Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/q613d485

EVALUATING HEALTHCARE WORKERS' INSIGHT AND AWARENESS ON EFFECTIVE BIOMEDICAL WASTE MANAGEMENT IN TERTIARY CARE HOSPITAL

Adnan Hashmi[1*], Mohammed Shafiq[2], Bherulal[3], Faria Khan[4], Ashok[5], Partab Puri[6], Remshah Faiz[7], Tooba Bhutto[8], Mahjabeen Baloch[9], Mukhtiar Ahmed[10]

[1*]Marketing Manager, BF Biosciences, Lahore, Pakistan
[2]ENT Specialist, Government Services Hospital, Karachi, Pakistan
[3]Nutrition Officer, Sir C J Institute of Psychiatry, Hyderabad, Pakistan
[4]Assistant Professor, Bhitai Dental & Medical College, Karachi, Pakistan
[5]Cheif Medical Officer, Lyari General Hospital, Health Department Sindh, Karachi, Pakistan
[6]Assistant Professor, Community Medicine, Muhammad Medical College, Mirpurkhas, Pakistan
[7]Senior Medical Officer, Burhani Hospital, Karachi, Pakistan
[8]Post Graduate Trainee, Zia-uddin University, Karachi, Pakistan
[9]Female Medical Officer, Naka Kharari, Health department, Distinct Hubb, Balochistan, Pakistan
[10]Demonstrator, Shaheed Mohtarma Benazir Bhutto Medical College, Lyari, Karachi, Pakistan

[*]**Corresponding Author:** Adnan Hashmi.
[*]Email: adnanhashmi18@gmail.com

ABSTRACT

Background: Biomedical waste encompasses any waste generated during healthcare activities that poses a risk to human health or the environment, including infectious materials like blood, bodily fluids, hazardous substances i.e, chemicals, sharps and non-hazardous waste

Objectives: The aim of this study is to assess knowledge, attitudes and practices of physicians regarding biomedical waste management in tertiary care hospital. **Study place and duration:** The study was conducted at Jinnah Postgraduate Medical Centre, Karachi, between May 2024 and October 2024.

Methodology: This is a cross-sectional study regarding biomedical waste management which was conducted over six months. A pre-designed questionnaire, validated by experts was used to collect data from participants.

Results: The study found that 49% demonstrated good knowledge of biomedical waste management, 61% lacked formal training and 89% recognized the importance of proper waste management. The majority (81%) recommended additional training, highlighted the need for improved education and resources in healthcare setting

Conclusions: The study concluded that multifaceted approach combining practical training and policy reforms is essential to address these issues and ensure effective biomedical waste management practices.

Keywords: Biomedical waste, healthcare professionals, knowledge, attitudes, practices

INTRODUCTION

Biomedical waste encompasses infectious, contaminated, hazardous materials like discarded sharps, body fluids, toxic chemicals, pharmaceuticals and radioactive substances poses significant risks to public health and the environment if not managed properly [1,2]. In urban areas like Karachi, waste management is particularly challenging due to the varied composition of waste and the lack of proper disposal sites, exacerbated by population growth. The generation of biomedical waste not only depletes natural resources but also consumes energy, water, stresses land and pollutes the environment, resulting in substantial economic costs [3-5]. The World Health Organization stresses that inadequate management can lead to infections, injuries and environmental damage, highlighting the importance of engaging healthcare staff in waste management protocols. Ultimately, the attitudes and knowledge of healthcare professionals, administrative personnel and supporting staff directly impact waste segregation, treatment and disposal practices, making their role crucial in ensuring proper biomedical waste management [6].

Research has highlighted a concerning trend among healthcare workers, where many lack adequate knowledge about proper waste segregation and the associated risks of mishandling biomedical waste [7,8]. This knowledge gap is particularly significant in clinical settings, where the improper management of medical waste can pose a substantial risk factor for disease transmission [9]. Although clinics generate a smaller volume of infectious waste compared to hospitals, the absence of effective waste management strategies can still have far-reaching consequences, including the potential for infection transmission and environmental contamination[10-14]. Several factors contribute to this issue, including healthcare workers' limited understanding of waste segregation protocols, inadequate awareness of the risks involved and the use of unsafe disposal methods, often due to limited financial resources[15-17].

The study showed that misconceptions about the nature of biomedical waste and insufficient training can lead to improper segregation practices, underscoring the need for targeted education and training programs to address these knowledge gaps that improve waste management practices in healthcare settings.

Objective of Study

The objective of the study is to assess the knowledge and awareness of healthcare workers regarding biomedical waste management practices, identify gaps in waste segregation, handling, disposal and determine the factors influencing proper waste management.

METHODOLOGY

This study employed a cross-sectional design to assess the knowledge, attitudes and practices of physicians involved in tertiary care hospital. The study was conducted at Jinnah postgraduate medical centre between May 2024 to october 2024 .The study was conducted over a period of six months, following approval from the Ethical Committee. A pre-designed questionnaire, developed based on previous studies and reviewed by experts in healthcare waste management, was given to each participant. Participants were fully informed about the study and provided their consent before participating. Data collection was carried out using a self-administered and self-completed questionnaire, ensuring that participants' responses were kept confidential.

Inclusion Criteria:

1. Physicians working in a tertiary care hospital.
2. Both male and female physicians are included.

Exclusion Criteria:

1. Healthcare professionals not primarily involved in tertiary care.

2. Medical students, interns or trainees lacking clinical experience.

Statistical Analysis

The collected data was analyzed using SPSS version 22.0 software. Descriptive statistics i.e, frequencies and percentages were used to summarize the demographic characteristics and responses of the participants. Inferential statistical analysis, specifically the Chi-square ($\chi 2$) test, was employed to determine the significance of associations between variables. The level of significance was set at $p < 0.05$, indicating that any observed differences or relationships with a p-value less than 0.05 would be considered statistically significant.

RESULTS

One hundred people participated and responded to the questionnaire, out of which 55% are female and 45% are male. Majority of them are physician (63%) while nurses are only 22%. Almost half of the respondent (49%) have work experience of more than 10 years while people with less than 1 year of experience respond in only 5% of total. Level of education also have direct correlation with response with people with Master's degree respond highest in 49% of time.

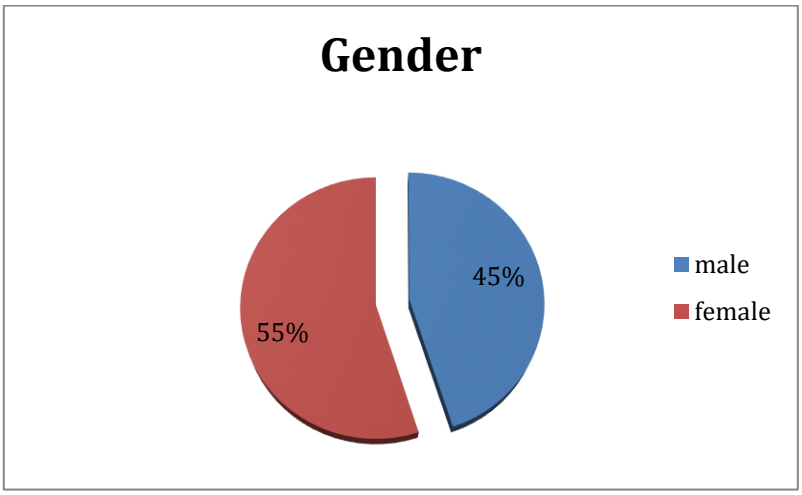

Table 1: Demographic and Professional Characteristics of Participants

Variable	Overall (n=100)	Doctor (n=63)	Nurse (n=22)	Administrative & Other Staff (n=15)	P-value
Gender					0.186
Male	45 (45%)	30 (47.6%)	6 (27.3%)	8 (53.3%)	
Female	55 (55%)	33 (52.4%)	16 (72.7%)	7 (46.7%)	
Designation/Position					<0.001
Doctor	63 (63%)	63 (100%)	0 (0%)	0 (0%)	
Nurse	22 (22%)	0 (0%)	22 (100%)	0 (0%)	
Administrative Staff	10 (10%)	0 (0%)	0 (0%)	10 (66.7%)	
Others	5 (5%)	0 (0%)	0 (0%)	5 (33.3%)	

Years of Experience in Healthcare					<0.747
Less than 1 year	5 (5%)	4 (6.3%)	1 (4.5%)	0 (0%)	
1–3 years	11 (11%)	6 (9.5%)	3 (13.6%)	2 (13.3%)	
4–6 years	16 (16%)	9 (14.3%)	6 (27.3%)	1 (6.7%)	
7–10 years	19 (19%)	13 (20.6%)	3 (13.6%)	3 (20%)	
More than 10 years	49 (49%)	31 (49.2%)	9 (40.9%)	9 (60%)	
Education Level					<0.001
Diploma level	14 (14%)	5 (7.9%)	9 (40.9%)	0 (0%)	
Bachelorette level	33 (33%)	18 (28.6%)	10 (45.5%)	5 (33.3%)	
Master level	45 (45%)	33 (52.4%)	3 (13.6%)	9 (60%)	
PhD level	8 (8%)	7 (11.1%)	0 (0%)	1 (6.7%)	

Table 2: Knowledge and Training on Biomedical Waste Management

Variable	**Overall (N=100)**	**Doctor (n=63)**	**Nurse (n=22)**	**Administrative & Other Staff (n=15)**	**P-value**
Received training on biomedical waste management					0.012
Yes	50 (50%)	25 (39.7%)	13 (59.1%)	12 (80%)	
No	50 (50%)	38 (60.3%)	9 (40.9%)	3 (20%)	
Knowledge of biomedical waste management practices					0.061
1 (poor)	9 (9%)	5 (7.9%)	3 (13.6%)	1 (6.7%)	
2 (fair)	10 (10%)	7 (11.1%)	1 (4.5%)	2 (13.3%)	
3 (good)	32 (32%)	26 (41.3%)	5 (22.7%)	1 (6.7%)	
4 (very good)	35 (35%)	21 (33.3%)	8 (36.4%)	6 (40%)	
5 (excellent)	14 (14%)	4 (6.3%)	5 (22.7%)	5 (33.3%)	
Sources to rely on for information					
Workshops/training sessions	64 (64%)	40 (63.5%)	11 (50%)	13 (86.7%)	0.073
Online resources	37 (37%)	28 (44.4%)	8 (36.4%)	6 (40%)	0.966

Colleagues/supervisors	36 (36%)	23 (36.5%)	8 (36.4%)	5 (33.3%)	0.973
Policy and procedures manuals	35 (35%)	29 (46%)	6 (27.3%)	0 (0%)	0.511
Other	6 (6%)	4 (6.3%)	2 (9.1%)	0 (0%)	0.511
Knowledge about: Segregation of waste					0.284
1 (poor)	10 (10%)	7 (11.1%)	3 (13.6%)	0 (0%)	
2 (fair)	20 (20%)	12 (19%)	6 (27.3%)	2 (13.3%)	
3 (good)	24 (24%)	17 (27%)	4 (18.2%)	3 (20%)	
4 (excellent)	25 (25%)	17 (27%)	4 (18.2%)	4 (26.7%)	

Half of the respondents (50%) did received training in waste management with administrative staff are the most in terms of percentage wise (81%) of total who did received training and they also feel that they have good knowledge about waste management. Around half of the participant (49%) have very good to excellent knowledge about waste management practices.
Majority of the biomedical waste are sharps (72%) followed by infectious waste (67%). In 80% of the places' colored coded bins are used for disposition of waste. In 77% of the places' designated containers are used for collection of waste. Majority of people feels that inadequate resources (57%) followed by the lack of training (50%) are the reason leads to improper waste management.

Table 3: Biomedical Waste Management Practices among Healthcare Staff

Parameter	Overall (N=100)	Doctor (N=63)	Nurse (N=22)	Admin & Other Staff (N=15)	P-value
Types of biomedical waste					
Infectious waste	67 (67%)	38 (60.3%)	16 (72.7%)	13 (86.7%)	0.121
Sharps	72 (72%)	46 (73%)	17 (77.3%)	9 (60%)	0.143
Chemical waste	35 (35%)	21 (33.3%)	6 (27.3%)	8 (53.3%)	0.238
Pharmaceutical waste	51 (51%)	36 (57.1%)	6 (27.3%)	9 (60%)	0.049
Other	8 (8%)	7 (11.1%)	0 (0%)	1 (6.7%)	0.249
Follow the segregation protocol for biomedical waste					0.042
Always	51 (51%)	24 (38.1%)	15 (68.2%)	12 (80%)	

Often	23 (23%)	21 (33.3%)	1 (4.5%)	1 (6.7%)	
Sometimes	17 (17%)	12 (19%)	3 (13.6%)	2 (13.3%)	
Rarely	3 (3%)	2 (3.2%)	1 (4.5%)	0 (0%)	
Never	6 (6%)	4 (6.3%)	2 (9.1%)	0 (0%)	
Frequency of correctly disposing biomedical waste					
Colour-coded bins	80 (80%)	52 (82.5%)	17 (77.3%)	11 (73.3%)	0.679
Incineration	36 (36%)	18 (28.6%)	6 (27.3%)	12 (80%)	0.001
Autoclaving	30 (30%)	21 (33.3%)	5 (22.7%)	5 (33.3%)	0.696
Landfill disposal	17 (17%)	13 (20.6%)	1 (4.5%)	3 (20%)	0.212
Designated containers for biomedical waste					
Yes	77 (77%)	45 (71.4%)	19 (86.4%)	13 (86.7%)	
No	15 (15%)	10 (15.9%)	3 (13.6%)	2 (13.3%)	
Frequency of biomedical waste collection					0.128
Multiple times a day	45 (45%)	22 (34.9%)	15 (68.2%)	8 (53.3%)	
Once a day	36 (36%)	28 (44.4%)	6 (27.3%)	2 (13.3%)	
Every other day	5 (5%)	3 (4.8%)	1 (4.5%)	1 (6.7%)	
Twice a week	3 (3%)	2 (3.2%)	0 (0%)	1 (6.7%)	
Weekly	6 (6%)	5 (7.9%)	0 (0%)	1 (6.7%)	
Others	5 (5%)	4 (6.3%)	0 (0%)	1 (6.7%)	
Challenges faced					
Lack of training	50 (50%)	34 (54%)	11 (50%)	5 (33.3%)	0.366
Inadequate resources	57 (57%)	38 (60.3%)	12 (54.5%)	8 (53.3%)	0.859
Insufficient storage space	34 (34%)	25 (39.7%)	6 (27.3%)	3 (20%)	0.188
Confusion about segregation	38 (38%)	31 (49.2%)	3 (13.6%)	4 (26.7%)	0.004

Waste majority of participants (89%) acknowledge that biomedical waste management is necessary for environmental protection (78%), patient safety (75%) and staff safety (68%) with 72% participants feels confident that they have ability to handle waste management.

Sixty-one (61%) of participant had either experience or observe the incident related to waste management.

Majority of the participants (62%) did not receive any formal training in biomedical waste management, 88% of them recommend that additional training is required for improved biomedical waste management in form of "on the job training" (72%) and "workshop" (71%).

Table 4: Training and Education on Biomedical Waste Management

Parameter	Overall (N=100)	Doctor (N=63)	Nurse (N=22)	Admin & Other Staff (N=15)	P-value
Received formal training on biomedical waste management					
Yes	38 (38%)	16 (25.4%)	10 (45.5%)	12 (80%)	<0.001
No	62 (62%)	47 (74.6%)	12 (54.5%)	3 (20%)	
Additional training is required					0.983
Yes	88 (88%)	55 (87.3%)	20 (90.9%)	13 (86.7%)	
No	7 (7%)	5 (7.9%)	1 (4.5%)	1 (6.7%)	
Type of training required					
Workshops	71 (71%)	45 (71.4%)	15 (68.2%)	11 (73.3%)	0.937
Seminars	39 (39%)	21 (33.3%)	12 (54.5%)	6 (40%)	0.213
Online Courses	37 (37%)	22 (34.9%)	8 (36.4%)	7 (46.7%)	0.697
On-the-job Training	72 (72%)	44 (69.8%)	17 (77.3%)	11 (73.3%)	0.794
Educational Materials (e.g., brochures, manuals)	39 (39%)	24 (38.1%)	9 (40.9%)	6 (40%)	0.970

DISCUSSION

The management of biomedical waste is a vital component of healthcare operations since it is necessary for ensuring the safety of both patients and staff, in addition to having an impact on environmentally friendly practices[18].Effective biomedical waste management requires a combination of knowledge, awareness and training to ensure safe handling, disposal and minimization of risks[19]. Healthcare professionals need to understand the types of biomedical waste, relevant regulations and risks associated with improper waste management. Awareness of proper segregation, labeling and storage of waste, as well as the importance of personal protective equipment (PPE), is crucial. Regular training sessions and updates on new guidelines and best practices help ensure compliance and a safe environment for patients, staff and the community[20-22]. Respondent gender, profession, experience and education help interpret survey results. Due to the predominance of female physicians with extensive experience and advanced degrees, this study may reflect the perspectives of more experienced and highly educated professionals, which may affect its generalizability to other healthcare workers.

It appears from this that the individuals who responded were seasoned professionals in the healthcare industry who were able to offer insightful perspectives on the procedures that are currently being used to manage biological waste. According to the findings, even though fifty percent of the individuals who participated in the survey had received formal training in waste management, a sizeable proportion of them still believed that extra training was required for the purpose of enhancing biological waste

management. Leonard et al. demonstrated the importance of implementing ongoing training and education programs in order to guarantee that healthcare professionals are equipped with the knowledge and skills necessary to appropriately manage biological waste[23]. Maharjan et al showed that the bulk of the biomedical waste that was produced consisted of infectious waste and sharps, which is consistent with the findings of several other studies[24]. It was observed that the introduction of color-coded bins and specific containers for garbage collection was a popular practice in healthcare institutions. This practice is intended to guarantee effective segregation and management of diverse waste streams. Due to the fact that more experienced healthcare workers are likely to have a greater awareness of waste management protocols and issues, the results may be skewed as a result of this overrepresentation of experienced experts. Mishra et al have shown that higher levels of educational attainment are connected with larger levels of participation in research and better levels of environmental awareness. The correlation between education and response rates, with persons having Master's degrees making up 49% of the sample, is in line with these findings [25]. A significant conclusion from this research is that only fifty percent of the people who participated in the survey stated that they had received training in the management of biomedical waste. A noteworthy fact is that the administrative staff had the largest percentage of individuals who had received training, with 81% of them saying that they had gotten such training. Gupta et al has shown that clinical staff, notably nurses and technicians, are typically more involved in waste management training. This finding stands in contradiction to said research [26]. The fact that individuals who received training reported feeling confident in their understanding of waste management, on the other hand, highlights the significance of focused training programs in terms of enhancing both competence and confidence in the management of trash.

Sharps (72%) and infectious waste (67%) were found to be the most prevalent kinds of biomedical waste. This was determined by investigating the types of garbage that were generated [27]. In addition, the fact that color-coded bins are used by 80% of the facilities that were examined and designated containers are used by 77% of them implies that the facilities have a relatively high level of knowledge regarding the proper separation of garbage. These numbers are comparable to those obtained from research carried out in industrialized nations, where regulatory compliance with waste segregation is enforced with a greater degree of stringency[28]. Nevertheless, the utilization of color-coded bins and containers is not sufficient to handle all of the issues that are associated with garbage management. This is because 57% of respondents indicated that there were insufficient resources, and 50% mentioned that there was a lack of training as major obstacles to efficient waste management [29].

Within the context of a particular healthcare environment, the purpose of this study is to evaluate the awareness, behaviors and views of biological waste management among healthcare personnel. Sixty-one percent of respondents reported witnessing or experiencing incidents pertaining to waste management, underscoring the persistent hazards linked to inadequate waste disposal practices. These occurrences emphasize the necessity for both training and the allocation of sufficient resources to ensure safe waste management. Prior research has demonstrated that similar occurrences occur more frequently at establishments with inadequate budget or poorly executed waste management systems.

CONCLUSIONS

The study concluded that healthcare professionals generally recognize the importance of biomedical waste management, there are still substantial problems that need to be addressed particularly in resource allocation and training. A multifaceted approach is necessary to overcome these issues, combining practical training initiatives with policy reforms to ensure effective waste management practices.

REFERENCES

1. World Health Organization (WHO). Safe management of wastes from health-care activities. 2nd Edition, 2014.
2. Bosmans, A., Vanderreydt, I., Geysen, D., & Helsen, L. (2013). The crucial role of Waste-to-Energy technologies in enhanced landfill mining: a technology review. Journal of Cleaner Production, 55, 10-23.
3. Song, Q., Li, J., & Zeng, X. (2015). Minimizing the increasing solid waste through zero waste strategy. Journal of Cleaner Production, 104, 199-210.
4. Hornsby, C., Ripa, M., Vassillo, C., & Ulgiati, S. (2017). A roadmap towards integrated assessment and participatory strategies in support of decision-making processes. The case of urban waste management. Journal of Cleaner Production, 142, 157-172.
5. Zaman, A. U. (2016). A comprehensive study of the environmental and economic benefits of resource recovery from global waste management systems. Journal of Cleaner Production, 124, 41-50.
6. Phuket City Municipality. Disposal of waste, Phuket province, January 2018.
7. International Committee of the Red Cross. Medical waste management, November 2018.
8. Nema A, Pathak A., Bajaj P., Singh H., Kumar S. A case study: biomedical waste management practices at city hospital in Himachal Pradesh. Waste Management Research, 2011.
9. Ndiaye M, El Metghari L, Soumah MM, Sow ML. Biomedical waste management in five hospitals in Dakar, Senegal. Bulletin de la Société de Pathologie Exotique, 2012.
10. Aderemi, T. J., Akpan, S. E., & Ojo, A. S. (2021). Knowledge and practices regarding biomedical waste management among health care workers in a tertiary hospital in Nigeria. International Journal of Health Sciences, 15(3), 20-27.
11. Gupta, S., Gupta, S., & Srivastava, A. (2019). Assessment of knowledge, attitude, and practices regarding biomedical waste management among healthcare personnel in a tertiary care hospital. Journal of Hospital Infection, 102(2), 199-205.
12. Thirunavukkarasu A, Al-Hazmi AH, Dar UF, Alruwaili AM, Alsharari SD, Alazmi FA, Alruwaili SF, Alarjan AM. Knowledge, attitude and practice towards bio-medical waste management among healthcare workers: a northern Saudi study. PeerJ. 2022 Jul 20;10:e13773. doi: 10.7717/peerj.13773. PMID: 35880221; PMCID: PMC9308458
13. Sarkar, P., Banerjee, D., & Mukherjee, A. (2020). Assessment of the effectiveness of a training program on biomedical waste management in a teaching hospital. Waste Management, 105, 39-
14. Priya, L Laasya, Rao, G Srinivasa, & Suresh, A Venkata %J Int J Acad Med Pharm. (2023). KNOWLEDGE, ATTITUDE AND PRACTICES ABOUT BIOMEDICAL WASTE MANAGEMENT AMONG NURSING STAFF IN A TERTIARY CARE HOSPITAL. *5*(3), 2240-2246.
15. Patwary, Masum A, O'Hare, William Thomas, & Sarker, Mosharraf H %J Safety science. (2011). Assessment of occupational and environmental safety associated with medical waste disposal in developing countries: a qualitative approach. *49*(8-9), 1200-1207.
16. Chhabra, Vivek, Meena, Durga Shankar, Bohra, Gopal Krishana, Midha, Naresh, Maheshwari, Bharat, & Rohilla, Amit %J Int. J. Commun. Med. Publ. Health. (2019). A survey of knowledge, attitude and practice of biomedical waste management among 150 nursing staff working in All Indian Institute of Medical Sciences, Jodhpur. *6*, 3008-3013.
17. Shyamala, R, & Naveen, G %J Int. J. Curr. Microbiol. App. Sci. (2016). A Cross Sectional Study on Health Care Waste Management among Health Care Personnel in a Tertiary Care Center, Kannur, Kerala, India. *5*(9), 340-345.

18. Mor, Rahul, Singh, Sarbjit, Bhardwaj, Arvind, & Osama, Mohammad %J Management Science Letters. (2017). Exploring the awareness level of biomedical waste management: Case of Indian healthcare. *7*(10), 467-478.
19. Akkajit, Pensiri, Romin, Husna, Assawadithalerd, Mongkolchai %J Journal of environmental, & health, public. (2020). Assessment of knowledge, attitude, and practice in respect of medical waste management among healthcare workers in clinics. *2020*(1), 8745472.
20. Kumar, Akhilesh, & Agrawal, Avlokita %J Current Research in Environmental Sustainability. (2020). Recent trends in solid waste management status, challenges, and potential for the future Indian cities–A review. *2*, 100011.
21. Patwary, Masum A, O'Hare, William Thomas, & Sarker, Mosharraf H %J Journal of environmental management. (2011). An illicit economy: Scavenging and recycling of medical waste. *92*(11), 2900-2906.
22. Pandit, Pritam P, Navathar, Sankalpa N, Chopade, Rushikesh L, Kumari, Supriya, Nagar, Varad, Gautam, Archana, Awasthi, Garima, Awasthi, Kumud Kant, & Sankhla, Mahipal Singh. (2024). Exploring the Relationship Between Food Waste and Heavy Metal Extraction through Biosorption.
23. Leonard, Colleen M, Chunga, Chipwaila Choolwe, Nkaama, Justine M, Banda, Kutha, Mibenge, Chilekwa, Chalwe, Victor, Biemba, Godfrey, Chilengi-Sakala, Sandra, & Mwale, Florence Kabinga %J PLOS Global Public Health. (2022). Knowledge, attitudes, and practices of health care waste management among Zambian health care workers. *2*(6), e0000655.
24. Maharjan, Amrit, Khatri, Singh Bahadur, Thapa, Luna, Pant, Ramesh Raj, Pathak, Pankaj, Bhatta, Youb Raj, Rijal, Kedar, & Bishwakarma, Kiran %J Himalayan Biodiversity. (2019). Solid waste management: Challenges and practices in the Nepalese context. 6-18.
25. Patwary, Masum A, O'Hare, William Thomas, & Sarker, Mosharraf H %J Journal of environmental management. (2011). An illicit economy: Scavenging and recycling of medical waste. *92*(11), 2900-2906.
26. Gupta, Pratham P, Bankar, Nandkishor J, Mishra, Vaishnavi H, Sanghavi, Shruti, & Badge, Ankit K %J Cureus. (2023). The Efficient Disposal of Biomedical Waste Is Critical to Public Health: Insights from the Central Pollution Control Board Guidelines in India. *15*(10).
27. Singh, Ekta, Kumar, Aman, Mishra, Rahul, & Kumar, Sunil %J Chemosphere. (2022). Solid waste management during COVID-19 pandemic: Recovery techniques and responses. *288*, 132451.
28. Okonkwo, Camillus Uchenna, Liyuan, Liu, Jianbo, Guo, Wang, Tongzhe, Meng, Cun, Qinzhong, Feng, Yang, Chen %J Waste Management, & Research. (2024). Review on medical waste management in China and Nigeria. 0734242X241271018.
29. Singh, Vir. (2024). Solid Waste Management. In *Textbook of Environment and Ecology* (pp. 299-307): Springer.