Integrated Environmental Assessment of Medical Waste Management in the Kingdom of Bahrain

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Abstract: As a global concern, medical waste (MW) links public health, environmental pollution, and resource sustainability. This study aims to assess the two issues related to medical waste in Bahrain: the increasing generation rate of MW and its management. The integrated Environmental Assessment (IEA) methodology was adopted, including the DPSIR (Drivers, Pressures, State, Impact, Responses) framework, analysis of existing policies, and the outlook. Consequently, data were collected from official health statistics in Bahrain, and related policies for the last two decades (2001 to 2021) were also collected, in addition to interviews with Bahrain medical waste (BMW) treatment company. The results show a vast increase in medical waste during COVID-19. Moreover, most of the existing policies address the impact of the BMW issues, but the policies are lacking in tackling the drivers and pressures; there is also a policy gap related to the generation rate. Accordingly, a set of policies was proposed to overcome the two medical waste issues. Moreover, to overcome issues associated with MW, the study recommended reforming regulations aiming to reduce and manage medical waste efficiently in order to focus more on drivers and pressure causing an elevation in MW issues in Bahrain.

Keywords: medical waste management; COVID-19; DPSIR; integrated environmental assessment; policy analysis

1. Introduction

Medical waste (MW) is defined as solid waste resulting from diagnosis, treatment, and vaccination, including testing, research activities, and manufacture of biological products [1]. This waste contains hazardous and non-hazardous wastes. The non-hazardous waste is primarily composed of general domestic waste, and it does not pose any particular chemical, biological, physical, or radioactive hazard. In contrast, hazardous waste is generally contaminated with pathogens. Thus, misusing this waste or poor handling and discarding can cause many infections and diseases. Adding to that, it can also cause environmental contamination in the case of mismanagement, which can result in pollution of land, plants, water, air, and animals, which can lead to the spread of diseases. Consequently, it needs restrictions and special requirements in the collection, disposal, and treatment methods [2]. Hazardous waste may include various types, such as infectious, genotoxic, pathogenic, chemical, sharps, pharmaceutical, and waste with heavy metals content, pressurized containers, and radioactive [3–5]. In the current pandemic, COVID-19-related medical waste (CMW) has increased with the new daily cases, diagnostic pandemic tests, and vaccination. Therefore, much medical waste was produced and is still being generated due to the epidemiological situation. The MW related to COVID-19 represents a challenge, as it must be disinfected before processing any secondary products. So, this hazardous waste must be disposed of and treated appropriately to protect the environment and human health [6,7], and all countries and communities must be well-equipped for any unwanted situation in future [8].
Management of MW needs also necessitates skilled employees to deal with it. Singh and coworkers [9] stated that about 40% of the health workers were injured, suffered from skin infections and musculoskeletal disorders, and obtained injuries in the eyes due to improper waste management and lack of experience and training in medical waste management. Additionally, it was discovered that the rate of trained workers is only 41%, and medical waste segregation has been accomplished at 38.9% only in 78 countries with transitional economies worldwide [9]. Several disposal and treatment technologies are used for medical waste, for example, thermochemical treatments (incineration, torrefaction, pyrolysis, and gasification), in addition to disinfection methods such as autoclave, microwave, chemical disinfection, and others. Therefore, the policies must be reviewed, revised, or approved to deal with medical waste, especially with CMW [7].

The rise in MW quantities and its mismanagement are growing issues worldwide. Furthermore, during the current pandemic and population growth, medical service demand increased, producing bulk medical waste [10]. The DPSIR (Drivers, Pressures, State, Impact, Responses) framework was adopted by United Nations Environment Program (UNEP) in 1995, and the Global Environment Outlook Reports until the latest GEO 6 [11]. This study used this framework to assess the Bahrain Medical Waste (BMW) issues in an integrated way. It was used to identify the drivers and pressure, investigate their impact, and comprehensively study the existing MW policies, consequently setting the outlook or the future scenarios to develop policy options and suggestions.

Several studies applied Integrated Environmental Assessment (IEA) and employed DPSIR in environmental areas such as municipal waste management, hazardous waste, and different other types of wastes [12,13]. However, to the best of our knowledge, none of the studies used IEA on medical waste, especially in Bahrain. Moreover, this work is based on a comprehensive survey of the legislative structure at the national level and international initiatives and agreements, attempting to figure out the policy gap by identifying the policies that are not focused on the relevant driving forces or pressures of the medical waste issues. The study further assesses the two issues related to medical waste in Bahrain, the increasing generation rate of MW and its mismanagement, by using the IEA methodology, including the DPSIR framework, analysis of existing policies, and the future outlook. Therefore, this study could improve MW management efficiency and related legislation, especially during an epidemiological situation such as COVID-19.

2. Materials and Methods

The methodology adopted in this research is Integrated Environmental Assessment (IEA), which could answer the five questions shown in Figure 1, using the DPSIR framework, policy analysis, including policy type, policy instruments and effectiveness, and finally, the future scenarios and policy options (UNEP, 2019). DPSIR was employed by numerous studies in a wide range of the environmental fields, including hazardous waste and municipal solid waste [12,13] and assessing facemasks in the environment [14].

Numerous groups investigated the high risk of the COVID-19 pandemic in the environment in various parts of the world. This study calculated the amount of CMW in kg/day using Equation (1) proposed by the Asian Development Bank [15]; the amount of CMW increases with increasing the number of infected cases. Furthermore, several studies have applied this equation to estimate the CMW in Asian countries (Purnomo et al., 2021 [7]; Al-Omran et al., 2021 [16]). Therefore, this equation seems promising in predicting the waste generated or to be generated in the future until the end of the current pandemic and in the case of other related situations.

\[
CMW \ (\text{kg/d}) = COVID\_19 \ \text{infected cases} \times 3.4
\] (1)

Data of new daily infected cases from the first case in Bahrain on 24 February 2020 to 20 December 2021 was collected from the public domain “Our World in Data” [17].
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Data of new daily infected cases from the first case in Bahrain on 24 February 2020 to 20 December 2021 was collected from the public domain “Our World in Data” [17]. Moreover, data on the medical waste quantities in tons from 2010 to 2020 were collected from the ministry of health statistics and published on Bahrain’s open data portal https://www.data.gov.bh/en/ResourceCenter, (accessed on 22 December 2021) [18]. Data on the number of violations of medical waste management in health facilities were collected from the annual reports issued by National Health Regulatory Authority—NHRA [19].

The collected data were used to visualize the increasing quantities of general medical waste, calculate CMW, and demonstrate the number of medical waste violations. Furthermore, an interview was conducted with a manager of Bahrain Waste Treatment Company (BWTC); this company collects and treats the MW generated by many governmental and private hospitals and health facilities.

3. Results and Discussion

This part of the study answers the five IEA questions (Figure 1) related to the two issues of BMW: increased medical waste quantity and mismanagement.

3.1. What Is Happening to Medical Waste in Bahrain “State”, and Why “Drivers and “Pressure”? 

To answer this question and demonstrate the increasing quantity of medical waste, the collected data from Bahrain’s open data portal was plotted to figure out the trend of the generated BMW from 2010 to 2020, as shown in Figure 2.

An evident, sharp, double increase in medical waste in 2020 can be observed in Figure 2 because of the COVID-19 pandemic. The rise in 2020 was more than double, and the main reason behind that increase is the COVID-19 pandemic [18]. Moreover, the Awali incinerator, which handles this type of waste, reported an approximately 50% increase in hazardous medical waste during the pandemic [20]. It is almost the same case with some other countries; for instance, one of the provinces of Turkey witnessed an increase in the amount of medical waste due to the COVID-19 pandemic, reaching 48% on average [21].

Proceeding precisely to the quantity of medical waste generated only during the pandemic, the daily COVID-19-infected cases and the calculated CMW from 24 February 2020 to 19 December 2021 are plotted in Figure 3. In the figure, the CMW is increasing with
the number of infected people; the quantity of CMW approached 11,128 kg (11.128 tones), with 3273 infected cases on 29 May 2021 (the highest daily new cases in the study period).

![Figure 2](image_url)

**Figure 2.** Medical waste quantities in tones generated from 2010 to 2020 in Bahrain.

![Figure 3](image_url)

**Figure 3.** The number of daily infected cases and amount of CMW (kg/day) from 24 February 2020 until 19 December 2021.

The high number of COVID-19 infections and polymerase chain reaction (PCR) tests resulted in an unambiguous rise in medical waste, a large proportion produced from health facilities dedicated to COVID-19 treatment.

Focusing more on the medical waste quantities, Al-Omran and others [16] estimated the CMW in Bahrain. The study found that the waste generated from facemasks were around 35.5 kg/day; personal protective equipment PPE used by the health facilities was 1864 kg/day; and the accumulated quantities of waste generated from vaccination and PCR test were approximately 16,633.5 kg and 53,551 kg, respectively, until 1 June 2021.

Several drivers could lead to issues related to MW as mentioned above. For the first issue, the increasing quantities of medical waste every year, the main driver is population growth. Population growth leads to more medical services and consumption [22]. For instance, the population in Bahrain in 2022 increased to 1,797,844, with a population growth rate of 3.68% in 2020 [23]. Another driver could be the free treatment and medication for Bahraini citizens and partially for immigrants.
Economic development could also be considered a significant driver. Attracting workers from abroad leads to an increase in medical services [24]. The medical tourism sector contributes to increasing economic diversification. It was mentioned that health tourism offers multiple opportunities for the Kingdom of Bahrain, contributing to the promotion of its exports and the diversification of its economic activities [25]. Making Bahrain an attractive destination for medical tourism leads to an increase in the number of tourists, attracting many workers and establishing more institutions and hospitals. As a result, the country’s private healthcare sector has considerably grown. The number of private healthcare facilities has increased from 500 in 2018 to 800 in 2019, leading to more health services and, thus, a high amount of MW [26,27]. The growth rate in health facilities from 2017 to 2020 reached 18% [28].

Medical technology is another driver, where high technology would lead to advanced medical services and consequently to more medical waste generation [29]. The Ministry of Health in the Kingdom of Bahrain is keen to work according to a unified governmental system based on the commitment to the Economic Vision 2030, which aims to keep pace with the technologies of the industrial revolution. Indeed, the Ministry of Health has been able to keep pace with these global developments and develop its health and treatment services through a serious follow-up to the latest developments in the medical device industry and its quest toward providing modern technologies to improve and raise the level of quality of treatment service for patients [30].

Additionally, a lack of public awareness is considered a strong driver for increasing medical waste. For instance, understanding the importance of the COVID-19 vaccine and its effectiveness in protecting against diseases. Likewise, the awareness of the importance of adhering to precautionary measures and social distancing at the beginning of the pandemic. Additionally, awareness about the importance of nutrition and following healthy behaviors could reduce medical waste quantities by decreasing exposure to the related disease.

Moreover, the absence of MW segregation is an essential driver, and the generated waste of the health institute is mixed. It was reported that there are violations related to medical waste segregation in different health facilities in Bahrain [19].

The second issue is the mismanagement of MW. The National Health Regulatory Authority [19] reported violations in 2019 and 2020, mainly in medical waste rooms, segregation, storage, and transportation (Figure 4), which implies a serious issue in disposing and managing MW.

![Figure 5](image-url)
For the MW treatment methods, it was mentioned during the interview with one of the responsible office bearers of BWTC that they use the incineration method for treating MW. It is well-known that this method emits CO\textsubscript{2} and other unwanted gases.

The most significant driver for this issue of MW management is the lack of monitoring of the practices of workers in the medical sector, as well as the lack of the polluter pays principle (PPP), which is the public enforcement of environmental laws and regulations. Therefore, it is a considerable driver for having an issue in managing the MW in health facilities as well as MW treatment centers.

Figure 5 illustrates the driving forces, pressures, and the role of the state of MW issues in Bahrain.

### Figure 5. The DPSIR framework of medical waste in the Kingdom of Bahrain.

#### 3.2. What Are the Consequences of Medical Waste for the Environment and Humanity? (Impact)

MW issues in Bahrain lead to negative impacts on health and the environment. One of the most significant adverse impacts is the spreading of the virus and increasing diseases and infections. Many cases were reported of acute hepatitis B (HBV) and C (HCV) infections in healthcare workers [32]. The World Health Organization (WHO) estimated that more than two million healthcare workers sustain percutaneous injuries from infected sharps each year [32]. There are serious risks of disease transmission to waste pickers, cleaners, health workers, patients, and the community in general. Likewise, the improper management of medical waste could increase the spread of infections in the same way, particularly in the case of COVID-19 [33].

It was indicated that the sources of COVID-19 MW are hospitalized patients, people in isolation at home, and in quarantine. The amount of MW has increased during the emergency of the COVID-19 pandemic [34]. The MW generated by the current pandemic poses a high risk to human health. A study identified that the PPEs used by medical staff could lead to indirect infections without contact with infected patients [35].

Environmental risk is another significant impact of inappropriate medical waste disposal. The incineration method is used for medical waste treatment in Bahrain, which can lead to harmful effects, such as causing high levels of dioxin emissions [36]. It was reported that the incineration of biomedical waste contains polycyclic aromatic hydrocarbons (PAHs) and a high concentration of heavy metals resulting in unfavorable amounts of hazardous materials, thus causing to pollute the surface and groundwater [37]. Furthermore, the incineration method produces ash residues which cause changes in the soil quality near...
waste-dumping sites [38]. Moreover, these issues cause financial challenges in managing, storing, transporting, and subsequent treatment associated with MW.

3.3. What Is Being Done to the Medical Waste, and How Effective Is It? (Response)

A few significant laws and policies have been adopted in Bahrain recently, namely, on 30 May 2019, the LEGISLATIVE DECREE NO. (10) of 2019 [39] concerning general hygiene was issued. It was the first decree that directly addressed medical waste. Moreover, it included different kinds of medical waste under “special waste”. Special waste is defined as “any waste resulting from various healthcare activities in all its forms, nursing, curative, and diagnostic, in hospitals and health centers, including laboratories, research centers, radiology, pharmacies, dental treatment, and physiotherapy”.

The Legislative Decree included two articles on medical waste. Article 5 obligates producers to take all necessary measures to separate medical wastes from other wastes by following the requirements and specifications established for the preservation, collection and transportation of such wastes stated by the executive regulations of this law. Article 8 prevents transferring medical waste, whatever its source is, from the site of its lifting to the treatment site, except through companies and institutions licensed and classified for this purpose, following the controls determined by the executive regulations of this law.

Moreover, anyone who violates the provisions of this decree articles related to other types of waste shall be penalized between BHD 50–300 (1 BD = 2.65 USD). On the other hand, in violation of the provisions of articles related to medical waste (5, 8), a fine of BD 500—1000 shall be punished. It is noticed that this Legislative Decree imposes penalties on environmental violations by producers of medical waste more stringently than producers of other waste (non-medical waste) due to the seriousness and danger of medical waste.

On 31 December 2020, MINISTERIAL EDICT NO. (3) of 2020 [40] concerning hazardous waste management for healthcare was issued. It includes 36 articles about healthcare waste management. This law aims to regulate the process of managing hazardous waste for healthcare safely and sustainably to control the waste and prevent its spread, guaranteeing the preservation of health and the environment. This Edict is applied to every producer, carrier, or treatment unit whenever the activity practiced by any of them is related entirely or partially to the management of hazardous waste for healthcare. The policies and regulations related to MW in Bahrain, including decrees, laws, international conventions, initiatives, and guidelines, are collected and then analyzed in Table 1 by checking whether it addresses drivers, pressures, status, or impact.

### Table 1. The summary of policies analysis of medical waste (driver D, pressure P, status S, and impact I).

<table>
<thead>
<tr>
<th>Issue</th>
<th>D/P</th>
<th>S</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase quantities of medical waste</td>
<td>DECREE NO. (10) of 2019</td>
<td></td>
<td>Law No. 39 of 2005 of Stockholm Convention</td>
</tr>
<tr>
<td></td>
<td>(Legislative, Proactive, Economic, ++++)</td>
<td></td>
<td>(Legislative, Reactive ++++)</td>
</tr>
<tr>
<td></td>
<td>MINISTERIAL EDICT NO. (3) of 2020</td>
<td></td>
<td>WHO Guiding Principles</td>
</tr>
<tr>
<td></td>
<td>(Regulatory, Reactive, ++++)</td>
<td></td>
<td>(Institutional, Reactive +++)</td>
</tr>
<tr>
<td>Medical waste mismanagement</td>
<td>MINISTERIAL EDICT NO. (3) of 2020</td>
<td></td>
<td>MINISTERIAL EDICT NO. (3) of 2020</td>
</tr>
<tr>
<td></td>
<td>(Regulatory, Reactive, Enhance +)</td>
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<td>(Regulatory, Reactive Enhance +)</td>
</tr>
<tr>
<td></td>
<td>DECREE NO. (10) of 2019</td>
<td></td>
<td>Royal Decree 75 of 2016 on ratifying the Paris Agreement</td>
</tr>
<tr>
<td></td>
<td>(Legislative, Proactive, Economic, ++++)</td>
<td></td>
<td>Law No. 39 of 2005 of Stockholm Convention (Regulative, Reactive ++)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Decree No. (26) of 2001 ratifying the Regional Protocol (Regulatory, Reactive ++)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WHO Guiding Principles</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(Institutional, Reactive, Enhance +)</td>
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</table>

The data summarized in Table 1 reveal that the policy instruments used to govern and manage MW are regulatory, economic, and institutional instruments. Some of the policies
were proactive, and others were reactive. The reactive approach is based on responding to events after they have already happened. However, the proactive approach focuses on eliminating and preventing problems before they have a chance to appear. Most of them aim to enhance the environment (Enhance). Some are strongly positively effective (+++), and one policy is neutral (0). It can also be noted that most policies address the negative impacts. In contrast, no policy tackles the state of increasing medical waste quantities, so there is a lack of policies tackling the drivers and pressures of both issues.

The economic instruments are considered an effective policy tool in minimizing, preventing, and managing waste. Moreover, the charges and fees are deemed economic instruments that can be used to recover the waste management costs and support the user polluter pays principal (PPP), ensuring the financial sustainability of waste management services.

The Rio Declaration and Agenda 21 of the Sustainable Development Goals (SDG) and UNEP_GEO reports, especially GEO5 (2012) and GEO6 (2019), emphasized the importance of economic instruments for environmental policy. Economic instruments embody a tool for national authorities to support the internalization of environmental costs and efficiently employ the polluter pays principle [41]. In addition, the economic instruments could help encourage the behavior changes necessary to achieve waste policy objectives—for instance, waste reduction or investment in technology for improved waste treatment [6].

3.4. Where Are We Heading with the Medical Waste? (Future Outlook)

Policy analysis of BMW management reveals that the current policies are insufficient to moderate the pressures and drivers, reduce the two main issues (BMW quantity and management) and mitigate their adverse impacts. For example, although there are policies on segregating medical waste at the generation source, they are not yet implemented in many health centers, as shown in Figure 5.

Two future scenarios (Scenarios for Outlooks) were predicted for determining strategic solutions to help the policy/decision-makers achieve sustainability in Bahrain, as summarized in Table 2. The first scenario is a business-as-usual prediction, corresponding to the current situation with no policy reforms or more government intervention. As a result, there will be a continuous increase in the generation rate. The second scenario, the sustainability scenario, assumes that the policy/decision-maker would be stricter in segregating the MW in the generation source to reduce the generated waste. This is to minimize the adverse human health, environmental, and economic impacts. It was found that 15–20% of the total healthcare waste is hazardous waste which is contaminated with pathogens and treated by a particular treatment technique, and 80–85% is non-hazardous waste [28]. Moreover, it was found that if a rigorous segregation program is implemented, the amount of waste that should be incinerated can be reduced by 80% [42]. Therefore, a large proportion of them could be recycled. Thus, some types of MW can be recycled with proper separation, thus encouraging investment in recycling medical waste that is suitable for recycling, such as plastic. MW also provides an opportunity for the circular economy, especially in the private sector [43].

Table 2. Proposed scenarios for medical waste management.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Actions</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business as usual–BAU</td>
<td>Conventional</td>
<td>All medical waste is mixed together and treated by the incineration method. The quantity of medical waste is increasing.</td>
</tr>
<tr>
<td>Sustainability Scenario</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Reduction in medical waste quantities.</td>
<td>Segregate the types of medical waste. Focus on segregation of the hazardous from non-hazardous waste from the source.</td>
<td>Around 80% of medical waste would be recyclable. 20% would be treated by incineration.</td>
</tr>
</tbody>
</table>
Although the top priority of any health facility is delivering high-quality care, complete waste minimization and recycling programs could be adjusted to save financial and environmental resources. In addition, any health institute can take steps to activate the circular economy model; these steps are: Establishing a “green team” (to ensure implementation of strategies of circular economy), measuring waste production, segregation, waste minimization, safe reuse, recycling, and reprocessing [44]. Emerging a circular economy is a bridge for sustainable waste management and a way to a sustainable future. However, many countries must adopt policy instruments to manage waste effectively [6]. The sustainability scenario focuses on implementing policies and regulations to reduce the quantities of medical waste and improve disposal and treatment methods. It is expected to apply alternative technologies rather than the incineration method. For example, the US Environmental Protection Agency (EPA) proposed alternative technologies for the disposal and treatment of medical waste: steam sterilization (autoclaving), thermal treatment (microwave technologies), chemical mechanical systems, and electropyrolysis [45].

3.5. What Actions Could Be Taken for Medical Waste for a More Sustainable Future? (Policy Options)

Increasing the quantities of medical waste and mismanagement of medical waste disposal and treatment is a long-term problem. Therefore, these issues need root solutions to the drivers and pressures. Additionally, these issues need instruments such as forming policies for medical waste producers and treatment units, reforming some regulations, and encouraging or discouraging specific behaviors and actions through introducing initiatives, incentives, or disincentives. Focusing more on implementing strict policies regarding efficient medical waste management is crucial. However, as indicated in the previous annual report of NHRA [19], the number of violations regarding the medical waste room, storage, segregation, and transportation for the year 2020 is much less than the violations of 2019. That reduction is because the visits to health institutions were stopped during the pandemic, and the authority only asked for pictures. Therefore, in this case, the truth is less.

This study suggests that the law should be applied in its true spirit more firmly, and a rise in the amount of penalty against violations can also have a positive impact. Moreover, the violators’ license must be permanently withdrawn when the offence is repeated, and final or temporary closure depends on the circumstances.

Furthermore, Edict 3/2020 must be activated regarding the necessity for health facilities to nominate an employee responsible for waste management and form a working group to achieve the highest levels of waste management. Furthermore, each work team member must abide by the responsibilities specified in the Edict, their commitment to the standards specified for storing hazardous waste within the facilities, and the period that must remain in the storage site before transferring it to the treatment unit.

Under the Bloodborne Pathogens Standard, the US Occupational Health and Safety Administration (OSHA) regulates the safety of medical waste in the workplace. The Bloodborne Pathogens standard requires that all personnel handling medical waste be trained annually concerning the proper storage, handling, labelling, and transportation of medical waste. The standard also obliges health facilities with occupational exposure to infectious substances to submit an annual exposure control plan that outlines all assessment procedures, potential risks, and a schedule detailing how the facility will remain compliant [46]. This study proposes a policy to require all health facilities to provide annual training for staff, including hospital administrators, doctors, nurses, paramedical staff, cleaners, porters, waste handlers, and others. In addition, it is recommended to consider the WHO healthcare waste training modules [47].

For proper medical waste treatment, it is proposed to provide guidelines for the treatment units on alternative technologies for medical waste treatment and select the best technique depending on the medical waste type. Before 1997, the incineration method was applied to more than 90% of potentially infectious medical waste. In August of 1997, EPA issued regulations setting strict emission standards for incinerators of medical waste due to
substantial concerns about harmful air quality affecting human health. However, the EPA’s Air Quality Planning and Standards Department is still reviewing and revising Hospital Medical Infectious Waste Incinerator (HMIWI) standards.

4. Significance of the Study

By realizing the sustainability scenarios that reduce the quantity and manage medical waste efficiently, the Kingdom of Bahrain would achieve SDG 12 and SDG 3, mainly targets 12.4 and 12.5 as well as 3.3, 3.9, and the other SDGs related to the medical waste management, which are SDG 3, 6, 7, 8, 11, 13, 14, 15, and Targets 6.3, 7.2, 8.3, 8.8, 11.6, 13.2, 13.3, 14.1, 15.1 (Figure 6).

![Figure 6. The interlinkages between medical waste and the SDGs.](image)

Finally, Bahrain is also committed to COP26 to reach “Net Zero” by 2060 and has set a range of goals to ensure proceeding without delay. By 2035, it targets to reduce emissions by 30% through carbon removal solutions and efficiency initiatives [48,49]. So, minimizing the quantities of medical waste will reduce CO₂ and other gas emissions and contribute to realizing the “Net Zero” target and Bahrain’s commitment.

Generally, integrated assessing for issues related to medical waste in Bahrain using the IEA procedure and considering the suggested actions that could be taken for a more sustainable future could lead to improved MW management efficiency and related legislation, especially during an epidemiological situation such as COVID-19.

5. Conclusion and Recommendations

IEA was implemented in this study to assess the environmental issues of BMW. Different social, economic, and technological drivers and pressures could increase the quantities and mismanagement of medical waste. These issues could cause adverse environmental, human health, and economic impacts. It is revealed as a result of policy analysis that most existing policies tackle the impacts of the issues. Therefore, it is recommended to reform policies and focus more on the main drivers and pressures, which are the root causes of the problem, to overcome this deadly environmental issue. New guidelines and policy reforms are required for medical waste management, especially after the COVID-19 pandemic, and to seek sustainable solutions for unexpected crises in future. In any community, solid waste aspects, including medical waste, are related to human needs; therefore, waste production, dealing, and disposal reflect people’s awareness. So, it is crucial to involve the community in this issue and dedicate efforts to change behavior to raise awareness among the people, i.e., on safe PPEs such as facemask disposal. Furthermore, it is important to educate young people about the importance of maintaining their health for themselves and a healthy
environment as well, and they should follow a healthy life free from harmful behaviors to their health. This aligns with the emphasis of COP26 in terms of raising awareness and focusing on the youth about environmental issues.

The study suggests providing training about the risks associated with medical waste and strategies for safe handling and disposing of it for all levels of medical staff frequently and extensively and educating them about the protocols and practices to ensure a healthier and safer working environment. Furthermore, more scientific research is highly recommended to study the increasing medical waste generation rate and its proper management. For example, empirical studies are desirable to determine the exact amount of generated medical waste in the case with segregation of all types of medical wastes from the source and compare it to the case without segregation. Identifying the precise rate could assist in transferring recycling and a circular economy. Moreover, it is important to determine the appropriate treatment technology for each type of medical waste considering the safe environment and public health. Such research works need to be supported by the government and followed up by specialized authorities such as Supreme Council for Environment (SCE), NHRA, and other parties.

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