

## RESEARCH ARTICLE

## POTENTIAL RISKS ASSOCIATED WITH MISMANAGEMENT OF HOSPITAL WASTEWATER IN TANZANIA

Shadrack Mwita Sabai

Department of Civil and Environmental Engineering, Ardhi University, Dar es Salaam, Tanzania

\*Corresponding Author Email: [shadrack.sabai@aru.ac.tz](mailto:shadrack.sabai@aru.ac.tz)

This is an open access article distributed under the Creative Commons Attribution License CC BY 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

## ARTICLE DETAILS

## Article History:

Received 03 June 2023  
Revised 09 August 2023  
Accepted 13 September 2023  
Available online 15 September 2023

## ABSTRACT

Hospital wastewater is harmful to the environment and public health if inadequately managed. Mismanagement of hospital wastewater pollutes soil, aquatic environments and spread infectious diseases that put public into health risks. Regardless on the toxicity of hospital wastewater, there are limited information on the impact of hospital wastewater mismanagement to the environment and surrounding community in the developing countries. This study aims to investigate the potential impacts of hospital wastewater mismanagement to the environment and surrounding community in Tanzania. Sixteen wastewater samples were collected from two national and regional referral hospitals in Tanzania using random stratified sampling technique. Chemical and biological parameters were analyzed in the laboratory following the standard methods from APHA-AWWA-WEF (1998). Thirty hospital cleaners, ten sewer attendants, thirty neighbouring community and ten hospital officials were interviewed to determine their level of awareness and measures taken to protect themselves against contamination. The results show that effluents discharged into water bodies has high concentrations of organic matters and pathogenic bacteria ( $0.5 - 23 \times 10^6$  cfu/100 ml). These results reveal that hospitals discharge is highly polluted and hence puts aquatic organisms and downstream water users into risks. Furthermore, 94% of interviewed were knowledgeable and the surrounding community was aware on the effects emanated from mismanagement of hospital wastewaters. This understanding is important for them to protect themselves however cannot safeguard aquatic ecosystems and downstream water users. Therefore, treatment of hospital wastewater with appropriate *state-of-the-arts* is required before discharging into the receiving water streams which is in line SDG 6.

## KEYWORDS

Hospital Wastewater, Mismanagement, Pollution. Public Health, Risks, Wastewater Management

## 1. INTRODUCTION

Hospitals are health facilities that produce waste of different kinds. Generally, hospital waste (liquid, solid or air form) can be categorized as a risk waste, non-risk waste, infectious waste, pathological waste, genotoxic waste, chemical waste and radioactive waste (Ali et al. 2017). The hospital wastewater is mostly loaded with pathogenic microorganisms, heavy metals, toxic chemicals, and radioactive elements and antibiotic resistant bacteria which are harmful to the environment and human health (Kumari et al., 2020, Kumarathilaka, 2015; Gautam et al., 2007; Rozman et al. 2020).

Wastewater discharge from hospitals is gaining attention in many countries due to its composition and concentration of its constituents. According to hospital wastewater contains various pharmaceuticals and pathogens which if it is improperly managed and leak to the environment that can risks life of microorganisms, organism, and human being (Zhang et al., 2020). Investigated on the hospital clinical laboratory wastewater and the pollution loads in Turkey (Akin, 2016). Has a studied on the presence of pharmaceutically active compounds in the hospital wastewater and surface water samples in Vietnam (Tran et al., 2013). That conducted their study on hospital wastewater management for government hospitals in Cairo, Egypt (Abd El-Gawad and Aly, 2011). Studied on the hospital effluent discharge disposal and regulatory

standard around the world toward its managements and treatment technologies (Khan et al 2020). It was found that hospital wastewater contains harmful compounds in higher concentrations resulting in development of resistant genes which needs strict laws for its management and treatment technologies which are still limited in the developing countries (Khan, et al., 2020). The presented further that risk assessment, periodic assessment of effluents, upgradation of existing treatment facilities, adopting new technologies and improving operation and maintenance are viable hospital wastewater management strategies (Khan et al., 2020). As has evaluated the ecotoxicological potential of the pharmaceuticals expected to occur in the wastewater of a general hospital and a psychiatric centre in Switzerland (Escher et al., 2011). These studies suggest that treatment of hospital wastewater that meets the local and international discharge limit is unavoidable decisions to be made by all nations including the developing countries like Tanzania. These previous studies indicate that studies on hospital wastewater are gaining attention in different parts of the world. However, in Tanzania there are limited studies on hospital wastewater and their potential toxicity and impact to environment and public health.

As it reported that mismanagement of the hospital wastewater discharge polluting soil, aquatic environments and spread infectious diseases, they end up to effect the biological imbalance of aquatic ecosystems at different trophic levels related to the action of toxic and genotoxic agents

## Quick Response Code



## Access this article online

Website:  
[www.jcleanwas.com](http://www.jcleanwas.com)

DOI:  
[10.26480/jcleanwas.02.2023.69.75](http://doi.org/10.26480/jcleanwas.02.2023.69.75)

(Ramírez-Coronel et al, 2023; Khan et al., 2021; Ali et al., 2017; Kumarathilakal et al., 2015). Despite the fact that the mismanagement of hospital wastewater has effect to the environment and public health, but still the knowledge and awareness of different stakeholders including cleaners (hospital attendants) who interact with wastewater on daily basis is still limited in most of the developing. Hospital attendants, cleaners and the general public should be aware and knowledgeable on the impact of mismanaging hospitals wastewater as presented by (Ramírez-Coronel et al., 2023). To presented that increasing the level of public awareness, managers and policy makers can raise knowledge and understanding on handling the hospital wastewater that results to reduce hazardous substances discharged into the environment (Ramírez-Coronel et al., 2023).

In some countries, liquid waste (wastewater) from hospitals is drained in public sewers without treatment (Ali et al. 2017). Due to the toxicity nature as presented by previous researchers, the hospital wastewater contains chemical materials, heavy metals, mutagenicity, infectious microorganisms and fetotoxic properties if left untreated, they can lead to receiving water bodies and the environment contamination, outbreaks of communicable diseases together with carcinogenic and radioactive pollution (Kumari et al 2020, Rozman et al. 2020, Ali et al. 2017; Kumarathilaka, 2015; Gautam et al., 2007). Due to complex constituents of hospital wastewater, it needs to be managed carefully including treatment (Ramírez-Coronel et al, 2023). A reviewed different technologies which applied for hospital wastewater treatment, worldwide (Verlicchi et al., 2015). Their study found that membrane bioreactors equipped with ultrafiltration membranes, ozonation followed by activated carbon filtration technologies can reduce the micropollutants from hospital water discharge into surface water and hence minimize the potential risks that spreading the pathogens causing endemic diseases to human (Verlicchi, 2021, Aukidy et al, 2017, Verlicchi et al. 2015). These treatment technologies applied elsewhere are expensive in the developing countries like Tanzania for just treating the wastewater from hospitals. As it is known that most of hospitals face financial constraints that affect their operations, so option for investing high technology for hospital wastewater treatment becomes a challenge. This condition suggests that studies on the affordable and effective hospital wastewater treatment technology in the developing countries are required. This study is aimed to investigate the potential risks of hospital wastewater mismanagement and knowledge level of hospitals attendants, cleaners, management officials and surrounding community who are involved in one way or another to manage the hospital wastewater and possible hospital wastewater management strategies in Tanzania.

## 2. MATERIALS AND METHODS

### 2.1 Hospital Selection

Two major hospitals were involved in the study, namely Muhimbili National Hospital (MNH) located in Dar es Salaam city, Dar es Salaam region and Tumbi Regional Referral Hospital (TRH) located in Coastal region. These hospitals were selected because are big hospitals which receive many patients from within and outside the country. So, their wastewaters should be adequately collected and treated to safeguard the public health. On the other hand, if their wastewaters are mismanaged, may end up putting hospital attendants, hospitals officials and surrounding community a risk. So these two hospitals were selected to represent other similar even lower levels hospitals in the country.

### 2.2 Hospital wastewater samples collection and analysis

Both purposive and random sampling approaches were used during the study. With purposive sampling, sixteen (16) wastewater samples were collected from national and regional referral hospitals in Tanzania with eight (8) samples from each hospital which were collected from manholes from wards, theatres, mortuary, pharmaceuticals, residences and

combinations of these. Physical, chemical and biological parameters were analyzed following standard methods as described in APAH-AWWA-WEF,

1998 and TZS 860:2006. Quality parameters analyzed included Fecal and Total coliforms, Streptococcus and Salmonella as bacterial parameters. Others parameters include pH, electric conductivity (EC), total dissolved solids (TDS), temperature, color, 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). Each sample was collected in 1 L sterile plastic bottle, stored in ice and then transferred to the Environmental Engineering Laboratory of Ardhi University within 6 hours for bacteriological analysis.

### 2.3 Structured interview

Structured interviews and checklist were administered at MNH and TRH to collect both qualitative and quantitative data from cleaners, hospital management and surrounding community to determine their level of knowledge and awareness on the risks of hospital wastewater. The judgmental sampling technique (Deshpande and Girm, 2019; Etikan and Bala, 2017) was applied to get the sample size of 80 respondents from the hospitals. The interview involved 30 hospital cleaners, 10 on-site sewage infrastructure attendants, and 30 surrounding household community. Additionally, 10 officials from Hospital Management were interviewed particularly heads of units and day-to-day cleaning supervisors from Estate Department. All involved interviewee were assigned the Consent Form (both English and Swahili versions) to express their willingness to participate in the research.

### 2.4 Data analysis

Excel (2016) was used for analysis of laboratory data while IBM SPSS statistics 20 and excel 2016 were used for analysis of interview data.

## 3. RESULTS AND DISCUSION

This section presents results and results of the laboratory analysis and field work as presented in the subsequent sections.

### 3.1 Chemical contamination

Concentrations of all heavy metals analyzed in both hospitals were below the detection limit for most of the sampling locations. However, exceptions were observed for a few locations where some heavy metals were detected but their concentrations were by far below the maximum threshold values as specified in the TZS 860:2006. Copper concentration ranged from  $\geq 0.01$  mg/l to 0.06 mg/l for wastewater from both hospitals which are well within the permissible level of 2 mg/l as presented in Table 1 and Table 2. The concentrations for zinc ranged from  $\geq 0.01$  mg/l to 0.37 mg/l for wastewater from both hospitals, which are within the permissible level set at 5 mg/l. The concentrations for chromium and Cadmium were below the detection limit for all sampling locations while the permissible level is set at 1.0 mg/l. The results of cadmium and nickel and TRH were all observed to be below the allowable levels according to TZS 860:2006. The results suggest that hospital activities do not significantly generate heavy metals. These findings are in line with other previous researchers on pathogenic organisms contaminations (Gautam et al., 2007; Abd El-Gawad and Aly, 2011; Amouei et al., 2012; Kumarathilaka, 2015). However, they are different on the heavy metal concentrations which show that hospital wastewater in Tanzania are lower than those reported for example that hospital and communal wastewaters contains antibiotic and antibiotic resistance gene (ARG) concentrations by (Paulus et al., 2019). These results suggest that the equipment used to detect the heavy metal concentrations in developing counties like Tanzania are suffering from lower detection limit compared to those equipment used in developed countries. Even though, the chemical results in this study indicates low contamination of heavy metals, but based on the previous studies the hospital wastewater contains antibiotic and antibiotic resistance gene (ARG) concentrations (Paulus et al., 2019) which can pose risks to human health and environment and hence needs treatment before disposal.

**Table 1: Concentrations of heavy metals at different sampling locations at TRH**

| Chemical Parameter | TRH-1       | TRH-2       | TRH-3       | TRH-4       | TRH-5       | TRH-6       | TRH-7       | TRH-8       | Standard* |
|--------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-----------|
|                    | mg/l        | mg/l        | mg/l        | mg/l        | mg/l        | mg/l        | mg/l        | mg/l        | mg/l      |
| Copper             | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | 2.00      |
| Zinc               | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | 5.00      |
| Chromium           | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | 1.00      |
| Cadmium            | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | 0.10      |
| Nickel             | 0.04        | 0.07        | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.02$ | $\geq 0.01$ | $\geq 0.01$ | $\geq 0.01$ | 0.50      |

\*Standard: TZS 860:2006

**Table 2: Concentrations of heavy metals at different sampling locations at MNH**

| Chemical Parameter | MNH-1 | MNH-2 | MNH-3 | MNH-4 | MNH-5 | MNH-6 | MNH-7 | MNH-8 | Standard* |
|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|
|                    | mg/l  | mg/l  | mg/l  | mg/l  | mg/l  | mg/l  | mg/l  | mg/l  | mg/l      |
| Copper             | 0.05  | ≥0.01 | ≥0.01 | ≥0.04 | 0.06  | ≥0.01 | ≥0.01 | ≥0.01 | 2.00      |
| Zinc               | ≥0.10 | 0.37  | ≥0.01 | 0.33  | ≥0.01 | 0.04  | ≥0.01 | 0.07  | 5.00      |
| Chromium           | ≥0.01 | ≥0.01 | ≥0.01 | ≥0.01 | ≥0.01 | ≥0.01 | ≥0.01 | ≥0.01 | 1.00      |

\*Standard: TZS 860:2006

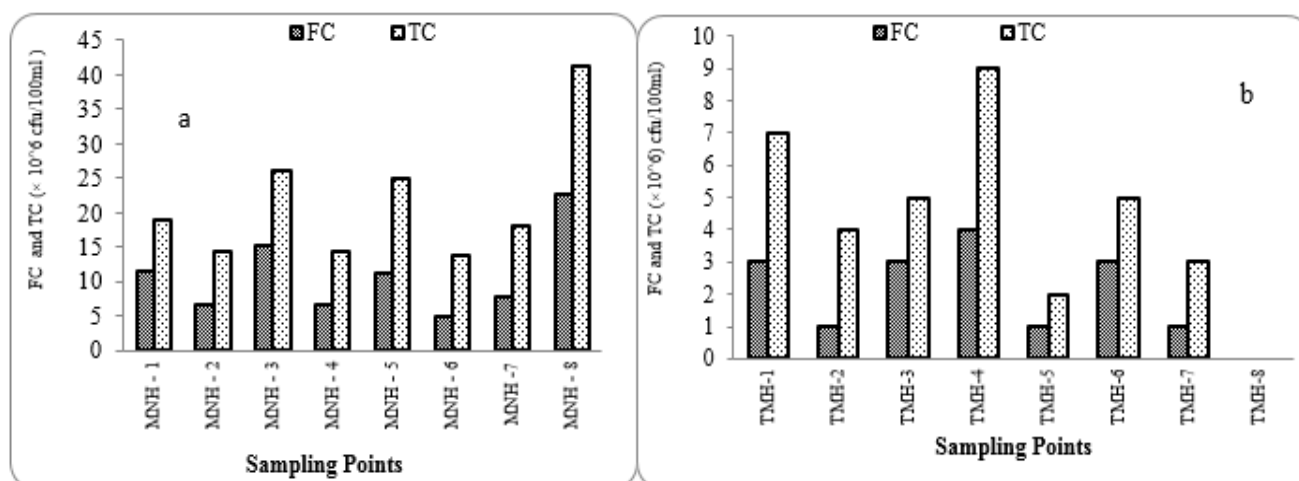
### 3.2 Bacteriological contaminations

Regarding to the fecal coliform (FC) and total coliform (TC), the results showed that at MNH ranges from 5 - 23 x 10<sup>6</sup> cfu/100ml and 14 - 41 x 10<sup>6</sup> cfu/100ml, respectively as presented in Sabai and Balengayabo (2021). The bacterial contamination results further present fecal and total coliform ranges from 0.5 - 4x10<sup>6</sup> cfu/100 ml and 0.5 - 9 x 10<sup>6</sup> cfu/100ml for wastewater from TRH. The results of FC and TC for both hospitals are far higher than the allowable standard as specified in Tanzania standard (TZS 860:2006) which limits to 0.01x10<sup>6</sup> cfu/100ml. The FC and TC results in Figure 1 show that the hospital wastewater is highly polluted with both FC and TC that imply that the wastewater is polluted with pathogenic organisms which may render the human health and other ecosystems. These results are contrary with what other previous research found like who reported that wastewater quality in the all investigated hospitals was similar to domestic wastewater quality and within WHO limits (Abd El-Gawad and Aly, 2011). The Salmonella results presented in Figure 4-10 confirms the pathogenic contaminants in the hospital wastewaters from both MNH and TRH hospitals in Tanzania. These results suggest that the prior treatment is necessary for hospital wastewater before discharging the hospital wastewater to the environment.

According to field visit, physical observation and face to face interview, it was found that in 2018-2019 (data collection time), the wastewater

generated from Muhimbili National hospital (MNH) was discharged direct to Msimbazi river and then to the Indian Ocean. Since, there is no pre-treatment is carried out apart from mixing with the Muhimbili University of Health and Allied Sciences (MUHAS)'s wastewater which is believed to compose of more organic waste from students' hostels, offices and classrooms, the polluted hospital wastewater was discharged directly into water bodies. According to TZS 860:2006, mixing/dilution is not a treatment of polluted wastewater like that discharged from MNH. The pre-treatment of hospital wastewater is therefore required prior discharges to the water bodies.

In TRH, there is a WSP which used to treat wastewater. However, the TRH wastewater does not reach the WSP instead it overflow on the combined chamber due to blockage. The overflow leads the hospital wastewater to spread on the land surface which is near to the staff settlements. Since it was found that the TRH wastewater is polluted with pathogenic bacteriological microorganisms, the continuing overflow to the land surface and spread on the surrounding near to the human settlement, may cause outbreak of water borne/related diseases like cholera and hence pose risk to the public health and ecosystems. It is therefore, recommended that the hospital wastewater from both hospitals i.e. MNH and TRH should be treated before discharging to the environment (either terrestrial or aquatic) in order to safeguard the public health and integrity of local ecology.



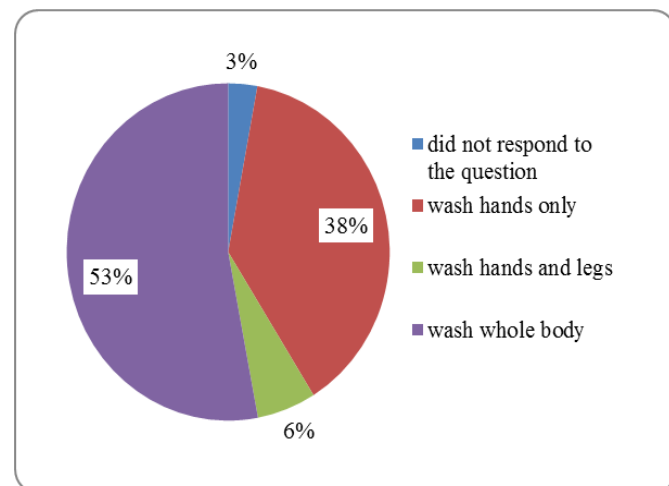
**Figure 1:** Concentration Fecal and Total coliforms in the wastewater from a) MNH and b) TRH (adopted from Sabai and Balengayabo, 2021)

### 3.3 Risks, perception and awareness of cleaners on the wastewater from hospitals

This Section presents the occupational health precautions of cleaners after work and their potential risks as presented in the subsequent sections.

#### 3.3.1 Occupational Health Precautions of Cleaners After Work At MNH

The hospital Cleaners were questioned on what they do after finishing cleaning activities at their job station. The results showed that out of 34 (113%) cleaners who participated in the study, 53% wash the whole body, 38% wash hands only, 6% wash both hands and legs while 3% did not respond to the interview as Presented in Figure 2. These findings show that most of the cleaners (i.e., 97%) observe the hygienic principle by at least washing their hands, hands and legs or the whole body for getting rid of contamination. However, it is difficult to establish the reason of 3% did not respond the question, but these results suggest that hygienic education should be offered to cleaner staff regularly and also the close supervision is required to ensure the adherence of the hygiene requirement to everyone in the hospital to be carried out after cleaning activities. Water and soap are main materials used for self-cleansing after cleaning.



**Figure 2:** Response on self-cleansing of cleaners after working

### 3.3.2 Occupational Health Precautions by Cleaners After Work at TRH

Three (3) wastewater attendants at Tumbi Regional Hospital participated in this research and all 3 (100%) attendants are washing hands every time when interact with the wastewater. They testified further that they all use water and soap during self-cleansing after working. This washing hands condition after work enables the wastewater attendants to be protected against potential health risks associated with contacts with wastewater hazard. However, washing hands only is not enough because sometime they are entering in the manhole in which the whole body may be contaminated with wastewater which requires washing the whole before going home. Not only that but also, these wastewater attendants have to use protective gears like gumboot, overall, gloves, masks and safety glasses. Response from the 3 sewerage attendants revealed that they all use protective gears especially gloves, gumboots and overall. It is therefore recommended to wash the whole body after work and changing the used protective gears especially when they enter into the inspection chambers for repairs. This will protect the wastewater attendants against contamination of pathogenic organisms from wastewater at Tumbi hospital and then spread of those pathogenic organisms to other areas which may cause the outbreak of communicable diseases.

### 3.3.3 Awareness of Cleaners on The Importance of Self-Cleansing After Work At MNH

Figure 3 presents results on the awareness of cleaners on the importance of self-cleansing after working at MNH. The results showed that 26.5% of cleaners wash in order to protect themselves against infections while 17.6% aimed to avoid disease transmission, and 55.9% did not respond to this question. The reasons stated on why most of Cleaners do not wash after cleanliness works were absence of specific area for washing (20.6%) and 12% of cleaners reported that washing facilities are not reliable. On the other hand, failure to respond to the question by majority of respondents (55.9%) may suggest that most of cleaners are not aware or have limited knowledge on the importance of self-cleansing after work or decided to ignore. All in all, this practice is dangerous as it may either cause infection to cleaners or spread diseases for all people interacting with cleaners at hospital or even at home. This condition indicates that awareness on the importance of self-cleansing after work is vital to cleaners in order to safeguard the health of cleaners and their families as well as the community at the hospitals.

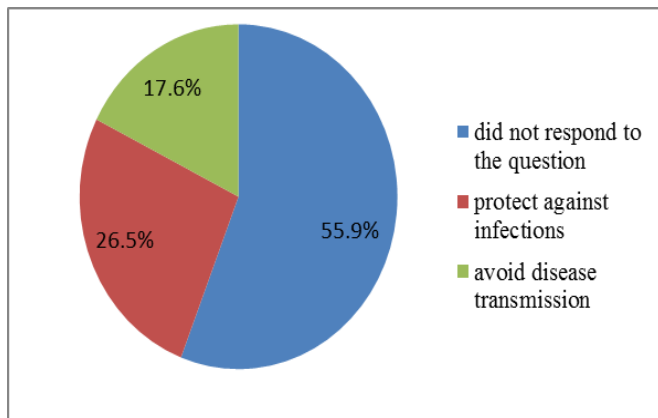


Figure 3: Response of cleaners on the importance self-cleansing after work

### 3.3.4 Awareness of Cleaners on The Importance of Self-Cleansing After Work At TRH

Responses at Tumbi Regional Hospital show that self-cleansing after work is important because the wastewater contains the infectious bacteria and protect the workers against infection as shown in Figure 4-13. The results indicate that the knowledge on the impact of wastewaters among the attendants is high. Furthermore, it was found that all interviewed wastewater attendants were aware that having physical contact with hospital wastewater may result into health problems. The wastewater problems associated with physical contact with wastewater include infectious bacteria and other harmful materials together with chemicals and other hazardous materials. To protect against those problems, the washing hands and using personal protective gears have been used as the strategy to avoid infections. The protective gears referred include gloves and gumboot (see Figure 4). These observations suggest that wastewater attendants and other practitioners are aware on the hygiene and protect them against any health effect which may arise due to poor hygiene.

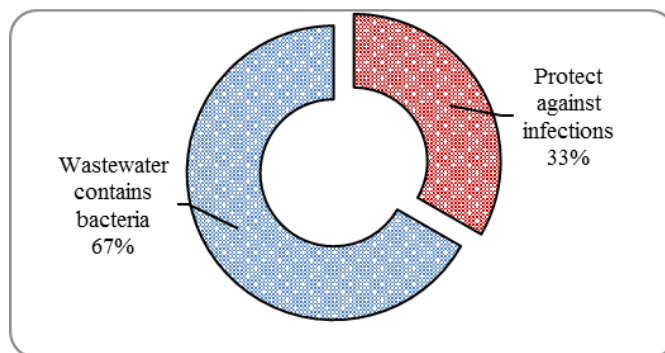


Figure 4: Reasons for observing hygiene practices at Tumbi regional hospital

### 3.3.5 Perceptions of Cleaners on The Effect of Contacting Hospital Wastewater

Understanding of cleaners on the effect of contacting wastewater released from the hospital is high as 94% of interviewed cleaners said that they understand that contacting the wastewater from hospital may cause health problems. The major problems associated with contacting hospital wastewater are disease transmission due to the presence of pathogenic micro-organisms and other chemical contaminants. Based on the laboratory analysis, the results show that the hospital waste contains pathogenic organisms and other organic and inorganic constituents. These findings are in line with what was reported by that hospital wastewater has toxic substances like pathogenic organisms and hazardous constituents which in turn affect the public health and environment at large (Amouei et al., 2012). Therefore, the awareness and understanding of cleaners and attendants of sewerage infrastructures on the effects of contacting wastewater from hospitals is encouraging and hence it helps them to protect themselves when carrying out their routine works at the hospital. The awareness should be regularly conducted to protect the workers against the effects of direct contact with hospital wastewater. The measures which are taken by workers at MNH to protect themselves against any health effects which may results from direct contact with contaminated hospital wastewater which include the use of personal protective equipment (PPE) all time when executing assigned job, observe best practices during cleaning activities. Others are self-cleansing after cleaning activities and Keeping the environment clean and store the cleaning facilities properly

All cleaners and sewage infrastructure attendants who participated in this research reported that there is enough personal protective equipment to use as shown in Figure 5. It is observed that almost all necessary PPE were used except noise mask during wastewater sampling activities by water technicians at MNH and TRH. This condition suggests that regular education and awareness on the importance of using PPE effectively is highly required.



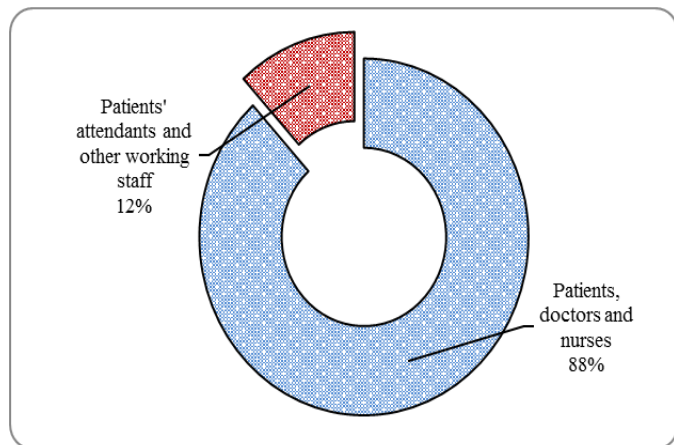
Figure 5: Level of using PPE by hospital wastewater attendants

### 3.3.6 Interactions of Cleaners and Wastewater Attendants at Work and Potential Risks

At Muhimbili National Hospital, cleaners and wastewater attendants mostly interact with patients, doctors and nurses (by 88.2%), while other group of people including relatives of sick people (patients' attendants) is limited to 11.8% (Figure 6). It was reported that the cleaners take

precaution when they meet with other people after working in order to avoid the spreading of infections. They wash hands before shaking hands with anybody after working. According to response from the management, taking precautions are resulting from trainings on occupational health and safety normally offered for new employees at MNH. This training should be maintained and conducted regularly in order to remind them on hygiene principles and hence protect them against any health risk and spread diseases.

While at Tumbi Regional Hospital, after or during working, the attendants of wastewater infrastructures used to interact with people from all hospital departments. It was reported that the precaution of washing hands and sometimes the whole body with soap and water is mandatory. It is hereby recommended that in order to maintain occupational health and safety, washing hands with soap should be strengthened by adequate supply of hand washing facilities and soap.



**Figure 6:** Interaction of cleaners at work

### 3.3.7 Perceived Risks to Those Dealing With Wastewater Infrastructures At Hospital

Workers at hospital are exposed to many risks which likely to affect them and even others. According to MNH wastewater attendants, the potential risks identified include contact with contaminated wastewaters (5%), injury from sharp objects (47%), transmission of diseases to other people (35%) and contracting infectious diseases (3%). Unfortunately, 9% of cleaners and wastewater attendants did not respond to this question. Therefore attendants of sewage infrastructure perceive more risk from injuries with sharp objects than contacting wastewater. This calls for more emphasis on personal protection and proper use of PPE to sewage attendants to avoid potential health effects on contacting wastewater. On the other hand none response may suggests that some workers are not aware of the risks around them or just ignorance.

### 3.3.8 Effect of Hospital Wastewater to The Neighboring Community

A study on the possible effects of hospital wastewater to the neighboring community at MNH was carried out by visiting and conducting interview to 30 different families at Kalenga Street, Upanda West ward in Ilala municipal, Dar es Salaam region. Results from the structured interview questions showed that only 20% of the neighboring community is affected by wastewater flowing (overflow) problem from MNH, the rest (80%) are not affected. Most of the affected people are those living in close proximity or along the sewer line that conveys wastewater to the disposal point. The concern of people along the sewer line is the frequent overflow of sewage through the inspection chambers. The overflow of the inspection chambers is frequently encountered because the sewage from MNH campus flows by pumping to the disposal point which makes the main sewer to flow full leading to overflow of the inspection chambers. It was reported that the common diseases affecting community members living around MNH include malaria (74%), diarrhea (3%), cholera (3%) and others (20%). The overflow condition exposes people to physical contact with this hospital wastewater. People at Upanga West reported that having the direct contact with this wastewater may lead to health effects especially skin disease, diarrhea, cholera, and fungus. This feedback from the community indicates that community surround MNH are aware on the health problems which are most likely to affect them in case of mismanagement of hospital wastewater. They even went further by mentioning the measures to control the problem of hospital wastewater found in the areas. The measures identified during interview with community members include

- Avoiding contacting with wastewater
- Controlling the flow by digging trench to allow wastewater to flow downstream
- Wearing gumboots (PPE)
- Improving sewerage and wastewater drainage systems
- Boiling drinking water
- Washing hands
- General cleanliness
- Report to the appropriate authority like hospital management on the problem and local government.
- Use bottled water for drinking

### 3.4 Wastewater management practices at MNH and TRH

It was observed that hospital wastewater at both hospitals MNH and TRH is managed by mixing wastewater from hospital activities/operations together with the wastewater from domestic activities. Both hospitals have onsite sewerage systems which collect wastewater from all of the hospital premises and convey it down to the treatment plants. The treatment and disposal methods differ for MNH and TRH in that TRH has waste stabilization ponds for biological treatment while MNH dispose the wastewater into Indian Ocean without treatment. However, during the study period the WSPs at TRH were not receiving wastewater from the hospital since the wastewater was overflowing through one of the inspection chamber due to blockage and was flowing unattended to the adjacent valley which is forest reserve. Although there are no people living adjacent valley where the wastewater is disposed, but this unsafe wastewater disposal practices at TRH pose risk to the environment and the downstream ecosystems. Based on the wastewater quality analysis (sample TRH 4), it was found that wastewater is highly contaminated with infectious fecal microorganisms like salmonella, and staphylococcus. Other contaminants include nutrients which are main agents for causing eutrophication in water bodies (Sabai and Balengayabo, 2021). These nutrients are also needed by plants species for growth but it puts health risks to human when get it into contact or ingest it. This condition suggests that wastewater overflowing is not safe and undesirable especially for the hospital wastewaters and hence, the Tumbi Regional Hospital management should solve this problem as soon as possible in order to safeguard the public health and environment.

As stated before, MNH has onsite sewerage system collecting wastewater from hospital premises. This hospital wastewater from MNH is then combined with wastewater from Muhimbili University of Health and Allied Sciences (MUHAS). By design this combined wastewater was to be pumped to the Dar es Salaam sewerage systems at city centre that discharge directly to the Indian Ocean for dilution and biological decomposition of the organic wastes present in the hospital wastewaters. During the study period, this option was not working instead the wastewater from MNH was discharged directly into the Msimbazi river through the by-pass sewerage system. The reason stated to influence the direct discharge of the wastewater to the Msimbazi River was the blockage of the pumping and sewerage systems which happened during the construction of the Dar es Salaam Rapid Bus Transit (DART). Even though, the DART started operation since 2016, the sewerage system at MNH was not yet repaired to be in operational. This practice is not safe and puts risks the surrounding community and ecosystems. Due to this fact, it is suggested that MNH should take urgent remedial measures for proper treatment and disposal of wastewater in order to safeguard health of the ecosystem and the surrounding community.

### 3.5 Hospital wastewater management options

Hospital wastewater treatment is a major challenge since the wastewater contains several micro and macro pollutants that cannot be removed efficiently by conventional treatment processes (Top et al. 2020). Different methods have been reported by the previous researchers (Khan et al, 2020; Top et al., 2020; Gautam et al., 2007).

The coagulated hospital wastewater effluents with  $\text{FeCl}_3$ , filtered and disinfected (Gautam et al., 2007). The experiment found that physico-chemical treatment method is potential and cost-effective for hospital wastewater treatment and disposal.

Has a evaluated efficacy of advanced methods for pre-treating hospital wastewater before discharged into sewage treatment plant (Khan et al., 2020). It was found that two out of seven treatment technologies i.e. membrane bio-reactor (MBR) and constructed wetland (CW) effectively can reduce conventional parameters and pharmaceuticals from secondary and tertiary treatment by 100% elimination of ibuprofen, carbamazepine, frusemide, and ofloxacin (Khan et al., 2020). Further found that combinations of advanced oxidation process viz ozonation ( $O_3$ ) and peroxone process ( $O_3-H_2O_2$ ) can oxidize pharmaceuticals and MBR coupled with ozone process indicated high performance and therefore recommended for hospital wastewater treatment (Khan et al., 2020).

To applied hybrid and multistage treatment methods of Supercritical water oxidation (SCWO) for hospital wastewater treatment in Turkey (Top et al., 2020). The treatment method removes emerging organic pollutants of pharmaceutical origin from hospital wastewater ( $25 \pm 1$  MPa) at the optimum conditions at 450 °C, 60 s, and 1:1 for temperature, reaction time, and oxidant ratio ( $H_2O_2/COD$ ) (Top et al., 2020). According to the method is able to remove COD, BOD, TOC, TN, and SS by 90% and greater than 90% phosphorus (Top et al., 2020; Top et al., 2020). These findings from reveal that SCWO method is capable to treat hospital in Turkey (Top et al., 2020). However, its applicability in the developing countries like Tanzania is still unknown and therefore an independent study is recommended to establish its applicability in developing countries.

The previous researchers have demonstrated the possibility of treating the hospital wastewater before discharged it to the water bodies or land surface as ultimate disposal. It is therefore recommended that in Tanzania, all hospitals to start either pre-treating or treating wastewater before ultimate disposal to the environment in line with Sustainable Development Goals (SDG.6).

## 4. CONCLUSION AND RECOMMENDATIONS

### 4.1 Conclusions

Both hospitals have sewer networks for effective collection of wastewater from the hospital premises; however treatment and safe disposal of wastewater remain a challenge as they were found discharging their wastewater to the water receiving bodies and the environment without a proper treatment. This practice is not environmental friendly since pollutes the water resources and the environment and hence poses risks to sorrowing community and downstream ecosystem.

Hospital wastewater was found have high concentrations of organic matter and pathogenic bacteria, for example fecal coliforms found to range from  $0.5 \times 10^6$  cfu/100 ml to  $23 \times 10^6$  cfu/100 ml). These findings reveal that pre-treatment of hospital wastewater with appropriate state-of-the-arts is mandatory before discharging to the receiving environment for final disposal in order to protect the public health and ecosystems.

This study concludes that hospitals workers including cleaners and attendants of wastewater infrastructures 94% of them are knowledgeable on the effects associated with contacts with hospital wastewater; and therefore use personal protective equipment (PPEs) and observe personal hygiene after work to protect them against any health effect associated with performing their duties. Additionally, the Surrounding community is aware on the effects that can be caused by mis-management of hospital wastewaters especially when pipe leaks, clog or manhole overflow. This understanding is important to enable them to protect themselves when the hospital wastewater is mismanaged.

### 4.2 Recommendations

Both MNH and TRH need to improve monitoring of the existing sewerage systems to identify challenges and conduct maintenance timely to avoid the observed overflow and discharge of wastewater to the environment which jeopardizes the public and environmental health.

Since only 27% of hospital cleaners and wastewater attendants for hospital infrastructure revealed that are adhering to the personal hygiene, it is therefore recommended that more emphasis on personal hygiene and personal protection is required in order to protect cleaners and attendants against health risks associated with contacts with wastewater on the course of execution of daily responsibilities. Furthermore, this study recommends that all hospitals in Tanzania to make sure that either pre-treating or treating wastewater before ultimate disposal to the environment in line with Sustainable Development Goals (SDG.6). Further research is recommended to establish the levels of chemicals constituents present in the hospital wastewaters other than those studied in this research work. More studies are needed to carry out the experiments in

dry and wet seasons and on daily basis to find out the hospital wastewater quality variability in the wet and dry season and the potential risk to the public and environmental health.

## ACKNOWLEDGEMENT

Authors would like to convey sincere gratitude to the funder of this research which is USAID through Peri Peri U Project at Ardhi University. More heartfelt gratitude goes to the Ardhi University management for granting us permission to execute this research. Appreciations go to Mr. Jonas Gervas Balengayabo from Ardhi University for support during data collection. Others include National Institute for Medical Research, Muhimbili National Hospital and Tumbi Regional Referral hospital managements for granting the permission to carry out research in their hospitals.

## DECLARATION OF INTEREST

Author declares no conflict of interest for anyone or organization.

## ETHICAL CONSIDERATION

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

## REFERENCES

- Akin, B. S., 2016. Contaminant properties of hospital clinical laboratory wastewater: a physiochemical and microbiological assessment. *Journal of Environmental Protection*, 7(05), Pp. 635.
- Ali, M., Wang, W., Chaudhry, N. and Geng, Y., 2017. Hospital waste management in developing countries: A Min review, *Waste Management & Research*. 35(6); Pp. 581-592
- American Public Health Association. American Water Works Association and Water Environment Federation. 1998. Standard methods for the examination of water and wastewater. Washington, D.C: APHA-AWWA-WEF.
- Amouei, A., Asgharnia, H. A., Mohammadi, A. A., Fallah, H., Dehghani, R., Miranzadeh, M. B., 2012. Investigation of hospital wastewater treatment plant efficiency in north of Iran during 2010-2011. *International Journal of Physical Sciences*, 7(31), Pp. 5213-5217
- Deshpande, B. and Girm, A., 2019. Sampling Techniques, Advances and Applications in Mathematical Sciences, 18(10); Pp. 1055-1062
- Escher, B.I., Baumgartner, R., Koller, M., Treyer, K., Lienert, J., McArdell, C.S., 2011. Environmental toxicity and risk assessment of pharmaceuticals from hospital wastewater. *Water Res.* 45: Pp. 75-92.
- Etikan, I, Bala, K., 2017. Sampling and sampling methods. *Biometrics and Biostatistics International Journal*. 5(6):Pp. 215-217. DOI: 10.15406/bbij.2017.05.00149
- Gautam, A. K., Kumar, S., and Sabumon, P. C., 2007. Preliminary study of physico-chemical treatment options for hospital wastewater, *Journal of Environmental Management*, 83(3),Pp. 298-306' <https://www.sciencedirect.com/science/article/pii/S0301479706001186>
- Jolibois, B., Guerbet, M., 2006. Hospital wastewater genotoxicity. *Ann. Occup. Hyg.* 50(2):Pp. 189-196.
- Khan, A.H., Khan, N. A., Ahmed, S., Dhingra, A., Singh, C. P., Khan, S.U., Mohammandi, A. A., Changani, F., Yousefi, M. Alam, S., Vambol, S., Vambol, V, Khursheed, A., and Ali, I., 2020. Application of advanced oxidation processes followed by different treatment technologies for hospital wastewater treatment, *Journal of Cleaner Production* 269(1). Pp. 122411 <https://www.sciencedirect.com/science/article/abs/pii/S0959652620324586>
- Khan, N.A., Ullah Khan, S., Ahmed, S., Farooqi, I.H., Hussain, A., Vambol, S. and Vambol, V., 2020. Smart ways of hospital wastewater management, regulatory standards and conventional treatment

- techniques: A short review, *Smart and Sustainable Built Environment*, Vol. 9 No. 4, Pp. 727-736. <https://doi.org/10.1108/SASBE-06-2019-0079>
- Kumarathilakal, P., Jayawardhana, Y., Dissanayaka, W., Herath, I., Weerasundara, L., and Vithanage, M., 2015. General characteristics of hospital wastewater from three different hospitals in Sri Lanka. In 6th International Conference on Structural Engineering and Construction Management 2015.
- Paulus, G.K, Hornstra LM, Alygizakis N, Slobodnik J, ThomaidisN, and Medema G., 2019. The impact of on-site hospital wastewater treatment on the downstream communal wastewater system in terms of antibiotics and antibiotic resistance genes, *Int J Hyg Environ Health*. 222(4):Pp. 635-644. doi: 10.1016/j.ijheh.2019.01.004.
- Ramírez-Coronel, A.A., Mohammadi, M.J Majdi, H.S. Zabibah, R.S., Taherian, M Prasetio, D.B., Gabr, G.A Asban, P., Kiani, A. and Sarkohaki, S., 2023. Hospital wastewater treatment methods and its impact on human health and environments, *Review on Environmental Health*, <https://doi.org/10.1515/reveh-2022-0216>
- Rusydi, A. F., 2018. Correlation between conductivity and total dissolved solid in various type of water: A review, *IOP Conf. Series: Earth and Environmental Science*, doi:10.1088/1755-1315/118/1/012019
- Sabai, S. M. and Balengayabo, J. G., 2021. Hospital wastewater physico-chemical and biological characteristics in the Coastal Zone Hospitals of Tanzania: A case of Muhimbili and Tumbi Hospitals, *Huria Journal*, 28(2);Pp. 53-71.
- Tanzania Bureau of Standards, 2006. National Environmental Standards Compendium: TZS 860: Municipal and Industrial Wastewaters-General Tolerance Limits for Municipal and Industrial Wastewaters.
- Top, S., Akgun, M., Kipcak, E. and Bilgil, M. S., 2020. Treatment of hospital wastewater by Supercritical Water Oxidation process, *Water Research*, 185:116279. [https://www.researchgate.net/publication/343516920\\_Treatment\\_of\\_Hospital\\_Wastewater\\_by\\_Supercritical\\_Water\\_Oxidation\\_Process](https://www.researchgate.net/publication/343516920_Treatment_of_Hospital_Wastewater_by_Supercritical_Water_Oxidation_Process).
- URT, 2007. Design manual for water supply and wastewater disposal, Volume II: Design Section, 3<sup>rd</sup> edition. Ministry of Water, Dar es Salaam.
- Verlicchi, P., 2021. Trends, new insights and perspectives in the treatment of hospital effluents, *Current Opinion in Environmental Science and Health*, 19, 100217, <https://doi.org/10.1016/j.coesh.2020.10.005>. <https://www.sciencedirect.com/science/article/pii/S2468584420300684>
- Verlicchi, P., Al Aukidy, M. and Zambello, E., 2015. What have we learned from worldwide experiences on the management and treatment of hospital effluent? — An overview and a discussion on perspectives, *Science of The Total Environment*, 514, Pp. 467-491, <https://doi.org/10.1016/j.scitotenv.2015.02.020>.
- Verlicchi, P., Galletti, A., Petrovic, M., Barceló, D., 2010. Hospital effluents as a source of emerging pollutants: an overview of micropollutants and sustainable treatment options. *Journal of Hydrology*, 389(3-4), Pp. 416-42
- Zhang, X., Yan, S., Chen, J., Tyagi, R.D. Li, J., 2020. 3 - Physical, chemical, and biological impact (hazard) of hospital wastewater on environment: presence of pharmaceuticals, pathogens, and antibiotic-resistance genes, Editor(s): R.D. Tyagi, Balasubramanian Sellamuthu, Bhagyashree Tiwari, Song Yan, Patrick Drogui, Xiaolei Zhang, Ashok Pandey, *Current Developments in Biotechnology and Bioengineering*, Elsevier, Pp.79-102, ISBN 9780128197226, <https://doi.org/10.1016/B978-0-12-819722-6.00003-1>. <https://www.sciencedirect.com/science/article/pii/B9780128197226000031>

