Hospital wastewater physico-chemical and biological characteristics in the Coastal Zone Hospitals of Tanzania: A case of Muhimbili and Tumbi Hospitals

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ABSTRACT
Hospitals wastewater contains a wide range of contaminants which may pose potential risks to the environment, public health and ecological damage. However, knowledge on the extent to which the hospital wastewater is contaminated in Tanzania is still limited. The study aimed to investigate the quality of hospital wastewaters discharged from Muhimbili national (MNH) and Tumbi regional referral (TRH) hospitals. Eight sampling points were established and sampled in triplicates at each of the two hospitals and analyzed for physical, chemical and biological parameters following the standard methods as presented in APHA-AWWA-WEF (1998) and TZS 860:2005. The results showed that pH, electric conductivity, total dissolved solids, cadmium, chromium, zinc and Nickel are within Tanzania Standards. However, MNH, PO4 NO_3 Pb and COD quality exceed the Tanzania standards. The COD ranged from 53 mg/l to 776 mg/l and 92 mg/l to 1099 mg/l for MNH and TRH, respectively. The COD has value higher than permissible level of 60 mg/l. Bacteriological results indicated that hospital wastewater is contaminated with pathogenic microorganisms. Faecal coliform (FC) and total coliform (TC) for MNH ranged from 5-23 x 10^6 cfu/100ml and 14 - 41 x 10^6 cfu/100ml, respectively, while FC and TC ranged from 0.5 - 4x10^6 cfu/100 ml and 0.5-9 x 10^6 cfu/100ml for wastewater from TRH. The results of FC and TC from both hospitals are far higher than the allowable standard as specified in Tanzania standard (TZS 860:2005) which limits to 0.01x10^6 cfu/100ml, which may render the human health and other ecosystems. The hospital wastewater is polluted physically, chemically and biologically which need treatment before disposal in order to protect human health and another ecosystems' life.

Keywords: *Hospital wastewater, quality, characteristic, contaminants*

INTRODUCTION

Wastewater emanating from hospitals, health centres and dispensaries contain parameters of complex mixtures of organic and inorganic matter including pharmaceuticals, radionuclides, detergents, antibiotics, antiseptics, surfactants, solvents, medical drugs, heavy metals, radioactive substances and pathogenic organisms (Emmanuel *et al,* 2005, Mesdaghinia*et al,* 2009, Akin, 2016*).* Paulus *et al.,* (2019) reported that hospital wastewater contains antibiotic and antibiotic resistance gene (ARG) concentrations. Carraro *et al* (2017) reported that hospital wastewater contains chemical, biological, and physical constituents that can risk public and environmental health. The particular attention is on the biological constituents since they have relatively high potential of occurrence in hospital wastewater with respect to other constituents.

Jenssen *et al,* (2004) reported that water supply and sanitation are cornerstones of public health as well as social and economic well-being. Sanitary and industrial wastewater are derived principally from the water supply which ranges from 70% to 130% of the water consumed (McGhee, 1991). McGhee (1991) further argued that it is fairly in some of the community to assume that the average rate of sewage flow is equal to the average rate of the water consumption. This assumption goes hand to hand with the hospital wastewater in which most of the food for patients is brought from homes and patients together with family members visiting patients at the hospitals usually drink bottled water. Under this condition, the supplied water is used for other uses like washing (20-40%), processing activities (15-40%) and kitchen activities (5-25%) (D'Alessandro *et al*, 2016). In that situation, it is possible to assume that most of water supply in hospital about 80% is turned into wastewater (Kumarathilaka, 2015). Sanitary sewage for example, it typically consistswashing water, organic matter, urine, as well as laundry wastewater and other liquid or semi-liquid wastes (URT, 2007).

Wastewater discharge from hospitals is currently gaining attention in many countries due to its composition and concentration of its constituents as stated by Carraro *et al,* (2017). According to Carraro*et al* (2017), the hospital wastewater gains attention because it contains substances that are hazardous for example pharmaceutical residues, chemical substances, pathogens, and radioactive. Studies (Kumarathilaka, 2015) have shown that hospitals consume large amount of water per day ranging between 400 to 1200 litres of which more than 80% is generated as wastewater. According to Tait and Dipper (1998), raw sewage from hospitals may contain large quantities of metals such as arsenic, cadmium, copper, mercury and lead as well as organic matter, petroleum products, fats, solvents and dyes. Due to the presence of heavy metals in the hospital wastewater and if not treated before discharged into the water bodies, may pose risk to anyone exposed to water contaminated with wastewater from hospitals. In hospitals, the wastewater originates from different sections of the hospital such as laboratories, surgery units, patient wards, and intensive care units (ICU), laundries and clinical wards. Therefore, the wastewater from hospital contains a wide range of contaminants depending on the activities in each generating unit. Because of many various origins, the composition of wastewater from hospitals consist of complex mixtures of organic and inorganic matter including pharmaceuticals, detergents, antibiotics, antiseptics, surfactants, solvents, medical drugs, heavy metals, radioactive substances and microorganisms (Prayitno *et al.,* 2013 and Kumarathilaka *et al.,* 2015). Furthermore, Amouei *et al.,* (2012) argued that wastewater from hospitals contains pathogenic organisms and hazardous constituents which may adversely affect the environment, biodiversity and public health exposed to this kind of wastewater. The presence of hospital wastewater in municipal wastewater treatment plants affects its performance by lowing treatment efficiency (Kaseva *et al*., 2008). This condition poses a challenge on how to improve livelihood for people through management of hospital wastewater and protect the environment, which is likely, to be contaminated/polluted by hospital wastewater in Tanzania. Since hospitals wastewater contains a wide range of contaminants which may pose potential risks to the environment, public health and ecological damage. However, knowledge on the extent to which the hospital wastewater is contaminated in Tanzania is still limited. The study aimed to investigate the quality of hospital wastewaters discharged from Muhimbili national (MNH) and Tumbi regional referral (TRH) hospitals that located in coastal zone of Tanzania and their health implications. The quality parameters analyzed were assessed against the Tanzanian standard to determine their compliance. The result of this study would inform on the proper management of hospital wastewater to safeguard public health, ecosystem, social and economic well-being in Tanzania.

MATERIALS AND METHODS

This section presents the materials and methods applied for data collection and analysis in this paper. The subsections include the case study area description, wastewater samples and sampling techniques, laboratory wastewater testing and analysis methods and procedures.

Description of the case study areas

The study was conducted at Muhimbili National Hospital (MNH) in Dar es Salaam and Tumbi Regional Referral Hospital (TRH) in Kibaha. The two hospitals were purposively selected based on the fact that they have wastewater management infrastructures, serve large number of people and are located in the coastal zone which was the target area for this study.

Muhimbili National Hospital (MNH) is located in Dar es Salaam City. It is a National Referral Hospital which receives approximately 2700 patients per week of which 1500 are in patients and 1200 out patients. In addition to hospital service, there is also an academic institution as an integral part of the hospital called Muhimbili University of Health and Allied Sciences (MUHAS). The hospital has approximately 2,866 employees and 840 students. The hospital is estimated to accommodate 8000 people every day. MNH is organized into 7 directorates which include clinical services, nursing services and quality, clinical support services, human resources, finance and planning, technical services, and information & communications technology directorates. The hospital gets water service from 2 main water sources namely groundwater and surface water sources. Groundwater source is found *in-situ* while the surface water is supplied by the Dar es Salaam Water Supply and Sanitation Authority (DAWASA). The total water demand is estimated to be 2500 m^3/day while, the water supply is estimated to be 2295 m^3/day. This condition makes 215 m^3/day (8.2%) water deficits. However, most of patients, doctors, nurses and attendants use bottled water for drinking. If we consider that everyone drinks 3 litres per day (bottled water), this gives 8.1 m^3/day of water added. It is estimated that the use of bottled water can reduce the water deficit by almost 8%at MNH to complement the water supply from Utilities. This condition may be the same as other hospitals and other health facilities like TRH. Almost all water supplied to the hospital functions turns into wastewater except that used for domestic activities of which 80% of water supplied becomes wastewater. With this situation, wastewater generated at MNH may be estimated to be 1836 m^3/day. This amount of wastewater is collected in the sewerage system that combines with wastewater from MUHASat one of the inspection chambers located near to the DAWASA wastewater pumping station.

Tumbi Regional Referral hospital (TRH) is located in Kibaha district, Coastal region about 40 km west of Dar es Salaam city. The hospital is located within Kibaha Education Centre (KEC).KEC is composed of Tumbi hospital, Kibaha secondary school, Nurse and Clinical officer training institutes and staff houses as well as student hostels. The institution gets water from the DAWASA and in-campus boreholes. The KEC like MNH has wastewater management infrastructures for collection, transportation and treatment. The treatment plant also receives faecal sludge from Kibaha area and the Soga Standard Gauge Railway camp.

Collection of wastewater samples at the hospitals

Sampling points were purposefully located at each of the two hospitals to generate information on the characteristics of wastewater from wards, theatres, mortuary, OPD and central wastewater treatment plants. At each hospital, eight (8) sampling points were established along the wastewater collection network based on the source of wastewater including medical wards, outpatients and pharmaceutical building, offices and laboratories and residential buildings. The residential buildings include the students' hostels, and staff houses as presented in Table 1. The samples were collected in triplicates at each of the sampling location and analyzed in the laboratory at Ardhi University.

Table 1: Description of sampling locations for the16wastewater samples at MNH and TRH

Name of Hospital	Sampling point code	Description	Remarks
Muhimbili National Hospital	MNH-1	Wastewater from wards	Mostly originated from food remains, sewage, and medical wastes.
	MNH-2	Wastewater from wards and physiotherapy clinic together with administration block.	
	MNH-3	Wastewater from kitchen, laundry and mortuary	Mostly originated from food remains, detergents and medical wastes.
	MNH-4	Combined wastewater from laboratory and blood banks	Mostly originated from chemical and medical waste.
	MNH-5	Wastewater originated from residential, hall of residence, church, mosque and MOI	Mostly contains sewage, food remains, chemical and medical waste
	MNH-6	Combined wastewater from MNH before mixed with those discharged from MUHAS	
	MNH-7	Combined wastewater from MNH and MUHAS	
	MNH-8	Contains wastewater that by-pass from MNH-7.	It (wastewater) is directly discharged into Msimbazi river.
Tumbi Regional Referral Hospital	TRH-1	Wastewater from OPD and hospital offices, wards and mortuary	Mostly contains sewage, food remains and chemical
	TRH-2	Wastewater from Tumbi health training institute, staff quarters, student dormitories, kitchen, public toilets and offices.	
	TRH-3	Wastewater from laboratory, theatre, and mother and child wards	

	TRH-4	Wastewater from private wards, maternity wards and general wards.	Mostly contains sewage, food remains, chemical and medical waste
	TRH-5	Combined wastewater from hospital buildings and buildings of Tumbi health training institute (TRH-1 to TRH-4)	
	TRH-6	Combined wastewater as influent of the WSP (TRH-5 and stream of sludge discharge point Combined wastewater)	
	TRH-7	Effluent from WSP	TSS, TDS, BOD, COB and dissolved chemicals
	TRH-8	Effluent discharged to the agricultural field	

Laboratory testing and analysis

The wastewater samples from Muhimbili National hospital (MNH) and Tumbi Regional Referral hospital (TRH) were collected and analyzed following standard methods as prescribed in Standard Methods for the Examination of Water and Wastewater APHA-AWWA-WEF (1998) and TZS 860:2005. The physical, chemical and biological parameters were analyzed to determine the quality of hospital wastewater. As stated before, the samples were analyzed at Ardhi University laboratory for physical, chemical and biological parameters. The hospital wastewater quality parameters analyzed include Faecal and Total coliforms, Streptococcus, Salmonella as bacterial parameters. Others parameters include pH, electric conductivity (EC), total dissolved solids (TDS), temperature, colour, nitrate-nitrogen, phosphorus, sulphate, chemical oxygen demand (COD) as chemical parameters. Heavy metals were also analyzed including: lead (Pb), copper (Cu), Zinc (Zn), Chromium (Cr) and nickel (Ni). The analysis of these parameters was in line with what was carried out by Mesdaghinia *et al (*2009) who quantified and qualified hospital wastewater of Tehran University of Medial Sciences by analyzing the Physical, chemical and biological parameters such as pH, total suspended solids (TSS), biological oxygen demand (BOD_5), chemical oxygen demand (COD) and total coliforms.

RESULTS AND DISCUSSION

Hospital wastewater characterization

The physical, chemical and biological characteristics of hospital wastewater sourced from Muhimbili National Hospital and Tumbi Regional Referral Hospitals are presented in the subsequent sections

Physical wastewater characteristics

The physical wastewater characteristics analyzed from Muhimbili National Hospital and Tumbi Regional Referral Hospitals include pH, colour, electric conductivity (EC) and total dissolved solids (TDS). The results and discussions are presented in the subsequent sections

pH value

The pH results for wastewater at MNH and TRH are presented in Figure 1. The pH values ranged from 6.79 to 7.35 and 7.0 to 7.6 for wastewaters from MNH and TRH respectively. The results showed that wastewater discharged from both hospitals is within the acceptable Tanzanian Standards of Municipal and Industrial Wastewater (TZS 860:2005) which ranges from 6.5 to 8.5. Since pH is an indicator for the degree of chemical contaminants whether acidic or alkaline, the results indicate that the hospital wastewater at MNH and TRH are relatively neutral. This suggests that organic matter and pharmaceuticals (chemical in nature) are likely to be the dominant constituents in the hospital wastewaters. The organic waste may be originating from residential area including staff residents, student hostels and wards, while, chemical wastes (pharmaceuticals) may be originating from wards, theatres, and OPD. The wastewater characteristics indicate that the quality of hospital wastewater is relatively similar to the domestic wastewater quality as reported by Abd l-Gawad and Aly (2011). On the basis of these findings, it can be concluded that hospital wastewater can be treated biologically like municipal wastewater to produce effluent that can be released in the environment without adverse impacts subject to further confirmation.

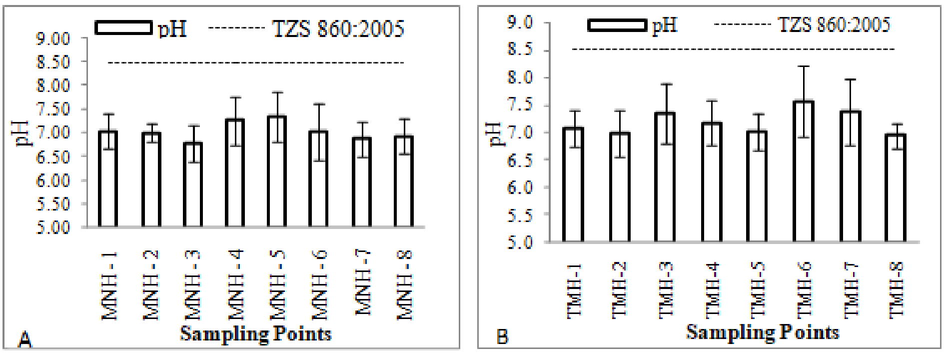

Figure 1: pH values for wastewater from (A) MNH and (B) TRH at different sampling locations

Electric conductivity and total dissolved solids

The electric conductivity (EC) results for both hospitals are presented in Figure 2. The results show that in MNH, the EC ranges from 500 µS/cm to 1000 µS/cm while, in TRH ranges from 500 µS/cm to 2000 µS/cm. Since, Electric conductivity (EC) is a measure of the ability of water to conduct electricity; it is sensitive to variations in dissolved solids, mostly mineral salts like chloride and sodium (Chapman and Kimstach, 1996). These results indicate that the wastewater at TRH is more polluted by mineral salts because its (EC) value exceeds 1000 µS/cm (Rusydi, 2018; Malandi *et al.,* 2013; Chapman and Kimstach, 1996). The results are in line with what was observed at both hospitals which indicated that the wastewater is composed of mixture of wastewaterfrom staff houses students' hostels and hospital operations and wards. The wastewater treatment plant at TRH is also receiving faecal sludge from a nearby workers construction camp. The camp accommodates more than 200 people who are workers at a standard gauge railway line (SGR) in Tanzania. Additionally, EC is an indicator of mineral content and hence used to establish a pollution zones in water surface when the value of EC exceeds the maximum allowable concentration value of 1000 µS/cm (Rusydi, 2018; Malandi *et al.,* 2013; Chapman and Kimstach, 1996). From these results, it can be concluded that hospital wastewater from TRH is highly polluted by mineral salts compared to those discharged from MNH and therefore the hospital wastewater especially from TRH should be treated before its dischargedirectly into water bodies.

Furthermore, Rusydi (2018) and Chapman and Kimstart (1996) described the relationship between electric conductivity (EC) and total dissolved solids (TDS) in ratios as ranging between 0.55 and 0.75 thought not always linear. When the ratio is close to 0.67, it implies that the water/wastewater is mainly dominated with sodium and chloride (domestic wastewater), and higher values imply high concentration of sulphate (Rusydi, 2018; Chapman and Kimstart, 1996). The results show that at MNH and TRH, the TDS ranges from 301 mg/l to 492 mg/l and 333 mg/l to 1030 mg/l, respectively. The ratio between TDS and EC ranges from 0.49 to 0.60 for MNH and 0.51 to 0.67 for TRH wastewaters. These ratios suggest that the hospital wastewater from TRH is rich in mineral salts like sodium and chloride than MNH, which seems to have relatively low mineral salts probably due to mixing of wastewater from hospital and university premises. These wastewaters mixing at MNH suggests that their possibility of dilution and hence reduce mineral salts concentration than those discharged from TRH.

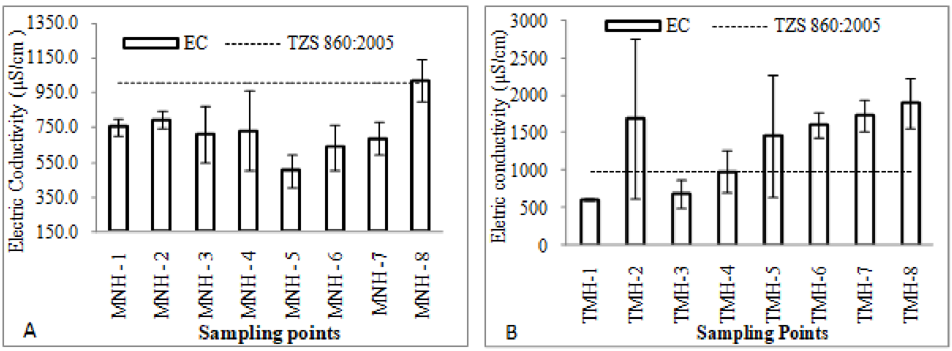

Figure 2: Electric Conductivity for wastewater from (A) MNH and (B) TRH at different sampling locations

Colour

According to laboratory testing and analysis, the color results of hospital wastewater at MNH show that the colour values ranged from 98.3 MgPt/L to 350.3MgPt/L. The results are relatively within TZS 860:2005 permissible value of 300 MgPt/L except 2 (25%) out of 8 sampling locations at MNH had colour values beyond the permissible limit. Since the sampling was carried during dry-season, there was no influence of storm water and therefore the results represent the true colour of hospital wastewater at MNH. These results indicate that most of constituents in hospital wastewater have less effect on the colour of wastewater. The results therefore reveal that the hospital wastewater requires treatment prior to disposal. This practice will ensure the effluent from hospital wastewater treatment plant is clean and therefore will not pollute the ecosystem in its discharge.

Nitrate and phosphate concentrations

Phosphate concentrations

The results for phosphate (PO_4) concentrations are as presented in Figure 3 which indicate that wastewater at MNH has phosphate concentration which range between 10 mg/l to 25 mg/l while it ranges from 30 mg/l to 90 mg/l at TRH. The levels of phosphate are higher than the acceptable (6mg/l) as specified in TZS 860:2005. This indicates that the wastewater discharged from some hospitals is rich in phosphates probably due to extensive use of detergents in cleaning operations plus wastewater from residential houses and student hostels. However, it was found that the levels of phosphate were higher for wastewater at TRH compared to MNH wastewater. Higher phosphate content for wastewater at TRH may be associated with lower dilution as compared to MNH where generation rate of wastewater is high. Furthermore, at the wastewater treatment plant at TRH, there is a disposal of faecal sludge from Kibaha area and the Soga SGR camp as observed during fieldwork, which could be another contributor of high phosphate level at TRH. Additionally, the results conform with the feedback received during interview with hospital management, which showed that TRH is one of the components of the special project that comprised of schools, medical college and residential houses for staff and students' hostels and hence the wastewater from TRH is well mixed with various sources of wastewater compared to that from MNH. Furthermore, the variation of phosphate in the wastewater at TRH was very high as indicated by the error bars, which is an indication of inconsistence of Phosphate concentration in the wastewater and may be associated with wastewater generation from multiple sources. Additionally, these results suggest that the hospital wastewaters from two hospitals that represent other hospitals in Tanzania should be treated before discharge into water bodies in order to protect the environment against eutrophication and generation of algae toxins that can harm human and animal health (EPA, 2020).

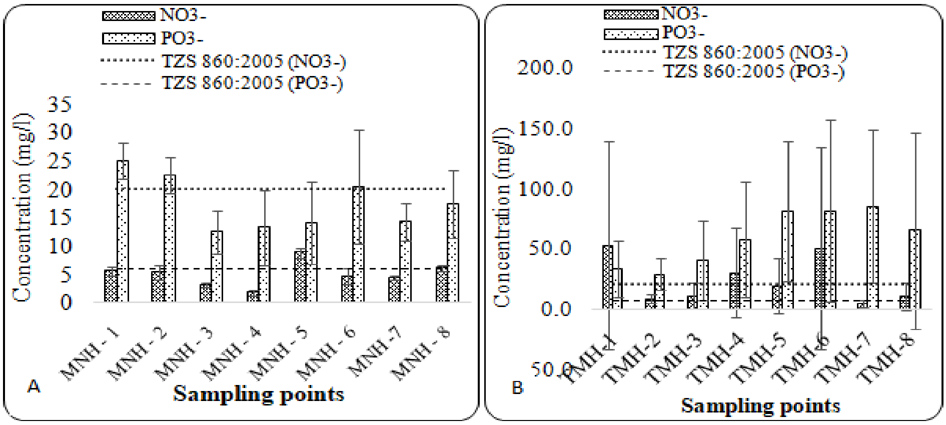

Figure 3: Nitrate and phosphate concentrations for wastewater from A) MNH and B) TRH at different sampling locations

Nitrate concentration

The results for concentrations of Nitrate for wastewater at MNH and TRH are presented in Figure 3. The concentrations of nitrate (NO_3) for wastewater at MNH ranged from 2 mg/l to 10 mg/l while for wastewater at TRH ranged from 2 mg/l to 55 mg/l. The results show that the NO_3 concentrations for wastewater from different source at MNH were below the acceptable level of TZS 860:2005, which stipulates that the NO_3 concentration should be not more than 20 mg/l for effluents discharged to the receiving water bodies. For wastewater at TRH, the concentrations ranged from 4.1mg/L to 52.7mg/L. The results show that wastewater from hospital operations (TMN-2 and TRH-3) had low NO_3 concentration compared to the wastewater from students' hostels and staff houses (TRH-1) and at a point where all wastewater combines(TRH-4). The NO_3 concentration for wastewater from students' hostels and staff houses was above to 20 mg/l that is acceptable level as specified in the TZS 860:2005 which suggests that the wastewater is rich in organic matter from human excreta. When wastewater from hospital operations is mixed with wastewater from residential houses it becomes rich in organic constituents and nutrients; and may have direct environmental and public health problems especially eutrophication and blue baby syndrome respectively if discharged to the environment without adequate treatment.

Chemical oxygen demand concentration

The results for concentration of chemical oxygen demand (COD) for wastewater at MNH and TRH are presented in Figure 4. The results show that the concentrations of COD ranged from 53mg/l to 776 mg/l for wastewater at MNH and 92mg/l to 1099mg/l for wastewater at TRH. The COD concentration for both hospitals is higher than the acceptable level as specified in the TZS 860:2005of 60 mg/l. This condition indicates that both hospital wastewaters contain higher chemical constituents which end up polluting the wastewater discharge and therefore require treatment before final disposal.

These COD concentration results reveal that hospitals wastewater originated from pharmaceuticals, laboratories, wards, mortuaries, laundries, offices and others which contribute to chemical ingredients of the wastewater emanating from hospitals (Carraro *et al*, 2017). The chemicals in the wastewater affect the treatability of wastewater by biological methods and may necessitate appropriate chemical treatment technologies prior to discharge into the receiving environment. The hospital wastewater can be treated to reduce COD by using Coagulation method, which was found to reduce the COD concentration by 64% (Gautam *et al.,* 2007).

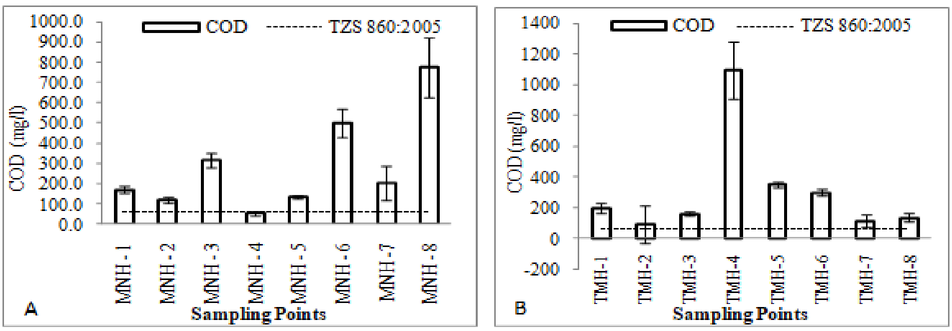

Figure 4: COD concentration for wastewaters at A) MNH and B) TRH

Heavy metals concentrations

Different heavy metals were analyzed for all samples from MNH and TRH following standard methods as presented in the laboratory testing and analysis section. The results are presented in the subsequent sections.

Lead concentration

The results for concentration of Lead (Pb) for wastewater at MNH and TRH are presented in Figure 5. The results show that wastewater from different sources for both hospitals have low concentration of lead (Pb) and below the level specified in TZS 860:2005 (i.e., 0.01 mg/l). Exceptions of relatively high concentrations of lead were observed for two sampling locations at MNH on MNH-5 and MNH-7, which represent combined wastewater from the hospital, student hostels, staff houses and Muhimbili University of Health and Allied Sciences (MUHAS). The high levels of lead at the two sampling locations may be associated with the use of unregulated cosmetics (WHO, 2020) in the student hostels and staff houses that eventually get into the wastewater streams through the bathrooms and laundries. Therefore, on the bases of the results from this study it may be deduced that hospital operations do not contribute significantly to the generation Lead (Pb) in the wastewater.

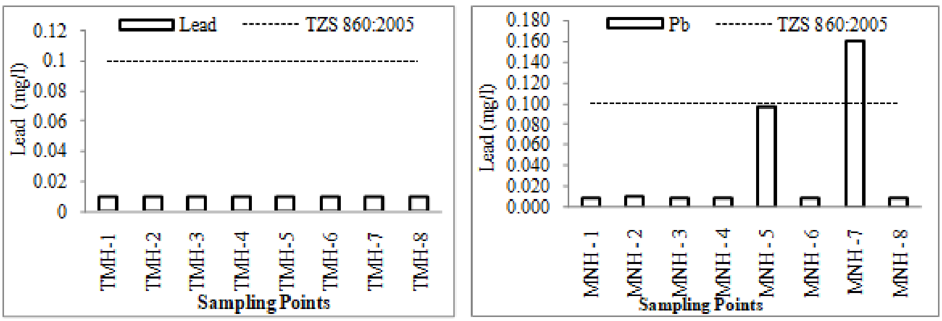

Figure 5 Lead (Pd) concentration for wastewater at A) MNH and B) TRH

Copper, zinc, chromium, cadmium and nickel concentrations

The laboratory results for other heavy metals such as copper, zinc, chromium, cadmium and nickel show that all heavy metals from both hospitals (MNH and TRH) were within the allowable values as specified in TZS 860:2005. More specifically, copper concentration ranged from 0.01mg/l to 0.06mg/l for wastewater from both hospitals, which are within the permissible level set at 2 mg/l (TZS 860:2005). The concentrations for zinc ranged from ≤0.01 mg/l to 0.37 mg/l for wastewater from both hospitals, which are within 5 mg/l as acceptable amount (TZS 860:2005). The concentrations for chromium and Cadmium were below the detection limit (≤ 0.01 mg/l) at all sampling locations while the permissible level is set at 1.0mg/l. The results of cadmium and nickel and TRH have the same trend in which their concentrations are within the allowable levels according to TZS 860:2005. These results suggest that hospital operations do not contribute significantly to the generation of most heavy metals that get into the wastewater streams. On the basis of these results, it may be deduced that wastewater from hospitals has less heavy metals contribution to the effluent receiving environment. These results are in agreements with findings from hospital wastewater in Turkey as presented by Akin (2016). His results show that Cd, Zn, Cu, Ni, and Cr concentrations were within the acceptable limits allowable for direct discharge into the water bodies in Turkey.Even though the concentrations of most heavy metals were found to be within the acceptable limit, still it is not recommended to discharge the hospital wastewater direct to the water bodies' prior treatment. The reason is that the continuous discharge of the raw hospital wastewater without treatment will result to the accumulation of these heavy metals in the discharged water bodies. Consequently, this direct discharge and disposal without treatment of hospital wastewater will eventually result into adverse impacts to the environment as well as human health. It can be therefore concluded that the hospital wastewater treatment is vital before being discharged into water bodies and/or land for its ultimate disposal.

Biological contaminants

The results for concentration of faecal coliform (FC) and total coliform (TC) for wastewater at MNH and TRH are presented in Figure 6. The results show that at MNH feacal coliform (FC) and total coliform (TC) ranges from 5-23 x 10^6cfu/100ml and from 14-41 x 10^6cfu/100ml respectively. At TRH the concentration of faecal coliform (FC) and total coliform (TC) ranges from 0.5-4x10^6cfu/100ml and 0.5-9 x 10^6cfu/100ml respectively. The results of FC and TC for both hospitals are far higher than the allowable standard as specified in Tanzania standard (TZS 860:2005) which stands at 0.01x10^6cfu/100ml. The FC and TC results show that the hospital wastewater is highly polluted with pathogenic organisms, which may render the human health and other ecosystems. In addition, the Salmonella results of up to 10 count/ml for MNH and 35 count/ml for TRH confirms that the hospital wastewater in Tanzania is contaminated by pathogenic organisms similar to the report by Liu *et al* (2018). The results suggest that treatment is necessary for wastewater before discharging the wastewater to the environment. During field visit, it was observed that that the wastewater generated from MNH was directly discharged into the Msimbazi River and then to Indian Ocean before pre-treatment. This discharge practice endangers public health.

At TRH, there is a WSP, which is used for wastewater treatment. However, some technical faults like blockage of sewer line was observed at combination chamber (TRH-4) which leads to overflow of wastewater to the forest. Since the TRH wastewater demonstrated pollution with pathogenic biological microorganism, the continuing overflow to the land surface and spread on the nearby surrounding to the human settlement may risks the human health (Alm *et al*, 2014). It is therefore, recommended that both hospitals should treat the wastewater before discharge to the environment to safeguard public health.

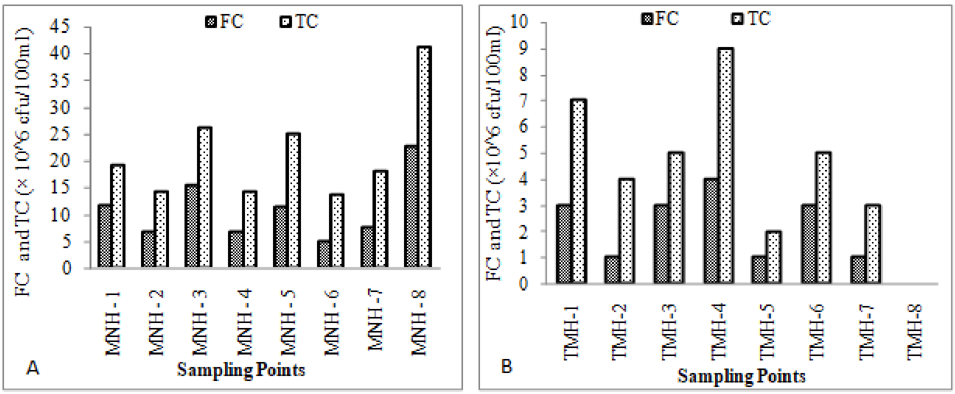

Figure 6: Faecal and Total coliforms present in the wastewater from A) MNH and B) TRH

CONCLUSIONS

This study concludes that the hospital wastewaters from both NMH and TRH hospitals are physically, chemically and biologically contaminated. The laboratory analysis results reveal that wastewater from hospitals located in Coastal Zone of Tanzania focusing to NMH and TRH hospitals is polluted with pathogenic organisms which may render the human health and other ecosystems if discharged directly to the water bodies and environment without proper treatment. Furthermore, the continuous discharge of hospital wastewater into water body prior treatment will result in accumulation of heavy metal and hence render the public health. The hospital wastewater pollutes the environment when they are discharged directly to the environment prior treatment. It is therefore recommended that treatment of hospital wastewater from NMH and TRH hospitals is important in order to safeguard the ecological system which may be affected if the hospital wastewater is discharging into the water bodies and environment in general without treatment.

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Ethical consideration
This study was conducted by observing ethical issues which include applying and securing ethical clearance from the National Institute for Medical Research (NIMR), Tanzania with a certificate number NIMR/HQ/R.8a/Vol.IX/2648. Consents of the participants were first requested prior to willful participation.

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