



# An Evaluation of Health Care Waste Generation and Disposal at Ramadi Teaching Hospital in Iraq

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## ABSTRACT

In recent years, hospital waste has been one of the most serious issues in Iraq and other parts of the world. The current study aims to measure and analyze hospital waste output across all departments at the Ramadi Teaching Hospital. The data on waste generation rates gathered for the study were primarily based on existing records of field management of hospital waste over the course of eight months (one week per month) for all departments in the hospital; however, some random sampling information was provided to supplement the data. The results revealed that the estimated rate of medical waste creation at Ramadi hospital was between 144 and 188 kg/day, whereas the general (non-medical) waste generation was between (240-278) kg/day. In terms of patient numbers and per occupied bed, the average medical waste generation rates were from 0.60 to 0.90 kg/patient/day and (0.85-1.11) kg/bed/day, respectively, whereas the average general trash generation rates ranged from 0.86 to 1.15 kg/patient/day and 1.42-1.64 kg/bed/day. The recent analysis concluded that the hospital's segregation procedure is still inefficient, and there is room for improvement in terms of reducing hazardous medical waste creation.

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## 1. Introduction

Al- Ramadi Teaching Hospital is one of the primary hospitals in Al-Ramadi city and the largest hospital in Al- Anbar province, having a total capacity of 400 beds but now functioning with less than 200. This hospital is located in the northwest sector of Al-Ramadi city center, on the bank of the Euphrates River. It has six stories and a total area of 80288 m<sup>2</sup>. Al-Ramadi hospital provided a wide variety of clinical and medical services to residents in Anbar province's towns and villages. This hospital contains a variety of departments, including surgery, emergency lab care, cardiology, internal medicine, resuscitation, intensive care unit, an artificial kidney (Dialysis), and specialty units.

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The World Health Organization (WHO) defined medical waste as waste generated by health care activities that include a wide range of materials, including used syringes and needles, soiled dressings, diagnostic samples, body parts, pharmaceuticals, chemicals, and blood, medical devices, and radioactive materials. Healthcare facilities contain 75 percent to 90 percent non-hazardous waste, with the remainder considered infectious (Chartier et al.2014). According to Olko and Winch (2002), roughly 50% of healthcare waste created annually may be categorized as municipal (non-hazardous) trash. According to Alagöz and Kocasoy (2008), 65 percent of healthcare waste created is general garbage, hence only 35 percent of this waste might be classified as hazardous waste, but in France, 15 to 20 percent of medical wastes are infectious-hazardous wastes (Galtier and Bekaert, 2002).

Table (1) summarized the findings of multiple types of research on medical waste production in various locations throughout Iraq and other Middle Eastern nations. Because there was a lack of administration in Iraq, particularly in Anbar area hospitals. Thus, the goal of this study was to calculate the quantity of medical waste created in all hospital departments and to assess disposal options. Other objectives, in addition to the aforementioned, were added, such as establishing the kind of trash created by the departments by classifying this garbage, as well analyzes the process of waste collection and storage in the hospital. In this research, proper waste collection, transportation, and disposal techniques will be presented to fulfill the hospital's current and future demands.

**Table 1 – Medical Waste Generation in Various Hospitals in Iraq and Other Countries**

Author	Year	Country	Medical Waste Generation
Al- Hashimi, & Al- Mandalawi	2007	Some hospitals, Baghdad- Iraq	0.32–1.6 Kg/(bed/day)
Alhumoud&Alhumoud	2007	Governmental hospitals, Kuwait	3.8- 7.44 Kg/(bed/day)
Abdulla et al.	2008	Northern Jordan	0.5 -2.5 Kg/(bed/day), average production rate 0.83 Kg/(bed/day); 90% of infectious waste
Al-Khatib et al	2009	Nablus city, Palestine	0.59-0.93 Kg/(bed/day)
Sawalem et al	2009	Libya	1.3 Kg/(bed/day);28% medical waste,72% general wastes
Birpinar et al	2009	Turkey	0.63 Kg/(bed/day); 63%. medical waste
Abd El- Salam	2010	El-Beheira, Egypt	2.07 Kg/(bed/day); 38.9% medical waste,60.1% general wastes
Mbarki, A et al	2013	Souss-Massa-Drâa Region Morocco	0.4 -0.7 Kg/(bed/day);0.53 Kg/(bed/day); 30.5% medical waste, 69.5% general wastes
Graimed,B.H	2013	Kut hospitals- Iraq	0.12-2.5 Kg/(bed/day)
Haleem et al	2013	Radiation and Nuclear Medicine, Baghdad- Iraq	2.6-3.27 Kg/(bed/day) 10.6% hazardous solid waste, 89.44% general waste
Jaafari, J et al	2015	Public hospitals, Iran	3.16 Kg/(bed/day); 42% medical waste, 56% general wastes
O. Alagha et al	2016	healthcare centers and hospitals, Eastern Province, Kingdom of Saudi Arabia	.51 Kg/(bed/day); 1.66 Kg/(bed/day)
Kizar,F,M	2016	Some hospitals,Najaf- Iraq	1.047- 3.844 Kg/(bed/day)
Ali S. & Jasim D.	2018	Al-Kadhimiya hospital ,Baghdad - Iraq Al-Yarmouk hospital ,Baghdad - Iraq	0.436 Kg/(bed/day); 1.007 Kg/(bed/day) 0.682 Kg/(bed/day)0.916 Kg/(bed/day)
Khudhair H.A	2018	Tikrit Teaching Hospital - Iraq	0.90 Kg/(bed/day) 36.96% hazardous waste 0.75 Kg/(bed/day); 63.04% general waste

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## 2. Methods and Materials

### 2.1. Sampling technique and sample size:

The teaching hospital in Al-Ramadi city is a major and substantial hospital. During the data collection period, the hospital had a total of 170 beds after what was originally a total of 200 beds. This research was conducted between January and August of 2020. This research is needed to provide a database, information, and statistics about healthcare waste origins, generation, collection, transportation, waste treatment, and disposal. This research was conducted between January and August of 2020. This study is necessary to provide a database, information, and statistics on healthcare waste sources, creation, collection, transportation, waste treatment, and disposal. An inventory of the trash is created in each of the following hospital departments: general surgery, renal dialysis, resuscitation, internal medicine, and intensive care unit, with the assumption that they constitute the largest source of waste generated in the hospital. The quantity of waste was calculated by assuming that the hospital had 100 percent occupancy.

There was not enough data available before the start of this study on the volume and composition of medical waste in the hospital, which may be inspected and compared with the current study.

### 2.2. Problems and challenges

The following is a list of the most pressing issues and challenges:

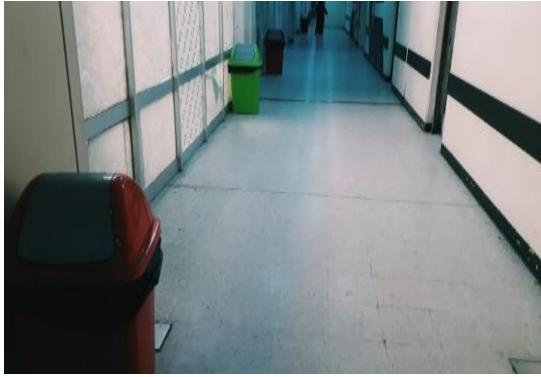
- 1) Unavailability of knowledge of waste management needs data documentation Formal records of the sorts of garbage and the amounts created before are kept.
- 2) There is a lack of data on the quantity of burnt trash that they incinerate on a daily and random basis, and they do not know the weight of the garbage.
- 3) Delays in getting survey forms are caused by the tough routine at some health facilities.

### 2.3. Procedures and Characterization

The amount of waste generated in the hospital should be known while making a better waste management system, through owning information about the amounts of different categories of waste, which is represented by field measurement, interviews, and physical and chemical checks. The amounts generated vary based on the treatment, medical service in each department, and units in the hospital. The data gathered were upon experiments, questionnaires, and checklists to write the indicators that occur in each department during the fieldwork.

The quantity of medical waste created by hospital departments was determined by collecting it and then weighting it using a calibrated sensitive weight scale before the actual measurement every day for seven consecutive days each month beginning in January and lasting until August 2020. The observational checklist and key informant interviews were used to obtain information regarding waste management status. The amounts of hospital waste observed in the field were given as (kg/day) of moist weight. Field visits were made to the Ramadi Hospital to acquire basic information, assess working conditions, and make the necessary administrative procedures. Data on medical waste generated in hospitals was gathered during the research period. It is critical that hospital trash be separated. Waste separation operations are carried out in each department of the hospital [Figure 1].

Throughout the research period, it was discovered that various sorts of garbage, such as medical and general waste, were put together in black and green bins. In general, it did not appropriately implement the various separation requirements in its manufacturing area in all of the analyzed parts. As a result, little bins of various colors are put in certain rooms across the hospital to allow employees to dispose of various waste pieces in suitable locations. As a result, a black color container for general garbage, a green color container for medical waste, a red color container for hazardous waste, and a safety box for sharp waste was dispersed across the hospital's departments. Through the period of the study, it was found some departments stored the medical waste inside the service rooms such as the general surgical and intensive care unit, knowing that we noticed that the dialysis units immediately transported the waste to the storage area of the hospital, which was located near the incinerator.



**Fig. 1 Different colored plastic containers for waste separation at the point of origin**



**Fig. 2 Uncontrolled storage areas of healthcare waste near the hospital**

The garbage collection station is around 50 meters distant from the hospital. A steel structure supports the containers on the outside. These waste containers are designed to be easily loaded, easy to push and pull, with different sizes to accommodate up to 50 kg waste, with a height similar to waste containers to facilitate minimal agitation and avoid spillages, to a specific waste type, easy to clean and disinfect, and remain secure during transportation. Figure (2) depicts an unregulated hospital waste storage space, yet uncovered and overflowing mixed trash was seen.

The rate of medical waste created per day was calculated using the number of occupied beds as well as the number of patients treated in the hospital's various departments each day. This waste is stated in terms of kg/bed/day and kg/patient/day, which are particularly useful for comparing different health-care facilities with varying degrees of availability, as the total number of beds is frequently employed. Outpatients are departments within a patient who spend less than six hours in the hospital. When a patient spends more than six hours or at least one night in the hospital, he or she is considered an inpatient. The following is how the inpatient bed occupancy rate (BOR) was calculated:

$$BOR(\%) = \frac{\text{Total No. of inpatient days for a given period}}{\text{Available beds} \times \text{No. of days in the period}} \quad (1)$$

Then, the medical waste generated (MWG) is calculated based on bed occupancy rate as follows.

$$MWG = \frac{\text{Total production of medical waste}}{BOR} \quad (2)$$

In addition, calculations are made depending on the type of service provided in the hospital's departments and units.

$$MWG = \frac{\text{Average daily production of medical waste(kg)}}{\text{Average patients per day}} \quad (3)$$

The waste generation rate (WGR) for medical and general wastes was estimated using Altin et al. (2003)'s model, which was based on the total number of beds in the hospital and assumed 100 percent occupancy;

$$WGR = (W_m + W_g) / N_p \quad (4)$$

Where:

WGR = waste generation rate (kg /bed/day)

W<sub>m</sub> = total medical waste (kg/day)

W<sub>g</sub> = total general waste (kg/day)

N<sub>p</sub> = the number of overnight patients.

In contrast, the proportion of medical waste ratio (MWR) to total trash is computed using the following formula:

$$\text{MWR (\%)} = \frac{\text{Amount of medical waste}}{\text{Total amount of waste}} \quad (5)$$

#### 2.4. Treatment and disposal of healthcare waste practices:

The primary medical waste treatment techniques include incineration, autoclaving or steam sterilization, irradiation, and thermal inactivation. The physical nature of the waste, as well as the technologies employed in the packing process, define the treatment approach used. Incineration is one of the best solutions for most hazardous healthcare wastes, and it is employed in many industrialized nations since it can thermally eradicate all germs while also reducing waste weight by more than 70% [Tsakalou & Tsakiridis].

Ramadi hospital's incinerator is a single chamber, Photo. (3,4) with a diesel engine and a fuel consumption of 25 l/h. The temperature reaches 300-400 °C, which is insufficient for burning medical waste. The incinerator chimney is 20 meters tall, and its capacity is around 270 kilograms every cycle. In most situations, the total medical waste surpasses this capacity, thus there is always a strain for medical institutes to get rid of garbage. The actual quantity burnt by the incinerator fluctuates between 400 and 620 kg per day, with the rate of medical waste incinerated by the incinerator being 160 kg per day. If 100 kg of medical waste is fed into the incinerator, 35 kilogram of ash is created. The ashes are skimmed every three days by a skimmer, and the weight of the calcified ash in the incinerator fluctuates between 200-250 kg. The ashes that remain in the incinerator are loaded into big containers, transported to the compressor, and then discharged into the landfill area. Whereas general trash is delivered by the Ramadi municipality's compressor and buried in a sanitary landfill located south of Ramadi on a daily basis.

The shredding machine with microwave is accessible in Al-Ramadi hospital, although it is currently not in use due to a shortage of skilled operators. This technical treatment procedure necessitates qualified personnel with high-pressure steam system maintenance expertise. The capacity of the shredder at Al-Ramadi hospital is 30 to 35 kg/cycle, with cycle duration of 40 minutes. The machine operates with a minimum of 16 kg of medical waste and heats the trash via microwave depending on the rise of wave frequency from 50 to 2000 HZ. The produced temperature is around 106 °C; at this temperature, medical waste is transformed to regular garbage by heating. Shredding is the process of reshaping or cutting garbage into tiny pieces so that it cannot be identified. This technique aids in the avoidance of bio-medical waste reuse and also acts as a means of showing that the waste has been decontaminated and is safe to dispose of [Babanyara et al.]. For outdoor transportation, a well-designed trolley with appropriate standards is employed. Although this truck is identical to a solid waste vehicle, off-site transportation vehicles are not labeled with the carrier's title and company.



Fig. 3 Incineration



Fig. 4 Combustion single chamber

### 3. Results and Discussion:

Data and information regarding the rate of hospital waste generation serve as the foundation for the design and assessment of a hospital waste disposal system. Several major factors influence the quantity of trash created in



each area and unit, including "the number of beds, the number of patients present at the time of measurement, and the type of services."

The rate of hospital waste creation is critical information for analyzing and constructing hospital waste disposal systems. The quantity of trash created in each department and unit was influenced by several important criteria, including "the number of beds, the number of patients present at the time of measurement, and the type of services employed for therapeutic purposes". Based on these criteria, one week waste generation data from hospital departments was determined in terms of kg/patient/day and kg/bed/day, and the findings are shown in Table (2) using equations (1-3). According to the findings, the average amount of medical waste created in the hospital was 0.7 kg/patient/day and 0.96 kg/bed/day, while the average amount of general hospital trash was 1.11 kg/patient/day and 1.5 kg/bed/day. However, the total number of inpatients in the hospital throughout the research period, which began in January 2020 and ended in August 2020, was an average of 238 per day, and the number of beds was greater than 170 for the entire study of five departments in the hospital. Table (3) displays the total quantity of garbage created by the hospital in each department in kilograms per day and kilograms per bed per day. The findings of the determinations for each of the departments for medical and general wastes, on the other hand, are shown in Table (4). The medical waste for each area of the hospital, in decreasing order, was determined to be as follows: general surgery (33.1 percent), kidney dialysis (26.5 percent), resuscitation (15.8 percent), internal medicine (14.6 percent), and intensive care unit (14.6 percent) (9.93 percent). The general surgery department created the most medical waste, whereas the Intensive Care unit produced the least of all hospital departments. This is because the number of treatments and patients each day in the critical care unit is limited, hence the quantity of trash created is lower. This discrepancy, however, is attributable to the features of each unit. Each unit needs a distinct form of diagnosis and therapy. Some diagnostic and treatment approaches generate more trash than others (Altin et al, 2003). The general surgery department was the highest generator of hazardous healthcare waste, according to (WHO-CEHA, 2002). The variance in the rate of waste creation from one unit to another in the hospital is typically and anticipated, as the nature of operations in each of its separate units is based on data and records. We discovered that the total waste produced in the hospital throughout the research period consisted of 64% general garbage and 36% medical waste, as computed from equations (4- 5) and as indicated in the tables (3-4). This differs with World Health Organization (WHO) estimates, which place the quantity of medical waste in underdeveloped nations around 16%. (Pruss et al. 1999). This appears to be owing to a lack of understanding and ignorance of the environmental dangers, pollution, and economic losses produced by combining ordinary and infectious wastes at all stages of manufacturing. Transportation and storage of waste in hospitals (Rahmanian & Yazdanpanah, 2017). This high degree of medical waste creation might be attributed to a lack of waste segmentation at the time of generation. Furthermore, patients' poor socioeconomic position may result in reduced output of general garbage, resulting in a larger proportion of hazardous waste in comparison. Furthermore, the amount of medical waste created waste (infectious waste, sharps, chemically hazardous waste, radioactive waste, non-hazardous waste) at the point of creation, with precise handling, treatment, and disposal criteria (Hayleeyesus & Cherinete, 2016). In the event of hazardous treatment materials, which are deemed hazardous waste, huge amounts of trash can be disposed of in household bags in typical patient treatments.

**Table 2- shows the amount of waste generated by all departments at Al-Ramadi Hospital.**

Month*	Internal Medicine Dept.	General Surgery Dept.	Dept. of resuscitation	intensive care unit	kidney Dialysis Dept.	Total (patient per day)	Total medical waste (Kg/day)	Average of medical waste (kg/pat./day)	Total general waste (Kg/day)	Average of general waste (kg/pat/day)	Average of medical waste (kg/bed/day)	Average of general waste (kg/bed/day)
Jan. 2020	40	194	30	4	35	303	183.62	0.60	263.50	0.86	1.08	1.55
Feb. 2020	46	199	34	3	32	314	188.75	0.60	278.85	0.88	1.11	1.64
March 2020	44	134	24	4	32	238	156.43	0.65	251.63	1.05	0.92	1.48
April 2020	41	97	24	3	35	200	147.94	0.73	243.17	1.21	0.87	1.43
May 2020	36	115	23	2	33	209	153.10	0.74	251.63	1.20	0.90	1.48
June 2020	50	101	15	2	29	197	158.18	0.80	244.81	1.24	0.93	1.44
July 2020	38	77	16	2	27	160	144.53	0.90	241.47	1.51	0.85	1.42
August 2020	36	195	15	3	34	283	176.88	0.62	265.26	0.93	1.04	1.56

- One week waste generation data per month from each department

**Table 3- Medical and General Generation from all departments of Al-Ramadi Hospital**

Departments	No. of bed	Range of Medical Waste (Kg/day)	Range of General Waste (Kg/day)	Range of Medical Waste (kg/bed/day)	Range of General Waste (kg/bed/day)
Internal Medicine	25	16.77 - 27.75	47.14 - 58.55	0.67 - 1.11	1.88 - 2.34
Resuscitation	30	15.2 - 32.8	31.2 - 42.6	0.50 - 1.09	1.18 - 1.42
General Surgery	80	32.8 - 61.6	57.6 - 77.6	0.41 - 0.77	0.74 - 0.89
Kidney Dialysis	25	33.18 - 46.0	10.15 - 17.25	1.32 - 1.84	0.40 - 0.69
Intensive Care Unit	10	10.31 - 19.9	10.95 - 16.2	1.03 - 1.70	1.09 - 1.62

**Table 4- Medical and General Waste Generation in Each Department of the Hospital**

Department	Average of Medical Waste Kg/day	Average of General Waste Kg/day	Medical Waste (%)	General Waste (%)
Internal Medicine	22.0	52.6	14.6	28.8
Resuscitation	23.8	37.0	15.8	20.1
General Surgery	49.63	67.2	33.1	36.4
Kidney Dialysis	39.6	13.32	26.5	7.06
Intensive Care Unit	14.6	13.84	9.93	7.6
	151	184		

#### 4. Conclusions

1. The highest waste generation of medical waste was reported in the general surgery department that was nearly 50 kg/ day with 33% of the total waste and lowest waste was observed in the intensive care unit that was almost 15 kg/ day.
2. The total waste produced during the period of this study was found to consist of 64% general waste and 36% medical waste.
3. Segregation waste in each department of the hospital is not satisfactory. However, the high proportion of medical wastes indicates inappropriate waste segregation processes and a lack of knowledge among workers in this field. Color-coding for various categories of waste is not followed.
4. The storage area is not safe for the generated waste and the storage containers are placed on are located on the shoulder of the street near the hospital building.
5. The departments of Al-Ramadi hospital did not perform the sufficient level of health care waste management, except in sorting and collection of waste, as well all the hospital departments were not correctly reporting waste quantities. However, there was no tool available to detect the weight of medical waste.
6. There is no uniform method for treating medical waste in hospital. The incinerator was operated by poorly trained workers, which did not comply with standards related to environmental protection. This may be due to the use of a single low-combustion chamber and the height of the chimney of the incinerator must be more 20 meters.
7. The height of the chimney of the incinerator is no enough to prevent air pollution in the surrounding hospital area.
8. The hospital waste is disposed of by throwing it in a random, irregular landfill belonging to the municipality of the city of Ramadi, and this will cause serious environmental problems for the city.

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