

## IMPACT OF COVID-19 ON MEDICAL WASTE MANAGEMENT IN JORDAN

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### ABSTRACT

Although the direct impact of COVID-19 is on human health, it has substantial impacts on economic, social, cultural and environmental issues. The priority of the international efforts was to find a vaccine for COVID-19. The impacts on other sectors, such as medical waste management, have not been given the same attention, especially in Jordan. The purpose of this paper is to determine the impact of COVID-19 on medical waste management in Jordan. The study investigated the amount of waste generated in 2018 and 2020 in 54 facilities that generate medical waste. The results showed that the governmental implementations and curfew period have significant impacts on the amount of medical waste. The hospital that treats COVID-19 patients, private hospitals and institutions, showed an increase in the quantity of medical waste while the governmental hospitals, health care centers, laboratories, and industries showed a decrease in waste generation during the year 2020. In some months, the amount of waste from COVID-19 hospitals increased up to 3 folds in 2020 compared with 2018 data. Health care centers, labs, institutions and industries generated zero waste during the curfew period. It was recommended to keep control and inspection on medical waste streams to avoid illegal disposal, or poor handling and transportation measures.

**KEY WORDS:** COVID-19, Medical Waste, Jordan, Environment

### INTRODUCTION

The first confirmed case of COVID-19 was reported in Wuhan, China, on 31 December 2019 which represent the spark of the deadly outbreak of the most harmful pandemic in this century. After that, COVID-19 spread dramatically around the world to reach 10.20, 32.7, 79.23 and 126.37 million cases in June, September, December 2020 and March 2021 respectively. Similarly, the death cases increased to 0.503, 0.991, 1.75, and 2.77 million for the same period respectively (WHO, 2021).

Jordan like the rest of the world was bombarded by the COVID-19 Pandemic. As of March 2020, extraordinary lock-down measures were implemented across the country and all cases were followed at central government locations. The real

rise in COVID-19 cases along with increasingly reported deaths was not until September-November, 2020 (MoH, 2021).

The daily generation of medical waste in Jordan is about 4.7 Tons, with a per bed generation of about 2.69 kg/bed/day (Abu-Qdais *et al.*, 2020). The quantity of medical waste produced during the pandemic was expected to be higher than that produced at the same time in 2018. The estimated amount according to a recently published study is 3.95 kg/bed/day with a huge increase in volume (Abu-Qdais *et al.*, 2020).

In China, biomedical waste as well as using personal protective equipment (PPE) generated from hospitals and diagnostic labs, have increased 5-6 folds than pre-Covid-19 period so that the biomedical waste treatment facility was loaded from

50 tons per day to 263 tons per day during the pandemic period (Ilyas *et al.*, 2020). In the USA, biomedical waste production jumped from 5 million tons annually to 2.5 million tones monthly. The waste management industry changed drastically in terms of operations, investment, manpower due to all economic breakdowns (Ilyas *et al.*, 2020).

The Lockdown measures that include restrictions on travelling into and out of the country, as well as the closure of many industries and commercial venues also changed the lifestyle of Jordanians. These include increased household and related plastic waste volume. Globally, there is an estimated number of more than 5 million people who die annually due to unmanaged medical waste, which shed a light on medical waste generates in homes during the COVID-19 pandemic.

In response to the pandemic, there was a drastic demand on items such as testing kits (PCR, rapid test, etc), PPE and relevant disinfectant products. These were altogether made most of the medical waste volume from health care institutions and laboratories. Also, there were many new emerging items that were not usually included in household waste such as masks, gloves, face shields, and sanitizers. Medical waste is globally expected to increase as more strict public health and infection control standards are tightly followed and monitored. These include face masks, shields, gloves, gowns as well as sanitizers. Household waste can be a confounding factor as many mild to moderate COVID-19 patients were isolated and quarantined at their homes which may underestimate the volume of COVID-19 related medical waste produced.

Since 2020, many published literatures focused on public health measures to prevent the spread of the disease and on the different management protocols. Appropriate medical waste management is one of the means that can help reduce the spread and can minimize the associated health hazards. Several publications try to address this issue with evaluation and recommendation, mostly as a narrative overview, single country or hospital experience, or as reports (Agamuthu and Barasarathi, 2020; Shobhana and Sahu, 2020; Sangkham, 2020; Suthar *et al.*, 2021; Sarkodie and Owusu, 2020; Giordano and Soares, 2021). The COVID-19 pandemic changed many things in health care standards that include but not limited to medical waste management. During the pandemic, the medical waste volume increased up to 6-folds in

china and about 2-folds in brazil.

Due to the pandemic nature and the restrictions, the medical waste management was unsustainable (You, *et al.*, 2020). The increasing volume of medical waste may overwhelm the treatment facilities. In addition to that, patients with mild symptoms or with home isolation will produce a significant amount of medical waste that will be very difficult to isolate. These may lead to unforeseen problems that will affect the medical waste management process variably. These include waste generation, waste receiving and recycling, and finally, waste management plans.

The current study aims to evaluate the change in medical waste quantity during the COVID-19 Pandemic in different health sectors and related facilities. The study will provide an overview of the effect of the pandemic on medical waste management in Jordan.

## METHODOLOGY

The data were collected from different sources such as Ministry of Health (MoH), medical waste facilities, and World Health Organization (WHO) reports. The medical waste was expressed as ‘weight’ in kg on monthly basis from each of the participating locations in the year 2018 and 2020. The study covers 54 different facilities that produced medical waste and transfers it to the central medical waste site. These facilities include governmental hospitals, private hospitals, COVID-19 treating hospital, institutions, universities, health care centers, and laboratories. The descriptions of these facilities are shown in Table 1. Institutions include two universities and the Royal Scientific Society (RSS). These institutions produce contaminated waste from labs and research centers. Industries include all facilities that generate medical, and biological contaminated waste. Health care centers are responsible for providing first aid, daily clinics

**Table 1.** Participating Facilities

Facility types	Number	Number of beds
Governmental hospital	12	1242
Private hospital	7	240
Hospital treat patients of COVID-19	1	680
Institutions/universities	3	
Health care centers	2	
Labs	11	
Industries	18	

and dental care centers. All Labs included in this study are on belong to the private sector and provide routine and specific medical tests for outpatients. The data collected were tabulated for descriptive statistics that describe the mean and the comparison between different facilities medical waste production was utilizing ANOVA.

All other data related to the pandemic situation were collected from the WHO as a confirmed reliable source.

## RESULTS AND DISCUSSION

### The COVID-19 Pandemic Situation

The number of COVID-19 cases significantly influences the type and quantity of the medical waste, so it is necessary to investigate the development in COVID-19 pandemic Situation. According to the WHO dashboard, the first case of COVID-19 in Jordan was reported on 2<sup>nd</sup> of March 2020, and the first death case was on 28<sup>th</sup> March 2020. The number of cases increased slightly and stay <1000 cases/month until August. After that, a tremendous increase in the number of cases that occurred reached 8,083 in September, 59,189 in October, 145,001 in November and then decreased to 78,760 cases in December as shown in Figure 1. On 31, Dec 2020, there were a total of 293,067 confirmed cases and 3,815 Deaths (WHO, 2021). The small number of cases during the period of March-August was attributed to the imposing of a curfew for all sectors. Also, the limited number of COVID-19 tests resulted in inadequate diagnostic of the active cases. By late August, restrictions were slowly eased, which explain the higher number of cases in September in comparison with previous months.

The Ministry of health took many actions in response to the pandemic that was not easy to track

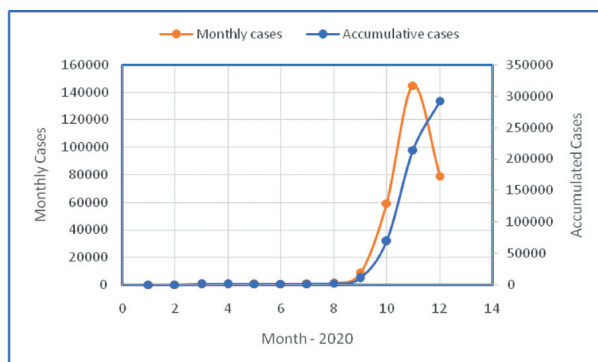


Fig. 1. Number of monthly and accumulated COVID-19 cases The Governmental Protocols

or justify. In the beginning and due to limited numbers of confirmed cases, two major government hospitals were dedicated to treating COVID-19 patients. However, with increasing numbers and the need for more intensive care facilities, these assignments were changed. The Jordan formal response to the COVID-19 pandemic and action with time is summarized in Table 2. The curfew system resulted in a high impact on the number of

Table 2. Government actions towards COVID-19 Pandemic in 2020 (Wikipedia, 2021).

Month	Government actions
March	2 March, the first case of coronavirus reported in Jordan. 19 March, the Jordanian government declared a state of emergency 21 March imposed a curfew 28 March, the first death resulting from COVID-19 - All who are required for "isolation", will be quarantined in hotels across the country, with the government covering the costs.
April	citizens to request permits to leave their homes for urgent matters
May	Return of Jordanian students at their own expense, quarantine
June-August	Quarantine in hotels and other facilities for 14 days at your own expense followed by 14 days of home quarantine.
August	By late August, restrictions were slowly eased. - Authorities permitted public gatherings of up to 20 people, - movement between governorates - reopening of the tourism industry. - Hotels, restaurants, bars, gyms, and nurseries could reopen at a limited capacity. - houses of worship were also reopened. - Public transportation would be operational at 50 percent capacity.
September	However, social distancing measures were to continue to be enforced, with individuals being compelled to wear protective gloves and masks in public spaces or receive a fine.
October	The airport reopened to commercial flights - Sharp COVID-19 outbreaks - Nationwide curfew on Fridays and Saturdays
November	Jordan became the Arab country with the highest number of COVID-19-related deaths per capita.
December	Vaccination Campaign started

cases as well as the quantity and composition of the medical waste. The closing of the industrial sector and institutions resulted in zero waste from these facilities during the curfew period. The impact of the governmental protocols on the quantity of medical waste from each sector will be discussed later in this paper.

### Total Waste Generation

Records for medical waste managed during the first year of the pandemic (2020) was collected and compared to the records in 2018 before the pandemic to evaluate the effect of the pandemic on medical waste. The amount of medical waste in (tons) in each month of the year in 2018 and 2020 for each type of participating facilities were shown in Table 3. The total generated waste decreased from 434,673 tons in 2018 to 373,934 tons in 2020. The hospital that treats COVID-19 patients, private hospitals and institutions, showed an increase in the quantity of medical waste while the governmental hospitals, health care centers, laboratories, and industries showed a decrease in waste generation during the year 2020. Statistical analyses show an insignificant correlation ( $P > 0.05$ ) between the quantity of waste in 2018 and that of 2020. This result indicates that COVID-19 and the governmental implementations affected strongly the waste generation in 2020 and provided an insignificant correlation between the two sets of data. A high standard deviation for 2020 data was found for the hospital treat COVID-19 patients, governmental hospital, institutions, and laboratories. This may be attributed to the variation in waste generation due to the governmental implementations and COVID-19 protocols in the hospitals. In Brazil, the international recommendations were compared to the local suggested recommendations towards handling of all

solid waste including medical waste products, however, there is uncertainty as most of these recommendations are highly dependent on the citizen's awareness and engagement.

### Waste Generation from a Hospital Treat COVID-19 Patients

During the first six months, only three hospitals have been designated for the treatment of COVID-19 patients, there are King Abdullah, Hamza, and Queen Alia.

The one hospital that treats patients with COVID-19 showed an increasing trend with a peak in April which was driven by precautionary strict measures and increase awareness among health care facilities for the use of all personal protection equipment (Fig. 2). During the first period (April-May), the official protocol recommended collecting all waste from COVID-19 sections without segregation, and all wastes were considered as medical waste even food waste. Such strict measures were slowly eased which explain the stable quantity of waste during June-August. However, a rise was seen in Oct-Dec that coincided with increasing numbers of COVID-19 cases admitted to the hospital as shown in Figure 1.

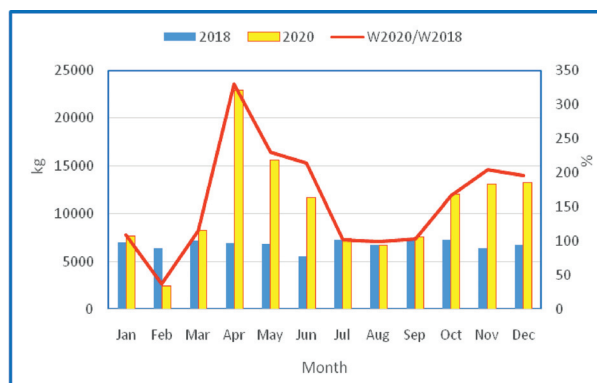


Fig. 2. Monthly medical waste weight for a Hospital treating COVID-19 patients

Table 3. Medical Waste generation in 2018 and 2020

Facility Type	Number	2018	2020	P-value
		Total Medical Waste (tons) $\pm$ SD	Total Medical Waste (tons) $\pm$ SD	
Governmental Hospitals	12	293570 $\pm$ 2085.7	204167 $\pm$ 3207.4	0.18
Private Hospitals	7	23343 $\pm$ 279.5	9858 $\pm$ 213.8	0.62
COVID-19 Hospital	1	81451 $\pm$ 521.7	128516 $\pm$ 5287.7	0.87
Institutions/ Universities	3	10029 $\pm$ 53.3	13632.5 $\pm$ 102.2	0.77
Health Care centers	2	11996 $\pm$ 439.7	6844 $\pm$ 365.8	0.028
Laboratories	11	3083 $\pm$ 53.3	2838.5 $\pm$ 102.2	0.54
Industries	18	11201 $\pm$ 687.4	8078 $\pm$ 283.4	0.32
Total		54	434673	373934

**Waste Generation from the Governmental Hospitals**

The trend in medical waste weight in the Governmental hospitals in 2020 showed a significant reduction than that in 2018 for the first half of the year as most of the COVID-19 cases were transferred or directed to that designated hospital. Also, most of the patients awarded to go to the government hospital to avoid infections. However, the waste volume started to increase as the lockdown period was over and these hospitals started to receive patients with COVID-19 as the country started to report a higher number of cases (Figure 3).

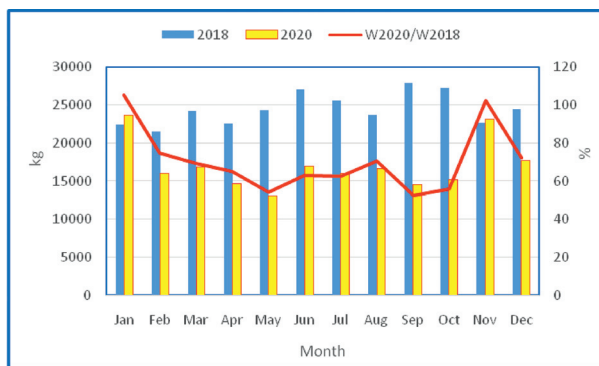


Fig. 3. Monthly medical waste weight from the Governmental Hospitals

**Waste Generation from the Private Hospitals**

In 2020, the private hospitals reported less than 2018 medical waste amount during all months (Fig. 4). The lower quantity of waste during March-May is attributed to the low beds' occupancy, imposing of curfew, and most of the patients admitted for emergency cases only. Also, due to the poor control/inspection on waste management by the authorized agencies, some hospitals disposed of their waste with municipal waste and not transfer them to the medical waste facilities. In November, a dramatic

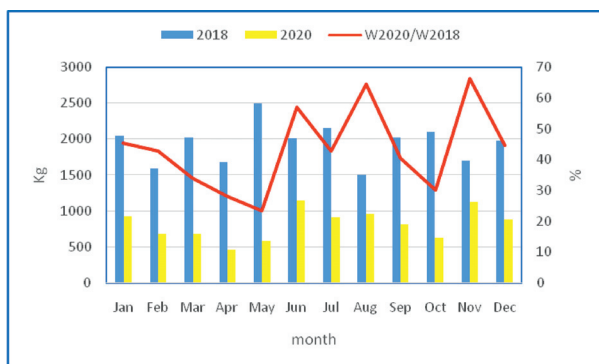


Fig. 4. Monthly medical waste from the private hospital.

increase in the number of cases was reported, and some of the private hospitals have been accredited to receive COVID-19 patients, which explain the increase in the amount of medical waste.

**Waste Generation from Health Care Centers**

In all months, the amount of waste during 2020 is less than that in 2018. The amount of waste during April and May was zero due to the imposing of curfew (Figure 5). Both health care centers included in this study are on belong to the governmental sector. Since most of the governmental employees were subjected to the curfew system, the generated waste from these centers during the curfew period was zero. The amount of waste starts increasing from June and reached the highest value in November. The high value in November may be explained by that most hospitals have been engaged with COVID-19 patients and all patients with ordinary cases were diverted to the health care centers. Also, health care centers are accredited for COVID-19 diagnostic tests. A decrease in the amount of waste in December followed the reduction in the number of COVID-19 cases.

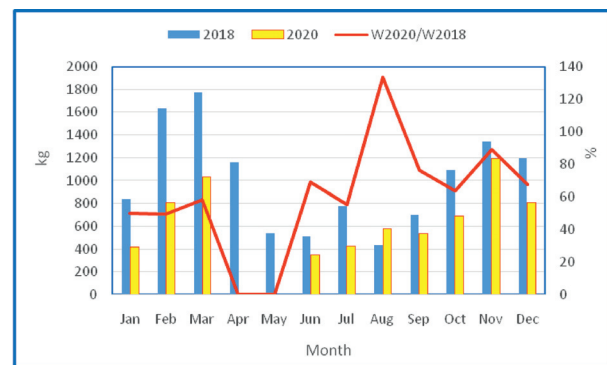


Fig. 5. Monthly medical waste from health care centers.

**Waste Generation from Laboratories**

Very low waste amount in April was reported due to the imposing of the curfew, and then the amount of waste increased significantly to reach the peak value in Jun (411kg) because of the pandemic and expectedly increasing the number of tests and consequently the medical waste volume (Figure 6). During April, medical waste from only one lab received to the central medical facility, while during May, waste from five labs received, this explains the low quantities of waste during April and May. At the beginning of COVID-19 Pandemic, only one private lab was designated for COVID-19 test, and now there are 40 accredited labs, 17 private's

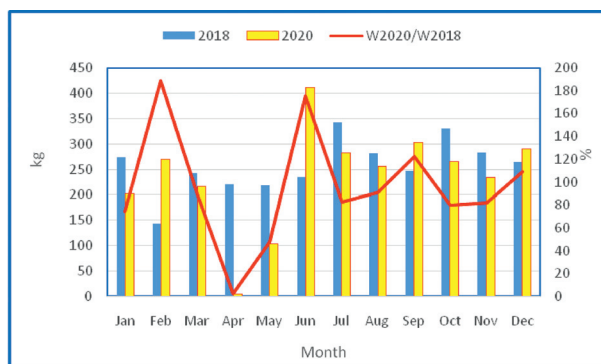


Fig. 6. Monthly medical waste from medical laboratories.

hospitals in addition to the governmental center (MoH, 2021).

### Waste Generation from Institutions

While a slight decrease in the amount of waste occurred in March 2020 in comparison with the same month of 2018, zero waste was reported during April and May (Figure 7). The peak value in July is attributed to the slowly eased of restrictions. During the months of July-December, the amount of waste in 2020 exceeded that of 2018. This result can be explained by two reasons: firstly, the researchers backed to their research centers and worked hard to compensate for the stopping period, secondly: RSS received more orders for testing of food, disinfectants, medicines, and goods, subsequently increased the amount of waste.

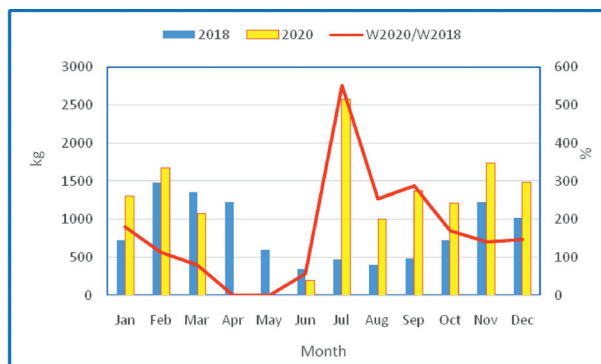


Fig. 7. Monthly medical waste from the institutions.

### Waste Generation from Industries

Similarly, to the institutions, zero waste from the industrial facilities during April and May of 2020 was reported. This may be attributed to the curfew period, and /or poor management of wastes and some of the wastes were not transferred to the central medical facility. The amount of waste increased during the period of June-October 2020

and exceeded the figures of 2018 in August, September, October and December (Figure 8).

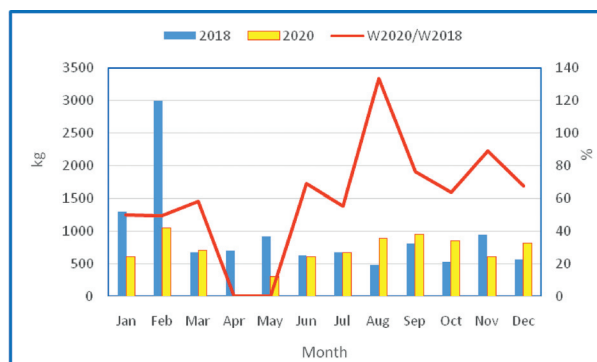


Fig. 8. Monthly medical waste weight in kg in every month of a year at industries.

## CONCLUSION

The COVID-19 pandemic era resulted in increasing in the medical waste generation in the hospitals treat COVID-19 patients that should be evaluated and addressed. More expert opinion should head start the efforts to manage the increasing volume of medical waste produced during COVID-19 pandemic. The medical waste sources now including households and civil service areas and pre-planning for waste collection, segregation, isolation and treatment can be different. The findings of this study may shed a light on the increasing load on medical waste management facilities that need to be addressed by the environmental planners. The patient registry is changing over time, more cases are reported weekly, and several hospital and non-hospital settings are involved in nationwide efforts to fight the pandemic. Although the importance of human health, the efforts should take into consideration the impact of COVID-19 on the environment especially medical waste management and disposal. Poor management of medical waste during the COVID-19 pandemic can cause serious impacts on water resources, the environment, subsequently human health.

## REFERENCES

- Abhilasha, T., Tyagi, V.K., Purnendu, V.V. and Suthar, S. 2020. Challenges, opportunities and progress in solid waste management during COVID-19 pandemic. *Case Studies in Chemical and Environmental Engineering*. Sep; 2: 100060. doi: 10.1016/j.cscee.2020.100060
- Abu-Qdais H.A., Al-Ghazo M. A., Alghazo E.M. 2020.

- Statistical analysis and characteristics of hospital medical waste under novel Coronavirus outbreak. *Global J. Environ. Sci. Manage.* 6: 1-10.
- Agamuthu, P. and Barasarathi, J. 2020. Clinical waste management under COVID-19 scenario in Malaysia. *Waste Management & Research.* September.
- Custodio, U. R., Liane, N. and Kondo, Y. 2021. COVID-19 pandemic: Solid waste and environmental impacts in Brazil. *Science of The Total Environment.* V. 755, P. (1): 142471. <https://doi.org/10.1016/j.scitotenv.2020.142471>.
- Haque, M.S., Uddin, S., Sayem, S.M. and Mohib, K.M. 2019. Coronavirus disease (COVID-19) induced waste scenario: A short overview. *J. Environ. Chem. Eng.* 9(1).
- Ilyas Sadia, Srivastava, R.R. and Kim, H. 2020. Disinfection technology and strategies for COVID-19 hospital and bio-medical waste management. *Sci. Total Environ.* 749: 141652.
- MoH 2021. Jordanian Ministry of Health, Annual Reports, Amman, Jordan
- Mostafizur, R.M., Bodrud-Doza, M., Griffiths, M.D. and Mamun, M.A. 2020. Biomedical waste amid COVID-19: perspectives from Bangladesh. *Lancet Glob Health.* 8(10): e1262. [https://doi.org/10.1016/S2214-109X\(20\)30349-1](https://doi.org/10.1016/S2214-109X(20)30349-1)
- Patrício Silva, A.L., Prata, J.C., Walker, T.R., Duarte, A.C., Ouyang, W., Barcelò, D. and Rocha-Santos, T. 2021. Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations. *Chem. Eng. J.* 405:126683. doi: 10.1016/j.cej.2020.126683.
- Penteado, C. S. G. and de Castro, M. A. S. 2021. Covid-19 effects on municipal solid waste management: What can effectively be done in the Brazilian scenario? *Resources Conservation and Recycling.* 164: 105152. <https://doi.org/10.1016/j.resconrec.2020.105152>.
- Ramteke, S. and Sahu, B. L. 2020. Novel coronavirus disease 2019 (COVID-19) pandemic: Considerations for the biomedical waste sector in India, Case Studies in *Chemical and Environmental Engineering.* V. 2: 100029. <https://doi.org/10.1016/j.cscee.2020.100029>.
- Sangkham, S. 2020. Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia, Case Studies in *Chemical and Environmental Engineering.* V. 2: 100052. <https://doi.org/10.1016/j.cscee.2020.100052>.
- Sarkodie, S.A. and Owusu, P.A. 2020. Impact of COVID-19 pandemic on waste management. *Environ Dev Sustain.* <https://doi.org/10.1007/s10668-020-00956-y>
- Suthar, S., Das, S., Nagpure, A., Madhurantakam, C., Tiwari, S.B., Gahlot, P. and Tyagi, V.K. 2021. Epidemiology and diagnosis, environmental resources quality and socio-economic perspectives for COVID-19 pandemic. *J Environ Manage.* 280: 111700. doi: 10.1016/j.jenvman.2020.111700.
- Wikipedia contributors, 2021, March 29. COVID-19 pandemic in Jordan. In Wikipedia, *The Free Encyclopedia*. Retrieved 12:05, April 3, 2021, from [https://en.wikipedia.org/w/index.php?title=COVID19\\_pandemic\\_in\\_Jordan&oldid=1014868224](https://en.wikipedia.org/w/index.php?title=COVID19_pandemic_in_Jordan&oldid=1014868224) Mohammed A Mamun
- WHO COVID-19 Dashboard. Geneva: World Health Organization, 2021. Available online: <https://covid19.who.int/> (last cited: 03, April, 2021)
- You, S., Sonne, C. and Ok, Y.S. 2020. COVID-19's unsustainable waste management. *Science.* 368 (6498) :. 1438. doi:10.1126/science.abc7778)
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