

RESEARCH ARTICLE

Assessment of Hospital Liquid Waste Management in Public and Private Hospitals in Tamale Metropolis, Ghana

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Abstract

In developing countries, hospital liquid waste management is an issue of major concern. The main objective of this study was to assess the types and current management practices of hospital liquid waste in public hospitals and private hospitals: one modern teaching hospital, two standard regional hospitals and two most attended private hospitals in the Tamale Metropolis. Quantitative and qualitative approaches were used in the data collection. The data was analysed using Statistical Package for Social Sciences (SPSS). The study revealed that most of the workers (45.5%) had 5 years and above working experience but there was no statistical significance ($p > 0.05$) between the number of years in service and how often one receives training on hospital liquid waste management. Majority of the respondents (61%) said they had received training on liquid waste management randomly or periodically. There was statistical significance ($p < 0.05$) between the type of profession and the training received in hospital liquid waste management. Majority of the respondents (57%) indicated their liquid wastes are treated prior to disposal and there was statistical significance ($p < 0.05$) between the type of hospital and the separation of liquid waste before disposal. The study revealed that the main sources of liquid waste generation from the hospitals are labour wards, laboratories and theatres. There was significant association ($p < 0.05$) between the type of hospital and the amount of liquid waste produced a day. Two health care facilities treat and properly disposed of their liquid waste into a soak-away pit. The hospitals discharged their liquid waste without any proper treatment directly into drains to be conveyed into the urban drainage system. Some dug-out pits were not well constructed which could result in polluting underground water and posing threat to people of the environs. Only three hospitals had a proper functioning waste management department. This affirmed the claim of majority of the respondents that indicated the non-availability of hospital liquid waste management policy or legislation. There was no statistical significance ($p > 0.05$) between hospital having liquid waste disposal policy and how often inspection or supervision is done. The study therefore recommends that regulatory bodies should enforce drafted legislations on liquid waste treatment to enhance the efficiency of liquid waste management in hospitals specifically Tamale metropolis.

Keywords: Hospitals; Infectious Waste; Liquid Waste; Personnel Training

Introduction

Hospital liquid waste refer to infectious, non-hazardous and hazardous liquid waste with sufficient free liquid arising from dental, medical, nursing, pharmaceutical or similar practice, care, investigation, treatment, teaching and or research that requires additional safety packaging to ensure safe transportation, treatment and storage [1]. Worldwide, hospital waste management is a major concern for most healthcare facilities [2]. In most developing countries, there is lack of technology and skills to implement and monitor hospital waste management programs [3]. The risks that have been associated with clinical liquid waste management have not received necessary attention [4]. About 5% are non-infectious but hazardous, around 10% are infectious, and 85% of hospital liquid wastes are actually non-hazardous [5]. However, the reuse of untreated clinical liquid waste can cause diseases such as cholera, plague, tuberculosis, hepatitis B, diphtheria etc [6].

The perception of administrators and health workers can influence the importance they attach to the management of health waste [7]. Improper management of healthcare waste can have direct impact such as the spread of drug-resistant microorganisms from health facilities into the immediate environment [5]. Liquid waste poses a serious threat to human health and the environment due to their ability to pollute ground water, enter watersheds, and drinking water when not properly handled and disposed [6]. It

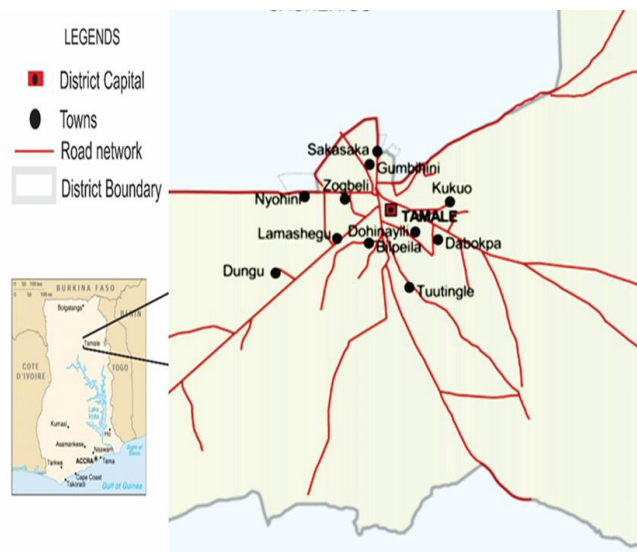
is therefore unethical and illegal to dispose untreated waste as it can extremely dangerous and even fatal in causing diseases like diphtheria, cholera, hepatitis B, tuberculosis, and plague among other and thus is a main problem for healthcare facilities [8]. Currently, poor treatment methods and practices of hospital liquid waste are creating serious environmental problems in local communities and cities, exposing residents and neighbours to air pollutants, contaminated water, foul odours and toxics from nearby healthcare facilities in Ghana [9]. Proper management of hospital liquid waste needs the greatest attention. Hence, any effective hospital liquid waste management programme should be able to provide protection to human health and the environment from hazards posed by the waste. The study was to assess the types and current management practices of hospital liquid waste in some selected hospitals in the Tamale Metropolis.

Methodology

Study Area

Northern region of Ghana has a population of 2,479,461 representing 10.1% of the total population (GSS, 2012) [10]. Tamale as shown in Figure 1 is the regional capital of Northern Region of Ghana. It is also known as the fastest growing city in West Africa. It lies between latitude $9^{\circ} 16'' - 9^{\circ} 34''$ North and longitude $00^{\circ} 36'' - 00^{\circ} 57''$ [10]. It has a tropical wet and dry/ savanna climate with a pronounced dry season in the low-sun months, no-cold season and wet season in the high-sun months. The Metropolis has health facilities including Tamale Teaching Hospital, Tamale Central Hospital, and Tamale West Hospital with about 30 other Clinics complementing the works of the hospitals dotted around the Metropolis.

Tamale Teaching Hospital is located along the Tamale-Salaga main road. It is the largest hospital in the Metropolis and provides effective health care to a greater population of patients. Kabsad Scientific Hospital located behind the Tamale-Salaga road total filling station. It is along the Nim avenue Street of Tamale Central. It is sited in the middle of the Tamale Central community and is one of the top private health care facilities in the metropolis. God Care's Community Hospital located along the Tamale-Tolon road in a community called Kasalgu. It also serves as a rescue point for people around and in Nyankpala community since they are deprived of a well operative hospital in the community. Tamale Central Hospital and Tamale West Hospital are the two regional hospitals which provide healthcare delivery services to patients of the Metropolis and the region at large.



Source: Ghana Statistical Service (GSS, 2012) [10]

Figure 1: Map of Tamale Metropolis

Sampling technique, data collection and analysis

Purposive sampling was used to select hospitals. A semi-structured questionnaire was administered to obtain information from respondents. The preliminary field survey was done by taking a transect walk through and around the various hospitals. It enabled the identification of septic tanks, dug-outs and other storage and disposal methods present in the hospitals. The topography of the lands was also observed to ascertain whether disposed liquid waste can easily join the public drains and nearby water bodies as well.

The questionnaire was administered in each hospital based on the number of workers in the facility. In total 94 respondents were given the questionnaire for their responses. In Tamale Teaching Hospital, thirty-one workers (Nurses, Doctors, Waste managers and Administrators) questionnaire was administered. Twenty (20) set of questionnaire was administered to Tamale Central Hospital and sixteen was administered to Tamale West Hospital. One set of questionnaire guide aided in an interview with the waste management department of both facilities to obtain information of their management practices. With Kabsad Scientific Hospital and God Care's Community Hospital, fourteen (14) questionnaires each was administered to the general staff.

Another set of questionnaire was designed for the legislative or policy making bodies. Each set was administered to the three

policy making bodies which are Environmental Protection Agency, Ministry of Health Regional Directorate and the Tamale Waste Management Department.

The questionnaires were put in three sections. The first part targeted at getting information on the general workers or staff of the health care facilities such as doctors, physician assistant, nurses, midwives, administrators and labourers. In designing the questionnaire, certain factors were put in place to obtain information from the respondents such as educational background, socio-economic background and their working experience. Information on types of liquid waste generated from the facility, their treatment and disposal, the safety of workers in handling and processing waste, the possible harm untreated waste could cause and the appropriate means of treating and disposing their liquid wastes. The section of the questionnaire was used to gather information on the waste management unit of the facilities.

A questionnaire was also designed for the legislative or policy making bodies to obtain information on their task and responsibility pertaining hospital liquid waste. The appropriate methods and standards set by the hospitals authorities. Data was also obtained from the legislative bodies such as Environmental Protection Agency, Environmental Health and Sanitation Unit and Tamale Waste Management Department. Statistical service unit of the metropolis also gave out some vital information in the accomplishment of this work.

Data Analysis

The data was collated and coded for analysis. Statistical Package for Social Science (SPSS) was used in processing the data, and results presented in tables and charts. We also employed Chi-Square statistical test of significance to determine the level of significance of association between variables at 95% confidence level.

Results and Discussion

Demographic Characteristics

Majority of the respondents (59%) from the hospitals were males whilst about 41% of them were females (Table 1). Most of the

	Variable	TTH	TCH	TWH	KSH	GCCH	Total
Sex	Male	19(63%)	12(60%)	9(56%)	9(64%)	5(45%)	54(59%)
	Female	11(37%)	8(40%)	7(44%)	5(36%)	6(55%)	37(41%)
Age	Less than 30	12(40%)	8(40%)	3(19%)	5(36%)	8(73%)	36(40%)
	31 to 45	10(33%)	7(35%)	9(56%)	6(43%)	0(0%)	32(35%)
	46 to 60	6(20%)	5(25%)	3(19%)	3(21%)	3(27%)	20(22%)
	Above 60	2(7%)	0(0%)	1(6%)	0(0%)	0(0%)	3(3%)
Religion	Christian	15(50%)	8(40%)	5(31%)	4(29%)	5(45%)	37(41%)
	Islam	15(50%)	12(60%)	11(69%)	10(71%)	6(55%)	54(59%)
Profession	Doctor	5(17%)	5(25%)	2(13%)	0(0%)	2(18%)	14(15%)
	Pharmacist	5(17%)	2(10%)	2(13%)	2(14%)	1(9%)	14(15%)
	Physician	7(23%)	2(10%)	2(13%)	2(14%)	1(9%)	14(15%)
	Nurse	1(3%)	3(15%)	3(19%)	5(36%)	4(36%)	16(18%)
	Midwife	3(10%)	2(10%)	3(19%)	1(7%)	3(27%)	12(13%)
	Lab. tech.	0(0%)	2(10%)	2(13%)	2(14%)	0(0%)	6(7%)
	Labourer	5(17%)	3(15%)	2(13%)	1(7%)	0(0%)	11(12%)
Qualification	Physiotherapy	4(13%)	0(0%)	0(0%)	0(0%)	0(0%)	4(4%)
	Certificate	3(10%)	3(15%)	0(0%)	5(36%)	5(45%)	16(18%)
	Diploma	5(17%)	5(25%)	5(31%)	4(29%)	2(18%)	21(23%)
	1 st degree	12(40%)	5(25%)	9(56%)	4(29%)	4(36%)	34(37%)
	2 nd degree	4(13%)	3(15%)	0(0%)	0(0%)	0(0%)	7(8%)
	HND	2(7%)	3(15%)	0(0%)	1(7%)	0(0%)	6(7%)
Years in service	None	4(13%)	1(5%)	2(13%)	0(0%)	0(0%)	7(8%)
	1	4(13%)	3(15%)	0(0%)	2(14%)	2(18%)	11(12%)
	2	3(10%)	3(15%)	5(31%)	2(14%)	2(18%)	15(16%)
	3	5(17%)	2(10%)	3(19%)	3(21%)	2(18%)	15(16%)
	4	2(7%)	2(10%)	2(13%)	3(21%)	0(0%)	9(10%)
Total	5 and above	16(53%)	10(50%)	6(38%)	4(29%)	5(45%)	41(45%)
		30	20	16	14	11	91

Table 1: Demographic characteristic of respondents

respondents fell within the youthful age of 30 years and below representing about 40%, age group of 31 to 45 years representing 35% and age group of 46 to 60 years representing 22% and the least age group recorded was 61 years and above representing 3% (Table 1). Majority of the respondents 59% were Muslims and 41% were Christians. The high number of Muslims to Christians could be because Tamale is predominantly Muslim. The percentages of profession of the respondents were evenly dispersed with 18% being professional Nurses followed by 15% each representing Doctors, Pharmacists and Physician Assistants and, the least of all was Physiotherapists representing 4%. Most of the workers had 5 years and above working experience representing 45% (Table 1).

Waste management and personnel training

Majority of the respondents (81%) indicated the facilities have personnel designated place for waste management. It is important waste handlers are extensively trained on how to handle all kinds of waste irrespective of their degree of hazard. Majority of the respondents (62%) said they had received training on liquid waste management randomly or periodically (Table 2). The training was conducted in the form of workshops and seminars usually on annual basis. Most of the personnel receive training on how to handle hospital liquid waste in the hospitals. There was no statistical association ($p > 0.05$) between the number of years in service and training received on liquid waste management. However, there was statistical significance ($p < 0.05$) between the type of profession and the training received in hospital liquid waste management. This findings is consistent with a similar study in South Africa that revealed that 48% health workers interviewed indicated that had not received any formal training in health care waste management and only 50% indicated that had received in-service training with higher knowledge among nurses [11].

The training condition in the study area are in consonance with Roe (2012) that stated that about 56% of medical waste managers are provided training on how safe they can protect themselves against hazardous environmental conditions [12]. Also, Abdulla, *et al.* (2008) reported that, about 71% of the hospitals provided training to doctors and other personnel about medical waste management and their potential hazards on site investigation of medical waste management practices in Northern Jordan [13]. A similar survey conducted on hospital waste management in Libya by Sawalem *et al.* (2009) that showed that 85% of waste management personnel including managers, cleaning staff, and environmental workers, were not trained in hospital waste management and did not have a detailed description of their duties in respect of waste handling, 55% of doctors and nurses were unaware of hospital waste management protocols and showed insufficient knowledge of the potential hazards [14].

Most of the personnel receive in-service training when they are employed to equip them for better delivery of duties. Personal protective equipment used by the medical waste managers was gloves, apron/ overall, boot, and nose mask which weren't adequate enough. The most effective personal protective equipment in reducing risk of injury is gloves to protect from exposure to blood, other potentially infectious materials and chemicals (WHO 2014) [5].

The study revealed that personnel at KSH had fair knowledge about training of personnel on hospital liquid waste management with a respondent percentage of 79%, which was followed by TWH with a percentage of 69%, TTH with 67% TCH with 55% and GCCH recorded the least in terms of personnel training on hospital liquid waste management with 27% (Table 2). This finding is in agreement with a study in South Africa in 2016 that indicated that there was poor knowledge among healthcare professionals and emphasized the need for regular training for improvement in their knowledge and practice regarding medical waste disposal [15]. The key informant believed there is inadequate training on liquid waste management and provision of modern facilities and PPE to aid in adequate management of the liquid waste generated. This was due to the lack of finances to make those provisions.

QUESTION	Response	TTH	TCH	TWH	KSH	GCCH	Total
Are person (s) designated for HLWM?	Yes	28(93%)	11(55%)	16(100%)	11(79%)	8(73%)	74(81%)
	No	2(7%)	9(45%)	0(0%)	3(21%)	3(27%)	17(19%)
Do they receive any training on HLWM?	Yes	20(67%)	11(55%)	11(69%)	11(79%)	3(27%)	56(62%)
	No	3(10%)	0(0%)	0(0%)	3(21%)	1(9%)	7(8%)
	Don't know	7(23%)	9(45%)	5(31%)	0(0%)	7(64%)	28(31%)
If yes, how often	Weekly	3	1	1	3	0	8
	Monthly	6	3	2	5	0	16
	Annually	7	2	8	3	2	22
	Randomly	5	5	0	3	1	14
Total		30	20	16	14	11	91

Table 2: Response on designated place for liquid waste management and training received

Treatment of liquid waste prior to disposal

Majority of the respondents (57%) alluded to the fact that liquid waste were treated prior to its disposal with 43% denying such claim were aware of waste management. The study revealed that, KSH treated their liquid before disposing it as they recorded

a higher percentage of 79%, closely followed by TTH with 70%, TCH 65% and GCCH 55% with TWH been entirely ignorant about treated of liquid waste prior to disposal with a minimal percentage of 6% (Table 3). Majority of the respondents indicated their liquid wastes are treated prior to disposal. There was statistical significance ($p < 0.05$) between the type of hospital and the separation of liquid waste before disposal. However, there were no significant differences ($p > 0.05$) between the training of personnel on liquid waste management and the treatment of hospital liquid waste before disposal. Further investigation revealed that treatment was specific to some departments' whilst others do not practice. This finding is consistent with a study in South Africa that revealed that just over half (54%) of health staff had a good attitude towards disposal of health care waste [11]. Proper management ensures that infectious liquid waste is handled in accordance with established and acceptable procedures from the time of generation through treatment of the waste and its ultimate disposal [14].

Question	Variable	TTH	TCH	TWH	KSH	GCCH	Total
Types of liquid waste generated	Non-hazardous	25	11	16	11	10	73
	Hazardous	18	10	16	7	0	51
	Infectious	24	15	16	12	8	75
Are liquid waste treated prior to disposal?	Yes	21(70%)	13(65%)	1(6%)	11(79%)	6(55%)	52(57%)
	No	9(30%)	7(35%)	15(94%)	3(21%)	5(45%)	39(43%)
Are waste separated before disposal?	Yes	25(83%)	14(70%)	3(19%)	11(79%)	9(82%)	62(68%)
	No	5(17%)	6(30%)	13(81%)	3(21%)	2(18%)	29(32%)
Are liquid waste stored together	Yes	8(27%)	9(45%)	7(44%)	3(21%)	2(18%)	29(32%)
	No	22(73%)	11(55%)	9(56%)	11(79%)	9(82%)	62(68%)
Are there drain(s) or septic tank(s)?	Yes	23(77%)	15(75%)	16(100%)	10(71%)	10(91%)	74(81%)
	No	7(23%)	5(25%)	0(0%)	4(29%)	1(9%)	17(19%)
Total		30	20	16	14	11	91

Table 3: Liquid waste management practices

About 68% of the respondents also alluded to the fact that separation of the different types of liquid waste was done before disposal. Segregation, minimisation and safe storage of hazardous materials are just as important for liquid wastes as they are for solid wastes (WHO 2014) [5]. Most of the respondents (Table 3) said they segregate the waste into its various components before treating and disposing appropriately. This was contradictory to the findings of Asante *et al.* (2013) that reported that a higher percentage (83%) of the healthcare centres visited do not segregate their waste in Accra [9]. Also, Athavale and Dhumale (2010) found that there was no segregation of the waste starting from generation to disposal in a study conducted at Pravara Rural Hospital, Loni and Maharashtra [16].

The majority also testified the availability of septic tanks at the hospitals. Most of the respondents agreed that they do not store the different types of liquid waste together after treatment (Table 4). There were no established sewage systems with sewer pipelines connected to these systems to dispose of their liquid waste but rather mere covered dug-outs where the liquid waste runs into.

Type of liquid waste	Treatment methods	Disposal methods
Non-hazardous liquid waste	Untreated	Drains Surrounding
Hazardous liquid waste	Untreated	Burial Incinerator Landfill
Infectious liquid waste	Bleaching	Dug-out pit Drains
	Untreated	Incinerator Landfill

Table 4: Liquid waste treatment and disposal methods

Types of hospital liquid waste produced daily

From the results obtained (Table 3), most of the waste generated were infectious liquid wastes followed by non-hazardous and hazardous liquid waste on a daily basis. Infectious liquid waste is generated in almost all the various departments of the hospital but hazardous liquid waste is generated less because its generation is specific to some departments. It was further confirmed through a key informant interview with the Waste Management Unit of TTH, TCH and TWH that, all the three types of liquid waste were generated. There was significant association ($p < 0.05$) between the type of hospital and the amount of liquid waste produced a day. Per the five hospitals studied, infectious liquid wastes were generated most with a leading 37.69% followed by non-hazardous liquid wastes of 36.69% and hazardous liquid wastes as 25.61%. Similar study by Khajuria and Kumar (2007) in Agra city, India reported 70-75% is non-infectious wastes; 20-25% is infectious wastes, and 5-10% hazardous waste [17]. Also, Galtier *et al.* (2002) reported

that 15%-20% of healthcare wastes in France to be infectious liquid whilst Gautam *et al.* (2010) report on “biomedical waste management/incineration” showed that 15% was classified as infectious and hazardous wastes in the United States of America [18,19]. WHO (2014) on “safe management of waste from hospital activities” reported that, 85% of hospital liquid wastes are non-hazardous, around 10% being infectious, and around 5% being hazardous liquid wastes [5].

Policies and legislations on hospital liquid waste management

In a key informant interview with health administrators of the hospitals, revealed there was no policy and legislation for hospital liquid waste. This affirmed the claim of majority of the respondents that indicated the non-availability of hospital liquid waste management policy or legislation (Table 5). There was no statistical significance ($p > 0.05$) between hospital having liquid waste disposal policy and how often inspection or supervision is done. Ahmed, *et al.* (2014) study in Sudan on assessment of hospital waste management in Khartoum State Hospital indicated that out of the many, only 25% of the hospitals studied have a documented policy outlining medical waste management [20]. A study by Agenda for a Reformed Cohesion Policy (2009) reported most countries lack elaborated legal policy specifically for health care waste, institutional framework for healthcare waste management in healthcare facilities and proper sanitary landfills [21].

The result indicates that majority of the respondents were not aware of the existence of hospital liquid waste policies (Table 5). Also, about 48% of respondents don't know of disposal guide and clearly outlined procedures put in place by the hospitals management concerning hospital liquid waste management (Table 5). In the quest to find out whether inspection or supervision is done in the hospitals concerning liquid waste management, majority (77%) testified that inspection is done randomly by Tamale Waste Management of the Tamale Metropolis and Environmental Protection Agency but daily inspection is done by internal supervision. There was no statistical significance ($p > 0.05$) between designated persons for liquid waste management and having liquid waste disposal policies or guidelines.

Question	Variable	TTH	TCH	TWH	KSH	GCCH	Total
Are you aware of any legislation/ policy for HWM?	Yes	20(67%)	8(40%)	0(0%)	5(36%)	3(27%)	36(40%)
	No	3(10%)	5(25%)	11(69%)	5(36%)	0(0%)	24(26%)
	Don't know	7(23%)	7(35%)	5(31%)	4(29%)	8(73%)	31(34%)
Is the hospital having LW disposal guide?	Yes	20(67%)	6(30%)	0(0%)	5(36%)	3(27%)	34(37%)
	No	3(10%)	5(25%)	4(25%)	1(7%)	0(0%)	13(14%)
	Don't know	7(23%)	9(45%)	12(75%)	8(57%)	8(73%)	44(48%)
Are there clearly defined procedure for the collection and handling of HLW?	Yes	15(50%)	9(45%)	0(0%)	3(21%)	3(27%)	30(33%)
	No	5(17%)	0(0%)	4(25%)	4(29%)	2(18%)	15(16%)
	Don't know	10(33%)	11(55%)	12(75%)	7(50%)	6(55%)	46(51%)
Is there inspection on how liquid wastes are disposed?	Yes	23(77%)	12(60%)	15(94%)	11(79%)	9(82%)	70(77%)
	No	0(0%)	3(15%)	0(0%)	2(14%)	1(9%)	6(7%)
	Don't know	7(23%)	5(25%)	1(6%)	1(7%)	1(9%)	15(16%)
If yes, by which institution?	EPA	7	6	3	2	2	20
	TaMA	0	5	3	2	0	10
	TWMD	9	11	3	4	0	27
How often is the inspection?	Internal supervision	24	7	8	10	8	57
	Daily	4	1	0	1	3	9
	Weekly	3	0	2	1	1	7
	Monthly	5	3	4	0	0	12
	Randomly	14	7	9	10	5	45
Total		30	20	16	14	11	91

Table 5: Response on hospital waste policies and legislation on liquid waste management

Procedures for collection and handling of hospital liquid waste management

The waste management practice at the hospitals of study is the drainage disposal system for non-hazardous liquid type. Infectious liquid wastes without prior treatment are disposed of in septic tanks available with the hazardous liquid waste washed into the drains which eventually joins other external drains. If infectious stools or bodily fluids are not treated before being disposed of, it can create and extend epidemics, since sewage treatment in Africa is almost non-existent. Since, An, *et al.* (2000) that contamination of water supply from untreated healthcare waste can also have devastating effects [22].

Conclusion

The types of hospital liquid waste generated in the hospitals of study were basically non-hazardous, hazardous and infectious liquid wastes. Two health care facilities treated and properly disposed of its liquid waste into a soak-away pit whilst three hospitals disposed of liquid wastes into drains. Infectious liquid waste is generated in almost all the various departments of the hospital but hazardous liquid waste is generated less because its generation is specific to some departments. Majority of the respondents indicated their liquid wastes are treated prior to disposal. Inadequate training programmes for waste handlers (odlers) in waste disposal practices as well as the insufficient production of PPE are the major problem hindering the proper waste management practices in Tamale Metropolis. The study revealed that poor practices of liquid waste management in the hospitals could be partly due to inadequate knowledge among health staff about hospital liquid waste management. Hospital liquid waste can be a major pollution source and its improper disposal can cause epidemic diseases and also environmental pollution risks. From the study, the following recommendations were made: The regulatory should enforce drafted legislations on liquid waste treatment to enhance the efficiency of liquid waste management in hospitals specifically Tamale metropolis.

Acknowledgement

We are grateful to the management and all the staff of the five hospitals in the Metropolis for their permission and assistance in the data collection.

Ethical clearance

Permission was sorted from selected hospitals. The respondents consent was sorted and they were also informed that they have full right to accept or withdraw at any time during the data collection and, were assured that their responses will be kept confidential and be used only for this study purpose.

References

1. Wiafe S, Nooni IK, Appiah BK, Nlasia MS, Fianko SK (2016) Clinical liquid waste management in three healthcare facilities-A case study of Sunyani Municipality. *B J Environ Sci* 4: 11-34.
2. Hossain MS, Santhanam A, Norulaini NN, Omar AM (2011) Clinical solid waste management practices and its impact on human health and environment-A review. *Waste Manag* 31: 754-66.
3. Ali M, Wang W, Chaudhry N, Geng Y (2017) Hospital Waste Management in Developing Countries: A mini review. *Waste Manag Res* 35: 581-92.
4. World Health Organization (WHO) (2007) Core principles for achieving safe and sustainable management of healthcare waste.
5. World Health Organization (WHO) (2014) Companion handbook to the WHO guidelines for the programmatic management of drug-resistant tuberculosis. In Companion handbook to the WHO guidelines for the programmatic management of drug-resistant tuberculosis.
6. Biswal S (2013) Liquid biomedical waste management: An emerging concern for physicians. *Muller J Medical Sci Res* 4: 99-106.
7. Kagonji IS, Manye SV (2016) Analysis of Health Workers' Perceptions on Medical Waste Management in Tanzanian Hospitals. *Engg* 8: 445-59.
8. Tewodros D (2015) The public health benefits of compact onsite wastewater treatment system at urban health care facilities (HCFs) (Doctoral dissertation, Addis Ababa University).
9. Asante BO, Yanful E, Yaokumah BE (2013) Healthcare waste management; its impact: A case study of the Greater Accra Region, Ghana. *Int J Sci Tech Res* 3
10. Ghana Statistical Service (GSS) (2012). 2010 Population and Housing Census, Accra, GSS.
11. Olaifa A, Govender RD, Ross AJ (2018) Knowledge, attitudes and practices of healthcare workers about healthcare waste management at a district hospital in KwaZulu-Natal, *S Afr Family Practice*.
12. Roe G (2012) Training requirement for medical waste handlers. *Int j environ res public health* 4: 212-36.
13. Abdulla F, Qdais H A, Rabi A (2008) Site investigation on medical waste management practices in northern Jordan. *Waste Manag* 28: 450-8.
14. Sawalem M, Selic E, Herbell JD (2009) Hospital waste management in Libya: A case study. *Waste Manag* 29: 1370-5.
15. Makhura R, Matlala S, Kekana M (2016) Medical waste disposal at a hospital in Mpumalanga province, South Africa: implications for training of healthcare professionals. *S Afr Med J* 106: 1096-102.
16. Athavale AV, Dhumale GB (2010) A study of hospital waste management at a rural hospital in Maharashtra. *Journal of ISHWM* 9: 21-31.
17. Khajuria A, Kumar A (2007) Assessment of healthcare waste generated by Government hospital in Agra city, India. *Our Nature* 5: 25-30.
18. Galtier L, Bekaert C (2002) Healthcare waste management on an international scale. *Appropriate environmental and solid waste management and technologies for developing countries* 1: 289-94.
19. Gautam V, Thapar R, Sharma M (2010) Biomedical waste management: Incineration vs. environmental safety. *Indian J Med Microbiol* 28: 191-2.
20. Ahmed NO, Gasmelseed GA, Musa AE (2014) Assessment of medical solid waste management in Khartoum state hospitals. *J Applied Industrial Sci* 2: 201-5.
21. Fabrizio Barca (2009) An Agenda for a Reformed Cohesion Policy A place-based approach to meeting European Union challenges and expectations. *European Communities*.
22. An WF, Bowlby MR, Betty M, Cao J, Ling HP, et al. (2000) Modulation of A-type potassium channels by a family of calcium sensors. *Nature* 403: 553-6.