annihilated with this method. Besides, its performance could not be perfect even for polluted solutions. Nevertheless, in certain hospitals in Kermanshah, like Songhor, this strategy is applied in view of its cost-effectiveness and low-level equipment.

**3.6 Removing safe biomedical wastes**

After destroying the pathogens and bacteria involved in biomedical waste, they have to be annihilated. The most popular ways in this regard are burning or landfilling the wastes. Without doubt, these could harm the environment in many ways, like a fracture on the cover of waste in landfilling or emission of some poisonous gases (effect of heat on heavy metals). Hence, the best way for annihilating is assumed to be recycling these materials or generating energy from them

**4. Discussion**

**4.1 Problems and drawbacks of biomedical management in Iran**

Management of biomedical waste through annihilation is of particular importance since any negligence can harm the environment. In general, as mentioned in the previous sections, biomedical management in Iran involves generation, storage, maintenance, sterling, and transportation of safe wastes and finally, annihilation. Besides, the way that is used in Iran for disposing biomedical wastes, is using hot and high pressure vapor that describe before. As mentioned above this type of devices only can use for infectious wastes. Hence, other types of biomedical wastes should annihilation in other dangerous ways such as chemical solutions, landfilling, burning and name it. As the result of poor theories and inefficient fundamental structures as laws of decontamination of biomedical wastes in Iran, the procedure faces with too many challenges. Inaccuracy in any of the steps can seriously endanger the environment; for example, in landfilling and burning, underground water and air pollution might occur. With an inappropriate transportation system, there is the probability of liquid waste leakage. Development in biomedical waste management could improve the efficiency of annihilation and possibilities of this performance will create further facilities.

In the following, some of the drawbacks and weaknesses of on-site management, which is carried out in Iran, are introduced.

**4.2 Drawbacks of outsourcing**

When the centers that generate the biomedical wastes, such as hospitals and clinics, do not have enough space, for example, for the process of annihilation of wastes, the step of sterilization are performed out of the center. However, other steps, like storage and keeping, are carried out in the center. The above-mentioned procedure, which is called outsourcing, is be done due to various issues, like lacking the ability to launch sterilization devices.

Dental clinics, health care clinics, and laboratories could be named as some examples of locations with shortage of space.

Outsourcing for biomedical waste is always done by companies validated by health organization.
Controlling the performance of these companies is usually highly challenging. On the other hand, there are plenty of small centers. Therefore, providing sterilization facilities for each small center is accompanied with critical problems. Hence, using these companies is inevitable. However, plenty of illegal actions by these companies have been observed which are shown in Figure 5.

Figure 5. Illegal actions by companies as outsourcing

In addition, the transportation system of these companies is not appropriate. There is no obligation from the related health organization for these companies to obey the transportation rules, such as using particular roads and vehicles, which could be problematic. In Figure 6, an example of transferring system of biomedical waste in Shohad hospital in Kermanshah is represented.

Figure 6. Transferring system of companies for biomedical wastes as outsourcing

Since there is no serious control over the performance of these companies and money is the priority of private sector like them, this is possible that the quality is overshadowed by time and money.

**4.3 Inappropriate separation**

As stated before, biomedical wastes generated in health centers include a vast range of other wastes like homemade, infected, tissues, and blood or sharp and keen, pharmaceutical, cytotoxic, chemical wastes and those with heavy metals, demonstrated in Figure 7.

(a)

(b)

Figure 7. Not separated cytotoxic wastes (a); Not separated sharp wastes

According to Figure 2, the rate of generation of these wastes is in the way that hazardous wastes account for a very low percentage of the entire amount. However, if various types of wastes are not properly separated, they could lead into pollutions; for instance, if infectious and homemade wastes are not separated, pathogens could transfer from infectious waste in homemade wastes and pollute all of the wastes. Thus, the entire amount of wastes gets converted to infectious waste. Furthermore, some annihilation devices, like autoclave, are not able to destroy certain types of waste, like pharmaceutical ones or those with heavy metal. If separation is not done properly, the device could not sterilization the waste and the mentioned types of waste remain unchanged and could pollute the outcome of the device.
Due to on-site management and multiplicity of the centers in Iran, observing and controlling the process of separation in centers encounters difficulties.

**4.4 Lack of close monitoring**

As mentioned before, due to the legal issues contained in the Iranian National Waste Management Law, the methods of management for annihilation for biomedical waste has been done as on-site process. Given that each hospital has to disinfect their own wastes which generate. Since in Iran, decontamination of infectious hospital waste is mostly done by autoclave, most of the biomedical wastes, like cytotoxic or pharmaceutical ones, are annihilated in other ways and some of them, such as those with heavy metals, are not destroyed at all. That is because autoclaves can only sterile infectious wastes. Some ways for disposing some types of biomedical wastes are shown in Figure 8.

Figure 8. samples of poor quality of the procedure of annihilation of cytotoxic and pharmaceutical wastes

Keen and sharp wastes are kept in boxes called safety box. Subsequently, using autoclave with shredder, they are conformed and after that sterilization process begins. Pharmaceutical wastes, are initially covered with

cement and then landfilled in a particular site. Finally, radioactive wastes are collected from hospitals and then transferred to a relevant organization to be destroyed.
On the other hand, smaller health care facilities employ outsourcing to annihilate their biomedical wastes.
The variety of methods for removing wastes via on-site management methods has brought up certain difficulties concerning the monitoring and controlling of the accuracy of annihilation process. However, if the process of annihilation is performed in a place out of the health facility, the problems of environment pollution decrease in compare of on-site management due to the help of organizations that have to monitor the process, the time and cost significantly decrease.

**4.5 Non-harmonic system**

In Iran, in spite of the variety of methods for annihilation of biomedical wastes (because of multiple types of wastes), there is a lack of a harmonic method for destroying biomedical waste, which is caused by poor management. Besides, using moist heat methods for sterilization of infected wastes which in many Iranian hospitals has become common, Proportion and harmony of the method is not considered; for instance, in “Bistoon” private hospital in Kermanshah, two devices are simultaneously utilized, one of which is autoclave and the other is hydro clave as shown in Figure 9.

Figure 9. Using two disposing device; auto-clave and hydro-clave

In addition, in “Farabi” and “hazrat-e-masume” hospitals, in spite of the rules for annihilation with government approvals, autoclave devices are used with external shredder as exhibited in Figure 10. Undoubtedly, this could trigger huge problems in biomedical management and as a result, harm the environment.

Figure 10. Devices auto-clave and shredder from one health center completely separated

**4.6 Drawbacks of the equipment used in health facilities**

On a number of occasions, the devices used in health facilities which generate biomedical wastes, facing technical problems (such as destruction in blades of shredder) and they are not able to annihilate until they get fixed. The process of mending these devices always takes almost a month or two and during this time, the centers have to outsource the wastes to the companies shown in Figure 11.

(a) (b)

Figure 11. Two samples of defective auto-clave

**4.6.1 Inefficient devices**

Annihilation using moist heat does not allow the destruction of all types of biomedical wastes, such as radio activate and heavy metal wastes. Besides, in both autoclave and hydro clave, using shredder is inevitable due to some wastes, like dialysis filters, set of dialysis, blood sac, and oxygenator, which have to be chopped before sterling. As mentioned before, the shredder of these devices can perform before, during, or after sterling. In all cases, the wastes have to be transferred between the shredder and autoclave chamber automatically to prevent infection release. However, in many health facilities in Kermanshah, these two are performed separately. In other words, in these centers, the wastes are initially broken with shredder and after that, the hazardous waste is transferred to the chamber by an operator who is in danger. Figure 12 demonstrates a sample of what was said above.

Figure 12. Samples of inefficient auto-clave without shredder

**4.6.2Using traditional and old systems**

Moreover, the systems that use vapor to make decontaminating of the wastes in some centers are old or still using some obsolete methods. In addition, some of autoclaves in health facilities have been used for over 10 to 20 years.

**4.7 Storing the wastes in the health center**

One of the other challenges in on-site biomedical wastes management is that the wastes are sterilized where the patients and staff are (hospitals, clinics, and in general generate centers). In these venters, there are no serious control over the process of keeping and storage. Figure 13 depicts the examples of unsuitable storage.

Figure 13. Samples of inefficient storage and accumulation of biomedical wastes

**4.7.1 Inappropriate landfilling**

In the way, as mentioned earlier, due to the inability of moist heat methods to sterilize of biomedical waste, the other types of hazardous wastes such as drugs, cytotoxic and heavy metals have to be disinfected by another method. One of these ways is landfilling. This way is particularly important since it can affect multiple factors in the environment, such as underground waters. In addition, the safe wastes that are outcome of some devices like autoclave have to landfill.

In the process of special wastes management, some hazardous wastes like those mentioned above must be landfilled, and as shown later, in a number of health centers in Kermanshah province, excellent equipment, ideal transportation and overall There is no Proper control over Sanitary landfilled of wastes.
Due to inaccurate landfilling, as time goes by, the material of wastes can break the coverage and penetrate in depth of the ground and as a result, pollute the underground water.
Another problem with thelandfilling process is recycling of those by profiteers and illegal working groups, mostly children. Because the polymers that compose some medical equipment often have the best quality

compared with other materials. Undoubtedly, recycling biomedical wastes in this way has multiple problems because of not being safe materials for reuse. Furthermore, they could harm the people who look for some materials in wastes.
Additionally, due to the rate of biomedical waste generation in Iran (up to 2.5 Kg /bed), a huge amount of wastes has to be landfilled daily, that next challenge in this area, will be shortage of landfilling sites. On the other hand, landfilling of biomedical waste is a metropolitan duty. Unfortunately, because the importance of dangerous biomedical waste to society and even governors has not been fully understood and the strategy applied for annihilation of these types of waste is as same as that used for home waste with only burning or landfilling. As said before, some of hazardous wastes, like those with heavy metals, are not removed with burning and burning only leads to emission of some poisonous gases. A sample of inappropriate landfilling is shown in Figure 14.

Figure 14. Situation of cytotoxic and chemical wastes in hospitals “Emem Reza” and “Shohada” In Kermanshah-Iran

**Conclusion**

Due to some issues associated with biomedical management that are described drawbacks of this systems, It seems that changing the method of management into the off-site and transporting biomedical wastes of all health care centers to a place out of the center and keeping them until the process of removing is begun could solve plenty of problems we are facing today.

In comparing these two ways, the on-site due to each health center which self-disposing their wastes, controlling of the procedure come across with too much cost and energy and finally dose not reach to the acceptable quality. Instead the off-site method since the project is done in one place, one technology and one method for disposing the wastes it can be more useful. In addition some ways such as land filling and burning the wastes could be disappeared.

For this purpose, it is necessary that all the generate centers operate as a unit. Hence, the controlling and monitoring would be more accurate than before.

A specific place has to be determined and perfect transportation system is required. Besides, this way, it is possible to recycle and generate energy because of the huge amount of wastes that are collected.

The main point in this system that could solve the challenges which exist now is improving the accuracy of monitoring and controlling the process.

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