

## CLINICAL LIQUID WASTE MANAGEMENT IN GHANAIAN HEALTHCARE FACILITIES – A CASE STUDY OF SUNYANI MUNICIPALITY

Wiafe, S<sup>1</sup>. Nooni, I.K<sup>2,3\*</sup>, Appiah Boateng, K<sup>1</sup>. Nlasia, M. S<sup>2</sup>. Fianko, S.K.<sup>4,5</sup>

<sup>1</sup> Civil Engineering Department, School of Engineering, Sunyani Polytechnic, Sunyani-Ghana

<sup>2</sup> Centre for Data Processing and Geo-spatial Analysis, P.O. Box OS 278, Accra-Ghana

<sup>3</sup> National Institute for Environmental Research & Advocacy, P.O. Box OS 2162, Accra-Ghana

<sup>4</sup> Faculty of Business, the Graduate School, Ghana Technology University College. PMB 100, Tesano. Accra-Ghana.

<sup>5</sup> Marshalls University College, Accra-Ghana

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**ABSTRACT:** *Clinical Liquid Waste management has become a huge task for the authorities of health care facilities in Ghana. It is therefore necessary to ascertain the managerial strategies currently being used in managing such waste and adopt possible remedial measures to be implemented. Therefore, the study objectives were to identify the clinical liquid waste management techniques presently being used by the hospitals, generation rate and to ascertain the efficiency of current clinical liquid waste treatment practices. The study employed both quantitative approach involving structured interview and participatory observation triangulated with documentary analysis. The results found different levels of clinical liquid waste generation in sampled health care facilities. From the analysis, the study revealed that clinical liquid waste is managed using strategies such as collection, segregation, handling, transportation, treatment and disposal. However, the study results revealed that different collection, transportation and treatment methods employed by sampled hospitals affect the quality of treatment. These findings were revealed from the results obtained from the microbial analysis of Total Coliform bacteria; Faecal coliform bacteria and heterotrophic bacteria of sampled hospitals; as the results do not meet both country and WHO standards. The findings results suggest an environment problem due to the contamination of treated effluent from the sampled hospitals which are used for agricultural irrigational purposes, drinking and cooking. The study recommend; an urgent remedial measure to prevent outbreak of communicable disease through creation of awareness to educate communities downstream on the need to boil and treat their water using locally reliable methods.*

**KEYWORDS:** Clinical Liquid Waste Management (CLWM), Microbial Analysis, Liquid Waste Strategy, Liquid Waste Generation Rate

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## INTRODUCTION

Clinical Liquid Waste Management (CLWM) has become an important concern for many healthcare facilities in the World (Abdulla et al., 2008; Hossain et al., 2013). The problems of managing safe disposal of clinical liquid waste is becoming more challenging in the 21<sup>st</sup> century as the number of infectious diseases treated in healthcare facilities escalates and the types of pathogens become more complex (WHO, 2014). Numerous literatures seem to suggest that the risks associated with clinical waste especially liquid waste are not given the needed attention it deserves (WHO, 2014). This is because the common practice of pouring untreated

liquid waste down the sanitary sewer into our water bodies and on the bare soil especially in developing countries is viewed by many as a normal practice. However, WHO and Center for Disease Control (CDC), U.S.A have empirically shown that clinical liquid waste contains large numbers of microorganisms that can be detrimental to humans who come into contact with it (Agarwal, 1998; Nema et al., 2011; WHO, 2014). Hence, the need for healthcare facilities and its personnel to ensure that appropriate technologies are utilised and that personnel are well trained on safely managing liquid clinical waste in our health facilities.

Numerous studies have empirically found and reported that poor management of clinical waste generally at healthcare facilities are highest in developing countries (Abd El-salam, 2010; Udofia & Nriagu, 2013; Wiafe et al., 2015). WHO, (2014) and Udofia & Nriagu, (2013) estimated that the African continent alone has over 67,000 healthcare facilities that generates over 283, 000 tonnes of clinical wastes annually. A WHO survey in 22 developing nations found that about 18% to 64% of healthcare centres' use inappropriate clinical waste treatment and disposal technologies (WHO, 2005a as cited in Wiafe et al 2015). Some factors such as financial sustainability (Lohri et al., 2014) and lack of skill expertise to manage and reliance on obsolete technology (Coker et al., 2003; Guerrero et al., 2013) are blamed as the course.

Although the risks from clinical liquid and its related wastes are dependent on exposure, liquid waste disposal problems place patients, healthcare staff, visitors at risk, while adding enormous costs to health care (Nemathaga et al., 2008; Udofia & Nriagu, 2013). Recently, healthcare workers' agitation over waste related infections in hospital are putting increasing international pressures on governments to maintain stringent handling practices and safe disposal of clinical waste (Manyele & Lyasenga, 2010; Lultrell et al., 2003; Hossain et al., 2013; Nema et al., 2011). Realising this potential gap in the healthcare system coupled with recent growth in hospital attendance, healthcare professionals through seminars and forums has urged and called for the introduction of new legislation by Government to propose strategies for waste management policies. The Ministry of Health and its allied agencies in Ghana over the years have implemented significant changes to their health care practices. However, these changes within the hospital waste management have placed requirements on the health care sector to develop and implement new protocols for the management of wastes generated across the sector specifically with the recent Ebola epidemic across some West African nations. The Ghanaian Ministry of Health and Ghana Health Service has embarked on processes to consider the implications of these changed policy directions to establish an overarching policy which addresses all aspects of clinical and its related waste management. The policy intends to harmonise the minimum requirements for all public and private health related services that generate relevant waste: the General Hospitals, Metropolitan/Municipal/Districts Hospitals, University hospitals, Polyclinics, Private hospitals and Clinics). The waste streams comprising clinical and related wastes have defined management processes for their segregation, storage, transport and disposal in or from health care settings (Wiafe et al., 2015).

However, in Ghana, there is growing concern over poor management practices and improper precautions taken by most clinical waste workers during the waste management process. Reasons such as delay in passing occupational health and safety legislation, non-existence of comprehensive waste management strategies coupled with lack of awareness of the healthcare workers regarding the infectious risk of clinical waste are attributed to the mismanagement of clinical waste in many healthcare facilities (Wiafe et al., 2015) in many health facilities of developing countries (Nema et al., 2011).

In Ghana, collection, transportation, treatment and disposal of clinical liquid wastes are major challenges for the healthcare facilities. These challenges are much aggravated when state institution whose mandate are to ensure safe disposal of clinical waste cannot monitor and evaluate the conditions of clinical waste before discharging them into the environment due to genuine logistical constraints. As a result some healthcare official's compromise on work ethics by breaching the CLWM standards and best practices to discharge untreated liquid waste into natural water bodies thus poses a public health risk.

Currently very few studies has focused and assessed how clinical liquid waste management process from generation, collection, treatment and disposal are carried out in Ghana. Sunyani Municipality located on geographically on longitude 2°10'W-2°30'W and latitude 7°05'N-7°20'N (Wiafe et al., 2015) with 248,496 inhabitants (according to 2012 population census) in Brong Ahafo Region of Ghana is one of the fastest growing cities in the country (GSS, 2014). The municipality is endowed with many natural rivers and streams with the inhabitants depend on for drinking, agricultural purposes, food processing and other important uses. So, If the current hospital admission rate of 49.19 higher than the national average of 43.79 and an outpatient attendance per capita of 1.15 higher compared to national average of 0.81, the need for adequate clinical liquid waste management in terms of monitoring of liquid treatment and its quality is necessary especially in the wake of incessant power outage that disrupt the operations of the liquid treatment plants. This study aims to fill the gap by investigating the challenges and opportunities in Ghana's healthcare facilities in managing clinical liquid waste and pointing out options on possible remedial measures to be implemented. The study explored within the Sunyani Municipality especially in three selected hospitals namely, Municipal Hospital, Regional Hospital and S.D.A Hospital. Thus the study specifically sought to:

- To identify the various liquid waste management techniques currently used by the three hospitals within the municipality
- To determine the clinical liquid waste generation in the sampled hospitals within the municipality
- To assess the microbial analysis of existing liquid waste treatment in the sampled hospitals within the municipality
- To recommend possible remedial measures to be implemented in Sunyani Municipality, Ghana.

### **Research Questions**

1. What are the various types of liquid waste management techniques currently used by the three hospitals within the municipality?
2. What is the clinical liquid waste generation in the three hospitals within the municipality Ghana?
3. What is the level of treatment of clinical liquid waste generated prior to disposal in the Sunyani Municipality?
4. What possible remedial measures can be implemented to improve CWM practices in the municipality?

## RESEARCH METHODOLOGY

The study utilized experimental method to assess the physical, chemical and bacteriological condition of treated liquid waste in our hospitals on one hand. And mixed methods of quantitative, and observation triangulated with documentary analysis concerning liquid waste management situation in Sunyani Municipality on the other hand.

Mixed methods used for this research involving documentary analysis, quantitative approaches, and observations are briefly summarized as follows:

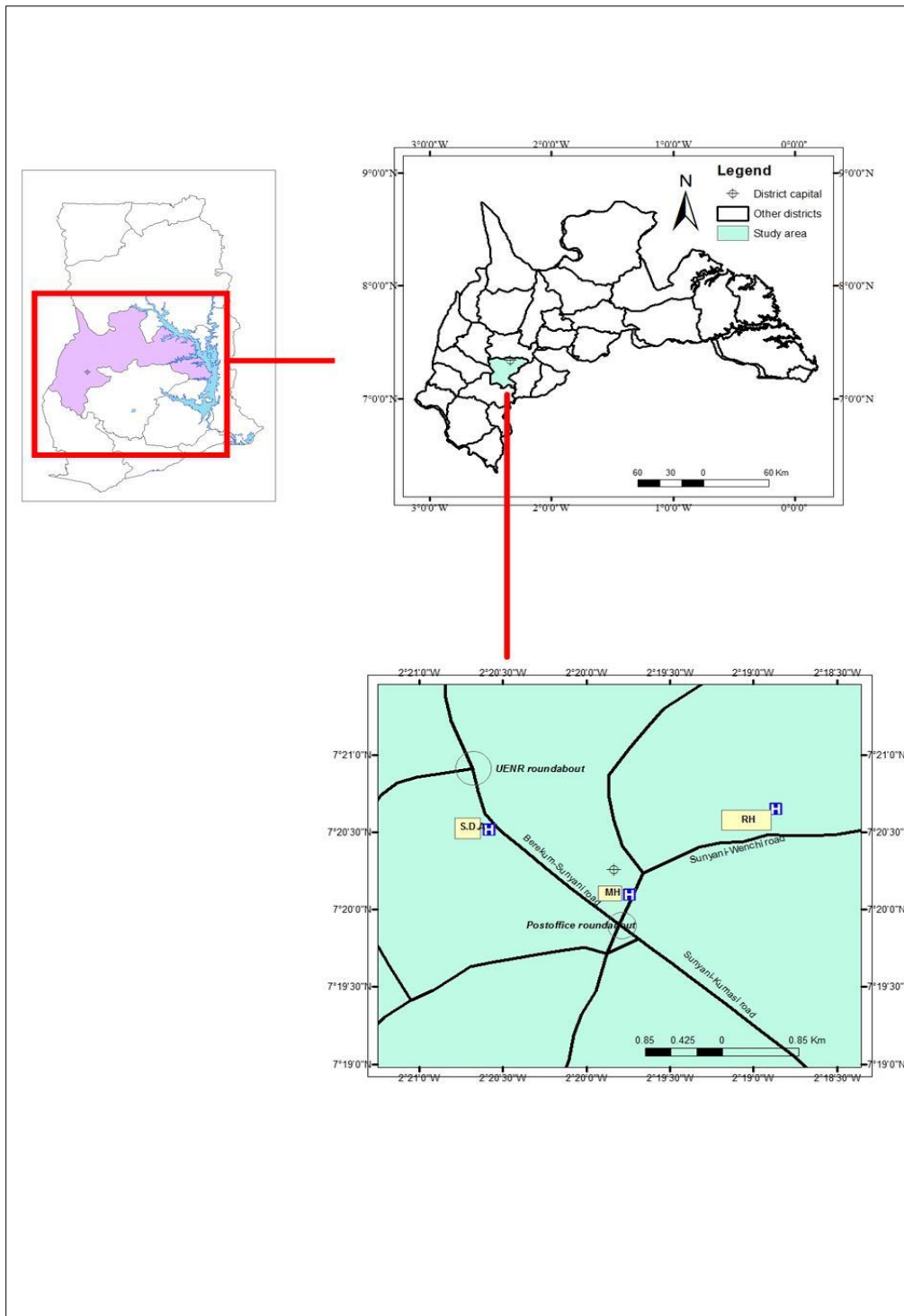
Document and literature analysis on clinical liquid waste directly or indirectly related to the topic was reviewed. The three hospitals, namely and geographically located on Regional hospital (RH) (2°18'51.60''W and 7°20'39.20''N), Municipal Hospital (MH) (2°19'43.42''W and 7°20'19.43) and a privately owned hospital called the Seventh Day Adventist (S.D.A) hospital (2°20'33.92''W and latitude 7°20'44.19''N) were sampled for the study using purposive sampling based on the following factors; hospital size, hospital location, type of health services and distance between them (Figure 1). The study undertook preliminary structured interview concerning the clinical liquid waste situation in the selected health facilities to understand the clinical waste management system setup in the municipality. The structured interview was prepared and administered by the researchers on a face-to-face interview method. Afterwards, material flow analysis with secondary data sources obtained from preliminary interviews of key informants involving a system description for liquid waste flows in the three sampled hospitals was conducted (Rodic et al., 2010). This enabled the researchers to design the structured questionnaire for management of health facilities (doctors, nurses, and health personnel) to obtain information on liquid waste generation, collection, treatment and disposal were obtained. The information on the number of beds and its occupancy, number of surgeries, amount of liquid wastes generated, and pretreatment, segregation, storage, treatment, and disposal of the wastes was collected from each of the hospitals through structured questionnaire administration during field work, liquid waste treatment log books, and observation. Information obtained from the structured questionnaire was cross checked with the set objectives to reassess information gaps. Reassessment questions were sent only to some health facilities personnel (i.e. doctors, nurses) and managers of liquid waste treatment facilities. Unobtrusive field observation of clinical liquid waste treatment facilities was done.

Ethical clearance was obtained from selected hospitals and Ghana Ministry of Health. For the purpose of facilitating field work, the study through a written consent, requested participants for their willingness to participate to this study. They were also informed that they have a right to withdraw at any time during the data collection and at the same time assured that their responses will be kept confidential and be used only for this study purpose (Wiafe et al., 2015).

The experimental method involved sample collection and laboratory analysis of some microbial parameters. Field measurement was done and sampling of liquid was carried out between 08:00 and 10:00 hours in the morning at the time when hospitals were operating (APHA, 2001). The liquid source was agitated during this period. Sterilized 200 ml glass bottles were used to collect samples from three different points in the sedimentation tanks and at 20-m intervals along the tanks. The sampling was performed on at least 3 different dates. Two samples each were collected from the sedimentation tanks of each sampled hospitals. The sampling and processing of the samples were done by the standard methods. The controls were always used with each sample, and if there was any contamination in any of the controls the

whole sampling was repeated on another sampling date. The samples were stored in cold icebox and transported to the laboratory for analyses. Any samples collected were analysed within 24 hours without loss of cool storage (APHA, 2001).

The sampled liquid collected were analysed for quantification, isolation and identification of the bacteria present. A total of 4 growth media were used to quantify and isolate bacteria from the samples. These were MacConkey agar (Medium for total coliform), Brilliant Green bile 2% Broth (medium for faecal coliform), Nutrient agar (NAM) (medium for heterotrophic Bacteria, Peptone H<sub>2</sub>O (medium for E-coli). To determine the total coliform, 35g of sample was suspended in 1 litre of distilled water. The substance was heated until completely dissolved, distributed into container filled with Durham's tubes and sterilized by autoclave at 121°C for 15 minutes. To determine faecal coliform, 40g of powder was weighed and dispensed into 1 liter of de-ionized water. The substance was allowed to soak for about 10 minutes, and then swirled to mix by gently warming to dissolve. The substance was dispensed into tubes with inverted Durham tubes and sterilized by autoclaving for 115°C for 15 minutes. Determination of E-coli was performed weighing 15g and dispensing in 1 litre of de-ionised water. The substance was allowed to soak for 10 minutes, swirled to mix before dispensing into final containers. The substance was then sterilized by autoclaving for 15 minutes at 121°C and carbohydrates and a pH indicator added for studying fermentation reactions. For heterotrophic Bacteria determination, of powder was weighed and dispensed in 1 litre of de-ionised water and allowed to soak for 10 minutes, swirled to mix then sterilized by autoclaving for 15 minutes at 121°C, cooled to 47°C. On each sampling date, the collected samples and de-ionised water inoculated in separate quadruple sets of petriplates containing the growth medium. Data collected from the field was checked for consistency and completeness before subsequent analysis. The results were presented in Tables and Figures.



**Figure 1: The study area in the Brong Ahafo region of Ghana shown as a green with selected hospital locations**

Source: (Wiafe et al., 2015)

## RESULTS

### Liquid Waste Generation in the Health Care Facilities

The results revealed that liquid wastes are generated mostly in the wards, surgical theatres, laboratories, pharmacy, mortuary, and the clinics by healthcare workers, patients and visitors. The results presented in Table 1 showed that the two most common liquid wastes generated at the surveyed healthcare facilities in the Sunyani Municipality are pathological and Infectious waste. The results in Table 1 indicates the highest liquid waste generation rate on average basis was found at MH with 33L/bed/day, 20L/bed/day was found at RH whilst S.D.A had the lowest generation rate of 2.5L/bed/day. The generation rate of clinical liquid waste was 15L/patient/day at RH and MH, 0.8L/patient/day at S.D.A hospital (Table 2). This resulted in an average of 30.8L/patient/day and 54.5L/bed/day for the three sampled healthcare centres. The results indicate that quantities of liquid waste generated vary with type and size of the healthcare facility, number of patients who visit the hospitals and type of services provided.

The results from Table 3 show greater proportion of liquid wastes (both pathological & infectious) generated in the wards of the study hospitals. The results from Table 3 show that the wards generate the highest liquid waste (7,817L/day) of which 199L is pathological waste and 7,618L is infectious waste. The surgical theatre followed with a total of 1,020L of which 560L is pathological waste and 1,060L is infectious waste. The mortuary generates 9,87L of liquid waste of which 412L is pathological waste and 575L is infectious waste. Allied department generates 363.5L of infectious waste but no pathological waste. The laboratory generates 192.5L of which 162L is pathological waste and 30.5 is infectious waste. The pharmacy and clinics generates 45.5L and 19L of infectious waste respectively.

Further the results showed that RH generates the highest waste (8,276L) from the health facility followed by MH (2,058L) and the least is S.D.A (58.5L) hospital. This result indicates that the amount of liquid waste generated is significantly linked to the size of the health facility and the findings is explained by the size of the hospitals where RH, MH and S.D.A hospitals have 413, 63 and 38 bed capacities respectively and also by average attendance rate per day (RH=550 patients/day, MH=135 patients/day, 76 patients/day).

In terms of pathological waste generation, the results show in Table 3 that the 'Surgical theatre' generates the highest liquid waste of 350L/day (RH), 210L/day (MH) respectively. The 'Mortuary' generates 310L/day (RH), 102L/day respectively. The 'wards' and the 'laboratory' RH generate 106L/day and 105L/day respectively, MH generates 86L/day and 54L/day whilst S.D.A generates 7L/day and 3L/day respectively. For infectious liquid waste generation, the results show in Table 3 that the 'wards' generate 6475L/day, 1125L/day and 18L/day respectively for RH, MH and S.D.A. The 'Theatre' follows with waste generate of 700L/day, 360L/day and 4L/day respectively. The 'Mortuary' generates 450L/day, 125L/day for RH and MH respectively. The 'Allied departments' generates 306L/day and 3.5L/day in RH and S.D.A respectively. The 'Pharmacy' generates 25L/day, 15L/day and 5.2L/day respectively in RH, MH and S.D.A. The 'laboratory' generates 15L/day, 12L/day and 3.5L/day respectively for RH, MH and S.D.A respectively.

**Table 1: Liquid Waste generation rate for sampled hospital per bed/day**

Hospital	Pathological (L/day)	Infectious (L)/day	Total (L)/day	No. of bed/day	Gen rate (L/bed/day)	Gen rate Pathological waste (L/bed/day)	Gen rate Infectious waste (L/day)
RH	871	7405	8276	413	20	2	18
MH	452	1606	2058	63	33	7	26
S.D.A	20	38.5	58.5	38	1.5	0.5	1.0

Source: Field data computation (2015)

**Table 2: Liquid Waste generation rate for sampled hospital per patients/day**

Hospital	Pathological (L/ day)	Infectious (L)/day	Total (L)/day	Av. patients / day	Gen rate (L/ patient / day)	Gen rate Pathological waste (L/patient/day)	Gen rate Infectious waste (L/patient /day)
RH	871	7405	8276	550	15	1.5	13.5
MHI	452	1606	2058	135	15	3.4	11.9
S.D.A	20	38.5	58.5	76	0.8	0.3	0.5

**Table 3: Liquid Waste generation rate in the Regional Hospital**

Department	Pathological waste(L)/day			Infectious Waste(L)/day			Total
	RH	MH	S.D.A	RH	MH	S.D.A	
Pharmacy	-	-	-	25	15	5.5	<b>40.5</b>
Laboratory	105	54	3	15	12	3.5	<b>192.5</b>
Wards	106	86	7	6475	1125	18	<b>7817</b>
Clinics	-	-	-	10	9	-	<b>19</b>
Theatre	350	210	-	700	360	-	<b>1620</b>
Mortuary	310	102	-	450	125	-	<b>987</b>
Allied Dept.	-	-	-	360	-	3.5	<b>363.5</b>
<b>Total</b>	<b>871</b>	<b>452</b>	<b>10</b>	<b>7405</b>	<b>1606</b>	<b>38.5</b>	

## PROCESS OF CLINICAL LIQUID WASTE MANAGEMENT

### Liquid waste segregation, collection and handling

The results from the interview and observation revealed that the three sampled hospitals use similar system of sewerage which is termed as the separate system. The study found that both infectious and pathological liquid waste from the different department are transported through



a pipe into a temporary holding areas called the ‘athwart pit’(Figure 2) whilst grey water from the kitchen and laundry are channeled directly into the storm drain. The purpose of providing temporary storage (i.e. athwart pit) in managing clinical liquid waste is to create a place for initial retention and settlement of solid particles for removal before entering the sedimentation tank further treatment and disposal.

### Temporary storage area and internal transportation

The liquid waste is internally transported through pipes buried in the ground from the hospitals departments by gravity into the temporary storage area called the anthwart pit as shown in Figure 2. The anthwart size varies across the three hospitals. The grey water from the kitchen and laundry are transported through open drain directly into the storm drains. The study results revealed the mode of liquid waste collection is similar among the two of the hospitals namely MH and S.D.A. At the temporary storage area, The MH and S.D.A hospitals liquid waste collection from the ‘anthwart pit’ are dislodged by private company called Zoom lion Ghana Limited whilst at RH, the liquid waste from the anthwart pit is pump into a chamber where further screening is done to any other solid material before finally channeled into the sedimentation tank for treatment. RH has two sedimentation tanks whilst MH and S.D.A has one each of the sedimentation pool. At RH, the clinical waste from the anthwart pit is pumped into a chamber where further screening is done to remove floating and any other settleable solid material found before the clinical liquid is pump into the sedimentation tank for treatment.



(a) Open anthwart pit

(b) Closed anthwart pit

**Figure 2: Temporary retention tank called anthwart pit**

### Treatment and disposal of liquid waste

The RH is the only hospital in the municipality that has a conventional sewerage treatment plant because of the size of the hospital. In the RH, the sedimentation tanks are in three sections with varying sizes. The treatment process is in three stages. The first section known as the primary settling tank (Figure 3) is used for grit removal and particulate-matter removal. The second stage of treatment in the sedimentation tank is purposely meant for biological-floc removal in the activated sludge settling tank and the removal of sludge. Also, the purpose of the second section of the sedimentation tank is where mixing of the liquid waste is done a period within the day for the removal of odour from the liquid waste. The liquid waste is then discharged into the last section of the sedimentation tank for chemical-floc removal. At this stage chlorine (Figure 4) is pumped through a piping system into the tank to disinfect the liquid

for any bacteria present and left over for a day and more before discharged into a tunnel joined to a stream.



Figure 3: First stage of sedimentation tank



Figure 4: Chlorination chamber

The result from the interview and observation show that MH and S.D.A. shares the same sedimentation pool geographically on longitude  $2^{\circ}10'W$ - $2^{\circ}30'W$  and latitude  $7^{\circ}05'N$ - $7^{\circ}20'N$  which is physically located behind Getfund hotel of the Sunyani Polytechnic. However, both Municipal Hospital and the S.D.A Hospital do not have a sewage treatment plant and as a result there is no pre-treatment of their liquid waste. They have contracted private companies such as Zoom Lion Company Ghana Limited and Alhaji Awudu Issaka waste management to dislodge the liquid waste to be disposed off into sedimentation pool owned by the municipality for land treatment or natural treatment.

### **Microbial Analysis of treated liquid waste**

The microbial analysis results of sample taken from the RH sewage treatment plant show that Total Coliform bacteria and Faecal coliform bacteria recorded 18 and 16 respectively. Both results means that total and Faecal coliform in comparison to both the WHO and GWCL standards do not meet the standards which are 0 and 0 respectively (Table 4). This finding indicates that there are still bacteria present in the treated effluent from the RH, and is far above

both the WHO and GWCL standards. The results of presence of E-coli bacteria in the treated effluent from the RH suggest presence of the bacteria from the samples as E-coli recorded 9 and in comparison with WHO and GWCL, do not meet their standards. Total coliform and Feecal coliform results indicate environmental pollution. The results confirmed presence of E. coli bacteria which indicates presence of infectious microorganisms in the water. Results obtained from the laboratory shows that large amount of heterotrophic bacteria (i.e. 1292) presence in the sample collected from the RH for testing. In comparison with WHO standard of 0 and GWCL of 500, the results clearly far exceed the acceptable limits.

The results from the sample taken from the sedimentation pool shared by MH and S.D.A showed 84 for Total coliform bacteria and 46 for Feecal coliform exceeding the recommended WHO and GWCL standards. The finding is an indication of bacteria presence in the sample carried from the sedimentation pool. The results obtained from the samples carried indicates presence of large of amount of E- Coli bacteria in the sample by recording 38 which is above WHO and GWCL standards of 0 and 0 respectively for MH and S.D.A. Results obtained from testing heterotrophic bacteria showed large amount of heterotrophic bacteria presence (i.e. 4525) in the sample collected which in comparison to WHO and GWCL higher than the standards of 0 (WHO) and GWCL (500).

Hospital	Total coliform	Feecal coliform	E-coli	Heterotrophic Bactria
RH	18	16	9	1292
MHI	84	46	38	4525
S.D.A	84	46	38	4525
WHO	0	0	0	0
GWC	0	0	0	500

## DISCUSSION

The study observed that the two most common type of liquid waste generated in the health care facilities in the Sunyani Municipality are Pathological waste and Infectious waste. The clinical liquid wastes are generated by the health workers such as doctors, nurses and veterinary officers and on the other hand from the patients which is the out- patients and the in-patients as well as the visitors. The findings from this study indicate that the quantities of liquid waste generated at the three surveyed hospitals depend on type and size of the hospital, number of patients and type of services rendered as they constitute the factors that explains significantly liquid waste generation rate. This findings is in line with clinical waste generate rate in Chen et al., (2009) and Abd El-Salam (2010). RH generates the highest clinical liquid waste than MH and S.D.A hospitals because RH serves as a teaching facility as well as referral hospital which receive a lot of patients from other healthcare facilities in Sunyani Municipality and surrounding districts. The waste generated by municipal hospitals and S.D.A. are explained by their size in terms of number of bed and number of patients visits. The daily clinical liquid waste generation rates for the three hospitals were consistent with past studies for developing countries and largely explained by the explained by their size in terms of number of bed and number of patients' visits as well as the type of health services provided by the facility.

The results findings found that the Pharmacy does not generate pathological waste because it's a place for storing and processing patients' drugs prescription. The low liquid waste generation rate in the clinics is attributed to the fact that the clinics in both the Regional (RH) and Municipal hospitals (MH) do not admit patients but rather diagnose their sickness/illness, treats and discharges the patients on the same day. Also, the clinics operate 8 hours daily and five days a week unlike the main hospitals where patients are admitted and operate on a 24 hour basis. The Allied department is combination of the kitchen, workshop and the laundry, and basically no pathological waste comes from this department because of the nature of the duties that's washing for the laundry, cooking for the Kitchen and storing of equipment, tools and materials meant for the Workshop. The S.D.A. hospital does not have a clinic and mortuary and thus explains why they don't generate both pathological and infectious disease. The findings from the Laboratory indicates it generates both low pathological and infectious waste as the laboratory is the place where experiments and series of test done but most of the surgeries do not go on in the laboratory but samples of blood are taken for the test. The size of the facility in terms of patients' visits as well as the type of test to be conducted determines the waste generation rate.

The findings suggest the wards generate the highest proportion of infectious waste in all three sampled hospitals. The ward is the place where in-patients are admitted to receive medical care. It is the ward size in terms of bed occupancy that tends to explain the size of a health facility in this municipality. On the hand, the operating theater where surgical operation in the health care facility takes place on in-patients that are to be operated on generates the highest pathological waste. Pathological waste from as tissues, organs, body parts, human fetuses and animal carcasses, blood and body fluids are generated in this department. The mortuary is where the dead bodies are been kept and preserved until the time and day of burier and is the second palace where both pathological and infectious waste are generated from as a results of autopsy made at this department and during autopsy many tissues are been removed from the body.

One of the specific aims of this study was to identify the current clinical liquid waste management strategies used by health facilities in Sunyani Municipality, Ghana. The result of waste segregation and collection practice in the selected hospitals were within Ghana Health Service and WHO standards as well as recommended best practice worldwide. The RH has a conventional treatment plant with varying size and have liquid waste from the different department which are collected, segregated and handled from source. The pathological and infectious waste passes through a different pipe line into the treatment facility. The liquid waste segregation and collection methods practice in all three selected hospitals could be explained by a strong internal administrative policy and Ghana Health Service guidelines for establishing a health facility.

However, some challenges remain significantly in the way both pathological and infectious wastes are stabilized in the sampled health facilities. The short-comings were associated with the level of treatment and disposal of liquid waste. The MH and S.D.A liquid waste do not receive any pre-treatment. From the study observation the sedimentation pool is open to air or expose to the atmosphere for the bacteria in the liquid waste to die due to the temperature acting on it. Base on the results of the sample collected from sampled hospitals, it is confirmed that there is the presence of large amount of total coliform bacteria, fecal coliform bacteria, E-coli and heterotrophic bacteria that far exceed the country's and international standards. The

findings suggest an environment problem due to the contamination of treated effluent from the sampled hospitals which are used for agricultural irrigational purposes, drinking and cooking.

In the case of RH, the treated wastewater effluents are discharged into a nearby stream which is mostly used for irrigational purposes and most instances stray animals drink from it. Villages downstream along the stream (not connected to the GWCL service pipeline) depend on the stream for cooking and drinking water. The poor treatment of the liquid waste from RH may be attributed to the serious power outage experienced in the country.

For MH and S.D.A. hospitals results showed a very high contamination and a problem to the environment because there are a lot of settlement around the sedimentation pool and there is a huge refuse dump also around, this is very dangerous to the inhabitants around the sedimentation pool because flies can go and sit on it and then sit on their foods and drinking waters, and this can also permeate into the ground water. Potential health effects include gastroenteric infections and diseases due to presence of faecal coliform and E-coli.

Nonetheless, further research is required to determine whether reasons such as season of the year, land encroachment which has destroyed some vital plants around the natural system and human settlement close to the natural system is blamed for the poor land treatment of liquid waste.

## CONCLUSIONS

Regardless of the potential health implication of handling, treatment and disposal of clinical waste poses to humanity and environmental at large, the study identified shortcomings associated with the current clinical liquid waste management process in three selected hospitals in the Sunyani Municipal Assembly of Ghana. The shortcomings basically are found in the treatment of liquid waste which do not comply with WHO and Ghana Health Service Sanitation Act. This could partly be attributed to insufficient education/awareness campaigns of health implication associated with exposure to clinical liquid waste. Clinical liquid waste management standards and best practices in treatment were not appropriately applied check after treatment before disposal into water bodies.

## Future Research

The sample collection for microbial analysis was relatively small and analysis was limited to only dry season for MH and S.D.A and in the case of RH, period of power outage that could explain the results obtained in Sunyani Municipality. Thus the results could not be used to generalize the entire healthcare facilities in Ghana. The study recommends further studies to increase sample size and coverage to include other public and private hospitals where infrastructural facilities and certain differ. Also, a further research should be conducted to include modeling seasonal variation and period of reliable power supply to ascertain clinical liquid waste treatments in the municipality.

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