TOTAL PETROLEUM HYDROCARBONS IN SOIL AND WATER, HEAVY METAL CONCENTRATION IN WATER AND RELATED HEALTH SYMPTOMS AMONG FUEL STATION'S WORKERS IN DAR ES SALAAM, TANZANIA

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Muhimbili University of Health and Allied Science

October 2021

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

SCHOOL OF PUBLIC HEALTH AND SOCIAL SCIENCES

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By

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Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Public Health of the Muhimbili University of Health and Allied Science

October 2021

CERTIFICATION

The undersigned, certifies that she has read this work and hereby recommend for acceptance by the Muhimbili University of Health and Allied Sciences, a dissertation entitled, **"Total petroleum hydrocarbons in soil and water, heavy metal concentrations in water and related health symptoms among fuel stations' workers in Dar es salaam, Tanzania"** in partial fulfilment of the requirements for the award of the Master of Public Health of Muhimbili University of Health and Allied Sciences.

_____

Dr. Stephen S. Kishinhi

(Supervisor)

Date: _____

DECLARATION AND COPYRIGHT

I, Linda Kavishe, hereby declare that this dissertation is my own original work and that it has been presented and will not be presented to any other University for a similar or any other degree award.

Signature_____ Date _____

ACKNOWLEDGEMENT

First, I am grateful to GOD, THE ALMIGHTY for establishing me to complete this dissertation.

I wish to express my sincerest thanks to my family for the love and care and motivating me in this journey. To my managing director at work Ms. Lucy Thomas this would only be a dream without your continuous support.

I am grateful to my supervisor, Dr. Stephen Kishinhi for his continuous guidance, tolerance, constructive suggestions throughout preparation and writing this dissertation.

I also thank the managers of the petrol stations in Dar es Salaam as well as their respective workers, who showed me endless support and allowed me to work on their forecourts.

Many thanks to my classmates for their comments and critics during the course of successful writing of this dissertation.

Finally, thank you to one and all who, directly or indirectly, have lent their helping hand in making this dissertation possible.

DEDICATION

I dedicate this dissertation to all those global citizens of the world who are fighting to make the world a better place.

ABSTRACT

Background: Petroleum hydrocarbons and heavy metals can be found in both soil and water. Petroleum hydrocarbons are complex substances formed from hydrogen and carbon molecules sometimes containing other impurities such as oxygen, sulphur, and nitrogen; while heavy metals are metallic chemical element commonly found in contaminated soils, is characterized by having relatively high density and is toxic or poisonous at low concentrations. Petroleum hydrocarbons and heavy metals found in petroleum and other materials, are known to cause various detrimental health conditions including dizziness, loss of consciousness, vomiting, headache and skin, lung or eye irritation. There is a noticeable growing number of fuel stations in Tanzania especially in the city Dar es salaam. Little is known about petroleum hydrocarbon in waters and soil, heavy metal concentration in the soil and also its associated health symptoms among fuel station workers in Tanzania.

Objective of the study: To assess total petroleum hydrocarbons in soil and water and heavy metal concentrations in water and related health symptoms among fuel station workers in Dar es Salaam.

Materials and Methods:

A quantitative cross section study was conducted at fuel stations U, V, W, X and Y at Ilala Kinondoni and Temeke in Dar es Salaam, Tanzania. Soil samples were obtained during drilling works using a Geomash PB U-2 rig. Samples were taken every half a meter and three samples with highest volatile organic compounds detected by photo ionization detector were taken to the laboratory for analysis of petroleum hydrocarbons. Water samples were obtained using a An Eijkelkamp 12 VDL peristaltic pump was used in obtaining water samples, together with the Geotech Interface meter (Model 122-P8-LM3-30M) and YSI (Yellow Springs Instruments) parameter meter. Obtaining of the samples was depending on the depth of the well and water level. Laboratory analysis method of samples for petroleum hydrocarbons was done by gas chromatograph method and laboratory analysis of petroleum related heavy metals in water samples was done using Inductively coupled Plasma Mass Spectrometer series 2.

The study also interviewed 25 respondents from fuel stations to determine whether fuel station workers wear personal protective equipment when at work and whether they had experienced any related health symptoms as a result to exposure to petroleum hydrocarbons and petroleum related heavy metals using both questionnaires and observation. Results were presented in a reporting form based on the findings from questionnaires done during field work.

Sample Analysis: Laboratory analysis by gas chromatograph analysis method was used to analyse both water and soil samples for different petroleum hydrocarbons in water and soil at fuel stations. Data was produced with an Agilent Chemstation chromatography software version 10. Analysis of heavy metals concentration in water samples was done using Inductively Coupled Plasma Mass Spectrometer series 2 based on the ionization of analytes in water sample, separation, and detection the ions for determination of metal concentration.
Related health symptoms among fuel station workers were presented in a reporting form based on the findings from questionnaires done during field work.

Results: The study findings revealed petroleum hydrocarbons concentration in fuel stations U, V, W, X, and Y were 417 mg/kg, 644.33 mg/kg, 1488.33 mg/kg 135.33 mg/kg and 129.97mg/kg respectively. These concentrations were high compared to the accepted threshold limit of 100mg/kg according to World Health Organisation standards. Highest petroleum hydrocarbon concentration in water was found at fuel station Y having a concentration of 9040ug/l. Comparing with the World Health Organisation threshold limit of 100ug/l, this concentration was relatively high. Petroleum hydrocarbons related heavy metals concentration such as Lead were found to be 31ug/l which is also above the World Health Organisation acceptable threshold limit of 15ug/l. Mercury concentration was found to be 0.2ug/l which was within the World Health Organisation accepted limit level of 2ug/l. The study found that 40% of fuel station workers were not wearing protective equipment such as mask. This was due to lack of equipment as well inadequate knowledge on harmful effects of petroleum hydrocarbons among workers. Health symptoms associated with petroleum hydrocarbons to petrol station attendants includes nausea, vomiting, and redness of the eyes. The findings from this study

indicates existence of health symptoms which was influenced by petroleum hydrocarbons at fuel stations.

Conclusion: Total petroleum hydrocarbon concentrations in the soil and water were above the recommended World Health Organization threshold limit, This study also indicates the heavy metal concentration in water samples analysed such Lead to be higher while that of Mercury is significantly lower compared to threshold limit established by World Health Organization. This finding suggests that fuel station workers continue to be exposed to petroleum hydrocarbons and heavy metals that eventually can pose health concern among fuel station workers. The study found that most of fuel station workers were not wearing protective equipment when at work and that majority of fuel station workers did experience health problems related to exposure of petroleum hydrocarbons and petroleum related heavy metals at workplace

Recommendations:

An emphasis should be put on correct prevention measure to exposure from petroleum hydrocarbons such as monitoring systems which can detect leakages of underground tanks. This can be achieved through availability of advance technologies that can detect contamination and as well as to impose fuel station owner to conduct clean-ups (remediation) after certain period of active operation. Government through its different agencies such as Occupational Safety and Health Authority should monitor SHEQ related issues such as availability of personal protective equipment as well as investigate and monitor the environmental aspects such as pollution cause by petroleum hydrocarbons. Also enacting of polices that aims at protecting those who work in oil industry especially fuel stations.

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LIST OF ABBREVIATIONS

AD	Anno Domini
ATEX	Atmospheres Explosible
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GC	Gas Chromatograph
LEL	Low Explosive Limit
MCA	Multi-Channel Analyse
PPE	Personal Protective Equipment
PID	Photoionization Detector
SHEQ	Safety Health Environment Quality
TPH	Total Petroleum Hydrocarbons
VOCs	Volatile Organic Compounds
WHO	World Health Organization
YSI	Yellow Springs Instruments

DEFINITION OF KEY TERMS

1. Total petroleum hydrocarbons: mixture of hydrocarbons that are found in crude oil
2. Hydrocarbon: an organic compound made up of hydrogen and carbon.
3. Volatile Organic Compounds (VOCs): are organic chemicals that have a high vapour pressure at ordinary room temperature
4. Organic chemicals: chemical compounds that contain carbon.
5. Gas chromatography analysis is analysis used in analytical chemistry for separation and analysing compounds that can be vaporized without decomposition.
6. ATEX zone: a place in which an explosive atmosphere considering of a mixture with air or flammable substances in form of gas, vapour or mist is likely to operation occasionally.
7. Photoionization detector (PID) is a gas detector that measures volatile organic compounds and other gases in parts per million
8. Pollution: introduction of contaminants into the natural environment that cause adverse change.
9. Environmental laws and policies: commitment of an organization or government to the laws, regulations and other policy mechanism concerning environmental issue
10. Environment: all things surrounding us

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the problem

Petroleum products are used across the entire economy in every country. Gasoline and diesel are the primary fuels used in road transport. Tanzania is among the countries which depend much on the use of petroleum product as the source of energy to drive its economy (1). Due to increase of the market demand of the petroleum products a number of oil companies have been formed which for many years have been dealing with both importation and distribution of petroleum product(1).

Tanzania like other countries, the selling of petroleum products is done in petrol stations. The most common fuels sold are petroleum, diesel, and kerosene. Most of the fuelling installation being located underground, pump machines in the forecourt and a point of services inside a building. As of 31st December 2019, there were 1,596 operational petrol stations/filling stations in the country compared to 1,460 reported in the previous year, equivalent to an increase of 9.32% (2). An increase in number of petrol stations is attributed to increased demand of petroleum products, growth in economic activities and increased road networks. However, most of the petrol stations are in the urban areas upon the fact that there is the trend shows that investment in the petrol stations across the country is growing (2). Dar es Salaam city is the first to have the most stations in the country. The city which is the centre of economic activity in Tanzania has 228 stations which is equivalent to 14.3% of all stations in Tanzania(2).

In Tanzania, fuel tanks are normally installed underground. Fuel is usually off-loaded direct from a tanker truck into tanks through a separate valve located on filling station perimeter. Fuel from tanks travels in the dispenser pumps through a system of underground pipes. At pump there are fuel station attendants who are responsible for filling customers' vehicles tanks or containers with petrol or diesel to the requested level as well as cleaning petrol pumps and surrounding driveways, shops and facilities (3). Numbers of workers at filling stations depends on the size of the station and number of filling pump available; mostly it ranges from 1 to 10 workers. In Tanzania, fuel station workers attend each car rather than self-services thus increase exposure to health symptoms to those workers. Petroleum filling stations workers do not wear personal protective equipment and personal hygiene is variable in workplace(3). In most, local petroleum companies' jobs are not permanent, they

hire and fire some of petroleum filling pump attendants are given a renewable contract of six months to one years. Some of local petroleum filling stations do not have safety guidelines placate in place for the attendants to observe. This makes petroleum filling pump attendants unaware of the danger of daily exposure (3).

Petroleum filling station workers and service station attendants are exposed to benzene due to the emission of volatile aromatic hydrocarbons. Under prevailing conditions, benzene can be absorbed in the lung by inhalation (Tunsaringkarn). Petroleum and its products therefore constitute health hazards. Some of such hazards include nervous system damage, blood disorders (including anaemia, leukaemia), renal damage, hepatic dysfunction and intoxication leading to serious psychotic problems, anaesthetic effects, dermatitis etc(4). Therefore, the study has done to assess total petroleum hydrocarbon (in soil and water) and heavy metal concentrations (in water) and related health symptoms among fuel stations' workers in Dar es Salaam.

1.2 Statement of the problem

Tanzania cities including Dar es Salaam are characterized by mushrooming of fuel stations along the main highways and sometimes in residential areas. Number of petrol stations has been increasing from 1596 fuel stations in 2019 to 1638 fuel stations in 2020 especially in Dar es Salaam (2). There are many people who are employed as fuel filling pump attendants in those areas. They experience repeated exposure to petroleum hydrocarbons evaporating from petrol, diesel, and kerosene with little or no personal protection from direct contact and inhalation. Naturally they are unaware of the situation, they are hired and work as fuel pump attendants because of economic hardship and lack of further education. Some local petroleum filling companies do not have safety guidelines placate in place for the attendants to observe. This makes fuel workers unaware of the danger of daily exposure.

Therefore, the main objectives of this study were: to the concentration of total petroleum hydrocarbon, heavy metal concentrations, utilization of personal protective equipment and related health symptoms among fuel station workers in Dar es Salaam This will help in the compilation of baseline data on heavy metal and TPH in soil and water samples from the vicinity of petrol stations in the area, thus providing reference data that are essential in monitoring by toxic substances.

1.3 Rationale of the study

This study aligned with the policy/guideline NEMC establishes to protect human and environment from pollution in oil industry with a focus on fuel retail stations and its workers. The findings could help governmental bodies such as National Environment Management Council (NEMC), and Energy and Water Utilities Regulatory Authority (EWURA) to enforce existing water and environmental pollution laws and regulations, the Environmental Management Act No. 20 of 2004 and its regulations. The findings of this study will realize the failure of some of the current environmental policies in Tanzania, thus providing useful information to policymakers such as the National Environmental Management Council and industrial managers to manage water, air and land pollution and manage data that can be used to create time frames for major treatment projects in the industrial zones of major cities in Tanzania. The findings will help reinforce current health laws and policies such as National Environment Policy of 1997 as well and increasing awareness programs to persons working in the oil industries to take protective measures put in place. Moreover, incorporation/ integration of other industries and disciplines such as Occupational Health and Safety in connection to health to do away with health-related diseases and problems.

1.4 Research Questions

1.4.1 Broad research question

What is the concentration of total petroleum hydrocarbon, heavy metal concentrations, utilization of personal protective equipment and related health symptoms among fuel station workers in Dar es Salaam?

1.4.2 Specific Questions

1. What is the concentration of total petroleum hydrocarbons in water and soil at fuel stations?
2. What is the concentration of heavy metals in water at the fuel stations?
3. What is the proportion of fuel station workers who wear personal protective equipment when at work?
4. What health symptoms are associated with total petroleum hydrocarbons and heavy metals concentrations among fuel station workers?

1.5 Objectives of the study

1.5.1 Broad objective

The main objective of this study is to assess total petroleum hydrocarbons, heavy metal concentrations, utilization of personal protective equipment and related health symptoms among fuel station workers in Dar es Salaam

1.5.2 Specific Objective

1. To determine concentration of total petroleum hydrocarbons in soil and water at fuel stations
2. To determine concentration of heavy metals in water at fuel stations
3. To assess fuel station workers who wear personal protective equipment when at work.
4. To assess health symptoms, associate with total petroleum hydrocarbons and heavy metal exposure among fuel station workers associated

1.6 Conceptual Framework

Health symptoms such as skin/lung/eye irritation, vomiting, headache, dizziness and fainting are just some of the health effects caused due to high intake of petroleum hydrocarbons by humans either through inhalation, ingestion or through dermal contact. To cause an adverse effect, the concentration levels must surpass a certain threshold level above which adverse effects may occur. This is also influenced by a factor of exposure time to either workers of petrol stations or residents near these stations (figure 1.1).

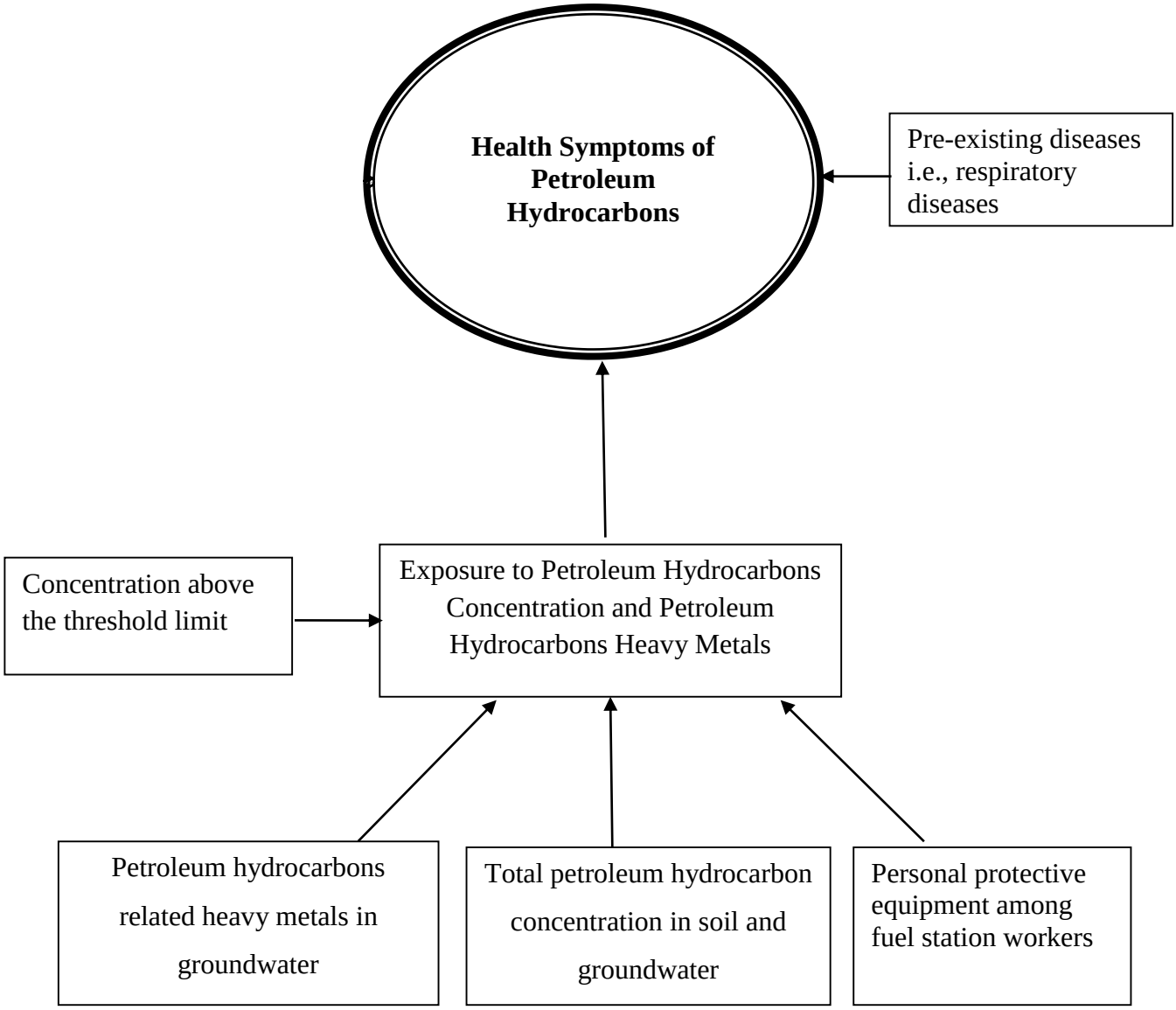

Figure 1.1 Conceptual framework

CHAPTER TWO

2.0 Literature Review

Petroleum hydrocarbons as complex substances formed from hydrogen and carbon molecules sometimes containing other impurities such as oxygen, sulphur, and nitrogen. Most hydrocarbons found on earth naturally occur in crude oil, where decomposed organic matter provides an abundance of carbon and hydrogen which, when bonded, can catenate to form seemingly limitless chains. Hydrocarbons are of different types such as saturated hydrocarbons which are the basis of petroleum fuels and are found as either linear or branched species, unsaturated hydrocarbons and aromatic hydrocarbons (5) . Total petroleum hydrocarbons enter the environment through industrial releases or as by products from commercials or private uses. These may be released directly into water through spills or leaks. Some total petroleum hydrocarbon fractions will float in water and form surface films while others will sink to the bottom sediments(6) . Crude oil has combination of different concentrations of chemicals. Everyone is exposed to petroleum hydrocarbon from many different sources, from breathing air at gasoline stations to using chemicals at home or work or using certain pesticides. Petroleum hydrocarbons can contaminate drinking water which is later ingested. Working in occupations that use petroleum products or living in an area near a spill or leak of petroleum products can result in touching soil contaminated with petroleum hydrocarbons (6). Pump attendants being exposed to fuels (petrol, diesel and others in addition of kerosene) on daily basis. Continuous inhalation of these products will at some point cause them to have health problems.

2.1 International standards on total petroleum hydrocarbons and heavy metal concentrations.

World Health Organization has put forward different standards acceptable for different concentrations in the composition of water and soil. These act as a threshold, above which can be detrimental to people's health (7).

According to World Health Organization benzene guideline, the value for drinking water is 0.01 mg/l (guideline values corresponding to the upper 95% confidence limit of modelled excess lifetime cancer risks of 10^{-4}, $10^{-5}$and 10^{-6} are 0.1, 0.01 mg/l and 0.001 mg/l respectively). An excess lifetime cancer risk of 10^{-4}, 10^{-5}or 10^{-6} means the risk of one new

cancer case above background levels per 10 000, 100 000 or 1 million people, respectively. Furthermore, for air, no specific guideline value has been developed(8) (9).

2.1.1 Benzene

According to World Health Organization benzene guideline, the value for drinking water is 0.01 mg/l (guideline values corresponding to the upper 95% confidence limit of modelled excess lifetime cancer risks of 10^{-4}, $10^{-5}$and 10^{-6} are 0.1, 0.01 mg/l and 0.001 mg/l respectively). An excess lifetime cancer risk of 10^{-4}, 10^{-5}or 10^{-6} means the risk of one new cancer case above background levels per 10 000, 100 000 or 1 million people, respectively. Furthermore, for air, no specific guideline value has been developed. Benzene is carcinogenic to human therefore no safe level of exposure can be recommended. Generally, the concentrations of airborne benzene associated with an excess lifetime risk of leukaemia of $10^{-4,}$ $10^{-5}$and $10^{-6}$are 17, 1.7 and 0.17 ug/m^3, respectively. Hence by this, we get to see that there is a clear connection between hydrocarbon concentration levels and the health of living things (8) (9).

2.1.2 Lead

Lead is found in all parts of the environment (air, water and soil) due to human activities such as mining and burning of fossil fuel. Lead is used to produce batteries, cosmetics, ammunition, and metal products such as pipes (10). According to Environmental Protection Agency, lead is a probable human carcinogen. High levels of exposure to lead leads to severe brain and kidney damage and may ultimately cause death. In pregnant women, it can cause miscarriage. In men, it can damage organs responsible for sperm production. According to Environmental Protection Agency, regulatory limits for lead in drinking water are 15 ppb (0.015 ppm) (11)

2.1.3 Mercury

Mercury is released into the environment by activities of various industries such as pharmaceuticals, paper, and caustic soda production. Mercury combines with other elements to form organic and inorganic compounds. Mercury in soil and water is converted by microorganisms to methylmercury, a bioaccumulating toxin. The human health concerns of mercury are such that all forms of mercury are sensitive to nervous systems and can be carcinogenic (12). Exposure to elevated levels of metallic, organic and inorganic

mercury can damage the brain, kidneys and the developing foetus. Short term exposure to high levels of metallic mercury vapours may cause lung damage, nausea, vomiting, diarrhoea, increase in blood pressure or heart rate, skin rashes and eye irritation(13) . History has shown this effect of mercury on human health with the famous Minamata disaster in Japan 1956 where continuous release of industrial wastewater from a chemical factory resulted in bioaccumulation in aquatic organisms in Minamata Bay. These fish and shellfish were consumed by the local population which resulted in severe mercury poisoning now referred to as Minamata disease (14). According to Environmental Protection Agency, regulatory limits for mercury in drinking water are 0.002 ppm (11).

2.2 The concentration of total petroleum hydrocarbons in water and soil at fuel stations

Global perspective, the study conducted in Saudi Arabia on soil contamination with petroleum hydrocarbons carried out in the area of petrol stations located in various places, the maximum values of total petroleum hydrocarbon in the range from 79.9 mg/kg to 956.9 mg/kg were determined. For individual locations, the maximum values were determined from various depths(15).

Another study carried out in United States of America soil samples originating from the areas of two fuel stations, contained 9367 mg/kg and 8075 mg/kg of petroleum hydrocarbons respectively(16).

The study done in China reported that soil samples from farmland located no more than 100 m from oil wells showed that the pollution with petroleum compounds (as a sum of n-alkanes) was below 40 mg/kg, much higher values were determined for wasteland located within a radius of 20 m from the source of pollution (even 460.79 mg/kg)(17).

The research on the total petroleum hydrocarbon content was also carried out in the Macabarie Island subantarctic area, selecting sites exposed to oil and gas. For samples from the depth of 0.5 m, the hydrocarbon content was in the range from below the level of determination to about 740 mg/kg (18).

In other study, in soil samples from the area of fuel terminal, the hydrocarbon content in the range above C12 was the 32147.85 mg/kg at 0.3 m depth, while at a depth of 2.0 m was 3938.2 mg/kg (19).

Regional perspective, the study conducted in Nigeria reported that soil contamination by total petroleum hydrocarbons has both a long-term and a short-term side effect on the soil quality and the proper functioning as well as the quality of food produced from the affected soil. The results obtained from the soil samples from the different universities were IAUE, 1475.56904 mg/Kg; RSU, 953.11949 mg/Kg and UNIPORT, 968.93886 mg/Kg with an average total petroleum hydrocarbons concentration of 1132.20913 mg/Kg. Total petroleum hydrocarbons contamination levels obtained in the three stations were higher than the 50mg/Kg limit allowed by DPR for agricultural soils(20)

2.3 The use of personal protective equipment among fuel stations workers.

Global perspective, the study done in Thailand reported that filling station workers were not wearing personal protective equipment. In Thailand where the feeling of discomfort and unease while wearing PPE was the main reason for non-usage(20).

Regional perspective, the study conducted in Nigeria reported that the low utilization of personal protective equipment (PPE) among fuel stations attendants. Considering the presence of hydrocarbon and other pollutants in gasoline, the poor use of PPE to workers led them at risk of several diseases which could affect many systems of the body. Lack of use of PPE may expose many of the attendants to accidental occurrences such as splashes of fuel on the skin and eyes. This volatile liquid easily gets absorbed into the body (21).

Another study conducted in Egypt reported that neither group had health insurance nor had pre-employment or periodic examination worn personal protective equipment at workplace due to their unavailability. The same study reported that the frequency of general health and respiratory complaints among petrol station attendants was low despite the non-use of PPE at work and this was attributed to the outdoor location of petrol stations together with the enclosed system for fuelling vehicles that could minimize exposure to benzene(22).

In Tanzania, the study done in Tanzania by Agnes indicated absence of protective gears among fuel stations workers. The same study reported that most of petroleum filling pump attendants was not aware of the risks concerning petroleum hydrocarbons at working place (3).

2.4 Health symptoms among fuel stations workers associated with total petroleum hydrocarbons and heavy metal concentrations.

Global perspective, the study conducted in Thailand reported that health symptoms associated with petroleum hydrocarbons to petrol station attendants includes chronic cough, breathlessness, nausea, vomiting, redness of the eyes, musculoskeletal disorders, low back pain, headache, fatigue, and dizziness. The same study cemented that inhalation of petrol on regular basis can trigger migraine headache in some individuals (23).

Regional perspective, another study conducted in Nigeria reported that the workers in the petrol stations and the residents living nearby the petrol stations have in one time or the other suffered various health effects as a result of working in petrol stations or being their close). The same study revealed that respiratory problems (diseases) had the highest percent. The most prevalent health problems affecting both the workers and some of the residents as a result of the inhalation of fuel contaminated air. However, skin and sight problems alongside other health complications were also issues of concern. If the situations continue thereafter, such could lead to narcotics effects with symptoms including headache, nausea, dizziness and mental confusion(24).

Another study done in India revealed that petrol vapour at low doses cause irritation to eyes, respiratory tract, and skin, it may also cause muscle weakness, cramps, dizziness and nausea. Exposure to higher concentration of petrol vapour produces effects such as staggered gait, slurred speech, and confusion. Very high concentration leads to in rapid unconsciousness and death due to respiratory failure and cause lung, brain and kidney damage(25).

In Tanzania, the study conducted in Dar es Salaam, Tanzania reported that most of filling stations attendants were not experiencing chronic respiratory symptoms. The workers were treated very well by the management as they were getting milk supplies whenever reported to the working shift as prevention for respiratory (3).

2.5 The concentration of heavy metals in water at fuel stations

Global perspective, studies conducted in China and Arab reported that regardless of origin, increase of heavy metal concentration in water is becoming a serious threat to human health and aquatic ecosystems. The common heavy metals of health concern to human include arsenic, cadmium, chromium, lead, nickel and zinc. When heavy metal concentrations in

water exceed environmental tolerance limits, use of such water in agricultural (irrigation and aquaculture) activities could be harmful to the aquatic ecosystem and human via the food chain(26,27).

Regional perspective, the study done in Nigeria on underground water revealed that heavy metal metals including Pb, Cd, Cr and Ni had overserved to have high concentration when compared to NSDWQQ at fuel stations across Ilorin Metropolis. The health risk impacts of heavy metals even at low concentrations make it a required assessment for water quality determination(28).

Tanzania, the study conducted in Tanzania reported that the concentration of heavy metals' levels in water were highest. The levels of heavy metals in water samples ranged from 0.99 to 1.26 mg/l, from 0.35 to 1.19 mg/l, from 0.46 to 0.55 mg/l, and from 0.11 to 0.17 mg/l for Fe, Zn, Pb, and Cu, respectively. The study reported that due to high level of concentrations in water has a lot of adverse effects and thus is of great concern to the public health, agricultural production, and environmental health(29).

Generally, various studies have not reported on total petroleum carbons concentration in water and soil and heavy metals concentration in water in perspective of Tanzania. Therefore, this study has discussed much the perspective of Tanzania.

CHAPTER THREE

3.0 Materials and methods

This chapter describes the methodology that was employed to conduct this study. It outlined the study area, evaluation design and study population; sample size and the sampling procedures, data collection methods, data management, analysis plan and concluded with the ethical considerations related to the study

3.1 Study design

A cross-sectional study design was used at fuel station U, V, W, X and Y to measure the soil and water total petroleum hydrocarbon and heavy metal concentration levels and health symptoms among fuel station workers.

3.2 Study population

The study population comprised petroleum filling station workers. The study was done in five fuel stations U, V, W, X and Y in Dar es Salaam. Fuel stations were selected considering the number of years of active operation. Observed total petroleum concentration levels from the laboratory tests of soil and water samples were paired against health symptoms and problems according to the World Health Organization.

3.3 Description of the study area

The study was conducted at petrol station U, V, W, X and Y all found at Ilala, Temeke and Kinondoni districts in Dar es Salaam region whose coordinate is 6°48 S 39°17'E. Petrol stations V, W and Y were found in Ilala, petrol station X was found in Kinondoni, and petrol station U was found in Temeke district. Distribution of petroleum hydrocarbons down the soil strata depends on the rising and falling of the water table. Where water table is relatively low, petroleum hydrocarbons vapour is expected to sit on the soil particles. Dar-es-salaam provides these features. Additionally, heavy metals contamination in water may be due to site use such as for industrial purposes, but also heavy metals can be naturally elevated in volcanic area, or where a lot of limestone and sandstone geology, as heavy metals may mobilise out of the rock or soil is quite common. Such geology was noted down when taking samples using and where found.

3.4 Sampling method

3.4.1 Human subjects sampling for health symptoms assessment

Convenience sampling was used during the study. All workers who were available in the fuel stations particularly those who agreed or gave consent to provide information were allowed to participate in the study. This was done due to small number of workers present in these fuel stations.

3.4.2 Soil sampling for determination of total petroleum hydrocarbons

Sampling was done for both soil and water at fuel stations U, V, W, X and Y in Dar-es-salaam. Soil samples for all stations were taken every half a meter, in which volatile organic compounds for each were measured using a photo-ionisation detector. Samples with highest volatile organic compounds were taken to laboratory for analysis.

3.4.3 Water sampling for determination of total petroleum hydrocarbons and heavy metals

Water sampling was done at fuel stations U, V, W, X and Y in Dar-es-salaam. Using a peristatic pump, water was drawn from three sampling points (12 metres) depth in each of the fuel stations. A total of 15 water samples each contained in a 500 ml glass jar from the five fuel stations were taken to the laboratory for analysis.

3.5 Sample Size

As fuel stations tend to have low number of workers, purposive sampling was used in that all fuel station worker who were present in the station were included in the study. Due to this, sample size was 25 respondents from five fuel stations found in Ilala, Kinondoni and Temeke were involved in this study. The study used 15 soil samples where by 3 samples collected from each fuel stations. The study also used 15 sample water samples on which 3 samples were taken from each fuel station.

3.5.1 Inclusion criteria

Apparently fuel station workers who are exposed to fuel over six months and workers who were voluntary granted consent to participate in the study.

3.5.2 Exclusion criteria

Fuel station owners and the public were excluded from the study as well as fuel station workers who were not granted consent were not involved in the study.

3.6 Study variables

3.6.1 Dependent variable

The dependent variable was the human health symptoms of petroleum hydrocarbons exposure.

3.6.2 Independent variables

1. Hydrocarbon concentration levels in relation to the exposure time
2. Heavy metal concentrations in relation to the exposure time
3. Personal factors such as wearing personal protective equipment

3.7 Data collection methods

Data collection was conducted using mainly quantitative method in which direct field observation and questionnaires were conducted. To obtaining primary data the questions were framed from the study objectives.

3.8 Data Collection tools

3.8.1 Direct field observation

As a form of primary data collection techniques, direct field observation provides information that reflects the natural situation. Observation checklist was framed (appendix 5) to obtain data from the field through note taking., a checklist was used to examine and ensure that necessary inductions such as safety inductions are done, usage of equipment such as LEL (Low Explosive Limit) and appropriate wearing of personal protective equipment by personnel involved in doing the research are all observed

3.8.2 Questionnaire

Questionnaire with semi structured questions English version (appendix 3) was distributed to workers for the purpose of filling some individual information such as age, profession, working experiences, health status.

3.9 Investigation tools

Soil samples were taken every half a meter during drilling works from three sampling points each from fuel stations U, V, W, X and Y. Drilling was done using a Geomash PBU-2 rig. This kind of rig was ideal for this work as it contained a mechanical drive of mobile rotator intended for engineering, geotechnical research and realizes all technologies of drilling with soil sampling; hence it was a perfect fit for environmental sampling. Soil samples were measured for volatile organic compounds using a handheld Tiger Photo Ionization Detector meter (Tiger PID) and recorded on a recording sheet. The Tiger VOC

detector is a revolutionary handheld PID instrument used for rapid, accurate detection of volatile organic compounds. Three samples with the highest volatile organic compounds (VOCs) were kept in sample jars which were all put in cooler boxes with reusable blue ice cooler packs and were taken to the laboratory. An Eijkelkamp 12 VDL peristaltic pump was used in obtaining water samples, together with the Geotech Interface meter (Model 122-P8-LM3-30M) and YSI (Yellow Springs Instruments) parameter meter. Obtaining of the samples was depending on the depth of the well and water level.

3.10 Pre-Testing the questionnaire and Instruments

The researcher pretested the designed tools at Camel oil fuel station at Africana (Kinondoni B, Dar es Salaam). This was done one week before the start of the study to assess if tools are correctly understood, and respondents give the answers as expected. The outcome of this pre-test was provided a clear indication on response to questionnaire as well as the average time allocated for one session. Also, the result from the pilot study helped to improve the tool accordingly.

3.11 Measurement procedure

Multiple underground wells were drilled at different levels depending on the ground conditions and water table level. With water table, if there was any occurrence of oil spillage or leakage, we would expect to have oil sitting on top of the water due to its low density. This was also be portrayed at different concentration levels of hydrocarbons at different depths of the ground depending on the rise and fall of the water table. For such kind of conditions, drilling was occurring up to seven metres with insertion of a pipe of the same length as well. On top of well pipes, we were put in well heads which will also have sampling units or points.

Where the water table is very low due to very dry conditions, drilling would occur to a depth of four metres because at this point, we would only expect to have hydrocarbon vapours adsorbed onto the soil particles. A pipe of the same length was also be inserted in the well. Hence soil samples were taken every half a metre tested for its volatile organic compounds. Furthermore, three samples with highest volatile organic compounds were taken to the laboratory tested for their individual total petroleum hydrocarbons. On top of well pipes, well heads were inserted as sampling units or points. Water was drowned from the well and put into 500 ml jars whereas well were taken to the laboratory to be tested for

different hydrocarbon component with a major focus on benzene and the sum of C5-C10 as well as petroleum hydrocarbon related heavy metals such as lead and mercury.

3.12 Sample Analysis

Laboratory analysis by gas chromatograph analysis method was used to analyse both water and soil samples for different petroleum hydrocarbons in water and soil at fuel stations. Holding time for both soil and water samples was 14 days from collection to Gas Chromatography analysis. Both samples were stored at less than 4 degrees Celsius. Where necessary upon arrival for samples had increased temperature, temperature stabilization was done before analysis was conducted. A 40mL amber vials with a whole cap and a Teflon septum was used to put water samples. Samples were preserved at pH<2.0 with HCL. 10 mL of water sample were removed and discarded through septum with glass syringe. 3 mL of n-pentane were then injected through the septum with a 5 mL syringe. Water samples were then extracted for 2 m in a vortex apparatus. The vial was then opened, and 1.5 mL of the organic extract were placed into the vial and sent for GC analysis. Soil samples analytical laboratory analysis was treated the same as the water samples. After adding n-pentane were shaken for 15 minutes by ultrasonic apparatus and allowed to settle for 60 minutes at room temperature. 1.0 mL from the soil samples analysed were then transferred into a vial and analysed by Gas Chromatography Flame ionization detector (GC-FID).

Gas chromatography flame ionization detector of total petroleum hydrocarbons was made on a Hewlett Packard gas chromatograph equipped with autosampler and FID detector. Oven temperature was programmed from 40 degrees Celsius (3 minutes) to 300 degrees Celsius at 15 minutes. Samples were injected in split less mode with relay open at 20 seconds. Detector and injector temperatures were 320 degrees Celsius and 250 degrees Celsius respectively. Helium was used as a carrier gas. Data was produced with an Agilent Chemstation chromatography software version 10.

Analysis of heavy metals concentration in water samples was done using Inductively Coupled Plasma Mass Spectrometer series 2 based on the ionization of analytes in water sample, separation, and detection the ions for determination of metal concentration. The technique involved calibration of spectrometer by introducing inductively coupled plasma and the mass analyser used to for generating a calibration curve. Stored water samples were then diluted by adding 5 mL of deionized water to 5 mL of sample and the solution acidified with nitric acid (1%) bringing concentrated analytes into the specified range. Spectrum

generated and displayed on a Multi-Channel Analyse (MCA) was compared to the calibration curve to identify the elements and determine their concentrations.

3.13 Ethical Consideration

The proposal was submitted for ethical clearance to conduct the study through Muhimbili University of Health and Allied Sciences (MUHAS), research and publications committee. All ethical issues were adhered to and addressed accordingly. Permission to conduct the study was requested from relevant authorities at fuel stations. Written or verbal consent were obtained from the participants before interview. Participants could decline to be interviewed and those interviewed were free to end the interview at any point. Participants were not given any incentives for taking part in the study. Confidentiality was observed throughout the study, no participant identifying information was recorded. Participants were informed about the objectives of the study and their participation was voluntary. There was no any risk involved on participating in this study.

CHAPTER FOUR

4.0 Results

This chapter presents and interprets study findings; A total of five fuel retail stations all found in Dar es Salaam region participated in the study. Soil and water samples were taken at different locations at the retail stations. Sample was then tested for the presence of petroleum hydrocarbons and heavy metals. Fuel station workers also participated in the study when capturing data for questionnaires. Workers included 16 (64%) pump attendants, 4 (16%) office or management workers and 3 (12%) station's accountants. Office workers, securities and workers at service and car wash bays making a total of 2 (8%) performed their duties away from fuel discharge points but within the fuel station area

4.1 Demographic information of the study population

Demographic information of workers at retail station U, V, W, X and Y include age, gender, and working period presented in Table 4.1 Results showed that were 13 (52%) male respondents and 12 (48%) female respondents. Majority of respondents were being between the ages of 26-30 years of age (11). The study indicates that most of respondents (14) were less than 5 years working in such fuel stations.

Table 4.1 Demographic information of the study population

Variables	**Categories**	**Frequency (n)**	**Percent (%)**
Age (in years)	20-25	5	20.0
	26-30	11	44.0
	Above 31	9	36.0
Gender	Male	13	52.0
	Female	12	48.0
Working period	Less than 5 years	14	56.0
	5 -10 years	10	40.0
	More than 10 years	1	4.0

4.2 Concentration of total petroleum hydrocarbons and heavy metal concentrations (in water and soil) at fuel stations

4.2.1 Concentration of total petroleum hydrocarbons concentration in soil at fuel stations

The study noted presence of Total petroleum hydrocarbons above threshold limit of 100 mg/kg in all the five sampled stations U, V, W, X and Y. Station W had the highest total petroleum hydrocarbon concentration (1488.33 mg/kg), followed by station V (644.33 mg/kg), station U (417mg/kg), station X (179 mg/kg) and station Y (129.97 mg/kg). While station U, had all sampling points with readings above 100mg/kg threshold level, station Y at sampling point Y3 recorded the least total petroleum hydrocarbon concentrations of 15.23mg/kg.

Table 4.2 Petroleum Hydrocarbon Concentrations in soil at fuel stations.

FUEL STATION	SAMPLING POINTS	C10-C40 (mg/kg)
U	U1	185
	U2	277.67
	U3	417
V	V1	-
	V2	151.33
	V3	644.33
W	W1	88.37
	W2	674.67
	W3	1488.33
X	X1	179
	X2	135.33
	X3	83.27
Y	Y1	129.97
	Y2	20.5
	Y3	15.23

C10-C40 - petroleum hydrocarbons

4.2.2 Concentration of total petroleum hydrocarbons concentration in water at fuel stations

Baseline laboratory results show presence of high petroleum hydrocarbon concentrations above threshold level in all the have fuel stations. Threshold level/limit used is the World Health Organization guideline for drinking water. Highest concentration was found at sampling point Y3 (9040 ug/l) and the lowest concentration at sampling point U1 (31.7 ug/l).

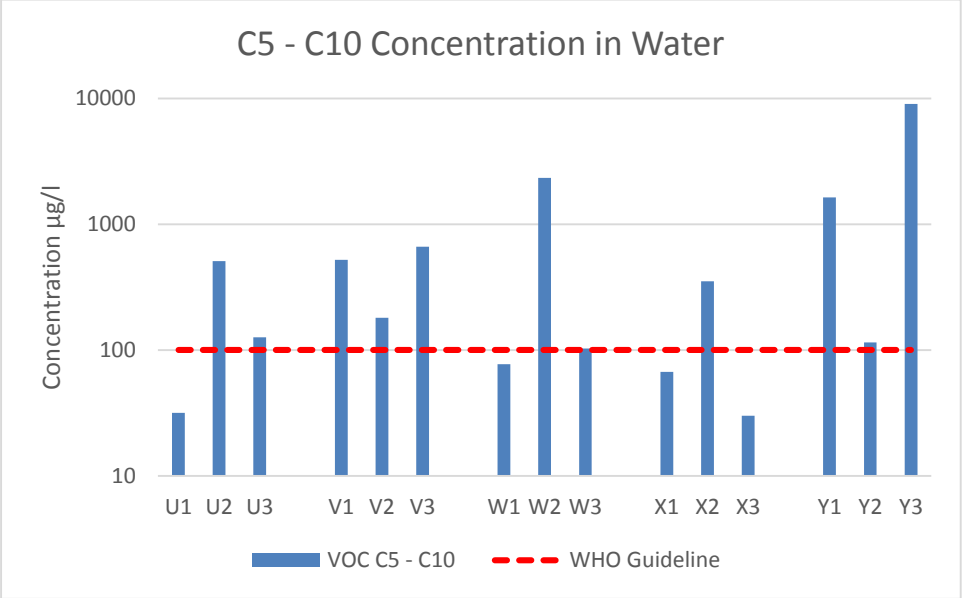

Figure 4.1 VOC C5-C10 concentration in water samples

C5-C10 – Concentration of Hydrocarbons

Benzene levels in soil and water samples

While benzene concentration in soil samples from the five fuel stations was relatively below 1mg/kg threshold limit (Figure 4.2); High benzene concentration levels in water were recorded in all the five stations at different sampling points (Figure 4.3). Highest reading was recorded at station W2 (4770 ug/l). Lowest reading was recorded at station X3 (1.66 ug/l).

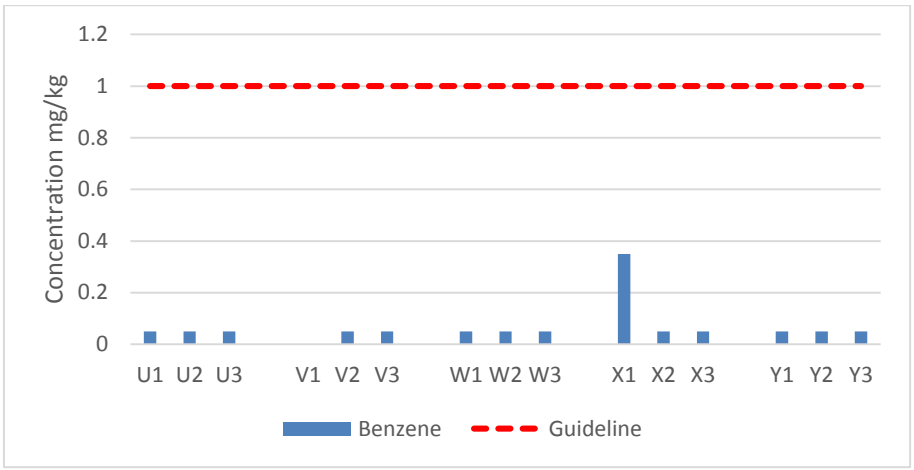

Figure 4.2: Benzene concentration in soil samples

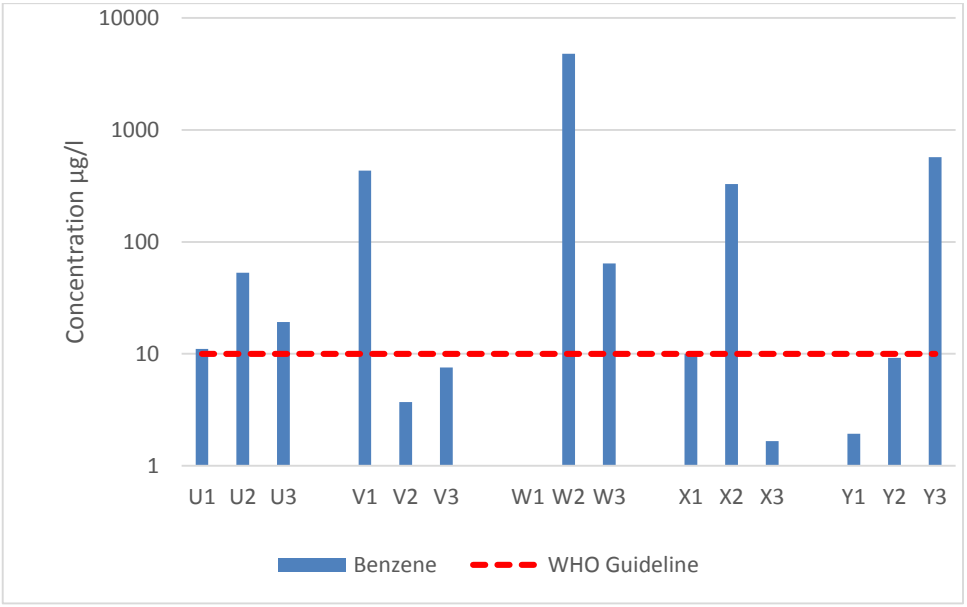

Figure 4.3: Benzene concentration in water samples

4.2.3 Heavy metals concentration in water samples

Lead

Lead concentration was tested at fuel station V and W because due to their geological formation underground. Sampling point V2 at station V had the highest Lead concentration of 31ug/l while at sampling point W2 at station W had the highest Lead concentration of 23ug/l (Figure 4.4). Both concentrations surpassed the threshold limit of 15ug/l put forward by World Health Organization

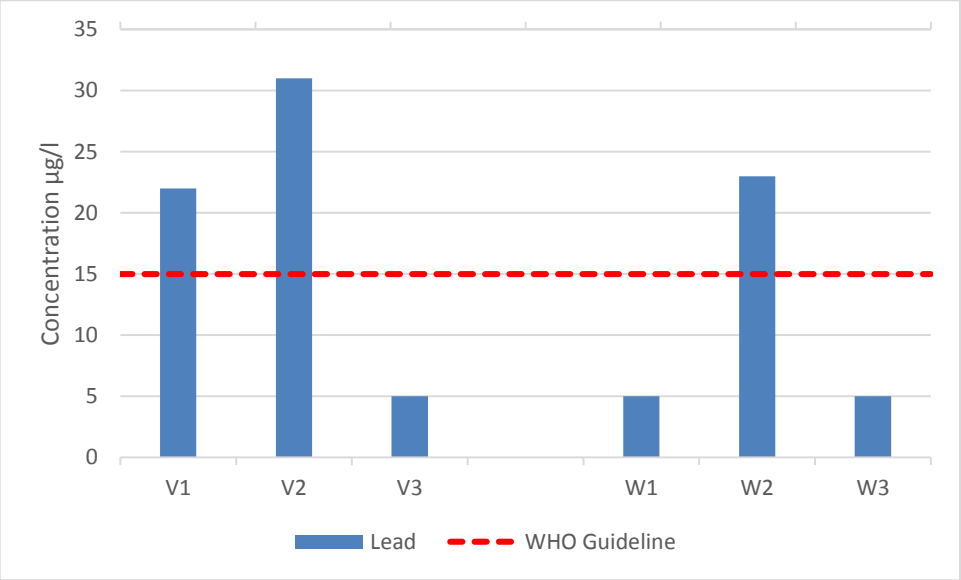

Figure 4.4: Lead Concentration in water samples

Mercury

Station V and W had low mercury concentration below the 2ug/l threshold limit. All sampling points from station V and W had mercury concentration reading of 0.2ug/l (Figure 4.5). Hence, noted mercury concentration from the study do not pose health threats to human beings.

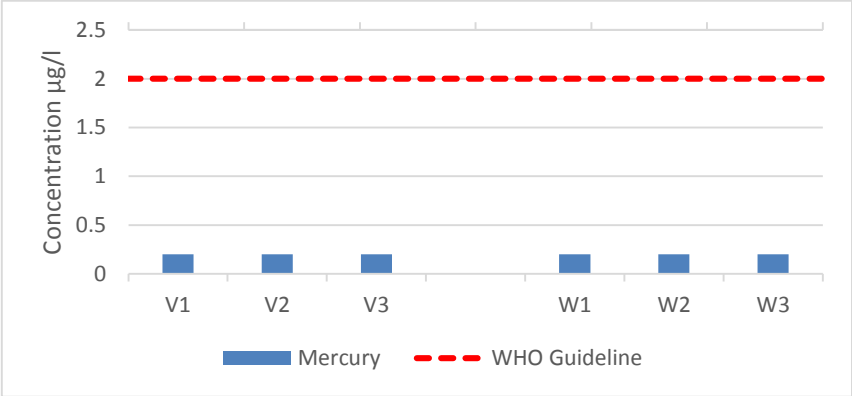

Figure 4.5: Mercury Concentration in water samples

4.3 Use of personal protective equipment among fuel stations workers

Fuel stations provide for unsafe environment for worker's to be in despite engineering and administrative control measures, the use of personal protective equipment provides for not only a good safety practice but also protect the health of fuel station workers. The study found; workers equipped with personal protective equipment during work wer10 (40%) while 15 (60%) were not equipped with personal protective equipment.

4.4 Health symptoms among fuel station workers associated with petroleum hydrocarbons concentration and heavy metals concentrations.

The study has shown that majority of respondents 20 (80%) reported that had experienced health problems related to petroleum hydrocarbons where by 5 (20%) reported had not experienced health problems related to petroleum hydrocarbons. It was noted that many of the station workers who experienced health problem related to petroleum hydrocarbons have no proper medical check-up. Among many other reasons, it is due to lack of health insurance coverage and raising standard of life. Respondents reported that the prevalence of health effects related to petroleum hydrocarbons among them was caused by lack and poor use of personal protective equipment at the fuel stations. Headache had the highest prevalence followed by skin irritation and fatigue while cancer and circulatory disorder were not prevalent. The respondents reported health symptoms related to exposure to petroleum hydrocarbons. These include skin irritation, eye irritation, headache, nausea, vomiting, weakness, fatigue, dizziness, lung irritation and consciousness loss.

CHAPTER FIVE

5.0 Discussion

The study revealed the following findings: existence of high petroleum hydrocarbon concentration levels at fuel stations; poor and low use of personal protective equipment among fuel station workers; and existence of health symptoms influenced by petroleum hydrocarbons at fuel stations. The study findings are interpreted and discussed with a comparison from what was reported by other studies done in developing and developed countries.

5.1 Existence of high petroleum hydrocarbons and heavy metal concentration levels at fuel stations.

Finding from this study indicates presence of high petroleum hydrocarbons and heavy metal concentrations from the soil and water samples taken and tested. Presence of Total petroleum hydrocarbons above threshold or limit level (100 mg/kg) were noticed in all the sampled fuel stations in Dar es Salaam. Petroleum hydrocarbon concentrations in water and soil are because of fuel spillages that occurred both primary and secondary. These oil spills contaminated both the soil and water once they reach the underground water table. Aquifers in the Dar es salaam city are likely to be affected from petroleum hydrocarbons because the pollution sources are in areas with moderate and high vulnerability classes, which covers about 80% of the Dar es salaam city. It is known that discharged petroleum hydrocarbons often sink into groundwater and the process of remediation of polluted groundwater can take many years(30). Low concentrations may not pose any immediate threat, but could trigger a great challenge over a long period of time (31). Studies have shown that petroleum hydrocarbons carried out in petrol stations located in various places has indicated high petroleum hydrocarbons concentration levels. Studies carried in Saudi Arabia has reported concentration ranged from 79.9 mg/kg to 956.9 mg/kg (15–19). Hence, there is need for adequate regulation and control of all activities contributing to the levels of petroleum hydrocarbon in water and soil for the safety of human, aquatic, and wildlife in the area.

5.2 Use of personal protective equipment among fuel station workers

Personal protective equipment is a very important aspect of both health and safety in oil and gas industry. Exposure to petroleum hydrocarbons in fuel stations is inevitable despite engineering and administrative controls put forward. The findings from this study indicated that majority of fuel station workers reported that were not wearing personal protective

equipment such as mask, gloves, and safety boots at workplace. The reason for PPE is not used by fuel station workers were due to unavailability of PPE at workplace. Fuel station workers who do not use the equipment allege the company does not provide the equipment; the company does not enforce its use; PPE is annoying/uncomfortable; or that equipment is not used during training(32). Studies have shown that low utilization of personal protective equipment (PPE) among fuel stations attendants. Considering the presence of hydrocarbon and other pollutants in gasoline, the poor use of PPE to workers led them at risk of several diseases which could affect many systems of the body (3,21,24). Some of local petroleum filling stations do not have safety guidelines placate in place for the attendants to observe. This makes petroleum filling pump attendants unaware of the danger of daily exposure. PPE protect professionals from risk and harm to health in the workplace and is among the main equipment protecting the most vulnerable routes of exposure against chemical products that are used in gas stations, such as: a hood for the head and neck; face shield and goggles; shoes; gaiters pants; overalls; safety kit (pants, jacket, or pullover); respirator; air purifier; and gloves. These devices should be provided by companies to their employees free of cost, according to the needs of the task performed(33).

5.3 Existence of health symptoms influenced by total petroleum hydrocarbons and heavy metal concentrations at fuel stations.

The study findings revealed that majority of fuel station workers do experience health problems at workplace. High prevalence of health problem due to petroleum hydrocarbon concentration was associated with lack and poor use of personal protective equipment at the fuel station. Health symptoms associated with petroleum hydrocarbons to petrol station attendants includes nausea, vomiting, redness of the eyes, low back pain, headache, fatigue, and dizziness. Occupational exposures to petrol/diesel vapours have been shown to affect functioning of different systems of the body. Fuel station workers are continuously exposed to the organic and inorganic substances present in petrol. The average daily exposure to these chemicals generally exceeds about 10 hours per day. Some of them are working for more than ten years now. Since petrol pumps are located on busy roads, hence, these workers in addition to diesel exhaust are exposed to other air pollutants(34,35).Studies have shown that most prevalent health problems affecting both the workers and some of the residents as a result of the inhalation of fuel contaminated air. Exposure to higher concentration of petrol vapour produces effects such as staggered gait, slurred speech, and

confusion. Very high concentration leads to in rapid unconsciousness and death due to respiratory failure and cause lung, brain and kidney damage(23–25)

5.4 Strengths and limitations

This is the first study conducted to access total petroleum hydrocarbon and heavy metals concentration and related health symptoms among fuel station workers in Tanzania. Despite of the strength, the study had some limitations; Logistic regression was not employed in determining health symptoms associated with exposure to observed total petroleum hydrocarbons and heavy metals. This was due to limited sample size.

Another limitation was sampling method; Convenient/purposive sampling was used, and it had several limitations such as inability to generalize research findings and it is vulnerable to errors.

CHAPTER SIX

6.0 Conclusion

Total petroleum hydrocarbon concentrations above threshold levels were noted. The study findings revealed existence of high petroleum hydrocarbon concentration levels in water and soil at fuel stations in Dar es Salaam. The study finding revealed existence of high Lead concentration in water in at least one of the sampling points in fuel stations, while mercury concentration in water was significantly low.

The study found that most of fuel station workers were not wearing protective equipment such as S3 EN ISO 20345 standard safety boots. This was due to lack of that equipment as well knowledge among workers.

The findings indicated existence of health symptoms influenced by petroleum hydrocarbons at fuel stations. Health symptoms associated with petroleum hydrocarbons to petrol station attendants includes nausea, vomiting, and redness of the eyes. Thus, fuel station workers continue to be exposed to health risks because of petroleum hydrocarbons.

6.1 Recommendations

- The government through National Environment Management Council (NEMC) and Energy and Water Utilities Regulatory Authority (EWURA) should enact the policy and regulations that control and regulate concentration of total petroleum carbons and heavy metals at fuel stations in Tanzania to reduce and combat side effect associated by it.
- The government through Energy and Water Utilities Regulatory Authority (EWURA) and Tanzania Petroleum Development Corporation (TPDC) should enact and amend laws to govern fuel stations owners and managers to provide personal protective equipment and education to filling station workers in Tanzania in order to reduce the risk of getting health problems at workplace.

6.1.2 Areas for further studies

- In the future, it would be reasonable to conduct the research on “Total Petroleum Hydrocarbons and Heavy Metal Concentrations in air and related heath symptoms among Fuel Stations’ workers in Tanzania”

- Furthermore, it would be reasonable to conduct research on “Total Petroleum Hydrocarbons and Heavy Metal Concentrations and related heath symptoms among gas Stations’ workers in, Tanzania”

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APPENDENCIES

Appendix 1: Informed Consent Form (English Version)

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

DEPARTMENT OF ENVIRONMENTAL AND OCCUPTIONAL HEALTH.

CONSENT TO PARTICIPATE IN A STUDY

FORM NO: ☐

PETROLEUM HYDROCARBON CONCENTRATIONS AND RELATED HEALTH SYMPTOMS AMONG WORKERS IN LINDI AND ARUSHA FUEL STATIONS

Dear sir/madam

You are hereby invited to participate in a study conducted by Ms, Linda M. Kavishe who is a postgraduate student at Muhimbili University of Health and Allied Sciences. Mr. Linda M. Kavishe is conducting this study for her Masters Dissertation.

Your participation in this study is entirely voluntary. Before deciding whether or not to participate in the study, please read the information below and ask questions about anything you do not understand. You are being asked to participate in this study because you are among the workers in this fuel station.

PURPOSE OF THE STUDY

The purpose of this study is to assess petroleum hydrocarbon concentrations (if there are any high hydrocarbon concentrations in the country) so as to determine if these are related to any health symptoms as per the world Health Organisation guidelines on potential health symptoms as a result to exposure to petroleum hydrocarbons.

No information regarding an individual's personal information or results will be provided

to an employer or external body. Summary results may be provided to your employer, MUHAS, and/or other industry groups and may contain statistical numbers and suggested actions based on the information provided.

VOLUNTARY PARTICIPATION

Please note that your participation in this study is voluntary and you have a right to refuse to consent. If you consent to participate, you have the right to withdraw from the study at any time if you wish to do so.

Your participation will involve the completion of the attached questionnaire. The length of the time required to complete the questionnaire is approximately 10 minutes.

EXPECTED BENEFITS

To date there is little information or data on the levels of petroleum hydrocarbon concentration, as well as little has been reported on effects workers who work in this industry face. This research will be conducted in two different work stations to compile a big picture so that environment, health, energy and gas sectors can plan interventions, education, and support programs.

RISKS AND DISCOMFORT

There are no risks or discomforts beyond normal day to day living associated with your participation in this study.

COMPENSATION FOR TIME

You will not receive any payment or other compensation for participation in this study. There is also no cost to you to participate in the study.

CONFIDENTIALITY

All comments and responses are anonymous and will be treated confidentially. The names of individual persons are not required in any of the responses. Any information we use for publication will not identify your name.

REVIEW AND APPROVAL

The review and approval of the study has been done by the Ethical committee of Muhimbili

University of Health and Allied Sciences (MUHAS).

RESULTS

The results of the study will be made available to you through a planned means of research dissemination. Results of this study will also be compiled in a research paper for publication and as part of a partial fulfilment of a master's degree.

CONSENT TO PARTICIPATE IN THE STUDY

I confirm that I have read and understood the purpose and significance of this study. I also have understood the conditions of participation.

I therefore have no objection to take part and for the inclusion of my information in the study as long as my identity is treated anonymous.

Participant's Name:

……

Participant's Signature: …….

Date……

Name of person obtaining authorization and consent

Signature: ……. Date…….

Contacts (MUHAS)

Please if you have questions or if you need more clarification regarding this research work, do not hesitate to contact Ms. Linda M. Kavishe, a master degree student at Muhimbili University of Health and Allied Sciences, P.O Box 65001 Dar es Salaam; Mobile number 0755 208142.

If you have questions regarding your rights as a participant you may contact Dr. Stephen Kishinhi; MUHAS: P.O BOX 65001, Dar es Salaam (Tel 0684 001 274) who is the supervisor of this research

Appendix 2: Informed Consent Form (Swahili Version)

RIDHAA YA KUSHIRIKI KWENYE UTAFITI - TOLEO LA KISWAHILI

CHUO CHA SAYANSI ZA TIBA MUHIMBILI

KURUGENZI YA UTAFITI NA MACHAPISHO

IDARA YA MAZINGIRA NA AFYA MAHALA PA KAZI

NAMBA YA FOMU: ☐

UTAFITI JUU YA MKUSANYIKO WA HYDROCARBON NA UHUSIONO WA HIZO HYDROCARBON NA MATATIZO ZA AFYA YANAYOTOKEA KWA WAFANYAKAZI KWENYE VITUO VYA KUUZA MAFATU LINDI NA ARUSHA

Mpendwa Msahili;

Nakukaribisha kushiriki katika utafiti unaofanywa na Bi. Linda M. Kavishe kwa ajili ya stashahada ya pili kutoka katika Chuo Kikuu cha Afya na Sayansi Shirikishi Muhimbili.

Kushiriki kwako katika utafiti huu ni kwa hiari unatakiwa kusoma taarifa zote katika fomu hii na kama kuna swali kuhusu jambo lolote ambalo halikueleweka unaweza kuuliza kabla hujaamua kushiriki au kutokushiriki katika utafiti huu. Umeombwa kushiriki katika utafiti huu kwa kuwa ni mmoja wa wafanyakazi katika kituo hiki cha mafuta

MADHUMUNI YA UTAFITI

Lengo la utafiti ni kukusanya taarifa juu ya mkusanyiko wa hydrocarbon zinaotokana na mafuta (diesal au petroli) na uhusiano wa hizo hydrocarbon na matatizo za afya

yanayowezatokea kwa wafanyakazi kwenye vituo vya kuuza mafatu kulingana na vielelezo vilivyotolewa na Shirika la Afya duniani. Taarifa yoyote binafsi kutoka kwa mfanyakazi haitasambazwa au kutolewa kwa muajiri, ila mjumuisho wa taarifa hizi kwenye mfumo wa takwimu ndio utakaotolewa kama matokeo kwa wadau husika mbalimbali.

USHIRIKI

Ushiriki wako katika utafiti huu ni wa hiari na una haki ya kukataa kushiriki katika utafiti. Kama umekubali kushiriki utatakiwa kuweka sahihi yako katika fomu hii nakujibu maswali utakayokuwa unaulizwa na msahili.

Ushiriki wako utahusisha mambo yafuatayo:

- kujibu maswali yaliyopo kwenye dodoso husika

FAIDA

Matokeo ya utafiti huu yatasaidia kuboresha sehemu zingine za kazi ili kuzuia ongezeko la magonjwa yasababishwayo na .

HASARA

Hakuna hasara za moja kwa moja zitakazotokana na utafiti huu.Washiriki wataulizwa maswali kwa mahojiano.

MALIPO

Hakuta kuwa na malipo yoyote kutokana na ushiriki wa utafiti huu na pia kama mshiriki hutakuwa na gharama zozote za wewe kushiriki katika utafiti huu.

USIRI

Taarifa zote zitakazokusanywa zitashughulikiwa kwa usiri wa hali ya juu na pia zinatolewa kwa ruhusa yako maalum kutokana na taratibu na sheria. Jina lako halitatumika katika taarifa zozote zitakazopatikana katika utafiti huu.

FOMU YA UTAFITI

Nakiri kwamba nimesoma maelezo yote kwa umakini na nimeelewa kila kilichoandikwa

katika fomu hii.Ninaelewa kwamba ninaweza kujitoa muda wowote nitakaotaka kujitoa.

Jina la Mshiriki:

……

Sahihi ya Mshiriki: ……. Tarehe……

Jina la Msahili ……

Sahihi ya Msahili: ……. Tarehe……

MAWASILIANO KUHUSIANA NA UTAFITI HUU

Kama una maswali au unahitaji ufafanuzi zaidi juu ya utafiti huu, usisite kuwasiliana na Mtafiti Mkuu Linda M. Kavishe, mwanafunzi wa shahada ya pili ya Afya ya Jamii katika chuo kikuu cha Afya na Sayansi Shirikishi, Muhimbili S.L.P 65001, Dar es Salaam au namba ya kiganjani 0755208142. Kama una swali juu ya stahili zako unaweza kuwasiliana na Dkt. Stephen Kishinhi ambaye ni msimamizi wa utafiti huu kutoka chuo kikuu Muhimbili, S.L.P 165001, Dar es Salaam kwa namba (0684 001 274).

Appendix 3: Study Questionnaire (English Version)

Questionnaire No: ..... **Date: .....**

GENERAL CHARACTERISTICS

1. ID .....
2. Age ..... years
3. Gender Male ☐ Female ☐

WORK ENVIRONMENT

4. Working fuel station and the products sold?

   .....

5. How long have you been employed in your current role? ..... years .....

   months

6. What is your job category?

   Pump attendant ☐ Accountant ☐

   Fuel station manager ☐ Others ☐

7. What type of Roster do you work? .....
8. What is your normal shift length? ..... hours
9. How many breaks do you have on your shift?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

10. Has there been any occurrence of both primary and secondary fuel/oil spills at the station?

    (Either in underground storage tanks or seen spills in the soil and water)

    Yes, ☐ No ☐ Unknown ☐

11. If yes, mention the type of spillage that occurred and how often it occurs.

    Spillage type ……...

    Once ☐ more than once ☐ Occasional ☐

12. Are you equipped with personal protective equipment during work?

    Yes ☐ No ☐

13. If yes, mention the PPE you have ……

14. When exactly do you use personal protective equipment?

    Full time ☐ While dipping only ☐ During offloading ☐

SYMPTOMS OF PETROLEUM HYDROCARBONS AND HEAVY METALS EXPOSURE

15. Have you experienced any of the following symptoms at work in the past 12 months?

    {Please tick "Yes" or "No" beside each symptom in the table below. If "Yes", please also tick the other boxes in that row to show how often you have had this symptom (once or more than once), and on what type of shift you were working at the time (day or night).}

S/N	Symptoms of Heat illness	Occurred		How Often		Shift	
		No	Yes	Once	More than Once	Day	Night
I	Skin irritation	☐	☐	☐	☐	☐	☐
II	Eye irritation	☐	☐	☐	☐	☐	☐
III	Fainting	☐	☐	☐	☐	☐	☐
IV	Headache	☐	☐	☐	☐	☐	☐
V	Nausea	☐	☐	☐	☐	☐	☐
VI	Vomiting	☐	☐	☐	☐	☐	☐
VII	Weakness	☐	☐	☐	☐	☐	☐
VIII	Fatigue	☐	☐	☐	☐	☐	☐
IX	Dizziness	☐	☐	☐	☐	☐	☐
X	Lung irritation	☐	☐	☐	☐	☐	☐
XI	Cancer	☐	☐	☐	☐	☐	☐
XVI	Circulatory disorder	☐	☐	☐	☐	☐	☐
XVII	Loss of consciousness	☐	☐	☐	☐	☐	☐

MEDICAL CONDITIONS AND PRESCRIBED MEDICATION

16. Have you been diagnosed with any of the following medical conditions?

(Please tick al that apply.)

Respiratory disorder ☐ Cancer ☐ Kidney disease ☐

Skin irritation/disorder ☐ Skin disorder ☐

Circulatory disorder ☐ Other

.....

17. Are you on any medications?

No ☐

Yes, prescribed ☐ Yes, non-prescribed ☐

What is the medication (s) you are currently taking;

.....

.....

.....

.....

18. How long have you been taking this medication?

3 months ☐ 6 months ☐ 1 year ☐ 3 years ☐

5 years ☐ 10 years ☐ Permanent prescription ☐

Thank you for completing this questionnaire

Appendix 4: Study Questionnaire (Swahili Version)
Namba ya Dodoso: ..... **Tarehe:**

.....

TAARIFA BINAFSI

1. UTAMBULISHO .....
2. Umri:Miaka .....
3. Jinsia Mwanaume ☐ Mwanamke ☐
4. Kimo: sm.....
5. Uzito kilogramu.....

MAZINGIRA YA KAZI

6. Jina la kituo cha mafuta na bidhaa zinazouzwa?

   .....

7. Una muda gani katika kitengo chako cha sasa?miaka ..... na miezi

   .....

8. Eneo lipi,kitengo cha mgodi unachofanyia kazi ?

   ☐

   Muhudumu wa mafuta Muhasibu ☐

   Meneja wa kituo cha mafuta ☐ Others ☐

9. Unafanya kazi katika zamu ipi ? Kutwa ☐ Usiku ☐
10. Je urefuwa zamu yako ya kawaida kazini ni upi? masaa

    .....

11. Unapumzika mara ngapi katika zamu yako?

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

12. Je, kumeshawahi kutokea kwa uvujaji wa mafuta katika hii station? (Aidha kwenye sehemu za kudhifadhi mafuta au umwagaji juu ya ardhi au kutokea kwa mafuta juu ya maji)

Ndio ☐ Hapana ☐ Sijui ☐

13. Kama ndio, taja aina ya umwagaji wa mafuta uliotoke na pia, ni mara ngapi ilishawahi kutokea …….

Mara moja ☐ Zaidi ya mara moja ☐ Mara kwa mara ☐

14. Je unatumia vifaa kinga wakati wa kazi?

Ndio ☐ Hapana ☐

15. Kama ndio, taja aina ya vifaa kinga unavyotumia ukiwa kazini

.....

16. Je mda gani haswa unatumia vifaa kinga ukiwa kazini?

Muda wote ☐ Nikiwa napima ujazo wa mafuta tu ☐

Nikiwa nashusha mafuta ☐

DALILI ZA MAGONJWA YATOKANAYO NA

17. Ulishawahi kuwa na dalili yoyote kati ya zilizohorodheshwa hapo chini katika kipindi cha mieazi 12 iliyopita?

{Tafadhali weka alama ya Pata kwenye kisanduku cha NDIO au HAPANA pembeni ya kila dalii iliyotajwa. Kama NDIO weka alama ya Pata kuonyesha ni mara ngapi umepata dalili hizo kwenye sehemu inayofuata na onyesha ni muda gani unaingia kazini (kutwa au usiku}

S/N	Dalili za ugonjwa	Ugonjwaulitokea		Mara ngapi		Shift	
		Hapana	Ndio	1	>1	Day	Night
I	Vipele vidogovidogo vyekundu katika ngozi	☐	☐	☐	☐	☐	☐
II	Kuwashwa macho	☐	☐	☐	☐	☐	☐
III	Kuzimia	☐	☐	☐	☐	☐	☐
IV	Maumivu ya kichwa	☐	☐	☐	☐	☐	☐
V	Kichefuchefu	☐	☐	☐	☐	☐	☐
VI	Kutapika	☐	☐	☐	☐	☐	☐
VII	Kukosa nguvu	☐	☐	☐	☐	☐	☐
VIII	Uchovu	☐	☐	☐	☐	☐	☐
IX	Kizunguzungu	☐	☐	☐	☐	☐	☐
X	Homa ya mapafu	☐	☐	☐	☐	☐	☐
XI	Kansa	☐	☐	☐	☐	☐	☐
XVI	Matatizo ya mfumo wa mzunguko wa damu	☐	☐	☐	☐	☐	☐
XVII	Kupoteza fahamu	☐	☐	☐	☐	☐	☐

HALI ZA KITABIBU NA MATIBABU

18. Ulishawahi kugundulika na ugonjwa wowote kati ya huu ?

    (Tafadhali weka alama ya pata panapo husika)

    Shinikizo kubwa la damu ☐ Ugonjwa wafigo ☐ Upungufu wa damu ☐ Ugonjwa wa ngozi ☐ Tatizo la upumuaji ☐ Matatizo ya mfumo wa mzunguko wa damu ☐

    mengine ☐ .....

19. Unatumia dawa zozote wakati huu?

    Hapana ☐

    Ndio,nimepewa na mtaalamu wa afya ☐

    Ndio, sijapewa na mtaalamu wa afya. ☐

    Ni aina gani ya dawa unazotumia wakati huu

    .....

    .....

    .....

    .....

    .....

20. Umetumia dawa hizi kwa muda gani sasa?

    Miezi 3 ☐ Miezi 6 ☐ Mwaka 1 ☐ Miaka 3 ☐

    miaka 5 ☐ Miaka kumi ☐ Maisha yote ☐

Asante kwa ushirikiano wako.

Appendix 5: Workplace assessment checklist (English)

SN	ITEM	YES	NO	COMMENT
1	**Work Environment**			
a.	Introducing myself to the site manager and explain the intent of the study			
b.	Site walkover and safety induction incase of an event of hazard			
c.	Simultaneous activities or Co-Activities			
d.	Number of present underground fuel storage tanks			
e.	Number of past underground fuel storage tanks			
f.	Number of fuel outlet pumps			
g.	Number of times refilling of fuel takes place at the station			
h.	Has there been occurance of any major oil/fuel spillage in large amounts before			
2	**Availability of personal protective equipment**			

	(PPE)			
	Clothing/overall			
	Safety shoes			
	Gloves			
	Mask			
	Are equipment provided and used by workers?			
3	**Utilization of personal protective equipments (PPE)**			
	Clothing/overall			
	Safety shoes			
	Gloves			
	Mask			

Kiambatisho 6: Tathimini ya mahali pa kazi (Vitu vya kuangalia)(Kiswahili)

SN	ITEM	YES	NO	COMMENT
1	**MAZINGIRA YA KAZI**			
a.	Kujitambulisha kwa meneja wa kituo cha mafuta and kumueleza dhumuni la tafiti			
b.	Kupewa maelekezo kuhusu usalama mahali pa kazi, pamoja na kufahamua kituo hii husaidia kama janga likitokea			
c.	Ufanyaji wa kazi zaidi ya moja kwenye kituo cha mafuta kwa wakati mmoja			
d.	Namba ya matenki ya kuhifadhia mafuta yanayotumika sasa kituoni			
e.	Namba ya matenki ya kuhifadhia mafuta ambayo hayatumiki sasa			
f.	Namba za mashine za kutolea mafuta			
g.	Mara ngapi kituo kinapokea mafuta			
h.	Je kumeshawahi kutokea kuwa mafuta yakamwagika			

	and kuvuja kituoni?			
2	**UPATIKANAJI WA VIFAA VYA KINGA BINAFSI**			
	Nguo/Ovaroli			
	Viatu vya kiusalama			
	Glavu			
	Barakoa			
	Je, vifaa vinatolewa and utumiwa na wafanyakazi kituoni?			
3	**MATUMIZI YA VIFAA KINGA BINAFSI (PPE)**			
	Nguo/Overoli			
	Viatu vya kiusalama			
	Glavu			
	Barakoa			

Appendix 6: Ethical clearance

UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES
OFFICE OF THE DIRECTOR - RESEARCH AND PUBLICATIONS

In reply quote;

Ref. No.DA.282/298/01.C/

Date: 22/12/2020

MUHAS-REC-12-2020-450
Linda Kavishe
MPH – Executive Track
School of Public Health and Social Sciences,
MUHAS

RE: **APPROVAL FOR ETHICAL CLEARANCE FOR A STUDY TITLED: PETROLEUM HYDROCARBON CONCENTRATIONS AND RELATED HEALTH SYMPTOMS AMONG WORKERS IN DAR ES SALAAM STATIONS**

Reference is made to the above heading.

I am pleased to inform you that the Chairman has on behalf of the University Senate, approved ethical clearance of the above-mentioned study, on recommendations of the Senate Research and Publications Committee meeting accordance with MUHAS research policy and Tanzania regulations governing human and animal subjects research.

APPROVAL DATE: 22/12/2020
EXPIRATION DATE OF APPROVAL: 21/12/2021

STUDY DESCRIPTION:
Purpose:
The purpose of this cross sectional study design is to assess petroleum concentrations and related health symptoms among workers in Dar es Salaam fuel stations.

The approved protocol and procedures for this study is attached and stamped with this letter, and can be found in the link provided: https://irb.muhas.ac.tz/storage/Certificates/Certificate%20-%20352.pdf and in the MUHAS archives.

The PI is required to:

1. Submit bi-annual progress reports and final report upon completion of the study.
2. Report to the IRB any unanticipated problem involving risks to subjects or others including adverse events where applicable.
3. Apply for renewal of approval of ethical clearance one (1) month prior its expiration if the study is not completed at the end of this ethical approval. You may not continue with any research activity beyond the expiration date without the approval of the IRB. Failure to receive approval for continuation before the expiration date will result in automatic termination of the approval for this study on the expiration date.
4. Obtain IRB amendment (s) approval for any changes to any aspect of this study before they can be implemented.
5. Data security is ultimately the responsibility of the investigator.
6. Apply for and obtain data transfer agreement (DTA) from NIMR if data will be transferred to a foreign country.
7. Apply for and obtain data transfer agreement (DTA) from NIMR if data will be transferred to a foreign country.
8. Apply for and obtain material transfer agreement (MTA) from NIMR, if research materials (samples) will be shipped to a foreign country.
9. Any researcher, who contravenes or fail to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine as per NIMR Act No. 23 of 1979, PART III section 10 (2)
10. The PI is required to ensure that the findings of the study are disseminated to relevant stake holders.
11. PI is required to be versed with necessary laws and regulatory policies that govern research in Tanzania. Some guidance is available on our website https://drp.muhas.ac.tz/.

Dr. Emmanuel Balandya
Ag. Chairman, MUHAS Research and Ethics Committee

Muhimbili University of Health and Allied Sciences
DIRECTOR
Research & Publications
Box 65001

Cc: Director of Postgraduate Studies, **MUHAS**

Appendix 7: Introduction letter

UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES
OFFICE OF THE DIRECTOR – POSTGRADUATE STUDIES

In reply quote;

Ref. No. Ref. No. HD/MUH/T.573/2018 — 28th December, 2020

TO WHOM IT MAY CONCERN:

Re: INTRODUCTION LETTER

The bearer of this letter is Linda Kavishe, a student at Muhimbili University of Health and Allied Sciences (MUHAS) pursuing MPH-Executive Track.

As part of her studies she intends to do a study titled: "**Petroleum Hydrocarbon Concentrations and Related Health Symptoms Among Workers in Dar es Salaam Stations.**"

The research has been approved by the Chairman of University Senate.

Kindly provide her the necessary assistance to facilitate the conduct of her research.

We thank you for your cooperation.

Ms. Victoria Mwanilwa
For: DIRECTOR, POSTGRADUATE STUDIES

cc: Dean, School of Public Health and Social Sciences, **MUHAS**
cc: Linda Kavishe

9 United Nations Road; Upanga West; P.O. Box 65001, Dar Es Salaam: Tel. G/Line: +255-22-2150302/6; Ext. 1015; Direct Line:+255-22-2151378;Telefax:+255-22-2150465;E-mail:dpgs@muhas.ac.tz;Web:https://www.muhas.ac.tz