

Research Article

# Current Methods and Challenges of Managing Clinical Solid Waste at Juba Teaching Hospital, South Sudan

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## Abstract

The amount of clinical solid waste generated at Juba Teaching Hospital has been increasing as a result of the increasing population of Juba city. Despite the increase in the amounts of clinical solid waste, few scientific studies were conducted and the studies focused only on municipal solid waste management and have not explored clinical solid waste management in Juba City. A survey study aimed to explore the current methods and challenges of clinical solid waste management (CSWM) at Juba Teaching Hospital was conducted. The data was obtained through questionnaires, observation and oral interview. Word-excel-2013 and Statistical Package for Social Sciences (SPSS) IBM – 2021 version were used to process the data. The results revealed inappropriate methods of clinical solid waste management practices such as irregular collection, mixing different types of solid wastes together, use of water bottles instead of safety boxes for segregation of sharps, manual transportation of solid wastes, unprotected storage site, irregular incineration, open burning and random dumping. Reasons such as insufficient equipment, negligence of hospital administrators and few numbers of waste collectors was attributed to the inappropriate management of clinical solid waste in the hospital. The study recommended adoption of recycling strategies, employment of more waste handlers, commensurate remuneration and motivation, provision of enough equipment, creation of staff awareness and capacity development on health implications of poor clinical solid waste management.

## Keywords

Clinical Solid Waste (CSW), Solid Waste Management, Challenges, Juba Teaching Hospital (JTH), Recycling Strategies

## 1. Introduction

In comparison to the volume of other waste streams generated, clinical solid waste only represents a smaller portion of the total waste yet very harmful if poorly managed [1]. Thus worldwide there is a great concern on safe handling of clinical solid waste in and around hospitals due to its potential effects on human health and the environment [2]. People are much concerned because clinical solid wastes contain

sharps and other infectious substances that pose a certain degree of hazard to the environment and the public [3]. Poor clinical solid waste management may lead to diseases transmission through various processes such as infectious agents, soil and water contaminated by hazardous chemicals, and improper discarding of sharps [3, 4]. In addition, improper management processes of clinical solid waste have the po-

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tential to expose patients, health care workers, and waste managers to injuries, infections and air pollution [5]. Hence clinical solid wastes should be managed and handled properly. However, waste management is not an easy task because it requires a comprehensive consideration of many aspects, including economical, technical, social, and environmental factors [6]. In China, clinical solid waste is given much attention than other waste categories since the outbreak of COVID-19 which have increased clinical solid waste from personal protective equipment (PPE) such as gloves, face masks and eye protection [7]. However, many hospitals in most African countries are having trouble managing clinical solid waste in their facilities [8]. The lack of infrastructure for collection, transportation, treatment, and final disposal, management planning, financial resources, technical know-how, and public attitude reduces the chances of improvement [9]. For instance, the segregation, collection, transportation and final disposal of both solid and liquid waste including clinical solid waste in South Sudan are inefficient or non-existent [10]. Commercial centres and markets in South Sudan usually leave most of their biodegradable or organic waste to decompose onsite, creating unpleasant smell and causing a serious health risk to local residents, and to those scavenging for food and other reusable materials. Public hospitals and private clinics in urban centres such as Juba do not manage the disposal of septic and pharmaceutical wastes [10, 11]. The amount of solid waste generated in hospitals such as Juba Teaching Hospital has been increasing with the increase of population yet there are few scientific studies generally conducted on municipal solid waste management in Juba city [12]. For example the few studies conducted focused only on municipal solid waste and did not explain much about clinical solid waste management in Juba City [13, 14].

The objectives of this study was to investigate the current methods of clinical solid waste management in practice, potential challenges that result into poor management of clinical solid waste at JTH and recommend solutions such as adoption of recycling strategies, employment of more waste handlers, commensurate remuneration and motivation, provision of enough equipment, creation of staff awareness and capacity development on health implications of poor clinical solid waste management.

## 2. Materials and Methods

The study area was Juba Teaching Hospital (JTH) that is located in Juba City of South Sudan. Its geographical location is on Latitude: 4 °51' 1" N and Longitude: 31 °36' 31" E [15].

The study used a cross-sectional survey design where both quantitative and qualitative methods of research were used during the study. Qualitative methods were used in order to generalize the findings of the study in lieu to the objectives. Quantitative methods were also used in order to provide the

factual figures by quantifying the findings. Despite the quantitative methods used, this study was purely qualitative in the sense that it aims to explore the real situation concerning CSWM at JTH.

According to the administration of JTH, "the hospital has a total number of 851 manpower". The study population was all the manpower (851) employed by the hospital. A sample size of 88 was selected from the study population using Yamane, 1967 formula ( $n = N/1+N*(e)^2$ ).

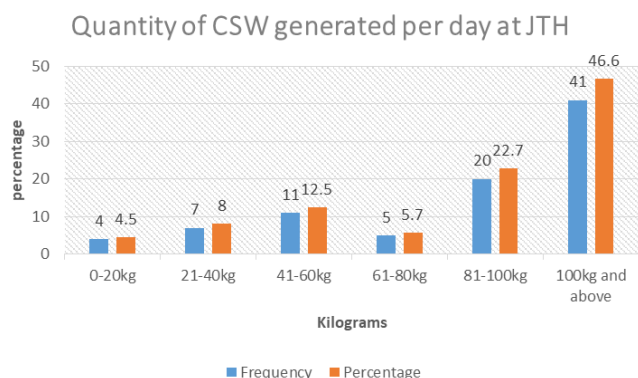
The survey employed tools such as questionnaires, oral interview and observation to collect primary data. The questionnaires were randomly distributed to the different hospital departments while oral interview was directed purposively to the public health officer, cleaners and hospital administrators. Initial observation involved on-site inspection of waste generation and collection areas, transportation equipment, waste disposal site, incinerator type, disposal site related impacts and its management and finally different departments of the hospital such as emergency rooms, out-patient department (O.P.D), operation theater, surgical ward, gynecology ward, general ward, pharmacy, X-ray laboratory, pathology laboratory, labor room, staff room, and admin block were visited and observed for data collection in order to determine the clinical solid waste categories and management methods. Clinical solid waste comprised of infectious, non-infectious, bio-hazard waste and chemical waste. All clinical solid wastes were collected using bags, baskets and bins of different sizes and colors. Transportation involved use of trollies and manual use of hands.

Word-excel-2019 and Statistical Package for Social Sciences (SPSS) IBM – 2020 version were used to process quantitative data into a graph, pie chart and statistical tables for interpretation and analysis. On the other hand, descriptive interpretation and analysis was also done during the study as an approach for qualitative data.

## 3. Results and Discussion

### 3.1. Quantity of CSW Generated Per a Day at JTH

The respondents (46.6%) indicated that 100kg and above of solid waste are generated daily at JTH (Figure 1). The results show that JTH generates large amount of clinical solid waste every day and require proper management. From the study, amounts of CSW generated depend on the type and size of the hospital, number of patients and type of services rendered. These factors could have a significant effect on the generation rate (100kg and above daily). These results are consistent with some studies conducted in China, Northern Jordan and Egypt where their findings linked the quantity of clinical waste generated from hospitals to the type and size of the healthcare institution [16-18].

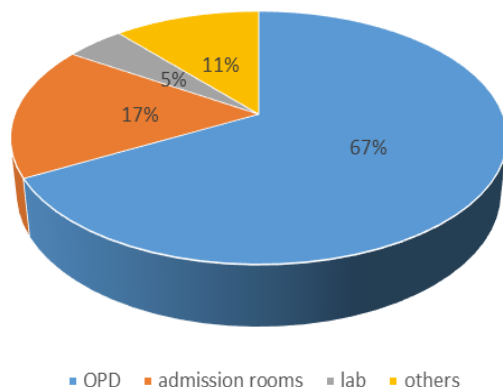


**Figure 1.** Quantity of CSW generated per a day at JTH.

### 3.2. Department that Generates the Biggest Amount of CSW at JTH

Most of the respondents (67%) shown that the OPD generates the biggest amount of CSW (figure 2). This is because the OPD receives patients and visitors who come along with wastes from their various places. Although the OPD generates the biggest amount of CSW, most of the wastes in this department are non-hazardous. This result is similar with some studies who found out that 64% of CSW in hospitals are generated in the OPD and are non-hazardous [19, 20].

Department that generates the biggest amount of CSW at JTH



**Figure 2.** Department that generates the biggest amount of CSW.

### 3.3. Segregation

42% of the respondents disagreed that solid waste are segregated in the hospital (Table 1). It was a common practice observed where both clinical and non-clinical solid waste were mixed together before initial collection (Figure 4). Observations reveal that the operation theatre, wards and laboratory segregate sharps only from other wastes into safety boxes and sometimes water bottles in absence of safe-

ty boxes (Figure 3). Majority of the departments do not sort their solid waste into infectious, non-infectious and bio-hazard and chemical waste. Generally, the segregation practice is not efficient and the cleaners linked this failure to insufficient supply of bins, colored bags and safety boxes. These results are contrary to a study in Ghana where it identified efficient segregation method in some selected hospitals in Ghana [21]. However this finding is similar to few studies in Nigeria and Iran where the segregation and collection methods were weak due to weak internal administrative policies and insufficient supply of segregation, collection and transportation equipment [1, 22].

**Table 1.** Segregation practice.

Variable	Frequency	%
Strongly agree	5	6
Agree	16	18
not sure	8	9
Disagree	37	42
Strongly disagree	22	25
Total	88	100

Source: Authors' field survey data, Feb. 2023



**Figure 3.** Segregation of sharps using safety box and water bottles.

### 3.4. Regular Collection

Majority (51%) of the respondents strongly agreed that solid wastes are regularly collected in the hospital (Table 2.). This result show that clinical solid waste collection is practiced in the hospital on daily basis but is inappropriate due to insufficient equipment for solid waste collection. Most hospitals in developing countries like Nigeria face these challenges of insufficient fund to buy waste bins, safety boxes and colored sacks. These challenges are mostly linked to weak internal policies and inadequate capacities of hospital administrators [1, 23].

**Table 2.** Shows response about regular collection of CSW.

Variable	Frequency	%
strongly agree	45	51
Agree	19	22
not sure	12	14
Disagree	10	11
strongly disagree	2	2
Total	88	100

Source: Authors' field survey data, Feb. 2023

### 3.5. Use of Colored Bags

The results (48%) indicate that clinical solid waste are collected using colored bags (Table 3). It is also observed that colored bags are generally used for all types of solid wastes mixed together except sharps. (Figures 4&5). Few departments such as the Tuberculosis unit, operation theatres and wards have red, black and yellow colored bags for infectious, non-infectious and bio-hazard and chemical waste respectively, while other departments were observed with only one colored bag. The waste cleaners stressed that the bags are not supplied adequately and regularly which hinders the efficient collection and segregation practices in the hospital. Besides, inadequate management practices such as; negligence, inadequate human resource, little awareness and weak internal administrative policies and procedures were all pointed out as some of the underlying causes of insufficient supply of colored bags. This finding is similar to some few studies which revealed the same issues resulting to the inefficient CSW segregation and collection in Nigeria [1, 22].

**Table 3.** Response about the use of colored bags.

Variable	Frequency	%
strongly agree	31	35
Agree	42	48
not sure	8	9
Disagree	5	6
strongly disagree	2	2
Total	88	100

Source: Authors' field survey data, Feb. 2023

**Figure 4.** Shows a colored bag (red) with different types of solid waste mixed together.**Figure 5.** Colored bags (red).

### 3.6. Random Dumping

**Table 4.** Random dumping.

Variable	Frequency	%
strongly agree	24	27
Agree	30	34
not sure	16	18
Disagree	11	13
strongly disagree	7	8
Total	88	100

Source: Authors' field survey data, Feb. 2023

Majority of the respondents (34%) agreed that random dumping is common at JTH while only 8% strongly disagreed (Table 4). Figure 6 shows evidence of random dumping at JTH. Plastic bottles, poly-ethene bags, empty cartons, cotton wools, wound plasters, facemasks, dirty clothes and food left over were observed in some rarely visited open spaces in the hospital. The public health officer including the cleaners explained that the random dumping is done by visitors, tea & restaurant owners, retailers, hawkers, co-patients and patient caretakers that cook at the hospital. The reason for random dumping of CSW at the hospital premises was due to lack of awareness from the public health unit to in-



struct such people to collect their waste and throw into designated waste bins or disposed at the temporal disposal site.



**Figure 6.** Evidence of Random dumping at JTH.

### 3.7. Incineration

Most of the respondents were not sure (43%) if incineration is regularly used at JTH (Table 5). Results got through interview with incinerator management revealed that the JTH incinerator is not in use while that one in use was installed by Medicines San Frontiers (MSF) and operates at three times a week (Figure 7). It operates three times a week because the capacity is small and medium temperature. Observations revealed a new big capacity incinerator installed by WHO which was yet to be launched. Incineration practice should be regular because it would reduce the volume of solid waste and its potential for infection. However, incineration without controlled burning would result in the emission of a variety of toxic pollutants [9]. In Malaysia, incineration is a popular treatment method for handling infectious and hazardous waste [24]. Its benefits include removing pathogens and reduce bulk volume of clinical solid waste [25]. However, the potential of producing secondary toxic gases remains the primary disadvantage of incineration, it contributes to air pollution that poses risks to human health [26].



**Figure 7.** The operational incinerator installed by MSF and the newly installed by WHO.

**Table 5.** Shows response on regular use of incinerator.

Variable	Frequency	%
strongly agree	13	15
Agree	20	22
not sure	38	43
Disagree	11	13
strongly disagree	6	7
Total	88	100

Source: Authors' field survey data, Feb. 2023

### 3.8. Open Burning

43% of the respondents strongly agreed that solid wastes are openly burnt in the air within the hospital premises (Table 6). Figure 8 shows evidence of open burning. Remains of partially burnt solid waste such as plastic bottles, papers, dry leaves, dirty clothes, poly-ethene bags and facemasks were observed in areas where open burning takes place. The interview results explained that the open burning was practiced by the cleaners and self-employed individuals. The reason was due to inadequate supply of cleaning materials to handle the high volume of solid waste generated every day. The burning of clinical solid waste at the temporary disposal point was due to delay from the company contracted to transport the solid waste to final disposal point. Few studies have identified the same short-comings in the existing CWM system. For example few healthcare centres in India contain separate systems for disposal of clinical waste while others mixed different waste category and burn openly [27].



**Figure 8.** Open Burning at JTH.

**Table 6.** Open burning.

Variable option	Frequency	%
strongly agree	38	43
Agree	22	25
not sure	12	14
Disagree	6	7
strongly disagree	10	11
Total	88	100

Source: Authors' field survey data, Feb. 2023

### 3.9. Challenges Related to Inappropriate CSW Management at JTH

The short-comings were associated with segregation and collection, transportation, temporal storage, treatment and disposal. (Table 7). For instance due to insufficient equipment, internal transportation of solid waste in the hospital used only wheeled trolleys and manual carrying of waste bins to the storage site. In similar way, a study reported a manual lifting of waste bins by hospital cleaners and waste collectors [18, 28].

JTH has a temporary storage area that does not meet the CWM standards and best practices. The site is small and the location is unsuitable. However to make it worse, the solid wastes in the temporal site are not separated into clinical and non-clinical wastes. Some of the clinical solid waste in the

site are burnt in open air (Figure 9).

**Figure 9.** The temporal disposal site at JTH.

A related study in South Sudan revealed that waste pickers working with recyclable materials are at higher risk of developing pulmonary diseases and hepatitis C as a result of contact with sharp items and hazardous clinical solid waste [29].

These challenges observed at JTH are similar to some studies which identified the same problems of lack of effective CWM in developing countries to insufficient resource allocation, lack of training and appropriate skills, risk awareness, ignorance, public apprehensions and misguided information on exposure, incinerator capacity and low salaries/wages [1, 16, 23]. This implies that the challenges related to clinical solid waste management at JTH are also faced in other places around the Globe but their intensity and frequency depend on the proper allocation of resources like finances and manpower.

**Table 7.** Related challenges of CSW at JTH.

Challenges of clinical solid waste management at JTH	
Variable	Results
Segregation and Collection stage	Insufficient containers to handle the volume of CSW generated.
	Inadequate PPEs such as heavy gloves, gumboots, aprons and sanitizers.
	Irregular waste segregation at generation points.
	Inadequate transport equipment such as wheelbarrows and wheeled bins.
	Few manpower to transport waste to temporal site.
Transportation process	Poor health of waste transporters.
	Indiscipline workers. Some waste transporters are addicted to drugs such as alcohol and cigarettes resulting to poor performance at work. I.e. some wastes fall down when transporting them to the temporal site.
	There is much delay by the Company contracted to transport clinical solid waste to final disposal point. The temporally stored clinical solid waste sometimes stays for about four to seven days.
	The temporary storage site have a very small capacity and space.
Temporal storage	The site is open - means not protected by a wall or fence. (Figure 9).
	Unsuitable location - it is near buildings that people use, causing unpleasant odors (Figure 9).

**Challenges of clinical solid waste management at JTH**

Variable	Results
Waste department	Insufficient remuneration and motivation (low salaries and wages).
	Inadequate skilled labors - most of wastes handlers are uneducated with limited knowledge on integrated waste management systems.
	Injuries as a result of exposure to sharp objects.
	Lack of consideration for specification of the right PPEs by the Public Health Unit (PHU) ahead of the procurement processes.

Source: Authors' field survey data, Feb. 2023

### 3.10. Recommendations

The hospital administration should provide trainings to the waste department to get more awareness on the importance of using PPEs and to acquire good skills of handling waste to avoid exposure and the risk of infection. Most workers in hospital don't know about hospital waste management plan and techniques, so there is a need to train them.

Recycling strategies should be adopted by the administration and the public health department of the JTH to reduce waste amount by recycling plastic materials such as water bottles. Contacting local recyclers to pick up recyclable items in the hospital is a good recycling strategy and should be adopted by the PHU.

The administration of the hospital should provide medical checkup at least every three months to know the health status of the waste handlers since most of them are always exposed to these hazardous wastes. Good health always yields good performance.

The administration of the hospital should prioritize the salaries and wages of the waste handlers by increasing to a reasonable amount in order to motivate them to work effectively.

The administration of the hospital should relocate the temporal disposal site from where it is to the downstream, the size has to be increased and be protected using a fence.

The supporting NGOs such as WHO, MSF, UNICEF, UNEP, UNFPA, ICRC, etc., should make sure their support directed to the waste department or the public health unit has to be known by the waste department as well as the administration. The fund or donations should be witnessed by the concerned departments to avoid corruption.

The company responsible for transporting the clinical solid waste to final disposal site should turn up daily to minimize CSW accumulation and decomposition onsite.

The ministry of Health and Environment including the authorities of Juba City Council (JCC) should align and provide regular monitoring and assessment by independent team of investigation to carry out supervision on regular basis to make sure the hospital administration and its public health unit are committed to proper clinical solid waste management

practices and are according to the standards of WHO and the ministry of health.

The ministry of health should strengthen the existing policies on medical waste management. There must be strict orders to be followed, failure to adhere to such regulations must result into fines and imprisonment.

## 4. Conclusion

In this research, the results show a very big volume of CSW generated daily (figure 1) and most of these CSW are generated from the OPD as shown in figure 2. This high amount of CSW could lead to serious health risks when poorly managed. There is no proper segregation of CSW during collection process in most of the hospital departments. Colored bags are insufficiently supplied by the hospital administration. Use of wheeled bins and manual hands for internal transportation of CSW is unsatisfactory and requires employment of extra transportation means. The temporal disposal point is very small, unprotected and is located in unsuitable position that is close to buildings (figure 9). Practices of open burning and random dumping are very common in the hospital. CSW treatment technique in the hospital is only limited to the use of incinerator that is not operating regularly. Most of the challenges facing the CSWM at the segregation, collection, transportation, and disposal points result from lack of consideration for specification of the right PPEs and other cleaning equipment by the Public Health Unit (PHU) ahead of the procurement processes. Besides, limited knowledge on integrated waste management systems and few number of waste handlers.

Recycling should be adopted by the hospital administration as alternative strategy of managing CSW to reduce waste generation rate in the hospital. Transportation and final disposal of CSW should be supervised by trained and active personnel to make sure that the waste is handled properly and safely. There should be training programs and workshops conducted from time to time for all relevant health personnel in order to minimize possible health hazards of clinical solid waste.

The current methods of CSWM that were applied for the collection, transportation, treatment, storage and disposal of



CSW in the hospital were inappropriate because of several challenges (table 7). Despite the inappropriateness, the surrounding of the hospital looks clean and halfway conducive.

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## References

- [1] Oke, I. A. (2008). Management of immunization solid wastes in Kana State, Nigeria. *Waste Management*, 12 (25); 12-21.
- [2] Hossain, M. S, Santhanam A, Norulaini, N. A. N. and Omar, A. K. N. (2011). Clinical solid waste management practices and its impact on human health and environment: A review. *Journal of Waste Management*, 31, 754-766.
- [3] Das, Atanu Kumar, et al. "COVID-19 pandemic and healthcare solid waste management strategy—A mini-review." *Science of the Total Environment* 778 (2021): 146220.
- [4] Doylo, T., Alemayehu, T., & Baraki, N. (2019). Knowledge and practice of health workers about healthcare waste management in public health facilities in Eastern Ethiopia. *Journal of community health*, 44, 284-291.
- [5] Mihai, F. C. (2020). Assessment of COVID-19 waste flows during the emergency state in Romania and related public health and environmental concerns. *International Journal of Environmental Research and Public Health*, 17 (15), 5439.
- [6] Ghasemi, Maryam Khadem, and Rosnah Bt Yusuff. "Advantages and Disadvantages of Healthcare Waste Treatment and Disposal Alternatives: Malaysian Scenario." *Polish Journal of Environmental Studies* 25.1 (2016).
- [7] Ma, Y., Lin, X., Wu, A., Huang, Q., Li, X., & Yan, J. (2020). Suggested guidelines for emergency treatment of medical waste during COVID-19: Chinese experience. *Waste Disposal & Sustainable Energy*, 1.
- [8] Yazie, T. D., Tebeje, M. G., & Chufa, K. A. (2019). Healthcare waste management current status and potential challenges in Ethiopia: a systematic review. *BMC research notes*, 12, 1-7.
- [9] Ferronato N, Torretta V (2019) Waste mismanagement in developing countries: A review of global issues. *Int J Environ Res Pub Health* 16: 1060. <https://doi.org/10.3390/ijerph16061060>
- [10] Sudan, South. "South Sudan: First State of Environment and Outlook Report 2018." (2018).
- [11] Chacarovski, Zoran, et al. "South Sudan vehicle workshop hazardous waste management." *Journal of Traffic and Transportation Engineering* 5.4 (2017): 157-169.
- [12] Ziraba, Abdhalah K., Tilahun Nigatu Haregu, and Blessing Mberu. "A review and framework for understanding the potential impact of poor solid waste management on health in developing countries." *Archives of Public Health* 74.1 (2016): 1-11.
- [13] Many, C. M. S., Leta, S., & Khan, M. M. (2017). Assessment of municipal solid waste management practices in Juba city, South Sudan, challenges and practical considerations: A review. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 11 (10), 13-25.
- [14] Loboka, M. K., Qi, S. H., Kang, J. X., Celestino, J. L., & Lukaw, Y. S. (2014). Assessment of the municipal solid waste pollution problem in the newest country: Case study of Juba, South Sudan. *Research Journal of Applied Sciences, Engineering and Technology*, 7 (5), 916-924.
- [15] Mindat.org, "Juba Teaching Hospital, South Sudan". Available from: <https://www.mindat.org/feature-11592908.html>. [Assessed 10 June 2023].
- [16] Cheng, Y. W., Sung, F. C., Yang, Y., Lo, Y. H., Chung, Y. T., and Li, K. C. (2009). Medical waste production at hospitals and associated factors. *Waste Management*, 29 (1), 440-44.
- [17] Abdulla F, Qudais HA and Rabe A (2008). A site investigation of medical waste management practices in Northern Jordan. *Journal of Waste Management*, 28 (2); 450-458.
- [18] Abd El-Salam, M. M. (2010). Hospital waste management in El-Beheira governorate, Egypt. *Journal of environmental management*, 91 (3), 618-629.
- [19] Sarkar, S. K. L., Haque, M. Z., Khan, T. A. (2006). Hospital waste management in Sylhet City, Bangladesh. *ARPN Journal of Engineering and Applied Sciences*, 1 (2); 1-9.
- [20] Azage, M. and Kumie, A. (2010). Healthcare waste generation and its management system: the case of health centers in West Gojjam Zone, Amhara Region, Ethiopia. *Ethiop. J. Health Dev*, 24 (2); 119-126.
- [21] Wiafe, S., Nooni, I. K., Nlasia, M. S., Diaba, S. K., & Fianko, S. K. (2015). Assessing clinical solid waste management strategies in Sunyani Municipality, Ghana—Evidence from three healthcare facilities. *Int J Environ Pollut Res*, 3 (3), 32-52.
- [22] Taghipour, H., and Mosaferi, M. (2009). Characterization of medical waste from hospitals in Tabriz, Iran. *Science of the total Environment*, 407 (5), 1527-1535.
- [23] Abor, P. A., and Bouwer, A. (2008). Medical waste management practices in a Southern African hospital. *International Journal of Health Care Quality Assurance*, 21 (4), 356-364.
- [24] Rahman, H. A. (2013). Incinerator in Malaysia: really needs?. *vol, 1*, 678-681.
- [25] He, P. J., Zhang, H., Zhang, C. G., & Lee, D. J. (2004). Characteristics of air pollution control residues of MSW incineration plant in Shanghai. *Journal of hazardous materials*, 116 (3), 229-237.



- [26] Manupati, V. K., Ramkumar, M., Baba, V., & Agarwal, A. (2021). Selection of the best healthcare waste disposal techniques during and post COVID-19 pandemic era. *Journal of cleaner production*, 281, 125175.
- [27] Patil, A. D., Shekdar, A. V. (2001). Health-care waste management in India. *Journal of Environmental Management*, 63; 211-220.
- [28] Muluken, A., Haimot, G., Mesafint, M., (2013). Healthcare waste management practices among healthcare workers in health care facilities of Gondar town, Northwest Ethiopia. *Health Science Journal*. 7 (3): 315-326.
- [29] Cowing MJ (2013) Health and Safety Guidelines for Waste Pickers in South Sudan. South Sudan: United Nations Environment Programme: South Sudan. 1st edition.  
<http://unep.org/SouthSudan/> Accessed 10 November 2020.