KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY - AFRICA INSTITUTE OF SANITATION AND WASTE MANAGEMENT (K-AISWAM) ACCRA, GHANA

MSc. ENVIRONMENT AND PUBLIC HEALTH

TOXIC METAL EXPOSURE AND SYMPTOMS OF RESPIRATORY INFECTION AMONG CHILDREN (UNDER-FIVE) RESIDING NEAR OPEN DUMPSITE: A CROSS-SECTIONAL STUDY AT ABOKOBI

BY

MICHAEL AFFORDOFE

(20403640)

A DISSERTATION IN THE SCHOOL OF MEDICAL SCIENCES SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF A MASTERS IN ENVIRONMENT AND PUBLIC HEALTH DEGREE

SEPTEMBER, 2019

DECLARATION

STUDENTS'S DECLARATION

I, Michael Affordofe, declare that thesis/dissertation/project, with the exception of quotations and references contained in publish works which have all been identified and dully acknowledged, is entirely my own original work, and it has not been submitted, either in parts or whole, for another degree elsewhere.

…………………………………… ……………………..………………

MICHAEL AFFORDOFE DATE

(STUDENT)

SUPERVISORS DECLARATION

I hereby declare that the preparation and presentation of this dissertation was supervised in accordance with the guidelines on the supervision of dissertation as laid down by the Kwame University of Science and Technology (KNUST)

…………………………………. …. ………………………………….

REGINALD QUANSAH (PhD DATE

(SUPERVISIOR)

………………………………….. …………………………………………

…………………………………. DATE

(HEAD OF DEPARTMENT)

ACKNOWLEDGEMENT

I wish to express my profound gratitude to the Almighty God for his unfailing love, care and grace to me throughout this programme.

This work has been done through the contributions of various people. Their support, contributions and constant encouragement played a vital role in seeing me through this programme successfully.

I am very grateful to my supervisor Dr. REGINALD QUANSAH for his guidance, insightful suggestions, support and time that led to the production of this useful work.

My appreciation goes to the stakeholders around the Abokobi dumpsite who graciously submitted themselves to be part of this study. I am indeed indebted to all of you.

My heartfelt gratitude also goes to Nuffic for their financial support throughout the programme.

To my other team members, I say thank you for being great team members. Your support and commitment made our task easy.

Finally, I thank my family for their support, encouragement and prayers for me throughout this programme.

DEDICATION

I dedicate this project work to my late lovely Dad Togbui Opeku V. whose fatherly love and support has been the main pillar of my personality. I also dedicate it to My Mum, Regina Okain. Mum I love you so much. Also to my lovely friend Lorinda Blue. Finally, to all my siblings.

ABSTRACT

The purpose of this study was to assess the prevalence of symptoms of acute respiratory infection defined as Upper Respiratory Infection (URI), the levels of toxic metals in biological (blood) media, and the association between toxic metals and symptoms of respiratory infection among under five children residing around Abokobi dump site of the Greater Accra Region. Participation in the study was voluntary; based on that, a population of 200 children under five (5) and their parents residing within 200meters around the dumpsite were recruited as participants for the study. Descriptive statistics was used to present data. It came out that, the proportion of self-reported symptoms of acute upper respiratory infection (AURI) was high in children aged 2 years. Also the proportion of children reporting symptoms of acute lower respiratory infection (ALRI) was higher among children age 3 years. The association between mean concentration of metals in hand washed water in blood and symptoms of ALRI and URI is greater as a result of Hg in hand wash water. However, the mean residue and standard deviation of Hg contributes to ALRI than AURI in blood than in hand wash water. The study therefore recommended public education of good practices in child care should be intensified to avert the development of preventable diseases such as acute upper respiratory infections. Awareness must also be created on proper waste management practices. Also regular checkup must be done for children who live close to dumpsites to avert any health risk they may be exposed to. Finally, Local Government Ministry and the Ministry of Sanitation and Water Resources should permanently ban or avoid the use of the dumpsite.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES ii

CHAPTER ONE INTRODUCTION

1.1 Background of the Study

Open dumpsite technique is one of the poorest services provided by municipal officials in Africa and parts of Asia as the facilities are unscientific, obsolete and inefficient. Solid waste disposal sites are located in and out of urban development towns.

This waste is tossed into municipal disposal locations and owing to bad and ineffective leadership, dumpsites are turning to sources of environmental and health risks for individuals residing near such dumps. (Sankoh et al. 2013).

Over the last three decades there has been increasing global concern over public health impacts attributed to environmental pollution, in particular, the global burden of disease. The World Health Organization estimates that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (UNEP, 2015). Most of these environment-related diseases are however not easily detected and may be acquired during childhood and manifested later in adulthood (United Nations Environment Programme (UNEP), 2015).

Globally, dumpsites receive about 40 percent of the world's waste and serve about 3.5-4 billion individuals (ISWA, 2015). The 50 largest dumpsites impact 64 million people's daily life, a population of France's size (ISWA, 2015). As urbanization and population growth proceed, dumpsites are anticipated to serve more than several hundred million individuals, mainly in the developing world (International Solid Waste Association Report (ISWA), 2014).

However, heavy metals maybe released into the environment from metal smelting and refining industries, scrap metal, plastic and rubber industries, and various consumer products and from burning of waste containing these elements. The elements that are of concern include lead, mercury, cadmium, arsenic, chromium, zinc, nickel and copper. On release into the atmosphere, they travel for large distances and are deposited onto the soil, vegetation and water depending on their density. Once deposited, these metals are not degraded and persist in the environment for many years poisoning humans through inhalation, ingestion and skin absorption. Acute exposure leads to nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis (UNEP, 2015)

In Ghana, management of waste is a very big challenge to most Metropolitan, Municipal and District Assemblies (MMDA'S) especially how to effectively dispose it. Abokobi is in no exception.

The populace of Ledzokuku-krowor, Madina-Nkwantanang, Ga-East and West and Adenta Municipalities all use Abokobi dump site of about 8,150.47 tons per mont. Waste pickers sift through the waste to retrieve materials considered to be of value economically. They therefore set a portion of the dump site on fire enabling them to easily obtain some materials like copper and other metallic materials (Ga-East Municipal Assembly, 2014).

Children who like to play around the dumpsite are exposed to the smoke that emanates from the dumpsite because of the activities of the waste pickers making the children prone to respiratory tract infection and other health conditions. Furthermore, the dumping of electronic materials that has cadmium, mercury and arsenic as parts of its content may be left in the soil during the dumping or burning process of these metals (Jerie, 2016). Most Children especially those under the age of 5 are mostly naive and are found playing in the soil making them highly exposed to these trace metals which will highly make them prone to respiratory tract infection.

Therefore, it is a necessity to assess the levels of trace metals and the linkage with the effect of respiratory tract infection on children under five (5).

1.2 Problem Statement

Infectious diseases retain the main cause of death in young kids, leading in nearly 4.4 million fatalities in 2010 among kids under the age of 5, despite significant improvements in immunization and sanitation programmes (Schuchat 2012; WHO 2010). Even infants born in industrialized countries such as the US face a heavy burden of infection-related morbidity and mortality, particularly before one year of age and mainly from respiratory and diarrhea diseases. (Mehal et al. 2012; Tregoning and Schwarze 2010). We are now starting to assess the possible effect of environmental agents on susceptibility to infection in children and to comprehend the impacts of toxicants such as arsenic, mercury and cadmium in changing the body's reaction to infection (Birnbaum & Jung 2010; Feingold et al. 2010; Karagas, 2010).

Non-occupational exposure to arsenic, mercury and cadmium happens mainly through contaminated drinking water, typically from unregulated private wells, contaminated soil and dumpsite leachate. (Jang, 2010).

There has been a public concern on the environmental hazards in connection with the Abokobi dumpsite recently and this has been a major discussion on some radio stations among the populace. Mismanagement of the dumpsite has led to serious environmental hazards, which may dangerously bring about health consequences.

Abokobi dump site situated in the Ga-East Municipal Assembly in Accra the Capital Region of Ghana was a temporary dump site some years back but now a major one with a total ground size of about 900-square metres. The populace of Ledzokuku-krowor, MadinaNkwantanang, Ga-East and West and Adenta Municipalities all use Abokobi dump site of about 8,150.47 tons per month (Ga-East Municipal Assembly, 2014).

Children who like to play around the dump site are exposed to smoke that emanates from the dump site as a result of the activities of waste pickers making the children prone to respiratory tract infection and other health conditions. Furthermore, the dumping of electronic materials that has mercury, cadmium and arsenic as parts of its content may be left in the soil during the dumping or burning process of these metals (Jerie, 2016).

Therefore, it is a necessity to assess the levels of trace metals and the linkage with the effect of respiratory tract infection on children under five (5).

1.3 Conceptual Framework

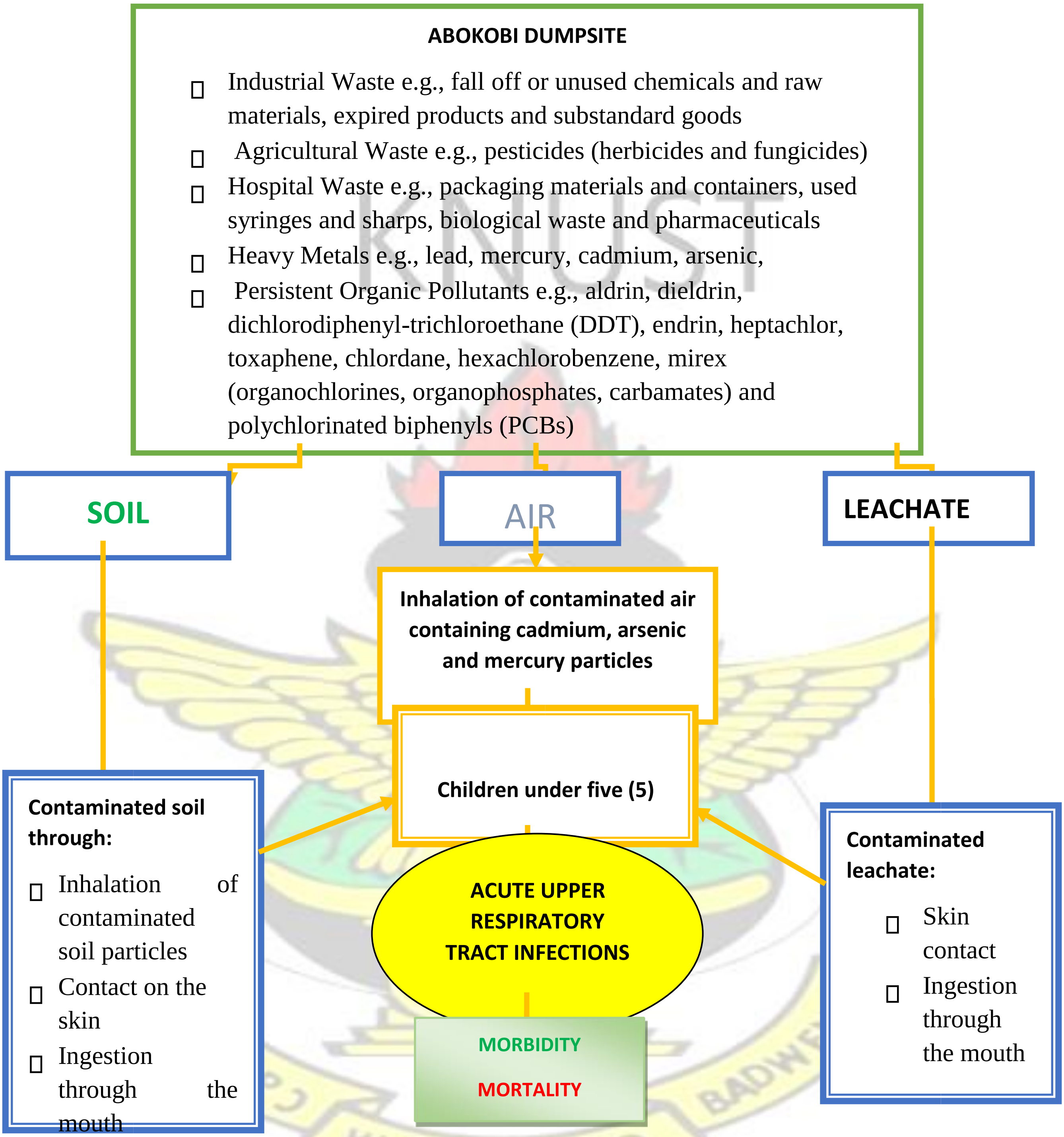

Figure 1. 1: Conceptual framework

Figure 1 above shows the relationship between toxic metals and other contaminants with acute respiratory tract infections in children under five (5).

Cadmium and Arsenic in municipal solid waste (MSW) landfill enters the waste stream from variety components of consumer products example used refrigerators, microwaves, among others. The total amount of Cd found in the municipal solid waste, enters the waste stream in the combustible fraction and can account for a major share of the Cd and As observed in fly ash and in atmospheric particulates. The most likely sources of Cd and As in the landfill are plastics, pigments, various industrial used and Nickel-Cadmium (NiCd) batteries (Edwin and Howell, 1990; ATSDR, 1999). The ingestion or inhalation of Cd may cause nausea, abdominal cramps, short breath, chocking fits, renal dysfunction and inhibition of iron absorption. Catarrhal and ulcerative gastroenteritis, congestion, pulmonary infarcts and subdural hemorrhages also may be found at necropsy (Donahoe et al., 2015).

Mercury in small, but varying concentrations can also be found virtually in all geological media (UNEP, 2010). Elemental and some forms of oxidized mercury are permanently coming to the atmosphere due to their volatility.

Arsenic exposure on the other hand affects virtually all organ systems including the cardiovascular, dermatologic, nervous, hepatobiliary, renal, gastro-intestinal, and respiratory systems (Tchounwou & Patlolla, 2003).

1.4 Justification of the Study

Different things are introduced into the environment in the quest of man to improve lives and make things easier. However, this can lead to contamination of the environment affecting both the soil and water as a whole. Contamination relates to the condition of soil or water where any chemical substance or waste has been added to the above ground level and is, or may be, an negative health or environmental impact (Worksafe, 2005). The persistence of heavy metals can lead to bioaccumulation and bio-magnifications that cause some bacteria to be more exposed than is the case in the ecosystem alone. (Adelekan & Abegunde, 2011).

Contamination of heavy metals threatens the human population with agriculture and other food sources as well as bad vegetation development and lower plant resistance to forest pests. This scenario presents a distinct kind of remediation challenge. People can also be subjected to soil contaminants by ingestion (eating or drinking), dermal exposure (skin contact) or inhalation (breathing), penetration via the skin or eyes (includes exposure to dust) (Shayley et al., 2009; Worksafe, 2005). Heavy metal exposure is usually chronic due to food chain transfer (exposure over a longer period of time). But acute (instant) poisoning by ingestion or dermal contact is uncommon, but it is feasible (Kumar et al., 2010; USDA and NRCS, 2000; Wei and Yang, 2010). Heavy metal toxicity is one of the main environmental health issues and is possibly hazardous due to bioaccumulation through the food chain (Rajaganapathy, 2011). Globally, human operations have influenced the biogeochemical cycling of heavy metals, leading to a gradual increase in the flow of bioavailable chemical types into the atmosphere (Yildiz et al., 2010). The metals are dispersed, focused and chemically altered through human operations, which can boost their toxicity. Although very little is known about their combined impacts, the combination of heavy metals with other chemical substances produces hazardous cocktails. The existence of heavy metals in water undermines their quality, which ultimately impacts human health (Rajaganapathy, 2011). Discarded computers, televisions, stereos, copiers, fax machines, electrical lamps, cell phones, audio equipment and batteries if disposed incorrectly, lead and other substances can leach into soil and groundwater (Ramachandra and Saira, 2004). This improves the activity of recycling to retrieve heavy metals from different equipment, increasing the heavy metals concentrations in the setting. Therefore, the presence of heavy metals in soil and water must be determined. This will serve as a guide to assist with different remediation operations and to raise awareness about their exposure to animals.

1.5 Research Questions

1. What is the prevalence level of symptoms of Acute Respiratory Infection (ARI)?

2. What are the self-reported indicators to toxic metals among children under five (5)?
3. What are the levels of toxic metals in biological media (blood)?
4. Are there any association between toxic metals in biological media and symptoms of Acute Respiratory Infection (ARI)?

1.6 Objectives of the Study

1.6.1 General Objective

The general objectives of this study is to assess the prevalence of symptoms of acute respiratory infection defined as Upper Respiratory Infection (URI) and Lower Respiratory Infectiojn the levels of toxic metals in biological (blood) media, and the association between toxic metals and symptoms of respiratory infection among under five children residing around Abokobi dump site in the Ga East Municipality.

1.6.2 Specific objective

5. To determine the prevalence of symptoms of AURI
6. To determine the self-reported indicators to toxic metals among children under 5
7. To quantify levels of toxic metals in biological media (blood).
8. To determine the association between toxic metals in biological media and symptoms of Acute Upper Respiratory Infection

1.7 Significance of Study

The outcome of this research would provide an overview of the crucial state of children living around dumpsites to enable stakeholders like Ministry of Health, Ministry of Local Government and Rural Development, Ministry of Environment, Science and Technology and

Ministry of Sanitation and Water Resources to be properly motivated to act in the mitigation of these extensive exposures to heavy metals.

1.8 Limitations of the Study

Factors such as time were the researcher's limitation. Due to that, the researcher was not able to carry out the study on a large sample size.

1.9 Scope/Delimitation

The target group was limited to residents around the dumpsite only but could be applied elsewhere.

1.10 Structure of Report

The study comprises five main chapters. The synopsis of the study was given as: chapter one gives the introductory of the study, related literature was reviewed in chapter two, chapter three details out the method, concept and parameters used for the study. The data collection method and instrument were explained here. Analysis, interpretation and illustrations with appropriate tables and figures were discussed in chapter four. Chapters five and six concludes the study with a summary of the findings, conclusion and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Scope of the Review

The study comprises review of theoretical and empirical literature relevant to the association between mercury, arsenic and cadmium on acute respiratory tract infections in children under five (5) around the Abokobi dumpsite. The literature review includes a brief history of waste dumpsite in Ghana including Abokobi dumpsite (Section 2.2**),** types of waste deposited at the dumpsite discussed under (Section 2.3), also in the discussion was the environmental (Section 2.4), and health (Section 2.5) impacts of open dumpsite, the last section reviewed studies on the relationship between open dumpsite respiratory infection (Section 2.6).

2.2 History of Waste Dumping Site in Ghana including Abokobi Dumpsite

It becomes the center of attraction for many financial and social activities as a city expands and becomes urbanized. Urban growth occurs without planning in most African nations resulting in low density development with deteriorating environmental circumstances (Yankson & Gough, 1999). And because population growth is inconsistent with planning, growth is suffering. This is because when big numbers of individuals move as a consequence of urbanization to a tiny region in search of livelihood, a issue for waste disposal is created as a consequence of enhanced waste generation connected with the growing population. (Yankson & Gough, 1999). Ghana's increasing number of towns in Africa, for that matter, faces the challenge of providing appropriate water supply, hygiene and solid waste services to their communities in perspective of the fast pace of urbanization. In the mid-1980s, the introduction of the Economic Recovery Program saw improvements in the Ghanaian economy (Yankson & Gough, 1999), with Accra becoming an attractive destination for all manner of people from various regions of the country. This resulted in an expansion and population increase from 450,000 in 1960 to 1,3 million in 1984 and an estimated 2 million in Accra in 2000. (Boadi and Kuitunen, 2003). This population increase has made it a governance challenge for local authorities to deliver efficient public services including solid waste services.

The cost and difficulties of managing waste are also increasing continually. Shubeler (1996) also noted that municipal solid waste management (MSWM) is a major responsibility of governments normally taking up between 20 to 30% of municipal budget in developing countries. Despite this huge budget, many countries collect less than generated.

The reality of this problem cannot be lost on Ghana, particularly in its major cities for instance Abokobi in Ga East Municipality which are wallowing in waste. Heaps of wastes are found at many places with landfill sites continuously running out of space for new waste generated while other options are fast depleting. This poses serious consequences for the public service including pressure on budget of government, growing demand for space consumed by waste as in landfill sites and the environmental, health and other social problems associated with improper waste management. There is thus the urgent need for efficient and alternative ways of generating and managing waste (Appiah, 2015).

For that matter waste has become a dilemma for the Ghanaian economy and health institutions, as well as environmental agencies so much that on 31st October, 2014, the President of the Republic declared every first Saturday of the month as a National Sanitation Day to address the embarrassingly poor sanitation situation of the country (Daabu, 2014). The country is currently overwhelmed with so much waste that government and private agencies have not been able to address the problems of waste adequately, particularly, in the major cities in the country (Selby, 2010).

Though there have been series of efforts by successive governments to help curb the problem of waste over the years, the situation has deteriorated. Solid waste presents a major challenge in Accra particularly among residents living within highly populated areas and low income communities. As at 2013, Accra was generating about 2,500 tonnes of solid waste daily (Arku, 2013). Solid waste management constitutes a serious problem in Ghana. Most municipalities do not collect the total amount of waste generated and of the waste collected, just a percentage receives proper disposal. The insufficient collection and inappropriate disposal of solid waste represent a source of pollution that poses risk to human health and the environment since the health status and productivity levels of the population are greatly influenced by the state of the environmental sanitation condition in which they live (Appiah, 2015).

Tema Municipal Assembly (2010) suggests that the problem of waste management in Ghana is a combination of factors prominent among which are poor spatial planning, inadequate and inappropriate equipment, inadequate expertise and underdeveloped private sector. The focus on waste management has been the centralized bureaucratic and conventional collection, transporting and dumping of waste in light of the inadequate resources and the overwhelming rate of waste generation to the neglect of other alternative means like pre-cycling, recovery of waste for reuse and recycling which could further lead to income generation particularly by households.

Nevertheless, speed of waste generation and management in the Ga East Municipality is a matter of great worry to the Assembly. The growing inflow of people into the municipality as a result of urbanization has led to an alarming rate of waste generation. The assembly estimates about 385 tonnes of solid waste generated per month (Ga East Municipal Assembly, 2014). However, only about 261 tonnes (67%) are collected. The 33% that is left builds up presenting various forms of health and environmental hazards.

The Municipal Planning Coordinating Unit (MPCU) of the Ga East Municipal Assembly based at Abokobi estimated the population of the municipality, using the 2010 population and housing census data, to be about 450,200 as at 2013 with 51% males and 49% females, and growing at an inter-censual rate of about 4.2% mainly as a result of migration inflows. The estimated population density of 1,214 persons per square kilometre (sq. km) is much higher than the national density of 79.3 persons per sq. km and the regional density of 895.5 persons per sq. km (Ga East Municipality Annual Report for 2013). With such an increase in the number of people in the municipality, there is great likelihood that has led the increased waste generation and disposal requiring informed research to solve the problems pertaining to waste management and the developmental problems associated with it (Appiah, 2015).

2.3 The Types of Waste

The International Solid Waste Association (ISWA, 2014-2015) states that, One of the most significant variables determining its health hazards is the waste streams disposed of at the dumpsite. In addition to municipal waste, waste from health care, hazardous waste and ewaste are prevalent streams discovered in dumpsites.

Municipal Waste

Organic waste in dumpsites is biodegraded, creating favourable circumstances for microbial pathogens' survival and development. If the waste is disposed of with pathogens from human body fluids such as faeces, urine, blood and sputum, these circumstances can be further improved. All of them are present in typical municipal waste through wetlands, sanitary pads and general vomiting discards and human secretions. Organic waste also provides food for enteric pathogens such as rodents, insects, birds and bigger wild mammals to carriers.

Thereafter, diffuse airborne emissions at dumpsites from biologically and chemically decomposing municipal solid waste are obviously a health danger. The decomposition of organic fractions in dumpsites results in the production of gasses and adds to the formation of leachate.

Thus the primary sources of a dumpsite's pollutant emissions are:

a. Wastes carried on site, usually in heavy-duty cars,
b. Transportation and bulldozers and compactors emissions,
c. Wind-blown waste as tipped or deposited at the dumpsite,
d. Dust produced from the dumpsite surface and tipped or unloaded waste,historical waste that have been already disposed of,
e. Any gas produced as a waste (if not gathered and handled) decomposes,
f. Any leachate generated by the decomposition of d waste.
g. Discharges from any leachate treatment process (if any).

While all these emissions are eliminated or completely controlled in contemporary sanitary landfills (owing to the use of sophisticated environmental protection measures such as liners, top covers, biogas and leachate management system, continuous monitoring), these emissions are uncontrolled in dumpsites and are in fact linked with severe health risks. The primary health-related pollutants in dumpsites are: permanent organic pollutants POPs such as dioxins and furans (PCDDs and PCDFs) are permanent non-biodegradable organic compounds generated by uncontrolled waste burning, natural methane gas generation and lowtemperature waste burning to recover metals. POPs cause biological reaction in animals, leading to neurological, immunological and reproductive issues (White, & Birnbaum, 2009).
POPs were also regarded accountable for respiratory disorders and increased risk of cancer (Krajcovicova, & Eschenroeder, 2007).

Heavy metals

In dumpsite leachate, air and soil generated either from plastic burning or scrap metal smelting and e-waste, heavy metals can be discovered. Lead, mercury, cadmium and arsenic are the primary heavy metals that cause neurological impairment, anemia, kidney failure, immune suppression, gastrointestinal and respiratory irritation, skeletal system defects, hepatic inflammation, hepatic cancer, and cardiovascular diseases after chronic exposure (UNEP, 2007).

Volatile organic compounds (VOCs)

Volatile organic compounds are damaging to humans and lead to ozone pollution at ground level, also known as smog. Inhaling certain VOCs can lead to irritation of the eye, nose, and throat, headache, loss of coordination, nausea, and liver, kidney, and central nervous system damage (EPA, Human Health, 2015).

Polynuclear Aromatic Hydrocarbons (PAHs)

The PAHs are a class of compounds consisting of two or more aromatic rings. (Nduka et al, 2013). Hundreds of them were recognized and discovered as mixtures of complexity. They are produced through incomplete combustion, forest fire and volcanic eruptions or other anthropogenic sources such as industrial manufacturing, transport and waste incineration.

They are categorized by the European Community (EC) and the United States Environmental Protection Agency (US EPA) as environmentally dangerous organic compounds and are included in the priority list of pollutants (Guillen et al, 2000).

Hydrogen Sulfide (H_2S)

Hydrogen sulfide is a flammable, colorless gas with a distinctive odor of rotten eggs. It is generated in dumpsites when mixed with biodegradable waste are sulphate-bearing materials (such as gypsum and plasterboard). The structure of the waste material and the on-site procedures will determine how much H_2S is generated. H_2S can lead to irritation of the mucous membranes of the eye and respiratory tract at low levels. High exposure results in central nervous system depression, loss of awareness and respiratory paralysis (HPA, 2009).

Although information on human impacts after repeated exposure are restricted and hard to interpret due to co-exposure to other chemicals, other health impacts have been recorded. (ISWA, 2015).

Particulates

Dumpsite activity produces both fine and coarse particulates, the composition of which depends on the on-site operations and the kinds of waste being handled (HPA, 2001). A variety of negative health impacts are known to be associated with exposure to particles that can enter the respiratory system. Particles with a diameter of more than 10 µm (particulate matter, PM10) are unlikely to penetrate beyond the nose and larynx, but as the particle diameter drops, the probability that they will enter the lungs and be deposited in the airways rises.

Particles with a diameter of less than approximately 2.5 µm (PM2.5) are referred to as Black Carbon or' fine' particles and are placed comparatively effectively in the deeper areas of the lung, such as alveolar spaces. Black Carbon comprises in several connected forms of pure carbon. It is created by the incomplete combustion of bio-components of dumpsites. According to WHO, 2012 the systematic analysis of accessible time series research, as well as data from panel research, offers adequate proof of an association of short-term (daily) differences in black carbon levels with short-term health modifications (all-cause and cardiac mortality and cardiopulmonary hospital admissions). Cohort studies provide adequate proof of all-cause and cardiopulmonary mortality associations with long-term average exposure to BC.

Particles in diameter between 2.5 and 10 µm are referred to as the coarse PM10 fraction. These particles can also have health impacts.

Particles that fall into both the PM10 and PM2.5 classifications will include dust emitted from dumpsites. Particularly susceptible to particulate air pollution are people with preexisting lung and heart disease, seniors and kids. Dust from dumpsites can become airborne and move off site by various processes. The quantity of dust removed from the dumpsite surface depends on the wind speed, surface situation, and dust particle size. Depending on the particle size and the wind speed and turbulence, the distance traveled by dust emissions.
Smaller particles of dust will remain longer in the air and spread across a wider region.

Odours

For dumpsites, odours are often a main problem, particularly those that receive biodegradable waste. Odours are typically associated with operations such as managing odorous waste and covering biodegradable waste or trace elements in gas or leachates. Societies reporting ill-health often follow emissions of odours (Steinheider, 1999). Individuals may report a wide range of non-specific health symptoms attributable to odor exposure, including nausea, headaches, drowsiness, fatigue, and problems with breathing. Health symptoms associated with odorous emissions may happen at olfactory detectable concentrations well below the levels associated with toxic effects or thresholds for mucous membrane irritation. Individual odour reaction is highly variable, and many factors, including sensitivity, age, and prior odour exposure, affect it. Psychological and social factors will also play an important role in an individual's response in relation to an individual's point of concern about the future harm to their health. Studies indicating a strong correlation between perceived odour disorder and subjective symptoms has been published (Dalton, 2003).

Leachate

The nature of leachate from landfill is a function of kinds of waste, solubility, decomposition and degradation. In addition to helping in the degradation process by wetting the waste, the contribution of rainfall can serve to dilute and wash contaminants. There may be a broad variety of substances in leachate, some of which may be detrimental to human health. Priority substances in landfill leachate include Aniline, Arsenic, Biphenyl, Cyanide, Di (2-ethyl hexyl) phthalate, Dichloromethane, Ethylbenzene, Fluoride, Mecoprop, Methyl chlorophenoxy acetic acid, Methyl tertiary butyl ether, Naphthalene, Nitrogen, Nonylphenol, Organotin compounds, Pentachlorophenol, Phenols, Phosphorus, Polycyclic aromatic hydrocarbons, Toluene, Xylenes.

In fact, the health risks posed by leachate demonstrate the huge difference between a dumpsite and a modern landfill. Any modern landfill is located through a proper site allocation and environmental Impact Assessment procedure that takes into account environmental vulnerability. Leachate in a modern landfill is discharged following treatment in an on-site process, and/or at an off-site sewage works. Modern landfill liners are also very effective in containing leachate and only a tiny amount of leachate might be released via the landfill lining system to land or groundwater. Modern landfills also impose continuous monitoring procedures, which identify leakages as soon as they happen. For all those reasons, it can be documented that leachate releases from modern landfills to surface or groundwater are unlikely to pose a significant risk of adverse effects on health (environment Agency (eA), 2003). In contrast, leachate releases by dumpsites are uncontrolled and surface and groundwater pollution should be considered as an almost certain consequence of the dumpsites operation. Taking into account that dumpsites are located without any proper procedures that take into consideration environmental vulnerability, it is not a surprise that serious surface and groundwater pollution is the rule in dumpsites (David, & Oluyege, 2014; Glenn Sia & Su, 2005).

Biogas

Biogas formation at dumpsites can result in explosion risks and several similar accidents have been reported, some of them with lethal consequences (see relevant paragraph). Carbon dioxide and methane are the two major components of biogas. The health effects of exposure to methane and carbon dioxide are well known.

Both are colourless, odourless gases which act as asphyxiants. Carbon dioxide is nonflammable and, at low concentrations or low levels of exposure, it increases the depth and rate of respiration, blood pressure and pulse (HPA, 2010). At increasing concentrations, a depressive phase develops which can culminate in cardio respiratory failure. Concentrations above 6% by volume can give rise to headache, dizziness, mental confusion, palpitations, increased blood pressure, difficulty breathing and central nervous system depression. Humans cannot breathe air containing more than 10% carbon dioxide without losing consciousness. In contrast to carbon dioxide, methane is a flammable gas, which is explosive in air at concentrations between 5 and 15% by volume. Inhalation can cause nausea, vomiting, headache and loss of coordination. At very high concentrations it may cause coma and death due to respiratory arrest (HPA, 2014).

In addition, municipal waste usually includes limited quantities of harmful substances like: Chemicals (pesticides, garden products, batteries, bleach, paint, varnishes, cleaning products) biologicals (human waste, green waste, animal infestations, dead animal carcasses, animal waste, used needles/syringes, drugs etc.).

According to HSe, 2014, a dumpsite, health risks from those harmful substances can occur via the following routes (for both workers and informal recyclers): Skin contact, especially through cuts and abrasions or contact with the eye's mucus membrane; Skin penetration through sharps injuries; sharp items, such as broken glass and tin cans may increase the risk of exposure; and also ingestion through hand-to-mouth contact (usually when eating, drinking or smoking); breathing in infectious aerosols/droplets from the air.

Hazardous waste

Hazardous wastes in dumpsites are a real threat for the lives of the workers and the nearby residents. WHO has estimated that environmental exposure contributes to 19% of cancer incidence worldwide (Vineis, P. and W. Xun, 2009). Additionally, a WHO Global Health risks report looked at five environmental exposures, (unsafe water, sanitation and hygiene, urban outdoor air pollution, indoor smoke from solid fuels, lead exposure and climate change), and estimated they account for nearly 10% of deaths and disease burden globally and around one quarter of deaths and disease burden in children under the age of five (WHO, 2009). Hazardous wastes are by-products of human activities that could cause substantial harm to human health or the environment if improperly managed. As an example, the United States Environmental Protection Agency (EPA) classifies liquid, solid, and gaseous discarded materials and emissions as hazardous if they are poisonous (toxic), flammable, corrosive, or chemically reactive at levels above specified safety thresholds. The term hazardous waste generally refers to potentially dangerous or polluting chemical compounds, other potentially hazardous industrial, military, agricultural, and municipal byproducts, including biological contaminants. Chemical manufacturing, primary metal production, metal fabrication, and petroleum processing are some of the most usual industrial hazardous waste generators. However, businesses of all sizes generate dangerous chemicals; as an example, USA EPA currently lists more than 250,000 facilities as “small-quantity generators” of hazardous waste. These diverse, smaller producers account for about 10% of the potentially harmful substances produced each year.

Obsolete pesticides, stored in leaking drums or torn bags, can directly or indirectly affect the health of anyone who comes into contact with them. during heavy rains, leaked pesticides can seep into the ground and contaminate the groundwater. Poisoning can occur through direct contact with the product, inhalation of vapors, drinking of contaminated water, or eating of contaminated food. Other hazards may include the possibility of fire and contamination as a result of inadequate disposal such as burning or burying. Chemical residues discharged into the sewerage system may have adverse effects on the operation of biological sewage treatment plants or toxic effects on the natural ecosystems of receiving waters (ISWA, 2015).

Asbestos is another common hazardous waste, directly linked with serious health impacts. Asbestos refers to a family of fibrous minerals found all over world. When the fibers break off and become airborne, they can create a health risk if inhaled. Asbestos exposure is associated with certain types of lung cancer, and long-term occupational exposure can also cause the lung disease asbestosis. In the past, asbestos was used in many household products and building materials because of its heat resistant and structural properties. As a result, building renovation and demolition projects produce much of the asbestos waste found today (ISWA, 2015).

A recent report published by blacksmith Institute (*black SmITH InSTITuTe, 2012*) estimates that hazardous industrial / municipal waste dumpsites rank fifth in the Top-Ten Industrial Pollution sources, while the first and second are lead battery recycling and lead smelting.
There are almost 150 industrial or municipal dumpsites in the blacksmith Institute's database that are polluting local communities, potentially putting almost 3.5 million people at risk. The largest shares of these dumpsites are in Africa and in eastern European and northern Asian countries. Combined, these regions make up more than half of the total at risk population in the blacksmith investigations of dumpsites. However, industrial and municipal dumpsites are prevalent throughout the developing world including in South and Central America and South and Southeast Asia.

At properly run municipal solid waste landfills, hazardous materials considered carcinogenic, corrosive, toxic, or flammable are not accepted and are directed to special treatment or disposal sites (Allen, Taylor, 2006). At informal or improperly run sites, all these items are disposed together, creating a toxic stew of waste exposed to heat, rain and air, causing the materials to break down and easily enter the environment. Industrial waste is one of the most toxic wastes at dumpsites and makes up a large portion of the pollution problem at the dumpsites investigated by blacksmith. The main sources of pollutants from dumpsites are either leachate (contaminated liquids leaching into the groundwater), dust from poorly covered dumpsites and gases. leachate can contain heavy metals, VoC's or hazardous organic compounds. These pollutants are carried into aquifers or surface waters. Dust from dumpsites may contain metals and human pathogens that come into contact with this pollution through contaminated groundwater and soil, or direct contact with the waste site(ISWA (International solid waste association, 2015).

Children often are seen playing in and around dumpsites, introducing direct exposure with hazardous waste through dermal contact, inhalation of dust or accidental ingestion. Informal neighborhoods are often built on top of previous dumpsites where the soil, groundwater and nearby surface waters are contaminated, indirectly exposing the local population to leached pollutants. A notable issue with dumpsites in the developing world is the presence of scavengers - workers and their families at dumpsites who make their living by recovering economically valuable materials in the waste. In such situations, people come into direct contact with the hazardous waste (ISWA, 2015).

In the blacksmith Institute's database of industrial or municipal dumpsites the most pervasive and harmful pollutants are lead and chromium. Combined they are the key pollutants in a third of the sites, potentially affecting almost 1.2 million people. The health impacts of these pollutants include lung cancer, neurological problems and cardiovascular disease. Other pollutants in the database of dumpsites include cadmium, multiple types of pesticides, and arsenic and VoCs. Researchers analyzed 373 toxic waste sites in India, Indonesia and the

Philippines, where an estimated 8.6 million people are at risk of exposure to lead, asbestos, hexavalent chromium and other hazardous materials. Among those people at risk, the exposures could cause a loss of around 829,000 years of good health as a result of disease, disability or early death (Chatham-Stephens et al, 2010). In comparison, malaria in these countries, whose combined population is nearly 1.6 billion, causes the loss of 725,000 healthy years (McGoodwin 2018) while outdoor air pollution claims almost 1.5 million healthy years, according to the World Health organization. In fact, this is a shocking finding: it seems that dumpsites are a more serious health risk than malaria at least for the 1.6 billion people of India, Indonesia and Philippines. (Mavropoulos, 2010)"

Health-care waste

Healthcare waste (HCW) is usually found in almost all the dumpsites in the developing world. Healthcare facilities, microbiological research laboratories, diagnostic laboratories, pharmaceutical firms and funeral homes have always generated a wide variety of waste components that have the potential of transmitting infectious agents to humans. These include discarded materials or equipment from the diagnosis, treatment and prevention of disease, assessment of health status or identification purposes that have been in contact with blood and its derivatives, tissues, tissue fluids or excreta, or wastes from infection wards (Salkin, 2004).

Typical elements of the HCW are the following:

Cultures and stocks of infectious agents and associated biologicals, including: cultures and stocks of infectious agents generated in research or clinical laboratories; wastes from the production of biologicals including vaccines, antigens and antitoxins, and sera. Pathological waste including tissues, organs, and body parts; body fluids that are removed during surgery, autopsy, or other medical procedures; specimens of body fluids. blood and blood products including discarded liquid human blood; discarded blood components (e.g., serum and plasma); containers with free flowing blood or blood components. Items or materials contaminated with blood or blood products. Sharps from health care, research, clinical laboratories and blood banks, including but not limited to: needles and syringes, scalpel blades, and broken or unbroken glassware, which were in contact with blood or blood derivatives. Animal waste including carcasses, body parts, body fluids, blood originating from animals from veterinary clinics or research institutes (Pruss et al., 1999).

The hazardous components of HCW pose physical, chemical, radiological and/or microbiological risks to the public and those involved in their handling, treatment and disposal. In most cases, the concentration of hazardous chemicals present in HCW is generally too low to be considered an occupational problem or a danger to the public (Collins, & Kennedy, 1992).

Physical injuries caused by discarded sharps are a more significant risk associated with HCW and may directly contribute to the transmission of microbial infectious agents. In addition, health risks may be generated through the release of toxic pollutants during dumpsite open burning or accidental fires (Collins, & Kennedy, 1992).

The most common and most investigated cause of the microbiological risks associated with HCW are injuries due to needles (Haiduven, 1999). Other sharps wastes presenting similar risks include glass and plastic ware employed in clinical and anatomic laboratories, blood collection systems for obtaining specimens, and scalpel blades from surgical procedures. These sharps may all have been in contact with microbial pathogens. More importantly, sharps can cause percutaneous injuries and thereby create an opening for infectious agents to enter the body. The latter is one of the five essential elements in the acquisition of microbial infections. (WHO, 2004)

Most exposures to biological hazards from healthcare wastes occur when workers or informal recyclers are trying to recover useful elements like metals. Workers may be exposed to blood and body fluids from leaking containers as well as airborne pathogens as the waste enters the dumpsite (WHO, 2004).

Healthcare waste components may also create microbiological risks as a source of infectious aerosols, i.e. droplets of less than 1- 3 microns in diameter, which contain etiologic agents of human and animal diseases (Centers for Disease Control and Prevention 1994, Gershon RR 1998). Weber 1999, states that cultures and stocks from the clinical laboratory contain high concentrations of many infectious agents, e.g. mycobacterium tuberculosis, which is naturally transmitted to their hosts through inhalation, although generally all infectious laboratory waste is treated at the source. Human and animal tissues, organs, and body parts have also been reported in scientific literature as sources of infectious aerosols. Finally, animal bedding materials, which have been saturated with body fluids, blood and excrement, can generate aerosols, which are a potential microbiological risk.

Leese et al., (n.d) added that blood and blood products, as well as various types of body fluids may be capable of transmitting pathogens when brought into direct contact with the mucosal lining of the mouth and nose, the eyes, and areas of the skin containing cuts and abrasions.

It should be also noted that many of the chemicals and pharmaceuticals used in healthcare establishments are hazardous (e.g. toxic, genotoxic, corrosive, flammable, reactive, explosive, shock-sensitive). These substances are commonly present in small quantities in healthcare waste; larger quantities may be found when unwanted or outdated chemicals and pharmaceuticals are disposed of. They may cause intoxication, either by acute or by chronic exposure, and injuries, including burns. Intoxication can result from absorption of a chemical or pharmaceutical through the skin or the mucous membranes, or from inhalation or ingestion. Injuries to the skin, the eyes, or the mucous membranes of the airways can be caused by contact with flammable, corrosive, or reactive chemicals (e.g. formaldehyde and other volatile substances). The most common injuries are burns. Disinfectants are particularly important members of this group: they are used in large quantities and are often corrosive. It should also be noted that reactive chemicals might form highly toxic secondary compounds (WHO, 1999).

E-waste

The term E-waste describes waste electronic goods, such as computers, televisions and cell phones, while WEEE also includes traditionally non-electronic goods such as washing machines, dishwashers, refrigerators and ovens. Computers and mobile telephones are disproportionately abundant because of their short lifespan. Components of electrical and electronic equipment such as batteries, circuit boards, plastic casings, cathode-ray tubes, activated glass, and lead capacitors are also classified as e-waste (United Nations Environment Programme (UNEP), 1989).

According to the most recent statistics by STEP (Solving the E-waste Problem) initiative (http://www.step-initiative.org/overview-world.html), in 2014 roughly 42 million tonnes of ewaste were generated.

E-Waste is chemically and physically distinct from other forms of municipal or industrial waste; it contains both valuable and hazardous materials that require special handling and recycling methods to avoid environmental contamination and detrimental effects on human health. Recycling can recover reusable components and base materials, especially Cu and precious metals. However, due to lack of facilities, high labor costs, and tough environmental regulations, rich countries have only recently begun to recycle E-waste as EPR systems have been implemented in Europe and elsewhere. Instead, E-Waste has been either landfilled, or exported from rich countries to poor countries, where it may be recycled using primitive techniques and little regard for worker safety of environmental protection (Cobbing, 2008).

The chemical composition of E-waste varies depending on the age and type of the discarded item. However, most E-waste is composed of a mixture of metals, particularly Cu, Al, and Fe, attached to, covered with, or mixed with various types of plastics and ceramics. Heavy WEEE items, such as washing machines and refrigerators, which are mostly composed of steel, may contain fewer potential environmental contaminants than lighter E-waste items, such as laptop computers, which may contain high concentrations of flame retardants and heavy metals (Kulkarn, 2017).

Virtually all E-waste contains some valuable components or base materials, especially Cu. These are environmentally important, because they provide an incentive for recycling, which occurs predominantly in poor countries, and may result in a human health risk or environmental pollution. Platinum group metals are included in electrical contact materials due to their high chemical stability and conductivity of electricity. The precious metal concentrations in printed circuit boards are more than tenfold higher than commercially mined minerals (Betts, 2004).

The concentrations of environmental contaminants found in E-waste depend on the type of item that is discarded and the time when that item was produced.

Some contaminants, such as heavy metals, are used in the manufacture of electronic goods, while others, such as polycyclic aromatic hydrocarbons (PAHs) are generated by the lowtemperature combustion of E-waste. The burning of insulated wire, which typically occurs in open iron barrels, generates 100 times more dioxins than burning domestic waste (Gullett, 2007).

Although recycling may remove some contaminants, large amounts may still end up concentrated in landfills or e-waste recycling centers, where they may adversely affect human health or the environment. Polybrominated diphenyl ethers (Pbdes) are flame-retardants that are mixed into plastics and components. There are no chemical bonds between the Pbdes and the plastics and therefore they may leach from the surface of e-waste components into the environment (Deng, et al, 2007). Pbdes are lipophilic, resulting in their bioaccumulation in organisms and biomagnification in food chains. Pbdes have endocrine disrupting properties (Tseng, 2008).

Obsolete refrigerators, freezers and air conditioning units contain ozone-depleting Chlorofluorocarbons (CFCs). These gases may escape from items disposed in landfills (ISWA, 2015).

Dust is a significant environmental media that can provide information about the level, distribution, and fate of contaminants present in the surface environment (Akhter & Madany, 1993). As an example, recent studies have demonstrated elevated body loadings of heavy metals (Huo, et al. 2007) and persistent toxic substances in children and e-waste workers, respectively, at Guiyu, China (Bi, et al 2007)

E-waste pollutants are released as a mixture, and the effects of exposure to a specific compound or element cannot be considered in isolation. However, a more complex understanding of the interactions between the chemical components of e-waste is needed. Exposure to e-waste is a complex process in which many routes and sources of exposure, different lengths of exposure time, and possible inhibitory, synergistic, or additive effects of many chemical exposures are all important variables. Exposure to e-waste is a unique variable in itself and the exposures implicated should be considered as a whole. Sources of exposure to e-waste can be classified into three sectors: informal recycling, formal recycling, and exposure to hazardous e-waste compounds remaining in the environment (ie, environmental exposure) (Wong et al. 2007).

Exposure routes can vary dependent on the substance and the informal recycling process. Generally, exposure to the hazardous components of e-waste is most likely to arise through inhalation, ingestion, and dermal contact. In addition to direct occupational (formal or informal) exposure, people can come into contact with e-waste materials, and associated pollutants, through contact with contaminated soil, dust, air, water, and through food sources, including meat (Robinson, 2007; ATSDR, 2012). Children, fetuses, pregnant women, elderly people, people with disabilities, workers in the informal e-waste recycling sector, and other vulnerable populations face additional exposure risks. Children are a particularly sensitive group because of additional routes of exposure (eg, breastfeeding and placental exposures), high-risk behaviors (eg, hand-to-mouth activities in early years and high risk-taking behaviors in adolescence), and their changing physiology (e.g. high intakes of air, water, and food, and low rates of toxin elimination) 22. The children of e-waste recycling workers also face take-home contamination from their parents' clothes and skin and direct high-level exposure if recycling is taking place in their homes (Grant, et al., 2013).

In a recent study of health risks posed by e-waste, 23 published epidemiological studies were reviewed, all from southeast China. The project recorded plausible outcomes associated with exposure to e-waste including change in thyroid function, changes in cellular expression and function, adverse neonatal outcomes, changes in temperament and behavior, and decreased lung function. Boys aged 8–9 years living in an e-waste recycling town had a lower forced vital capacity than did those living in a control town. Significant negative correlations between blood chromium concentrations and forced vital capacity in children aged 11 and 13 years were also reported. Findings from most studies showed increases in spontaneous abortions, stillbirths, and premature births, and reduced birth weights and birth lengths associated with exposure to e-waste. People living in e-waste recycling towns or working in e-waste recycling had evidence of greater DNA damage than did those living in control towns (Grant, et al., 2013).

In other studies, according to Fangxing, et al., (2011), researchers have linked e-waste to adverse effects on human health, such as inflammation and oxidative stress – precursors to cardiovascular disease, DNA damage and possibly cancer. Although the toxicology of many e-waste components is well characterized, some newer materials, such as gallium and indium arsenides found in newer semiconductors, are less well understood. Their incorporation into nanomaterials may increase bioavailability in unanticipated ways. Developing children and fetuses may be particularly vulnerable to toxins found in e-waste, and early epidemiological studies near informal e-waste recycling sites indicate potential developmental neurotoxicity. Understanding the hazards of e-waste, the impacts of its disposal, and the dangers of informal or careless recycling will help reduce or prevent disease outcomes associated with exposure to e-waste components (Dalh, 2012).

Open burning

"Open burning" of waste is a usual practice in many dumpsites, as a means to reduce the waste volume. The practice of open burning results in many harmful public health and environmental effects (ISWA, 2015).

Worldwide scientific research has conclusively demonstrated that burning of waste at dumpsites produces air toxins. Typically, burning occurs at low temperatures (250 ^{o}C to 700 ^{o}C) in oxygen-starved conditions. Hydrocarbons, chlorinated materials and pesticide compounds under these conditions produce a wide range of toxic gases harmful to the environment and public health. These gases contain dioxins / furans, volatile organic compounds, particulate matter (Pm), hydrogen chloride (HCl), carbon monoxide (Co) and oxides of sulfur and nitrogen and liberate metals including antimony, arsenic, barium, beryllium, cadmium, chromium, lead, manganese, mercury, phosphorus and titanium (Nammari, et al, 2004).

The United States Environmental Protection Agency estimates in 2004 that uncontrolled mixed garbage burning is a larger source of dioxins than coal combustion, ferrous metal smelting, hazardous waste incineration or bleached pulp mill operations.

The burning of waste produces two types of ash, bottom and fly ash. Fly ash is made of light particles which is carried out by combustion gas and is laden with toxic metals, dioxin / furan and other products of incomplete combustion which can travel thousands of kilometers before they drop out where they enter into the human food chain. Open burning emissions are troubling from a public health perspective because of several reasons:

Open burning emissions are typically released at or near ground level instead of through tall stacks, which aid dispersion; Open burning emissions are not spread evenly throughout the year; rather, they are typically episodic in time or season and localized/regionalized; Open burning sources are non-point sources and are spread out over large areas; Compliance to any bans on open burning are difficult to enforce. Open burning is a transient combustion phenomenon, frequently with heterogeneous fuels; it is difficult to attribute emissions to a single component of the fuel.

One of the most harmful pollutants released during open burning is dioxin. Dioxin is a known carcinogen and is associated with birth defects. Dioxin can be inhaled directly or deposited on soil, water and crops where it becomes part of the food chain. Burning mSW can release hexchlorobenzene (HCb) to the environment. This compound is a highly persistent toxin that degrades slowly in the air. Therefore, it can travel long distances in the atmosphere. It bioaccumulates in fish, marine animals, birds, lichens, and animals that feed on fish and lichens. HCb is a probable human carcinogen, and based on animal studies, longterm, low-level exposures to HCb can damage a developing fetus, lead to kidney and liver damage, and cause fatigue and skin irritation.

Formaldehyde is released when pressed wood products, paints, coatings, siding, ureaformaldehyde foam, and fiberglass insulation are burned. Exposure to formaldehyde can result in watery eyes, a burning sensation in the eyes and throat, nausea, difficulty in breathing (i.e., coughing, chest tightness, wheezing), and skin rashes. Prolonged exposure to formaldehyde may cause cancer.

Burning of plastics, or polyvinyl chloride (PVCs), can produce hydrogen chloride gas, or hydrochloric acid, which can cause fluid buildup in the lungs and possible ulceration of the respiratory tract.

The visible smoke from burning is composed of tiny particles (particulates), which contain toxic pollutants. If inhaled, these microscopic particles can reach deep into the lungs and remain there for months or even years. Breathing particulates increases the chances of respiratory infection, can trigger asthma attacks, and causes other problems such as coughing, wheezing, chest pain, and shortness of breath (Nammari, 2004).

Black Carbon is a very usual output of open burning practices. Besides being the secondgreatest contributor to global warming after carbon dioxide, black carbon also poses risks to human health, including cardiovascular disease, respiratory disease and premature death (PnAS, 2014).

Carbon monoxide is harmful when breathed because it displaces oxygen in the blood and deprives the heart, brain, and other vital organs of oxygen, which can cause permanent damage or death, a condition known as anoxemia (Occupational Safety and Health Administration (OSHA).

Of particular health concern are tyre fires. Tyres are composed of natural rubber from rubber trees, synthetic rubber made from petrochemical feedstock, carbon black, extender oils, steel wire, up to 17 heavy metals, other petrochemicals and chlorine. A coal and tyre chlorine content comparison showed that tyres might contain as much as 2 to 5 times the chlorine level of typical western coal. Tyre fires burn for a long time allowing the buildup of the byproducts of combustion around surrounding areas. Burning tyres are known to emit dioxins and benzene derivatives, which have been linked with reproductive impairment and cancer in humans (Adeolu o et al, 2004). Tyre fires releases a dark, thick smoke that contains carbon monoxide, sulphur dioxide and products of butadiene and styrene. Further, tyre fires can be extremely difficult to contain and extinguish and therefore burn and smolder for a long period of time. Even after they are extinguished, tyre fires can flare up again weeks, even months later. This can cause a build-up of the byproducts of combustion in confined areas such as surrounding homes, which creates an additional health hazard (United States Fire Administration (USFA).

2.4 Dumpsites and Environment

Mercury (Hg)

Mercury is generally found at very low concentrations and is very reactive in the environment. Total mercury levels are generally less than 10 ng/g in crustal materials such as granites, feldspars and clays (Davis et al., 1997), and in the range of 40 to 200 ng/g in soils and sediments that are not directly impacted by anthropogenic discharges. Generally, the majority of mercury in aquatic systems is in organic forms (about 95 to 99%) and is found in sediments rather than the dissolved phase. There are both natural and anthropogenic sources of mercury to the environment. For example, mercury is a trace component of many minerals and economic ore deposits for mercury occur as native mercury and Cinnabar (HgS). Various industrial discharges, coal combustion and medical waste incineration are important anthropogenic sources. Abandoned mines, where mercury was used for extraction purposes, are also important sources.

General Waste Information

Inorganic mercury exists in three known oxidation states: as elemental mercury (Hg°), as mercurous ion (Hg+) and as mercuric ion (Hg2+). The oxidation state of mercury in an aqueous environment is dependent upon the redox potential, the pH, and the nature of the anions and other chemical forms present with which mercury may form stable complexes (Reimers*et al.*, 1974). Mercurous compounds (Hg+) are not common as they are rapidly oxidized to mercuric forms (Hg2+) by hydrolysis (Booer, 1944). The presence of organic matter in the sediments can either enhance mercury mobility, by forming soluble organic complexes, or retard mobility, by creating an environment conducive to precipitation of mercuric sulphides. The presence of iron oxyhydroxides (precipitated from the seepage waters) at the sediment surface may also scavenge mercury by absorption onto the hydrated oxyhydroxide surface. In general, the sediment water interface tends to accumulate inorganic mercury, and both pore water and the water column are possible sites for mercury methylation (Beak International Incorporated, 2002).

An important characteristic of mercury is its low solubility as a result of its high probability to coagulate that is to be removed from the soluble aqueous phase. This can occur by a number of physicochemical processes, example, precipitation as mercuric sulphide, coprecipitation with hydrated iron and manganese oxides, complexation with organic matter. The solubilization/coagulation of mercury depends on the forms of mercury present, on the amounts and nature of the organic and inorganic matter present, as well as on the environmental conditions, example, pH and chloride levels. Balogh et al. (1998) showed that total mercury levels in water are strongly correlated with total suspended solids concentrations, suggesting that mercury can remain suspended in the water column attached to colloidal and particulate matter. In aquatic systems, dissolved mercury can be partitioned between inorganic and organic forms and this is largely controlled by rates of methylation and demethylation by microorganisms (Pak and Bartha, 1998). Organic mercury can occur as an organomercuric salt

(RHgX), example, methylmercuric chloride, or as an organomercuric compound (R_2Hg), example, dimethylmercury. While the majority of mercury in aquatic ecosystems is in the inorganic form (about 95 to 99 %) (Krabbenhoft, 1996), organic mercury complexes remain important influences on the mobility and bioavailability of mercury. Evidence suggests that, when dissolved mercury in natural water systems exists mostly in organic forms, a high level of mercury in fish tissues is observed (Gill and Bruland, 1990). Mercury methylation is a biologically mediated process between dissolved inorganic mercury and, primarily, sulphate reducing bacteria (Driscoll, et al., 1994).

The factors that influence the amount of methyl mercury present in an aquatic system include the amount of dissolved inorganic mercury and physicochemical characteristics of the aquatic system such as pH, organic matter, dissolved sulphate and sediment sulphide (Pak and Bartha, 1998). For example, mercury methylation activity in sediments was found to be positively correlated with the level of organic matter (Driscoll *et al*., 1994). Thus, anaerobic zones such as the basins of small lakes, flooded forest soils and wetlands provide ideal conditions for mercury methylation.

However, the science of mercury methylation and dimethylation is not fully understood, and rates of methylmercury formation are not readily predictable. The relative abundance of methylated mercury species is of particular concern since these compounds are highly toxic, they are the major form of mercury that accumulates in fish tissues, and they can enter the food chain by direct uptake from solution (Driscoll, et al., 1994). Two aspects of chemical structure confer the unique toxic properties of methyl mercury. The bond between mercury and the methyl group is stable, with the methyl group providing a lipophilic character to the compound, while Hg (II) has a tendency to bind with sulfhydryl (or selenol) groups (Craig, 1986; Carty & Malone, 1979). Consequently, methylmercury is both membrane permeable and thiol reactive, properties which contribute to the toxicity, the long biological half-time, and the tendency toward bioaccumulation of mercury in aquatic organisms.

The organomercuric salts exhibit properties and reactions similar to those of inorganic mercuric salts, and thus do not bioaccumulate as well as methylmercury. The organomercuric compounds other than methyl mercury species are generally subject to abiotic environmental degradation, being volatile, thermally unstable and light sensitive, example, decomposition by ultraviolet radiation to elemental mercury and free radicals

Considerations for Mine Effluents and Receiving Waters

Mine effluent likely contains dissolved inorganic species of mercury. The behaviour of inorganic mercury species is well known and thermodynamic data are available. Two mercury compounds are predominant: hydrated mercuric oxide (HgO·H2O) at high pH and mercuric chloride (HgCl2) at low pH. However, at high concentrations of chlorides (and low pH), the very stable and water-soluble mercuric tetrachloride complex (HgCl4) will form. The receiving environment has a variety of biogeochemical conditions that may influence the behaviour of mercury. The formation and dissolution of inorganic Hg solids is controlled by redox and pH conditions and redox conditions in particular occur over a wide range in surface water environments. Under aerobic conditions, at lower pH, mercuric chloride is the dominant solid, and at higher pH hydrated mercuric oxide is found. Waters in equilibrium with these solids would have very high concentrations of mercury. For example, water in equilibrium with mercury hydroxide $Hg(OH)_2$ has mercury concentrations that range from approximately 350 mg/L at pH 6 to approximately 75 mg/L at pH 8 to 11. Because mercury is not found in effluents at concentrations near these levels, it is unlikely that solids precipitation will affect mercury concentrations in mill effluent.

Under anaerobic conditions, mercury is stable in two forms: elemental mercury and mercuric sulphide. Mercury exhibits a very high affinity for sulphide in mildly reducing environments such as stream and lake sediments, forming the relatively insoluble mercury sulphide (HgS (s)) (Davis et al., 1997; Wang & Driscoll, 1995). Typical pore water concentrations range from approximately 2 ng/L at pH 6 to several mg/L at pH values greater than 8.5. In highly anaerobic systems, the mercuric sulphide may be reduced to elemental mercury and sulphide, whereas under alkaline conditions with high levels of sulphides the more soluble mercuric disulphide complex (HgS22-) may exist.

Interactions with Other Metals, including Adsorption

Dissolved mercury sorbs strongly to sediment and suspended solids including organic material and Fe- or Mn-oxyhydroxides (Balogh, et al., 1998). Gagnon and Fisher (1997) demonstrated that the binding strength of mercury to sediments is very high at near neutral pH values and that very little desorption (less than 10%) occurs at lower or acidic pH values (pH <5). Therefore, the increase in iron oxyhydroxides present on the sediment surface (resulting from precipitation of iron and manganese from seepage waters) may be accompanied by a decrease in mercury mobility, due to the tendency of inorganic mercury and mercury bound organic complexes to adsorb onto these iron oxyhydroxide surfaces (Schutler, 1997). There is a large body of literature demonstrating the antagonism of selenium towards mercury toxicity in animals (Rudd et al., 1980). In spite of several demonstrations that selenium interacts with Hg in surface waters (Rudd, et al., 1980; Rudd, et al., 1983; Bjornberg, et al., 1988; Paulsson & Lundberg, 1989), the mechanism(s) responsible for the interactions remain unknown (Pelletier, 1985). Selenium may bind with mercury, mercury and selenium may become bound as insoluble mercuric selenide in sediments, making mercury unavailable for methylation, or selenium may cause indirect effects (as a toxicant) inhibiting bacterially mediated mercury methylation. One specific hypothesis relates to this possibility; the methylation of sedimentary selenium to dimethyl selenide may be stimulated by elevated selenium concentrations, which may in turn inhibit mercury methylation. Because of the relative infancy of the research field, there is little information available in the literature with which to judge the relative merits of these potential mechanisms.

Cadmium

Contrasting numerous other metals, cadmium has been used by man, only relatively in recent times. It was discovered independently and almost simultaneously by the two German investigators, (ATSDR, 1999). It is an element that occurs naturally in the earth's crust and got rank 7 of ATSDR's "Top 20 list" (ATSDR, 1999). Because Cadmium is found in insecticides, fungicides, sludge, and commercial fertilizers which are consistently used in agriculture; its percentage in the upper soil has been snowballing. Dental alloys, electroplating, motor oil and exhaust are other sources of Cd pollution. Hence, anthropogenic activities have augmented Cd magnification in the environment. 10% of total Cadmium in the environment is consequential from natural sources, whereas remaining 90% is derived from anthropogenic activities (Okada, et al., 1997). Volcanic activities contribute about 62%of natural emissions and other natural causes include decaying of vegetation (25%) airborne soil particles (12%) and forest fire (2%). Its non-corrosive and accumulative nature has made it very important to its applications in electroplating or galvanizing. Cadmium is used for the following: batteries (83%), pigments (8%), coating and plating (7%), stabilizers for plastic
(1.2%), nonferrous alloys, photovoltaic devices, and other uses (0.8%) (Thornton, 1992).
Anthropogenic undertakings like; smelting operations, use of phosphate fertilizers, pigment, cigarettes' smokes, automobiles etc. have contributed to the admittance of cadmium into human and animal food chain (WHO, 1992; Okada, et al.,1997; Kumar, et al., 2007).

Chemical and physical properties of cadmium

In crystalline form, cadmium forms a close-packed hexagonal, silver white metal (Dunnick et al., 1979). The only valence state for cadmium is Cd^{2+}

Major compounds of cadmium include Cadmium Acetate, Cadmium Chloride, Cadmium Nitrate, Cadmium Oxide, Cadmium Sulphates and Cadmium Sulphide. Some physical and chemical properties of cadmium include atomic number 48 a.m.u, Atomic weight 112.411g/mol, electronegativity 1.5, crystal ionic radius 0.97, ionization potential 8.993, 0xidation state of +2, electronic configuration [Kr] $4d15s^2$, density of $8.64 g/cm^3$, melting point of 320.9^oC, boiling point of 76^oC.

Effluents from industries involved in mining, manufacturing, electroplating, agriculture, motor oil, paints etc. are sources of cadmium into aquatic environments. Most aquatic organisms have the capability of concentrating metals by feeding and metabolic processes, which can lead to accumulation of extraordinary concentrations of metals in their tissues. Metals interact with ligands in proteins particularly; enzymes and may inhibit their biochemical and physiological activities (Passow, et al., 1961) metals by feeding and metabolic processes, which can lead to accumulation of extraordinary concentrations of metals in their tissues. Metals interact with ligands in proteins particularly; enzymes and may inhibit their biochemical and physiological activities (Passow, et al., 1961). Cadmium belongs to Group II of the Periodic Table. It is found mainly in magmatic and sedimentary rocks with concentrations up to 0.3 μg/g. In the weathering process of the rock minerals; it moves enthusiastically into the soil solution, where it is generally found in the form Cd^{2+}. This chemical form is the most common form of Cd. Other ionic forms that may be found in the soil solution are: $CdC^{l+,}$ $CdOH^+$, $CdHCO^{3+}$, $CdCl^{3-}$, $CdCl_4^{2-}$, $Cd(OH)^{3-}$ and $Cd(OH)_4^{2-}$ (Kabata-Pendias, et al., 1992). Cadmium and other metals released from mining sites can contaminate drinking and other water sources (Pep low et al. 2004; Younger et al. 2002). As metals are both; persistent and toxic; metal contamination in aquatic systems is a particular apprehension (Clark, 1992). When, where, and how an animal consumes cadmium can play a role in behavior of its effect. Animals that accumulate cadmium in their bodies ("body burden") can be eaten by others, and so on, such that cadmium will both accumulate and biomagnified in the food chain (EPA, 2000). Fish can accumulate cadmium from the water and by eating foods contaminated with cadmium (contaminated food chain). It is important to note that bioaccumulation as well as bio magnification occur when a substance cannot be easily metabolized or excreted. Cadmium exhibits this persistence (ATSDR Medical FactSheet, 2008).

Arsenic

According to (Tchounwou, et al., Author manuscript; available in PMC 2014 August 26), Arsenic is a ubiquitous element that is detected at low concentrations in virtually all environmental matrices. Arsenic as a ubiquitous element that is found in all small concentrations in atmosphere, in aquatic environments, in soils and sediments and in organism, occurs as a major constituent in more than 200 minerals as elemental (World Health Organization ,1981).

As, arsenide's, sulfides, oxides, arsenates (Smedley & Kinniburgh, 2002). Where its mobility, absorption and speciation depends on various abiotic factors in the environment (e.g. Cullen & Reamer, 1989, Lahermo, et al., 1996, Huang, et al., 2011). In natural conditions the speciation of Arsenic is controlled by chemical properties of the environment such as change in pH and oxidation/reduction conditions along with absorption, desorption and ion exchange reactions (Ferguson, Gavis, & Sadiq, 1997). Microbial activity, dissolution and precipitation also affects the chemical speciation of As (Lahermo, et al., 1996). The redox equilibrium between different As forms is highly pH-dependent and speciation of As is affected strongly by redox-potential (Violante, et al., 2008). As is a problematic element due to its relatively high mobility over a wide range of redox-conditions and its toxicity to humans, animals and plants can cause acute death or chronic adverse effects (Turpeinen, et al., 1999). The major inorganic forms of arsenic include the trivalent arsenite and the pentavalent arsenate. The organic forms are the methylated metabolites – monomethylarsonic acid (MMA), dimethylarsinic acid (DMA) and trimethylarsine oxide.

Environmental pollution by arsenic occurs as a result of natural phenomena or processes (such as weathering, biological and volcanic eruptions, soil erosion) and anthropogenic activities. Study shows that in Ghana as well as Finland a typical anthropogenic sources has been mining activities, paint oil refinery industries, and landfills (Hakala & Hallkainen, 2004). Several arsenic-containing compounds are produced industrially, and have been used to manufacture products with agricultural applications such as insecticides, herbicides, fungicides, algicides, sheep dips, wood preservatives, and dye-stuffs. They have also been used in veterinary medicine for the eradication of tapeworms in sheep and cattle. Arsenic compounds have also been used in the medical field for at least a century in the treatment of syphilis, yaws, amoebic dysentery, and trypanosomaiasis (Hutchinson, 1887). Arsenic-based drugs are still used in treating certain tropical diseases such as African sleeping sickness and amoebic dysentery, and in veterinary medicine to treat parasitic diseases, including filariasis in dogs National Academy of Science (1977).

It was estimated that several million people are exposed to arsenic chronically throughout the world, especially in countries like Ghana, Bangladesh, India, Chile, Uruguay, Mexico, and Taiwan, where the ground water is contaminated with high concentrations of arsenic.

Exposure to arsenic occurs via the oral route (ingestion), inhalation, dermal contact, and the parenteral route to some extent (ATSDR, 2000., Tchounwou, et al., 1999). Arsenic concentrations in air range from 1 to 3 ng/m^3 in remote locations (away from human releases), and from 20 to 100 ng/m^3 in cities. Its water concentration is usually less than

10µg/L, although higher levels can occur near natural mineral deposits or mining sites like Obuasi, Tarkwa, and Konogo and among others in Ghana. Its concentration in various foods ranges from 20 to 140ng/kg. Natural levels of arsenic in soil usually range from 1 to 40 mg/kg, but pesticide application or waste disposal can produce much higher values.

Analyzing the toxic effects of arsenic is complicated because the toxicity is highly influenced by its oxidation state and solubility, as well as many other intrinsic and extrinsic factors. Several studies have indicated that the toxicity of arsenic depends on the exposure dose, frequency and duration, the biological species, age, and gender, as well as on individual susceptibilities, genetic and nutritional factors. Most cases of human toxicity from arsenic have been associated with exposure to inorganic arsenic. Inorganic trivalent arsenite (As $_{III}$) is 2–10 times more toxic than pentavalent arsenate As (V). By binding to thiol or sulfhydryl groups on proteins, As (III) can inactivate over 200 enzymes. This is the likely mechanism responsible for arsenic's widespread effects on different organ systems. As (V) can replace phosphate, which is involved in many biochemical pathways. One of the mechanisms by which arsenic exerts its toxic effect is through impairment of cellular respiration by the inhibition of various mitochondrial enzymes, and the uncoupling of oxidative phosphorylation. Most toxicity of arsenic results from its ability to interact with sulfhydryl groups of proteins and enzymes, and to substitute phosphorous in a variety of biochemical reactions (Tchounwou, et al., 2014). Arsenic in vitro reacts with protein sulfhydryl groups to inactivate enzymes, such as dihydrolipoyl dehydrogenase and thiolase, thereby producing inhibited oxidation of pyruvate and beta-oxidation of fatty acids. The major metabolic pathway for inorganic arsenic in humans is methylation. Arsenic trioxide is methylated to two major metabolites via a non-enzymatic process to monomethylarsonic acid (MMA), which is further methylated enzymatically to dimethyl arsenic acid (DMA) before excretion in the urine (Tchounwou, et al., 2003, Hughes, 2002). It was previously thought that this methylation process is a pathway of arsenic detoxification, however, recent studies have pointed out that some methylated metabolites may be more toxic than arsenite if they contain trivalent forms of arsenic (Tchounwou, et al., 2003).

Tests for genotoxicity have indicated that arsenic compounds inhibit DNA repair, and induce chromosomal aberrations, sister-chromatid exchanges, and micronuclei formation in both human and rodent cells in culture and in cells of exposed humans.

Reversion assays with Salmonella typhimurium fail to detect mutations that are induced by arsenic compounds. Although arsenic compounds are generally perceived as weak mutagens in bacterial and animal cells, they exhibit clastogenic properties in many cell types in vivo and in vitro (Basu, et al., 2001). In the absence of animal models, in vitro cell transformation studies become a useful means of obtaining information on the carcinogenic mechanisms of arsenic toxicity. Arsenic and arsenical compounds are cytotoxic and induce morphological transformations of Syrian hamster embryo (SHE) cells as well as mouse C3H10T1/2 cells and BALB/3T3 cells (Landolph, 1989; Takahashi, et al., 2002).

Based on the comet assay, it has been reported that arsenic trioxide induces DNA damage in human lymphophytes and also in mice leukocytes (Saleha, et al., 2001). Arsenic compounds have also been shown to induce gene amplification, arrest cells in mitosis, inhibit DNA repair, and induce expression of the c-fos gene and the oxidative stress protein hemeoxygenase in mammalian cells (Saleha et al., 200; Hartmann & Peit, 1994). They have been implicated as promoters and comutagens for a variety of toxic agents (Barrett, 1989). Diet, for most individuals, is the largest source of exposure, with an average intake of about 50 µg per day. Intake from air, water and soil are usually much smaller, but exposure from these media may become significant in areas of arsenic contamination. Workers who produce or use arsenic compounds in such occupations as vineyards, ceramics, glassmaking, smelting, refining of metallic ores, pesticide manufacturing and application, wood preservation, semiconductor manufacturing can be exposed to substantially higher levels of arsenic (National Research Council, 2001). Arsenic has also been identified at 781 sites of the 1,300 hazardous waste sites that have been proposed by the U.S. EPA for inclusion on the national priority list (National Research Council, 2001). Human exposure at these sites may occur by a variety of pathways, including inhalation of dusts in air, ingestion of contaminated water or soil, or through the food chain (Tchounwou & Centeno, 2008).

Contamination with high levels of arsenic is of concern because arsenic can cause a number of human health effects. Several epidemiological studies have reported a strong association between arsenic exposure and increased risks of both carcinogenic and systemic health effects (Tchounwou, et al., 2003). Interest in the toxicity of arsenic has been heightened by recent reports of large populations in Ghana including West Bengal, Bangladesh, Thailand, Inner Mongolia, Taiwan, China, Mexico, Argentina, Chile, Finland and Hungary that have been exposed to high concentrations of arsenic in their drinking water and are displaying various clinic pathological conditions including cardiovascular and peripheral vascular disease, developmental anomalies, neurologic and neurobehavioral disorders, diabetes, hearing loss, portal fibrosis, hematologic disorders (anemia, leukopenia and eosinophilia) and carcinoma (Tchounwou, 2004; ATSDR, 2000; Centeno 2005).

Arsenic exposure affects virtually all organ systems including the cardiovascular, dermatologic, nervous, hepatobiliary, renal, gastro-intestinal, and respiratory systems (Tchounwou et al. 2003)

Again according to (Tchounwou et al., 2003), research has also pointed to significantly higher standardized mortality rates for cancers of the bladder, kidney, skin, and liver in many areas of arsenic pollution. The severity of adverse health effects is related to the chemical form of arsenic, and is also time- and dose-dependent. Although the evidence of carcinogenicity of arsenic in humans seems strong, the mechanism by which it produces tumors in humans is not completely understood.

Environmental Effects of Arsenic

As is considered one of the most toxic metals for humans, animals and plants. The toxicity of Arsenic is dependent on chemical forms, speciation, oxidation state and its complexes with organic ligands and inorganic substances (e.g. Cullen & Reimer, 1989; Pongratz, 1998; Huang, et al., 2011). The volatile arsines, arsine, monomethylarsine (MMAA), dimethylarsine (DMA) and trimethylarsine (TMA) are the most toxic As compounds to mammals (Petrick et al. 2000). They are anyhow readily oxidized to less toxic As products and in general, inorganic forms arsenite (III) and arsenate (V) are known to be the most toxic predominant As species (Poser, 2006; Zavala et al., 2008; Huang et al. 2011). Organic forms like monomethylarsonic acid (MMAA) and dimethylarsinic acid (DMAA) are less toxic and organ Asarsenonobetaine (AsB) and arsenocholine (AsC) are considered to be non-toxic (Cullen & Reimer 1989, Pongratz 1998). Among inorganic forms, arsenite is 25-60 times more toxic than arsenate (Violante et al. 2008). Inorganic As have capability to alter metabolic pathways (Peralta-Videa et al.2009). Because different species exhibit wideranging levels of toxicity to various organism, the toxicity of As should be examined by analyzing As should be examined by analyzing As speciation instead of total concentration.

2.5 Dumpsites and Health

Several population studies document (scientifically) that dumpsites can have serious effects on the health and wellbeing of the population (Guerriero & Cairns, 2009). A wide range of toxic substances can be released into the environment from uncontrolled waste disposal, for example, methane, carbon dioxide, benzene and cadmium. Many of these pollutants have been shown to be toxic for human health. The International Agency for Research on Cancer (IARC, 1993) classifies exposure to cadmium and benzene as highly carcinogenic for humans. In addition, dumpsites are likely to contain highly hazardous compounds resulting from industrial production, for example asbestos and lead. Previous epidemiological studies have found that two main health outcomes – cancer and congenital malformations – are statistically associated with waste exposure in dumpsites.

The International Agency for Research on Cancer further stresses that the health impacts related to dumpsites are directly linked to the types of the different waste streams that are disposed of. Different waste streams involve different health and safety risks. Dumpsites' onsite activities might increase or decrease the related health risks. Uncontrolled scavenging and open burning of waste, either for volume reduction or for metal recovery, are two of the most usual causes for increased health risks."

Some of the pollutants that play a part in whether or not adverse health effects may result from an exposure are discussed below:

Cadmium and Human Health

Cadmium has no known beneficial function in the human body. Cadmium accumulates in animal tissue, and its toxicity can increase as accumulation increases. Cadmium causes cancer, birth defects, and genetic mutations. The maximum cadmium accumulation is found in the kidneys and the liver. Urinary cadmium excretion is slow; however, it is the primary mechanism by which the body eliminates cadmium. Due to slow excretion, cadmium accumulates in the body over a lifetime and its biologic half-life may be up to 38 years. In India, different levels of cadmium concentration have been reported to be present in aquatic ecosystem which is more than 5ng/ml in the Yamuna river water at Agra, Delhi, Etawah and Mathura (Ajmal, et al., 1985) and 0.50-114.8 mg/kg in the Yamuna river sediments at Agra and Delhi. But the water around the industrial areas have been found to comprise higher levels of cadmium (Singh, 2001; Kaushik et al., 2003). Similarly, Hindon River (Uttar Pradesh) has also been contaminated with heavy metals including cadmium (Jain et al., 2001; Sharma, 2003). Furthermore, high concentration of cadmium (70-100 ng/ml) has been detected in Bombay city (Agrawal et al., 1978) and Lalbaug pond water of Baroda city (Kannan, 1997).

Bio accumulation of cadmium takes place at tropic level (Pinto, et al., 2003). It also accumulates in considerable concentrations in various organs of fish (Sindayigaya et al., 1994; Kumar et al., 2008). De Smet et al., (2001) reported that cadmium accumulates in tissues of carp Cyprinuscarpio in following order: kidney> Liver> Gills. Some insects can also accumulate high levels of cadmium without showing any adverse effects (Jamil, et al., 1992). Kidney is the prime target structure for cadmium. The liver also stores a considerable quantity of the accumulated cadmium. Cadmium is redistributed to these organs directly following uptake through the gills and intestine, but there may also be redistribution of cadmium from other organs (Olsson, et al., 1996).

Biological half-time

The little excretion rate of cadmium leads to a very efficient retention in the body. The retention functions for cadmium are multi-phasic and the half-time of the slowest compartment is usually more than 20% of the life-span for most animal species and humans (Nordberg, et al., 1985). The different compartments are likely to reflect retention in different tissues. Cadmium in the blood compartment may exchange with various tissues compartments as the binding of cadmium in the tissues is much stronger than in the blood (Herber, 1994). Human data suggest that the muscle depot of cadmium has one of the longest halftime more than 30 years. Kidney-cadmium has a halftime of 10 to 30 years and livercadmium has a half-time of 5-15 years. The cadmium accumulation curve for body burden is almost straight from age 0 to about age 50 (Nordberge, et al., 1985). Because of this long half-time and continuous transfer of cadmium from other tissues, cadmium accumulation in the kidney will take place during the whole life-span (Friberg, 1986).

Arsenic and Human health

Humans may be exposed to arsenic through inhalation, water or food and the main pathways are respiratory organs or digestive tracts (Turpeinen, et al., 1999). Exposure may rarely occur through skin contact with water and soil polluted by As. The absorption and subsequent metabolism of As and the effects in man greatly depends on the chemical form, the dose, the length of exposure and the absorption path (Hakala & Hallkainen, 2004). Soluble inorganic forms of As are rapidly absorbed through the lungs and intestine (Cullen & Reimer, 1989). In the human body inorganic As is partly methylated into less toxic organoass, mainly dimethylarsine, and is extracted in urine. Methylation is believed to be part of the detoxification mechanism in living organisms (Peralta et al. 2009). As is excreted from the body in three main stages and about 50% of total As is excreted in urine and feces in two days. Some of the less soluble forms of As, like lead arsenate and As sulfide, are absorbed slowly from the lungs and may stay several years in respiratory organs. Arsenite accumulates in keratin rich tissues: skin, nails and hair. In bones, the phosphate of apatite is readily substituted by arsenate (Hakala & Hallkainen, 2004).

As can cause acute death or chronic adverse effects: A lethal dose of As oxide is generally regarded as 70-120mg, but acute poisonings are rather rare. Ingestion of large doses of soluble inorganic As leads to gastrointestinal symptoms, disturbances of cardiovascular and nervous system functions. Long-term exposure for large doses of Arsenic also raises the risk of different kinds of cancer and As-associated skin lesions. Lesser chronic exposure can cause nausea, the lack of appetite and weakness of limbs (Hakala & Hallkainen, 2004). The World Health Organization (WHO) has set a value of 2µgAskg^{-1}body weight as a tolerable daily intake (Peralta-Videa, et al., 2009). For instance, the daily dietary intake of As in Finland is about 10-20µg (Hakala & Hallkainen, 2004).

Toxicity of cadmium

Cadmium toxicity may be manifested by a variety of syndromes and effects including renal dysfunction, hypertension, and hepatic injury, lung damage after inhalation exposure, reproductive toxicity, teratogenic effects and bone defects (Friberg et al., 1974; Nriagu, 1989). In humans, the main organs for cadmium accumulation are kidney, liver, lung and pancreas (Cherry, 1981). The kidney is a critical organ; in long-term, low level exposures can prove to be lethal, because of a 30-year biological half-life in this organ (Friberg, et al., 1974). Symptoms of cadmium toxicity to the kidney include tubular proteinuria, decreased capacity for concentrating urine, glucosuria, calcuria and micro globulinuria (Kazantzis, 1979). Cadmium is also absorbed following oral and inhalation exposure. Cadmium was first reported to cause Itai-itai (ouch-ouch) disease in 1955 among the human population of Toyoma, Japan. Symptoms include femoral pain and lumbago painful sites spread all over the body and duck-like gait. The condition progresses and bone fractures are common. Pathological changes include osteomalacia and osteoporosis (most prevalent in postmenopausal woman) and toxicity in the kidney. Patients showed normochromic anemia, increased granulocyte count and decreased lymphocyte count (Nriagu, 1981).

2.6 Dumpsite and Respiratory Infection

The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of age, race, religion, and political belief, economic or social condition (WHO 1998). WHO (1979, 1984) and Grant (1980) have stressed that the health status of children in any country is very crucial because it is an indicator for measuring socio-economic development as well as for determining the future prospects of a country. Gwatkin, (1980) has also stated that for children to grow into healthy able adults, and to live through the perilous first years of life, they need good food, clean water, education, and medical care. Besides these factors, they also need to be boom healthy and need mothers who are healthy as well as the families that can give them care and attention.

Childhood diseases in developing countries are mainly malaria, diarrhoea, measles, neonatal tetanus, whooping cough, tuberculosis and bronchopneumonia (Morley & Mac William, 1961; Ghana Statistical Service 1998). Out of every three deaths that occur in the world one is a child under the age of five. Grant, (1990) has noted that almost all childhood diseases are preventable. With vigorous public education on health promotional practices coupled with compulsory immunization for all children in developing countries, the wide gap in infant mortality between developed and developing countries will be narrowed. Grant, (1990) has anticipated that every week more than a quarter of a million children will die in a quiet carnage of infection and under nutrition. In sub-Saharan Africa, this problem has assumed worse dimension due to frequent political and tribal upheavals coupled with poor management of the National economy.

In Ghana, since the attainment of political independence many policies and programmes have been adopted to improve the health status of children. Such interventions include the establishment of Ghana National Commission on Children in 1979, the adoption of Primary Heath Care Programme, and the ratification of the United Nations Convention on the Right of the Child and Education on Nutrition and Vitamin Supplements.

Through such interventions, Ghana has reduced infant mortality from 100 per 1000 live births to 57 per 1000 live births in the past 20 years. This led to a percentage decline of 43 while under five mortality fell by an equal amount from 187 to 108 deaths per 1000 live births in 1996 (Ghana Demographic and Health Survey, 1998). GDHS (1998) has indicated that childhood morbidity in Ghana is attributed mainly to acute respiratory infection (ARI), malaria and diarrhoea. Acute respiratory infections (ARI) are found in either the upper or lower respiratory tract. Signs and symptoms for upper respiratory tract infections include common cold, frequent sneezing, and restlessness and cough while that of the lower tract include foul breath, fast breathing, difficult breathing, cough and chest in-drawing.

In Ghana, 14 percent of children under five years of age show symptoms of ARI (GDHS, 1998). The prevalence of ARI varies by age of the child. Children aged between 6 - 1 1 months are the most vulnerable to this disease. Rural children are more susceptible to ARI than urban children. Children of mothers with little or no education are also very vulnerable than those with post-secondary education. This is because mothers with higher educational levels may be more aware of the causes of ARI and preventive health care strategies than the mothers with little education. ARI could be treated with antibiotics when diagnosed early
(GDHS, 1998). The use of health facility for the treatment of ARI symptoms is low in Ghana. One in every four children suffering from the symptoms of ARI uses modem health facility. The most preferred facility for the treatment of ARI is through pharmacies and or drugstores, which signifies that self- medication is an important treatment outlet for ARI in Ghana (GDHS 1998). This scenario should prompt policy makers on the enormity of the task in promoting child health. In this light, health-seeking behaviour should be sought in a more diversified manner to include all ranges of practices that exist in both the traditional and western bio-medical health care systems. Omorodion, (1993) has stressed that it is when the above realization has been met that total health belief that influences mother's treatment decision and behaviour would be understood and subsequently help in the effective management of childhood diseases.

A number of writers have written on various aspects on children. These include sociologists and anthropologists, clinicians, and policy makers. Child health attracts writers because it is a critical index for assessing the level of a nation's development. Ruutu et al. (1994) in their expository study on respiratory infections have stated that until 1979, many developed countries did not consider childhood Acute Respiratory Infection (ARI) as a threat to the survival of children. This situation was due to unreliability of official statistics and the inability of health practitioners to establish a relationship between specific causative agents of childhood

ARI. These situations according to them have led to many preventable deaths among children. Most of such deaths were considered
mysterious and were thought to emanate from spiritual causes.

Even though Ruutu's study was the collection of other people's work, it is an important source for understanding the history and early perceptions on the etiology of childhood ARI. The educational component in his study is also instrumental in understanding control programs of ARI in developing countries where most mothers home treat their children suffering from ARI.

Lang, et al., (1986) made another important contribution to the understanding of the management of childhood ARI. This was a longitudinal study carried from February 1983 to March 1984 in Bana Township, in Burkina Faso. The study was designed to assess the importance of ARI as a source of morbidity and also to determine the factors that influence its incidence, so that control strategies can be implemented.

The outcome of Lang et al's study was that all children under study have as many as 8 to 13 episodes of ARI in a year. It also indicated that as high as half of the yearly incidence of ARI emanates from acute lower respiratory conditions. Lang et al. further indicated that a child with an aim circumference of less than 13.5cm suffers more episodes of both upper and lower respiratory infections than were children with larger arm circumference. Mtango and Neuvian (1986) also undertook a longitudinal study in Tanzania to evaluate case-management strategies for the control of ARI. These strategies stressed early detection of Acute Lower Respiratory Infection (ALRI) through the identification of danger signs and symptoms such as chest in - drawing and fast breathing. The education on the appropriate antibiotic treatment of primary health care personnel and mothers was also emphasized.

The longitudinal studies (Lang et al, 1986; Mtango & Neuvian, 1986) have proven to be more effective in providing detailed information on the incidence of ARI morbidity and mortality. However, their use is limited by the fact that they are expensive and timeconsuming in execution. Due to these constraints, there are very few of such studies on childhood ARI.

Other studies on etiology of childhood ARI have been carried out. One of such studies was undertaken by Wall et al (1986). Their studies researched into bacteria etiology of pneumonia in the Gambia. It was also found that the most dominant bacterium in the culture was streptococcus pneumonia.

Omer, et al. (1985) also undertook a bacteriology study on sore throats in the Sudanese population. A total of 164 outpatients were used for this study. The study found out that bacteria constitute an important cause of sore throat among the outpatients who attend hospital in the Sudan, and their relative isolation rate was 51 percent.

Berman and McIntosh (1985) conducted another study on bacteria etiology on ARI. They aimed at improving strategies for the control of ARI in developing countries. The outcome of their study was that as high as 65 percent of the patients were infected with bacteria causing pneumonia and the dominant bacteria were haemophilus influenza and streptococcus pneumonia.

In Kenya, Mutie, et al., (1976) looked at viral etiology of severe ARI. The study examined 41 children aged less than two years old who were admitted for bronchiolitis or bronchopneumonia. The study found that 39 percent of the patients had Respiratory Syncytial Virus (R S V) infections, 7.3 percent had Parainfluenza Vims and less than 5 percent of the patients were infected with adeno virus, cytomegalo virus, echo virus and rhino virus.

The review of these studies (Mutie, et al., 1976; Berman & McIntosh, 1985; Omer, et al., 1985; Wall, et al., 1985) on bacterial and viral etiology of ARI has established that bacterial infections constitute the most common cause of acute lower respiratory infections. However, some limitations to these studies were that, their studies only concentrated on episodes of acute lower respiratory infections without highlighting upper respiratory tract infections. This weakness does not make the study complete since any holistic study on ARI should include episodes on both lower and upper tract infections. Also these studies were mainly epidemiological in nature. They did not consider ethnomedical perceptions on the etiology of ARI. The lack of ethnomedical perceptions on the etiology of ARI can hamper the effectiveness of any control programme.

Tupasi, et al., (1990) undertook an ARI risk reduction study in the Philippines. The study sought to establish a relationship between malnutrition and acute respiratory tract infections in Filipino children. The study found out that malnourished children Senah, et al., (1994) in their anthropological study in the Kasena and Nankane communities in the Upper East Region of Ghana indicated how socio-cultural practices affect childhood mortality and morbidity. The study found among others that, there is extremely high gender bias against women in such communities such that their level of participation in decision-making and access to the acquisition of income and other property are virtually non-existent. The ripple effect of these practices on their children is that women are always constrained in terms of decision - making and material support when their children are sick. It was also found that even though mothers know how to manage childhood diseases such as cough, malaria, diarrhoea and measles, they are not allowed to manage these ailments themselves when their children are ill. This is because such roles are the joint responsibilities of the head and the senior woman in the compound.

Malm, et al., (1994) in their study of caretakers' perceptions of ARI and home management practices in the Dangme West District described the local terminologies that are used to describe ARI. They also determine danger signs and symptoms of ARI, and home management practices associated with ARI. Among others, the study indicated that there are ten (10) ARI related illness terminologies in the Dangme West District. The choice for health care outlet for the treatment of ARI varies according to what caretakers perceive to be the cause of the illness. Awedoba, et al., (1995), carried out an ethnographic study in the Brong Ahafo, Upper West and Volta regions of Ghana. The study focused on identifying the local terminologies, danger signs, perceived cause, and partners in health seeking for the treatment of childhood ARI. It was found that there was no single term for describing ARI. Differentlocal names were used to describe such disease episodes. Pneumonia was identified to be the most threatened form of ARI. The main cause was attributed to cold air entering the head or chest of children. It was also observed that fathers were involved in health care decision most of the time (56.7 percent of the cases). Iyun and Goran (1996) focused on mothers' perceptions on etiology and treatment of childhood ARI in rural settlements in Oyo State, Nigeria. Most mothers regarded ARI episodes as ordinary coughs and cold. Mothers believed that these are mostly caused by exposure to cold. The dominant treatment practices was either the use of irritants (bitter remedies) such as drinking cow urine to help the child vomit obstructed mucus, or the use of remedies with warming and soothing properties.

Muhe, (1996) conducted another ethnographic study. He emphasised on mother’s perception on the nature, signs and symptoms of ARI in an urban community in Ethiopia. The study found that mothers considered ARI episodes as cold and cough. ARI was considered to be serious when it becomes persistent. He also found that runny nose, fast breathing, fever, cough, restlessness; body pains are some of the general signs and symptoms of childhood ARI.

Bamikale, et al., (1997) used survey methods to study the impact of cultural beliefs on mother’s management of childhood diseases in Yoruba, Nigeria. The main concern for the study was to determine the perceived etiology of measles, diarrhoea and malaria and to determine whether mother’s believed in the existence of spirit children. The study showed that

4.4 percent of the mothers have adequate knowledge of the cause of measles, 55.8 percent of diarrhoea, and66.4 percent of malaria. It was also found that majority of mothers (56.2 percent) believed in the existence of spirit children, 30.6 percent did not believe in. While 13.2 percent were not sure of their beliefs. Mothers who believed in indicated that repeated deaths of children of couple, deformity of children, frequent indisposition, are among the evidence of Abiku.

The GDHS (1998) indicated that 14 percent of children in Ghana aged less than five years had symptoms of ARI during the time of the study. It was also seen that the prevalence rate of ARI varies according to the ages of children and it is higher among children aged 6-11 months. In terms of geographical distribution, children residing in rural areas have higher occurrence of ARI than their counterparts in the urban centers.

It was also found out that children of mothers with little or no formal education have higher occurrence rate of ARI than children born to mothers with secondary education. The most dominant treatment outlet for children suffering from ARI is the government health facility followed by the pharmacy shops or drug stores.

Asenso-Okyere, et al., (1998) in their study of malaria care, identified that the health financing reforms that culminated in the introduction of user charges and full cost recovery for drugs in health care facilities have made it very difficult for many people to access modem health care. It was also identified that there is often a delay in reporting illnesses to bio-medical health care providers and during these periods certain home management practices are adopted as cost saving measures. Brokensha (1966) undertook an anthropological study at Larteh to determine the social changes that have taken place. He found among other things that in terms of medicine and health, there are different treatment paths. These are used based on the health-seeker's perception on the nature and cause of the ailment.

Acute respiratory infection is an infection that may interfere with normal breathing. It usually begins as a viral infection in the nose, trachea (windpipe), or lungs. If the infection isn't treated, it can spread to the entire respiratory system. ARI's are infectious which means they can spread from one person to another. This disease is quite widespread and it is particularly dangerous for children, older adults, and people with immune system disorder.

However, ARIs in children take a heavy toll on life, especially where medical care is not available or is not sought and are classified as upper respiratory tract infections (URIs) or lower respiratory tract infections (LRIs). The upper respiratory tract consists of the airways from the nostrils to the vocal cords in the larynx, including the paranasal sinuses and the middle ear. The lower respiratory tract covers the continuation of the airways from the trachea and bronchi to the bronchioles and the alveoli. ARIs are not confined to the respiratory tract and have systemic effects because of possible extension of infection or microbial toxins, inflammation, and reduced lung function. Diphtheria, pertussis (whooping cough), and measles are vaccine-preventable diseases that may have a respiratory tract component but also affect other systems. Except during the neonatal period, ARIs are the most common causes of both illness and mortality in children under five, who average three to six episodes of ARIs annually regardless of where they live or what their economic situation is (Kamath and others 1969; Monto and Ullman 1974). However, the proportion of mild to severe disease varies between high- and low-income countries, and because of differences in specific etiologies and risk factors, the severity of LRIs in children under five is worse in developing countries, resulting in a higher case-fatality rate. Although medical care can to some extent mitigate both severity and fatality, many severe LRIs do not respond to therapy, largely because of the lack of highly effective antiviral drugs. Some 10.8 million children die each year (Black, Morris, and Bryce 2003). Estimates indicate that in 2000, 1.9 million of them died because of ARIs, 70 percent of them in Africa and Southeast Asia (Williams and others 2002). The World Health Organization

(WHO) estimates that 2 million children under five die of pneumonia each year (Bryce and others 2003).

What are the levels of the symptoms of ARI?

The early symptoms of acute respiratory infection usually appear in the nose and upper lungs. These symptoms include**:** Congestion, either in the nasal sinuses or lungs**,** Runny nose**,** Cough**,** Sore throat**,** Body aches**,** Fatigue and if the disease advances, there may be high fever and chills. Other serious symptoms are difficulty in breathing, dizziness, low blood oxygen level, loss of consciousness among others. However complications of acute respiratory infection are extremely serious and can result in permanent damage and even death. They include**:** respiratory arrest, respiratory failure and congestive heart failure. Nevertheless most causes of an acute respiratory infection aren't treatable. Therefore, prevention is the best method to ward off harmful respiratory infections. Practice good hygiene by doing the following**:** Wash your hands frequently, especially after you've been in a public place, always sneeze into the arm of your shirt or in a tissue although this may not ease your own symptoms, it will prevent you from spreading infectious diseases and finally avoid touching your face, especially your eyes and mouth, to prevent introducing germs into your system
(India Development Gateway, 2018).

What are the levels of the symptoms of ALRI?

Acute Lower respiratory tract infection (ALRTI) is infection below the level of the larynx and may be taken to include**:** bronchiolitis**,** bronchitis**,** Pneumonia Laryn,
Gotracheobronchitis (croup)the common ALRIs in children are pneumonia and bronchiolitis. The respiratory rate is a valuable clinical sign for diagnosing acute ALRI in children who are coughing and breathing rapidly. The presence of lower chest wall in drawing identifies more severe disease (Mulholland and others 1992; Shann, Hart, and Thomas 1984**).** Currently, the most common causes of viral ALRIs are RSVs. They tend to be highly seasonal, unlike

parainfluenza viruses, the next most common cause of viral ALRIs. The epidemiology of influenza viruses in children in developing countries deserves urgent investigation because safe and effective vaccines are available. Before the effective use of measles vaccine, the measles virus was the most important viral cause of respiratory tract–related morbidity and mortality in children in developing countries.

What are the levels of the symptoms of URI?

URIs are the most common infectious diseases. They include rhinitis (common cold), sinusitis, ear infections, acute pharyngitis or tonsillopharyngitis, epiglottitis, and laryngitis - of which ear infections and pharyngitis causes the more severe complications (deafness and acute rheumatic fever, respectively). The vast majority of URIs have a viral etiology. Rhinoviruses account for 25 to 30 percent of URIs; respiratory syncytial viruses (RSVs), para influenza and influenza viruses, human meta pneumovirus, and adenoviruses for 25 to 35 percent; corona viruses for 10 percent; and unidentified viruses for the remainder (Denny 1995). Because most URIs are self-limiting, their complications are more important than the infections. Acute viral infections predispose children to bacterial infections of the sinuses and middle ear (Berman 1995a), and aspiration of infected secretions and cells can result in LRIs.

CHAPTER THREE

RESEARH METHODOLOGY

3.0 Introduction

This chapter presents the methodological approach for this study. Specifically, it discussed the study area, study design, target population, data collection methods and research instruments, which the researcher used to collect the data. It also emphasized on sources of data, data presentation, and analysis as well as ethical consideration and pre-testing of the research instrument for the study.

3.1 Study Design

The study was a population-based cross-sectional study involving 200 households (i.e. children under five(5) and their parent(s)) residing around the Abokobi dumpsite. A questionnaire was administered to the parents of all the 200 children under five (5). Blood samples were taken from the children for lab analysis for heavy metals. Hand washed water was also taken from the children for lab analysis of heavy metals.

3.2 Study Area

Abokobi open dumpsite

The Ga East Municipal Assembly, established in 2004, is located in the northern part of the Greater Accra Region. The Ga East Municipal Assembly is one of the ten Districts in the Greater Accra region and spans an area of about 166 square km (ghanadistricts.com). It is made up of 65 settlements. Abokobi is on the boundary west by the Ga-West Municipal Assembly, on the east by the Adentan Municipal Assembly, the south by Accra Metropolitan Assembly (AMA) and the north by the Akwapim South District Assembly. The 2010 National Population and Housing Census reported that the District's population at 259,668 with a growth rate of about 2.3%. The development of the population is primarily due to the impact of migration inflows. "The population structure is approximately 51 percent male and 49 percent woman. There are 66, 286 households in the municipal. The population constitutes 82% of the district total population with the remaining 18% residing in the rural portion towards the Akwapim Hills. These communities include Ablor Adjei, Evangelical Presbyterian area (EP), Paraku Estates and Pantang. The district can therefore be described as predominantly urban with the population concentrated largely along the urban areas of the district predominantly along the border with AMA to the south" (GEMA, 2013).

The communities have problem of land litigation, encroachment on the few open spaces, rapid waste generation, open defecation, indiscriminate refuse disposal, and construction of illegal structures are some of the development challenges the Assembly has. Malaria continues to be the major cause of Out-Patients Department (OPD) attendance in the Ga East Municipal accounting for approximately 40.8% of morbidity. Frequent outbreaks of cholera in the district are also of great concern and poor environmental sanitation is a known and major contributory factor (GEMA, 2013). Below is the map of the Ga East Municipality and key institution relation to the dumpsite.

Figure 3.1: Map showing Ga East Municipal Assembly

Figure 3. 2: Dumpsite and the Community Living in the Area

3.3 Source/Study Population

The source population for the study includes all children below the age of 5 residing in households within 200meters of the Abokobi open dumpsite. The study population involved 200 children under five(5) and their parents.

3.3 1 Inclusion & Exclusion Criteria

A household which met the following inclusion criteria was selected to be part of the study (i) children under five(5) (ii) the households should have been staying around the area for more than a year (iii) the individual should be willing to follow the study protocol. This helps eliminate the influence of selection bias, however individuals who have not lived for more than one year and did not stay in the study area were excluded.

3.4 Study Variables

3. 4.1 Main determinants

The main determinants of interest include (i) blood levels of mercury, cadmium, and arsenic, and lead (ii) three (3) exposure indicators at home (iii) three (3) exposure indicators outside the home and hand washed water of children. Exposure indicators at home or/and outside the home was defined as mouthing behaviour, food handling practices, hygiene practices and contact with contaminated surfaces.

3.4.2 Outcomes of interest

The main outcome of interest includes self-reported symptoms of acute respiratory infection (ARI). ARI was defined as acute lower respiratory infection (ALRI) and also upper respiratory infection (URI). ALRI refers to cough accompanied by short and rapid breathing at any time in the 2-weeks period preceding the survey interview; and URI defined as symptoms of runny nose, wheezing, cough, phlegm production and breathlessness at any time in the 2-weeks period preceding the survey interview. These definitions are in agreement with literature (Misra, 2003; Bautista, et al., 2009; WHO).

3.4.3. Confounding variables

The following variables were considered as potential confounders; level of parental education, gender of child, any sign of illness more than two (2) weeks, and was based on literature (Smith, Samet, Romieu, & Bruce, 2000)

3.5 Sampling Procedure

Participation was voluntary. This was done by inviting all the community members to a durbar where they were briefed about the purpose of the study. The research team addressed questions on the benefits and risks involved in participating in the study. The Population of 200 children under five (5) and their parents residing within 200meters around the dumpsite were recruited as participants for the study.

3.6 Data collection procedure

The fieldwork was implemented in three (3) phases: (i) stakeholder meeting, (ii) selection and enrollment of study participants, (iii) data collection.

Stakeholder meetings

Three meetings were held with stakeholders in and around the dumpsite to seek their view on the conditions in and around the dumpsite and also seek their consent to enter the community without any apprehension. Some identifiable stakeholders were (a) The Chief and

Elders (b) Waste Landfill Company Ltd. Adenta, (c) The Head Pastor of Faith Anointing Ministry (d) The Assembly Member of the electoral areas (Agbogba, Ablorh Adjei, Pantang and Abokobi) (e) The unit committee members (f) The Head Pastor of the Presbyterian Church and (g) and the rest of the students from KNUST working at the same project site. The research team was headed by Dr. Reginald Quansah (School of Public Health, University of Ghana, Legon) and Dr. Udofia (University of Ghana Medical School). Other members of the team include; a Laboratory Technicians, Crenstil Kofi Bempah, Jacob Asomaning and Prof. Mary Boadu from Ghana Atomic Energy Commission (GAEC) and Dr. Bannerman a pediatrician from Korle-Bu Teaching Hospital. The Assemblyman of Ablorh Adjei; Hon. Jacob Ablorh was nominated by the elders of the communities to lead the project team to the community. The subsequent meetings were held at the Abokobi District Assembly.

Selection and enrolment of study participants

The study participants were made up of 200 children under 5. Parents of these selected children were asked to express their willingness to participate in the study. Children with severe illnesses (e.g. dysentery, typhoid fever etc.) were not allowed to take part in the study. Contacts were made with the nearest health facility (Pantang Hospital) for early diagnosis and treatment.

Figure 3.3: Participants at a durbar for the commencement of the study

Data Collection

The data collection tools for the study include a modified respiratory questionnaire, blood sampling kit for blood sampling and a container for hand washed.

Coding

The 200 participants were given an identifiable code starting from 001 to 200. For blood samples the code reads B001-B200c and HW001-HW200 for hand washed respectively.

Taking of vitals

The vitals of the participants were taken. This include; temperature, and height and weight for Body Mass Index (BMI). Participants who were detected of any ailment were referred to a team of Nurses for early diagnosis and treatment.

Questionnaire

A modified questionnaire was used in this study to elicit information on personal characteristics, environmental risk exposures and dietary habits of the respondents. This questionnaire was filled up by the parents or the guardians of the respondents. The questionnaire consists of 3 parts; Part A the socio-demographic background, Part B the respiratory health information, Part C the associated health problems. The questionnaires were administered by members of the research team. Participants who cannot read or write were assisted by the research team.

Figure 3.4: A member of the research team administering a questionnaire

Blood sample Collection

Following explanation of the test procedure, 2.5ml of whole blood was collected from the median cubital and cephalic veins into three separate haematology tubes (Sarstedt, Smonovette, Germany), two free and one containing Z-gel, an additive carrier and a clot activator (for serum separation) using a butterfly needle and a tourniquet. The blood samples with the additive was centrifuged and the supernatant, the serum collected for subsequent refrigeration at 4-8°C for analysis at the Ghana Atomic Energy Commission.

Figure 3.5: A Laboratory technician taking a blood sample from a child assisted by the mother

Blood sample analysis for heavy metals

Blood samples were pretreated with nitric acid and triton. Samples was analyzed using high resolution continuum source atomic absorption spectrophotometry (HRCS-AAS Contr AA 700 Analytik Jena) at the Ghana Atomic Energy Commission for heavy metals.

Figure 3.5: Blood sample ready for analysis at Ghana Atomic Energy Commission

Hand washed water collection

The hands of the children were washed and hand-washed water collected in a container for analysis at Ghana Atomic Energy Commission.

Figure 3.6: Mother assisting the child to undergo handwashing

3.8 Data Analysis

The data was crossed checked to identify missing values and other lapses for appropriate treatment. It was examined for validity. The data was double checked to reduce errors and improve results and before entry into Epi- Info 7 (Centre for Disease Control, CDC, USA).

For normally distributed data, means and standard deviations were computed as summary measures and the median and interquartile ranges for skewed data. Chi square and Wilcoxon ranked-tests were used to compare characteristics of the compared groups as well as the level of awareness of potential respiratory hazards.

3.8.1 Informed consent

Informed consent was sought and obtained and/or assent parents of the children. An oral script introducing the study was read to parents who can read and write and by a translator for those who cannot read nor write. Written consent form was read by the participant and/or by a translator and any questions raised by the subjects was answered. Interested participants were interviewed.

3.8.2 Protection of subjects' privacy

Parents of children do not have to answer any survey questions that they feel was an invasion of their privacy. Also, participants do not have to participate in any particular aspects of the study that they find invasive.

3.8.3 Provision to prematurely end a particular subject's participation in the study

A parent of a child can opt to be interviewed in a location of their choice to increase privacy. In the case of an adverse event or situation of distress, a subject's participation in the study was concluded. There was a little likelihood that such an event or distress may occur, so no specific criteria or parameters can be identified.

3.8.4 Record storage and protection

All research records, data and specimens were protected and retained for at 3-5years against inappropriate use or disclosure, or malicious or accidental loss or destruction in order to protect the confidentiality of subject data. Hard copy data was under locked and soft copy data were protected with a password on a secured laptop. There was a routine electronic back up and encryption of digital data. Security software (firewall, anti-virus, anti-intrusion) were installed and regularly updated on all servers, workstations, laptops, and other devices used in the project. There was be safe disposition/destruction of data or devices, as appropriate (e.g., shredding paper documents, destroying disks or thumb drives, secure erasure of electronic media).

3.8.5 The data and/or any specimens will be destroyed at the conclusion of this study

Specimens of blood were destroyed as well as the identifiers on their storage containers after laboratory analysis. The interviews will be destroyed by deleting them from their storage device (digital format) after 10 years' retention. Study survey forms (hard copy) were destroyed at the conclusion of the study. The data/specimens were retained until the completion of the research program. The data collected was linked to subjects' identities in anticipation of the need to be able to return metals analysis results to those participants who desire it, and if significant new knowledge is obtained that must be relayed.

3.8.6 Retention of Data and/or Specimens Detail

Retention was for future research by the investigator and/or the creation of a bank or repository. In the case of return to the community or future research on this area, a longitudinal study can be done to show how conditions have changed over time. Also, in order to deliver individual participants' results on a subsequent return visit, these data must be retained.

3.8.7 Compensation of Subjects or Other Incentives for their time/participation

Subjects received cash and token gift for their participation in the study. A payment of 10 Ghana new cedis (approximately US$3) was given to study participants who complete all proposed data collection elements. Compensation was given at the time of data/specimen collection.

3.9 Ethical Consideration

Ethical clearance was sought from the Kwame Nkrumah University of Science and Technology Ethical Review Board. Permission was also sought from the leaders of the community. Oral or written consent was obtained from every participant. Before the individual respondents give their consent, the participant information leaflet and the consent form, which contained the benefits, risks and the procedures for research was read out and explained to each participant before they append their signatures or thumbprints. They had the liberty to ask questions, and to seek clarifications or withdraw unconditionally.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the findings of the study. This was divided into five parts: Demographic characteristics of study participants, Proportion of children with symptoms with Acute Upper Respiratory Infection (AURI), Self-reported exposure indicators to toxic metals among children below 5 years, Concentration of toxic metals in blood samples and Association between toxic metals and symptoms of AURI. Tables, charts and percentages were used to present and analyze the data.

4.1 Demographic characteristics of study participants

Characteristics of the study population of children are shown in Table 4.1. Most of the children were females (58%), aged 2 years (31.0%) and in crèche (38.5%). **Table 4.1: Demographic characteristics of study participants (n=200)**

	Frequency	Percentage
Gender of child		
Male	84	42.0
Female	116	58.0
Age of child		
≤1	39	19.5
2yr	62	31.0
3yrs	58	29.0
4yrs	41	20.5
Education		
Not started school	37	18.5
Crèche	77	38.5
Nursery	59	29.5
Kindergarten	27	13.5

4.2 Proportion of children under five (5) years with symptoms of AURI and ALRI The proportion of children reporting symptoms of acute upper respiratory infection (AURI) was higher among children aged between 2 years (32.9%) and least common among children who were 4 years old (15.7%). Also the proportion of children reporting symptoms of acute lower respiratory infection (ALRI) was higher among children age 3 years (30.3%) (Figure 4.1)

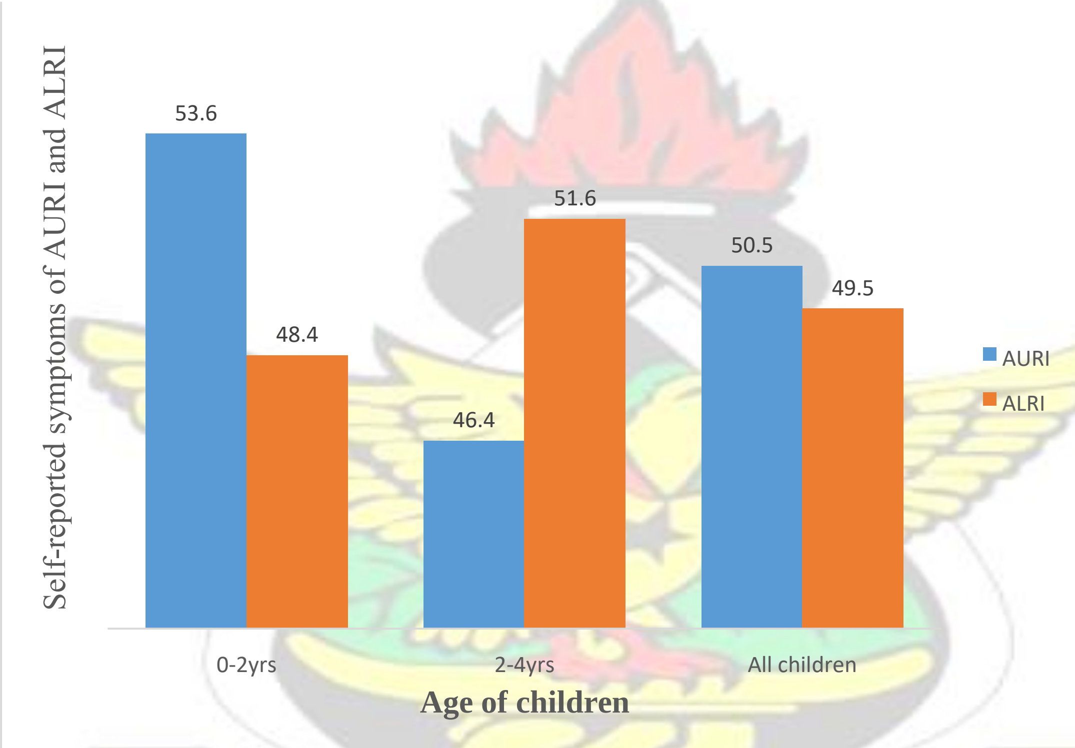

Fig. 4.1 Proportion of children under five (5) years with symptoms of AURI and ALRI

4.3 Mean concentration of toxic metals in blood and hand wash water and symptoms of ALRI and AURI among children under five (5) living near Abokobi dumpsite

Four (4) traces of toxic metals were detected in the extract of blood samples and hand wash water of children under five years (Figures 4.2-4.5). The mean residue and standard deviation of Hg contributes to ALRI than AURI in blood than in hand wash water (1.47 µg/L; 2.77 vs 0.21 µg/L; 1.29). Also, concentration of Cadmium contributes more to ALRI in blood (2.66 µg/L; 0.41) than in hand wash water (1.26 µg/L; 0.16).

A

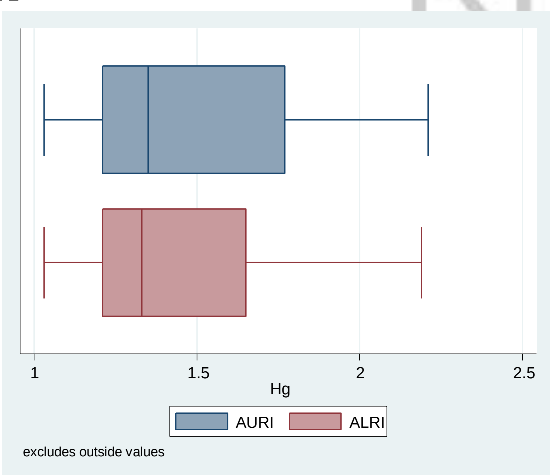

Fig. 4.2A Mercury and ARI in blood

B

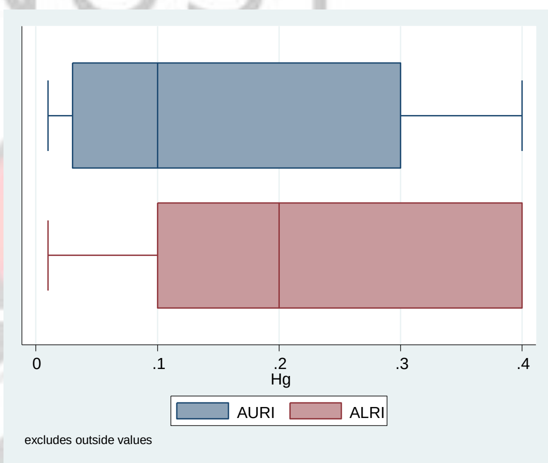

Fig. 4.2B Mercury and ARI in handwash water

A

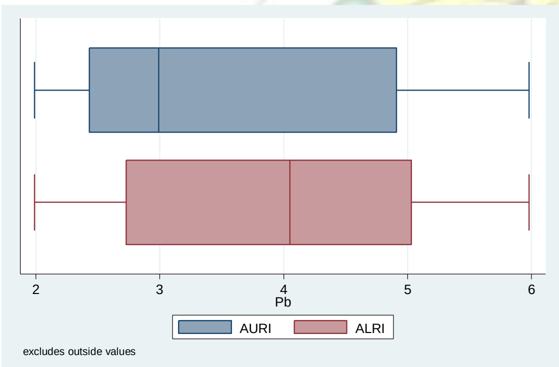

Fig. 4.3A Lead and ARI in blood

B

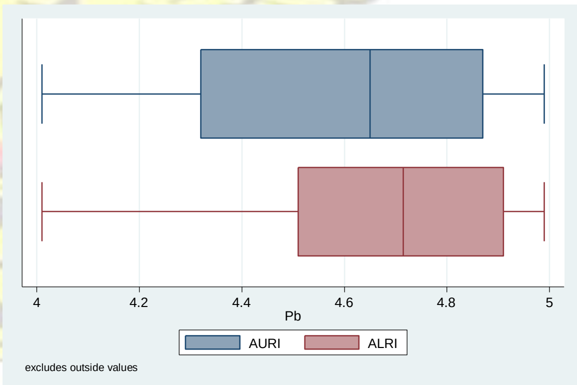

Fig. 4.3B Lead and ARI in hand wash water

A

B

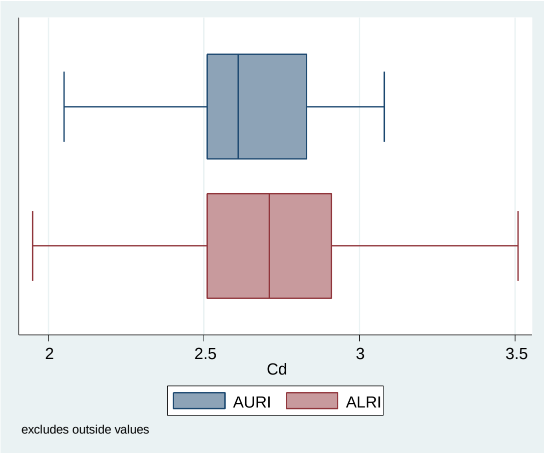

Fig. 4.4A Cadmium and ARI in blood

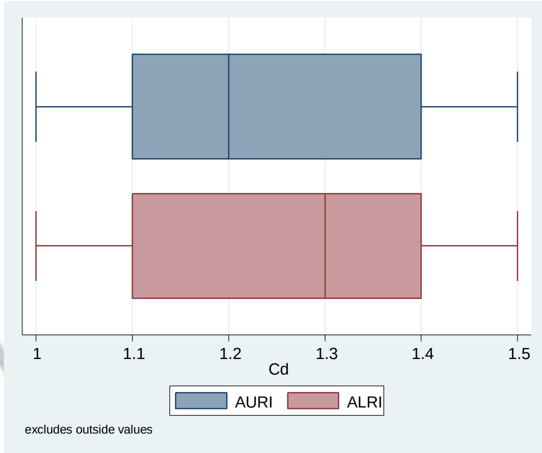

Fig. 4.4B Cadmium and ARI in hand wash water

A

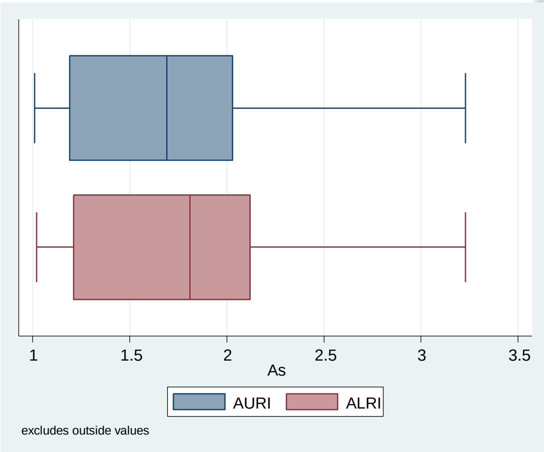

Fig. 4.5A Arsenic and ARI in blood

B

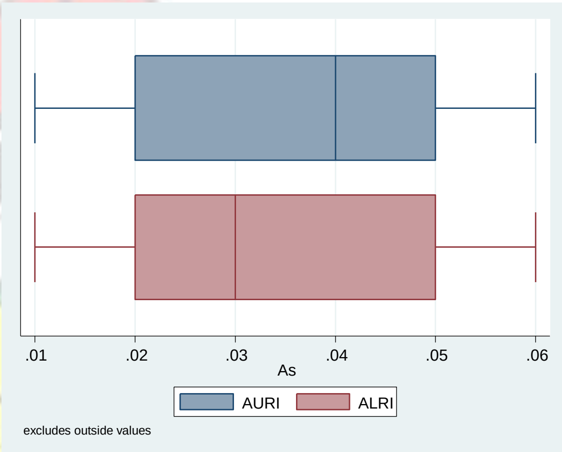

Fig. 4.5B Arsenic and ARI in hand wash water

4.4 Concentration of toxic metals in blood among children under five (5)

Four (4) traces of toxic metals were detected in the extract of blood samples of children under five years (Table 4.2). The mean residue and standard deviation of "As" was higher in children aged 2-4yrs (1.82 µg/L; 0.61) compared to children aged 0-2yrs (1.67 µg/L; 0.49). On the contrary, the mean residue concentration and standard deviation of Cd was higher in children aged 0-2yrs (2.74 µg/L; 0.46) compared to children aged 2-4yr (2.68 µg/L; 0.42).

Table 4.2: Concentration of toxic metals in blood samples of children under 5 living near Abokobi dumpsite (n=200)

	All children

Toxic metals	LOD	Mean	SD	Median	LQ	UQ	Min	Max
Hg	0.01	1.47	0.33	1.34	1.21	1.72	1.03	2.32
Cd	0.01	2.71	0.44	2.67	2.51	2.90	1.95	3.91
As	0.01	1.74	0.56	1.75	1.21	2.08	1.01	3.23
Pb	0.01	3.64	1.27	3.54	2.45	5.01	1.99	5.98
				0-2yrs				
Hg	0.01	1.45	0.33	1.31	1.21	1.67	1.04	2.32
Cd	0.01	2.74	0.46	2.67	2.51	2.90	1.95	3.91
As	0.01	1.67	0.49	1.62	1.21	1.99	1.01	3.19
Pb	0.01	3.64	1.25	3.54	2.45	5.01	1.99	5.98
				2-4yrs				
Hg	0.01	1.50	0.33	1.36	1.22	1.74	1.03	2.32
Cd	0.01	2.68	0.42	2.71	2.51	2.89	1.95	3.91
As	0.01	1.82	0.61	1.91	1.21	2.12	1.01	3.23
Pb	0.01	3.64	1.31	3.54	2.43	5.01	1.99	5.98

LOD=Level of detection SD=Standard deviation LQ=Lower quartile UQ=Upper quartile Min=Minimum Max=Maximum

4.5 Correlation between levels of metals in blood samples

There was no significant correlation between levels of metals in blood samples of the children (Table 4.3).

Table 4.3 Correlation between levels of metals in blood samples

Variables	Hg	Cd	As	Pb
Hg	1.000			
Cd	0.011	1.000		
As	0.039	-0.008	1.000	
Pb	0.098	0.070	0.115	1.000

4.5 Concentration of toxic metals in hand wash water samples among children under five (5)

Four (4) traces of toxic metals were detected in the hand washed water of children under five years (Table 4.4). The mean residue and standard deviation of Hg was higher in children aged 2-4yrs (0.21 µg/L; 0.15) compared to children aged 0-2yrs (0.15 µg/L; 0.14). However, the mean residue concentration and standard deviation of 'As' was same in children aged 0-2yrs (0.03 µg/L; 0.02) and children aged 2-4yrs respectively.

Table 4.4 Concentration of toxic metals in hand wash water samples of children under 5 living near Abokobi dumpsite (n=200)

				All children				
Toxic metals in hand wash water	**LOD**	**Mean**	**SD**	**Median**	**LQ**	**UQ**	**Min**	**Max**
Hg	0.01	0.19	0.15	1.34	0.03	0.40	0.01	0.40
Cd	0.01	1.27	0.16	1.30	1.10	1.40	1.00	1.50
As	0.01	0.03	0.01	0.04	0.02	0.05	0.01	0.06
Pb	0.01	4.61	0.29	4.67	4.33	4.87	4.01	4.99
				0-2yrs				
Hg	0.01	0.15	0.14	0.10	0.02	0.30	0.01	0.40
Cd	0.01	1.27	0.15	1.30	1.10	1.40	1.00	1.50
As	0.01	0.03	0.02	0.03	0.02	0.05	0.01	0.06
Pb	0.01	4.62	0.30	4.65	4.33	4.87	4.01	4.99
				2-4yrs				
Hg	0.01	0.21	0.15	0.20	0.10	0.40	0.01	0.40
Cd	0.01	1.28	0.16	1.30	1.10	1.40	1.00	1.50
As	0.01	0.03	0.02	0.04	0.02	0.05	0.01	0.06
Pb	0.01	4.62	0.30	4.67	4.33	4.91	4.01	4.99

4.6 Correlation between levels of metals in hand wash water samples

There was negative significant correlation between of metals Pb and 'As' in hand wash water. However, no significant associated was established among the other metals (Table 4.5).

Table 4.5 Correlation between levels of metals in blood samples

Variables	Hg	Cd	As	Pb
Hg	1.000			
Cd	0.116	1.000		
As	-0.044	0.040	1.000	
Pb	-0.184	-0.006	-0.299*	1.000

*p>0.05

4.7 Environmental exposure indicators of hand wash water and blood samples and symptoms of AURI and ALRI among children under five years in Abokobi

There was significant association between residual levels of Arsenic in blood samples and symptoms of AURI. Similarly there was significant association between residual levels of Cd and symptoms of ALRI (COR=1.84; 95%CI, 0.92-3.68)). However, there was no significant association between residual levels of the other toxic metals in blood samples and symptoms of AURI and ALRI (Table 4.6).

The association between metals in blood samples and levels of metals in hand washed water is shown in Table 4.7. There was no significant association between blood samples and levels of metals in hand washed water.

The association between mean concentration of metals in hand washed water in blood and symptoms of ALRI and URI is shown in Table 4.8. The odds of suffering ALRI is 1.79 folds greater as a result of Hg in hand wash water (AOR=1.79; 95%CI, 1.00-3.18).

There was no significant association between metals in blood samples and levels of metals in in hand washed water (Table 4.9).

Table 4.6: Mean concentration of toxic metals in blood and symptoms of ALRI and URI

Toxic metals	ARI		AURI		ALRI	
	Crude OR	Adjusted OR	Crude OR	Adjusted OR	Crude OR	Adjusted OR
Hg	0.76(0.32-1.81)	0.84(0.36-1.95)	1.04(0.41-2.63)	0.97 (0.39-2.42)	0.74 (0.31-1.78)	0.80 (0.34-1.88)
Cd	1.72(0.90-3.31)	1.77(0.92-3.38)	1.02(0.51-2.05)	1.01 (0.51-2.01)	1.84 (0.92-3.68)	1.86 (0.94-3.69)
As	1.15(0.69-1.92)	1.18(0.72-1.96)	0.64(0.37-1.10)	0.63 (0.37-1.08)	1.31 (0.77-2.23)	1.32(0.78-2.23)
Pb	1.20(0.96-1.50)	1.21(0.97-1.51)	0.93(0.73-1.18)	0.91 (0.72-1.15)	1.11 (0.89-1.41)	1.14 (0.91-1.43)

Hg-Silver Cd-Cadmium As-Arsenic Pb-Lead AURI-Acute upper respiratory infection ALRI-Acute lower respiratory infection ARI-Acute respiratory infection

*** Age, gender and education*

Table 4.7 Association between metals in blood samples and levels of metals in in hand washed water

	Levels of metals in blood			
	Hg	**Cd**	**As**	**Pb**
Metals in hand washed water	**Coef (95%CI)**	**Coef (95%CI)**	**Coef (95%CI)**	**Coef (95%CI)**
Hg	0.16 (0.32-0.65)	0.17 (0.40-0.74)	0.19 (0.58-0.96)	0.14 (1.53-1.82)
Cd	0.04 (0.43-0.51)	0.01 (0.55-0.56)	0.61 (0.23-0.71)	0.15 (1.49-1.79)
As	1.36 (3.21-5.93)	1.51 (3.88-6.90)	5.98 (1.25-13.22)	6.36 (9.53-22.25)
Pb	0.09 (0.15-0.34)	0.15 (0.14-0.44)	0.08 (0.32-0.47)	0.19 (0.67-1.05)

Table 4.8 Mean concentration of metals in hand washed water in blood and symptoms of ALRI and URI

Metals in hand washed water	ARI		AURI		ALRI	
	Crude OR	Adjusted OR**	Crude OR	Adjusted OR**	Crude OR	Adjusted OR**
Hg	1.08 (0.52-2.28)	1.48 (0.85-2.59)	1.15 (0.51-2.58)	1.22 (0.66-2.24)	1.37 (0.64-2.90)	**1.79 (1.00-3.18)**
Cd	1.18 (0.58-2.38)	1.27 (0.73-2.24)	1.82 (0.83-3.99)	1.68 (0.90-3.17)	0.69 (0.33-1.42)	0.82 (0.46-1.46)
As	1.35 (0.58-3.14)	**1.73 (0.98-3.03)**	0.93 (0.37-2.35)	1.44 (0.78-2.64)	1.51 (0.64-3.62)	1.57 (0.89-2.78)
Pb	1.65 (0.72-3.76)	**1.90 (0.92-3.93)**	1.50 (0.59-3.83)	1.42 (0.62-3.22)	1.11 (0.46-2.67)	1.65 (0.76-3.57)

*** Age, gender and education*

Table 4.9 Association between levels of metals in blood and metals in in hand washed water

	Metals in hand washed water			
	Hg	**Cd**	**As**	**Pb**
Levels of metals in blood	**Coef (95%CI)**	**Coef (95%CI)**	**Coef (95%CI)**	**Coef (95%CI)**
Hg	0.90 (0.25-3.31)	1.41 (0.80-2.46)	0.57 (0.14-2.32)	0.96 (0.52-1.77)
Cd	1.65 (0.56-4.84)	1.62 (0.91-2.89)	1.22 (0.39-3.76)	1.02 (0.55-1.91)
As	0.45 (0.19-1.05)	0.66 (0.36-1.22)	0.78 (0.37-1.66)	1.57 (0.88-2.78)
Pb	0.74 (0.42-1.29)	0.75 (0.35-1.61)	0.79 (0.43-1.46)	0.77 (0.43-1.36)

CHAPTER FIVE

DISCUSSION

5.1 Main findings

The proportion of self-reported symptoms of acute upper respiratory infection (AURI) was high in children aged 2 years. Also the proportion of children reporting symptoms of acute lower respiratory infection (ALRI) was higher among children age 3 years. Also, there was significant association between residual levels of Arsenic and Cadmium in blood samples and symptoms of AURI. However, there was no significant association between residual levels of the other toxic metals in blood samples and symptoms of AURI and ALRI in children. The proportion of children to suffer ALRI was 1.79 times higher for children who eat without washing hands compared to those that wash their hands before eating outside the home.

The association between mean concentration of metals in hand washed water in blood and symptoms of ALRI and URI is greater as a result of Hg in hand wash water. However, The mean residue and standard deviation of Hg contributes to ALRI than AURI in blood than in hand wash water. Also, concentration of Cadmium contributes more to ALRI in blood than in hand wash water.

The mean residue and standard deviation of Hg was higher in children aged 2-4yrs compared to children aged 0-2yrs. However, the mean residue concentration and standard deviation of 'As' was same in children aged 0-2yrs and children aged 2-4yrs respectively

There was negative significant correlation between metals Pb and 'As' in hand wash water. However, no significant associated was established among the other metals.

5.2 Methodological validity

The residents (children) in Abokobi who live close to the dumpsite, from which samples were selected for this study, had a high participation rate therefore, minimizing selection bias. Trained Nurses were involved in the collection of the samples. The population for this study comprised parents with children (<5years) who were voluntarily recruited. Data on heavy metals exposure was collected objectively and subjectively and findings on the heavy metals body burden and prevalence of exposure experience were the same. Thus, the effect of information bias in this study was minimal. The study population was homogeneous with regard to culture and by socio-economic status, reducing the potential effect of unmeasured confounding.

Again, to the researcher, this is the first study in Ghana to look at this association.

Irrespective of the strength of this study, the study had some limitations. The study used voluntary participation to select participants; it was possible that some residents (children) and vital information may have been missed. Self-reporting of outcomes was another limitation, that is whether the participants understood the questions. Different people administering the questionnaire cannot guarantee the consistency of the outcome but it was not proven in the study. However, the effect of this on the study estimates need to be verified. Irrespective of the fact that traces of Lead are metabolized easily in humans, it was measured and traces was detected. To still detect Lead residues in the urine samples suggested that exposure to heavy metals was common in the study population and that a single measurement as applied in this present study reflects average exposure over a longer period. Again, the crosssectional design restricted the ability to discern any temporality. Future studies that follow residents that live close to dumpsites prospectively and collect data on occupational and non-occupational exposures will help to clarify this possibility.

5.3 Comparison of present findings with previous studies

The proportion of self-reported symptoms of acute upper respiratory infection (AURI) and acute lower respiratory infection (ALRI) was high in children aged 2 years and 3 years respectively. The proportion of children reporting symptoms of respiratory infection is in agreement with a study which found that children under five years of age show symptoms of ARI varies with age with children aged between 6-11 months the most vulnerable to this disease (GDHS, 1998). The high proportion of children suffering ARI in the study area could be due to their restrictive arm circumference as confirm by a study which found that a child with an aim circumference of less than 13.5cm suffers more episodes of both upper and lower respiratory infections than were children with larger arm circumference (Lang et al. 1986). Another major danger from the waste dump is the regular unpleasant odours which can pose problems by causing congestion, either in the nasal sinuses or lungs.

Bad mouthing behavior, poor food handling behavior; bad hygiene practices and poor hand washing behavior was common among all children. The finding means that children who like to play around the dump site are exposed to the smoke that emanates from the dump site making the children prone to respiratory tract infection and other health conditions. Furthermore, the dumping of electronic materials that has cadmium, mercury and arsenic as parts of its content may be left in the soil during the dumping or burning process of these metals. Most of the children especially those under the age of 5 are mostly naive and are found playing in the soil making them highly exposed to these trace metals which will highly make them prone to respiratory tract infection.

A significant association was observed between residual levels of Arsenic and Cadmium in blood samples and symptoms of AURI. The finding is consistent with a study which found that the there is a significant association between Arsenic and ARI in children. The study continued that the relationship depends on the absorption and subsequent metabolism of Arsenic and the effects in children greatly depends on the chemical form, the length of exposure and the absorption path (Hakala & Hallkainen, 2004). The finding is consistent with a study which found that the ingestion or inhalation of Arsenic may cause nausea, abdominal cramps, short breath and inhibition of iron absorption (Donahoe et al., 2015). The finding was confirmed by results that soil around dump site is usually rich in toxic heavy metals as a result of the dumped waste and used by the people living around the dump for planting vegetables and fruits. These plants bio-accumulates heavy metals from the soil and when they are eaten by children, the heavy metal accumulate in the body with serious health effects (USEPA, 2002; UNDP, 2006; Rotich et al., 2006).

This study was conducted among children under five years in a predominately dumping site community where precautionary and safety measures are problematic. To the best of my knowledge, this study is the first to have investigated the association between heavy metals exposure and ARI among children under five years living close to a commercial dumpsite.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The prevalence of symtoms AURI of respiratory infection was high. The proportion of self-reported symptoms of acute upper respiratory infection (AURI) and acute lower respiratory infection (ALRI) was high in children aged 2 years and 3 years respectively. There was significant association between residual levels of Arsenic in blood samples and symptoms of AURI. Similarly there was significant association between residual levels of Cd and symptoms of ALRI. However, there was no significant association between residual levels of the other toxic metals in blood samples and symptoms of AURI and ALRI. The concentrations of the entire residue in the blood samples were above the level of detection. The study concludes that the concentrations mean residue of Lead (Pb) was higher in children.

6.2 Recommendations

The study recommended public education of good practices in child care should be intensified to avert the development of preventable diseases such as acute upper respiratory infections. Awareness must also be created on proper waste management practices.

Also regular checkup must be done for children who live close to dumpsites to avert any health risk they may be exposed to. Finally, Local Government Ministry and the Ministry of Sanitation and Water Resources should permanently ban or avoid the use of the dumpsite

REFERENCE

Addico, G. N. L. (2000). *Acute Respiratory Infections in Under Fives A Study of the Determinants of Care Seeking And Home Management Practice in Akatsi District* (Doctoral dissertation, University of Ghana).

Adelekan B. A. and Abegunde K. D. (2011). Heavy Metals Contamination of Soil and Groundwater at Automobile Mechanic Villages in Ibadan, Nigeria. International Journal of the Physical Sciences vol. 6(5), pp. 1045-1058.

Adelman, I.R. and L.L. Smith Jr. (1976). *Standard test fish development. Part I & II. Fathead minnows (Pimephalespromelas) and goldfish (Carassiusauratus) as standard fish in bioassays and their reaction to potential reference toxicants*. EPA/600/3-76/061a & 061b. Environmental Research Laboratory, ORD, USEPA, Duluth, MN, Grant # R800940.

Adeolu o. Aderemi, Adebayo A. Otitoloju (2012) An *Assessment of landfill Fires and Their Potential Health effects- A Case Study of a municipal Solid Waste landfill in Lagos, nigeria # IJeP Vol. 2 no. PP.22-26* www.ij-ep.org

Agency for Toxic Substances and Disease Registry (ATSDR) (1999). *Toxicological Profile for Cadmium*. US Department of Human and Health Services.

Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile for Arsenic TP-92/09. Georgia: Center for Disease Control, Atlanta; 2000.

Agency for Toxic Substances and Disease Registry (ATSDR), (2008). ATSDR Medical Fact Sheet; *Division of Toxicology and Environmental Medicine*. US

Agency for Toxic Substances and Disease Registry (ATSDR). Toxicoloigcal profi le for chromium. Atlanta, GA: US Department of Health and Human Services, Public Health Service, 2012.

Agrawal V.K. and K.P.S. Raj, (1978). *Metal contents in the drinking water of Cambay. Air and Soil Pollution.*9: 129-134. 4.

Aimal, M., Khan, M. A., & Nomani, Z. A. (1984). Environ. Monitoring Assessment, 1985, 5%, 205; SN Chattopadhyaya, T. Routh, VP Sharma, HC Arora and RK Gupta. Indian J. Envirin. Health, 26, 244.

Ajmal, M., M.A. Khan and A.A. Nomani, (1985). *Distribution of heavy metals in plants and fishes of the Yamuna River*. Environ. Monitoring Assess. 5: 361

Akhter, M. S.; Madany, I. M. Heavy metals in street and house dust in Bahrain. Water Air Soil Pollut. 1993, 66, 111–119.

Allen, A.r., Taylor, R (2006). '*Waste disposal and landfill: Control and protection." Protecting Groundwater for Health: managing the Quality of drinking- water Sources, WHo drinking Water Quality Series monograph,* IWA Publishing.

Appiah J.O 2015. Turning household solid wastes into resources for poverty alleviation: a case study of Abokobi in the Ga east municipality. University of Ghana. Thesis submitted to the institute of statistical, social and economic research.

Arku, F. S., & Fiasorgbor, D. (2013). Millennium Development Goal (MDG) On Sanitation and Water: The Advocates and the Rural-Urban Differentials in Ghana through the Media. *International Journal of Community Development*, *1*(1), 44-47.

Asenso-Okyere, W. K., Faber, D., & Meijerink, G. (1998). Natural Resources Management Oriented Agricultural Research and Policy Change: Comparing two Ghanaian Research Experiences. *Closing the Loop: From Research on Natural Resources to Policy Change*, 47.

Asowa-Omorodion, F. I. (1997). Women's perceptions of the complications of pregnancy and childbirth in two Esan communities, Edo State, Nigeria. *Social science & medicine*, *44*(12), 1817-1824. str m, M., Deng, H. (2003). Assessment of the mobility of trace elements in acidic soils using soil and stream geochemical data. *Geochemistry: Exploration, environment, analysis*, *3*(2), 197-203.

Awedoba, A. K. (1999). Overcoming cultural barriers to patient care for acute respiratory infections in young children. *Research Review*, *15*(2), 13-33.

Balogh, L., & Tomalia, D. A. (1998). Poly (amidoamine) dendrimer-templated nanocomposites. Synthesis of zerovalent copper nanoclusters. *Journal of the American Chemical Society*, *120*(29), 7355-7356.

Balogh, S., Meyer, M., & Johnson, K. (1998). Diffuse and point source mercury inputs to the Mississippi, Minnesota, and St. Croix Rivers. Science of the total environment, 213(1-3), 109-113.

Balogh, S.J., M.L. Meyer and D.K. Johnson. 1998. Transport of mercury in three contrasting river basins. Environmental Science and Technology. Vol. 32: 456-462.

Bamikale, M. (1997). Mothers Management of Childhood diseases in the Yurobaland. The Influence of Cultural beliefs, Health Transition Review, Vol. 7, No. 1, pp 221-234.

Barrett JC, Lamb PW, Wang TC, Lee TC. Mechanisms of arsenic-induced cell transformation. Biol. Trace Ele Res. 1989;21:421–429. [PubMed]

Basu A, Mahata J, Gupta S, Giri AK. Genetic toxicology of a paradoxical human carcinogen, arsenic: a review. Mutat Res. 2001;488:171–194. [PubMed]

Baylis, K., Peplow, S., Rausser, G., & Simon, L. (2008). Agri-environmental policies in the EU and United States: A comparison. *Ecological economics*, *65*(4), 753-764.

Beak International Incorporated, 2002. Literature Review of Environmental Toxicity of Mercury, Cadmium, Selenium and Antimony in Metal Mining Effluents.

The TIME Network and sponsored by Natural Resources Canada, The Mining Association of Canada and Environment Canada

Belzile, N., Chen, Y. W., Yang, D. Y., Truong, H. Y. T., & Zhao, Q. X. (2009). Selenium bioaccumulation in freshwater organisms and antagonistic effect against mercury assimilation. *Environmental Bioindicators*, *4*(3), 203-221.

Berman, A., Ahn, D. J., Lio, A., Salmeron, M., Reichert, A., & Charych, D. (1995). Total alignment of calcite at acidic polydiacetylene films: cooperativity at the organic-inorganic interface. *Science*, *269*(5223), 515-518.

Berman, S., & McIntosh, K. (1985). Selective primary health care: strategies for control of disease in the developing world. XXI. Acute respiratory infections. *Reviews of infectious diseases*, *7*(5), 674-691.

Besarab, A., Bolton, W. K., Browne, J. K., Egrie, J. C., Nissenson, A. R., Okamoto, D. M., ... & Goodkin, D. A. (1998). The effects of normal as compared with low hematocrit values in patients with cardiac disease who are receiving hemodialysis and epoetin. *New England Journal of Medicine*, *339*(9), 584-590.

Betts k (2008), *Producing usable materials from e-waste. environ Sci Technol; 42:6782–3.* bi, x. H.; Thomas, G. o.; Jones, k. C.; Qu, W. y.; Sheng, G. y.; martin, F. l.; Fu, J. m. *(2007) exposure of electronics dismantling workers to polybrominatetd diphenyl ethers, polychlorinated biphenyls, and organochlorine pesticides in South China. environ. Sci. Technol. 2007, 41, 5647–5653*

Birnbaum LS, Jung P.(2010) *Evolution in environmental health: incorporating the infectious disease paradigm.* Environmental health perspectives. 118(8): a327– a328. [PMC free article][PubMed]

Bjornberg, A., L. Hakanson and K. Lundbergh. (1988) A theory on the mechanisms regulating the bioavailability of mercury in natural waters. Environ. Poll. 49: 53.

Black R. E., Morris S. S., Bryce J.(2003) Where and Why Are 10 Million Children Dying Every Year? Lancet. 361(9376):2226–34. [PubMed]

Black, R. E., Morris, S. S., & Bryce, J. (2003), Where and why are 10 million children dying every year?. *The lancet*, *361*(9376), 2226-2234.

blACkSmITH InSTITuTe, *The World's Worst Pollution Problems: Assessing Health risks at Hazardous Waste Sites, 2012*

Bloom, N.S. and S.W. Effler (1990), *Seasonal variability in the mercury speciation of Onondaga Lake* (New York). Water, Air and Soil Pollution. 53:251-265

Boadi, K. O., & Kuitunen, M. (2003). Municipal solid waste management in the Accra Metropolitan Area, Ghana. *Environmentalist*, *23*(3), 211-218.

Booer, J.R. (1944), The behaviour of mercury compounds in soil. Ann. Appl. Biol. 31: 340-359.

Brett H. (2009*) robinson, e-waste: An assessment of global production and environmental impacts, Science of the Total environment 408 183–191*

Brokensha, D. W. (1966). African Studies in the United States. *African Studies Bulletin*, *9* (1),38-80.

Bullen, T. D., Krabbenhoft, D. P., & Kendall, C. (1996). Kinetic and mineralogic controls on the evolution of groundwater chemistry and 87Sr/86Sr in a sandy silicate aquifer, northern Wisconsin, USA. *Geochimica et Cosmochimica Acta*, *60*(10), 1807-1821.

Buor, D. (2003). Mothers' education and childhood mortality in Ghana. *Health policy*, *64*(3), 297- 309.

Carla Guerriero and John Cairns (2009), *the potential monetary benefits of reclaiming hazardous waste sites in the Campania region: an economic evaluation, Environmental* Health, 8:28 doi:10.1186/1476-069X-8-28

Carty, A.J., and S.F. Malone. (1979), The chemistry of mercury in biological systems. In: J.O. Nriagu [Ed.]. The Biogeochemistry of Mercury in the Environment. Elsevier/ North- Holland Biomedical Press, Amsterdam. 203 p.

Cella, D., Riley, W., Stone, A., Rothrock, N., Reeve, B., Yount, S., ... & Cook, K. (2010). The Patient-Reported Outcomes Measurement Information System (PROMIS) developed and tested its first wave of adult self-reported health outcome item banks: 2005–2008. *Journal of clinical epidemiology*, *63*(11), 1179-1194.

Centeno JA, Gray MA, Mullick FG, Tchounwou PB, Tseng C.(2005) Arsenic in drinking water and health issues. In: Moore TA, Black A, Centeno JA, Harding JS, Trumm DA, editors. Metal Contaminants in New Zealand. New Zealand: Resolutionz Press; pp. 195–219.

Centers for Disease Control and Prevention. Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care facilities. Morb Mort Weekly Rpt, 1994, 43:RR-13. 14

Challis, J. R. G., Sloboda, D., Matthews, S. G., Holloway, A., Alfaidy, N., Patel, F. A., ... & Newnham, J. (2001). The fetal placental hypothalamic–pituitary– adrenal (HPA) axis, parturition and post-natal health. *Molecular and cellular endocrinology*, *185*(1-2), 135-144.

Chatham-Stephens, Kevin, Jack Caravanos, Bret Ericson, Jennifer Sunga-Amparo, Budi Susilorini, Promila Sharma, Philip J. Landrigan, and Richard Fuller (2010). "Burden of Disease from Toxic Waste Sites in India, Indonesia, and the Philippines in." Environmental Health Perspectives 121, no. 7 (May 4, 2013): 791–96. https://doi.org/10.1289/ehp.1206127.

Cherry, W. H. (1981). Distribution of cadmium in human tissues. In Cadmium in the Environment. Part II: Health Effects (J. O. Nriagu, Ed.), pp. 69-536. John Wiley and Sons, New YorkNriagu, J. O. (1981). Cadmium in the Environment. Part II: Health Effects. John Wiley and Sons, New York.

Clark, D. D., Shenker, S., & Zhang, L. (1992, October). Supporting real-time applications in an integrated services packet network: Architecture and mechanism. In *ACM SIGCOMM Computer Communication Review* (Vol. 22, No. 4, pp. 14-26). ACM.

Cobbing M. Toxic Tech: Not in Our Backyard. Uncovering the Hidden Flows of ewaste. Report from Greenpeace International.

http://www.greenpeace.org/raw/content/
belgium/fr/press/reports/toxictech.pdf, Amsterdam,, 2008.

Collins CH and Kennedy DA (1992). The microbiological hazards of municipal and clinical wastes. J.Appl. Bacteriology. 73:1-6.

Craig, J.P. (1986). Organomercury compounds in the environment. In: P.J. Craig [Ed.]. Organometallic Compounds in the Environment. Wiley, N.Y. pp. 65.

Cullen, W. R., & Reimer, K. J. (1989). Arsenic speciation in the environment. Chemical reviews, 89(4), 713-764.

Daabu, M. A (2014, November 1). National Sanitation Day Gets Off to a Promising Start. Myjoyonline. *Retrieved from* http://www.myjoyonline.com/news/2014 on 21st, November, 2014.

Dalton P., *Upper airway irritation, odour perception and health risk due to airborne chemicals. Toxicol Lett, 140–141, 239–48, 2003*

Danell, K., Bergström, R., Duncan, P., & Pastor, J. (Eds.). (2006). *Large herbivore ecology, ecosystem dynamics and conservation* (Vol. 11). Cambridge University Press.

Daniel Peplow and Robert Edmonds, (2004). Health Risks Associated with Contamination of Ground water by Abandoned Mines near Twisp in Okanogan County, Washington, USA. Environmental Geochemistry and Health, 26(1):69-79.

David, o. m., & Oluyege, A. O (2014) , *effect of open refuse dumpsite on the Quality of underground Water used for domestic Purposes in Adoekiti, nigeria - A Public Health Awareness Study, Journal of environment and ecology, Vol. 5, no. 2, ISSn 2157-6092*

Davis, A., B.S. Bloom and S.S. Que Hee. (1997). The environmental geochemistry and bioaccessibility of mercury in soils and sediments: A Review. Risk Analysis, Vol: 17: 557 – 569

Davis, A., B.S. Bloom and S.S. Que Hee. (1997). The environmental geochemistry and bioaccessibility of mercury in soils and sediments: A Review. Risk Analysis, Vol: 17: 557 - 569.

De Boodt, M. F., & Verdonck, O. F. (1985). *U.S. Patent No. 4,494,975*. Washington, DC: U.S. Patent and Trademark Office.

De Smet, H., & Blust, R. (2001). Stress responses and changes in protein metabolism in carp Cyprinus carpio during cadmium exposure. Ecotoxicology and environmental safety, 48(3), 255-262.

Deng WJ, Zheng JS, bi xH, Fu Jm, Wong mH *(2007) distribution of Pbdes in air particles from an electronic waste-recycling site compared with Guangzhou and Hongkong, South China. environ Int;33:1063–9.*

Denny, F. W. Jr. (1995). "The Clinical Impact of Human Respiratory Virus Infections." American Journal ofRespiratory and Critical Care Medicine 152 (4, part 2): S4–12.

Dinye, R., D. (2006). *Economies of Private Sector Participation in Solid Waste Management in Takoradi- Ghanaian City*. Journal of science and technology, 26(1), 60-75.

Donahoe, S. L., Lindsay, S. A., Krockenberger, M., Phalen, D., Šlapeta, J. (2015). *A review of neosporosis and pathologic findings of Neosporacaninuminfection in wildlife*. International Journal for Parasitology: *Parasites and Wildlife*. 4(2), 216–238. doi:10.1016/j.ijppaw.04.002

Driscoll, C. T., Yan, C., Schofield, C. L., Munson, R., & Holsapple, J. (1994). The mercury cycle and fish in the Adirondack lakes. *Environmental Science & Technology*, *28*(3), 136A- 143A.

Dunnick, N. R., Jones, R. B., Doppman, J. L., Speyer, J., & Myers, C. E. (1979). Intraperitoneal contrast infusion for assessment of intraperitoneal fluid dynamics. *American Journal of Roentgenology*, *133*(2), 221-223.

eA (environment Agency), *updating the landfill leachate Pollution Inventory Tool. r&d Technical report no. PI-496/Tr(2). Shrewsbury, enviros Consulting ltd. , 2003*

eA (environment Agency), updating the landfill leachate Pollution Inventory Tool. r&d Technical report no. PI-496/Tr(2). Shrewsbury, enviros Consulting ltd. , 2003

Edwin, A. K. & Howell, H. H. (1990). *Sources and Fates of Lead and Cadmium in Municipal Solid Waste*. Journal of the Air & Waste Management Association. 40:9, 1220-1226, DOI: 10.1080/10473289.1990.1046676

Ekberg, K., Björkqvist, B., Malm, P., Bjerre-Kiely, B., Karlsson, M., & Axelson, O. (1994). Case- control study of risk factors for disease in the neck and shoulder area. *Occupational and environmental medicine*, *51*(4), 262-266.

EPA, Human Health,25 June 2014, Available at http://www.epa.gov/osw/nonhaz/municipal/backyard/health.htm, access on 22 January 2015

Erica L Dahl 2012, Importance of Toxicology to Disease Prevention—2012 Session on E-Waste Recycling. Society Of Toxicology. To Toxchange.

Fahy, D. M., O'callaghan, Y. C., & O'brien, N. M. (2004). Phytosterols: lack of cytotoxicity but interference with β-carotene uptake in Caco-2 cells in culture. *Food additives and contaminants*, *21*(1), 42-51.

Fangxing yang et al, *Comparisons of Il-8, roS and p53 responses in human lung epithelial cells exposed to two extracts of Pm2.5 collected from an ewaste recycling area, China 2011, environ. res. lett. 6 024013 doi:10.1088/1748-9326/6/2/024013*

Feigin, R. D., Cherry, J. D., & Kaplan, S. L. (1981). *Textbook of pediatric infectious diseases* (Vol. 1, pp. 1338-1373). G. J. Demmler (Ed.). Philadelphia, PA: Saunders.

Feingold, B. J., Vegosen, L., Davis, M., Leibler, J., Peterson, A., & Silbergeld, E. K. (2010). A niche for infectious disease in environmental health: rethinking the toxicological paradigm. Environmental health perspectives, 118(8), 1165-1172.

Ferguson, J: F &Gavis, J.G. (1972) .*A review of arsenic cycle in natural waters*. Water research 6, 1259-1274.

Foday Pinka Sankoh, Xiangbin Yan1, Quangyen (2013). Tran1 *Environmental and Health Impact of Solid Waste Disposal in Developing Cities: A Case Study of Granville Brook* Dumpsite, Freetown, Sierra Leone

Forrester, M. B., & Merz, R. D. (1999). Epidemiology of abdominal wall defects, Hawaii, 1986– 1997. *Teratology*, *60*(3), 117-123.

Friberg, J. (1974). A simple and sensitive micro-method for demonstration of sperm - agglutinating activity in serum from infertile men and women. Acta Obstetricia et Gynecologica Scandinavica, 53(S36), 21-29.

Friberg, L., Elinder, C., Kjellstrom, T., & Nordberg, G. F. (1985). Cadmium and health: A toxicological and epidemiological appraisal Volume II: Effects and response.

Ga-East Municipal Assembly. (2013). Municipal Profile.

Gagnon, C., & Fisher, N. S. (1997). Bioavailability of sediment-bound methyl and inorganic mercury to a marine bivalve. *Environmental Science & Technology*, *31*(4), 993-998.

Gagnon, C., & Fisher, N. S. (1997). The bioavailability of sediment-bound Cd, Co, and Ag to the mussel Mytilus edulis. *Canadian Journal of Fisheries and Aquatic Sciences*, *54*(1), 147- 156.

Geneva, World Health Organization, 1999.

Gershon RR, Vlahov D, Escamilla-Cejudo JA, et. al. Tuberculosis risk in funeral home employees. J Occup Environ Med, 1998, 40:497-503

Ghana Innovation Marketplace. (2009). *Waste Management Conference and Exhibition*. Retrieved from www.africanbusinessnetwork.org › Projects on 21st March, 2015.

Ghana Statistical Service (GSS) (2013b).2010 *Population and Housing Census: Greater Accra*

Ghana Statistical Service and MI. GDHS 1998. Calverton, Maryland; 1994:101.

Ghana Statistical Service. (1999) Ghana Demographic and Health Survey 1998. Macro International Inc. USA

Ghana. Statistical Service, Macro International. Demographic, & Health Surveys. (1999). *Ghana demographic and health survey*. Ghana Statistical Service.

Gill, G. A., & Bruland, K. W. (1990). Mercury speciation in surface freshwater systems in California and other areas. *Environmental Science & Technology*, *24*(9), 1392-1400.

Gonzaga, N. C., Navarro, E. E., Lucero, M. G., Queipo, S. C., Scbroeder, I., & Tupasi, T. E. (1990). Etiology of infection and morphologic changes in the lungs of Filipino children who die of pneumonia. *Reviews of infectious diseases*, *12*(Supplement_8), S1055-S1064.

Goon, D., & Klaassen, C. D. (1989). Dosage-dependent absorption of cadmium in the rat intestine measured in situ. *Toxicology and applied pharmacology*, *100*(1), 41-50.

Government of Ghana. (2010). *National environmental sanitation strategy and action plan.* Accra: Environmental Health and Sanitation Directorate, Ministry of Local Government and Rural Development.

Grant, A., & Middleton, R. (1990). An assessment of metal contamination of sediments in the Humber Estuary, UK. *Estuarine, Coastal and Shelf Science*, *31*(1), 71-85.

Guillen MD, Sopelana P, Partearroyo MA. *Determination of polycyclic aromatic hydrocarbons in commercial liquid flavouring of different composition by gas chromatography-mass spectrometry.* Journal of Agricultural and Food Chemistry. 2000;48:126-131.

Gullett bk, linak WP, Touati A, Wasson SJ, Gatica S, king CJ. *(2007) Characterization of air emissions and residual ash from open burning of electronic wastes during simulated rudimentary recycling operations. J mater Cycl Waste manage; 9:69– 79*

Gwatkin, D. R. (1980). Indications of change in developing country mortality trends: The end of an era?. *Population and Development Review*, 615-644.

Haiduven DJ, Simpkins SM, Phillips ES, Stevens DA. A survey of percutaneous/mucocutaneous

Hakala, E., & Hallikainen, A. (2004). Exposure of the finnish population to arsenic, effects and health risks. Arsenic in Finland: distribution, environmental impacts and risks, 1st edn. Geological Survey of Finland, Espoo, 153-166.

Herber, R. F. M., & Stoeppler, M. (Eds.). (1994). *Trace element analysis in biological specimens* (Vol. 15). Elsevier.

Holmström, K., Gräslund, S., Wahlström, A., Poungshompoo, S., Bengtsson, B. E., & Kautsky, N. (2003). Antibiotic use in shrimp farming and implications for environmental impacts and human health. *International journal of food science & technology*, *38*(3), 255-266.

Horváth, I., Glatz, A., Varvasovszki, V., Török, Z., Páli, T., Balogh, G., ... & VIgh, L. (1998). Membrane physical state controls the signaling mechanism of the heat shock response in Synechocystis PCC 6803: identification of hsp17 as a "fluidity gene". *Proceedings of the National Academy of Sciences*, *95*(7), 3513-3518.

HPA (Health Protection Agency), *Carbon dioxide. Incident management. Available at http://www.hpa.org.uk/web/HPAwebFile/ HPAweb_C/1279889001588 , 2010*

HPA (Health Protection Agency), Compendium of Chemical Hazards. Hydrogen

Sulphide. Available at http://www.hpa.org.uk/web/ HPAwebFile/HPAweb_C/1246260029655 2009

HPA (Health Protection Agency), Compendium of Chemical Hazards. methane. Available at http://www.hpa.org.uk/web/HPAwebFile/ HPAweb_C/1287147970726 , 2009

HPA (Health Protection Agency), Impact on health of emissions of landfill sites, 2011

HSe, Health and hazardous substances in waste and recycling, uk, 2014

Hughes MF. Arsenic toxicity and potential mechanisms of action. Toxicol Lett. 2002;133:1–16. [PubMed

Hughes, M.F., Thomas, D.J &Kenyon, E.M. 2009. Toxicology and Epidemiology of arsenic and it Compounds. In publication Henke, K.R.2009 (ed.) Arsenic: Environmental Chemistry, Health Threaths and Waste Treatments Wiley

Hunt, R. J., Krabbenhoft, D. P., & Anderson, M. P. (1996). Groundwater inflow measurements in wetland systems. *Water Resources Research*, *32*(3), 495-507.

Huo, X.; Peng, L.; Xu, X. J.; Zheng, L. K.; Qiu, B.; Qi, Z. L.; Zhang, B.; Han, D.; Piao, Z. X. Elevated blood lead levels of children in Guiyu, an electronic waste recycling town in China. Environ. Health Perspect. 2007, 15, 1113– 1117.

Hutchinson J (1887a). Arsenic cancer. Br Med J 2: 1280–1281.

India Development Gateway (InDG) 2018. Accessed on Viskapedia on 20th January 2019. http://vikaspedia.in/health/diseases/lungs-related/acute-respiratoryinfection-ari#section-6

International Agency for Research on Cancer (IARC): Monographs on the Evaluation of Carcinogen Risks to 29. Humans. Beryllium, Cadmium, Mercury and the Glass Manufacturing Industry. Volume 58. Lyon: International Agency for 30. Research on Cancer; 1993.

ISWA (International solid waste association) 2015. Wasted Health. the tragic case of dumpsites

ISWA's Scientific and Technical Committee Work-Program 2014-2015, p.6

Iyun, B. F. and Goran, T. (1996) Acute respiratory infections: Mothers' perceptions of etiology and treatment in south-western Nigeria. Social Science and Medicine, Vol.42, No.3 Pp 437-445.

Iyun, B. F., & Tomson, G. (1996). Acute respiratory infections—Mothers' perceptions of etiology and treatment in South-Western Nigeria. *Social Science & Medicine*, *42*(3), 437-445.

J. K. Nduka et al, Polyaromatic Hydrocarbons (PAHs) and Inorganic Chemical Contaminants at Refuse Dumpsites in Awka, South Eastern Nigeria: A Public Health

Implication, Journal of Scientific Research and Reports, ISSN: 2320– 0227, Vol.: 2, Issue.: 1 (January-June). P. 173-189, 2013

J. Krajcovicova and A.Q. Eschenroeder, Comparative Health Risks of Domestic Waste Combustion in Urban and Rural Slovakia. Environmental Science & Technology, 2007, 41(19), 6847-6853p

Jamil K. and S. Hussain, (1992). Biotransfer of metals to the insect Neochetina eichhornae via aquatic plants. Archives Environ. contamin. and Toxicol. 22: 459-463.

Jerie. S. 2016. Occupational Risks Associated with Solid Waste Management in the Informal Sector of Gweru, Zimbabwe

Journal of Environmental Protection, 2013, 4, 665-670 http://dx.doi.org/10.4236/jep.2013.47076 Published Online July 2013 (http://www.scirp.org/journal/jep)

K.O. Boadi and M. Kuitunen, *Environmental and health impacts of household solid waste handling and disposal practices in third world cities: the case of the Accra Metropolitan Area, Ghana, Journal of environmental health*,2005. 68(4), 32-36p

Kabata-Pendias, A. and Pendias, H. (1992). Trace Elements in Soils and Plants. 2nd Edition, CRC Press, Boca Raton, pp.1-87, 131-141.

Kamath K. R., Feldman R. A., Rao P. S. S., Webb J. K. Infection and Disease in a Group of South Indian Families. American Journal of Epidemiology. 1969;89:375–83. [PubMed]

Kanat, G. (2010). Municipal solid-waste management in Istanbul. *Waste management*, *30*(8-9), 1737-1745.

Kannan, K., & Falandysz, J. (1997). Butyltin residues in sediment, fish, fish-eating birds, harbour porpoise and human tissues from the Polish coast of the Baltic Sea. *Oceanographic Literature Review*, *9*(44), 1056-1057.

Karagas, M. R. (2010). Arsenic-related mortality in Bangladesh. Lancet, 376(9737), 213.

Kashyap, D. R., Dadhich, K. S., & Sharma, S. K. (2003). Biomethanation under psychrophilic conditions: a review. *Bioresource technology*, *87*(2), 147-153.

Kaushik, A., S. Jain, J. Dawra and P. Sharma, (2003). Heavy metal pollution in various canals originating from river Yamuna in Haryana. J. Environ. Biol., 24(3): 331-337.

Kavlock, R. J., Daston, G. P., DeRosa, C., Fenner-Crisp, P., Gray, L. E., Kaattari, S., ... & Miller, R. (1996). Research needs for the risk assessment of health and environmental effects of endocrine disruptors: a report of the US EPA sponsored workshop. *Environmental health perspectives*, *104*(suppl 4), 715-740.

Kazantzis, G. (1979). Renal tubular dysfunction and abnormalities of calcium metabolism in cadmium workers. *Environmental health perspectives*, *28*, 155-159.

Klocke, F. J., Baird, M. G., Lorell, B. H., Bateman, T. M., Messer, J. V., Berman, D. S., ... & Sutton, M. G. S. J. (2003). ACC/AHA/ASNC guidelines for the clinical use of cardiac radionuclide imaging—executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/ASNC Committee to Revise the 1995 Guidelines for the Clinical Use of Cardiac Radionuclide Imaging). *Journal of the American College of Cardiology*, *42*(7), 1318-1333.

Krabbenhoft, D.P. 1996. Summary Document for the USGS Workshop on Mercury Cycling in the Environment.

Kristen Grant, Fiona C Goldizen, Peter D Sly, Marie-Noel Brune, Maria Neira, Martin van den Berg, Rosana E Norman. (2013) Health consequences of exposure to e-waste: a systematic review

Kulkarn 2017, E- Waste Problem and its biological solution. International Journal of Innovative Research in Computer and Communication Engineering

Kumar P, Prasad Y, Patra AK and Swarup D (2007). Levels of Cadmium and Lead in Tissues of Freshwater Fish (Clarias batrachusL.) and Chicken in Western UP (India). Bull. Environ. Contamin. and Toxicol.79: 396-400

Kumar, P., & Singh, A. (2010). Cadmium toxicity in fish: An overview. *GERF Bulletin of Biosciences*, *1*(1), 41-47.

Lahermo, P., Väänänen, P., Tarvainen, T., & Salminen, R. (1996). Geochemical Atlas of Finland. Part 3, Environmental Geochemistry–Stream Waters and Sediments. Geological Survey of Finland, Espoo.

Landolph JR. Molecular and cellular mechanisms of transformation of C3H/10T1/2C18 and diploid human fibroblasts by unique carcinogenic, non- mutagenic metal compounds. A review. Biol Trace Elem Res. 1989;21:459– 467. [PubMed]

Lang, R. J. (1986). Anion effects in alkali-catalysed steam gasification. *Fuel*, *65*(10), 1324- 1329.

Leese ke et al, Assessment of blood-splash exposures of medical-waste treatment workers. enviro Health, January/February 1999, 8-11.

Leung, A. O., Duzgoren-Aydin, N. S., Cheung, K. C., & Wong, M. H. (2008). Heavy metals concentrations of surface dust from e-waste recycling and its human health implications in southeast China. Environmental science & technology, 42(7), 2674-2680. Ltd. London.magnitude, characteristics and mitigation," TriData Corporation, Arlington, Virginia, USFA Tech. Rep. FA-225,

Malm, S., Anum, P., Agyapong, I., Odai, E., and Taggi, E. (1994) Perceptions of ARI and Home Management practices and Self- medication in the Dangme West District. Dangme West Research Unit. Dodowa. Ghana.

Mavropoulos, (2010) "Wasted Health: The Tragic Case of Dumpsites"; ChathamStephens et al., "Burden of Disease from Toxic Waste Sites in India, Indonesia, and the Philippines in 2010."

McGoodwin (2018), Mitigating the Municipal Waste Management Crisis in Emerging Markets: A Cost-benefit Analysis of Enhancing Waste Management Intervention. Harvard Kenedy School.

Mehal JM, Esposito DH, Holman RC, Tate JE, Callinan LS, Parashar UD(2005 2007). *Risk factors for diarrhea-associated infant mortality in the United States*,. The Pediatric infectious disease journal. 2012;31(7):717–721. [PubMed]

Metzger, M. J., Bunce, R. G. H., Jongman, R. H., Mücher, C. A., & Watkins, J. W. (2005). A climatic stratification of the environment of Europe. *Global ecology and biogeography*, *14*(6), 549-563.

Minakova, I., Bukreeva, B. T., & Timofeeva, O. (2018). Improvement of solid waste management: Organizational and technological aspects. *Journal of Applied Engineering Science*, *16*(1), 99-103.

Mohapatra, M., Anand, S., Mishra, B. K., Giles, D. E., & Singh, P. (2009). Review of fluoride removal from drinking water. *Journal of environmental management*, *91*(1), 67-77.

Monto A. S., Ullman B. M. Acute Respiratory Illness in an American Community: The Tecumseh Study. Journal of the American Medical Association. 1974;227(2):164–69. [PubMed]

Morley, D. C., & MacWilliam, K. M. (1961). Measles in a Nigerian community. The West African medical journal, 10, 246-253.

Morley, D.C., and MacWilliam, K.M. (1961) Measles in a Nigerian Community. West African Medical Journal .Vol 16. Pp 246-253

Morrow, H. (2000). Cadmium and cadmium alloys. *Kirk‐Othmer Encyclopedia of Chemical Technology*, 1-36.

Mtango, F. D. E., & Neuvians, D. (1986). Acute respiratory infections in children under five years. Control project in Bagamoyo District, Tanzania. *Transactions of the royal society of tropical medicine and hygiene*, *80*(6), 851-858.

Muhe, L. (1996). Mothers' perceptions of signs and symptoms of acute respiratory infections in their children and their assessment of severity in an urban community of Ethiopia. *Annals of tropical paediatrics*, *16*(2), 129-135.

Mulholland E. K., Simoes E. A., Castales M. O., McGrath E. J., Manalac E. M., Gove S. Standardized Diagnosis of Pneumonia in Developing Countries. Pediatric Infectious Disease Journal. 1992;11:77–81. [PubMed] [Ref list]

Munoz-Rojas, M., Jordán, A., Zavala, L. M., Rosa, D. D. L., Abd-Elmabod, S. K., & Anaya- Romero, M. (2012). Organic carbon stocks in Mediterranean soil types under different land uses (Southern Spain). *Solid Earth*, *3*(2), 375-386.

Murri, M. B., Pariante, C., Mondelli, V., Masotti, M., Atti, A. R., Mellacqua, Z., ... & Innamorati, M. (2014). HPA axis and aging in depression: systematic review and meta- analysis. *Psychoneuroendocrinology*, *41*, 46-62.

Mutie, D. M., Metselaar, D, Hillman, E. S., and McDonald, K. (1976). Isolation of respiratory syncytial virus from patients with lower respiratory tract infections in a paediatric observation ward in Kenya. East African Medical Journal, Vol.53, No. 2, Pp 320-325.

Nammari, d.r., Hog¬land, W., marques, m., nimmermark, S. and moutavtchi, V. (2004) emissions from a Controlled Fire in municipal Solid Waste Bales. Waste Management, 24, 9-18

National Academy of Science (1977). Arsenic. Author, Washington, DC.

National Research Council. Arsenic in Drinking Water. 2001 Update. 2001 On line at: http://www.nap.edu/ books/0309076293/html/

Nicholas, S. A. A. (2003). Management of Childhood Acute Respiratory Infections Among the people of Larteh.

Nordberg, GF. KjelIstom, T., & Nordberg, M. (1985). Kinetics and Metabolism. In L. Friberg, T. Kjellstrom, CF. Elimder, & GF. Nordberg (Eds.), Cadmium and Health. A Toxicological and Epidemiological Appraisal (pp. 103-178). Boca Raton, Florida: CRC Press

Nriagu, J. O., Wong, H. K. T., & Coker, R. D. (1981). Particulate and dissolved trace metals in Lake Ontario. *Water Research*, *15*(1), 91-96.

Occupational Safety and Health Administration (OSHA), "Carbon monoxide poisoning," OSHA fact sheet, 2002.

Okada, I.A., A.M. Sakuma, F.D. Maio, S. Dovidemskas and O. Zenebon, (1997). Evaluation of lead and cadmium in milk due to environmental contamination in Paraiba Valley region of South Eastern Brazil., Revista- de-SaudePublication., 31: 140-143.

Olsson, P. E., Larsson, Å., & Haux, C. (1996). Influence of seasonal changes in water temperature on cadmium inducibility of hepatic and renal metallothionein in rainbow trout. *Marine Environmental Research*, *42*(1-4), 41-44.

Omer, Al Fadhil A., Abu El Gasim E.H., Sakhi, E.S. Bacteriology of sore throats in a

Omer, E. E., Forsey, T., Darougar, S., Ali, M. H., & El-Naeem, H. A. (1985). Seroepidemiological survey of chlamydial genital infections in Khartoum, Sudan. Sexually Transmitted Infections, 61(4), 261-263.

Omorodion, F. I. (1993) The socio-Cultural context of health behaviour among the Essan community. Edo State, Nigeria. Health Transition Review, Vol. 3 No.2, Pp 125-136

Omorodion, F. I. (1993). The socio-cultural context of health behaviour among Esan communities, Edo State, Nigeria.

Onibokun A.G. and Kumuyi A.J. Governance and Waste Management in Africa Document(s) 3 of 11

Oteng-Ababio, M. (2010). Private sector involvement in solid waste management in the Greater Accra Metropolitan Area in Ghana. *Waste Management & Research*, *28*(4), 322-329.

Oteng-Ababio, M., Arguello, J. E. M., & Gabbay, O. (2013). Solid waste management in African cities: Sorting the facts from the fads in Accra, Ghana. *Habitat International*, *39*, 96-104.

Pak, K. R., & Bartha, R. (1998). Mercury methylation and demethylation in anoxic lake sediments and by strictly anaerobic bacteria. *Appl. Environ. Microbiol.*, *64*(3), 1013-1017.

Parks, J. W. (1988). Selected ecosystem relationships in the mercury contaminated Wabigoon- English River system, Canada, and their underlying causes. *Water, Air, and Soil Pollution*, *42*(3-4), 267-279.

Passow, H.; Rothstein, A and Clarkson, T. W. (1961): The general pharmacology of heavy metals. Pharmacol Rev., 33: 185- 224.

Paul L. Younger, Steven A. Banwart and Robert S. Hedin, (2002). Mine Water Hydrology, Pollution, Remediation. Vol.5 in the Environmental Pollution Series by Kluwer Academic Publishers, 442 pp.

Paulsson, K. and K. Lundbergh. 1989. The selenium method for treatment of lakes for elevated levels of mercury in fish. Sci. Total Environ. 87/88: 495.

Pelletier, E. 1985. Mercury-selenium interactions in aquatic organisms: A review. Mar. Environ. Res. 18: 111.

Pelletier, J., & Sonenberg, N. (1985). Insertion mutagenesis to increase secondary structure within the 5′ noncoding region of a eukaryotic mRNA reduces translational efficiency. *Cell*, *40*(3), 515-526.

Pennefather, J. N., Lecci, A., Candenas, M. L., Patak, E., Pinto, F. M., & Maggi, C. A. (2004). Tachykinins and tachykinin receptors: a growing family. *Life sciences*, *74*(12), 1445-1463.

Peralta-Videa, J. R., Lopez, M. L., Narayan, M., Saupe, G., & Gardea-Torresdey, J. (2009). The biochemistry of environmental heavy metal uptake by plants: implications for the food chain. *The international journal of biochemistry & cell biology*, *41*(8-9), 1665-1677.

Peralta-Videa, J. R., Lopez, M. L., Narayan, M., Saupe, G., & Gardea-Torresdey, J. (2009). The biochemistry of environmental heavy metal uptake by plants: implications for the food chain. The international journal of biochemistry & cell biology, 41(8-9), 1665-1677.

Petrick, J. S., Ayala-Fierro, F., Cullen, W. R., Carter, D. E., & Aposhian, H. V. (2000). Monomethylarsonous acid (MMAIII) is more toxic than arsenite in Chang human hepatocytes. *Toxicology and applied pharmacology*, *163*(2), 203-207.

Pinto, E., Sigaud-kutner, T. C., Leitao, M. A., Okamoto, O. K., Morse, D., & Colepicolo, P. (2003). Heavy metal–induced oxidative stress in algae 1. Journal of phycology, 39(6), 1008-1018.

Pinto, E., Sigaud-kutner, T. C., Leitao, M. A., Okamoto, O. K., Morse, D., & Colepicolo, P. (2003). Heavy metal–induced oxidative stress in algae 1. *Journal of phycology*, *39*(6), 1008-1018.

PnAS, "Highway Proximity and black Carbon from Cookstoves as a risk Factor for Higher blood Pressure in rural China," 2014, available at http://www.pnas.org/content/111/36/13229

Pongratz, R. (1998). Arsenic speciation in environmental samples of contaminated soil. Science of the Total Environment, 224(1-3), 133-141.

Pruss A, Giroult E, Rushbrook P (eds). Safe management of wastes from health-care activities.

Rajaganapathy, V., Xavier, F., Sreekumar, D., & Mandal, P. K. (2011). Heavy metal contamination in soil, water and fodder and their presence in livestock and products: a review. *Journal of Environmental Science and Technology*, *4*(3), 234-249.

Ramachandra T.V. and Saira V. K. (2004). Environmentally Sound Options for Ewastes Management. Envis Journal of Human Settlements, pp. 1-11 *Regional* Analytical Report. Accra: GSS.

Reimers, R.S., P.A. Krenkel and A.J. Englade, Jr. 1974. Transport and distribution of mercury in sediments. In: Proc. Internat. Conf. Transport of Persistent Chemicals in Aquatic Ecosystems, National Research Council of Canada, Ottawa, Ontario. pp. II-79-II-92.

Ringden, O., Ruutu, T., Remberger, M., Nikoskelainen, J., Volin, L., Vindelov, L., ... & Ljungman, P. (1994). A randomized trial comparing busulfan with total body irradiation as conditioning in allogeneic marrow transplant recipients with leukemia: a report from the Nordic Bone Marrow Transplantation Group. *Blood*, *83*(9), 2723-2730.

Robinson BH. E-waste: an assessment of global production and environmental impacts. Sci Total Environ 2009; 408: 183–91.

Rudd, J.W.M., M.A. Turner, A. Furitani, A.L. Swick and B.E. Townsend. 1983. The English- Wabigoon river system: I. Synthesis of recent research with a view towards mercury amelioration. Can. J. Fish. Aquat. Sci. 40: 2206.

Rudd, J.W.M., M.A. Turner, B.E. Townsend, A. Swick and A. Furitani. 1980. Dynamics of selenium in mercury-contaminated experimental ecosystems. Can. J. Fish. Aquat. Sci. 37: 848.

Rummer, B., Prestemon, J., May, D., Miles, P., Vissage, J., McRoberts, R., ... & Miller, S. (2005). A strategic assessment of forest biomass and fuel reduction treatments in western states. *Gen. Tech. Rep. RMRS-GTR-149. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 17 p., 149*.

Russell, D. A., & Paesler, M. A. (2003). Environments of mid-Cretaceous Saharan dinosaurs. *Cretaceous Research*, *24*(5), 569-588.

Ruutu, P. and Marilla, G.(1994) Health and diseases in developing countries. Macmillan Press Ltd. London.

S.S. White and L.S. Birnbaum, (2009) *An Overview of the Effects of Dioxins and Dioxin- Like Compounds on Vertebrates, as Documented in Human and Ecological Epidemiology, Journal of Environmental Science and Health*, Part C., 27(4), 197-211p

Saleha Banu B, Danadevi K, Kaiser Jamil, Ahuja YR, Visweswara Rao K, Ishap M. In vivo genotoxic effect of arsenic trioxide in mice using comet assay. Toxicol. 2001;162:171–177. [PubMed]

Salkin, I. F., & Kennedy, M. E. (2004). Review of health impacts from microbiological hazards in health-care wastes. Genebra: World Health Organization.

Sastry, K. V., & Gupta, P. K. (1979). Thein vivo effect of mercuric chloride on some digestive enzymes of a fresh water teleost fish, Channa punctatus. *Bulletin of environmental contamination and toxicology*, *22*(1), 9-16.

Satyakala, G., & Jamil, K. (1992). Chromium-induced biochemical changes in Eichhornia crassipes (Mart) solms and Pistia stratiotes L. *Bulletin of environmental contamination and toxicology*, *48*(6), 921-928.

Schübeler, P., Christen, J., & Wehrle, K. (1996). Conceptual framework for municipal solid waste management in low-income countries (Vol. 9). St. Gallen: SKAT (Swiss Center for Development Cooperation).

Schuchat Aa JP. [accessed 7-10-2012 2012];*Child Health: Bacterial and other infectious diseases*.2012 Available: http://www.cdc.gov/reproductivehealth/ProductsPubs/DatatoAction/pdf/Chltl.pdf.

Schutler, K. 1997. Sorption of inorganic mercury and monomethyl mercury in an iron-humus podzol soil of southern Norway studied by batch experiments. Environmental Geology. Vol. 30: 266-279

Selby, H. (2010). Waste Generation: A Dilemma for the Economy and Health of Ghana. Modern Ghana News. Retrieved from http://www.modernghana.com/news/296201/1/waste-a-dilemma-for-theeconomy- and-healt.html. Accessed on December 15, 2014.

Senah, K. A., Adongo, P. B., Bawa, A. A., Gyapong, M., Binka F. (1994) The sociocultural context of infant and child morbidity in Kassena-Nankan District. Department of Sociology, University of Ghana- Legon.

Shafi, K. V., Gedanken, A., Prozorov, R., & Balogh, J. (1998). Sonochemical preparation and size-dependent properties of nanostructured $CoFe_2O_4$ particles. *Chemistry of Materials*, *10*(11), 3445-3450.

Shann F., Gratten M., Germer S., Linnemann V., Hazlett D., Payne R. Aetiology of Pneumonia in Children in Goroka Hospital, Papua New Guinea. Lancet. 1984;2(8402):537–41. [PubMed

Shann F., Gratten M., Germer S., Linnemann V., Hazlett D., Payne R. Aetiology of Pneumonia in Children in Goroka Hospital, Papua New Guinea. Lancet. 1984;2(8402):537–41. [PubMed]

Shann F., Gratten M., Germer S., Linnemann V., Hazlett D., Payne R. Aetiology of Pneumonia in Children in Goroka Hospital, Papua New Guinea. Lancet. 1984;2(8402):537–41. [PubMed]

Shayley H., McBride M, and Harrison E. (2009). Sources and Impacts of Contaminants in Soils. Cornell Waste Management Institute.pp.1-6.

Shimamura, M., Yasue, H., Ohshima, K., Abe, H., Kato, H., Kishiro, T., ... & Okada, N. (1997). Molecular evidence from retroposons that whales form a clade within even-toed ungulates. *Nature*, *388*(6643), 666.

Simoes, E. A., Cherian, T., Chow, J., Shahid-Salles, S. A., Laxminarayan, R., & John, T. J. (2006). Acute respiratory infections in children.

Simoes, E. A., Cherian, T., Chow, J., Shahid-Salles, S. A., Laxminarayan, R., & John, T. J. (2006). Acute respiratory infections in children.

Sindayigaya, E., R.V. Canwnbergh, H. Robberecht and H.Deelstra, (1994). Copper, zinc, manganese, iron, lead,cadmium, mercury and arsenic in fish from lake Tanganyika, Burundi. Sci. Total Environ. 144: 103-115.

Smedley, P. L., & Kinniburgh, D. G. (2002). A review of the source, behaviour and distribution of arsenic in natural waters. *Applied geochemistry*, *17*(5), 517-568.

Steinheider B (1999), *Environmental odours and somatic complaints. Zentralblatt für Hygiene und Umweltmedizin [International Journal of Hygiene and Environmental Medicine],* 202, 101–19,

Su, G. S. (2005). Water-borne illness from contaminated drinking water sources in close proximity to a dumpsite in Payatas, the Philippines. JRTPH, 4, 43-48.

Sudanese population. J.Trop. Med. Hyg. , 1985, 88: 337-341.

Takahashi M, Barrett JC, Tsutsui T. Transformation by inorganic arsenic compounds of normal Syrian hamster embryo cells into a neoplastic state in which they become anchorage-independent and cause tumors in newborn hamsters. Int J Cancer. 2002;99:629–634. [PubMed]

Tchounwou et al. Author manuscript; available in PMC 2014 August 26th) The Biogeochemistry of Mercury in the Environment. Elsevier/North-Holland Biomedical Press, New York, U.S.A., pp. 655-670.

Tchounwou PB, Patlolla AK, Centeno JA. Carcinogenic and systemic health effects associated with arsenic exposure-a critical review. Toxicol Pathol. 2003;31(6):575–588. [PubMed]

Tchounwou, P. (1999). Development of Public Health Advisories for Arsenic in Drinking Water. Reviews on environmental health, 14(4), 211-230.

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy metal toxicity and the environment. In *Molecular, clinical and environmental toxicology* (pp. 133-164). Springer, Basel.

Thornton, G. C., & Rupp, D. E. (1992). *Assessment centers in human resource management*. Reading, MA: Addison-Wesley.

Tregoning, J. S., & Schwarze, J. (2010). Respiratory viral infections in infants: causes, clinical symptoms, virology, and immunology. Clinical microbiology reviews, 23(1), 74-98.

Tseng lH, li mH, Tsai SS, lee CW, Pan mH, yao WJ, et al. developmental exposure to decabromodiphenyl ether (Pbde 209): effects on thyroid hormone and hepatic enzyme activity in male mouse offspring. Chemosphere 2008;70:640–

Tupasi, T.E., Velmonte, A. and Sanvictores, M. (1990) Malnutrition and acute respiratory tract infections in children. Review Infectious Disease, Vol.l2, Pp 1047-1054.

Turpeinen, R., Pantsar-Kallio, M., Häggblom, M., & Kairesalo, T. (1999). Influence of microbes on the mobilization, toxicity and biomethylation of arsenic in soil. *Science of the Total Environment*, *236*(1-3), 173-180.

Turpeinen, R., Pantsar-Kallio, M., Häggblom, M., & Kairesalo, T. (1999). Influence of microbes on the mobilization, toxicity and biomethylation of arsenic in soil. Science of the Total Environment, 236(1-3), 173-180.

Twumasi P. A. (1975) Medical Systems in Ghana. Ghana publishing Corporation.

Ghana.

Umair, S., Björklund, A., & Petersen, E. E. (2015). Social impact assessment of informal recycling of electronic ICT waste in Pakistan using UNEP SETAC guidelines. *Resources, Conservation and Recycling*, *95*, 46-57.

UNEP. (2010*). Global Mercury Assessment Report*, 1-258.

United Nations Environment Programme (UNEP). Environmental Pollution and Impacts on Public Health: Implications of the Dandora Municipal Dumping Site in Nairobi, Kenya Based on a study by Njoroge G. Kimani in cooperation with United Nations Environment Programme and the St. John Catholic Church, Korogocho E

United Nations Environment Programme (UNEP). Basel convention on the control of transboundary movements of hazardous waste and their disposal. 1989. http://www.basel.int/ Portals/4/Basel%20Convention/docs/text/BaselConventionText-e. pdf (accessed Oct 17, 2018).

United Nations Environment Programme, Environmental Pollution and Impacts on Public Health: Implications of the Dandora Municipal Dumping Site in

Nairobi, Kenya, 2007

United States Fire Administration (uSFA), *"landfill fires, their magnitude, characteristics and mitigation," Tridata Corporation, Arlington, Virginia, USFA Tech. Rep. FA-225, 2002.*

United States Fire Administration (USFA), "Landfill fires, their Urban Environment Unit

US Geological Survey, Water Resources Division. http://wwwrvares.er.usgs.gov/toxics/pubs/hg/summary.shtml.

USDA and NRSC (2000). Heavy Metal Soil Contamination. Soil Quality-Urban Technical Note.No.3. pp.1-7

Vahter, M., Friberg, L., Rahnster, B., Nygren, Å., & Nolinder, P. (1986). Airborne arsenic and urinary excretion of metabolites of inorganic arsenic among smelter workers. *International archives of occupational and environmental health*, *57*(2), 79-91.

Vineis, P. and W. xun. "The emerging epidemic of environmental cancers in developing countries." Annals of oncology 20: 205–212, 2009.

Violante, A., Cozzolino, V., Perelomov, L., Caporale, A. G., & Pigna, M. (2010). Mobility and bioavailability of heavy metals and metalloids in soil environments. *Journal of soil science and plant nutrition*, *10*(3), 268-292.

Wall, R. A., Corrah, P. T., Mabey, D. C. W., and Greenwood, B ,M. (1986). The etiology of lobar pneumonia in Gambia. Bulletin of the World Health Organization, Vol,64.Pp 553-558.

Wang, W. and C.T. Driscoll. 1995. Patterns of total mercury concentrations in Onondaga Lake, New York. Environmental Science and Technology, Vol. 29: 2261-2266.

Wang, Y. J., Wang, J., Zhang, H. Y., He, H. B., & Tang, X. (2007). Formulation, preparation and evaluation of flunarizine‐loaded lipid microspheres. *Journal of pharmacy and pharmacology*, *59*(3), 351-357.

Ware, C. B., Horowitz, M. C., Renshaw, B. R., Hunt, J. S., Liggitt, D., Koblar, S. A., . & Thoma, B. (1995). Targeted disruption of the low-affinity leukemia inhibitory factor receptor gene causes placental, skeletal, neural and metabolic defects and results in perinatal death. *Development*, *121*(5), 1283-1299.

Weber, Am, boudereau, y, mortimer Vd. Health hazard evaluation report 98-00272709, Stericycle, Inc, morton, Washington. Cincinnati, national Institute for occupational Safety and Health, 1999.

Wei B. and Yang L. (2010). A review of Heavy Metal Contamination in Urban Soils, Urban Road Dust and Agricultural Soils from China. Microchemical Journal, 94, pp.99-107.

White, S. S., & Birnbaum, L. S. (2009). An overview of the effects of dioxins and dioxin- like compounds on vertebrates, as documented in human and ecological epidemiology. *Journal of Environmental Science and Health, Part C*, *27*(4), 197-211.

WHO *Europe, Health effects by Black carbon, 2012, available at http://www.euro.who.int/__data/assets/pdf_file/0004/162535/e96541.pdf*

WHO WHO. [accessed Nov 1 2018] ; *Global Health Observatory, causes of child mortality*. 2010 Available: http://www.who.int/gho/child_health/mortality/causes/en/

WHO, (2004) Review of Health Impacts from Microbiological Hazards in Health-Care Wastes. Department of Blood Safety and Clinical Technology and Department of Protection of the Human Environment World Health Organization Geneva 2004

WHO, *Global health risks: mortality and burden of disease attributable to selected major risks.", 2009.*

WHO, *review of Health Impacts from microbiological Hazards in Health-Care Wastes, 2004*

WHO, *Safe management of wastes from health-care activities, Chapter 3 - Health impacts of health-care waste, 1999.*

Williams B. G., Gouws E., Boschi-Pinto C., Bryce J., Dye C. Estimates of Worldwide Distribution of Child Deaths from Acute Respiratory Infections. Lancet Infectious Diseases. 2002;2:25–32. [PubMed]

Williams, S. E., Bolitho, E. E., & Fox, S. (2003). Climate change in Australian tropical rainforests: an impending environmental catastrophe. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *270*(1527), 1887-1892.

Wong CS, Duzgoren-Aydin NS, Aydin A, Wong MH. Evidence of excessive releases of metals from primitive e-waste processing in Guiyu, China. Environ Pollut 2007; 148: 62–72.

Worksafe V. (2005). Industry Standard Contaminated Construction Sites. EPA Victoria, www.worksafe.vic.gov.au, First Edition. pp. 1-28.

World Health Organisation. (1984). Summary of the ad hoc survey on infant and early childhood mortality in Sierra Leone. WHO Statistical Quarterly, Vol 34, Pp 220- 238

World Health Organization. (1979) Maternal and Child Health: Report presented at 32nd World Health Assembly. Geneva

Xia, Y., Sheffield, J., Ek, M. B., Dong, J., Chaney, N., Wei, H., ... & Wood, E. F. (2014). Evaluation of multi-model simulated soil moisture in NLDAS 2. *Journal of hydrology*, *512*, 107-125.

Y.-C. Jang, "Waste electrical and electronic equipment (WEEE) management in Korea: generation, collection, and recycling systems," Journal of Material Cycles and Waste Management, vol. 12, no. 4, pp. 283–294, 2010.

Yankson, P. W. K., & Gough, K. V. (1999). The environmental impact of rapid urbanization in the peri-urban area of Accra, Ghana. *Geografisk Tidsskrift Danish Journal of Geography*, *99*(1), 89-100.

Yildiz D., Kula I., AY G., Baslar S. and Dogan Y. (2010). Determination of Trace Elements in the Plants of Mt.Bozdag, Izmir,Turkey. DOI:10.2298/ABS100 3731Y.Arch.Biol.Sci., 62(3), 731-738.

Yoada, R. M., Chirawurah, D., & Adongo, P. B. (2014). Domestic waste disposal practice and perceptions of private sector waste management in urban Accra. *BMC public health*, *14*(1), 697.

Zavala, Y. J., & Duxbury, J. M. (2008). Arsenic in rice: I. Estimating normal levels of total arsenic in rice grain. Environmental Science & Technology, 42(10), 3856-3860.

Zhao, D., Huang, Z., Umino, N., Hasegawa, A., & Kanamori, H. (2011). Structural heterogeneity in the megathrust zone and mechanism of the 2011 Tohoku‐oki earthquake (Mw 9.0). *Geophysical Research Letters*, *38*(17).

APPENDIX

APPENDIX A: PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

Title of Research:

Toxic metal exposure and symptoms of respiratory infection among children (underfive) residing near open dumpsite: a cross-sectional study at Abokobi

Name(s) and affiliation(s) of researcher(s):

This study is being conducted by Mr Michael Affordofe of the KNUST African Institute of Sanitation and Waste Management (K-AISWAM), Accra.

Background (Please explain simply and briefly what the study is about):

Globally, open dumpsite approach also referred to as crude dumping of solid waste is seen as a primitive stage of solid waste management. Open dumpsite method is one of the most poorly rendered services by municipal authorities in Africa and parts of Asia as the systems applied are unscientific, outdated and in- efficient. Solid waste disposal sites are found both within and on the outskirts of developing urban cities. Increase in the global population, rising demand for food and other essentials led to the increase in the amount of waste being generated. This waste is ultimately thrown into municipal disposal sites and due to poor and ineffective management, the dumpsites turn to sources of environmental and health hazards to people living in the vicinity of such dumps. One of the main aspects of concern is the pollution caused to the earth-be it land, air and water (Sankoh et al, 2013).

Over the last three decades there has been increasing global concern over public health impacts attributed to environmental pollution, in particular, the global burden of disease. The World Health Organization estimates that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (UNEP, 2015).Most of these environment-related diseases are however not easily detected and may be acquired during childhood and manifested later in adulthood (UNEP, 2015).

Dumpsites across the globe receive roughly 40% of the world's waste and they serve about 3.5-4 billion people (ISWA, 2015). The 50 biggest dumpsites affect the daily lives of 64 million people, a population the size of France (ISWA, 2015). As urbanization and population growth will continue, it is expected that at least several hundreds of millions more people will be served by dumpsites, mainly in the developing world (International solid waste association report, 2014).

However, heavy metals maybe released into the environment from metal smelting and refining industries, scrap metal, plastic and rubber industries, and various consumer products and from burning of waste containing these elements. The elements that are of concern include lead, mercury, cadmium, arsenic, chromium, zinc, nickel and copper. On release into the atmosphere, they travel for large distances and are deposited onto the soil, vegetation and water depending on their density. Once deposited, these metals are not degraded and persist in the environment for many years poisoning humans through inhalation, ingestion and skin absorption. Acute exposure leads to nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis (UNEP, 2015)

In Ghana, management of waste is a very big challenge to most Metropolitan, Municipal and District Assemblies (MMDA'S) especially how to effectively dispose it. Abokobi is in no exception.

The populace of Ledzokuku-krowor, Madina-Nkwantanang, Ga-East and West and Adenta Municipalities all use Abokobi dump site of about 8,150.47 tons per month (Ga-East Municipal Assembly, 2014). Waste pickers sift through the waste to retrieve materials considered to be of value economically. They therefore set a portion of the dump site on fire enabling them to easily obtain some materials like copper and other metallic materials

Purpose(s) of research:

The general purpose of this study is to assess the prevalence of symptoms of acute respiratory infection defined as Acute Lower Respiratory Infection (ALRI) and Upper Respiratory Infection (URI), the levels of toxic metals in environmental (soil, water, dust and leachate) and biological (urine, blood) media, and the association between toxic metals and symptoms of respiratory infection among under five children residing around Abokobi Dump site in the Ga East Municipality.

Procedure of the research, what shall be required of each participant and approximate total number of participants that would be involved in the research: The source population for the study will include all children below the age of 5 residing in households within >1 to 4km of the Abokobi open dumpsite. From this population 300 parents of the children in these households will be interviewed. One child per a household will be selected into this study. A sample of 300 children will be randomly selected to provide urine and blood samples. Any child who will be included in the study should come from a household who meets the eligibility criteria of the main study. In the main study a household will be defined as home that has a man and/or a woman who are the biological parents of a child under five.

Urine Sample collection

Parents of the children under five (5) will be provided with clean water and soap for hand washing before handing out to them sterile meta-free plastic urine containers for urine collection. They will be cautioned to void out the first portion of the urine stream before collecting 75 mls midstream urine into the plastic urine container. 10mls of the urine will be drawn into four sterile sample tubes (Sarstedt, Smonovette, Germany).

Blood Sample Collection

Following explanation of the test procedure, 7.5ml of whole blood will be collected from the median cubital and cephalic veins into three separate haematology tubes

(Sarstedt, S-monovette, Germany), two free and one containing Z-gel, an additive carrier and a clot activator (for serum separation) using a butterfly needle and a tourniquet

Risk(s):

There is not much risk in using urine samples for analysis of heavy metals. However, 7.5mls of blood samples from under 5 children may cause weakness. It is therefore advisable for parents to properly feed children involve in the study before samples are taken. Children with severe illnesses example typhoid and dysentery will be withdrawn from the study.

Benefit(s):

The study will serve as a guide to help in various remediation activities and also to create awareness concerning exposure of heavy metals to humans.

The outcome of this research would provide an overview of the crucial state of children living around dumpsites so stakeholders like Ministry of Health and Ministry of Environment would be properly motivated to act in the mitigation of these extensive exposures to heavy metals.

Confidentiality:

I would like to assure you that whatever information provided will be handled with strict confidentiality and will be used purely for the research purposes. Your responses will not be shared with anybody who is not part of the research team. Data analysis will be done at the aggregate level to ensure anonymity. No name will be recorded. Data collected cannot be linked to you in anyway. No name or identifier will be used in any publication or reports from this study. However, as part of our responsibility to conduct this research properly, we may allow officials from the

Ecolab University of Ghana, Noguchi Memorial Institute for Medical Research (NMIMR) University of Ghana, Central Lab of Korle-Bu Teaching Hospital, Supervisors, and Committee on Human Research Publication and Ethics (CHPRE) of KNUST to have access to your records.

Voluntariness:

Participation in this study is voluntary and one can choose not to answer any particular question or all questions. You are at liberty to withdraw from the study at any time. However, it is encouraged that you to participate since your opinion is important in determining the outcome of the study.

Alternatives to participation:

If you choose not to participate, this will not affect you in any way.

Withdrawal from the research:

Parents of children do not have to answer any survey questions that they feel are an invasion of their privacy. Also, participants do not have to participate in any particular aspects of the study that they find invasive.

Consequence of Withdrawal:

There will be no consequence or loss of benefit to you if you choose to withdraw from the study. Please note however, that some of the information that may have been obtained from you without identifiers like name, before you chose to withdraw, may have been modified or used in analysis reports and publications. These cannot be removed anymore. We do promise to make good faith effort to comply with your wishes as much as practicable.

Costs/Compensation:

Subjects will receive Cash and token gift for their participation in this study. A payment of 10 Ghana new cedis (approximately US$5) will be given to study participants who complete all proposed data collection elements. Compensation will be given at the time of data/specimen collection.

Contacts:

If you have any question concerning this study, please do not hesitate to contact Mr Michael Affordofe (Principal Investigator) on 0245406516/0206060495.

Further, if you have any concern about the conduct of this study, your welfare or your rights as a research participant, you may contact:

The Office of the Chairman

Committee on Human Research and Publication Ethics

Kumasi

Tel: 03220 63248 or 020 5453785

CONSENT FORM

Statement of person obtaining informed consent:

I have fully explained this research to ____ and have given sufficient information about the study, including that on procedures, risks and benefits, to enable the prospective participant make an informed decision to or not to participate.

DATE: _______________________

NAME: _____________________________________

Statement of person giving consent:

I have read the information on this study/research or have had it translated into a language I understand. I have also talked it over with the interviewer to my satisfaction.

I understand that my participation is voluntary (not compulsory).

I know enough about the purpose, methods, risks and benefits of the research study to decide that I want to take part in it.

I understand that I may freely stop being part of this study at any time without having to explain myself.

I have received a copy of this information leaflet and consent form to keep for myself.

NAME:____

DATE: _____________

SIGNATURE/THUMB PRINT: ____________________

Statement of person witnessing consent (Process for Non-Literate Participants):

I ________________________________ (Name of Witness) certify that information given to

_________________________________ (Name of Participant), in the local language, is a true reflection of what l have read from the study Participant Information Leaflet, attached.

WITNESS' SIGNATURE (maintain if participant is non-literate): ______________________

MOTHER'S SIGNATURE (maintain if participant is under 18 years):

____

MOTHER'S NAME:

____

FATHER'S SIGNATURE (maintain if participant is under 18 years):

____

FATHER'S NAME:

____

APPENDIX B: QUESTIONNAIRE

ID: AB/………./……..…

A. GENERAL INFORMATION

1. Date………………………….. Name:

,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,………………………

2a. Age: ……………………….. 2b. Age of child:……………………………......

3a. What is your gender? □ Male □Female 3b. Gender of child? □ Male □Female

4. What is your highest level of education? □ No formal education □ Primary □ secondary □ Tertiary □ Trade/technical/vocational training 4b. Is your child at School □ Yes □ No 4c. If yes which class? ....

4c. Is your child breastfeeding? □ Yes □ No

5. Occupation? □Employed □Unemployed □Scavenger □Dumpsite worker

6. Type of Housing? □ Brick House □ Wooden structure or Shed □ Squatter

7. Number of people in a household? 1 2 3 4 5 6

8. Proximity to Dumpsite (in kilometers)? Under 1 1 – 2 2 – 3 3 – 4 4 - 5

9. Number of years at current residence? < 1year 1-2 2-3 3-4 4-5 >5

10. Source of Water? □Borehole □Well □ Stream □Tap-water

11. Toilet Facilities? □VIP □WC □ Pour flush □Pit latrine □ Public toilet [□ KVIP,

□ WC □Pit latrine] □ Open defecation

B. THE NEXT SET OF QUESTIONS IS ABOUT RESPITATORY HEALTH INFORMATIONS

Children

12a. Has your child been ill with cough in the last 12 months? a. Yes b. No

12b. If yes, is the child's cough accompanied by fast breathing than usual with short and/or rapid breathing? a. Yes b. No

13a. Did the child have any wheezing during the last 12 months? (Wheezing refers to wheezing caused by bronchi, not by nose) a. Yes b. No

13b. Two (2) weeks before this survey did the child experienced any wheezing? a. Yes b. No

14. Did the child have any cold with or without flu during the last 12 months? a. Yes b. No

15. Two (2) weeks before this survey did the child experienced cold? a. Yes b. No

16. Did the child have any difficulty in breathing or chest tightness during the last 12 months? a. Yes b. No

17.Two (2) weeks before this survey was the child having difficulty in breathing or chest tightness?
a. Yes b. No

18. Did the child have any ache in the ear during the last 12 months? a. Yes b. No

19. Two (2) weeks before this survey was the child having any arch in the ear?
a. Yes b. No

20. Did the child have any eye problems during the last 12 months? a. Yes b. No

21. Two (2) weeks before this survey did the child experienced this eye problem?
a. Yes b. No

22. Did the child have any skin problems during the last 12 months? a. Yes b. No

23. Two (2) weeks before this survey did the child experienced this skin problem?
a. Yes b. No

24a. When the child is allowed to play outside the home, how often does your child eat food dropped on the floor?

a. Never b. Rarely c. Sometimes d. Most of the time e. Always

24b. When the child is allowed to play outside the home, how often does the child eat food with fingers?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

25. When the child is allowed to play with friends, how often does the child wash hands before eating?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

26. When the child is allowed to play with friends, how often does the child come into contact with the contaminated soil(Examples-modify it)?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

27. When the child returns from the playground, how often does the parent hold or carry the baby when he has not changed into clean clothes?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

28. When the child is at home, how often does the child eats pick soil on the floor at home?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

29. When the child is at home, how often does the child crawls on the floor?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

30. When the child is at home, how often does the child places thumb/fingers in the mouth?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

31. When the child is at home, how often does the child pick nonfood items from the floor into the mouth?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

32. When the child is at home, how often does the child eat food dropped on floor?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

33. When the child is at home, how often does the child eat food with fingers?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

34 When the child is at home, how often does the child eat on the floor while sitting or lying on the floor?

a. Never b. Rarely c. Sometimes d. Most of the time e. Always

35. When the child is at home, how often does the child wash hands before eating?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

36. When the child is at home, how does the father hold or carry the baby when he has not changed into clean clothes?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

37. When the child is at home, how does the mother hold or carry the baby when she has not changed into clean clothes?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

Past illnesses - Children

38a. Did your child experience any other health problem before the current age? a. Yes b. No

38b. If you answered yes to question 71b, did a doctor diagnose it? a. Yes b. No

39 Did your child ever had any attacks with asthma? a. Yes b. No

40. Do your child experience any other chest illness?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

C: THE NEXT SET OF QUESTIONS IS ON ANTHROPOMETRIC MEASUREMENTS

41. Weight__________ Kg

42. Height___________ meters

43. BMI_______________ Kg/m2

D: THE NEXT SET OF QUESTIONS IS ON ANTHROPOMETRIC MEASUREMENTS

44	BP	1st reading	2nd reading	3rd reading	Mean
Systolic (mmHg)		………….	…………..	………….	…………….
Diastolic (mmHg)		…………	…………..	………….	……………..

Thank you very much. We really appreciate your participation in this study