UNIVERSITY OF GHANA

COLLEGE OF BASIC AND APPLIED SCIENCES

ENVIRONMENTAL IMPACT OF THE MOBILE TELECOMMUNICATION TECHNOLOGY IN ACCRA, GHANA.

BY

WORLANYO KWABENA AGBOSU

(ID. NO. 10358709)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF PhD ENVIRONMENTAL SCIENCE DEGREE.

INSTITUTE FOR ENVIRONMENT AND SANITATION STUDIES

DECEMBER, 2015

DECLARATION

I hereby declare that except for references which have been cited, this work is the result of my own research and that it has not been presented in part or whole for any other degree in the University of Ghana or elsewhere.

……………………………………………..   ..……………………………………

(WORLANYO KWABENA AGBOSU)   **(PROF. DICKSON ADOMAKO)**

PRINCIPAL SUPERVISOR

……………………………………..

(DR. JOSEPH K. AMOAKO)

SUPERVISOR

……………………………………..

(DR. EMMANUEL M. ATTUA)

SUPERVISOR

ABSTRACT

Currently, there are over 10,000 telecommunication base stations (BSs) in Ghana. Experts insist the number of BSs is practically inadequate to ensure quality service nationwide. However, in Accra and other urban centers the installation of BSs to expand coverage has met opposition from the public. Accra has a population density of over 15,000 persons per km^2 with an annual growth rate of 4.4%; hence, the number of people estimated to live closer to BSs is higher in Accra than in any other city in Ghana. This study was carried out to assess the environmental impact (EI) of the devices of the mobile telecommunication technology (MTT) that depends on the frequencies 900MHz and 1800MHz. The study focused on critical perspectives of exposure to radiofrequencies, risk assessment, perception and communication as well as waste and noise pollution. Individual Based Models (IBMs) are therefore deemed appropriate for predicting the level of environmental impact as evaluated at the local level by a well-informed individual. The methodology for data collection involved both the quantitative and qualitative approaches. The significant activities performed included measurements of some physical and chemical environmental pollutants (quantities) and the administration of questionnaire to help understand the influence of human behaviour on the MTT. A statistical package (SPSS) was used in the data analysis, which included; Analysis of Variance (ANOVA), Pearson correlation analysis, Principal component analysis (PCA), Hierarchical cluster analysis (HCA) and Cluster analysis (CA), or otherwise combining both quantitative and qualitative evidence. Both descriptive and inferential statistical techniques (Chi-square) were used to analyze the data for comparison between groups at 0.05 (95%) level of significance. The results of this study indicated reality and perception or a combination of both depending critically on the source of information to the public.

Radiation levels (electric field values) at the vicinity of BSs were below the ICNIRP threshold of 41.25V/m (SAR of $4.5W/m^2$) and 58.3V/m (SAR of $9W/m^2$) for frequencies of 900MHz and 1800MHz respectively. Noise levels from generator sets at BSs in residential areas were not always below the EPA threshold of 48dB within the hours of 22:00pm to 06:00am at a distance of 50m from BSs. Heavy metals at specific levels in mg/kg at dumpsites indicated that, Hg and Cd levels were not below the US EPA (2011) threshold of 0.2mg/kg and 1.2mg/kg respectively. Questionnaire survey was necessary to provide information on what the public considered risky but has been proven otherwise scientifically. Information gathered revealed that, what is lacking is an effective strategic environmental communication which ought to be supervised by the MMDA to eliminate some of the variables that increase the RVI. At the end of the study, it was concluded that, Hg and Cd may pose potential health risk to the public whilst noise may equally pose potential health risk to inhabitants living nearby BSs. Considering the routes of contact of heavy metals to individuals, the recovery and recycling of all WEEE must be encouraged to reduce its adverse effect in the future. Again, minimum setback distances must be strictly enforced using passive barriers, though the use of active barriers is equally important. Indeed, there should therefore be a careful examination of all uncertainties and the transparency of assumptions and limitations at this early stage.

DEDICATION

This work is dedicated to; *my children*

ACKNOWLEDGEMENT

Glory be to my Creator for guiding me through this challenging research successfully. Again, I am grateful for his blessings throughout even the difficult periods in my life. Indeed, His mercies endure forever.

My sincerest thanks and appreciation go to all my supervisors namely; Prof. Dickson Adomako, Dr. Joseph K. Amoako and Dr. Emmanuel M. Attua for always being encouraging, patience and supportive in diverse ways up to the end of this study. I am also grateful to Dr. Selasie Adanu and his team at CERSGIS Legon for the wonderful assistance they provided during the period. I also recognize and thank Samuel Osei and Emmanuel Adofo at GAEC and Kobina Annobil Forson for their support and open discussions concerning this research.

I deeply thank my mother, Margaret Forson and madam Mavis Abena Agyeiwaah for their financial assistance during my period of study.

Finally, I honestly acknowledge the generosity of my brother, Akpenyo Kwao Agbosu, my sisters, my parents, my entire family, Solomon Odei-Appiah and the numerous individuals who assisted in various ways to bring this research to a successful end. Thanks a lot.

TABLE OF CONTENTS

CONTENT **PAGE**

CONTENT **PAGE**

CONTENT PAGE

CONTENT PAGE

CONTENT PAGE

LIST OF FIGURES

LIST OF TABLES

CONTENT PAGE

LIST OF ABBREVIATIONS

MTT	Mobile telecommunication technology
BS	Base station
RF	Radiofrequency
FCC	Federal Communications Commission
GSS	Ghana statistical service
PHS	Population and housing unit
EPA	Environmental Protection Agency
WEEE	Waste electrical and electronic equipment
EEE	Electrical and electronic equipment
UNEP	United Nations environmental program
IPCS	International Programme on Chemical Safety
DNA	Deoxyribonucleic acid
EHS	Electromagnetic hypersensitivity
WHO	World Health Organization
GCAA	Ghana Civil Aviation Authority
RPI	Radiation Protection Institute
NCA	National Communication Authority
EIA	Environmental Impact Assessment
US EPA	United States, Environmental Protection Agency
SEA	Strategic Environmental Assessment
TA	Technical Assessment
GIS	Geographical information systems

LIST OF ABBREVIATIONS

HIA	Health Impact Assessment
IAIA	International Association of Impact Assessment
HHRA	Human health risk assessment
ITD	Inter Tropical Discontinuity
IBM	Individual Based Models

CHAPTER ONE

1.0 INTRODUCTION

1. 1 Background

Recent years have seen an unprecedented increase in the number and diversity of sources of electric and magnetic fields (EMF) used for individual, industrial and commercial purposes Nnorom and Osibanjo (2009). All these technologies have made life richer and easier. The mobile telecommunication technology (MTT) has greatly enhanced the ability of individuals to communicate with each other and have facilitated the dispatch of emergency medical, relief and police aid to persons in both urban and rural environments Zain (2005). Mobile phone use has enhanced the efficient use of time (WHO fact sheet N181). This dynamics has led to the development of meaningful competition by telecommunication service mode, with global mobile service exceeding fixed-line subscription by the year 2002, Banerjee and Ros (2004).

Consequently, the investment in telecommunications infrastructure, with its ability to create spillover effects, can impact growth far more significantly than can any other alternative infrastructure Nadiri and Nandi (2003) and Roller and Waverman (2001). About half the economic growth in industrialized countries is related to some aspect of technology Sachs (2000), however, these technologies have brought with them concerns about the life cycle assessment (LCA) of devices used and the possible health risks associated with their use. Heart (2009) was of the view that, the consequences of LCA are usually ignored or even unknown. In specific terms Hilty et al. (2006) emphasized that, "there is the risk that information communication technology (ICT) will become counterproductive with regard to especially environmental sustainability".

Currently, in Ghana, there are over 10,000 telecommunication base stations (BSs) EPA (www.epa.gov.gh, 2014) serving 36, 395, 116 mobile phone subscribers according to the NCA, Daily Graphic (12/7/16). Experts insist the number of BSs is woefully inadequate to ensure quality service Amoako et al. (2009). In Ghana and especially in Accra, the installation of BSs has met opposition from the public because of concerns that, the radiofrequency (RF) emissions from these BSs might have some health consequences.

The spatial distribution pattern of BSs in Ghana is basically irregular with as many as 2000 BSs installed only in Accra. Although Accra has a modest surface area of 200 km^2 it has an enormous estimated population of over 3,000,000 GSS PHS (2010). In view of this, Accra therefore has a population density of over 15,000 persons per km^2 and a BS density of 10 BSs per km^2. Hence, there is an average of 10 BSs on a square kilometer plot in Accra as compared to a nationwide average of less than 1 (0.04) BS on a square kilometer plot. Others have reported of population densities as high as; 23,802 persons per km^2 in Ablekuma and 37,857 persons per km^2 in Ayawaso World Bank (2010).

York (2004) argued that, technological innovations are environmentally destructive since they result in increased pollution. Specifically The Climate Group and GeSI (2008) stated that, the ICT sector and its products are responsible for about 2% of the global greenhouse gas emissions and that this will increase unless mitigated. Indeed, with the current inconsistent power supply in Ghana, generator sets at BSs could possibly if not effectively maintained or monitored be of concern to neighbourhoods. Therefore, urban noise and air quality are of concern to most urban populations since they have significant consequences on health conditions. In this regard, the EPA has established a permissible ambient noise level of 55dB during the day (0600-2200) and

48dB during the night (2200-0600). This by law is to be enforced by the Metropolitan, Municipal or District Assembly (MMDA), Local Government Act; 462 (1993).

In developing countries, the most popular adopted methods to manage solid waste disposal include open burning and dumping at uncontrolled dumpsites. However, there are always technical and environmental problems with both the site and the technology Bali Post (2008). These methods of disposal cause serious environmental problems including health hazards Ball and Denhann (2003).

Waste electrical and electronic equipment (WEEE) has been considered to be one of the most important waste streams of the last decade and will continue to be so in the future Mark (2006) and Menad et al. (1998). WEEE is also a complex stream, because electrical and electronic equipment (EEE) covers a wide variety of products, ranging from mechanical devices to highly integrated systems such as computers and mobile phones Crowe et al. (2003). Furthermore, about 75% of the heavy metals found in landfills are from WEEE Leke et al. (2011).

According to the UNEP (2005), the increase in WEEE worldwide is at approximately 4% per annum. Jiang et al. (2008) projected that, more than 50 million tons and 72 million tons of WEEE were discarded globally in the years 2009 and 2014 respectfully.

In Ghana, considering the number of mobile phone subscribers and an estimated 2 million people using the internet ITU (2016), there is the need for environmental measures on WEEE. Hischier and Eugster (2007) ascertained that, a desktop computer with accessories weighs 22kg, a laptop weighs 3.5kg and a mobile phone weighs 0.5kg. With these figures, the number of tons of mobile phones, desktop computers and laptops deposited in Ghana is estimated to be not less than

43,427 tons per annum. Amoyaw-Osei (2011) however, projected that an amount of 109,000 tons of WEEE was generated in Ghana in the year 2009.

Ghanaians, notwithstanding the radiation levels consistently below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) standards Amoako et al. (2009) are concerned about electromagnetic radiation from BS antennae whichare of lower intensity but can be continuous Trower (2001). The ICNIRP thresholds used by most countries including Ghana are 41.25V/m (SAR of 4.5W/m^2) and 58.3V/m (SAR of 9W/m^2) for frequencies of 900MHz and 1800MHz respectively.

Indeed, this concern is based on the “belief” that, radiation could in the long term cause cancer, brain tumor, damage to DNA and destroy body cells. However, this public concern could be attributed to the fact that, there is no clear and definitive assessment as to whether there exists a health risk from long-term exposure to radiofrequency radiation EMF-NET (2009).

However, there are studies reporting of adverse effects Mann and Röschke (1996), Preece et al. (1999), Huber et al. (2000), Koivisto et al. (2000), Krause et al. (2000), D’Costa et al. (2003), Cook et al. (2002), Hossmann and Hermann (2003), Sienkiewicz et al. (2005) and also others reporting of no effects Besset et al. (2005), Ozturan et al. (2002), Arai et al. (2003) Bak et al. (2003), Parazzini et al. (2005), Uloziene et al. (2005) have been documented on both animals and humans worldwide.

The few studies on residential exposure to RF fields from transmitters had serious limitations, however, they are suspected to be the cause of a variety of non-specific self-reported symptoms such as headache, fatigue, dizziness and concentration difficulties Ahlbom et al. (2004).

This emerging development of non-specific medically unexplained health problems attributed to

EMFs is described as "electromagnetic hypersensitivity" (EHS). Although symptoms described as EHS are real and may be severe and disabling, a relationship between symptoms and RF field exposure has not been proven WHO (2005), Koivisto et al. (2001), Seitz et al. (2005) and Rubin et al. (2005).

To properly manage the challenges of the MTT in Ghana, a network operator is mandatory to obtain separate permits from the Ghana Civil Aviation Authority (GCAA); Radiation Protection Institute (RPI); Environmental Protection Agency (EPA); and the Metropolitan, Municipal or District Assembly (MMDA).

In fact, countries such as the UK, Netherlands, Denmark, Germany, Austria, Spain and the USA have regulations and practices that encourage companies to improve upon their environmental performance voluntarily Peltonen et al. (2004) and Henriques and Sadorsky (2007).

1.2 Statement of Problem

There are currently over 4 million BSs worldwide with over 7.4 billion mobile phone subscribers GSMA (2016). Radiation emitted by the antennae of BSs could possibly cause health hazards Frick et al. (2002), Kristiansen et al. (2009) and WHO (2011).

In fact, the WHO itself has called for precaution in mounting telecommunication BSs and has further emphasized the need for research on the possible effects of BS signals UNCED (1992). In definite terms, the Stewart Report (2000) stated that, "Although the balance of evidence does not suggest that emissions from BSs put the UK population at risk", it also concluded that, "the possibility of harm cannot be ruled out with confidence".

In Ghana, complaints about the technology continue to increase, though mobile phone operators insist the BSs are safe but this sounds unconvincing to the public.

For example, the EPA (2010) has a list of complaints from individuals and institutions. The nature of the complaints includes;

- BSs erected without neighbourhood consent.
- BSs close to people's homes and to schools.
- Masts falling on property.
- Noise, fumes and vibration from generators at BSs.
- Health concerns about electromagnetic radiation emitted.

However, it should be noted that, at "Ashale Botwe" a suburb in Accra, a mast collapsed, killing one person and injuring others (Daily Graphic, 25/3/10). Indeed similar complaints have also been made in several countries worldwide The Scottish Parliament Information Centre (1999).

In developing countries such as Ghana, research on the MTT has not been done extensively and hence the urgent need to conduct studies into all the environmental challenges of the MTT.

However, possible health risks of radio waves from mobile phone antennae identified in the developed world according to Hutter et al. (2006), Frey (1998) and Trower (2001) include but not limited to the following;

- Increased frequency of seizures among children with epilepsy
- Headaches and nose bleeding
- Cancer and skin rashes

Indeed, research has been conducted to determine the levels of RF exposed to the public Amoako et al. (2009) and Deatanyah et al. (2012). However, as the extensive use of the MTT is envisaged, much research is needed on the prolonged effects of;

- Exposure to noise by populations living near BSs.
- Disposal of devices.
- Perception on the acceptability of the MTT.

1.3 Hypotheses

- There is no significant risk associated with living close to telecommunication BSs.
- There is no significant difference between risk perception and the involvement of residents in the selection of sites for mounting BSs.
- Distance has a significant effect on risk to the public.
- There is a significant difference between international and local monitoring regulations of the MTT.

1.4 Research Questions

Questions would be framed to cover the following areas;

- Are telecommunication operators really committed to EIA principles?
- Do the EIA measures implemented actually attain their expected effects?
- Do BSs have other significant adverse impacts other than those anticipated during the design phase?
- Is there an issue of risk perception among people living close to BSs?
- Do the permitting agencies monitor and evaluate measures implemented to mitigate

environmental impacts (EI)?

- What major factors are taken into consideration by regulatory institutions before permitting BS proposals?
- Is there a minimum legal distance for locating BSs from the public?
- Are neighbourhoods consulted before BSs are installed close to their homes?
- Are material wastes or products of the telecommunication industry (plastics, metals, glasses, batteries, SIM cards and chargers) properly managed?

1.5 The main objective of the research

To evaluate the environmental impact of the MTT in Accra, Ghana.

1.6 Specific objectives of the study

The specific objectives of the study are;

- To assess the level of RF radiations emitted by BSs and compare the results to the standards set by ICNIRP.
- To measure the level of noise from generator sets at BSs and compare the results to the standards set by EPA.
- To assess the effectiveness of the EIA system in addressing the risk factors identified.
- To evaluate how material wastes or products of the MTT (plastics, metals, chargers, glasses, batteries, SIM cards and gases emitted from generators) are managed.

1.7 Scope of study

This research focused on the usage or LCA of EEE (mobile phones, laptops and computers) that use the frequencies 900 MHz and 1800 MHz and the infrastructure required for this MTT.

1.8 Limitation of study

The following limitations were identified;

- Lack of data to really quantify radiation levels absorbed by individuals or affected populations since it is not always reliable to depend only on background scientific knowledge.
- Some major stakeholders such as the mobile telecommunication operators did not participate in this research.
- Financial constraints further limited the soil sampling and the administration of questionnaires.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Environmental Policy

Public support plays a major role in decisions especially by politicians on whether or not to implement an environmental policy Christoph et al. (2008). Politicians are often reluctant to introduce environmental policies that face strong public resistance Banister (2008) and Garling and Schuitema (2007). However, the implementation of these policies is often perceived to be essential in order to safeguard the global and local environmental quality Steg and Vlek (2009). It is therefore important to understand which factors influence the acceptability of environmental policies Jakobsson et al. (2000).

Acceptability has been suggested as one of the main dimensions of attitudes and has been used as a tool for assessing attitudes in researchSchuitema et al. (2011), Steg et al. (2005) and Teh et al. (2007). Studies on the acceptability of policies have shown that, an important determinant of acceptability is the perceived effectiveness of policies Bamberg and Schmidt (2003), Eriksson et al. (2008) and Schade and Schlag (2003).

Research also suggests that individual characteristics are important when evaluating policy acceptability De Groot and Steg (2010), Schade and Schlag (2003) and Steg et al. (2005).

Other researchers have stated policy characteristics as influencing the acceptability of policies.

Garling and Schuitema (2007) and Poortinga et al. (2003) mentioned the level of coerciveness of a policy (pull or push measures) as the foremost characteristic. Pull measures encourage the desired behaviour and are generally regarded as non-coercive Eriksson et al. (2006) and Loukopoulos et al. (2005). Push measures are more coercive than pull measures and are likely to enforce behavioural change Garling and Schuitema (2007) and Steg et al. (2005). Various empirical studies indeed show that push measures are evaluated as less acceptable than pull measures Eriksson et al. (2006, 2008) and Schuitema et al. (2011).

Secondly, the behavioural target of a policy (targeting high or low cost environmental behaviours) Garling and Schuitema (2007) and Poortinga et al. (2003).

These are policies aimed at altering various pro-environmental behaviours. The effort it takes to change these behaviours varies, and hence referred to as behavioural costs. In this context, the definition of costs is not limited to financial costs, but also includes the perceived convenience and effort of the specific behaviour that is addressed in a policy. Hence, policies that target high cost take much effort to change whilst low cost behaviour takes little effort to change. Policies targeting low cost behaviour are more acceptable than policies targeting high cost behaviour, Poortinga et al. (2003) and Steg et al. (2005).

Perceived social norm is an important determinant for explaining policy acceptability Jakobsson et al. (2000) and Schade and Schlag (2003). A stronger social norm results in higher acceptability levels of a policy and vice versa Schade and Schlag (2003). The importance of social norms in explaining the acceptability of environmental policies can be further explained by the concept of social dilemmas Biel and Thøgersen (2007) and Von Borgstede et al. (2012). In a social dilemma, each selfish decision creates a negative outcome (or cost) for the people involved Von Borgstede et al. (2012).

If a large number of people make selfish choices, negative outcomes accumulate, creating a situation in which everybody would have been better off if they had not acted in their own interest Dawes (1980). Hence, people's expectation about the behaviour of others (social uncertainty) becomes an important factor in this respect Wilke (1991) and Yamagishi (1986).

People expect that others do not defect, the perceived effectiveness of policies will increase and subsequently, the acceptability of environmental policies will also increase Eriksson et al. (2006, 2008) and Schuitema et al. (2011). A strong social norm suggests that one can trust that other people accept the measure as well (decrease in social uncertainty) Yamagishi (1986).

2.2 Critical perspectives of exposure to EMF

A causal relationship between EMF exposure and symptoms in provocation studies has never been demonstrated. The reason for such symptoms, according to Rongen et al. (2009) is basically psychological. To eliminate the psychological factor Hyland (2000) stressed the importance of animal studies where there can be no claim that measured symptoms are psychosomatic.

However, with human health, children's health status is considered as an important population marker of environmental threats. As such Etzel (2003) and Brent et al. (2004), identified children as a sensitive subgroup of the population hence, necessitating the need for monitoring sentinel health end-points.

In fact, in relation to environmental agents, both relative risk and absolute risk are larger for individuals exposed as children than for those exposed as adults Kodama et al. (2003).

Proximity to sources, either natural or anthropogenic, is an important determinant for exposure to environmental contaminants McGee et al. (2002).

Exposure is described in terms of the intensity, frequency, duration of contact and also expressed as mass per unit time US EPA (1992). When evaluating absorbed doses, the quantitative evaluation of the dose–response nature is most preferred IPCS (2004, 2005) and US EPA (2005).

Traditionally, a threshold is stated, however, this assumption is based on the known capacity of the organism to compensate for or repair damage at various levels of biological complexity Kimmel et al. (2006).

Practically, few attempts to study symptom prevalence and symptom severity in relation to exposure to RF fields from BSs have been done. Measurements of RF fields by Hutter et al. (2006) in the bedrooms of inhabitants living between 20m – 600m away from ten selected BSs was performed in Austria. The participants were classified into three exposure groups based on calculations of the theoretical maximal power density from the selected BSs (when the BS is using 100% of its capacity). The mean power densities were $1.3mW/m^2$, $0.23mW/m^2$ and $0.04mW/m^2$, in the respective groups. Three out of fourteen self-reported symptoms (headache, cold hands or feet and difficulties to concentrate) were significantly reported in the highest exposure group.

Again, a relationship between RF and symptoms in healthy volunteers was investigated in one provocation study. No increase in symptoms was observed during RF exposure as compared to sham exposure Koivisto et al. (2001). However, Zwamborn et al. (2003) have insisted that, people's well being may be adversely affected by the environmental impact of mobile phone BSs sited next to houses, schools or other buildings, as well as by fear of perceived direct effects.

Therefore, all applications and notifications for permits should be accompanied by a declaration that, the equipment and installation is designed to be in full compliance with appropriate ICNIRP guidelines on public exposure

2.3 Environmental Impact Assessment (EIA)

EIA is a process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decisions being taken and commitments made Ridgeway et al. (1996).

Again, strategic environmental assessment (SEA) is defined as "the formalized, systematic and comprehensive process of evaluating the EI of a policy, plan or program and its alternatives, the report on the findings, and the use of the findings in public accountable decision making" Therivel et al. (1992). SEA has started internationally, and has been used most successfully in civil aviation, waste disposal; water and power supply (Wilson, 1993). Earlier, Coates (1976) had used the term "Technical Assessment" to describe EIA and further elaborated that, "TA" emphasizes those consequences that are unintended, indirect, or delayed.

The methods and techniques applied in SEA vary and may include among others the use of GIS, expert judgments Fischer (2007) and Therivel (2004) and public participation Wood (2003). GIS facilitate the preparation of maps and thereby, present a SEA support tool to illustrate and analyze data Therivel (2004), particularly in land use planning Fischer (2007). Again, GIS is increasingly used and widely incorporated in both EIA and SEA practices Vanderhaegen and Muro (2005). It is increasingly obvious that the assessment of likely significant environmental effects is critically dependent upon the spatial representation and analysis of both environmental sensitivities and likely patterns of development Skehan and González (2006).

Budic (1994) argued that, GIS improves the "operational effectiveness" of SEA as they enhance the quality and quantity of environmental or planning information by incorporating the geographic dimension. The use of GIS in development plans commonly link land use to location and spatial evidence approaches which significantly benefit decision-making CEC (2001). Additionally, GIS can identify the spatial and or temporal variability amongst impacts Patil et al. (2002) and have the potential to augment conventional techniques by providing spatial evidence as compared to traditional methods González (2010), Vanderhaegen and Muro (2005) and González et al. (2008). Presenting baseline data in graphic form improves the delivery of information, enhances the understanding of the distribution patterns and linkages between relevant environmental factors Vanderhaegen and Muro (2005). As a result, GIS guarantees more accurate description, better quantification and identification, improved evaluation of spatialand temporal variability of impacts and the prediction of cumulative effects. Therefore, GIS has the potential to facilitate a more robust spatial analysis as they enable the integration of various datasets and visualize thejuxtaposition or cumulative nature of different impacts Harrison and Haklay (2002).

Nevertheless, a number of constraints affecting the effectiveness of GIS as a tool have been reported. This includes data availability, accessibility, costs and data quality in terms of scale, completeness and currency Rybaczuk and MacMahon (1995), Vanderhaegen and Muro (2005) and van Loenen and Onsrud (2004). Subsequently Therivel (2004) observed that, SEA is subject to great levels of uncertainty as a result of the ambiguity about future environmental, economic and social conditions. Partidário (2007) reinforces this observation, suggesting that data accuracy and quality aspects are overcome with some acceptance that SEA often needs to deal with higher levels of uncertainty. Due to such greater complexity and larger geographic context, it is generally accepted that environmental aspects in SEA cannot be described in great scientific and spatial detail João (2007) and Therivel (2004).

An effective EIA procedure should among others involve public participation Wood (2003). Its adoption has increased the amount of environmental information available to citizens Hokkanen (2007) and Pölönen (2007). However, public participation in many situations has often been reduced to a procedural exercise. Analyses by Shepherd and Bowler (1997) and Del Furia and Wallace-Jones (2000), confirmed that, public participation is no guarantee for effective public involvement in environmental decision making. Public participation also faces many challenges; the most important of these seems to be the inconsistent utilization of the public's contribution in decision making Hokkanen (2007) and Pölönen (2007).

From a practical perspective, Bond et al. (2004) argued that, the general public has always not been fully involved in EIA processes. In most cases Palerm (1999) observed that, public participation has been a mere formality where the government acts as an agency for the people. Others have also held to this assertion, for example, in China Cheng et al. (2007) identified four participants in the implementation of the EIA system. They include; the government, EIA organizations, enterprise entities, and the general public. However, according to Cheng et al. (2007) the public usually plays a silent role.

Another important factor about the public described by Krek (2005) was that, many citizens are "rationally ignorant". According to this theory, citizens decide to be rational, ignoring participatory processes, because, participation requires a high investment of time and effort. Krek (2005) applied it to public participation in urban planning. The theory of rational ignorance has also been presented in public choice theory by Buchanan and Gordon (1962) and Gunning (2002). In fact, most people prefer not to take the initiative to be actively involved in the EIA evaluation process Cheng et al. (2007).

EIA's primary purpose is to ensure the minimization of the environmental impacts of projects Glasson et al. (2005). Therefore, an effective EIA system should provide comprehensive coverage of projects likely to have significant adverse effects on the environment Heinma and Põder (2010).

A core question on the effectiveness of environmental policy tools has been; whether the instrument works, or is used as intended and whether it meets the purposes for which it is designed Sadler (1996) and Mickwitz (2003). Hilding-Rydevik (2006) and Similä (2007) directly linked the "effectiveness" of environmental policy tools to the achievement of policy goals. Therefore, the need to integrate EIA within existing governance processes, and in particular the development approval and licensing procedures is widely acknowledged Leknes (2001), El-Fadl and El-Fadel (2004) and Weston (2002).

Inter and intra agency collaboration and institutional coordination or integration have been identified by Saarikoski (2000) as a key element for the effective implementation of EIA in general. If the advantages of an integrated model are obvious, though, yet to be implemented, then Clarke (1984) and Hollick (1986) have argued that, it is likely that, the processes lack the tools to achieve integration. Recently, Brown and Hill (1995) have proposed that, EIA be considered as an input to decision making.

Though EIA is expected to be made obligatory, others, for example Hokkanen (2007) and Sairinen (2000) have argued that, it would result in unreasonable economic burdens.

Indeed EIA of programs and policies is already carried out routinely in countries, such as New Zealand, the U.S., Canada, and Germany. Professional capabilities for this assessment are well advanced Buckley (1994b) and Vanclay and Bronstein (1995) however; Buckley (1994b, c) again identified barriers to their adoption and application in most jurisdictions as political, legal, and economic rather than technical.

Ahmad (1996) indicated that, the decision to approve or to reject a project is heavily influenced by political considerations. Further complexity is added through the intertwining of political, technological, cultural, social and organizational factors Meredith and Mantel (1995) and Cicmil (2000). Governments, the overall representative of the general public, are mostly in an uncomfortable position of facing the dilemma of economical benefits and social costs. This may explain why EIA is nonexistent or lagging behind in some development projects Leknes (2001) and Saunders and Bailey (2009).

EIA has some basic constraints, for example Stewart-Oaten et al. (1986) identified scientific uncertainty about environmental effects of a specific technology as a major factor. However, Stewart-Oaten et al. (1986) further suggested a research tool such as Before-After-Control-Impact (BACI) design as a remedy to reduce uncertainty. Other researchers have delineated statistical constraints as a factor and again nonscientific constraints such as organizational constraints, bureaucracy and the duration of operation among others Osenberg et al. (1992). Biological considerations according to Jones and Kaly (1996), is again a complex constraint affecting the EIA process.

Qiao Zhiqi (1994) on the other hand, emphasized that, despite the challenges, great progress has been made in recent years on EIA in China. This progress Qiao Zhiqi (1994) explained, has been marked by; a continual increase in the number of projected EIAs that have been completed, the extension of EIA's field, continued research work on EIA and the diversification of EIA's objectives among others.

To satisfy the various activities required in the conduction of EI studies, numerous methods (tools) including risk assessment have been utilized. The objectives of the various activities differ, as do the usable methods for each Canter (1996).

There are both major and minor differences in the way EIAs are conducted across a wide range of jurisdictions Wood (1995). Two characteristics dominate its universal nature; the production of a stand-alone report and its provision of advice to assist in the final decision on the proposal.

The primacy of the final report in EA leads one to the conclusion that, the requirements of EA are such that, it is done rather than anything be done with it Brown and McDonald (1995). Secondly, it results in the environmental information becoming available too late in the project planning process Wood and Djeddour (1992).

Graybill (1985) is succinct on this, suggesting that much EIA practice is involved in dispute creation and not in dispute resolution. Tripp and Alley (2003) have concluded that, if the function of EIA and participation is no more than to legitimate the process and project or control the public, EIA easily creates more distrust and new disputes.

Marshall et al. (2005) identified 'follow-up' as the last part of an ideal EIA process. They explained that, 'follow-up' determines the actual outcomes of the project and its goal is to prevent and minimize the negative consequences of developments. More specifically, the functions of 'follow-up' can be divided into three categories; controlling, learning and democratic. However, provisions on 'follow-up' should leave room for flexible interpretations so that 'follow-up' could be tailored to each context Marshall et al. (2005).

2.4 Health Impact Assessment (HIA)

The International Association of Impact Assessment (IAIA) defines HIA as a "combination of procedures, methods and tools that systematically judges the potential and sometimes unintended, effects of a policy, plan, program or project on the health of a population and the distribution of those effects within the population"WHO, European Centre for Health Policy (1999).

HIA is a growing sub-discipline of IA that uses diverse and often novel qualitative or quantitative methods to judge the impacts of policies, programs, plans, and projects on population health or its determinants Collins and Koplan (2009) and Kemm and Parry (2004). HIA further identifies appropriate actions to manage those effects Quigley et al. (2006). Health determinants refer to the range of personal, social, economic and environmental factors which determine the health status of individuals or populations WHO (1998). Many of these health determinants are associated empirically with health status measures, including life-expectancy, disease and injury rates, and measures of health care utilization through empirical research Marmot and Wilkinson (2006) and Kawachi and Berkman (2003). Diseases can be accentuated through beliefs and attitudes that are indigenous to a particular locality or culture Collins et al. (2006). It is of particular importance due to the added exposure impoverished households face in relation to multiple disease risks. Farmer (2001) stated that, the poor have no option but to be at risk from diseases. Therefore, gaining an understanding of what individuals perceives as risk factors, and influences on their reaction to these risk factors, will assist in improving the effectiveness of current risk reduction strategies.

Human health risk assessment (HHRA) is one of the most common tools for quantitative estimation in HIA O'Connell and Hurley (2009) and is also used in EIA practice Steinemann (2000) and environmental risk management decisions (NRC, 2009). The quality of evidence and analytic methods and validity of predictions are prominent concerns for practice quality Mindell et al. (2001) and Veerman et al. (2007).

Internationally, cases where projects affect human exposure to a known physical environmental hazard, including air, soil and water pollutants, noise, radiation, and biological contaminants, currently appear most amenable to quantitative estimation Veerman et al. (2005).

Efforts to develop standardized quantitative or predictive models broadly applicable in HIA practice have also been met with limitations. These limitations include the inability to estimate effects on different populations, assumptions of steady-state health, over-complexity, and lack of transparency in the causal pathways Lhachimi et al. (2010).

Despite these limitations, quantitative forecasts have been generated in a number of HIAs internationally on a range of policies, including those that affect environmental pollutants, traffic hazards, infectious disease risks, housing conditions, and tobacco and alcohol consumption Veerman et al. (2005) and O'Connell and Hurley (2009). Making prospective quantitative estimates of future health effects of policies or projects first require a logical and plausible model linking the decision to health outcomes Mindell et al. (2001). Prior reviews have established the essential information requirements needed for quantitative estimation in HIA Hertz-Picciotto (1995), Mindell et al. (2001), Veerman et al. (2005) and O'Connell and Hurley (2009).

Quantification also requires data on affected populations and on exposures and changes to exposures as well as valid effect measures, models, or exposure–response functions or relationships to relate policy effects with health effects Hertz-Picciotto (1995), Mindell et al. (2001) and O'Connell and Hurley (2009).

Measures of association among health outcomes and risk factors for disease, illness, or injury have been estimated through epidemiological research, but the evidence on how structural conditions (for example culture and environment) and policy change influence the risk factors is scant Dow et al. (2010). It is critical to consider cumulative impacts from the additive effects of new and existing exposures. Particular population vulnerabilities (for example, sensitivity to exposures, higher disease prevalence, poverty, unemployment, and poor sanitation) also may modify the exposure–response relationships Pope and Dockery (2006) and Makria and Stilianakis (2008).

Hübel and Hedin (2003) have mentioned that, interest in HIA is developing in the EU but Kemm and Parry (2004) emphasized that, experience of HIA already exists in countries, such as, New Zealand, Australia, Germany, Netherlands, UK and Canada.Kemm (2004) stated that, though HIA is already being carried out, it is done on voluntary basis. HIA is multidisciplinary and participatory British Medical Association (1998) and, therefore, must be integrated into social, environmental or strategic IA Bhatia and Wernham (2008).

To support valid judgments, practitioners recommend a careful examination of uncertainty and transparency of assumptions and limitations Quigley et al. (2006). A study by Cave et al. (2005) revealed that, only one in every three development planners claimed to have a good understanding of HIA. This is of concern because, monitoring is a critical link to enable policies to be modified in light of new information and changing environmental conditions Steinemann (2000).

There is also evidence that those who typically commission the HIAs are health practitioners who lack knowledge in environmental policy Davenport et al. (2006). However, the limited ability to influence national policy at the local level, regardless of the findings of the assessment process, was considered to hinder the value of the process Greig et al. (2004).

The strength of HIA is the use of a number of analytical approaches (including stakeholder interviews and expert consensus) to answer inherently complex questions O'Connell and Hurley (2009). Steinemann (2001) provided evidence of the applicability of interviews to offer a richer understanding of the circumstances that influence both how and why HIAs are conducted.

2.5 Risk Assessment

Risk is defined as judgments concerning the likelihood, severity or importance of a threatening event or condition (US EPA). However, risk in an environmental context is defined as "the probability of the dose–response effect that may cause harm" Calow (1998).

The many definitions related to risk are interrelated and interchangeable and each of them has certain advantages in different applications Plate (2002) and Barredo et al. (2007).

Gregory and Mendelsohn (1993) identified some characteristics of risk as; Unknown, Uncertain, Unfair, Dreaded, Dangerous to children, Catastrophic, Immoral, Uncontrollable, Involuntary and Unfamiliar among others. Risk, as evaluated by Covello (2003) should be of great concern as it is related to; Health, Safety, Environment, Family, Community, Economic, Trust, Benefits, Control, Fairness, Respect and Accountability.

Controversially, risks are often interrelated. Decreasing the risk of a particular failure scenario may increase the risk of other failure scenarios Pickford (2001). The only protection against interrelated risks is an integrated risk management approach Pickford (2001).

"Risk assessment" is the process whereby the potential adverse consequences (hazards) associated with a technology or development is identified, and the probability (risk) of their occurrence estimated NRC (1983). Risk assessment, according to Wilson and Crouch (1987) is the process of estimating both the probability that an event will occur and the probable magnitude of its adverse effects; economic, health, safety related or ecological over a specified period.

Risk assessment is the process that is used to quantitatively or qualitatively estimate and characterize risk from exposure of an individual or a population to a chemical, physical or biological agent WHO (1998).

It includes the components of;

- Hazard identification (Is there an adverse effect?),
- Dose–response assessment (How severe is it?),
- Exposure assessment (What is the level of exposure?), and
- Risk characterization (What is the risk?) NRC (1983) and IPCS (2000).

The identification of health hazards and the estimation of its associated risks may be based on various sources of information.

Epidemiological studies of people are also important. This involves comparing rates of disease in different groups of people according to their exposure to known or suspected hazards.

Each source of information has advantages and disadvantages to its use. Background scientific knowledge can be applied relatively cheaply and quickly, however, experience indicates that it is not always reliable. For example, it would have been difficult to predict the hazard of cancer from asbestos on the basis of scientific knowledge at the time the mineral first came into use Stewart report (2000).

Again, by knowing the risks and their consequences, people are capable of creating a safe process. A typical characteristic of a safe process is that, risks and risk management actions are continuously discussed Dekker (2006). A risk analysis process gives a starting point for these continuous risk discussions, and the documentation of this process provides a depiction of an organization's competence to meet inevitable failures in the process.

Therefore Rasmussen et al. (2007) have argued strongly that, since risk assessment has a strong science base, the evaluation framework must assign value to state-of-the-art tools and concepts. Risk assessment involves a number of well-documented procedures and tools Sundararajan (1991). Thus, 'hazard and operability' (HAZOP) studies and 'preliminary hazard analysis' (PHA) are widely employed tools for identifying possible hazards and their effect Sundararajan (1991) and Sutton (1992). For example, a large amount of fuel stored in a fuel depot is a major safety hazard. Structural thinking, analysis of past failures and lessons learned, going through various scenarios, are other useful techniques which are frequently used.

The first step as identified by Olin and Sonawane (2003) and Renwick et al. (2003) in any risk assessment is problem formulation. This Olin and Sonawane (2003) and Renwick et al. (2003) further included assessments carried out for the purpose of determining the potential risk from exposures. Problem formulationis expected to result in a conceptual model, based on the qualitative characterization of hazard and exposure Olin and Sonawane (2003), Daston et al. (2004) and US EPA (2005). By applying the risk analysis tradition (loss-prevention) in an environmental context Pollard and Guy (2001) and Kletz (1999) stressed on linkages that address proactive risk analysis in identifying risks in order to avoid and manage them. Other scientists, for example Suter et al. (2003), on justifying the importance of problem formulation observed that, all frameworks developed by IPCS and other agencies now incorporate the concept of problem formulation.

A challenge of risk assessment identified by Durgin (2009) is the use of insufficient samples for exposure assessment. Furthermore Suzanne (2004) highlighted a challenge of risk assessment as the use of only a very limited set of data for the risk analysis. Suzanne (2004) further complained of how insufficient or incomplete data made flood risk analysis difficult in Australia.

On RF exposure Ahlbom et al. (2004) were critically concerned about the quality of assessments made in various studies and also the availability of data on the consequences of exposure. However, when data are not available or are incomplete, a number of assumptions are applied in the characterization US EPA (1991), IPCS (2005) and Kimmel et al. (2006). These assumptions include:

- It is assumed that, an agent that produces an adverse effect following exposure during development in experimental animals will potentially pose a risk to humans following sufficient exposure during childhood.
- It is assumed that, the types of effects seen in animal studies are not necessarily the same as those that may be produced in humans.
- It is assumed that, for health effects other than cancer, a threshold or non-linear dose-response relationship exists.

In order not to deal with assumptions, Kimmel et al. (2006) stressed that; human data are preferred for determining the potential health effects of exposure. This confirms why the application of human data in risk assessment for especially children has been detailed in a number of publications US EPA (1991), Richter-Reichhelm et al. (2002) and IPCS (2005).

Problem formulation should lead to hazard identification IPCS (2000). The IPCS defines hazard identification as "the identification of the inherent capability of a substance to cause adverse effects when a population is exposed to that substance".The challenge in life stage risk assessment is not only to identify the hazard but to determine, in the later stage of risk characterization, whether any adverse effects place a disproportionate risk on potentially susceptible subpopulations IPCS (2000). In addition to the potential for harm, the long-term consequences of early exposure as precursors for later onset of adult disease must be considered IPCS (2001). Therefore it is expected that, exposure assessments identify the pathways, magnitude, frequency, and duration of human exposures from various sources Needham et al. (2005). The toxicity of a hazard, according to Pelkonen, et al. (1997) depends on numerous identified and highly studied factors including;

- Form and intrinsic chemical activity
- Dose-response relationship and exposure route
- Metabolism, excretion and ability to be absorbed by the body
- Distribution within the body and target organs affected
- Presence of other chemicals, age, sex and ethnicity.

The final phase of the risk assessment process is risk characterization. Santos (1987) explained that, the risk characterization process estimates the incidence and severity of harm to human health and the environment that may occur as a result of exposure to pollutants. It also describes the uncertainties and limitations of the overall process. Risk characterization further involves the synthesis of critically evaluated information and data from exposure assessment, hazard identification, and dose-response considerations into an overall evaluation of the assessment that can be communicated to risk managers and public health officials NRC (1983) and IPCS (2000).

Risk characterization should be based on the purpose for the risk assessment. Henley and Kumamoto (1981), have argued that, generally, the purpose of any risk assessment or analysis is to provide support in making correct management decisions. Three types of descriptors of human risk are especially useful and important in risk characterization Kimmel et al. (2006).

They are;

- Inter individual variability- the range of variability in population response to an agent and the potential for highly susceptible subpopulations.
- Exposed individuals- individuals who are more highly exposed because of occupation, residential location, behaviour, or other factors.
- Margin of exposure (MOE) - the ratio of the NOAEL (BMDL/BMCL) from the most appropriate or sensitive species to the estimated human exposure level from all potential sources. This means that the lower the MOE, the greater the risk.

According to Kimmel et al. (2006), the risk assessor must effectively communicate what is known, what is not known, and what is questionable, in order for the risk assessment to be appropriately factored into the overall risk management process.

François et al. (2007) identified confidence building as a level in risk assessment. They explained that, risk assessment is not an isolated activity; it has no value without risk communication.

Communication therefore has an implicit role of building confidence. The importance of the interactions of risk assessment with risk management and risk communication has again been recognized NRC (1994) and Renwick et al. (2003).

2.6 Risk Communication

In 1997, the Codex Alimentarius Commission (CAC) defined risk communication as "an interactive exchange of information and opinions concerning risk among risk assessors, risk managers, consumers and other interested parties" WHO (1998).

Baker (1990) defined risk communication as “the process of informing people about potential hazards to their person, property or community”. Others, for example Lundgren, et al. (1995) defined risk communication “as a science-based approach for communicating effectively in situations of high stress, high concern or controversy”.

Effective risk communication is crucial to cooperative risk management and the resolution of controversial risk-related issues Slovic (1987). The role of emotions was largely ignored in the practice of risk communication until researchers started to demonstrate the underlying mental structures of risk in the public’s mind Slovic (1999). Risk is not only about coolheaded judgment on the magnitudes and probabilities of potential losses, as typically managed by experts, but also related to a variety of strong emotions, such as fear and anger Slovic (1999).

Different causes of hazards can induce specific emotions Brun (1992). Specific emotions, according to Lazarus (1991) and BÖhm and Pfister (2000) lead to specific actions.

As a result, the responsibilities of risk management largely depend on the type of hazard. For example, technological risks usually elicit more anger than natural disasters because people or agencies can be blamed. By contrast, natural catastrophes may elicit more sympathy for the suffered victims Brun (1992). Emotions interact with risk judgments as well as actions. Without understanding the role of emotions in risk communication, effective risk communication can hardly be achieved Loewenstein et al. (2001).

From the risk manager's perspective, the purpose of risk communication is to help residents of affected communities to understand the processes of risk assessment and management Bier (2001). According to Bier (2001), this explains scientifically the likely valid perceptions of the hazards, and again makes it obligatory for managers to participate in making decisions about how risk should be managed.

Understanding and communicating risk has clearly been shown by the NRC (1989) to be influenced by a host of additional factors;

- Whether the risk is voluntary or involuntary
- Whether the distribution of risk and benefit is equitable
- The transparency of the process
- The extent to which risk managers are trusted
- The degree of personal control
- The individual dread of the adverse effect and
- The extent to which the risk is unknown.

Risk communication tools are; written, verbal, or visual statements containing information about risk. They should put a particular risk in context, possibly add comparisons with other risks, include advice about risk reduction, and encourage a dialogue between the sender and the receiver of the message DeRosa (1998).

In fact, dialogue is the commonly used tool in externalization. Dialogue triggers the unconscious elements of knowing and not knowing, as well as revealing gaps in knowledge compared with what the community knows Ayas (1996). Social constructionists for example Burr (1995) regard language as a co-ordination of action and therefore a fundamental tool in knowledge creation.

Risk theorists have proposed four theories of risk communication Covello (2003);

- Mental Noise Theory

When people are upset, angry, fearful, outraged, under high stress, involved in conflict, or feel high concern, they often have difficulty processing information.

- Trust Determination Theory

When people are upset, angry, fearful, outraged, under high stress, involved in conflict, or feel high concern, they often become distrustful.

- Negative Dominance Theory

When people are upset, angry, fearful, outraged, under high stress, involved in conflict, or feel high concern, they often give greater weight to negative information than to positive information.

- Risk Perception Theory

Perception equals reality. There is virtually no correlation between public perceptions of risk and scientific or technical experts. What matters most in determining risk perceptions and public outrage are factors such as trust, benefits, familiarity, voluntariness, control, dread, uncertainty, memorability, fairness and accountability.

The solution then is providing risk information to the public in such a compelling way as to result in reductions in the exposures to agents of morbidity, mortality or injury Covello et al. (1986).

Covello et al. (1991), further outlined Seven Cardinal Rules of Risk Communication;

- Accept and involve the public as a legitimate partner in the decision-making process.
- Listen to your audience and meet the needs of the media.
- Be truthful, honest, frank, and open.
- Coordinate, collaborate and partner with other credible sources.
- Speak clearly and with compassion.
- Prepare, plan carefully and evaluate your communication performance.

2.7 Risk Perception

Risk perception is the influence of human values on risk Sjoberg (1997) and Slovic (1986). There are various qualitative factors which affect risk perception.

The basic factors identified by Slovic et al. (1990) and WHO (2002) include;

- Voluntary or involuntary (imposed).
- Within one's control or not within one's control.
- Familiar or unfamiliar.
- Risk well distributed or unevenly distributed.
- Risk periodic or catastrophic.
- Natural or man-made.
- Risks perceived to be generated by a trusted source or by a non-trusted source.

The diversity of opinions surrounding the concept "risk perception" is also reflected in the range of interpretations available. There is considerable debate surrounding the concept of perception as objective or subjective, real or constructed, determined by individual psycho cognitive processes or socio-cultural factors Bickerstaff (2004) and Slovic (2000). However, as the concept of risk is often linked to decision making, researchers now argue that, the value each perspective holds is now converging with increased recognition Taylor-Gooby and Zinn (2005).

Within health risk research, theoretical models of health and risk behaviour Becker (1974), Bandura (1994) and Triandis (1995) have been criticized for concentrating too heavily on the individual and neglecting the social context Lupton (1999) and Paton and Johnston (2001). In fact, models of individual risk perception and behaviour have been developed in industrialized countries where levels of autonomy and access to health information allow greater scope in the assessment of health risk and responses WHO (2002). Another perspective is of the role of society in shaping risk perceptions including the individualization view of Beck's (1992) "Risk Society". However, this model has been criticized for only being applicable to societies in which individuals have high levels of autonomy Rose (1999). This critique is applicable to the context of many developing countries in which levels of agency among the poor can be extremely restricted Farmer (2001).

While debate may continue over the factors influencing risk perceptions, it is generally agreed that understanding context-specific factors affecting risk perception is important for public health-related behavior change interventions Nettleton (2006). The individual, although pessimistic about societal risk factors, is optimistic about their own risk vulnerability Tyler (1984). Tyler (1984) therefore suggested that, if people feel being part of a community, they apply the same risk assessment to themselves as they do to the wider community. Public perceptions of risk can therefore be upheld by the social environment Bishop et al. (2000).

For example, Paton and Johnston (2001) explained that, people's sense of place identity can encourage community response, increasing participation and capacity, which in turn reduces feelings of hopelessness and improves levels of resilience and coping.

People usually perceive risks as negligible, acceptable, tolerable, or unacceptable Slovic (1987). The nature of the risk is then compared to the benefits. Where the benefits greatly exceed the risk, then the risk may be considered worth taking. Opinions and decisions will depend on a person's age, sex, education and cultural background WHO (2002).

The nature of the risk can lead to different perceptions. Surveys have revealed that, the particular characteristics of a situation affect a person's view of the risk of EMF WHO (1998):

- Voluntary or involuntary exposure.

People who do not use mobile phones perceive the risk from BSs as high. In contrast, most mobile phone users perceive the fields from their phones as low even though they are in fact much more intense.

- Lack of personal control over a situation.

If people have no input over the installation of BSs, especially near their homes, schools or play areas, they will perceive the risk from such installations as being high.

- Familiar or unfamiliar situation.

Where people are familiar with a situation or feel they understand the technology, the level of perceived risk is lower. The perceived risk increases when the situation or the technology, is new or unfamiliar or difficult to understand. However, the perception about the level of risk can be significantly increased where there is an incomplete scientific understanding of the potential health effects from a particular situation or technology.

- Degree of dread.

Some diseases and health conditions, such as cancer, severe or lingering pain and disability, are more feared than others. Thus, even the smallest possibility of cancer, especially in children, from EMF exposure receives significant public and media attention.

- Fairness or unfairness of situation.

If people are exposed to RF fields from BSs, but do not have a mobile phone, they consider it unfair and are less likely to accept any associated risk.

On a broader point of view, it is important, to examine the factors that affect laypeople's perception of risk. This is because; public risk perception influences the acceptance of new technologies Siegrist (2000). For laypeople, the most important source of information about health issues and risks seems to be the news media Krewski et al. (2006). Research over a period suggests that, the media are more likely to report about studies suggesting that a technology is risky than about studies suggesting that a technology is safe Koren and Klein (1991). This according to Siegrist and Cvetkovich (2001) is because; people seem to have more confidence in studies indicating that a technology is risky compared to studies indicating that a technology is not risky. Siegrist and Cvetkovich (2001) further explained that, this negativity bias exhibited by laypeoplemay cause unnecessarily or excessive concern about a technology.

Additionally, Slovic (1993) pointed out that, there is an asymmetry in trust judgments, with trust being difficult to establish but easy to destroy. Several possible explanations for this "trust asymmetry" have been proposed. For example Taylor (1991) suggested that, negative information triggers a stronger reaction than positive information. Slovic (1993) further assigned a negativity bias as another explanation for the "trust asymmetry"principle. A negativity bias has been demonstrated in a number of studies Rozinand Royzman (2001). Rozin and Royzman (2001) further hypothesized that; there may be innate predispositions to give greater weight to negative entities. It has been argued that negative information often has a greater diagnostic value than positive information Skowronski and Carlston (1989).

Other reasons for a negativity bias are associated with the fact that, for most people it is more important to avoid losses than to realize gains Kahneman and Tversky (1979). Experimental studies have shown that, people have more confidence in hypothetical scientific results suggesting a danger than in results indicating a low level of risk Siegrist and Cvetkovich (2001). Similar findings reported by Poortinga and Pidgeon (2004), showed that, negative events had a greater impact on trust than positive events. This asymmetry between positive and negative information may be one of the reasons why laypeople are concerned about technological risks, even when risk assessment studies indicate that there is a low probability of a risk Macri and Mullet (2007) and Siegrist et al. (2005).

Koehler (1993) mentioned confirmatory bias, as another explanation for this “trust asymmetry”. According to this view, new information is mostly interpreted in such a way that it accommodates already-held convictions. This bias, according to Koehler (1993) has been demonstrated in studies suggesting that, research reports that confirmed prior beliefs were judged to be of greater quality than reports that did not confirm prior beliefs. Consequently, new information is often interpreted so that it meshes with already-held beliefs Plous (1991). Therefore, the interpretation of positive or negative information about a hazard may be shaped by prior attitudes. For example, prior attitudes were shown to moderate the effect of message valence on trust White et al. (2003). People have more confidence in messages that are in line with their prior attitudes. Consequently, White et al. (2003) on the contrary concluded that, prior attitudes and not a negativity bias, is the reason why people have greater trust in negative messages than in positive messages about hazards.

Indeed, it has been shown recently that, under some circumstances, positive information and not negativity bias can have a stronger impact on trust White and Eiser (2005).

2.8 Management of mobile telecommunication waste

Berkhout and Hertin (2004) studied the direct, indirect and structural impacts of the ICT sector and concluded that, the sector and its impacts are "complex, interdependent, deeply uncertain and scale dependent". Agamuthu (2001) has confirmed that, the proper management of municipal solid waste (MSW) is one of the emerging issues in developing countries.

In reality, rapid urbanization has further exerted heavy pressure on land and water resources in especially cities resulting in serious environmental and social problems Simone et al. (2001). Most countries, especially in the developing world are struggling to deal with the growing waste problems Agamuthu et al. (2009) and Hiramatsu et al. (2009).

Additionally, the increasing production and consumption of manufactured and packaged goods has led to the massive production of solid waste. For example, according to Sutanto (2007) in Indonesia, per capita production of solid waste increased ten folds between 1971 and 2000 though, Indonesia has a poorly-developed infrastructure for waste management Supriadi et al. (2000).

Others for example Huisman et al. (2007) maintained that, in the year 2005, the 27 EU member states generated an amount of 8.3-9.1 million tons of WEEE. China and the USA reportedly generated 11.1 million tons and 10 million tons of WEEE respectively in only the year 2012 StEP (2013). Though the developing world does not generate much WEEE, unfortunately Wang et al. (2012) have estimated that 50% to 80% of WEEE from developed countries are exported to the developing countries.

The environmental and human health consequences of severe pollution by WEEE may affect surrounding lands and rivers Nnorom and Osibanjo (2008). These environmental concerns have prompted the EU to publish Directive 2002/96/EC on WEEE European Parliament and Council (2003). The Directive imposes recovery, reuse and recycling targets for 10 WEEE categories. However, these targets cannot be reached by metal and glass recovery alone, because WEEE contains from 10% to 30% plastics Taurino et al. (2010). Other researchers have estimated the amount of plastic found in WEEE to be nearly 34.6% Dimitrakakis et al. (2009) whilst others have also estimated values more than 50% Chancerel and Rotter (2009).

Widmer et al. (2005) also estimated the fraction of Fe, Cu, Al, Au and other metals in WEEE to be over 60% whilst plastics account for about 30%, with hazardous pollutants comprising about 2.7%. For this reason Chancerel and Rotter (2009) further argued that, plastics must subsequently be included in the recovery or material recycling streams.

WEEE recovery is challenging because of the presence of a diverse number of materials they contain ITU (2003). Electronic devices contain up to 60 different elements, many of which are valuable whilst some are hazardous Wang et al. (2012). For example, according to the ITU (2003) a mobile phone contains not less than 20 rare metals, and the need to recycle these metals is necessary – a ton of Au ore yields just 5g of Au, whereas a ton of used mobile phones yields 400g of Au. Considering only the plastic content of WEEE, EEE (and the WEEE of the near future) can be based on more than 15 different types of engineering plastics, including; acrylonitrile–butadiene–styrene (ABS), high-impact polystyrene (HIPS), polypropylene (PP), polystyrene (PS), styrene-acrylonitrile (SAN), polyesters, polyurethane (PU), polyamide (PA), blends of polycarbonate (PC)/ABS and blends of HIPS/poly (p-phenylene oxide) (PPO) Vilaplana and Karlsson (2008).

Along with this significant variety of materials, the numerous additives (both organic and inorganic) that are also added to plastics, which are often hazardous substances, are capable of changing the material properties such as colour, melting point, flammability and density, for legal, design and/or cost purposes. These additives may be pigments (TiO_2, ZnO, Cr_2O_3, Fe_2O_3, Cd), flame retardants (often brominated organics combined with Sb_2O_3 or polychlorinated biphenyls (PCBs) and various stabilizers or plasticizers (compounds of Ba, Cd, Pb, Sn and Zn, or PCBs) Dimitrakakis et al. (2009), Erickson and Kaley (2011) and Schlummer et al. (2007).

However, a possible solution to promote better WEEE management is the eco-design approach. The eco-design approach should be promoted, to make the dismantling step easier. Directive 2009/125/EC European Parliament and Council (2009), which set the eco-design requirements, could promote normalization in EEE. This is intended to make more efficient the dismantling and recycling processes when the products reach the end of their life cycle.

Heavy metals are considered as the major indicators of anthropogenic impact from various sources such as dry ash deposition, industrial effluents, road runoff and leachate Singh et al. (2008). Once dispersed in the environment, heavy metals are slowly removed by geological and biological processes Jarup (2003). Therefore, any quantity that can be mobilized and absorbed by plants insidiously concentrate along food chains and ultimately in consumers of contaminated foods Jarup (2003). Moreover, the metal ions released in water become distributed into the surrounding areas by lateral and vertical movements in the ground Regli et al. (1991). The adverse effects according to Regli et al. (1991) are that, metal-contaminated soils often have restrictive physical, chemical and biological characteristics that hinder self-regenerating mechanisms Regli et al. (1991).

The routes by which humans are affected by heavy metal exposure include breathing in airborne dust and dirt, eating contaminated food or nonfood items, and the skin coming into direct contact with contaminated dust, soil, and cosmetics Wu et al. (1996). Consequently, monitoring of heavy metal concentration is very important in ascertaining the level of impact of dumpsites on groundwater and soil quality. Studies indicate that, heavy metals like Cd, Cr, Pb, Zn, Cu, Ni and Fe are found in groundwater surrounding dumpsites Barry et al. (1995), Martinez and Motto (2000) and Mor et al. (2006). Because of the perceived effects on food quality and safety, which are now seen as essential components of public health, the control of potentially hazardous elements in soils has become important for sustainable agriculture Howe et al. (2005).

Arsenic pollution, according to Mukherjee and Bhattacharya (2001) has been the most widely discussed and researched issue and is often regarded as the biggest mass poisoning in human history. However, the presence of natural arsenic, which is carcinogen, is at elevated concentrations in groundwater and sedimentary environments Madhavan and Subramanian (2000).

Though heavy metals in the environment have the potential to damage virtually any organ, lead is probably the environmental pollutant that has most affected human health across the ages Bernard (2004). Lead can cause several unwanted effects, such as disruption of the biosynthesis of haemoglobin and anaemia, brain damage, disruption of the nervous, reproductive and circulatory systems in humans Bulut and Bayasal (2006) and Low et al. (2000). A large amount of Pb absorbed in a child may induce anaemia, kidney damage, colic, muscle weakness, and brain damage, which ultimately can kill the child Borja-Aburto et al. (1999). A lower-level lead absorption may lead to premature newborns, lower birth weight, problems of physical growth and mental development, and cause lower intelligence later in childhood Borja-Aburto et al. (1999). However, Borja-Aburto et al. (1999) further cautioned that, the risks may increase when contaminated cereals are used for the production of baby foods.

The presence of Fe in water changes the colour of groundwater. Also ingestion of large quantities of Fe results in haemochromatosis, a condition in which normal regulatory mechanisms do not operate effectively.

Although Zn has traditionally been regarded as relatively nontoxic, recent studies according to Elliott (2001) have increasingly showed that, free Zn^{2+} is a potent killer of neurons, glia, and other cell types. Accidental and intentional ingestion of Zn salts have resulted in deaths but debilitating sequelae, such as vomiting, diarrhea, red urine, icterus (yellow mucous membrane), liver and kidney derangement and anaemia is often the recorded consequence Fosmire (1990).

Berry and Ralston (2009) have emphasized that Hg disrupts the function of the pituitary, thyroid, and adrenal glands even at low-level exposure. A variety of disturbances primarily in the sensory and motor nerves have also been confirmed Ballatori (2002). Hg in both organic and ionic forms according to Clarkson (1995) accumulates in the heart and causes hypertension, tachycardia, and ventricular arrhythmias. Ballatori (2002) mentioned that, the main effect of chronic absorption is irreversible damage to the central nervous system and further described Hg as mutagenic, teratogenic and carcinogenic.

Cd is also associated with renal and arterial hypertension Lewis (1991). Cd salts cause cramps, nausea, vomiting and diarrhoea.

Ni in groundwater has a potential to cause allergic reactions and also impairs the functions of the liver Das et al. (2008).

However, the traditional treatments for metal contamination in soils are expensive and cost prohibitive when large areas of soil are contaminated US EPA (1993). Treatments are extremely expensive and can be done *insitu* (on-site), or *ex situ* (removed and treated off-site). For example Watanabe (1997) estimated that, traditional cleanup *in situ* may cost between \$10.00 and \$100.00 per m^3, whereas removal of contaminated material (*ex situ*) may cost as high as \$30.00 to \$300 per m^3. Therefore, Watanabe (1997) in comparison suggested phytoremediation which may only cost \$0.05 per m^3 as a relevant alternative.

Research performed by Wenzel et al. (1999) and Brady and Weil (1999) has also demonstrated that plants are effective in cleaning up contaminated soils.

Some treatments that are available include US EPA (1993);

- High temperature treatments (produce a vitrified, granular, non-leachable material).
- Solidifying agents (produce cement-like material).
- Washing process (leaches out contaminants).
- Liming to a neutral pH and dilution by the addition of uncontaminated soil.

The actual toxicity of a heavy metal will be affected by soil texture, organic matter content and soil pH. The health effects of exposure to heavy metals depend on the amount and duration of exposure (the volume of contaminated soil or food consumed over time).

With the advent of data and intensive cellular standards, power-consumption for each BS can increase up to 1,400W and energy cost per BS can reach $3,200 per annum with a carbon footprint of 11 tons of CO_2 TMT (2010). CO_2 gas from automobiles and power plants and Freon (refrigerant gas) released into the atmosphere may be involved in deleterious climatic changes Schroeder et al. (1996).

2.9 Noise Pollution

Berkau et al. (1975) defines noise as discordant sound resulting from non- periodic vibrations in air or, unwanted sound. Noise is generally defined as unwanted sound and is perceived as a pollutant and a type of environmental stressor Smith (2003).

Moszynski (2011) explained "noise pollution" as sound that is incoherent and irregular, and produces an unpleasant sensation that is unwanted or that interferes with the ability to hear.

Noise is measured in decibels (dB) using a sound level meter. Normal conversation is within the range of 50-60dB. However, permissible levels of noise vary from place to place Smith (2003).

The potential risk of adverse health effects associated with exposure to noise is dependent on the duration of exposure (acute or chronic), intensity (decibel level) and sound frequency Passchier-Vermeer and Passchier (2000). For example, noise-induced hearing loss can result from a one-time exposure to 120dB level of sound or exposure to 85dB level of sound over an extended period of time Passchier-Vermeer and Passchier (2000). Chronic exposure to noise is associated with increased risk of hearing impairment, hypertension and ischemic heart disease Moszynski (2011). For example, in the United States, excessive noise is one of the most pervasive problems, causing some degree of hearing loss directly among an estimated 16 million people US EPA (1974).

Noise, according to Cohen and Weinstein (1981) acts as a general stressor, and environmental noise exposure can lead to poor psychological health in several ways. Firstly, acute noise exposure directly causes a number of short-term physiological responses such as increased blood pressure, enhanced endocrine secretion, and raised heart beat rate. Secondly, these physiological outputs may be activated by annoyance. Annoyance may lead to stress responses for some individuals that potentially could lead to symptoms and illness. Kempen et al. (2006) identified ailments like; indigestion, ulcers, gastrointestinal malfunctions, heart abnormalities, circulatory, digestive and nervous disorders as well as vision, emotional upset and irritability as impacts associated with noise exposure.

Terry (1979) further explained that, noise can alter the normal functions of the endocrine, cardiovascular and neurological systems. It may affect equilibrium and cause a rise in blood pressure, a change in heart rhythm and constriction of blood vessels. Passchier-Vermeer and Passchier (2000) again identified; annoyance, sleep disturbance, interference with communication, decreased school performance, increased levels of stress, and modification of social behaviour as potential impacts associated with noise exposure.

Since sleep is the body's regenerative process, then, any interference with sleep will affect the emotional, psychological and physical health directly Berkau et al. (1975). Uninterrupted sleep is a prerequisite for good physiological and mental functioning especially in children Bistrup (2003). The primary effects of interrupted sleep identified by Muzet (2007) and Haines et al. (2003) are; difficulty in falling asleep, awakenings and alterations of sleep stages, increased blood pressure and heart beat rate, vasoconstriction, and changes in respiration and cardiac arrhythmia. Another long-term exposure to noise in children mentioned by Stansfeld et al. (2005), WHO (1999) and Moszynski (2011) is learning disability.

2.10 Environmental Model

2.10.1 Purposes of models

Without defining the model's purpose its degree of success cannot be judged and its structural complexity cannot be advantageously tuned Beven (2002) and Jakeman et al. (2006).

The purpose of the model should determine its structure; scope, resolution, and complexity; its user interface and output; and how it is evaluated Starfield (1997), Nichols (2001) and Kettenring et al. (2006).

In defining the purpose for a model, certain multiple issues ought to be addressed;

- Who are the intended end users of the model? What are the technical skill levels of the end users?
- How will the model be used; for evaluating management alternatives, determining high priorities for future research or communicating what is known to other stakeholders among others?
- What spatial and temporal context is being explored? For example, is it about breeding season patterns only, modeling short-term forecasts or long-term dynamics, a specific management area or an ecological province?
- How will the model be evaluated?
- Is the model built for long-term use? How will it be updated if the understanding of the system improves?

Researchers, for example Pielke (2003) have argued that, the prediction for science versus the prediction for making policy is an instance where different purposes are frequently confused.

2.10.2 Uses of models

Any model development process requires the modeler to make a series of simplifying assumptions or hypotheses Gupta et al. (2005). In addition to this Heeks and Molla (2009) cited the use of scenarios and forecasting to establish impacts in different situations. This is necessary to enable complex natural systems to be described using much simpler mathematical models.

To a large extent all models are aimed at explanation, but models which are good at explaining a system's causal mechanisms, behaviour or patterns are not always designed to predict Jakeman et al. (2006). In most disciplines, a "good" model is one that promotes a better decision than could be made without it Starfield (1997) and Johnson (2001).

In general Beven (2002) and Jakeman et al. (2006) argued that, models can be used to;

- Measure and represent.
- Describe structure, behaviour and pattern.
- Reconstruct past or predict future behaviour.
- Generate and test theories and hypotheses.
- Display, encode, transfer, evaluate and interpret knowledge.
- Guide development and assessment of policies.
- Facilitate collective learning and settlement of disputes Beven (2002) and Jakeman et al. (2006).

Johnson (2001) has also made known three categories of uses of models; explanatory, predictive and decision making.

- Explanatory models are used to describe or decipher the workings of systems. Such models attempt to identify the mechanisms involved in the system.
- Predictive models are used to forecast future states of systems or results of management actions. Prediction is a common use of landscape models and allows the user to determine the potential impacts of various proposed management actions Shifley et al. (2006).
- Decision-support models are used to identify management strategies that will produce desired results. Optimization technique is a useful example of decision-support model used in planning resource management Moore et al. (2000).

Practical uses of models may be blurred or overlapping, but this does not change the implications of the intended purpose for model development Bankes (1993). Bankes (1993) cautioned against confusion between the purposes of consolidative and exploratory models. A consolidative model according to Bankes (1993) sums up facts known to be correct in a single package, used as a surrogate for management interventions.

Exploratory models, according to Pielke (2003) are models in which not all components of the system can be established independently or are known to be "correct".

2.10.3 Modeling as a concept

Models are abstract descriptions of systems or processes Starfield and Bleloch (1991) and Haefner (1996) and therefore have become pervasive tools in natural resource management, large-scale planning and landscape ecology Shenk and Franklin (2001) and Scott et al. (2002).

Consequently models help address fundamental questions; for example, models are useful for evaluating the potential impacts of management alternatives and assessing economic implications of management decisions Morrison et al. (1998), Larson et al. (2004) and Shifley et al. (2006). Although many general models are structurally similar (matrix models for demographic analyses), specific models are uniquely suited for specific regions and applications Caswell (2001).

Numerous models that have emerged over the last 20 years have used individuals as their basic unit Grimm (1999), Judson (1994) and Uchman'ski and Grimm (1996). In contrast with the classical analytical models, the so-called Individual Based Models (IBMs), actually made an improvement by being developed "bottom-up" rather than "top-down" Grimm (1999). IBMs describe systems from the individual's point of view; hence, the individual's behaviour and characteristics (size, age, sex, physiology, genotype among others) determine the emergent properties of the system within which the individual operates Lomnicki (1988) and DeAngelis et al. (1994). Competitive interactions are local and usuallystrongly influenced by certain characteristics (size,age, physiology, genotype among others) Berger et al. (2008), Herben et al. (2000), Murrell et al. (2001) and Purves and Law (2002).

Landscape models take many forms, including statistical models that quantify relationships and patterns among variables Hepinstall et al. (2002) conceptual models that offer a qualitative construct of a system and simulation models that project landscape features into the future He et al. (1996) and Oliver et al. (1999).

2.10.3.1 The parametric modeling approach:

The parametric approach, introduced by Little and Robin (1983), starts from the perspective of limited data and also developed using the "bottom-up" concept Grimm (1999) and consequently considered as relevant for this research. The parametric approach aims to estimate the complete vulnerability value of a system by using only a few readily available parameters relating to that system, though the implementation of the approach is not simple. To reinforce this Ginzburg and Jensen (2004) further pointed out that; attempts to include more details than can be justified by the quality of the available data may result in decreased predictive power.

Four types of parametric approaches have been developed by the scientific community;

- Estimating the complete vulnerability value of a system by using only few parameters relating to that system, Little and Robin (1983).
- Estimation of "the imputation of non-observable values", where the observed parameters are used to model the non-observed values, Glynn et al. (1993).
- The "parametric modelisation via maximum likelihood", which is not a direct approach but is based on a large number of assumptions, Little and Robin (1987).
- The "semi-parametric approach", which allows the modeling of only what, is strictly necessary, Newey (1990).

Indeed researchers have identified three significant factors of vulnerability; exposure, susceptibility and resilience Bosher et al. (2007).

Exposure can be understood as the humans who are present at the location where a hazard exists Penning-Rowsell et al. (2005).Susceptibility is defined as the extent to which elements at risk within the system are exposed, which influences the chance of being harmed Messner and Meyer (2006). Resilience describes the ability of a system to preserve its basic roles and structures in a time of distress and disturbance. Therefore, Pelling (2003) and Walker et al. (2004) have argued that, resilience can be considered only in places with past events, since the main focus is on the experiences encountered.

For example Balica et al. (2009), used the parametric method to develop a Flood Vulnerability Index (FVI). This was based on four components; social, economic, environmental and physical dimensions and their interactions.

The conceptual FVI equation is given by;

$$\text{FVI} = \frac{E * S}{R} \tag{2.1}$$

where; E = exposure, S = susceptibility and R = resilience.

The indicators belonging to exposure and susceptibility are directly related to FVI therefore they increase with FVI; however the indicators belonging to resilience decrease with FVI as it is inversely related to FVI Dinh et al. (2012).

The vulnerability notion has come from different disciplines; from economics and anthropology to psychology and engineering; the notion has been evolving giving brilliant justifications for differences in the extent of damage occurred from hazards Adger (2006). Facility location models are used in a wide variety of applications, for example, locating hazardous material sites to minimize exposure to the public Hale and Moderg (2003). However, studies on environmental inequality by researchers, for example Hamilton (1995) have convincingly argued that political empowerment is the most important factor in predicting the areas targeted for facility location and not facility location models.

2.10.4 Validation of models

The term model uncertainty which is linked to model validation is used to represent lack of confidence that the mathematical model is a "correct" formulation of the problem to be solved Mayer and Butler (1993). Tsang (1991) explained that, model uncertainty exists if the model produces an incorrect result even if the inputs were the exact values for all of the model parameters.

The best method for assessing model uncertainties, according to Hoffman and Hammonds (1994) is through model validation; a process in which the model predictions are compared to numerous independent data sets obtained. Therefore a common definition of validation can be the demonstration that a model, within its domain of applicability, possesses satisfactory accuracy consistent with the intended application of the model Curry and Deuermeyer (1989). This demonstration indicates that the model is acceptable, however, that does not imply that it is the best model as Box (1979) firmly concluded that, "all models are wrong, but some are useful".

The literature on the definition and the concept of validation of models are abundant and sometimes confusing Power (1993) and Rykiel (1996). Power (1993) considered validation as sometimes essential whilst Oreskes and Belitz (1994) considered validation as sometimes impossible. However, some scientists have strongly indicated that, models can only be invalidated McCarl (1984). In the case of large (complex) models, it is extremely difficult to verify that the model is entirely accurate and error free under all circumstances. Therefore, the absolute validity of a model can never be determined NRC (1990). If the context changes, the model must be re-validated; however, that does not invalidate the model for the context in which it was originally validated Rykiel (1996).

2.10.5 Avoiding model uncertainty

A key to successful modeling is the avoidance of common missteps that make models unreliable. Ineffective or unreliable models maintain the following characteristics and therefore should be avoided.

- Explicit accounting for processes that are not relevant or well understood, Starfield (1997). It is possible to consider ways to structure models that rely on well known parameters, Nichols (2001).
- Dependence on parameters that cannot be estimated precisely. With greater uncertainty, it becomes even more important to limit the number of input parameters, Mangel et al. (2001).
- Dependence on too many parameters, Burnham and Anderson (2002).
- Uncritical application of pre-existing models, Mangel et al. (2001).

Because of uncertainty surrounding our knowledge of a system and limited data, the use of complex models may not improve one's understanding of a system; therefore one should construct the simplest model that fulfills one's purpose adequately Starfield (1997) and Nichols (2001).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of study area

3.1.1 Accra metropolis

Accra is located approximately between latitudes 05°47'30'N and 05°31'0'N, and also between longitudes 05°25'30'W and 0°3'30'W as shown (Fig.3.1). Although Accra has an enormous estimated population of over 3 million, it has a modest surface area of 200km^2 and consequently a population density of 15,000 persons per km^2 with an annual growth rate of 4.4% GSS PHS (2010). Therefore, the number of people estimated to live closer to BSs is higher in Accra than in any other city in Ghana.

Accra, has contributed considerably to the economic development of Ghana by hosting a number of industries, oil companies, financial, telecommunication, tourism, education and health institutions among others, however, fishing still contributes to household income GSS (2008). Economic liberalization and increase in the intensity of engagement with global capital have enhanced the growth of the city in the last three decades Grant and Nijman (2002), Grant and Yankson (2003) and Owusu (2008). Konadu-Agyemang (1998) has argued that, the rapid growth of Accra's population has created the situation in which a wide gap now exists between the needs for, and the provision of, housing and related infrastructure. This situation according to Songsore (2003) has led to the first stage of urban environmental transition wheremost of the environmental problems tend to occur close to homes.

Practically, considering the size of the study area, time, financial limitations and zoning issues, there was the need to narrow down the focus of the research to specific study sites for an in depth analysis.

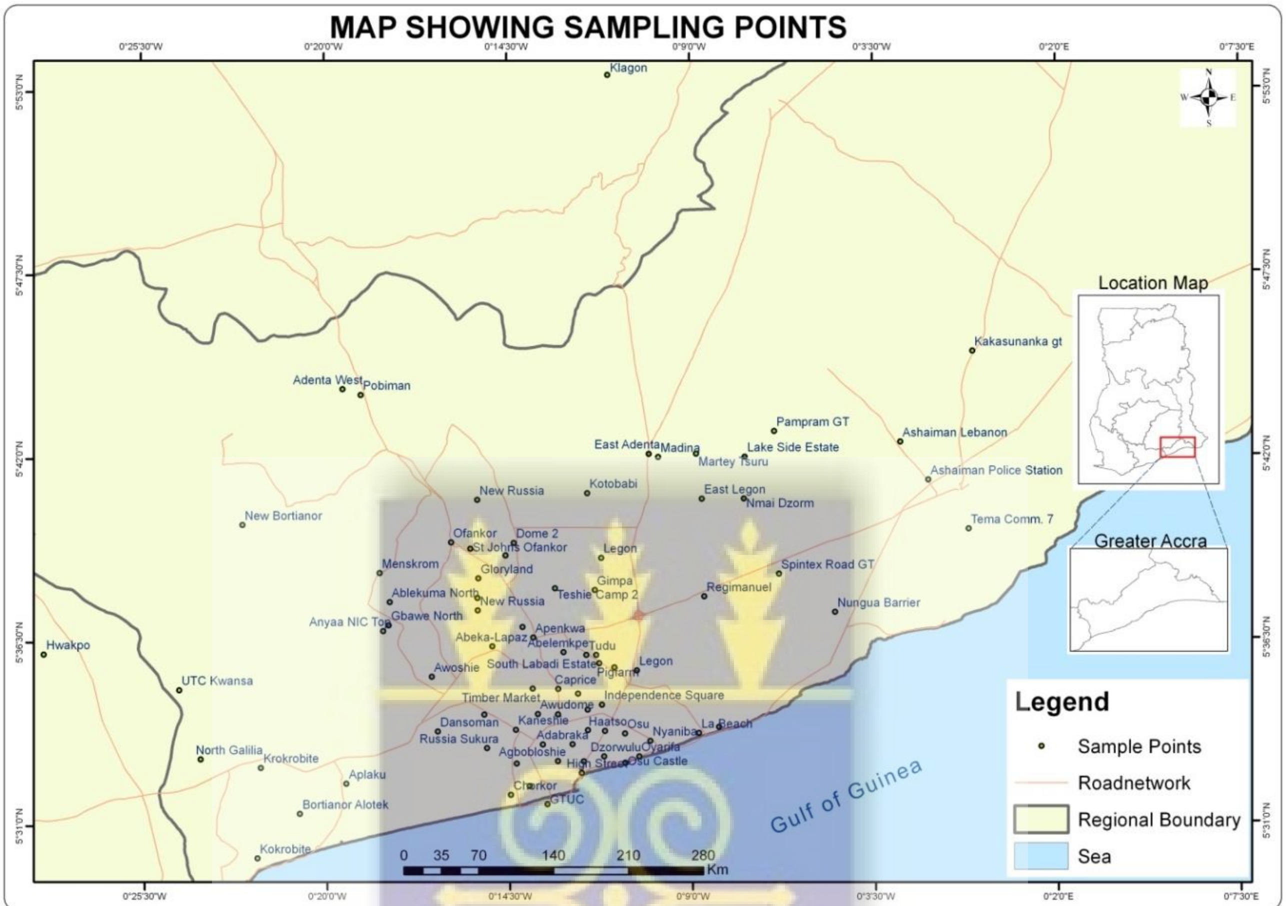


Figure 3.1: Map showing the study area.

3.1.2 Drainage

Several rivers (Volta, Pra, Birim, Ankobra and Tano among others) flow across Ghana into the Gulf of Guinea with the Volta River basin dominating the country's river system. Ghana's coastal area consists of plains and numerous lagoons near the estuaries of rivers CEPA (2000). The Densu River Catchment area and the Sakumo Lagoon are the largest of all the coastal basins within Accra covering a total drainage area of about 2500km^2. The Korle-Chemu catchment area is the next coastal basin covering an area of 250 km^2 whilst the Kpeshie catchment area covers a relatively small catchment area of 110 km^2 (Fig 3. 2).

Poor drainage is the major problem which affects many parts of Accra. Natural features such as the underlying geology, soil conditions and localized topographic features contribute to the drainage challenges. Infrastructural development should not have been permitted in some areas; however, poorphysical development control has led to urban landencroachment.

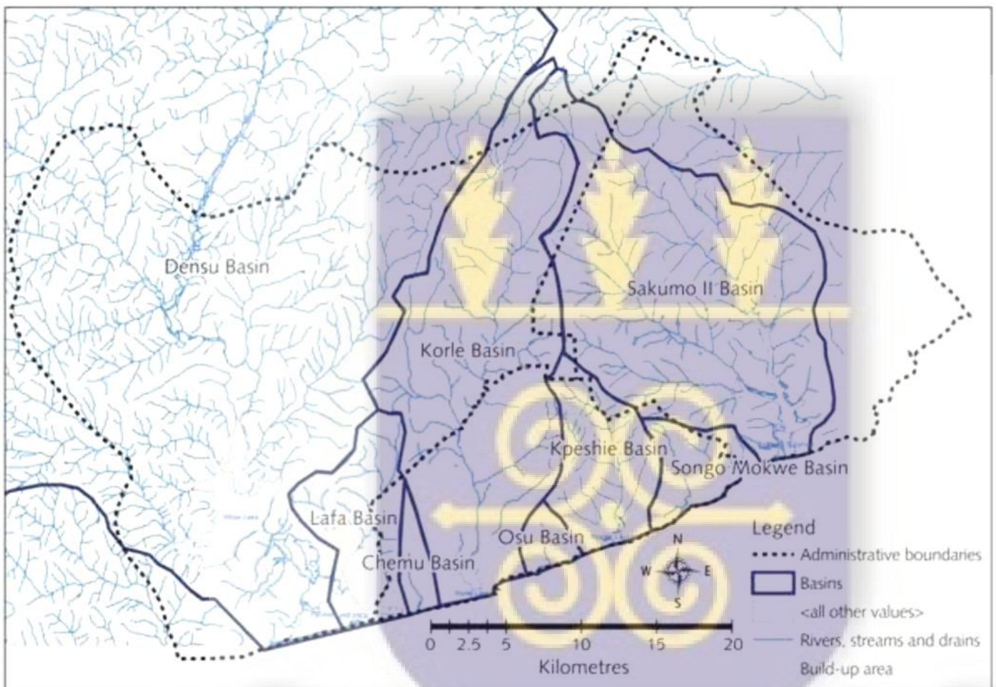


Figure 3.2: Map showing basins in Accra

3.1.3 Climate

The climate of Ghana is characterized by dry and wet seasons, a typical tropical monsoonal climate. Rainfall in this region is mainly associated with mesoscale convective systems and controlled by the advection of moisture from the Gulf of Guinea in the low level atmosphere Sultan and Janicot (2003).This system is usually referred to as the West African Monsoon (WAM), and its driven by the energy and temperature gradient between the Gulf of Guinea and the Sahara. The maritime tropical air mass, which originates from the Atlantic Ocean, is moisture laden and converges with the dry northeast continental tropical air mass, usually along the Inter-Tropical Discontinuity (ITD) Mounier (2008). Therefore, the spatial pattern of annual rainfall is closely related to the Northward and Southward migration of the ITD, resulting in changes in therainfall regime from the South to North of the country Manzanas (2014). This gives rise to two rainfall regimes: bi-modal in the South, consisting mainly of coastal and the forest zones, and uni-modal in the Northern part of the country, consisting of part of the transition and savanna zones Manzanas (2014). Annual rainfall ranges from about 1,100mm in the north to about 2,100mm in the south-western part of the country Dickson and Benneh (1988).

The study area experiences two rainy seasons with a mean annual total rainfall of below 1000mm. The first rainy season begins in May and ends in mid-July whilst the second season begins in mid-August and endsin October. Rains usually fall in intensive short storms leading to flooding which is currently a major disaster risk in the study area. Flooding in Accra is always predictable, because of the flat and low-lying terrain, inadequate drainage facilities, haphazard location of buildings along water courses and the built up environment which encourages rapid run-off Songsore et al. (2005). The flat terrain is estimated to consist of slopes less than 5% and many not exceeding 1% Boateng (1998).The mean monthlytemperature ranges from 24.7°C in August to 28°C in March withan annual average of 26.8°C. Relative humidity is high varying from 65% in the day to 95% at night Muff and Efa (2006).

The predominant wind direction in Accra is from the WSW whilst wind speeds normallyrange between 8-16km/hr with 107.4km/hr as the maximum wind speed ever recorded AMA (2010-

2013). Indeed, high wind gusts occur with thunderstorm activity which passes insquall line along the coast causing damage to property.

3.1.4 Vegetation

Accra lies in the savannah zone with three broad vegetation zoneswhich comprise; shrub land, grassland and coastal lands. The shrub land consists of dense clusters of small trees and shrubs, which grow to an average height of 5m with ground herbs at the edge of the shrubs. The grassland consists of a mixture of grass speciesfound in the undergrowth of forests. The grasses are short, and rarely grow beyond 1m. The coastal zone comprises of two vegetation types (wetland and dunes). The coastal wetland zone consists of mangroves and salt tolerant grasses whilst the dune lands also consist of several shrubs, grasses, coconuts and palms.

In addition to the natural vegetation zones, a number of introduced trees and shrubs also thrive in Accra.

3.1.5 Geology and Soil

The geology of southern Ghana is dominated by Middle Precambrian Rock and Birimian formation Bekoe et al. (2009) and CEPA (2000).

The geology of Accra consists of Precambrian Dahomeyan Schists, Granodiorites, Granites, Gneiss and Amphibolites to late Precambrian Togo Series comprising mainly Quartzite, Phillites, Phylitones and Quartz Breccias. Other formations found are the Palaeozoic Accraian Sediments (Sandstone, Shales and Interbedded Sandstone-Shale with Gypsum Lenses). The coastline has a series of resistant rocks and sandy beaches; however, it is subjected to severe erosion because of the close proximity of the continental shelf and a strong coastal wind action.

The soils along the coast of Ghana include the savannah ochrosols and savannah lithosols Bekoe et al. (2009) and CEPA (2000).

The soils in Accra consist of four main groups;

- Drift materials resulting from deposits by windblown erosion.
- Alluvial and marine motted clays of recent origin derived from underlying shales.
- Residual clays and gravels derived from weatheredquartzites, gneiss and schist rocks.
- Lateritic sandy clay soils derived from weathered Accraian sandstone bedrock formations.

Alluvial 'black cotton' soils are found in many low lying poorly drained areas CEPA (2000). These soils have a heavy organic content which readily expands and contracts, hence causing major problems to foundations and footings. In some areas, lateritic soils are strongly acidic and also cause major problems to foundations and footings, however, near the foothills are the large areas of alluvial laterite gravels and sands.

3.1.6 Seismicity

Accra, with a growingnumber of large industrial activities is located in the earthquake-prone zone. Bacon and Quaah (1981) stated that, most of the earthquakes experienced in Ghana occurred in the western part of Accra at the junction of the two major fault systems (the coastal boundary fault and the Akwapim fault zone).

In 1858 an earthquake was reported to have been felt in Accra Ambraseys and Adams (1986). In 1862 an earthquake with magnitude 6.5 struck Accra and caused considerable damage to many important structures Quaah (1980) and Ambraseys and Adams (1986). Two severe shocks rocked Accra in 1871 and 1872 Ambraseys and Adams (1986) whilst Junner (1941) reported of similar shocks in 1883, 1907 and 1911.

The most destructive earthquake in Ghanathat caused a lot of damage to property and loss of life occurred in 1939 and was assigned a magnitude of 6.5 Junner (1941). The intensityof the shock was greatest in James town (a suburb of Accra), killing 17 people and injuring 133 people Junner (1941). In 1964 and 1969 earth tremors of magnitudes 4.5 and 4.7 respectively were felt in Accra Quaah (1980).

The latest tremor, of magnitude 4.8 which was felt in all the regional capitals, occurred in 1997 Amponsah (2002). Specifically, Ayetey (1988) in zoning Ghana positioned Accra in the highest risk area (zone 4) whilst the northern part of Ghana was located in the lowest risk zone (zone 0). Ayetey (1988) further listed the seismically active areas in Accra to include; McCarthyHill, Weija, Bortianor, Oblogo, James /Ussher Town and all towns along the coast.

3.1.7 Economy of the study area

Notwithstanding the economic boom, there exist a number of challenges; high unemployment levels of about 16% and increasing urban poverty. Indeed, while poverty in Ghana is generally reducing (from 39.5% in 1998/99 to 28.5% in 2005/06), that of Accra is increasing (from 4.4% in 1998/99 to 10.6% in 2005/06) WDI (2008) and ADI (2008).

3.1.8 Mobile technology use

According to GSS PHS (2010), only 2.3% of households in Ghana have fixed telephone lines whilst ownership of mobile phones by individuals is much higher in Greater Accra region (73.5%) followed by Ashanti region (56.1%). Additionally, 7.9% of households in Ghana own either laptops or desktop computers with Greater Accraregion leading by 16.8% followed by Ashanti region with 9.3%. Urban dwellers are more likely to own mobile phones (63.4%) and use the internet (12.7%) than rural dwellers (29.6% and 2.1% respectively).

3.1.9 Private import

Private importers (travelers who enter the country with EEE that are not declared at customs)importing several tons of EEE have been estimated by Amoyaw-Osei et al. (2011) as detailed in Table 3.1 (a).

Indeed Amoyaw-Osei et al. (2011) emphasized that the statistics from GIS and CEPS are gross under-statements and estimated that, about 5.7 million mobile phones become obsolete every year in Ghana (see also table 3.2).

Table 3.1 (a): CEPS Import Data in units (2006-2009)

EEE	**2006**	**2007**	**2008**	**2009**
Mobile phones	61,000	860,000	175,000	34,000
PCs/Laptops	187,000	125,000	23,000	151,000

Source: Amoyaw-Osei et al. (2011).

Table 3.1 (b): Estimated Undeclared Private Imports through KIA; Private Imports in Units and Tons (2009)

Equipment	Passengers Import	Number of Units	Tons
Laptop	10%	52'500	184
Mobile Phone	50%	262'500	131
Camera	10%	52'500	37
DVD Player	10%	52'500	263
Game Console	10%	52'500	630
MP3 Player	10%	52'500	11
TOTAL	100%	525,000	1'255

Source: Amoyaw-Osei et al. (2011).

10% means that percentage of all people arriving at Kotoka import one Laptop. The 50% for mobile phones implies, that probably 10% bring 5 phones or 5% bring 10 phones at once (not that 50% bring one phone).

Table 3.2: Installed Base (from consumer surveys) of some EEE (units and tons, 2009)

Installed Base (units)	Private	Enterprises	Institutions	Total (units)	Total (tons)
PC	622'000	471'000	367'000	1'460'000	32'000
Laptop	283'000	70'000	97'000	450'000	1'600
Mobile Phone	17'351'000	N/A	N/A	17'351'000	8'700

Source: Amoyaw-Osei et al. (2011).

3.1.10 Soil Sampling Site

The settlement of Agbogbloshie (Old Fadama) consists of about 6,000 families or 30,000 people, situated on the left bank of the Odaw River, and in the upper reaches of the Korle Lagoon in Accra Amoyaw-Osei et al. (2011). There are at least four different socio-economic factorsthat drive the establishment and growth of AgbogbloshieAmoyaw-Osei et al. (2011).

They include:

- Spill-over population associated with the size and growth of the adjacent market;
- Migration from the north of Ghana, as an outcome of tribal conflict;
- Social downward movement by those forced out of more expensive areas in Accra, partly attributable to the impact of the Structural Adjustment Programme initiated in the early 1980s; and

- Cheaper settlement area free from bureaucratic constraints and high rentals in recognized formal areas in Accra.

The Agbogbloshie site started as a food stuff market for onions and yam. Over the years it has grown into a slum with people dealing in all kinds of scrap, and a dumping ground for old electrical and electronic products and household waste (fig 3.3). The scrap yard has grown steadily into a popular recycling area for WEEE. Hundreds of tons of WEEE end up at Agbogbloshie every month, where they are broken apart to salvage Cu, Fe, Pb, Ni and other metallic components.

In order to quantify soil and ash as well as sediment contamination in Agbogbloshie and Korforidua, Greenpeace Research Laboratories carried out a sampling campaign Bridgen et al. (2008). The two soils and ashes samples with the highest contamination, taken at burning sites in Agbogbloshie showed Cu, Pb, Sn and Zn concentrations over 100 times higher than typical background levels. Concentrations of Sb and Cd exceeded typical background soil levels by around 50 times for Sb and 5 times for Cd. The sample taken from an open burning site in Korforidua showed similar metal contents, which could lead to the conclusion that similar materials were burnt Bridgen et al. (2008).

Figure 3.3: Location and size of the Agbogbloshie scrap yard

3.2 Data Collection

The main feature of any exposure assessment activity is quantitative estimation MacIntosh and Spengler (2000). However, current approaches to quantitative estimation have included personal measurements or environmental monitoring, modeling and the use of questionnaires MacIntosh and Spengler (2000). Questionnaires are more frequently used to give complementary data to the actual exposure assessment Zartarian et al. (2005).

The techniques employed for data collection in this study are;

- Observation
- Radiation Measurements
- Noise Measurements
- Soil analysis for heavy metals
- Administering of questionnaires

3.2.1 Observation

Visual information assessment (observation) is associated with landscape planning activities and is considered very important since it is impossible to be performed with the help of software tools Clay and Smidt (2004). On site observations were done to visually assess the use of warning signs at BSs and also the compliance to local and international regulations governing the mounting of BSs.

3.2.2 Radiation Measurements

BSs for the study were selected based on their nearness to residential areas. The technique by Amoako et al. (2009) and Kuhn (2009) in assessing RFs within the vicinity of BSs was used in this study. Eighty (80) BS sites at residential areas in Accra were randomly selected for radiation measurements. The locations of some mobile telecommunication BSs within Accra where radiation measurements were performed are in Appendix A. The equipment used for the study was a stop watch, an Anritsu Spectrum Masterand a log periodic antenna. Data from the Anritsu Spectrum Masterwere loaded on to a laptop computer. At each BS, the measurements were done at randomly strategic positions within the vicinity during the peak periods (when most calls are done) for 6 minutes.

According to Amoako et al. (2009) the peak periods during the day are between 10.00a.m. and 1.00p.m. and in the evenings are between 4.30p.m. and 7.30p.m.

A global position system (GPS), Oregon 200 manufactured by Germin Limited was used to record the geographic coordinates of the BSs and the locations where radiation measurements were performed (Appendix A).

The calibrated spectrum analyzer (Anritsu's Spectrum Master) with serial number MS2721B was used to display and/or record the electric field strength versus frequency. The spectrum analyzer measures the electric or magnetic field strength from one or more sources in a "narrow" frequency band.

The spectrum master was connected via a coaxial cable to the antenna located at a height of 1.5m above the ground so as to maintain a direct line of sight with the RF source Amoako, et al. (2009). The log periodic antenna was mounted on a non-conductive tripod stand and connected via a lead shielded coax cable to the Anritsu Spectrum Master MS2721B. The antenna cable was matched to the receiver input impedance as well as to the antenna load impedance. All other properties especially of the antennas (general electrical and mechanical properties) were not considered for this study.

The set up was allowed 5 minutes to warm up; whilst the field assistants from the GAEC retreated a distance of at least 4 m from the antenna to prevent perturbation of the field around the antenna. RF measurement was made directly at a point in space and at a time where there was no interception of radiation.

GPS coordinates of locations of and from BSs were taken using the Geo explorer whilst ELF measurements were taken from antennae at BSs using the Anritsu's Spectrum Master and the readings recorded.

The cable loss and the antenna factor were then added using equation 3.1

$$F = U_{RX} + K + A_k \tag{3.1}$$

where,

F is the field strength level in dBμV/m

U_{RX} is the receiver input voltage across 50Ω in dBμV

K is the antenna factor in dB/m

A_k is the cable loss in dB

The field strength level F in dBμV/m was then converted to E in V/m using the relation in equation 3.2

$$E\ (V/m) = 10^{(F-120)/20} \tag{3.2}$$

where,

F is the field strength level, in dBμV/m from equation 3.1

The power density at each location was calculated using equation 3.3 (FCC, 1997).

$$S = \frac{E^2}{377} = 377H^2 \tag{3.3}$$

where,

S = power density in W/m^2

E = electric field strength in V/m

H = magnetic field strength in A/m

3.2.3 Noise Measurements

A digital sound level meter with model number AZ8928 which could measure sound levels within 4 ranges; 40-70dB, 60-90dB, 80-110dB and 100-130dB was used for the measurement of sound levels. Noise levels were measured at 16 BSs in the evenings (22:30pm to 23:30pm) to ensure that the only source of noise was the generator set at the BS.Noise levels or intensities were measured directly from the digital sound level meter at specific distances from BSs (20m, 50m, 100m and 150m). A technique ISO (1975) to hold the sound level meter at arm's length in the direction of the sound to minimize the reflection of sound from the body was observed to increase consistency. The wind direction (WSW) and average wind speed (8-16 km/hr) AMA (2010-2013) which is less than 24km/h therefore made all measurements valid. At any specific radius, four (4) readings were recorded at approximately the geographical N, S, E and W positions (Appendix B). Measurements were recorded only when a stable minimum and maximum noise levels were observed. BSs with initial (at 20m radius) levels less than the permissible noise level of 48dB set by the EPA from 22:00pm to 6:00am were not recorded in the study. The essence of measuring noise level was to determine the extent to which noise from generator sets complied with the EPA standards (compliance coefficient).

3.2.4 Soil analysis for heavy metals

Other studies have used ashes for this analysis; however, this research considered the claim by Lapa et al. (2002) that, the chemical characterization of ash does not necessarily reveal its toxic properties. Therefore, the top soil was deemed as very appropriate as WEEE are deposited at backyards and also on farmlands, hence releasing heavy metals into the soil which are subsequently absorbed by plants.

Three sites A, B and C with heavy deposits of used computers/laptops/mobile phones were identified and soil samples taken at a depth of 8cm Jarup (2003) for laboratory analysis at the chemistry department of the GAEC. A Grid Cell Sampling Technique Mallarino and Wittry (2001) and Rains and Thomas (2001), involving specifically a regular systematic sampling grid scheme Franzen (2011) and Mylavarapu and Lee (2011) was used to increase experimental consistency. The coordinates of soil sampling points at sites at “Agbogbloshie” can be found in Appendix C. The sizes of sites A, B and C as well as the blocks used were as follows; site A-total area of site is 25m X 9m whilst each block is 5m X 3m, site B- total area of site is 30m X 15m whilst each block is 6m X 5m and site C-total area of site is 40m X 21m whilst each block is 8m X 7m (Fig 3.4).

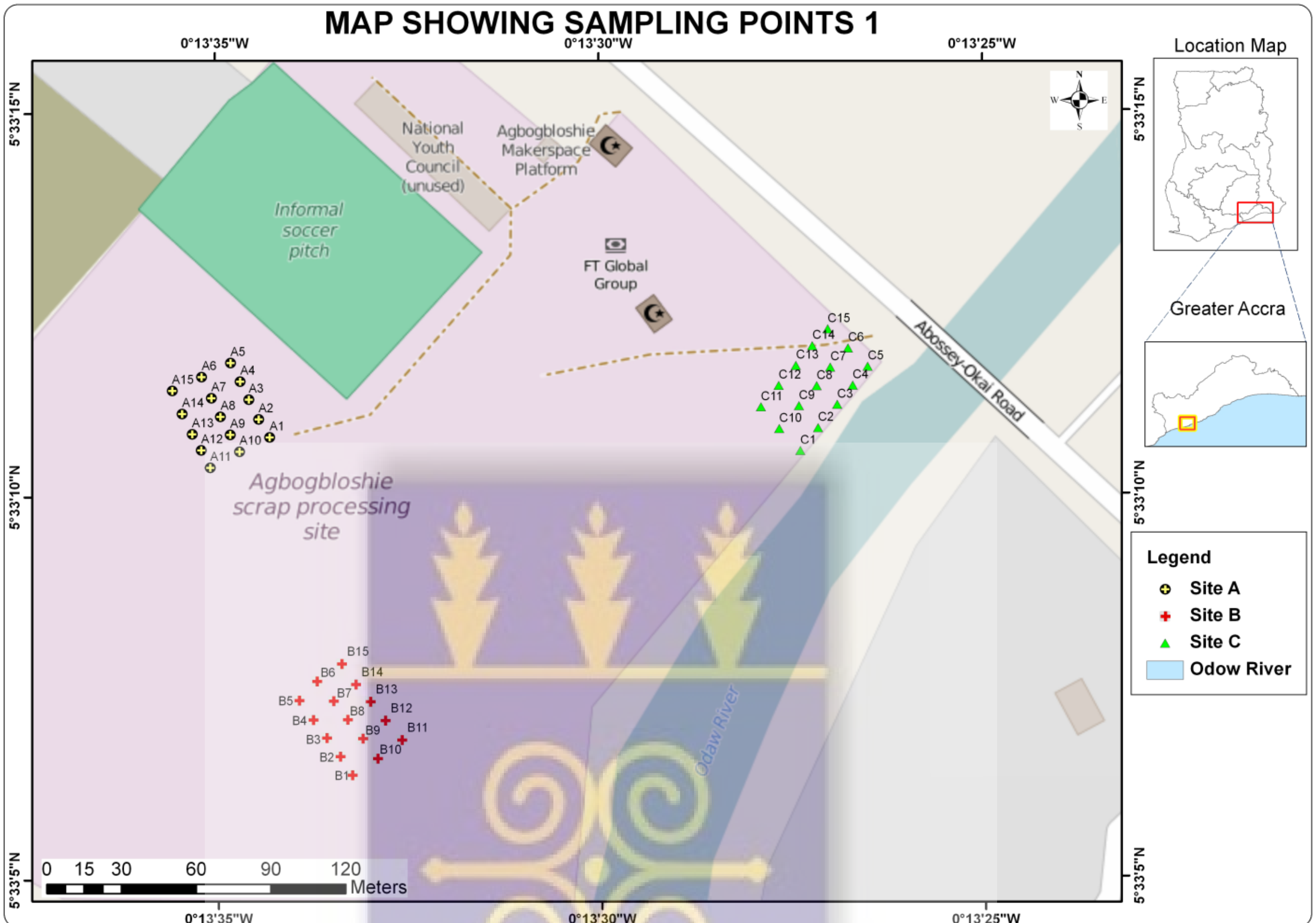


Figure 3.4: Map showing soil sampling points at "Agbogbloshie"

3.2.4.1 Digestion protocol for soil sample using milestone acid (Atomic Absorption Spectrometry)

The digestion method for heavy metal analysis was used to determine the presence and levels of specific heavy metals in soil samples. The digestion involved the following steps;

- 1.5g of each sample was weighed into a Teflon beaker.
- 6ml of HNO_3 (65%), 3ml of HCl (35%) and 0.25ml of H_2O_2 were added to each sample, covered tightly in Teflon bombs and loaded onto the rotor using the

wrench or torque. The rotor with the Teflon bombs was placed in the ETHOS 900 Microwave Digester and Digested using the below microwave Program (Report Code: 308)

MICROWAVE PROGRAMME

STEP	TIME (min)	POWER (W)	PRESSURE	TEMP °C 1	TEMP °C 2
1	00:05:00	250	100	400	500
2	00:01:00	0	100	400	500
3	00:10:00	250	100	400	500
4	00:05:00	450	100	400	500

VENT: 00:05:00 ☐ **Rotorctrl on** ☐**Twist on**

The complete assembly was microwave irradiated for 21 minutes using the Milestone Microwave Labstation Ethos 900, MLS-1200 Mega. Ref: Milestone Acid Digestion Cookbook update 1st January 1996.

After digestion, the Teflon bombs mounted on the microwave carousel were cooled in a water bath to reduce internal pressure and allow volatilized material to re-stabilize. The digestate was diluted up to 20ml (nominal volume) with double distilled water and assayed for the presence of Fe, Hg, Ni, Cd, Cr, Cu, Zn, Pb and As.

Reference Standards for the elements of interest, blanks and duplicates of the samples were digested under the same conditions and procedures as the actual samples were digested. These served as internal positive controls. Reference standards used are from FLUKA ANALYTICAL, Sigma-Aldrich Chemie GmbH, a product of Switzerland.

The following Quality Control and Quality Assurance (QC/QA) measures were employed during the analysis;

- BLANKS: They are to check contaminations during sample preparation.
- DUPLICATES: To check the reproducibility of the method.
- STANDARDS: To check the efficiency of the equipment used.

The Basic Principles of Atomic Absorption spectroscopy can be expressed by three basic statements;

- All atoms can absorb light. The wavelength at which light is absorbed is specific for each element. If a sample containing Ni, for example, together with elements such as Pb and Cu is exposed to light at the characteristic wavelength for Ni, then only the Ni atoms will absorb this light.
- The amount of light absorbed at this wavelength will increase as the number of atoms of the selected element in the light path increases, and is proportional to the concentration of absorbing atoms.
- The relationship between the amount of light absorbed and the concentration of the analyte present in known standards can be used to determine unknown concentrations by measuring the amount of light they absorb.
- The elemental concentration was calculated employing the equation below:

Conc. (mg/kg) = Conc (mg/L)*(Nominal Volume)/Sample weight (g).

Sample weight = 1.5g

Nominal Volume = 20ml

3.2.4.2 Statistical Analysis

This was done using Analysis of Variance (ANOVA), Pearson correlation analysis, Principal component analysis (PCA), Hierarchical cluster analysis (HCA) and Cluster analysis (CA) using SPSS (version 20) software package (SPSS Inc., Chicago, IL) for windows.

3.2.5 The use of questionnaires

The decision to use questionnaire for the study was based on the numerous advantages of using questionnaire surveys Zartarian et al. (2005). The advantages include; responses being gathered in a standard manner, the speed of collecting information using questionnaires and the quantifiable and reliable information obtained that can be generalized for a larger population. Zartarian et al. (2005) mentioned some disadvantages of questionnaires; open ended questions generate large amounts of data that can take a long time to process and analyze, and the superficial answers provided by respondents if questions take a long time to complete.

The questionnaire survey consisted of both opened and closed ended questions Bond et al. (1998) and May (2001). Questions investigated the possibility of a significant difference between selected parameters with distance from a BS within the study area.

Reliable primary information was gathered from major stakeholders;

- MMDA in Accra.
- Residents who have lived within a radius of up to 150m from BSs for at least a period of 5 years were targeted. At least 8 individuals were selected from each BS site.
- Government institutions in charge of environmental protection.

All the above mentioned sources and other nonconventional sources of information were collaborated to ensure reliability.In situations where different sources presented contradictory views, judgment was based on objectivity and preponderance of evidence as well as technical and professional knowledge on EIA.

Indeed, to unravel the current and local issues in a study area, community participation and consultation is identified to be more important Andrew et al. (2009). One of the key characteristics of SEA is an emphasis on the use of participatory and consultative processes with those who are to be affected by the proposed policy, plan or program Ahmed et al. (2005) and Kjorven and Lindhjem (2002).

Practice in this regard is, however, just emerging in developing countries and currently researchers are testing community-based approaches to SEA for achieving more meaningful local participation Sinclair et al. (2009).

3.2.5.1 Designing of questionnaires

Following the evaluation of methods in some countries' EIA system, Wood (2003) proposed "method and 14 point criteria" was adopted (Appendix D). This technique was based on effective EIA best guidance practices, with questions directed to the components and requirements of a country's EIA system, as well as the system's capacity to influence decision making. Wood (2003) proposed “method and 14 point criteria” was juxtaposed against the Ghanaian procedures, to enable potential weaknesses and areas for improvement to be identified. Based on the environmental concept of community participation or involvement, personal opinion was also factored into the designing to seek information from residents living closer to BSs.

3.2.5.2 Questionnaires at residential areas

3.2.5.2.1 Sampling procedure

The study design is qualitative based, using prospective cohort approach targeting;

- Parents with children below 15years of age who have lived near BSs for at least 5years.
- Individuals who were in residence before BSs were mounted.
- Landlords

Individuals who were in residence before BSs were mountedwere selected as researchers have argued that, any effective EIA procedure should involve public participation Wood (2003) though, Palerm (1999) observed that, this has been a mere formality.

Again, long-term consequences of early exposure as precursors for later onset of adult disease IPCS (2001) prompted the involvement of landlords and parents with children below 15 years of age who have lived near BSs for at least 5 years.Indeed, Etzel (2003) and Brent et al. (2004) have identified children as a sensitive subgroup of the population hence, necessitating the need for monitoring sentinel health end-points.

Proximity to sources, either natural or anthropogenic, is an important determinant for exposure to environmental contaminants McGee et al. (2002). Studies by Petts and Eduljee (1994) and

Loscher and Kas (1998) stressed on distance as a critical factor in terms of the siting of certain sensitive facilities.

Hence BSs were defined by circles with a radius of 20m, 50m, 100m and 150m (Appendix B). The sampling procedure was chosen after a preceding feasibility study to obtain at least 8 samples in a specific study area (November 2013 to January, 2014; n = 144 parents). The sample area was not very extensive because the research objective was to undertake a deep case-oriented analysis which some researchers have argued require few samples Sandelowski (1995).

Data collection at 13 residential areas on household basis was carried out using the purposive sampling technique (Thurstone, 1959) which is expected to involve individuals who are "information rich" Patton (1990) and Creswell (2002).

The snowball sampling technique Goodman (1961) was also used as participants' were encouraged to suggest next potential interviewees.

3.2.5.2.2 Approach to administering questionnaires

Respondents were informed that their responses were only for academic purposes; as such their views were anonymous. The questions were then asked systematically and answers given by respondents were written on the questionnaire. Leading questions such as asking respondents if they knew that radiation causes cancer were avoided. This was necessary as it could adversely affect performance by leading respondents to exceedingly focus on a few facts or ideas to the exclusion of other important information Proctor and Van Zandt (2008). Appendix E shows the questionnaire used for collecting data at residential areas.

Interviewing an expected sample size of 200 people "on-site" mainly on Saturday mornings was a substantial task. To maximize time efficiency, a total of 6 research assistants were recruited for the data collection. At the end of each working day, all collected questionnaires were reviewed (by the Researcher and the Field Assistants) and responses that were not clearly written on the questionnaires were discussed with the respective research assistants.

To obtain information on perception of potential health impacts and scope of assessment, self-completion questionnaires provide an appropriate method for finding out the current situation in a particular field of study Bond et al. (1998) and May (2001). Figure 3.5 shows locations where questionnaires were administered in Accra.

3.2.5.3 Government Institutions

The EPA and the NCA participated in this research work by responding to the same set of questions. The Researcher introduced himself to the heads of departments (at the headquarters) in charge of issuing permits to the operators and also submitted the questionnaires to them. The Researcher and the heads of departments then decided on a convenient date for the collection of data and also any possible informal discussions. Appendix E shows the questionnaire used for collecting data at the EPA and the NCA.

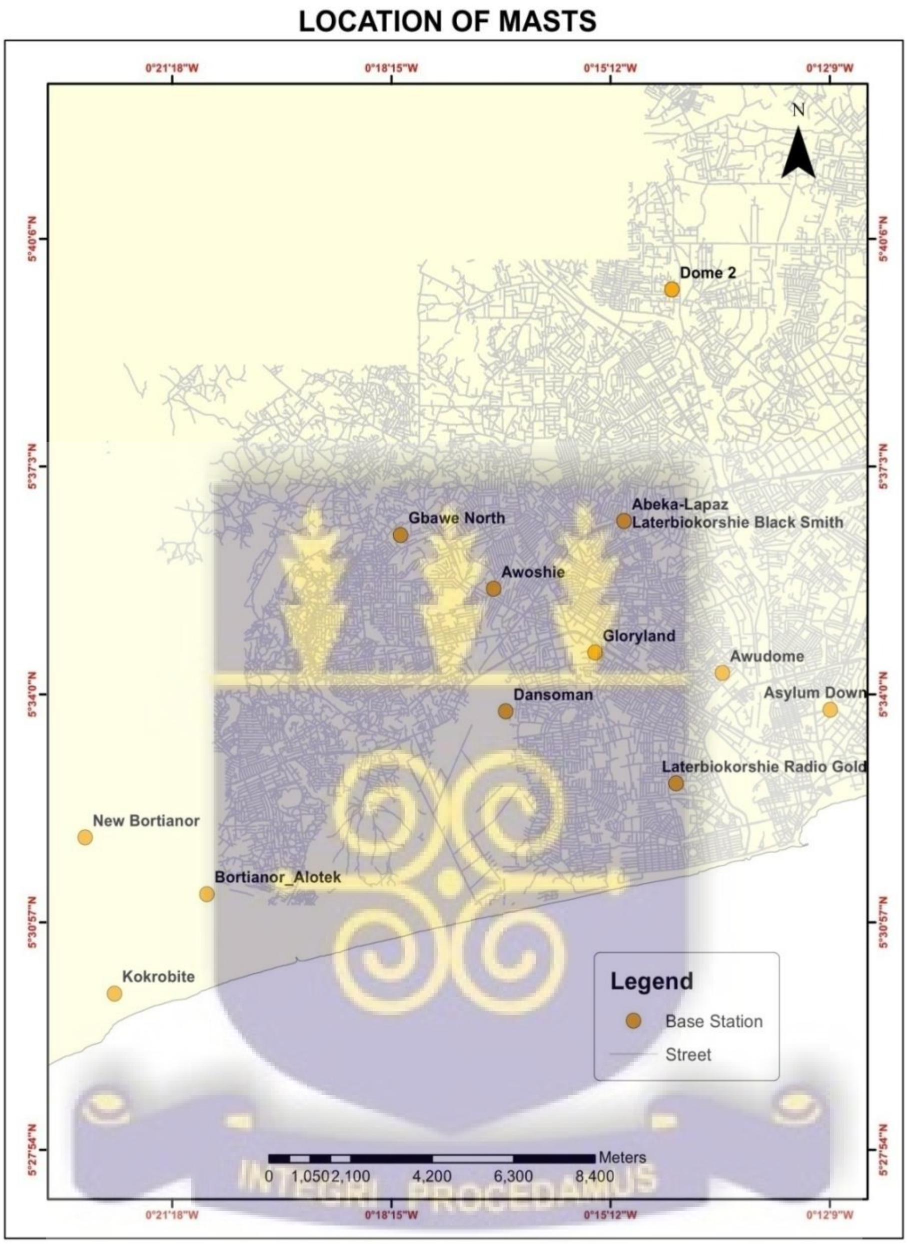


Figure 3.5: BSs at residential areas in Accra where questionnaires were administered

3.2.5.4 MMDA

Table 3.3 indicates all the assemblies in Accra as well as the departments that participated in the research work. MMDA that did not participate in this research work directed the Researcher to the EPA. Again, the Researcher introduced himself to the heads of the relevant departments (town planning and engineering) and also submitted the questionnaires to them. The Researcher and the heads of departments then decided on a convenient date for the collection of data and also any possible informal discussions. Appendix E shows the questionnaire used for collecting data at the MMDA.

3.3 Ethical Considerations

According to Babbie (2005) a study should be conducted in conformity with ethical standards in social research. Therefore, this study was conducted by ensuring voluntary participation, causing no harm to the participants, anonymity, confidentiality and compliance with other codes of ethics. Additionally, informed consent of interviewees was sought before the interview schedules were administered. Other codes of ethics regarding accuracy of research design, data collection and processing, as well as acknowledging sources of information have been adhered to in this study.

Table 3.3: MMDAs in Accra which participated in the research work.

MMDAs	CAPITAL	TOWN PLANNING DEPARTMENT	WORKS DEPARTMENT
Ga South	Weija	X	X
Ga Central	Sowutuom	X	√
Ga West	Amasaman	√	X
Ga East	Abokobi	√	√
La Nkwantang-Madina	Madina	√	X
Adentan	Adentan	√	√
AMA	Accra	√	X
La Dade-Kotopon	La	X	X
Ledzokuku-Krowor	Teshie-Nungua	X	X

Source: Field Survey Data, 2014

Where "√" represents assemblies that took part and "X" represents assemblies that did not take part in the research

3.4 Data Analysis

The Researcher and Field Assistants made notes from their observations and interactions with the respondents. These notes along with the interviews and discussions with key informants and other information gleaned from secondary sources were collated and edited for consistency.

An overview of the open-ended responses in the questionnaire was critically performed. A coding manual was prepared after a careful categorization of responses into thematic areas. Each response was assigned a numeric code which was used in coding the questionnaire.

Data analysis was executed with the aid of a professional software programme -The Statistical Product for Service Solutions (SPSS) package. The data analysis consists of categorizing, examining, tabulating, testing or otherwise recombining both quantitative and qualitative evidence to address the initial proposition of the study. In essence, data analysis involves turning a series of recorded observations into quantitative and descriptive statements for practical application. Both descriptive and inferential statistical techniques (Chi-square) were used to analyze the datafor comparison between groups at 0.05 (95%) level of significance. Descriptive statistics such as frequencies with percentages and cross tabulations to examine relationships were the basis for the presentation and interpretation of the results.

3.5 Application of the parametric model to the study

The parametric approach is deemed very applicable to this research as it;

- Starts from the perspective of limited data.
- Comprises IBMs.
- Aims to estimate the complete vulnerability value of a system.

All the significant characteristics mentioned above are perfectly required in the long term to entirely provide details to clarify the myth or otherwise surrounding the MTT.

However, the specific model to be designed is based on risk vulnerability as concluded either on perception or on scientific evidence or on both by a well-informed individual. Therefore, considered as an IBM developed "bottom-up" Grimm (1999) describing a system (an index) from the individual's point of view Lomnicki (1988) and DeAngelis et al. (1994).

The design is focused on the FVI equation developed by Balica et al. (2009) as sited earlier, equation (2.1);

$$\text{FVI} = \frac{E*S}{R} \qquad (3.4)$$

The indicators that increase the FVI are therefore placed in the nominator whilst those that decrease the FVI are placed in the denominator Dinh et al. (2012).

The risk vulnerability index of the MTT will therefore be represented as;

$$\text{RVI} = \sum (\text{indicators that increase the RVI}) \text{ duration} \qquad (3.5)$$

$$\text{RVI} = \sum (X_1 X_2 X_3 X_4 X_5 \ldots\ldots\ldots\ldots X_n)\, y \qquad (3.6)$$

where; X_n represents the last identified indicator that can increase the RVI and y represents the number of years the indicators (variables) have persisted.

When y values vary significantly, then equation (4.6) can be expanded as;

$$RVI = (X_1y_1+X_2y_2+X_3y_3+X_4y_4+X_5y_5…….. X_ny_n) \quad (3.7)$$

Bertrand (2005) studied movement patterns in Accra and argued that, "as time passes and individuals age, stability becomes more of the norm and the tendency to relocate diminishes. This therefore suggests that, the duration "y" is likely to increase the cumulative effect.

Additionally, findings suggest that X_n may also alter as risk perceptions vary over time and are interpreted on the basis of visible contamination, cognition and context Collins et al. (2006).However, it should be noted that, the construction and use of environmental risk indices have been widely documented in literature Alister and Kogan (2006), Mendoza and Izquierdo (2009), Xu and Liu (2009) and Senese et al. (2010).

In reality, the role of risk perception is an important factor in determining the capacity of individuals and communities to reduce vulnerability to risk WHO (2002).

CHAPTER FOUR

4.0 RESULTS

4.1 Observations made at selected BSs

The following remarks can objectively be made after visual assessment at some BSs;

- Some BSs do not have warning signs.
- Some BSs do not have aerial lamps.
- Some BSs have traces of fuel on their concrete platforms.
- Some BSs are less than 20m from the nearest residential structure.

Figure 4.1 Traces of fuel on the concrete floor of a BS.

4.2 Radiation levels in the vicinity of BSs

Table 4.1: Radiation levels recorded in the vicinity of BSs

AWUDOME N05°34.289´,W000°13.646´			
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N05°34.297´,W000°13.654´	21.25m	5.29E-03	6.97E-04
B N05°34.322´,W000°13.602´	101.94m	7.76E-03	3.47E-03
C N05°34.297´,W000°13.603´	81.19m	1.01E-02	1.23E-03
D N05°34.246´,W000°13.655´	80.73m	2.43E-06	7.77E-04
E N05°34.276´,W000°13.679´	66.18m	4.43E-03	5.91E-04

ASYLUM DOWN N 5.56327075, W 0.20241766			
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N5°33'47.74",W0°12'09.14"	13.94m	1.06E-03	1.07E-01
B N5° 33'47.82",W0°12'09.11"	12.7m	2.95E-03	4.64E-01
C N5°33' 47.66",W0°12'08.82"	5.07m	5.20E-03	5.60E-01
D N5° 33'47.82",W0°12'08.93"	7.29m	4.64E-02	3.64E-01
E N5° 33'48.30",W0°12'07.65"	36.07m	6.52E-02	2.50E-02
F N5° 33'48.32",W0°12'08.65"	17.02m	5.29E-03	4.14E-02
G N5° 33'49.32",W0°12'08.10"	51.24m	3.11E-01	4.11E-02

DANSOMAN N5°33.774´, W0°16.659´			
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N5°33.789´,W0°16.652´	31.64m	1.63E-02	1.58E-06
B N5°33.825´W0°16.650´	96.62m	1.78E-02	1.58E-06
C N5°33.796´W0°16.604´	111.48m	1.78E-02	2.45E-02
D N5°33.791´W0°16.563´	180.65m	2.33E-02	1.58E-04
E N5°33.742´W0°16.538´	232.92m	3.44E-02	1.58E-04

GBAWE NORTH N5°36.136´, W0°18.121´			
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N05°36.131'W000°18.126'	13.47m	3.59E-02	1.58E-04
B N05°36.164'W000°18.103'	62.66m	2.47E-02	1.58E-02
C N05° 36.202'W000°18.190'	177.56m	2.11E-02	1.58E-04
D N05° 36.153'W000° 18.250'	240.96m	1.59E-02	1.58E-04
E N05° 36.115'W000° 18.289'	311.75m	1.68E-02	1.58E-04

KOKROBITE	N05°29.997´,W000°22.104´		
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N05°29.999´W000°22.414´	578.19m	1.65E-03	5.98E-04
B N05°29.047´W000°22.072´	1023.73m	6.33E-04	7.63E-05
C N05°29.032´W000°22.157´	434.63m	4.18E-03	5.18E-05
D N05°29.960´W000°22.076´	91.59m	1.74E-03	1.09E-04
E N05°29.920´W000°22.034´	193.55m	3.49E-03	7.29E-05

AWOSHIE	N5°35.415´, W0°16.829´		
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N5°35.419´W0°16.847´	34.64m	2.39E-02	1.58E-04
B N5°35.441´W0°16.822´	49.68m	3.07E-02	1.58E-02
C N5°35.481´W0°16.790´	141.72m	2.15E-02	1.58E-04
D N5°35.391´W0°16.817´	51.72m	2.24E-02	1.58E-02
E N5°35.373´W0°16.852´	88.59m	1.54E-02	1.58E-02

LATERBIOKORSHIE RADIOGOLD	N5.54680403, W0.23818963		
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N5º 32’ 48.94”W0º 14’17.93”	18.82m	3.61E-03	5.66E-04
B N5º 32’ 48.45”W0º14’18.13”	20.28m	7.70E-02	8.70E-04
C N5º32’ 48.98”W0º 14’17.68”	16.66m	5.63E-04	9.68E-04
D N5º 32’ 49.62”W0º 14’17.81”	36.43m	6.22E-04	5.32E-04
E N5º 32’ 49.60”W0º 14’21.36”	125.51m	3.54E-04	2.17E-04
F N5º 32’ 46.71”W0º 14’18.75”	67.21m	2.23E-03	2.02E-04
G N5º 32’ 46.36”W0º 14’18.24”	70.29m	4.16E-04	2.16E-04

BORTIANOR ALOTEK	N05°31.327´, W000°20.817´		
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N05°31.333´W000°20.808´	20.83m	2.58E-02	2.14E-02
B N05°31.387´W000°20.806´	112.29m	5.00E-02	2.79E-02
C N05°31.422´W000°20.885´	215.98m	4.30E-02	2.75E-02
D N05°31.439´W000°20.796´	211.67m	1.91E-02	2.02E-02
E N05°31.479´W000°20.918´	337.24m	1.68E-02	1.78E-02

GLORYLAND	N5°34.560´, W0°15.417´		
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N05° 34.597'W000°15.359'	126.22m	8.10E-03	2.63E-02
B N05° 34.566'W000°15.337'	150.13m	3.30E-02	3.46E-02
C N05° 34.521'W000°15.346'	150.43m	1.49E-02	1.58E-04
D N05° 34.572'W000°15.474'	111.47m	4.30E-02	1.58E-04
E N05° 34.572'W000°15.510'	181.17m	3.21E-02	3.46E-02

DOME 2	N05°39.420´, W000°14.346´		
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N05°39.419´W000°14.345´	3.48m	5.20E-03	2.71E-04
B N05°39.360´W000°14.333´	113.14m	7.91E-03	2.00E-03
C N05°39.364´W000°14.378´	118.83m	2.11E-02	3.22E-04
D N05°39.410´W000°14.385´	73.37m	2.10E-03	1.66E-04
E N05°39.450´W000°14.364´	64.85m	5.71E-03	1.30E-03

LATERBIOKORSHIE BLACKSMITH		N5.60537000, W0.25021000	
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N5º32'49.49"W0º14'46.45"	135.34m	2.48E-04	2.45E-04
B N5º 32'49.14"W0º14'46.35"	142.16m	3.91E-04	1.99E-04
C N5º32' 49.13"W0º14'46.20"	194.36m	3.56E-03	2.56E-04
D N5º 32'48.12"W0º14'46.92"	185.84m	1.89E-04	2.00E-04
E N5º 32'48.10"W0º14'44.68"	85.36m	1.72E-04	2.17E-04

NEW BORTIANOR		N5°32.086´, W0°22.512´	
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N05°32.083'W000°22.514'	7.25m	1.00E-02	1.58E-02
B N05°32.082'W000°22.540'	53.53m	1.86E-02	1.58E-02
C N05°32.077'W000°22.483'	59.04m	1.95E-02	1.58E-02
D N05°32.065'W000°22.447'	125.82m	5.68E-02	1.58E-04
E N05°32.113'W000°22.454'	117.41m	3.42E-02	1.58E-04

ABEKA LAPAZ	N5.60537, W0.25021		
MEASUREMENT POSITIONS	DISTANCE FROM BASE STATION	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
A N5º36’21.32”W0º14’56.83”	135.05m	2.57E-01	3.87E-01
B N5º 36’21.50”W0º14’56.73”	140.16m	6.81E-04	4.86E-01
C N5º 36’22.84”W0º14’55.50”	194.76m	2.23E-07	4.53E-02
D N5º 36’21.39”W0º14’55.09”	185.46m	5.36E-04	6.86E-02
E N5º 36’20.59”W0º14’58.28”	86.73m	6.18E-02	7.10E-02

Source: Field Survey Data, 2014

4.3 Mean noise levels at specific distances from BSs

Table 4.2: Mean noise levels (dB) recorded at specific distances from BSs, ** indicates values < 40

BS site	20m	50m	100m	150m
A	66	52	**	**
B	68	50	**	**
C	76	60	44	**
D	70	58	42	**
E	61	45	**	**
F	67	47	**	**
G	70	60	44	**
H	56	46	**	**
I	51	48	**	**
J	62	50	44	**
K	65	48	**	**
L	54	45	**	**
M	58	50	43	**
N	60	48	**	**
O	57	41	44	**
P	65	58	44	**
Mean	62.9dB	51dB	43.6dB	**

Source: Field Survey Data, 2014.

4.4 Levels of heavy metals in soil samples

Table 4.3: Levels of heavy metals (mg/kg) recorded in soil samples at "Agbogbloshie", ND indicates "not detected".

SampleID	Cr	Cd	Ni	As	Hg	Pb	Fe	Zn	Cu
A1	4.68	2.37	8.98	7.80	0.97	15.15	14.47	1.21	14.81
A2	8.00	1.73	23.79	7.57	0.88	12.31	15.02	1.37	15.55
A3	8.02	3.07	24.62	7.44	0.83	11.50	14.98	1.36	14.88
A4	8.78	1.20	9.97	7.40	0.76	10.40	15.02	1.32	14.80
A5	7.28	1.69	23.69	7.46	1.03	15.15	15.13	1.34	14.73
A6	5.95	1.57	17.82	6.67	0.56	8.26	15.07	1.31	13.70
A7	9.17	1.17	15.72	6.81	0.60	8.78	15.21	1.26	13.71
A8	4.17	0.52	4.17	6.48	0.51	7.22	14.74	1.19	7.36
A9	7.77	1.57	12.00	6.96	0.53	7.69	15.01	1.35	13.96
A10	11.86	10.69	27.61	7.09	0.73	10.38	14.82	1.38	15.15
A11	6.00	0.97	7.16	7.46	0.77	11.88	14.78	1.31	15.35
A12	6.76	1.39	16.46	6.49	0.57	8.23	14.99	1.39	14.59
A13	9.78	1.80	20.10	6.00	0.49	6.40	15.12	1.41	13.73
A14	6.97	1.01	17.04	2.95	0.28	2.06	14.89	1.30	14.47
A15	3.80	0.45	4.05	2.80	0.21	1.69	14.28	1.44	11.59
Mean	7.30	2.08	15.55	6.49	0.65	9.14	14.90	1.33	13.89

Sample ID	Cr	Cd	Ni	As	Hg	Pb	Fe	Zn	Cu
B1	2.93	0.12	2.53	2.72	0.40	2.32	14.19	0.87	11.27
B2	4.63	0.11	3.92	4.81	0.52	3.93	14.60	1.01	10.99
B3	4.37	0.33	4.11	4.40	0.47	3.53	14.82	1.06	11.85
B4	6.43	0.35	8.29	4.51	0.53	4.76	15.09	1.28	6.84
B5	4.96	ND	2.13	2.81	0.16	1.42	14.31	0.69	3.84
B6	11.98	0.08	13.45	4.28	0.44	2.50	14.60	1.38	5.95
B7	6.29	2.13	4.49	4.69	0.39	3.30	14.41	1.37	2.42
B8	9.22	1.23	7.57	6.56	0.63	5.75	14.91	1.27	11.59
B9	5.48	0.17	6.09	1.48	0.09	0.69	18.36	1.13	14.76
B10	3.04	0.04	2.17	8.04	1.17	16.03	13.14	0.34	1.60
B11	7.52	1.56	35.60	6.01	0.53	7.43	15.17	1.41	15.20
B12	4.45	0.29	3.48	1.17	0.37	2.11	14.88	1.08	14.79
B13	3.51	0.32	2.56	1.24	0.40	2.50	16.61	1.02	2.98
B14	5.91	1.83	31.99	4.88	0.44	3.37	14.37	1.44	6.55
B15	3.79	0.53	8.10	4.80	0.51	3.26	14.84	1.15	5.98
Mean	5.63	0.65	9.10	4.16	0.47	4.19	14.95	1.1	8.44

Sample ID	Cr	Cd	Ni	As	Hg	Pb	Fe	Zn	Cu
C1	5.68	0.33	8.30	2.77	0.19	1.17	15.15	1.22	6.24
C2	6.05	ND	2.49	1.67	0.15	1.08	14.55	0.66	2.91
C3	6.72	0.17	8.65	4.99	0.56	4.25	14.59	1.22	10.15
C4	3.93	ND	8.38	4.93	0.51	4.12	14.66	1.15	15.00
C5	6.85	ND	12.42	6.19	0.67	6.94	14.86	1.22	13.55
C6	6.90	ND	13.41	6.55	0.71	5.63	14.91	1.54	12.53
C7	22.83	0.91	23.79	7.06	0.67	10.35	15.01	1.39	14.77
C8	18.24	1.19	22.25	7.73	0.91	14.51	14.97	1.43	15.54
C9	11.92	1.31	26.94	7.64	0.95	13.69	14.97	1.42	15.11
C10	3.76	ND	2.99	4.33	0.40	2.61	14.17	1.00	11.74
C11	2.91	0.13	3.37	4.64	0.29	3.04	13.86	0.90	13.34
C12	2.85	ND	1.89	2.75	0.19	1.19	18.79	0.44	7.35
C13	2.85	0.04	2.19	2.68	0.16	0.77	13.87	0.46	3.05
C14	3.57	0.23	2.35	2.76	0.19	1.49	14.04	0.68	4.50
C15	9.14	0.91	20.35	6.92	0.67	8.83	15.14	1.33	14.63
Mean	7.61	0.58	10.65	4.91	0.48	5.31	14.90	1.07	10.69

Source: Field Survey Data, 2014

4.5 Data from questionnaire responses

4.5.1. Responses from residential areas

Table 4.4: Respondents at selected BSs

BS site	Frequency	Percent
Awudome	13	9.0
Dansoman	10	6.9
Gbawe	14	9.7
Gloryland	13	9.0
Laterbiokorshie (Radio Gold)	12	8.3
New Bortianor	6	4.2
Bortianor Alotek	11	7.6
Abeka Lapaz	14	9.7
Laterbiokoshie (Blacksmith)	10	6.9
Kokrobite	12	8.3
Dome2	10	6.9
Awoshie	12	8.3
Asylum down	7	4.9
Total	144	100.0

Table 4.5: Distance of telecommunication BS from respondents

Distance from BS	Frequency	Percent
20 m radius	40	27.8
50 m radius	35	24.3
100 m radius	35	24.3
150 m radius	34	23.6
Total	144	100.0

Source: Field Survey Data, 2014

Table 4.6 (a): Cross tabulation indicating the relationship between distance and content

		Distance of telecommunication BS from respondents								Total	
		20 m radius		50 m radius		100 m radius		150 m radius			
		Count	%	Count	%	Count	%	Count	%	Count	%
Are you content living closer to a BS?	Yes	5	12.5	5	14.3	16	45.7	25	73.5	51	35.4
	No	35	87.5	30	85.7	19	54.3	9	26.5	93	64.6
Total		40	100.0	35	100.0	35	100.0	34	100.0	144	100.0

Source: Field Survey Data, 2014

Table 4.6 (b): Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	39.231[a]	3	.000
Likelihood Ratio	40.785	3	.000
Linear-by-Linear Association	35.424	1	.000
N of Valid Cases	144		

a. 0 cells (0.0%) have expected count <5. The minimum expected count is 12.04.

Table 4.7 (a): Cross tabulation indicating the relationship between distance and health risk in children

		Distance of telecommunication BS from respondents								Total	
		20 m radius		50 m radius		100 m radius		150 m radius			
		Count	%	Count	%	Count	%	Count	%	Count	%
Have you identified any health risk in your children that you can link to BSs?	Yes	2	5.0	0	.0	0	.0	0	.0	2	1.4
	No	38	95.0	35	100.0	35	100.0	34	100.0	142	98.6
Total		40	100.0	35	100.0	35	100.0	34	100.0	144	100.0

Source: Field Survey Data, 2014

Table 4.7 (b): Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.273[a]	3	.153
Likelihood Ratio	5.198	3	.158
Linear-by-Linear Association	3.267	1	.071
N of Valid Cases	144		

a. 4 cells (50.0%) have expected count <5. The minimum expected count is .47.

Table 4.8 (a): Cross tabulation indicating the relationship between distance and health risk in neighbourhood

		Distance of telecommunication BS from respondents								Total	
		20 m radius		50 m radius		100 m radius		150 m radius			
		Count	%	Count	%	Count	%	Count	%	Count	%
Have you identified any health risk in your neighbourhood that you can link to BSs?	Yes	2	5.0	0	.0	0	.0	0	.0	2	1.4
	No	38	95.0	35	100.0	35	100.0	34	100.0	142	98.6
Total		40	100.0	35	100.0	35	100.0	34	100.0	144	100.0

Source: Field Survey Data, 2014

Table 4.8 (b):Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.273[a]	3	.153
Likelihood Ratio	5.198	3	.158
Linear-by-Linear Association	3.267	1	.071
N of Valid Cases	144		

a. 4 cells (50.0%) have expected count < 5. The minimum expected count is .47.

Table 4.9 (a): Cross tabulation indicating the relationship between consultation and content

		If yes, were you consulted before the siting of the BS?				Total	
		Yes		No			
		Count	%	Count	%	Count	%
Are you content living closer to a BS?	Yes	6	23.1	37	35.9	43	33.3
	No	20	76.9	66	64.1	86	66.7
Total		26	100.0	103	100.0	129	100.0

Source: Field Survey Data, 2014

Table 4.9 (b): Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.541[a]	1	.214		
Continuity Correction[b]	1.018	1	.313		
Likelihood Ratio	1.618	1	.203		
Fisher's Exact Test				.251	.156
Linear-by-Linear Association	1.529	1	.216		
N of Valid Cases	129				

a. 0 cells (0.0%) have expected count < 5. The minimum expected count is 8.67.

b. Computed only for a 2x2 table

Table 4.10 (a): Cross tabulation indicating the relationship between familiarity and highest level of education

	Familiarity with the MTT				Total	
	Yes		No			
	N	%	N	%	N	%
None	2	2.3	0	.0	2	1.4
JHS	2	2.3	7	12.5	9	6.3
SHS	12	13.6	8	14.3	20	13.9
Post-secondary	40	45.5	29	51.8	69	47.9
Tertiary	32	36.4	12	21.4	44	30.6
Total	88	100.0	56	100.0	144	100.0

Table 4.10 (b): Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.795[a]	4	.044
Likelihood Ratio	10.543	4	.032
Linear-by-Linear Association	3.541	1	.060
N of Valid Cases	144		

a. 3 cells (30.0%) have expected count <5. The minimum expected count is .78.

Table 4.11 (a): Cross tabulation indicating the relationship between relocation and landlord or tenant

	Will you relocate when compensated?				Total	
	Yes		No			
	N	%	N	%	N	%
Landlord	6	21.4	62	53.4	68	47.2
Tenant	22	78.6	54	46.6	76	52.8
Total	28	100.0	116	100.0	144	100.0

Source: Field Survey Data, 2014

Table4.11 (b):Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.279[a]	1	.002		
Continuity Correction[b]	8.038	1	.005		
Likelihood Ratio	9.827	1	.002		
Fisher's Exact Test				.003	.002
Linear-by-Linear Association	9.214	1	.002		
N of Valid Cases	144				

a. 0 cells (.0%) have expected count < 5. The minimum expected count is 13.22.

b. Computed only for a 2x2 table

4.5.2. Responses from EPA

The EPA listed its main duties as;

- Conducting screening and site verification
- Preparation of draft schedules and schedules for telecommunication BSs

The EPA maintained that, residents are consulted or educated before the siting of BSs, but suggested that, compensation should be considered for people to relocate as the fear of radiation related effects and the possible collapse of towers still exists in communities.

The EPA stated the possible risks associated with the MTT as;

- Potential collapse of towers and noise from generator sets
- Leakages from fuel tanks and smoke from generator sets

Additionally, the EPA listed the following as complaints received from residents;

- Noise from generator sets and radiation emission from antennae
- No consultation with residents

According to the EPA, complaints are resolved by;

- Investigating to determine whether it merits taking an action, inviting the two parties to resolve the issue and the imposition of penalty for the operator to pay
- Requesting the operator to either fix the problem or remove the structure

The EPA stated that, indeed operators comply with local and international regulations and are also committed to EIA principles, however, the EIA measures implemented have “not fully” attained their expected effects. The plot size and minimum legal distance of BSs from the public and other sensitive installations were mentioned as the major environmental factors considered before permitting BS proposals.

Indeed, the EPA confirmed that, material wastes or products of the MTT are not properly managed.

4.5.3. Responses from NCA

The NCA maintained that, residents are consulted or educated before the siting of BSs and further stated that, there are no possible risks associated with the MTT. The NCA stated that indeed they receive complaints from residents, but did not list the nature of complaints. However the NCA maintained resolving complaints by;

- Analyzing the complaints and investigating immediately
- Filing a formal complaint with the service provider and giving feedback to the consumer.

The NCA stated that, the issue of risk perception among residents living close to BSs still existsbut did not list the nature of risks perceived. Furthermore, the NCA added that, there are no possible risks associated with the MTT. On the other hand, the minimum legal distance for locating BSs from the public was further confirmed by the NCA. Again the NCA stated that, operators comply with local and international regulations. All other questions were either not answered or simply answered "enquire from EPA".

4.5.4. Responses from MMDA:

Table 4.12: Possible risks associated with the MTT and consultation.

Possible risks associated with the MTT			
MMDA	Response	Possible risks	Are residents consulted/educated
Ga East (TP)	Yes	Some of theBSs are mounted without permits in residential zoning	Yes- When permits are acquired No- When permits are not acquired
Adentan (TP)	Yes	Risk of possible collapse of masts in built-up areas eg. A mast (Glo) collapsed, killing two(2) persons working to erect the mast at "Adenta Housing" phase four (4)	No
Adentan (WD)	Yes	1. Normally the risk of collapse of the masts 2. Electromagnetic radiation which is perceived to cause cancer	Yes
AMA	Yes	The effect of the radiation on the health of residents	No
Ga West	Yes	1. Collapse of towers 2. The perceived emission of radiation (harmful)	Yes

Ga Central	Yes	1. Falling of mast towers due to poor supervision in its construction 2. The perceived emission of radiation (harmful)	Yes
Ga East (WD)	No	-	Yes
La Nkwantanang-Madina	Yes	When BSs are constructed without obtaining appropriate development and building permits	Yes

Source: Field Survey Data, 2014

Table 4.13: Complaints from residents close to BSs and methods of resolving complaints

Complaints from residents dwelling close to BSs			
MMDA	Receive complaints from residents?	If yes, what are the complaints?	How do you resolve the complaints?
Ga East (TP)	Yes	Landlords are compensated therefore they lose focus of its future damage	1. Company is ordered to remove structure or to give necessary safety report to minimize risk. 2. Applicant pay penalty for

			mounting without permit
Adentan (TP)	Yes	1.Fears of microwave emissions 2. Possible collapse of masts 3.Noise/vibrations from electric generators	1. Refer to EPA for investigation 2. Defer permit, till issues are investigated and resolved
Adentan (WD)	Yes	1. Fear of structural collapse. 2. Cancerous emissions from BSs.	Involve stakeholders in evaluating permit application.
AMA	Yes	Health issues and security (strength) of the BS	1. Educate residents on the need for the BS 2. BSs should be sited outside dense populated residential areas.
Ga Central	Yes	The fear of the perceived emission of harmful radiations from the antennae.	We educate them that it is not scientifically proven so they should not panic or have any fear concerning the BS.
Ga East (WD)	Yes	No response	No response
La	Yes	1. Siting of BSs close to	1.Conduct neighbourhood

Nkwantanang-Madina		residential buildings and it impacts on the residents. 2. The potential health dangers to residents	consent 2. Embark on public education to explain permit proceedings.
Ga West	Yes	1. No neighbourhood consultation	By educating and explaining issues to residents

Source: Field Survey Data, 2014

Table 4.14: Risk perception among people living close to BSs and compensation for residents to relocate

MMDA	Is there an issue of risk perception among people living close to BSs?		Will you consider compensation for people to relocate?
	Response	What are the risk perceptions?	
Adentan(WD)	Yes	1. People living around BSs perceive the notion that they may develop cancer in the future.	No
La Nkwantanang-Madina	Yes	1. The effect of radiation on residents. 2. The structural integrity of towers.	Yes
Ga East (WD)	No	No response	No
Ga Central	Yes	Emission of harmful rays into the environment	No
AMA	Yes	1. Possible collapse of masts.	No

		2. Issues relating to health.	
Adentan (TP)	Yes	Perceptions of excessive micro wave effects that cause cancer, sexual weakness and all sorts of diseases especially in our largely ignorant society.	No response
Ga East (TP)	Yes	Radiations emitted from antennae	Yes
Ga West	Yes	1. The risk of fear of developing cancer over time. 2. Collapse of masts.	Yes

Source: Field Survey Data, 2014

Table 4.15: Minimum setback distances and management of material waste products.

MMDA	Is there a minimum legal distance for locating BSs from the public?	What major environmental factors do you consider before permitting BS proposals?	Are material wastes or products of the MTT properly managed?
Ga East (WD)	No	Change of use of the area from residential to mixed used/ commercial	Yes, This measures is in the environmental permit
Adentan (TP)	Yes	EPA report	Don't know
Adentan (WD)	Yes, normal setback rules as applied in the L.I 1630, 1996	E.P.A report	No response
AMA	Yes	1. Safety report 2. Structural details	No
Ga Central	No	It should not be sited in a densely populated area	No response
Ga East (TP)	No	1. Architecture drawings 2. Structural details 3. Safety report 4. E.P.A report	No idea

La Nkwantanang-Madina	Yes, the minimum setback required is not less 20m	1. E.P.A report 2. G.C.A.Areport 3. G. A. E. C report	No idea
Ga West	Yes, about 300m	Based on EPA recommendations	No

Source: Field Survey Data, 2014

4.5.5 Wood (2003) proposed "method and 14 point criteria"

This technique was based on effective EIA best guidance practices, directed towards the components and requirements of a country's EIA system, as well as the system's capacity to influence decision making. Institutions that issue permits to operators compared Wood (2003) proposed "method and 14 point criteria" to the Ghanaian procedures, to identify potential weaknesses and areas for improvement.

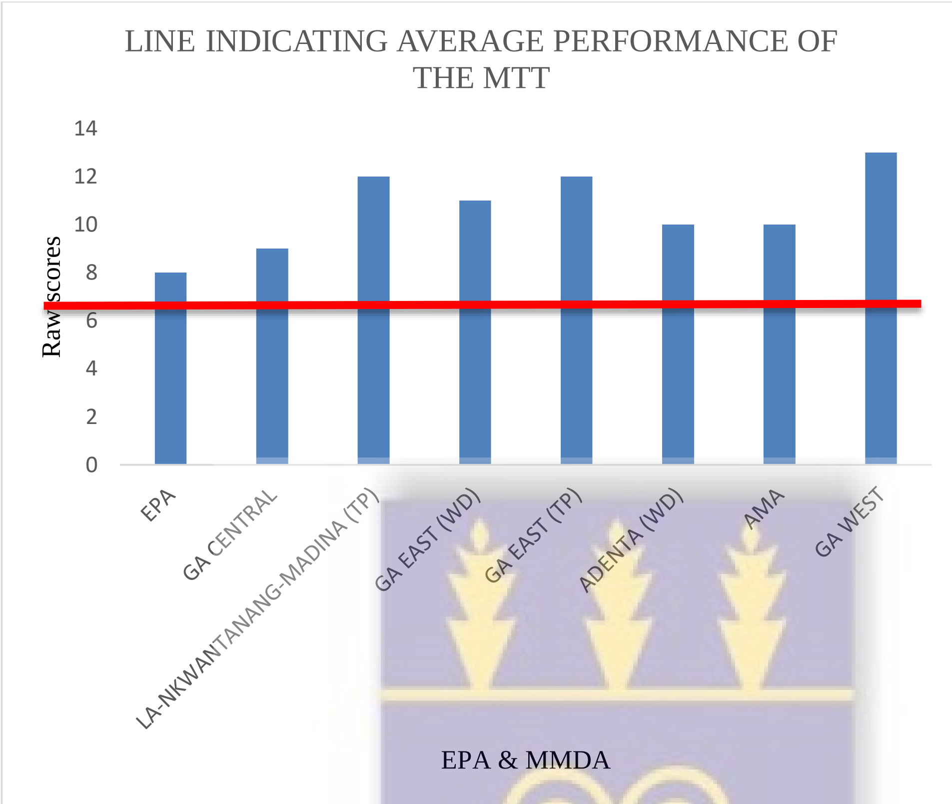


Figure 4.2: Results of Wood (2003) proposed technique indicating above average of the Ghanaian EIA system

4.6 Contribution to knowledge

Finally, this research has made the following contribution to scientific knowledge;

- Noise is a risk factor to people within a radius of 50m from BSs.
- All the heavy metals analyzed were detected in the soil samples; however Hg has exceeded its threshold whilst Cd has reached its threshold.

CHAPTER FIVE

5.0 DISCUSSION OF RESULTS

5.1 Discussion of observations

Visual information assessment made at some BSs indicated that, the complaints from the public (Table 4.13) which were also highlighted by the EPA and the MMDA respectively, confirms the relevance of observation as argued by Clay and Smidt (2004). This study confirms the claim that lack of information, ignorance and poverty in the study area Songsore and McGranahan (1993) have contributed greatly to the offering of plots by landlords for the installation of BSs. Furthermore, it confirms the claim that, people usually perceive risks as negligible, acceptable, tolerable, or unacceptable Slovic (1987). For example, absence of aerial lamps and the traces (leakages) of fuel at BSs were not considered by residents as hazardous. Additionally, the planning of Accra is sporadic and non-compliant World Bank (2010) and hence forcing frustrated land developers to precede with development without the required permits Yeboah and Obeng-Odoom (2010).

5.2 Discussion of Radiation levels around BSs

In this study, the measurement design permitted radiation measurements at different locations around specific BSs due to the settlement pattern in the vicinity and accessibility. Radiation levels presented a wide range of electric field values (Table 4.1 and Appendix A) at specific distances from BSs, yet all the values were below the ICNIRP threshold. The values obtained in this study were in accordance with values recorded by Amoako et al. (2009) and Deatanyah et al.

(2012) where signals were measured within a radius of about 300m from BSs during peak periods.

The values recorded suggested that, the concern by the public of the health implication of radiation from BSs cannot presently be supported by this study. If certainly prolonged exposure to low level emissions is harmful Neshev and Kirilova (1996), then possibly arguments raised by Chagnaud et al. (1999) and Heikkinen et al. (2001) that, short term effects produce no adverse health effects could be supported by this research. The argument that, RFs reduce melatonin in humans should be subsequently investigated in neighbourhoods around BSs, since melatonin can inhibit the growth of some types of cancer and has been proven to suppress the growth of breast cancer Cherry (2000) and Levallois et al. (2001).

Indeed it should also be highlighted that, though the strength of EMFs decreases as distance increases, this study revealed patterns that are on the contrary (Figs 5.1, 5.2, 5.3, 5.4). This can occur due to; more power radiated by antennae as the number of users increase Abdel-Rassoul et al. (2006), the nearness to antennae and the physical environment WHO (2006). For this reason minimum setback distances cannot scientifically be used solely to resolve the suspicion of health implications related to radiation.

These arguments are quite important, because if the number of subscribers increases without a corresponding increase in the number of BSs, emission levels arebound to go higher. This therefore, implies that, reliable zoning and consistent monitoring of radiation levels should not be compromised. Subsequently, this research suggests long term monitoring as it takes into consideration the report by Stewart and Kleihues (2003) which estimated the global annual new cases of cancer as 10.1 million in 2000 and projected an increase to 15 million by the year 2020.

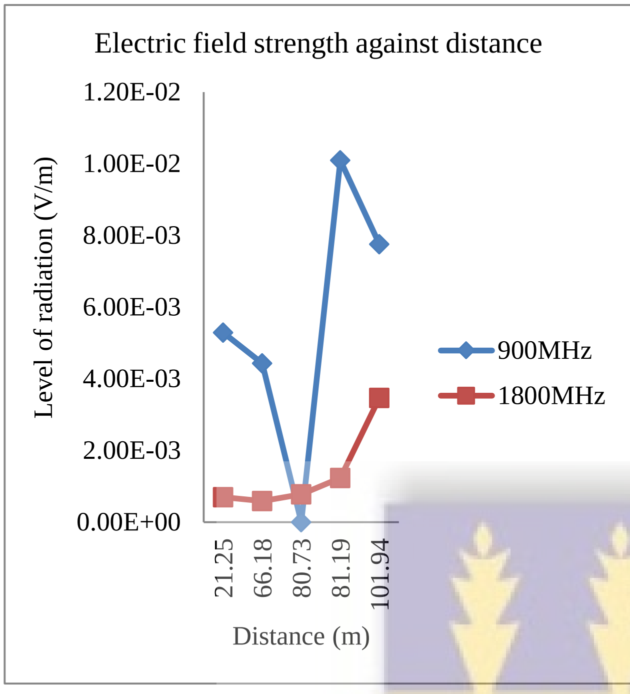


Figure 5.1: Radiation pattern at Awodome

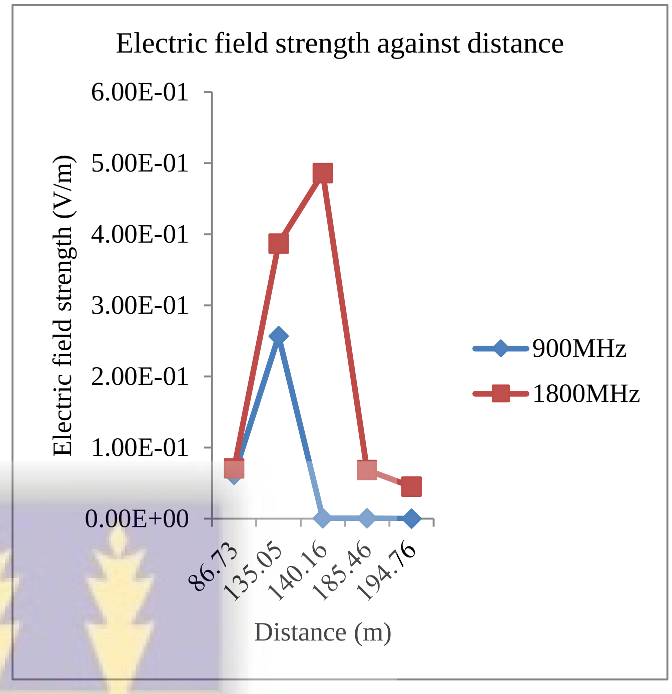


Figure 5.2: Radiation pattern at Abeka Lapaz

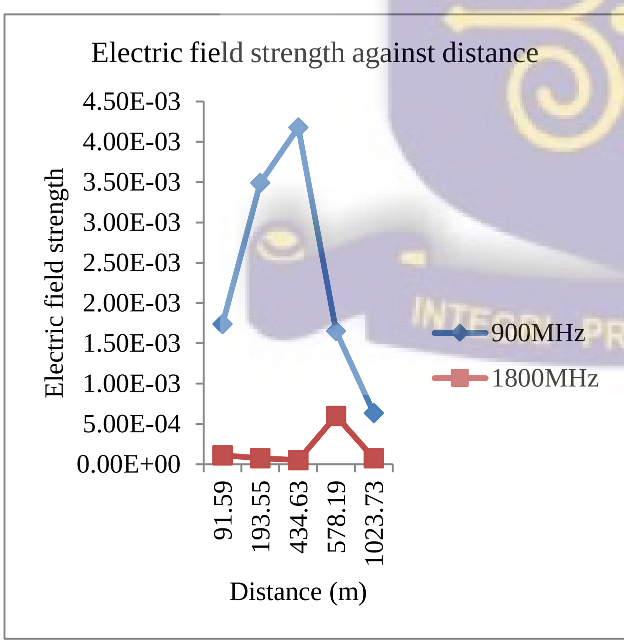


Figure 5.3: Radiation pattern at Kokrobite

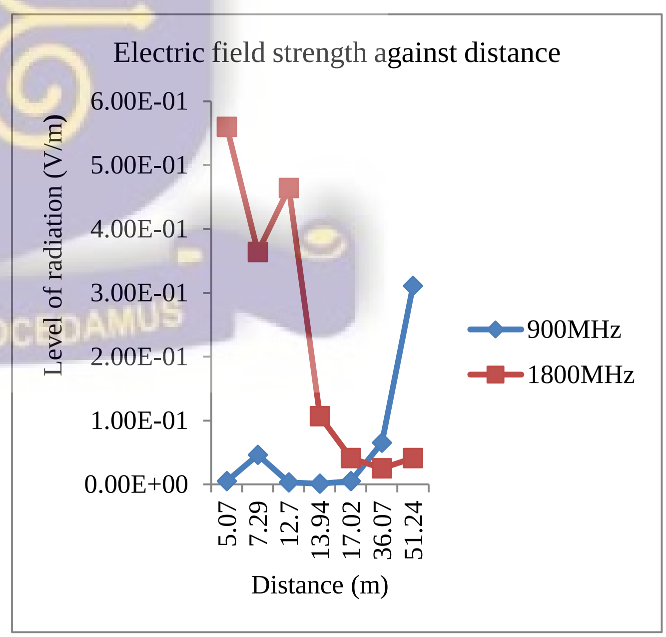


Figure 5.4: Radiation pattern at Asylum Down

5.3. Discussion of mean noise levels recorded around BSs

There are various sources of noise in the communities, however, this study considered noise levels from solely generator sets at BSs within a period where residential areas are expected to record noise levels ≤ 48dB.

Though the highest wind speed (5km/h) was recorded at Kokrobite, the sound level at 50m was 50dB as compared to New Bortianor with a wind speed of 2km/h but recorded 58dB at 50m (Fig 5.5). Possible reason accounting for compliance co-efficient <1 beyond 50m could be due to the reflection of sound by physical structures.

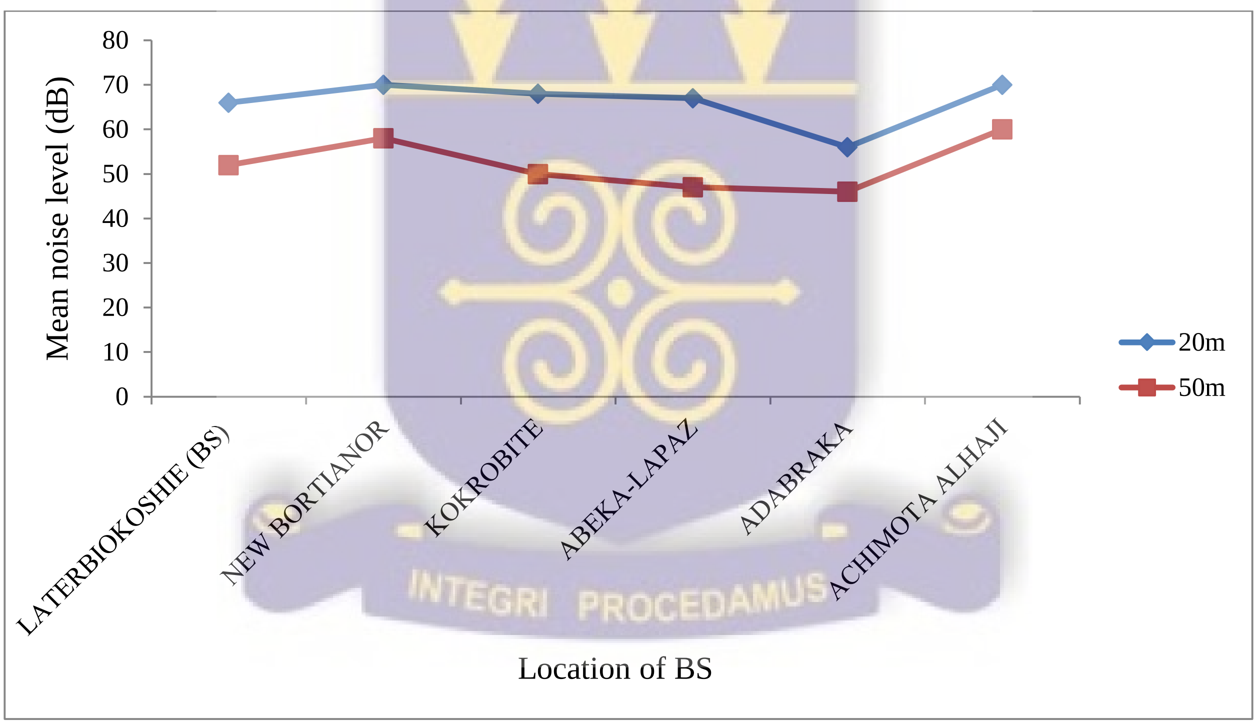


Figure 5.5: Mean noise level patterns at some BSs

The compliance coefficients of noise levels calculated were 1.3 and 0.9 at distances of 20m and 50m radius respectively from BSs (Table 4.2). Though the compliance coefficient at 50m radius was <1, there is the need to be concerned as some BSs at that distance recorded noise levels

>48dB. With a compliance coefficient >1 at a radius of 20m and in some instances 50m, populations are definitely susceptible to potential risk of noise pollution Passchier-Vermeer and Passchier (2000), Muzet (2007), Haines et al. (2003) and Stansfeld et al. (2005).

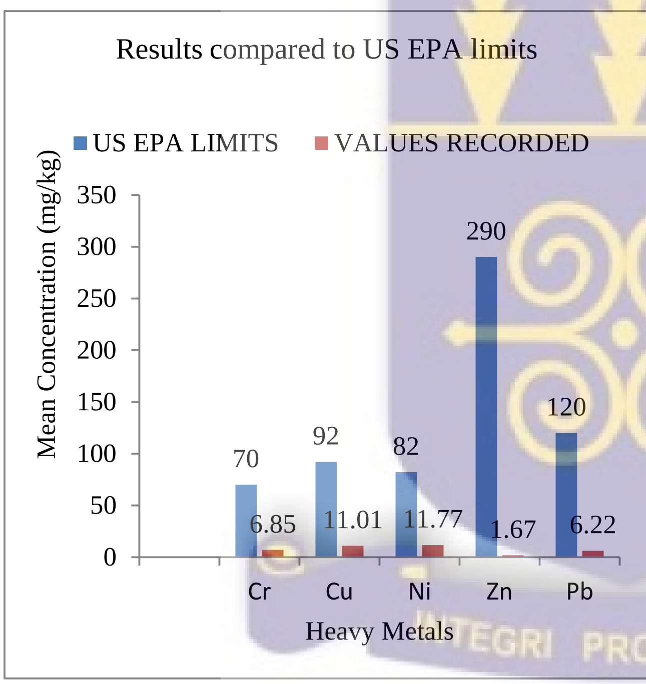
Indeed, if "Adult Sleep Disturbance" can reduce secretion in melatonin Abelin (1999) which suppresses the growth of breast cancer and prevents depression Cherry (2000) and Davis et al. (2001) then, this study critically considers the situation in residential areas as disturbing.

The number of residents that will be affected within a specific radius from a BS can be calculated using $\pi r^2 d$. Where all r values (20m, 50m, 100m and 150m) are converted to km and d represents population density of Accra (15, 000 persons/km^2). Hence, suggesting the number of persons within a radius of 20m, 50m, 100m and 150m to be above 19, 118, 150 and 2250 respectively. The number of persons becomes huge with respect to a specific radius when considered across all BSs in residential areas.

This study confirmed that, at least, the issue of noise as a variable contradicts the concept of social dilemma as emphasized by Von Borgstede et al. (2012) and indeed substantiate a strong social norm Yamagishi (1986). Information from residents revealed that most generators become noisy after a period of 2 years of usage at BSs, hence suggesting the need for barriers. However, considering the variety of barriers; physical, procedures, instructions and practices Hollnagel (1999), this research suggests the use of zoning in physical planning.

5.4 Discussion of levels of heavy metals in soil samples

According to Hermann et al. (2000), mobile phones/laptops/computers consist mostly of Cu, Pb, As, Ni, Hg, Ag, Li, Zn, Cd, Be, Ta, Pd, Sb and Au plating. This study however, tested for the presence of Cr, Cd, Ni, As, Hg, Pb, Fe, Zn and Cu at sites A, B and C (Fig 3.4). Though permissible mean concentrations vary worldwide Chen et al. (1999) and De Vries and Bakker (1998), this study compared the results obtained to the permissible mean concentrations of the US EPA (2011) (Figs 5.6, 5.7).



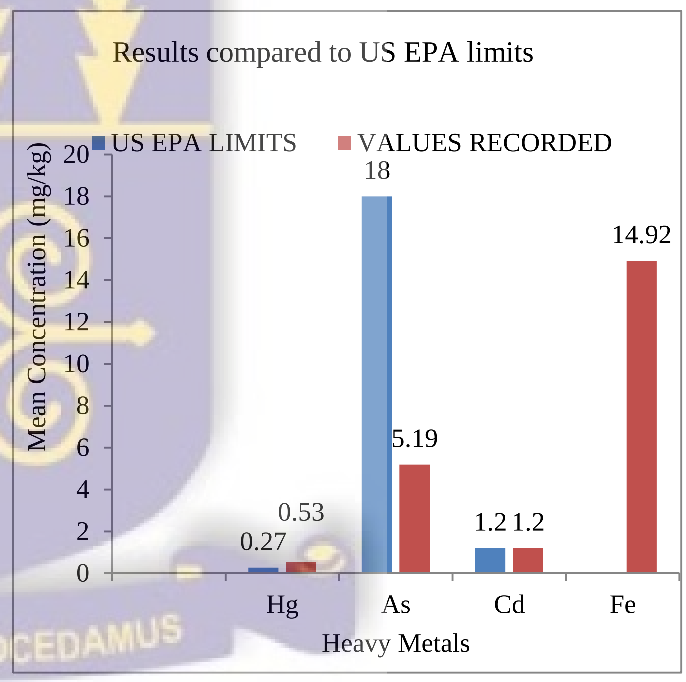


Figure 5.6: Results compared to US EPA limits Figure 5.7: Results compared to US EPA limits

All the heavy metals analyzed were detected at low levels; however, Hg has exceeded its threshold whist Cd has also reached its threshold (Figs 5.6, 5.7). This therefore suggests that timely intervention measures ought to be introduced. Again, since metal ions in water are distributed by lateral and vertical movements Regli et al. (1991) and may affect surrounding lands and rivers Nnorom and Osibanjo (2008) or even groundwater surrounding dumpsites

Martinez and Motto (2000), the introduction of dumpsites cannot be supported by this research. Therefore, this research can confirm that, soils and water bodies at "Agbogbolishie" predispose the public to especially the health implications of Hg and Cd.

5.4.1 One Way ANOVA

One-way ANOVA was conducted to determine whether there is a significant difference ($p \leq 0.05$) in the average concentration of the heavy metal depending on the sampling site. Two variables were therefore defined; the concentration of the heavy metal (dependent variable) and the sampling sites (grouping variable).

Firstly, the normality of distribution and equality of variances which are the requirements for the application of ANOVA were accordingly tested. The assumption about distribution normality was also satisfied, however Levene's test for equality of variances showed that this assumption was not justified for four heavy metals (Cr, Ni, Hg and Fe) and were accordingly excluded in the ANOVA analysis.

The result from the one-way between-groups ANOVA (Appendix G) with post-hoc test indicates that, there were significant differences in the average concentrations of Cd, As, Pb, Zn and Cu depending on the sampling site. For example, sampling site A significantly differs in the concentration of Cd and Pb from sampling sites B and C. However, there was no statistical significant difference between the concentrations of Cd and Pb from sampling sites B and C. Again, the total content of As and Cu from sampling site A was significantly different from those of sampling sites B and C. Nevertheless, the concentration of As and Cu from sampling site C did not differ significantly as compared to those of sampling sites A and B.

5.4.2 Correlation analysis

In order to quantitatively analyze and confirm the relationship among soil heavy metal content, a Pearson's correlation analysis was applied to the dataset. The Pearson correlation coefficients were calculated for each pair of variables (Table 5.1).

Table 5.1: Pearson's correlation matrix of heavy metals in the soils, ** indicates correlation is significant at the 0.01 level (2-tailed).

	Cr	Cd	Ni	As	Hg	Pb	Fe	Zn
Cd	.537**							
Ni	.802**	.694**						
As	.572**	.565**	.620**					
Hg	.547**	.476**	.597**	.939**				
Pb	.550**	.584**	.617**	.967**	.964**			
Fe	.459**	.327*	.461**	0.162	0.215	0.228		
Zn	.745**	.640**	.834**	.499**	.464**	.479**	.331*	
Cu	.521**	.481**	.652**	.575**	.565**	.601**	.395**	.497**

The correlation between the metal pairs was positive and linear in all cases. The correlation coefficient between the metal pair As-Pb is 0.967, which indicates a very strong linear correlation at the 0.01 significance level and a common origin of these metals. Hg also exhibited a very strong correlation with Pb (0.964) and As (0.939) suggesting they probably originated from a common source. Ni exhibited strong positive correlations with both Zn (0.834) and Cr

(0.802). These high correlations between soil heavy metals may reflect the fact that these heavy metals had similar pollution levels and similar pollution sources.

Moderate correlation was also observed between some of the metal pairs. Cd correlated moderately with Ni (0.694), Zn (0.640), Pb (0.584) and As (0.565). Additionally, Ni depicted a similar moderate correlation with As (0.620), Pb (0.617), Cu (0.652) and Hg (0.597). Furthermore, Cu correlated moderately with Pb (0.601), As (0.575) and Hg (0.565). Such elemental association may signify that each paired of elements has identical source or common sink in the soil samples.

Generally, Fe exhibited the lowest correlation with majority of the elements studied. Very low correlation was observed between Fe with Cr, Cd and Ni. There was no significant correlation between Fe and the heavy elements; As, Hg and Pb. The lack of significant correlation between Fe and these heavy metals suggests that, Fe had different sources from the other metals. The apparent lack of correlation of Fe with the other heavy metals, which are mainly from anthropogenic sources, suggests that, Fe occurs naturally at high levels and is hardly affected by human activities (Fig 5.8).

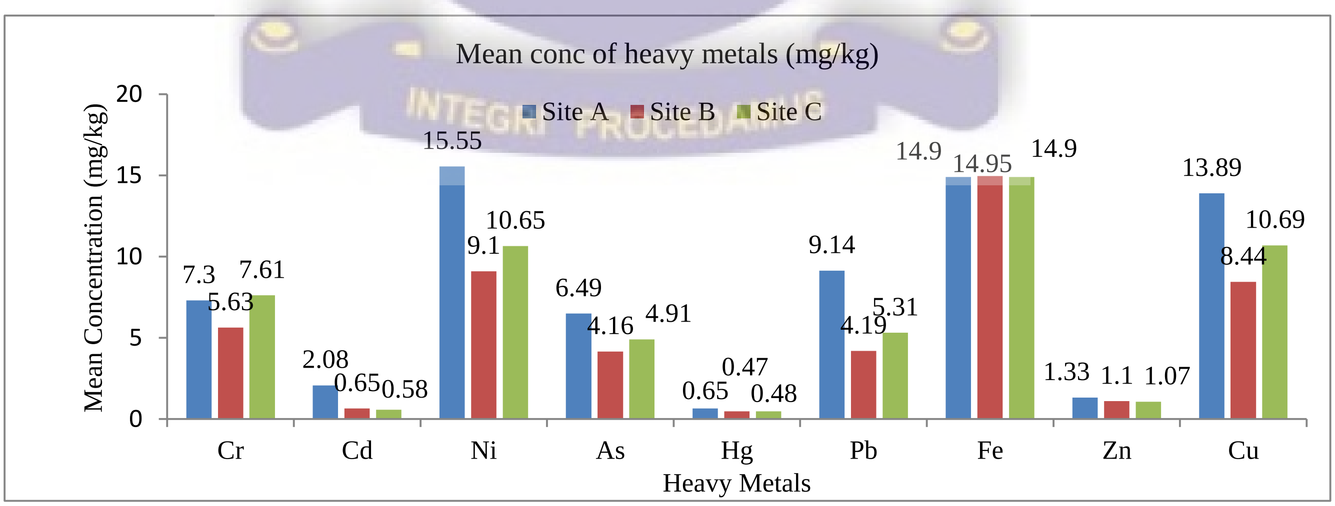


Figure 5.8: Mean levels of heavy metals at sites A, B and C.

5.4.3 Factor Analysis - Principal Component Analysis (PCA)

For PCA, the value of KMO (Kaiser-Meyer-Olkin) measure of sample adequacy was 0.801, which meets the limit of 0.600 conventionally held as a critical value. Bartlett's test of sphericity showed that PCA could be applied to the data at the $p < 0.001$ level. Two principal components (PCs) were identified using Varimax with Kaiser Normalization for the seven variables (Table 5.2).

Table 5.2: Principal component loadings (Varimax-normilzed) for heavy metals in the soil samples

Variables	Rotated Components	
	PC_1	PC_2
Cr	0.689	
Cd	0.568	
Ni	0.802	0.308
As	0.885	-0.338
Hg	0.827	-0.448
Pb	0.862	-0.377
Fe		0.711
Zn	0.698	0.425
Cu	0.682	0.348
Eigen Value	4.611	1.459
Total Variance (%)	51.238	16.209
Commutative Variance (%)	51.238	67.447

The PCs accounted for 67.45% of the total variance in the variable set. PCA was performed on normalized data sets to reduce the dimensions of the original data sets. This method enhances the identification of different groups of metals that correlate and hence can be considered as exhibiting a similar behaviour and also from a common origin. The number of significant PCs was determined based on both screen plot and eigenvalue-one criterion. The eigenvalue-one criterion indicates that PCs with eigenvalues greater than one are regarded as significant when the correlation matrix is used in the analysis.

According to these results (Table 5.2), the eigenvalues of the two extracted components are greater than those before and after the matrix rotation. Consequently, heavy metals could be grouped into a two-component model that accounts for 67.45% of all the data variation. In the rotated component matrix, the first principal component (PC_1) had an eigenvalue of 4.61, accounting for 51.24% of the total variance. It had strong positive loadings on As, Pb, Hg, Ni, Cr, Zn and Cu. However, PC_1 was mainly dominated by four of the afore-mentioned heavy elements (As, Pb, Hg and Ni) reflecting the anthropogenic contamination in the soil samples. This implies that these heavy metals in the soil may have originated from similar pollution sources. The second principal component (PC_2) had an eigenvalue of 1.46 and accounts for 16.21% of the total variance. It is constituted by only Fe suggesting a possible natural source in the soil.

PC_1 with 51.24% variance is heavily loaded on As, Pb, Hg and Ni and can be defined as anthropogenic component which confirms the claim on the components of mobile phones/laptops/computers made by Hermann et al. (2000).

PC_2 on the other hand is heavily depended on Fe with a total variance of 16.21%. Fe being the only component in PC_1 confirms that, it is weakly correlated; thus, separate from the other heavy metals regarding their correlation coefficient analysis and PCA. This separation between Fe and other heavy metals may suggest Fe originated from local natural sources.

From this study, it can be suggested that, the unregulated recycling techniques (open-pit acid baths, heating, chipping and melting, burning etc) at sampling sites have contributed to the elevated heavy metal content. Considering this, it seems reasonable to conclude that PC_1

constitute an anthropogenic component, whereas PC_2 appears to be within the parent rock (natural source).

5.4.4 Hierarchical Cluster Analysis (HCA)

Performing HCA on variables rather than on cases is preferred in most research studies Kaufman and Rousseeuw (1990). HCA was developed in the present study on soil samples in order to identify similarities in metal contents between the analyzed soil samples. This approach was selected instead of trying to discriminate between the different sources of metals as already accounted for by PCA.

Thus, the aim in performing HCA was to identify the samples which represented different areas where metal content followed a similar pattern. This different approach was also considered since the results obtained by both the HCA and PCA are complementary. PCA helped to group metals according to their different origin. Once this information is known, HCA allowed clustering the areas affected by the different metals, that is, affected or not affected by anthropogenic activities.

Three main clusters can be distinguished in the dendrogram (Appendix H), performed with the Ward method, which uses the squared Euclidean distance as a similarity measure. Cluster 1 includes fourteen soil samples (sample IDs; A1, A4, A11, A15, B1, B2, B3, B8, B9, B12, C3, C4, C10 and C11) affected by higher Cu and Fe contents. Soils associated with this cluster had a local natural origin as the predominant source. Cluster 2 comprises of twelve soil samples (sample IDs; A8, B4, B5, B7, B10, B13, B15, C1, C2, C12, C13, and C14). This cluster contains the lowest contents of all the heavy metals under investigation. In these cases, normal levels of some of the heavy metals (especially Cd) were identified. Soil samples belonging to cluster 2 are the least contaminated. Soils samples (sample IDs; A2, A3, A5, A6, A7, A9, A10, A12, A13, A14, B6, B11, B14, C5, C6, C7, C8, C9, and C15) belonged to clusters 3. The soils in this cluster contain the highest concentrations of all the nine heavy elements under study. Cluster 3 soil samples were the most polluted with the heavy metals.

This study, though supports critical monitoring, it considers the adoption of the EU Directive 2002/96/EC on WEEE which imposes recovery, reuse and recycling as a reliable long term option. Presently, as every individual is vulnerable to heavy metals and as global annual new cases of cancer increases, Stewart and Kleihues (2003), this research suggests that serious investment be made in recycling.

5.5 Discussion of questionnaire responses

5.5.1. Discussion of responses from residential areas

In this study, residents were sampled according to the distance (20m, 50m, 100m and 150m) they reside from BSs. It was assumed that there is no significant difference among the residents' levels of satisfaction (content) or their levels of satisfaction (content) are the same.

The chi-square test for independence was used to determine whether a resident's level of satisfaction (content) for living nearby a BS is related to distance from the BS. This test compared the frequency of cases found in the resident's level of satisfaction with the BS in the neighbourhood across the different categories of distance from the BSs. On the other hand, is the proportion of residents at 20m, 50m, 100m and 150m from the BS the same for residents who are either satisfied or not satisfied living in the neighbourhood?

This test was used because the study wanted to explore the relationship between two categorical variables (resident's level of content with a BS and distance from the BS).

From table 4.6 (b) the assumptions of chi-square concerning the 'minimum expected cell frequency', which should be ≥ 5 (or at least 80% of cells have expected frequencies of ≥ 5). This means that, the data have not violated the assumption as all expected cell sizes were ≥ 5.

The main value of interest is the Pearson chi square value, which is presented in the final table, titled "Chi-Square Tests". In this study the Chi-square value is 39.231 with an associated significance level of .000.

To be significant, the Sig. value needs to be ≤ 0.05, but in this case the value of 0.000 is less than the alpha value of 0.05, hence it can be concluded that the result is significant.

Therefore, it has been statistically proven from the Chi-Square Test that;

- There is significant risk associated with living close to BSs.
- There is no significant difference between risk perception and the involvement of residents in the selection of sites for mounting BSs.
- Distance has significant effect on risk to the public.
- Distance has no significant effect on health risk in children and neighbourhoods.

5.6 Discussion of data from questionnaire responses

Strategic procedures are required to fulfill all the relevant principles identified in EIA either on short or long term durations. These procedures ought to take into consideration;

- The knowledge level of all stakeholders or targeted groups

  How to involve all stakeholders to enhance transparency in all procedures
- How to communicate what is either known, unknown or suspected to stakeholders

- Evaluation of implemented measures

Concepts of EIA principles relevant to this study include;

5.6.1. Participative

The process should provide appropriate opportunities to inform and involve the interested and affected stakeholders. Additionally, the inputs and concerns of stakeholders should be addressed explicitly at the decision making stage or in any documentation.

5.6.1.1 Consultation

This study considers the claim that public participation is an indicator of an effective EIA procedure (Wood, 2003) and the argument that perception equals reality, Covello et al. (1991) as critical factors as the MTT is still new to Ghanaians. This study supports the adoption of the Seven Cardinal Rules of Risk Communication highlighted by Covello et al. (1991) as sited in chapter two.

There is virtually in most instances no correlation between public perceptions of risk and the available scientific evidence, hence consultation is expected to; increase the knowledge level of all stakeholders as well as eliminate or reduce hypersensitivity.

It is worth noting that, according to the Guidelines on Communication Towers (2010); neighbourhood consultation should be done within a radius of 500m (involving 11,775 persons). In this study (within a radius of 150m), out of 129 respondents forming 90.8% who were in residence before BSs were mounted only 26 admitted they were consulted. The failure to consult is considered by this study as the major contributing factor that has led to the misconceptions, doubts and perceptions that has created discontent (dissatisfaction) in neighbourhoods. Though all stakeholders admitted perceptions exist, this study however, does not accept "collapsing of towers and noise" as perceptions. Therefore, this study suggests a critical scrutiny of the factors that affect laypeople's perception of risk as considered by Siegrist (2000) and Krewski et al. (2006). This study can therefore support prior reviews cited by WHO (2002), Slovic (1987) andSlovic et al. (1990) and caution that risk perception could be extremely high if the present pattern of consultation does not change.

Again, only 2 residents admitted their suggestions were taken into consideration, hence confirming a study by Palerm (1999) and Bond et al. (2004)that, practically, public participation has been reduced to a mere formality in EIA processes. However, another dimension highlighted by Hokkanen (2007) and Pölönen (2007) is that, the public's contribution is not used in decision making and this has been confirmed by this research.

This research further revealed that, out of a total of 144 respondents, 88 forming 61.1% insisted they are familiar with the MTT. When requested to indicate where they acquired this knowledge from, a majority 46 forming 52.9% mentioned the "news media" as their source. This therefore confirms the assertion by Krewski et al. (2006) that, the most important source of information about health issues and risks for laypeople seems to be the news media. This study can confirm that, the discontent in neighbourhoods (even at 150m from BSs) is partly due to the news media which according to Koren and Klein (1991) are more likely to report studies suggesting that a technology is risky than studies suggesting that a technology is safe.

Again, the argument by Siegrist and Cvetkovich (2001) that, people have more confidence in hypothetical scientific results suggesting a danger than in results indicating a low level of risk has also been demonstrated in this research.

The NCA emphasized that, neighbourhoods are consulted before BSs are mounted close to their homes. To verify this assertion, the NCA was asked to list the complaints they receive from residents dwelling close to BSs. Though the NCA admitted receiving complaints, they did not state the nature of complaints. Indeed, when institutions that issue permits do not provide answers to specific questions in such studies, it therefore becomes very difficult to objectively vindicate such institutions.

The EPA affirmed that, neighbourhoods are consulted before BSs are mounted close to their homes. To verify this assertion, the EPA was asked to list the complaints they receive from residents dwelling close to BSs. Though the EPA claimed consultations are done, the EPA furthered listed "no consultation" as a complaint among others they receive from residents. This therefore contradicts a major EIA procedure highlighted by Wood (2003) which has further been described as fundamental. Indeed, the application for EPA permit requires among others a written "evidence of consultation with neighbours" within up to a distance of 500m from a BS Guidelines on Communication Towers (2010). This study can suggest that, since the EPA is not represented at the MMDA, participation in activities at the community level therefore become very challenging for the EPA. This study, finds it difficult to single out either political or organizational factor or even both as reiterated by Meredith and Mantel (1995) and Cicmil (2000) as being responsible for this weakness.

Out of the 8 responses from the MMDA who participated in this study, 6 respondents forming 75% maintained that, residents are consulted whilst the remaining 2 respondents forming 25%

gave a negative response. However, this research cannot fully associate with the MMDA after critically considering the responses obtained at residential areas.

5.6.2 Credibility

This describes how the process should be carried out with professionalism, firmness, fairness, objectivity, impartiality and balance, and be subjected to independent checks and verification.

5.6.2.1 Possible adverse impacts

This study accepts the claim that, in environmental management, it is neither possible to anticipate everything beforehand, nor is it possible to write a condition that covers everything Lindström et al. (2007). Therefore, complaints received by institutions that issue permits could possibly indicate that, significant adverse impacts other than those anticipated during the design phase might have been encountered. This could possibly confirm a basic constraint such as scientific uncertainty about environmental effects of a specific technology in EIA processes Stewart-Oaten et al. (1986).

Though the NCA confirmed receiving complaints from residents, they declined to specifically elaborate on the nature of complaints received. The NCA in responding specifically to whether BSs have significant adverse impacts other than those anticipated during the design phase, responded “enquire from EPA”. This response could be interpreted objectively as the NCA not being aware of any adverse impacts other than those anticipated during the design phase if any exists. The improvement upon the performance of projects in terms of environmental concerns and safety Saad et al. (2002) and Flyvbjerg et al. (2003) cannot become relevant with this response. However, this research views the recommendation by Quigley et al. (2006) to careful examine all uncertainties and the transparency of assumptions and limitations as very necessary at this stage.

The EPA has in this study stated that, they continuously receive complaints from residents dwelling close to BSs and has also admitted that, there are possible risks associated with the MTT. This reveals the EPA's professional awareness of the characteristics of risk; unknown, uncertain, involuntary, unfamiliar among others Gregory and Mendelsohn (1993) and possibly as risk is related to; health, safety, environment among others Covello (2003). The EPA listed some possible risks, however; leakages from fuel tanks could lead to possible fire outbreaks at BSs. This indeed verifies informal discussions with environmental expects who mentioned the incidence of self propagating battery fires as battery jars do craze and crack. This the ITU (2008) have already explained could be caused by;

- Aging and manufacturing defect(s)
- Chemical degradation between jar material, sulfuric acid, and other chemicals
- Abuse, accidents, earthquakes, fires and improper installation

Though traces of fuel indicating leakages were observed on the concrete floors at some BSs (Fig. 4.1), samples of concrete could not be taken for quantitative analysis as has been recommended in risk assessment Veerman et al. (2005) and WHO (1998). Indeed, further discussions at neighbourhoods confirmed that, such fire outbreaks have been reported at some sites in some towns including Agona Swedru. However, this study cannot support any effective practical intervention or policy to mitigate even the anticipated significant adverse impacts and this indeed contradicts the fundamentals of an effective EIA system Heinma and Põder (2010) and Glasson et al. (2005).

This study revealed that indeed almost all the MMDA are aware of some possible risks associated with the MTT except only one assembly (Ga East-WD) forming 12.5%. For example, the AMA confirmed instances of tower collapse, but (Adentan-TP) mentioned a collapse leading to two deaths in the assembly's jurisdiction, therefore prompting the need for periodic inspection and maintenance Hale et al. (2004). The responses from the MMDA suggest the strict enforcement of policies on public education Wood (2003), the creation of physical barriers Hollnagel (1999) and Hale et al. (2004) and inter and intra agency collaboration as well as institutional coordination Saarikoski (2000). Therefore, this indicates that, there could possibly be other significant adverse impacts other than those anticipated during the design phase. Again, this study cannot confirm any effective practical measure aimed at mitigating the adverse impacts mentioned by the MMDA.

At residential areas, a basic indicator such as HHRA which according to Steinemann (2000) is used in EIA practice and also for estimation in HIA O'Connell and Hurley (2009) was used to determine significant adverse impacts. Therefore, residents were to confirm or otherwise whether they have identified any health risk in their children that they can link to BSs. Only 2 respondents forming 1.4% out of a total number of 144 respondents claimed they have identified headache as a health risk in their children. Their claim contradicted the door-to-door interviews performed by Eger and Neppe (2009) which recorded 23 cases of cancer and also a study by Trower (2001) which recorded cases of pain, headache, general weakness and anaemia.However, because HIA is expected to involve many samples Mindell et al. (2001) and O'Connell and Hurley (2009), the study further sought from residents any health risk in their neighbourhood that they can link to BSs. Again, only 2 respondents forming 1.4% out of a total number of 144 respondents claimed they have identified two individuals with health risks they suspect can be linked to BSs. Unfortunately for this study, these respondents could not assist the research team to locate these persons for further interrogation. Furthermore, this claim contradicts two studies conducted by Santini and Santini (2001) and Santini et al. (2002) who surveyed people living up to 300m from BSs and recorded statistical significant correlations between distance from BSs and health problems. Tiredness was recorded up to a distance of 300m; headache, sleep disruption and "discomfort" up to 200m; depression, memory loss, dizziness and visual perturbations up to 100m. Therefore, they concluded that, BSs should be sited more than 300m from residential dwellings. Therefore, this research at this stage cannot confirm a correlation between RF from BSs and any health risk as confirmed by WHO (2005), Trower (2001), Hutter et al. (2006), Frey (1998) and Santini et al. (2002) and also contradicted by Rubin et al. (2005), Koivisto et al. (2001) and Seitz et al. (2005).

If indeed possible health risks exist around BSs, then currently, the issue of age, sex and ethnicity among others argued by Pelkonen, et al. (1997) as influencing the response to hazards cannot be cited as possible reasons for not identifying significant health risk in this study. However, the assertion that, short duration may produce no effects Chagnaud et al. (1999) and Heikkinen et al. (2001) and especially ignorance of residents Songsore and McGranahan (1993) might have led to their inability to directly link possible symptoms to BSs.

5.6.2.2 Monitoring and evaluation

This study supports the views of researchers Marshall et al. (2005) and Stewart-Oaten et al. (1986) who have outlined the importance of monitoring and evaluation as significant in EIA procedures. Consequently, monitoring and evaluation is expected to;

- Improve effective consultation and reduce the number of complaints from residents
- Ensure compliance with local and international regulations

The NCA responded “enquire from EPA” in relation to monitoring and evaluation of measures implemented to mitigate environmental impacts. This response was not considered as due to legal barriers Buckley (1994a, b) but considered as the NCA not realizing the need for monitoring and evaluation. Certainly, the possible reason that can be assigned by this study is scientific uncertainty about environmental effects as identified by Stewart-Oaten et al. (1986). All responses provided by the NCA indicated an indirect involvement in environmental issues despite all the controversies. This attests to the argument that, the treadmill of production model has also affected the MTT Gould et al. (2004).

The EPA gave a positive response in relation to monitoring and evaluation of measures implemented to mitigate environmental impacts and insisted it is done once in every 18 months. A critical consideration of the Guidelines on Communication Towers (2010), can categorically stress that, the EPA is not performing effectively. For example, the guidelines insists that, the EPA and MMDA issue separate permits before BSs are constructed, however, the EPA and MMDA have also complained of constructions without their permits. Perhaps what might have accounted for this lapse as evaluated by this research could be the absence of the EPA at the local level whilst the MMDA are virtually weak. In fact, this study supports the argument by researchers Gough and Yankson (2000), Grant (2009), Antwi and Adams (2003), Owusu (2008) and Yeboah and Obeng-Odoom (2010) who have attributed construction without permits to delays in obtaining permits from institutions that issue permits.

However, this lapse could possibly be attributed directly or indirectly to the intertwining of political, technological, cultural, organizational and social factors as argued by Meredith and

Mantel (1995) and Cicmil (2000) whilst many studies have simply described these institutions as weak Farvacque-Vitkovic et al. (2008).

A critical consideration of the responsibility assigned the MMDA Guidelines on Communication Towers (2010); stipulates that, the MMDA are to perform a supervisory role for all the institutions or agencies that issue permits. For example, the MMDA shall among others;

- Be the receiving and/or collection points for building and environmental permits in respect of the construction of towers after the requisite approvals have been obtained from the GCAA and RPI.
- Verify all submitted documents (including evidence of neighbourhood consultation) at the time of submission for compliance.

Therefore in assessing to what extent the MMDA are involved in monitoring and evaluation, the response revealed a split disclosure; out of the 8 responses, 4 forming 50% gave an affirmative response whilst the other 4 gave a response to the contrary. This indeed confirms the constraint posed by the fragmentation in licensing procedures Kennett and Perl (1995) and firmly suggests the implementation of inter and intra agency collaboration and institutional coordination Saarikoski (2000). For example, Ga East and Adenta Assemblies had their town planning and engineering departments providing different figures to the number of BS permits they have issued (Appendix F). Moreover the MMDA who responded to the contrary further explained that, they are not technically equipped to monitor and evaluate mitigating measures. Controversially, it becomes very difficult to explain why towers are not inspected every 6 months to assess especially their structural integrity. Certainly, this study again cannot ignore the influence of political, technological, cultural, social and organizational factors as earlier mentioned Meredith and Mantel (1995) and Cicmil (2000). However, informal interviews and discussions done revealed frustrations from the MMDA and hence support the argument that political factors are probably the most influential Ahmad (1996).

In assessing to what extent institutions monitor and evaluate measures implemented, some indirect questions were posed. This strategy was used in agreement with the ideals of Hilding-Rydevik (2006) and Similä (2007) that directly linked the "effectiveness" of environmental policy tools to the achievement of policy goals. For example, compliance with regulations governing the mounting of BSs was used as a fundamental indicator. However, all residents who claimed they were aware of some regulations were categorical that, operators do not fully comply. In fact, 65 residents cited "not to mount closer to homes" whilst 20 sited "to seek public consent" among others as regulations operators do not comply.

5.6.3 Focused

This describes the ability of the EIA process to concentrate on significant environmental effects and relevant issues that ought to be taken into account in making decisions.

5.6.3.1 Environmental requirements

This study consents to the argument by Pölönen (2007) that, the preconditions for granting environmental permits are intended to prevent significant negative effects on the environment and unreasonable burdens on properties. However, considering the main responsibilities of the NCA, this study did not identify any direct responsibility linked to environmental concerns. This further suggests that perhaps because most studies have produced no adverse results, as emphasized by Chagnaud et al. (1999) and Heikkinen et al. (2001) permitting agencies are still not critical on precautionary measures.

The EPA listed "distance of BSs from residents, schools or hospitals" and "plot size" Guidelines on Communication Towers (2010) as the major environmental factors they consider before issuing permits. Though, this study can confidently assert that, this is practically to the contrary as observed in residential areas, nevertheless, the EPA at the time of this study insisted that, all operators will comply by May, 2015. Indeed, as this research directly links "effectiveness" of performance to achievement of goalsHilding-Rydevik (2006) and Similä (2007), it yet cannot point to the cause of this "ineffectiveness".

The MMDA are to issue permits only when twelve conditions are satisfied; however, those below are strictly designed to minimize environmental impacts, consequently, strengthening the principles of Glasson et al. (2005).

They are;

- A design of the structure showing its effective height, foundation, guys used, members, ladders, rest and work platforms, earthing, lighting protection and aviation lighting.
- Permit issued by the GCAA for the installation of the tower in the proposed location.
- Evidence of accident insurance policy and neighbourhood consultation.
- Structural integrity report and geo-technical investigation report

On the contrary, objective field survey conducted during this research cannot attest to operators fully satisfying all these conditions. Therefore in further assessing the achievement of goals as proposed by Hilding-Rydevik (2006) and Similä (2007) this research cancontend the effectiveness of the MMDA. However, Greig et al. (2004) concluded that, the limited ability to influence national policy at the local level, regardless of its importance hinders the value of EIA.

Residents were required to confirm whether operators comply with regulations governing the mounting of BSs as insisted in EIA Wood (2003). Eighty one respondents forming 56.3% who claimed being aware of the basic requirements, insisted that operators do not comply with regulations governing the mounting of BSs. This indeed to some extent contradicts the assertion that, many citizens are “rationally ignorant” in urban planning Krek (2005). Residents subsequently listed the regulations that companies flout in a descending order as;

- Mounting closer to homes or residential areas.
- To seek public consent.
- To educate the public.
- Co-Location

Therefore, if honestly, negativity bias has not been demonstrated as at times suspected by Rozin and Royzman (2001), then the public’s view does not contradict that of the EPA and the MMDA.

5.6.3.2 Minimum legal distance

The maintaining of physical barriersto reduce harm, as recommended by Haddon (1973) is indeed very relevant in developing countries as other restrictions Hale et al. (2004) andHollnagel(1999) are more likely to be flouted.

The NCA and the EPA confirmed that, there are specific minimum legal distances for locating BSs from residents Guidelines on Communication Towers (2010). This suggests that, these agencies perhaps are not in a position to effectively enforce the mitigating measures implemented. Though other factors could account for this, however, political factors as observed are the most influential Ahmad (1996) and is still perceived or suspected by this study.

The response from the MMDA revealed almost a split disclosure; out of the 8 responses, 5 forming 62.5% insisted minimum setbacks exist whilst the others surprisingly maintained their ignorance. This further reveals the lack of an integrated model as asserted by Clarke (1984) and Hollick (1986) and hence suggests an approach which builds on the concept of EIA as an input to decision making Brown and Hill (1995).

This study can associate the inability of the MMDA to enforce minimum distances with political, cultural, social and organizational factors Meredith and Mantel (1995) and Cicmil (2000).

Residents as discussed earlier have already cited the mounting of BSs to homes as the regulation mostly flouted by operators. Therefore, this study can confirm that, distance is a critical factor in terms of the siting of certain sensitive facilities as further argued by Petts and Eduljee (1994), Löscher and Käs(1998) and Guidelines on Communications Towers (2010).

5.6.4 Systematic

The process should result in full consideration of all relevant information on the affected environment. This should include proposed alternatives, their impacts and measures necessary to monitor and investigate residual effects.

5.6.4.1 Waste Management

The NCA's response to all EIA related questions and specific questions on WEEE of the MTT were simply "enquire from EPA".

The EPA unfortunately did not mention any activity performed in managing WEEE as far as the MTT is concerned, however, the Guidelines on Communications Towers (2010) specified that, the disposal of used batteries should be supervised by the EPA. Controversially, the EPA stated that, WEEE of the industry is not scientifically managed in Ghana, hence confirming the assertion by Amoyaw-Osei et al. (2011) that, Ghana has no policy on WEEE. Indeed, Oteng-Ababio (2010) has further concluded that, despite a wide range of environmental legislation in Ghana, there are no specific laws for WEEE recycling. This consequently reinforces other studies reporting of difficulties in WEEE management in most countries Agamuthu et al. (2009) and Hiramatsu et al. (2009).

The MMDA responded "no" to this specific question except the Ga East Assembly (WD) that responded to the affirmative and subsequently pointed that, this measure is in the environmental permit issued by the EPA. Though the application for EPA permit requires the performance of EIA to avert any detrimental effect to the environment Guidelines on Communication Towers (2010), the guidelines failed to highlight the holistic management of WEEE.

Residents were not to respond to this question as they know of the commonly adopted methods of open burning and dumping at uncontrolled dumpsites Agamuthu (2001) which scientists claim cause serious environmental problems including health hazards Ball and Denhann (2003).

However, almost all stakeholders involved in this research expressed serious concern about the indiscriminate dumping of WEEE and suggested that the EPA should play a leading role in the management.

5.6.5 Adaptive

The process should be adjusted to the realities, issues and circumstances of the proposal underreview. Therefore, relevant techniques and experts in diverse disciplines including traditional knowledge should be used in achieving accepted objectives.

5.6.5.1 Commitment of stakeholders to EIA principles

The main duty of the NCA that this study can confirm the agency attaches great commitment to is "equipment standards and type approval". Indeed, this research revealed that, radiation levels measured are indeed in compliance with the ICNIRP threshold as confirmed by levels measured by Amoako et al. (2009). In responding directly to whether operators are committed to EIA principles, the NCA responded "enquire from EPA". This response clearly indicates inconsistencies to the quality of regulatory governance and confidence as cited by Melody (1997) and Stern and Holder (1999).

This study sought the capacity of the EPA relative to its duties as argued by Ridgeway et al. (1996) and discussed earlier. A direct question demanding whether operators are committed to EIA principles and compliance with local and international regulations were replied in the affirmative.

All the MMDA indicated a direct link to environmental concerns as far as their duties are concerned. This therefore, places the MMDA in a better position to confirm whether operators are really committed to EIA principles. All the eight respondents except one (Adentan TP) which forms 12.5% gave an affirmative response to this question. If this claim can be fully supported by this study, then complaints and risk perception from residents should be at a minimal as sought by effective EIA principles Sadler (1996) and Mickwitz (2003).

Complaints and risk perception from residents as discussed above can be used as a measure to indicate the level of commitment of operators and institutions that issue permits. Results of this study contravene the claim by Slovic et al. (1990) that, a qualitative factor such as unfamiliarity could increase discontent as 81 respondents forming 61.1% out of 144 respondents claimed they are familiar with the MTT.

Therefore, discontent for the MTT by residents could subsequently be linked to “electromagnetic hypersensitivity” Ahlbom et al. (2004) and Koivisto et al. (2001), especially with those in close proximity to facilities of the technology McGee et al. (2002). As a result of this, “compensating people to relocate” is considered by this study as a relevant option since a causal relationship between EMF exposure and symptoms is yet to be scientifically established WHO (2005), Koivisto et al. (2001), Seitz et al. (2005) and Rubin et al. (2005). However, this study has also revealed that relocation is indeed not acceptable to residents Hayes and Morrison-Saunders (2007) as only 28 respondents forming 19.4% claimed they will relocate when compensated.

5.6.5.2 Achievement of EIA objectives

The achievement of EIA objectives is considered in line with the claim by Glasson et al. (2005) to be linked directly to the effective implementation of EIA measures. Therefore, this study considers the reduction in the number of complaints from all stakeholders especially residents as a practical measure of achievement. Additionally, issues of scientific uncertainty Stewart-Oaten et al. (1986) as well as that of statistical and nonscientific constraints Osenberg et al. (1992) about the MTT should be resolved. In resolving, this study recommends the research tool “Before-After-Control-Impact” as prescribed by Stewart-Oaten et al. (1986) to enhance understanding of environmental effects.

Therefore, achievement of EIA objectives of the MTT can be judged based on all the discussions done in this chapter as further reiterated by the EPA "not fully", hence suggesting that, more should be done.

5.7 Risk vulnerability index (RVI)

Based on the results obtained from this study, the following variables have been identified to increase the RVI of the MTT;

X_1 = Heavy metals

X_2 = Noise

X_3 = Possible collapse

X_4 = Possible fire outbreak

X_5 = Geohazard

X_6 = Perception

X_7 = Absence of aerial bulb

Therefore, employing equation (4.7), the RVI for the MTT can be calculated with all the variables assigned a mathematical value of 1 and RVI expected to be greater than zero (0).

Where X_1 is considered as a constant.

X_n may alter as risk perceptions vary over time and are interpreted on the basis of context. This model does not have any denominator to reduce the RVI; because all individuals including babies are susceptible Koranteng-Addo et al. (2010) and Cobbinah et al. (2013) and also cannot resist the constant X_1. This RVI, though results in negative emotions it is expected to promote sustainable behavior Malott (2010) since sustainability does not come naturally Dawkins (2001).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This chapter provides the conclusions to significant findings of this study with the main intention of revealing and resolving misconceptions, doubts and perceptions about the MTT. Though few studies have focused on quantitative analysis, this research has gone further to include qualitative variables for analyses to arrive at relevant techniques to assist reduce risks.

RF emissions from BSs were ranging from 2.23E-07 to 3.11E-01 for the 900MHz and also from 1.58E-08 to 5.60E-01 for the 1800MHz, hence suggesting that RFs do not pose any health threat to the public as confirmed by (Amoako et al., 2009). The suspicion based on the "belief" that, radiation from BS antennae could in the long term cause adverse health effects could not be supported by this study. Indeed, this research revealed that, radiation levels are in compliance with the ICNIRP threshold. However, this public concern could be attributed to the fact that, there is no clear and definitive assessment as to whether there exists a health risk from long-term exposure to RFs.

Possible adverse effects of noise could be experienced by people within a radius of 50m from BSs as noise levels were above the EPA standards around some BSs between the hours of 22:00pm to 06:00am. Hence, considering only a BS sited in a residential zoning, about 118 individuals are therefore prone to the adverse effects of noise. However, this number of individuals increases as the number of BSs as well increase.

This research focused on the presence of heavy metals as they are bio-accumulative, persistent and can virtually damage any organ. All the heavy metals analyzed were detected at low levels, except Hg which has exceeded its threshold whist Cd has also reached its threshold and may possibly pose health risk to the public. This confirms the claim by Koger et al. (2005) and Obiri et al. (2010) that, there is increasing evidence linking toxicants such as Hg, Pb, As, and Cd to the incidence of cognitive impairments, especially in children, and cancers of all sorts. Though Fe recorded high values in the soil samples, the statistical analysis performed suggested that, only Fe occurred naturally and is hardly affected by human activities. Indeed, the application for EPA permit requires the performance of EIA to avert any detrimental effect to the environment, the guidelines failed to highlight the holistic management of WEEE.

Finally, this study cannot support any effective practical intervention or policy to mitigate even the anticipated significant adverse impacts and this indeed contradicts the fundamentals of an effective EIA system. Objective deductions from all respondents and observations pointed categorical to the fact that, operators do not fully comply with the rules and regulations governing the MTT. However, the inability to influence national policy at the local level, regardless of its importance hinders the value of EIA.

Additionally, ineffective strategic environmental communication has been highlighted as the major factor required to increase the knowledge level and content of all stakeholders, therefore reducing perception among populations and not necessarily distance from BSs. As such research fatigue was expressed by almost all residents indicating the desire to have access to credible information on the MTT and not necessarily to participate or contribute to what is not meaningful to them.

6.2 Recommendations

Considering the diverse significant importance of the MTT to individuals and the society at large, it is therefore necessary to have regulations and practices that are relevant to encourage all stakeholders to voluntarily improve upon their environmental performance.

Therefore the following recommendations are made;

- To EPA

I. Inter and intra agency/institutional collaboration should be initiated at the local level to ensure the effective implementation of all policies.

II. An independent telecommunications regulator (ITR) should therefore be mandatory for the effective regulation of the MTT. The ITR should be deemed truthful, honest, frank and transparent by all stakeholders and be supervised by the EPA.

- To MMDA

I. Should supervise public consultation in all the EIA procedures (from decision making to evaluation) as this is crucial to cooperative risk management and the resolution of controversial risk-related issues.

II. Should strictly enforce a minimum setback distance of not less than 50m of BSs from the nearest residential structure.

III. Should invest in the recovery and recycling of all WEEE to reduce the extraction of raw metals from the earth and the exposure to heavy metals.

- To Operators

I. Should comply with all the conditions in the guidelines provided by government for mounting BSs.

II. Should compensate residents who would wish to relocate under very verifiable and acceptable conditions to all stakeholders. This is aimed at eliminating hypersensitivity especially in individuals who were in residence before BSs were mounted.

- To Government

I. Should initiate a research project that would really quantify radiation levels absorbed by individuals to provide a consistent database which will be needed for future studies since it is not always reliable to depend only on background scientific knowledge.

II. Should initiate a research project that would test for heavy metals in body fluids of residents around dumpsites.

REFERENCES

Abelin, T (1999). "Sleep disruption and melatonin reduction from exposure to a shortwave radio signal". Seminar at Canterbury Regional Council, New Zealand. August, 1999.

Abdel-Rassoul, G., Abou, E. O., Abou Salem, M., Michael, A., Farahat, F., El-Batanouny, M and Salem, E (2006). Neurobehavioral effects among inhabitants around mobile phone base stations, *NeuroToxicology*, doi:10.1016/j.neuro.2006.07.012: 4.

Accra Metropolitan Assembly (AMA) (2010-2013). Medium term development plan. Ghana shared growth and development agenda.

Adger, W. N (2006). Vulnerability. Global Environmental Change 16: 268-281.

ADI (2010). African Development Indicators, Open Data by Country. Available at: http://data.worldbank.org/data-catalog/africa-development-indicators

Agamuthu, P (2001). Heavy metals contamination of soil-derived interstitial water in the coastal regions of Selangor Malaysia. *Malaysian Journal of Science*, 20: 127–134.

Agamuthu, P., Khidzhir, K. M and Hamid, F. S (2009). Drivers of sustainable waste managementin Asia. Waste Management and Research 27: 625–633.

Ahlbom,A., Green, A., Kheifets, L., Savitz, D and Swerdlow, A (2004). Epidemiology of Health Effects of Radiofrequency Exposure. Environmental Health Perspectives; 112(17): 1741-1754.

Ahmad, B (1996). Public participation in EIA: a case study analysis. *Environ Impact Assess Review*; 22: 213–234.

Ahmed, K., Mercier, J. R and Verheem, R (2005). Strategic environmental assessment - concept and practice. Environment strategy notes. No.14. Washington: The World Bank.

Alister, C and Kogan, M (2006). Environmental risk index. A simple proposal to select agrochemicals for agricultural use. Crop Protection, 25(3): 202–211.

Ambraseys, N. N and Adams R. D (1986). Seismicity of West Africa, *Ann. Geophysicae*, 4B (6): 679-702.

Amoako, J. K., Fletcher, J. J. and Darko, E. O (2009) Measurement and analysis of radiofrequency radiations from some mobile phone base stations in Ghana. Radiation Protection Dosimetry, Vol. 135, No. 4: 256–260.

Amoyaw-Osei, Y (2011). Ghana e-Waste Country Assessment: 69-77.

Amponsah, P. E (2002). Seismic activity in relation to fault systems in Southern Ghana, *J. African EarthSci.*,35: 227-234.

Andrew, A. A., Takem, G. E. E and Nkeng, G. E (2009). Water resources management and integrated water resources management (IWRM) in Cameroon. Water Resources Management, 24(5): 871–888.

Antwi, A. Y and Adams, J (2003). 'Rent-Seeking Behaviour and its Economic Costs in Urban Land Transactions in Accra, Ghana; *Urban Studies*, 40: 2083-2098.

Arai, N., Enomoto, H., Okabe, S., Yuasa, K., Kamimura, Y and Ugawa, Y (2003). Thirty minutes mobile phone use has no short term adverse effects on central auditory pathway. *Clin Neurophysiol*; 114: 1390-1394.

Ayas, K (1996). Design for learning and innovation. Long Range Planning 29(6): 898–901.

Ayetey, J. K (1988). Earthquake site response study of Accra Area, Ghana. *Bulletin Int. Assoc. of Eng. Geol.*, No.38.

Babbie, E (2005). The basics of social research. 3rd Ed. Thomson: Wadsworth

Bacon, B and Quaah, A. O (1981). Earthquake activity in Southeastern Ghana 1977-1980, *Bull. Seismol.Soc. Am.*, 71: 771-784.

Bak, M., Sliwinska-Kowalska, M., Zmyslony, M and Dudarewicz, A (2003). No effects of acute exposure to the electromagnetic field emitted by mobile phones on brainstem auditory potentials in young volunteers. *Int J Occup Med Environ Health;* 16: 201-208.

Baker, F (1990). "Risk Communication about Environmental Hazards." *Journal of Public Health Policy* 2, No. 3: 341.

Bali Post (2008). 'Bencana Lingkungan Ancam Denpasar'. Bali Post, 2 August.

Balica, S. F., Douben, N and Wright, N. G (2009). Flood Vulnerability Indices at varying spatial scales. *Water Science and Technology Journal* 60 (10): 2571-2580.

Ball, J. M and Denhann, L. B (2003). A South African project to remediate dumpsites. In Proceeding of ninth international waste management and landfill symposium, Cagliari, Italy.

Ballatori, N (2002). Transport of toxic metals by molecular mimicry. Environmental Health Perspectives 110: 689-694.

Bamberg, S and Schmidt, S (2003). Incentives, morality or habit? Predicting students' car use for university routes with the models of Ajzen, Schwartz and Triandis. Environment and Behavior 35: 264–285.

Bandura, A (1994). Social Cognitive Theory and Exercise of Control over HIV Infection . New York: Plenum.

Banerjee, A and Ros, A (2004). Patterns in global fixed and mobile telecommunications development: A cluster analysis. Telecommunications Policy, 28: 107–132.

Banister, D (2008). The sustainable mobility paradigm. Transport Policy 15: 73–80.

Bankes, S (1993). Exploratory modeling for policy analysis. Operational Research 41 (3): 435–449.

Barredo, J. I., de Roo, A and Lavalle, C (2007). Flood risk mapping at European scale. Water Science and Technology 56 (4):11-17.

Barry, G. A., Chudek, P. J., Best, E. K and Moody, P. W (1995). Estimation sludge application rates on land based on heavy metal and phosphorous sorption characteristics of soil. Water Resources, 29: 2031–2034.

Beck, U (1992). Risk Society. Towards a New Modernity. London: Sage.

Becker, M (1974). The Health Belief Model and Personal Health Behaviour . New Jersey: Slack.

Bekoe, E. O., Logah, F. Y and Kankam-Yeboah, K (2009). Evidence of the modification of hydrological cycle in Ghana. CSIR WRI/TR No. 178, 2009.

Berger, U., Piou, C., Schiffers, K and Grimm, V (2008). Competition among plants: concepts, individual-based modelling approaches, and a proposal for a future research strategy. Perspect. *Plant Ecol. Evol. Syst.* 9: 121–135.

Berkau, E. E., Cordle, S. R., Hart, F. D and Simon G. R (1975). "An Assessment of the Federal Noise Research, Development and Demonstration Activities: FY 73-FY 75," EPA 600/2-75-010, US EPA, Washington DC.

Berkhout, F and Hertin, J (2004). De-materializing and re-materializing: digital technologies and the environment. *Futures*; 36(8): 903–920.

Bernard, A (2004). Renal dysfunction induced by cadmium: Biomarkers of critical effects. *Biometals* 17: 519-523.

Berry, M. J and Ralston, N. V. C (2009). Mercury toxicity and the mitigating role of selenium. *Ecohealth* 5: 456-459.

Bertrand, P. (2005). Possible social policy developments and corresponding statistical requirements. *Review of income and wealth:* Vol (29): 89-93.

Besset, A., Espa, F., Dauvilliers, Y., Billiard, M and de Seze, R (2005). No effect on cognitive function from daily mobile phone use. *Bioelectromagnetics*; 26: 102-108.

Beven, K. (2002). Towards a coherent philosophy for modelling the environment. *Proc. R. Soc. Land.* A 458: 1–20.

Bhatia, R and Wernham, A (2008). Integrating human health into environmental impact assessment: an unrealized opportunity for environmental health and justice.*Environ Health Perspect* 116: 991.

Bickerstaff, K (2004). Risk perception research: Socio-cultural perspectives on the public experience of air pollution. Environment International 30: 827 – 840.

Biel, A and Thøgersen, J (2007). Activation of social norms in social dilemmas: a review of the evidence and reflections on the implications for environmental behavior. *Journal of Economic Psychology* 28: 93–112.

Bier, V. M (2001). "On the State of the Art: Risk Communication to Decision-Makers." *Reliability Engineering& System Safety* 71, No. 2: 151–157.

Bishop, B., Paton, D., Syme, G and Nacarrow, B (2000). Coping with environmental degradation: Salination as a community stressor. Network 12: 1 – 15.

Bistrup, M. L (2003). Prevention of adverse effects of noise on children. *Noise Health* 5: 59-64.

Boateng, E (1998). Proceedings of Workshop on Land Use Planning. FAO Land Use Planning Project. New York: Food and Agriculture Organization of the United Nations, TCP/GHA/6715/A, 1998.

BÖhm, G and Pfister, H. R (2000). Action tendencies and characteristics of environmental risks. *Acta Psychologica*; 104: 317–337.

Bond, A. J., Mortimer, K. J and Cherry J (1998). The focus of local agenda 21 in the UK. *J Environ Plan Manag;* 41: 767–776.

Bond, A. J., Palerm, J and Haigh, P (2004). Public participation in EIA of nuclear power plant decommissioning projects: a case study analysis. *Environ Impact Assess*; 24: 617–641.

Borja-Aburto, V. H., Picciotto, I. H and Lopez, M. R (1999). Blood lead levels measured prospectively and risk of spontaneous abortion. *American Journal of Epidemiology* 150: 590-597.

Bosher, L., Dainty, A., Carrillo, P and Glass, J (2007). Built-in resilience to disasters: a preemptive approach, Engineering. Construction and Architectural Management 14 (5): 434-446.

Box, G. E. P (1979). Robustness in scientific model building. Pages 201–236 in R. L. Launer and G. N. Wilkinson, editors. Robustness in statistics. Academic Press, New York, New York, USA.

Brady, N. C and Weil, R. R (1999). The nature and properties of soils. 12th Ed. Prentice Hall. Upper Saddle River, NJ.

Brent, R. L., Tanski, S and Weitzman, M (2004). A pediatric perspective on the unique susceptibilities and resilience of the embryo and the child to environmental toxicants: The importance of rigorous research concerning age and agent. *Paediatrics,* 113: 935–944.

Bridgen, K., Labunska, I., Santillo, D and Johnston, P (2008). Chemical Contamination at E-wasteRecycling and Disposal Sites in Accra and Korforidua, Ghana. Greenpeace International Amsterdam.

British Medical Association (1998). Health and environmental impact assessment: an integrated approach. London: Earthscan Publications.

Brown, A. L and Hill, R. C (1995). Decision-scoping: making EA learn how the design process works. Project appraisal, 10 (4): 223-232.

Brown, A. L and McDonald, G. T (1995). From environmental impact assessment to environmental design and planning. *Australian Journal of Environmental Management*, 2 (2): 65-77.

Brun, W (1992). Cognitive components in risk perception: Natural versus manmade risks. *Journalof Behavioral Decision Making;* 5(2): 117–132.

Buchanan, J and Gordon, T (1962). The calculus of consent: Logical foundations of a constitutional democracy. University of Michigan Press: Ann Arbor.

Buckley, R. C (1994a). Cumulative environmental impacts: Problems, policy and planning law. *Environmental and Planning Law Journal*, 11: 344-347.

Buckley, R. C (1994b). Strategic environmental impact assessment. *Environmental and Planning Law Journal*, 11: 166-168.

Budic Z. D (1994). Effectiveness of geographic information systems in local planning. *Journal of the American Planning Association*; 60(2): 244–263.

Bulut, Y and Bayasal, Z (2006). Removal of Pb (ii) from wastewater using wheat bran. *Journal of Environmental Management*, 4: 78–79.

Burnham, K. P and Anderson, D. R (2002). Model selection and multimodel inference: A practical information-theoretic approach. 2 Ed. Springer-Verlag, New York, USA.

Burr, V (1995). An Introduction to Social Constructionism. London: Routledge.

Calow, P (1998). Handbook of Environmental Risk Assessment and Management. Blackwell: Oxford.

Canter, L.W(1996). Cumulative effects and other analytical challenges of NEPA. In Environmental policy and NEPA: Past, present, and future. Clark, E.R., and Canter, L.W., eds. Winter Park, Fla.: St. Lucie Press.

Caswell, H (2001). Matrix population models: Construction, analysis, and interpretation. Second edition. Sinauer Associates, Sunderland, Massachusetts, USA.

Cave, B., Bond, A., Molyneux, P and Walls, V (2005). Reuniting health and planning: a training needs analysis. Cambridge: East of England Public Health Group; 2005.

CEPA (2000). Soil Classification in Ghana. Ghana, Selected Economic Issues. Centre for Policy Analysis, No. 35; http://www.ghana.com.gh/cepa

Chagnaud, J. L., Moreau, J. M and Veyret, B (1999). No effect of short-term exposure to GSM-modulated low power microwaves on benzo(a)pyrene-induced tumours in rat. *Int J Radiat Biol* 75(10): 1251-1256.

Chancerel, P and Rotter, S (2009). Recycling-oriented characterization of small waste electrical and electronic equipment. *Waste Manag*. 29: 2336–2352.

Chen, Z. S., Lee, D. Y., Lin, C.F., Lo, S. L and Wang, Y. P (1999). Contamination of rural and urban soils in Taiwan. In: Contaminants and the Soil Environment in the Australasia-Pacific Region, R. Naidu, R.S. Kookuna, D.P. Oliver, S. Rogers, M.J. McLaughlin (Eds.). Kluwer Academic Publishers, Boston, London: 691-709.

Cheng, H. G., Qi, Y., Pu, X., Gong, L and Hao, F. H (2007). Game theoretic analysis of environmental impact assessment system in China. *Front Environ Sci Eng* 2007; 4: 448–453.

Cherry, N (2000). Health effects associated with mobile base stations in communities: the need for health studies. www.starweave.com

Christoph, I. B., Bruhn, M and Roosen, J (2008). Knowledge and attitudes towards acceptability of genetic modification in Germany. *Appetite* 51: 58–68.

Cicmil, S (2000). Quality in project environments: a non-conventional agenda. International *Journal of Quality and Reliability Management* 17(4/5): 554–570.

Clarke, B. D (1984). The aims and objectives of environmental impact assessment. In Perspectives on environmental impact assessment, eds. B. D. Clarke, A. Gilad, R. Bisset, and P. Tomlinson: 3-13. Dordrecht, Holland: D. Reidel.

Clarkson, T. W (1995). Environmental contaminants in the food chain. *American Journal of Clinical Nutrition* 61: 682-686.

Clay, G. R and Smidt, R. K (2004). Assessing the validity and reliability of descriptor variables used in scenic highway analysis. *Landsc. Urban Plan* 66: 239–255.

Coates, J. F (1976). Technology assessment- A toolkit. *Chemtech,* (June): 372-383.

Cobbinah, S. J., Michael, K., Salifu, L and Duwiejua, A. B (2013). Rainwater quality assessment in the Tamale municipality. *Int. J. Sci. Technol. Res.* 2013, *2*: 1–10.

Cohen, S and Weinstein, N (1981). Non-auditory effects of noise on behavior and health. *Journalof Social Issues* 37: 36-70.

Collins, J and Koplan, J. P (2009). Health impact assessment: a step toward health in all policies. JAMA; 302: 315–317.

Collins, A. E., Lucas, M. E., Islam, M. S and Williams, L. E (2006). Socio-economic and environmental origins of cholera epidemics in Mozambique: Guidelines for tackling uncertainty in infectious disease prevention and control. *International Journal ofEnvironmental Studies,* Special Issue on Africa 63 (5): 537 – 549.

Commission of the European Communities (CEC). Directive 2001/42/EC, of 27th June, on the assessment of the effects of certain plans and programmes on the environment. *Official Journal of the European Union* 2001; L 197/30, 21st July.

Cook, C. M., Thomas, A. W and Prato, F. S (2002). Human electrophysiological and cognitive effects of exposure to ELF magnetic and ELF modulated RF and microwave fields: A review of recent studies. *Bioelectromagnetics*; 23: 144-157.

Covello, V. T (2003). Best practices in public health risk and crisis communication: *Journal Health Commun.* 8 Suppl (1): 5-8.

Covello, V. T., McCallum, D. B and Pavlova, M (1991). "Effective Risk Communication." Environment International 17, No. 4: 388-392.

Covello, V. T., von Winterfeldt, D and Slovic, P (1986). "Communicating Risk Information to the Public." Risk Abstracts: 3: 1–14.

Creswell, J. W (2002). Educational research: Planning, conducting, and evaluating quantitative and qualitative research. Upper Saddle River, NJ: Pearson Education.

Crowe, M., Elser, A., Göpfert, B., Mertins, L., Meyer, T., Schmid, J., Spillner, A. and Ströbel, R (2003). Waste from electrical and electronic equipment (WEEE) – quantities, dangerous substances and treatment methods. European Environmental Agency.

Curry G. L and Deuermeyer B. L (1989). Discrete simulation. Holden-Day, Oakland, CA.

Das, K. K., Das, S. N and Dhundasi, S (2008). Nickel its adverse health effects and oxidative stress. *Indian Journal of Medical Research*, 128: 412–425.

Daston, G., Faustman, E., Ginsberg, G., Fenner-Crisp, P., Olin, S., Sonawane, B., Bruckner, J andBreslin, W (2004). Framework for assessing risks to children from exposure to environmental agents. *Environ Health Perspect*, 112(2): 238–256.

Davenport, C., Mathers, J and Parry, J (2006). Use of health impact assessment in incorporating health considerations in decision making. *J Epidemiol Community Health*; 60: 196–201.

Davis, S., Kaune, W. T., Mirick, D. K., Chen, C and Stevens, R. G (2001). Residential Magnetic

Fields, Light-at-Night, and Nocturnal Urinary 6-Sulfatoxymelatonin Concentration in Women. *American Journal of Epidemiology* Vol. 154, No. 7: 591-600.

Dawes, R. M (1980). Social dilemmas. Annual Review of Psychology 31: 169–193.

Dawkins, R (2001). Sustainability does not come naturally-A Darwinian perspective on values, the values platform for sustainability. Inaugural lecture at the Royal Institution. Fishguard, UK: The Environment Foundation.

D'Costa, H., Trueman, G., Tang, L., Abdel-Rahman, U., Abdel-Rahman, W and Ong, K (2003). Human brain wave activity during exposure to radiofrequency field emissions from mobile phones. *Australas Phys Eng Sci Med*; 26: 162-167.

Deatanyah, P., Amoako, J. K., Fletcher, J. J., Asiedu, G. O., Adjei, D. N., Dwapanyin G. O and Amoatey E. A (2012). Assessment of radiofrequency radiation within the vicinity of some GSM base stations in Ghana. Radiation Protection Dosimetry; 4–5.

De Groot, J. I. M and Steg, L (2010). Morality and nuclear energy: perceptions of risks and benefits, personal norms and willingness to take action related to nuclear energy. Risk Analysis 30: 1363–1373.

DeAngelis, D. L., Rose, K. A. and Huston, M. A (1994). Individual oriented approaches to modeling ecological populations and communities. In: Frontiers in Mathematical Biology. Springer, Berlin: 390–410.

Dekker, S (2006). Chronicling the emergence of confused consensus. InResilience Engineering. *Concepts and Precepts*, Hollnagel E, Woods DD, Leveson N (eds). Ashgate: Aldershot, Hampshire: 77–92.

Del Furia, L and Wallace-Jones, J (2000). The effectiveness of provisions and quality of practices concerning public participation in EIA in Italy. *Environ Impact Assess*; 20 (4): 457–479.

DeRosa, C (1998). “Public Health Implications of Environmental Exposures.” Environmental Health Perspectives 106(Suppl. 1): 369–378.

De Vries, F and Bakker, D (1998). Manual for calculating critical loads of heavy metals for terrestrial ecosystem: Guidelines for critical limits, calculation methods and input data TNO Institute of Environmental Sciences, Energy Research and Process Innovation. Den Helder, The Netherlands: 144.

Dickson, K. B and Benneh, G (1988). A New Geography of Ghana. Longman Group UK Limited. Longman House, Burnt Mill, Harlow, Essex, England.

Dimitrakakis, E., Janz, A., Bilitewski, B and Gidarakos, E (2009). Small WEEE: determining recyclables and hazardous substances in plastics. *J. Hazard. Mater*. 161: 913–919.

Dinh, Q., Balica, S., Popescu, I and Jonoski, A (2012). Climate change impact on flood hazard, vulnerability and risk of the Long Xuyen Quadrangle in the Mekong Delta. *International Journal of River Basin Management* 10 (1): 103-120.

Dow, W. H., Schoeni, R. F., Adler, N. E and Stewart, J (2010). Evaluating the evidence base: policies and interventions to address socioeconomic status gradients in health. *Ann NY Acad Sci*; 1186: 240–251.

Durgin, G. D (2009). The practical behaviour of various edge diffraction formulas. IEEE. *Antennas Propag Mag* 51: 24–35.

Eger and Neppe (2009). Incidence of cancer adjacent to a mobile telephone base station in Westalia, Germany. *Journal epidem:* 22(1): 55-60.

El-Fadl, K and El-Fadel, M (2004) Comparative assessment of EIA systems in MENA countries: Challenges and prospects. *Environ Impact Assess*; 24(6): 553–593.

Elliott, J. L (2001). Zinc and copper in the pathogenesis of amyotrophic lateral sclerosis. Progressin Neuro-Psychopharmacology and Biological Psychiatry 25: 1169-1185.

EMF-NET: European Funded Project (2009). Effects of the Exposure to Electromagnetic Fields: From Science to Public Health and Safer Workplace. Annual reports. http://web.jrc.ec.europa.eu/emf-net/

Environmental Protection Agency (www.epa.gov.gh , online report: 2010 and 2014).

Erickson, M. D and Kaley, R. G (2011). Applications of polychlorinated biphenyls. *Environ. Sci. Pollut. Res.* 18: 135–151.

Eriksson, L., Garvill, J and Nordlund, A. M(2008). Acceptability of single and combined transport policy measures: the importance of environmental and policy specific beliefs. Transportation Research Part A: Policy and Practice 42: 1117–1128.

Eriksson, L., Garvill, J and Nordlund, A. M (2006). Acceptability of travel demand management measures: the importance of problem awareness, personal norm, freedom, and fairness. *Journal of Environmental Psychology* 26: 15–26.

Etzel R. A (2003). Pediatric environmental health, 2nd ed. Elk Grove Village, IL, American Academy of Pediatrics, Committee on Environmental Health.

European Parliament and Council (2003). Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE). *Off. J. Eur. Union* L37: 24–38.

European Parliament and Council (2009). Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products. *Off. J. Eur. Union* L285: 10–35.

Farmer, P (2001). Infections and Inequalities. California: California University Press.

Farvacque-Vitkovic, C., Raghunath, M., Eghoff, C and Boakye, C (2008). 'Development of the Cities of Ghana: Challenges, Priorities and Tools', *Africa Region Working Paper Series* No. 110: World Bank.

Federal Communications Commission (FCC) Office of Engineering and Technology(1997).Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.Additional Information for Amateur Radio Stations.Washington, D.C. 20554. *Supplement B (Edition 97-01) to OET Bulletin 65* (Edition 97-01).

Fischer, T. B (2007). Strategic environmental assessment- an introduction; Retrieved from; http://www.penta-eu.net/docs/WebText.pdf (last accessed: September 2010).

Flyvbjerg, B., Bruzelius, N and Rothengatter, W (2003). Megaprojects and Risk: An Anatomy of Ambition. Cambridge: Cambridge University Press.

Fosmire, G. J (1990). Zinc toxicity. *American Journal of Clinical Nutrition* 51: 225-227.

François, L., Fortin, C and Campbell, P. G. C (2007). pH modulates transport rates of manganese and cadmium in the green alga Chlamydomonas reinhardtii through non competitive interactions: Implications for an algal BLM. *Aquatic Toxicol* 84: 123–132.

Franzen, D. W (2011). "Collecting and Analyzing Soil Spatial Information Using Kriging and Inverse Distance." Chap. 4 in *GIS Applications in Agriculture*: 61-80. Boca Raton, FL: CRC Press.

Frey, A. H (1998). Headaches from cellular telephones: are they real and what are the implications? *Environ Health Perspect* 106(3): 101-103.

Frick, U., Rehm, J and Eichhammer, P (2002). Risk perception, somatization, and self report of complaints related to electromagnetic fields—A randomized survey study. *International Journal of Hygiene and Environmental Health* 205: 353–360.

Garling, T and Schuitema, G (2007). Travel demand management targeting reduced private car use: effectiveness, public acceptability and political feasibility. *Journal of Social Issues* 63: 139–153.

Ghana Statistical Service (2008). Pattern and Trends of Poverty in Ghana.

Ghana statistical service (2012), 2010 Population and Housing Census.

Ginzburg, L. R and Jensen, C. X. J (2004). Rules of thumb for judging ecological theories. Trends in Ecology and Evolution 19: 121–126.

Glasson, J., Therivel, R and Chadwick, A (2005). Introduction to environmental impact assessment. 3rd Ed. Oxon: Routledge.

GSMA (2016). Global System Mobile Association (online report).

Glynn, P. W., Heidelberger, P., Nicola, V., Shahabuddin, P (1993). Efficient estimation of the mean time between failures in non-regenerative dependability models. In: Proceedings of the 1993 Winter Simulation Conference: 311-316.

González, A (2010). Incorporating spatial data and GIS to improve SEA of land use plans: opportunities and limitations- case studies in the Republic of Ireland. Lambert Academic Publishing.

González, A., Gilmer, A., Foley, R., Sweeney, J and Fry, J (2008). Developing and applying a participative web-based GIS for integration of public perceptions into strategic environmental assessment. In: Mount N. J, Harvey G. L, Aplin P, Priestnall G, editors. Representing, modeling and visualizing the natural environment: innovations in GIS 13. Florida: CRC Press: 117–133.

Goodman L. A (1961). Snowball sampling. *The Annals of Mathematical Statistics* 32(1): 148–170.

Gough, K. V and Yankson, P. W. K (2000). 'Land Markets in African Cities, the Case of Peri-Urban Accra, Ghana', *Urban Studies*, 37: 2485-2500.

Gould, K. A., Pellow, D. N and Schnaiberg, A (2004). Interrogating the treadmill of production. Organization & Environment, 17: 296-316.

Grant, R (2009). Globalizing City: The Urban and Economic Transformation of Accra Ghana (Syracuse, N.Y.: Syracuse University Press).

Grant, R and Nijman, J (2002). "Globalization and the Corporate Geography of Cities in the Less Developed World", *Annals of the Association of American Geographers*, 92: 320-340.

Grant, R. and Yankson, P (2003). "City Profile, Accra". *Cities,* Vol. 20: 65-74.

Graybill, D. L (1985). If environmental impact assessment is everything, maybe it's nothing-some arguments for more attention to practical aspects of implementation, *The Environmental Professional*, 7: 344-351.

Gregory, R and Mendelsohn, R (1993). "Perceived Risk, Dread, and Benefits." Risk Analysis 13(3): 259–264.

Greig, S., Parry, N and Rimmington, B (2004). Promoting sustainable regeneration: learning from a case study in participatory HIA. *Environ Impact Asses*; 24: 255–267.

Grimm, V (1999). Ten years of individual-based modelling in ecology: what we have learned and what could we learn in the future? *Ecol. Model.* 115: 129–148.

Guidelines for the Deployment of CommunicationTowers, Ghana Gazette No. 3, Friday 14th January,2011.

Gunning, P (2002). Understanding democracy: An introduction to public choice. http://www.fortunecity.com/meltingpot/barclay/212/votehtm/cont.htm.

Gupta, H. V., Beven, K. J and Wagener, T (2005). Model calibration and uncertainty estimation. In: Anderson, M.G., McDonnell, J.J. (Eds.), Encyclopedia of Hydrological Sciences. JohnWiley and Sons Ltd., Chichester, UK: 1–17.

Haddon, W. Jr (1973). Energy damage and the ten counter-measure strategies, *Human Factors Journal.*

Haefner, J. W (1996). Modeling biological systems: Principles and applications. Chapman and Hall, New York, USA.

Haines, M. M., Brentnall, S. L., Stansfeld, S. A and Klineberg, E (2003). Qualitative responses of children to environmental noise. *Noise Health* 5: 19-30.

Hale, A., Goossens, L., Ale, B., Bellamy, L., Post, J., Oh, J and Papazoglou, I. A (2004). Managing safety barriers and controls at the workplace, Proceedings of PSAM7-ESREL'2004 conference, 14–18 June, Berlin: 609–613.

Hale, T. S and Moderg, C. R (2003). Location science research: a review. Annals of Operations Research 123: 21–35.

Hamilton, J. T (1995). Testing for environmental racism: Prejudice, profits, political power? *Journal of Policy Analysis and Management* 14: 107–132.

Harrison, C and Haklay, M (2002). The potential of public participation. GIS in UK environmental planning: appraisals by active publics. *International Journal for Environmental Planning and Management*; 45(6): 841–864.

Hayes, N and Morrison-Saunders, A (2007). Effectiveness of environmental offsets in environmental impact assessment: Practitioner perspectives from Western Australia, *Impact Assess Proj Apprais* 25 (3): 209–218.

He, H. S., Mladenoff, D. J and Boeder, J (1996). LANDIS, a spatially explicit model of forest landscape disturbance, management and succession. LANDIS 2.0 user guide. University of Wisconsin, Madison, USA.

Heart, S (2009). *International Journal of Environmental Engineering:* 1(4):335-351.

Heeks, R and Molla, A (2009). Impact Assessment of ICT-for-Development Projects: A Compendium of Approaches. Paper No. 36, Development Informatics Working Paper Series. http://www.sed.manchester.ac.uk/idpm/research/publications/wp/di/documents/di_wp36.pdf.

Heikkinen, P., Kosma, V.M., Hongisto, T., Huuskonen, H., Hyysalo, P., Komulainen, H., Kumlin, T., Lahtinen, T., Lang, S., Puranen, L and Juutilainen, J (2001). Effects of mobile phone radiation on X-ray induced tumor genesis in mice. *Radiat Res*: 156: 775-785.

Heinma, K and Põder, T (2010). Effectiveness of environmental impact assessment system in Estonia.*Environ Impact Assess Rev*; 30: 273.

Henley, E. J and Kumamoto, H (1981). Reliability Engineering and Risk Assessment, Prentice-Hall Inc.

Henriques, I and Sadorsky, P (2007). Environmental management systems and practices: an international perspective. In *Environmental Policy and Corporate Behaviour*, Johnstone N (ed.). OECD–Elgar: Northampton, MA: 34–87.

Hepinstall, J. A., Sader, S. A and. Krohn. W. B (2002). Effects of niche width on the performance and agreement of avian habitat models. Pages 593–606 in J. M. Scott, P. J. Heglund, M. L. Morrison, J. B. Haufler, M. G. Raphael, W. A. Wall, and F. B. Samson, editors. Predicting species occurrences: Issues of scale and accuracy. Island Press, Washington, D.C., USA.

Herben, T., During, H. J., Law, R (2000). Spatio-temporal patterns in grassland communities. In: Geometry of Ecological Interactions: Simplifying Spatial Complexity, Cambridge University Press: 48–64.

Hermann, F., Klotz, G and Urbach, H (2000). Guidance Document on Substances under Special Attention, IEEE Symposium on Electronics and the Environment: 217-222.

Hertz-Picciotto, I (1995). Epidemiology and quantitative risk assessment: a bridge from science to policy. *Am J Public Health*; 85: 484–491.

Hilding-Rydevik, T (2006). Environmental assessment. Effectiveness, quality and success. In: Mariussen Å, Uhlin Å, editors. Trans-national practices. Systems thinking in policy making. Stockholm: Nordregio: 77–93.

Hilty, L., Arnfalk, M. P., Erdmann, L., Goodman, J., Lehmann, M and Wäger, P. A (2006). The relevanceof information and communication technologies for environmental sustainability - a prospective simulation study. *Environ Model Software*; 21(11): 1618–1629.

Hiramatsu, A.Y., Hara, M., Sekiyama, R., Honda, R and Chiemchaisri, C (2009). Municipal solid waste flow and waste generation characteristics in an urban-rural fringe area in Thailand. Waste Management and Research 27: 951–960.

Hischier, P and Eugster M., R. (2007). Key environmental impacts of the Chinese EEE industry –a life cycle assessment study. State Secretariat for Economic Affairs (SECO). St.Gallen / Switzerland; Beijing / China, Swiss Federal Laboratories for Materials Testing and Research (Empa); Tsinghua University China: 90.

Hoffman, F. O and Hammonds, J. S (1994). Propagation of uncertainty in risk assessments: the need to distinguish between uncertainty due to lack of knowledge and uncertainty due to variability. *Risk Anal* 14(5): 707–712.

Hokkanen, P (2007). Kansalaisosallistuminen ympäristövaikutusten arviointimenettelyssä. Acta Universitatis Tamperensis 1285. Tampere: Tampere University Press; 89: 104-145.

Hollick, M (1986). Environmental impact assessment: an international evaluation. Environmental Management, 10 (2): 157-178.

Hollnagel E. (1999). *Accidents and Barriers*. http://www.ida.liu.se/~eriho/ [28 June 2007].

Hossmann, K. A and Hermann, D. M (2003). Effects of electromagnetic radiation of mobile phones on the central nervous system. *Bioelectromagnetics*; 24: 49-62.

Howe A., Hoo Fung L., Lalor G. C., Rattray R and Vutchkov M (2005). Elemental composition of Jamaican foods 1: A survey of five food crop categories. Environmental Geochemistry and Health 27: 19-30.

Huber, R., Graf, T., Cote, K.A., Wittmann, L., Gallmann, E., Matter, D (2000). Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG. *Neuroreport* ; 11: 3321-3325.

Hübel, M and Hedin, A (2003). Developing health impact assessment in the European Union. Bull World Health Organ; 81: 463–464.

Huisman, J., Magalini, F., Kuehr, R., Maurer, C., Delgado, C., Artim, E. Szlezak, J., Ogilvie, S., Poll, J and Stevels, A (2007). 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE) (Final Report). United Nations University Study No. 07010401/2006/442493/ETU/G4, Bonn, Germany.

Hutter, H. P., Moshammer, H., Wallner, P and Kundi, M (2006). Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occup Environ Med*; 63: 307-316.

Hyland, G. J (2000). Physics and biology of mobile telephony: *The Lancet*; Vol 356:1833-1936.

ICNIRP (1998). Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz). Health Phys. 74: 494–522.

International Organization for Standards (1975).(ISO) "Acoustics-Standard Reference Zero for Calibration of Pure Tone Audiometers," ISO 389-1975 (1975).

IPCS (2000). Human exposure assessment. Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 214).

IPCS (2001). Neurotoxicity risk assessment for human health: Principles and approaches. Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 223).

IPCS (2004). IPCS risk assessment terminology. Part 1: IPCS/OECD key generic terms used in chemical hazard/risk assessment; Part 2: IPCS glossary of key exposure assessment terminology. Geneva, World Health Organization, International Programme on Chemical Safety (Harmonization Project Document No. 1).

IPCS (2005). Chemical-specific adjustment factors for interspecies differences and human variability: Guidance document for use of data in dose/concentration–response assessment. Geneva, World Health Organization, International Programme on Chemical Safety (Harmonization Project Document No. 2).

ITU (2016). Manual for assessing ICT access and use by households and individuals.

ITU (2008). World telecommunications indicators. International Telecommunication Union, Geneva.

ITU (2003). Climate change and protection of the environment. itu.int/ITU-T/

Jakeman, A. J., Letcher, R. A and Norton, J. P (2006). Ten iterative steps in development and evaluation of environmental models. Environmental Modelling and Software 21 (5): 602–614.

Jakobsson, P. J., Thoren, S., Morgenstern, R and Samuelsson, B (2000). *Proc. Nath. Acad. Sci.* USA 96: 7220-7225.

Jarup, L (2003). Hazards of heavy metal contamination. British Medical Bulletin 68: 167-182.

Jiang, P., Harney, M., Chen, B., Song, Y., Chen, Q., Chen, T., Lazarus, G., Dubois, L., Korzenski, M (2008). *Improving the End-of-Life for Electronic Materials via Sustainable Recycling Methods.* Advanced Technology Materials Incorporated, Inc. Print.

João, E. M (2007). The importance of data and scale issues for strategic environmental assessment. Environmental impact assessment review, special issue on data and scale issues for SEA; 27(5): 361–364.

Johnson, D. H (2001). Validating and evaluating models. Pages 105–119 in T. M. Shenk and A.

B. Franklin, editors. Modeling in natural resource management: Development, interpretation, and application. Island Press, Washington, D.C., USA.

Jones, G. P and Kaly, U (1996). Criteria for selecting marine organisms in biomonitoring studies. *Detecting Ecological Impacts*: Judson, O.P (1994). The rise of the individual-based model in ecology. *Trends Ecol. Evol.* 9: 9–14.

Junner, N. R (1941). The Accra Earthquake of June 1939, *Gold Coast Geol. Surv. Bull.*, 13: 3-41.

Kahneman, D and Tversky, A (1979). Prospect theory: An analysis of decision under risk. *Econometrica* 47: 263–291.

Kaufman, L and Rousseeuw, P. J(1990). Finding Groups in Data: An Introduction to Cluster Analysis. New York: Wiley.

Kawachi, I and Berkman, L. F (2003). Neighborhoods and health. New York: Oxford University Press.

Kemm, J (2004). What is health impact assessment and what can it learn from EIA? Environ Impact Asses Rev; 24: 131–134.

Kemm, J and Parry, J (2004). The development of HIA. In: Kemm J, Parry J, Palmer S, editors. Health impact assessment. Oxford: Oxford University Press: 15–23.

Kempen, V. E., Kamp, V. I., Fischer, P., Davies, H., Hanthuijs, D., Stellato, R and Clark, C (2006). “Noise exposure and children’s blood pressure and heart rate: the RANCH project”. *Occupational and environmental medicine* 63 (9): 632-639.

Kennett, S and Perl, A (1995). Environmental impact assessment of development-oriented research. *Environ Impact Assess Rev*; 15(4): 341–360.

Kettenring, K. M., Martinez, B. T., Starfield, A. M and Getz, W. M (2006). Good practices for sharing ecological models. *BioScience* 56: 59–64.

Kimmel, C. A., Kimmel, G. L and Euling, S. Y (2006). Developmental and reproductive toxicity risk assessment for environmental agents. In: Hood RD ed. Developmental and reproductive toxicology, a practical approach. Boca Raton, FL, CRC Press.

Kjorven, O and Lindhjem, H (2002). Strategic environmental assessment in World Bank operations. Environment strategy papers. no. 4. USA: World Bank.

Kletz, T. A (1999). The origins and history of loss prevention. Loss Prevention Bulletin, Trans IchemE 77(B): 109–116.

Kodama, K., Preston, D. L., Pierce, D. A., Shimizu, Y., Suyama, A and Tahara, E (2003). Radiation effects on cancer mortality among atomic bomb survivors. Proc Am Assoc Cancer Res, 44: 1278 (Abstract No. 6394).

Koehler, J. J (1993). The influence of prior beliefs on scientific judgments of evidence quality. Organizational Behavior and Human Decision Processes 56: 28–55.

Koger, S. M., Schettler, T., Weiss, B (2005) Environmental toxicants and developmental disabilities:A challenge for psychologists. *Am. Psychol.*, 60: 243–255.

Koivisto, M., Haarala, C., Krause,C.M., Revonsuo, A., Laine, M and Hämäläinen, H (2001). GSMphone signals do not produce subjective symptoms. *Biolelectromagnetics* ; 22: 212-215.

Konadu-Agyemang, K (1998): The Political Economy of Housing and Urban Development in Africa: Ghana's experience from colonial times to 1998.

Koranteng-Addo, E. J., Bentum, J. K., Sackitey, O. J., Tuffuor, J. K., Essumang, D. K and Owusu-Ansah, E (2010). Lead, Cadmium and Arsenic in breast milk of lactating mothers in Odumanse-Atua community in Manya Krobo district of eastern region of Ghana. *J. Chem. Pharm. Res.*, 2010, 2(5): 16-20.

Koren, G and Klein, N (1991). Bias against negative studies in newspaper reports of medical research. *J Am Med Assoc* 266: 1824–1826.

Krause, C. M., Sillanmaki, L., Koivisto, M., Haggqvist, A., Saarela, C and Revonsuo A (2000).

Effects of electromagnetic field emitted by cellular phones on the EEG during a memory task. *Neuroreport*; 11: 761-764.

Krek, A (2005). Rational ignorance of the citizens in public participatory planning. In 10th Symposium on information- and communication-technologies (ICT) in urban planning and spatial development and impacts of ICT on physical space, CORP 05. Vienna University of Technology: Vienna, Austria.

Krewski, D., Lemyre, L and Turner, M. C (2006). Public perception of population health risks in Canada: Health hazards and sources of information. *Hum Ecol Risk Assess* 12: 626–644.

Kristiansen, I. S., Elstein, A. S., Gyrd-Hansen, D., Kildemoes, H. W and Nielsen, J. B (2009). Radiation from mobile phone systems: Is it perceived as a threat to people's health? *Bioelectromagnetics* 30: 393–401.

Kuhn, S (2009). EMF Risk Assessment: Exposure Assessment and Compliance Testing in Complex Environments.SwissFederal Institute of Technology, Zurich, Switzerland: Hartung-Gorre Verlag Konstanz. *PhD thesis, Diss.* ETHNr. 18637.

Lapa, N., Barbosa, R., Morais, J., Mendes, B., Méhu, J and Santos Oliveira, J (2002). Ecotoxicological assessment of leachates from MSWI bottom ashes. *Waste Manage.* 22; 583–593.

Larson, M. A., Thompson, F. R., Millspaugh, J. J., Dijak, W. D and Shifley S. R (2004). Linking population viability, habitat suitability and landscape simulation models for conservation planning. Ecological Modelling 180: 103–118.

Lazarus, R. S (1991). Emotion and Adaption. Oxford: Oxford University Press.

Leke, L., Akaahan, T. J and Simon, A (2011) Heavy metals in soils of auto mechanic shops and refuse dumpsites in Markurdi, Nigeria. *J. Appl. Sci. Environ. Manage.* 15, (1): 207.

Leknes, E (2001). The role of EIA in the decision-making process. *Environ Impact Assess*; 21(4):309–334.

Levallois, P., Dumont, M., Touitou, Y., Gingras, S., Masse, B., Gauvin, D., Kroger, E., Bourdages, M. and Douville, P (2001). Effects of Electric and Magnetic Fields from High-power Lines on Female Urinary Excretion of 6-Sulfatoxymelatonin. *American Journal of Epidemiology Vol.* 154, No.7: 601-609.

Lewis, R. J (1991). Hazardous chemical desk reference (2nd Ed): 1–71. Van Nostrand Reinhold, New York, USA.

Lhachimi, S. K., Nusselder, W. J., Boshuizen, H. C and Mackenbach, J. P (2010). Standard tool for quantification in health impact assessment a review. *AmJ Prev Med*; 38: 78–84.

Lindström, M., Attila, M and Koskela, S (2007). Incidental Releases from Industrial Installations. Final Report, European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) Report 2006/17. 49.

Little, R. J. A and Robin, D. B (1983). On jointly Estimating Parameters and Missing Data by Maximizing the Complete-Data Likelihood. In: The American Statistician, vol. 37 (3). Published by American Statistical Association: 218-220.

Little, R. J. A and Robin, D. B (1987). Statistical Analysis with Missing Data. J. Wiley & Sons, New York.

Loewenstein, G. F., Weber, E. U., Hsee, C. K and Welch, N (2001). Risk as feeling. Psychological Bulletin; 127(2): 267–286.

Lomnicki, A (1988). Introduction: basic models of population ecology and intra population variability. In: Population Ecology of Individuals. Princeton University Press, Princeton; 1–19.

Löscher, W and Käs, G (1998). Conspicuous behavioural abnormalities in a dairy cow herd near a TV and Radio transmitting antenna. *Practical Veterinary surgeon*, 29 (5): 437-444.

Loukopoulos, P., Jakobsson, C., Gärling, T., Schneider, C. M. and Fujii, S (2005). Public attitudes towards policy measures for reducing private car use. Environmental Science and Policy 8 (1): 57–66.

Low, K. S., Lee, G. K and Liew, S. C (2000). Sorption of cadmium and lead from aqueous solutions by spent grain. Process Biochemistry, 36: 59–64.

Lundgren, R (1995). "Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks Technical communication." 42, No. 3: 504.

Lupton, D (1999). Risk and Sociocultural Theory: New Directions and Perspectives. Cambridge: Cambridge University Press.

MacIntosh D. L and Spengler J. D (2000). Human Exposure Assessment. International Programme on Chemical Safety. Environmental Health Criteria 214; Geneva: WHO.

Macri, D and Mullet, E (2007). Cross-national validation of an eight-factor model of societal risk perception. *Hum Ecol Risk Assess* 13: 1352–1358.

Madhavan, N and Subramanian, V (2000). Sulphide mining as a source of arsenic in the environment. Current Science 78(6): 702-709.

Makria, A and Stilianakis, N. I (2008). Vulnerability to air pollution health effects. *Int J Hyg Environ Health;* 211: 326–336.

Mallarino, A and Wittry, D (2001). Management Zones Soil Sampling: A Better Alternative to Grid and Soil Type Sampling? Ames: Iowa State University Extension: 159-164.

Malott, R. W (2010). I'll save the world from global warming-tomorrow: Using procrastination management to combat global warming. *The Behavior Analyst*, 33: 179–180.

Mangel, M., Fiksen, O and Giske, J (2001). Theoretical and statistical models in natural resource management and research. Pages 57–72 in T. M. Shenk and A. B. Franklin, editors. Modeling in natural resource management: Development, interpretation, and application. Island Press, Washington, D.C., USA.

Mann, K and Roschke, J (1996), Effects of pulsed high-frequency electromagnetic fields on human sleep. Neuropsychobiology 33(1): 41-47.

Manzanas, R., Amekudzi, L., Preko, K., Herrera, S., Gutierrez, J (2014). A comparison of methods to determine the onset of the growing seasons in Nigeria. *Clim. Chang* (124): 805-819.

Mark, F. E (2006). The Characteristics of Plastics-rich Waste Streams from End-of-life Electrical and Electronic Equipment. Plastics Europe, Belgium.

Marmot, M and Wilkinson, R (2006). The Social Determinants of Health. New York City: Oxford University Press.

Marshall, R., Arts, J and Morrison-Saunders, A (2005). International principles for best practice EIA follow-up. Impact assessment and project appraisal. *Impact Assess Proj Apprais*; 23: 175–181.

Martinez, C. E and Motto, H. L (2000). Solubility of lead, zinc and copper added to mineral soils. Environmental Pollution, 107: 153–158.

May, T (2001). Social research: issues, methods and process. Buckingham: Open University Press.

Mayer, D. G and Butler, D. G (1993). Statistical validation. *Ecol Model* 68 (1–2): 21–32.

McGee, R., Reeder, A., Williams, S., Bandaranayake, M and Tan, A. H (2002). Observations of summer sun protection among children in New Zealand: 1998–2000. *N ZMed J*, 115: 103–106.

Melody,W (1997). On the meaning and importance of 'independence' in telecom reform. Telecommunications Policy, 21(3): 195–199.

Menad, N., Blörkman, B and Allain, E. G (1998). Combustion of plastics contained in electri celectronic scrap. Resour. Conserv. Recycl. 24: 65-85.

Mendoza, F. J. C and Izquierdo, A. G (2009). Environmental risk index: a tool to assess the safety of dams for leachate. *Journal of Hazardous Materials*, 162(1): 1–9.

Meredith, J. R and Mantel, S. L (1995). Project Management – A Managerial Approach, 4th edn. New York: John Wiley & Sons.

Messner, F and Meyer, V (2006). Flood damages, vulnerability and risk perception-challenges for flood damage research. In: Schanze, J., Zeman, E., Marsalek, J. (Eds.), Flood Risk Management: Hazards, Vulnerability and Mitigation Measures. Springer: 149-167.

Mickwitz, P (2003). A framework for evaluating environmental policy instruments. Evaluation, 4: 421.

Mindell, J., Hansell, A., Morrison, D., Douglas, M and Joffe, M (2001). What do we need for robust, quantitative health impact assessment? *J Public Health Med 2001*; 23: 173–178.

Moore, C. T., Conroy, M. J and Boston, K (2000). Forest management decisions for wildlife objectives: System resolution and optimality. Computers and Electronics in Agriculture 27: 25–39.

Mor, S., Ravindra, K., Dahiya, R. P and Chandra, A (2006). Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. Environmental Monitoring and Assessment, 118: 435–456.

Morrison, M. L., Marcot, B. G and Mannan, R. W (1998). Wildlife-habitat relationships: Concepts and applications. Second edition. University of Wisconsin Press, Madison, Wisconsin, USA.

Moszynski, M (2011). Social system of production in Germany- a model for future? Hannover, Germany.

Mounier, F., Janicot, S., Kiladis, G. N (2008). The West African Monsoon Dynamics, Part III. The Quasi-Biweekly zonal dipole. *J. Clim.* (21): 1911-1928.

Muff, R and Efa, E (2006). Environmental and Engineering Geology for urban planning in the Accra-Tema area, Geological Service Department- Ghana and federal institute for Geoscience and natural resources, Hannover, Germany.

Mukherjee, A. B and Bhattacharya, P (2001). Arsenic in groundwater in the Bengal Delta Plain: Slow poisoning in Bangladesh. Environmental Review 9: 189-220.

Murrell, D.J., Purves, D. W and Law, R (2001). Uniting pattern and process in plant ecology. *Trends Ecol. Evol.* 16: 529–530.

Muzet, A (2007). Environmental noise, sleep and health. *Sleep Medicine Reviews* 11(2): 135-142.

Mylavarapu, R. S and Lee, W. D (2011). "UF/IFAS Nutrient Management Series: Soil Sampling Strategies for Precision Agriculture." IFAS Extension, University of Florida. http://edis.ifas.ufl.edu/pdffiles/SS/SS40200.pdf

Nadiri, M. I and Nandi, B (2003). Telecommunications infrastructure and economic development. InG.Madden(Ed.), Telecommunications Network: The International Handbook of Telecommunications Economics, Vol.1: 293–314.Northampton: Edward Elgar Publishing.

National Research Council (NRC) (1983) Risk assessment in the federal government: Managing the process. Report of the Committee on the Institutional Means for the Assessment of Risks to Public Health, Commission on Life Sciences. Washington, DC, National Academy Press.

National Research Council (NRC) (1989). Improving Risk Communication. Report of the Committee on Risk Perception and Communication, Commission on Social Sciences. Washington DC, National Academy Press.

National Research Council (NRC) (1990). Groundwater models; scientific and regulatory applications. Washington, DC: 303.

National Research Council (NRC) (1994). Science and judgment in risk assessment. Washington, DC, Commission on Life Sciences, Committee on Risk Assessment of Hazardous Air Pollutants.

National Research Council (NRC) (2009). Science and decisions: advancing risk assessment. Washington, DC: National Academies Press.

Needham, L. L., Ozkaynak, H., Whyatt, R. M., Barr, D. B., Wang, R. Y., Naeher, L., Akland, G., Bahadori, T., Bradman, A., Fortmann, R., Liu, L. J. S., Morandi, M., O'Rourke, M. K., Thomas, K., Quackenboss, J., Ryan, P. B and Zartarian, V (2005). Exposure assessment in the national children's study: introduction. *Environ Health Perspect* 113(8): 1076–1082.

Neshev, N. N and Kirilova, E. I (1996). Environmental-health aspects of pulse-modulated microwaves. *Rev Environ Health* 11(1-2): 85-88.

Nettleton, S (2006). The Sociology of Health and Illness. Cambridge: Polity Press.

Newey, W. K (1990). Semi-parametric efficiency bounds. *Journal of Applied Econometrics*

5; 99-135.

Nichols, J. D (2001). Using models in the conduct of science and management of natural resources. Pages 11–34 in T. M. Shenk and A. B. Franklin, editors. Modeling in natural resource management: Development, interpretation, and application. Island Press, Washington, D.C., USA.

Nnorom, I. C and Osibanjo, O (2008). Electronic waste (e-waste): Material flows and management practices in Nigeria. Waste Management 28: 1472-1479.

Nnorom I. C and Osibanjo O (2009). *Journal of Hazardous Materials* 161: 183-188.

Obiri, S., Dodoo, D. K., Essumang, D. K., Armah, F. A (2010). Cancer and non-cancer risk assessment from exposure to arsenic, copper, and cadmium in borehole, tap, and surface water in the Obuasimunicipality, Ghana. *Hum. Ecol. Risk Assess.*22: 651–665.

O'Connell, E and Hurley, F (2009). A review of the strengths and weaknesses of quantitative methods used in health impact assessment. Public Health; 123: 306–310.

Olin, S. S and Sonawane, B. R (2003). Workshop to develop a framework for assessing risks to children from exposure to environmental agents. *Environ Health Perspect*, 111(12): 1524–1526.

Oliver, C. D., Boydak, M. Segura, G and Bare B. B (1999). Forest organization, management, and policy. Pages 556–596 in M. L. Hunter, Jr., editor. Maintaining biodiversity in forest ecosystems. Oxford University, United Kingdom.

Oreskes, N and Belitz ,K (1994). The meaning of models – response. Science 264(5157): 331–341.

Osenberg, C. W., Holbrook, S. J and Schmitt, R. J (1992). Implications for the design of environmental studies. Pages 75-89 in Griffman P. M. and Yoder S. E., editors. Perspectives on the marine environment of southern California.

Oteng-Ababio, M (2010). E-waste: an Emerging Challenge to Solid Waste Management in Ghana". *Int. Development Planning Review* (IDPR). 32 (2).

Owusu, G (2008), 'Indigenes and Migrants Access to Land in Peri-Urban Areas of Ghana's largest City of Accra', *International Development Planning Review* (IDPR), 30/2: 177-198.

Ozturan, O., Erdem, T., Miman, M. C., Kalcioglu, M. T and Oncel, S (2002). Effects of the electromagnetic field of mobile telephones on hearing. *Acta Otolaryngol;* 122: 289-293.

Palerm, J. R (1999). Public participation in EIA in Hungary: analysis through three case studies. *Environ Impact Assess;* 19: 201–220.

Parazzini, M., Bell, S., Thuroczy, G., Molnar, F., Tognola, G and Lutman, M. E (2005). Influence on the mechanisms of generation of distortion product otoacoustic emissions of mobile phone exposure. *Hear Res;* 208: 68-78.

Partidário M. R (2007). Scales and associated data - what is enough for SEA needs? Environmental impact assessment review, special issue on data and scale issues for SEA; 27(5): 460–478.

Passchier-Vermeer, W and Passchier, W. F (2000). Noise exposure and public health. Environmental Health Perspectives, 108 (supplement 1):123-131.

Patil, A. A., Annachhatre A. P and Tripathi N. K (2002). Comparison of conventional and geo-spatial EIA: a shrimp farming case study. Environmental impact assessment review; 22(4): 361–375.

Paton, D and Johnston, D (2001). Disasters and communities: Vulnerability, resilience and preparedness. Disaster Prevention and Management 10: 270 – 277.

Patton, M. Q (1990). Qualitative research and evaluation methods(2nd Ed). Newbury Park, CA: Sage.

Pelkonen, P., Lang, M. A., Negishi, M., Wild, C. P and Juvonen, R. O (1997). Interaction of aflatoxin B1 with cytochrome P450 2A5 and its mutants: Correlation with metabolic activation and toxicity. Chemical Research in Toxicology, 10: 85-90.

Pelling, M (2003). The Vulnerability of Cities; Natural Disaster and Social Resilience. Earth

Scan Publications, UK & USA.

Peltonen, T., Suoheimo, S., Huimala, U., Pennanen, J and Sahivirta, E (2004). Voluntary Environmental Management Systems and the Permitting Procedure in the EU Member States. The Finnish Environment 677. Finnish Environment Institute: Helsinki.

Penning-Rowsell, E., Floyd, P., Ramsbottom, D and Surendran, S (2005). Estimating injury and loss of life in floods: a deterministic framework. Natural Hazards 36: 43-64.

Petts, J and Eduljee, G (1994). Environmental impact assessment for waste treatment and disposal facilities. Chichester: Wiley.

Pickford, J (2001). Mastering Risk, Vol. 1: Concepts, Pearson Education Ltd.

Pielke, J. R. A (2003). The role of models in prediction for decision. In: Canham, C., Lauenroth, W. (Eds.), Understanding Ecosystems: The Role of Quantitative Models in Observations, Synthesis, and Prediction. Princeton University Press, Princeton, NJ: 113–137.

Plate, E. J (2002). Flood risk and flood management. *Journal of Hydrology* 267: 2-11.

Plous, S (1991). Biases in the assimilation to technological breakdowns: Do accidents make us safer? *J Applied Social Psychol* 21: 1058–1082.

Pollard S and Guy J (2001). Risk Assessment for Environmental Professionals. A publication of the Chartered Institution of Water and Envionmental Management: London.

Pölönen, I (2007). Ympäristövaikutusten arviointimenettely. Tutkimus YVA-menettelyn oikeudellisesta asemasta ja kehittämistarpeista ympäristöllisen vaikuttavuuden näkökulmasta. Jyväskylä: Suomalaisen Lakimiesyhdistyksen julkaisuja A-sarja: 34-35.

Poortinga, W., Steg, L., Vlek, C and Wiersma, G (2003). Household preferences for energy saving measures: a conjoint analysis. *Journal of Economic Psychology* 24 (1): 49–64.

Pope, C. A and Dockery, D. W (2006). Health effects of fine particulate air pollution: lines that connect. *J Air Waste Manage Assoc*; 56: 709–742.

Power, M (1993). The predictive validation of ecological and environmental-models. *Ecol Model* 68(1–2): 33–50.

Preece, A. W., Iwi G., Davies-Smith, A., Wesnes, K., Butler, S and Lim E (1999). Effect of a 915MHz simulated mobile phone signal on cognitive function in man. *Int J Radiat Biol;* 75: 447-456.

Proctor, R and Van Zandt, T (2008). *Human Factors In Simple And Complex Systems*, 2nd Edition, Mallory International.

Purves, D. W and Law, R (2002). Fine-scale spatial structure in a grassland community: quantifying the plant's-eye view. *J. Ecol.* 90: 121–129.

Qiao Zhiqui (1994). The application of EIA in China. Environmental Management and Technique. Beijing: China Environmental Science Press.

Quaah, A. O (1980). Microseismicity, past seismic Activity and seismic Risk in Southern Ghana, *Ph.D.Thesis* (University of London).

Quigley, R., den Broeder, L., Furu, P., Bond, A., Cave, B and Bos, R (2006). Health Impact Assessment, International best practice principles. Special publication series No. 5. Fargo, USA: International Association for Impact Assessment.

Rains, G. C and Thomas D. L (2001). Soil-Sampling Issues for Precision Management of Crop Production. The University of Georgia, College of Agricultural and Environmental Sciences, *Bulletin 1208.*

Rasmussen, P. E., Wheeler, A. J., Hassan, N. M., Filiatreault, A and Lanouette, M (2007). Monitoring personal, indoor, and outdoor exposures to metals in airborne particulate matter: Risk of contamination during sampling, handling and analysis. Atmos Environ 41: 5897–5907.

Regli, S., Rose, J. B., Haas, C. N and Gerba, C. P (1991). Modeling the risk from Giardia and viruses in drinking water. *J. Am. Water Works Assoc.* 83: 76–84.

Renwick, A. G., Barlow, S. M., Hertz-Picciotto, I., Boobis, A. R., Dybing, E., Edler, L., Eisenbrand, G., Greig, J. B., Kleiner, J., Lambe, J., Muller, D. J., Smith, M. R., Tritscher, A., Tuijtelaars, S., van den Brandt, P. A., Walker, R and Kroes, R (2003) Risk characterisation of chemicals in food and diet. *Food Chem Toxicol*, 41(9): 1211–1271.

Richter-Reichhelm, H. B., Althoff, J., Schulte, A., Ewe, S and Gundert, R. U (2002). Workshop report. Children as a special subpopulation: focus on immunotoxicity. Federal Institute for Health Protection of Consumers and Veterinary Medicine, Germany. *Arch Toxicol*, 76(7): 377–382.

Ridgeway, B., McCabe, M., Bailey, J., Saunders, R., Sadler, B (1996). Environmental Impact Assessment Training Resource Manual. Prepared for the United Nations Environment Programme by the Australian Environment Protection Agency. Nairobi, Kenya.

Roller, L. H and Waverman, L (2001). Telecommunications infrastructure and economic development: A simultaneous approach. American Economic Review, 91(4); 909–923.

Rongen, E van, Croft, R., Juutilainen, J., Lagroye, I., Saunders, R., de Seze, R., Tenforde, T., Vershaeve, L., Veyret B and Xu Z (2009). Effects of radiofrequency electromagnetic fields on the human nervous system. *J Toxicol and Env*. Health Part B; 12: 572-597.

Rose, N (1999). Powers of Freedom. Cambridge: Cambridge University Press.

Rozin, P and Royzman, E. B (2001). Negativity bias, negativity dominance, and contagion. *Personality and Social Psychol Rev* 5: 296–320.

Rubin, G. J., Das Munshi, J and Wessely, S (2005). Electromagnetic hypersensitivity: a systematic review of provocation studies. *Psychosom Med*; 67: 224-232.

Rybaczuk, K and MacMahon, H (1995). Accessing geographic information for Ireland. Dublin: Forbairt and the Irish Institution of Surveyors.

Rykiel, E. J (1996) .Testing ecological models: the meaning of validation. *Ecol Model* 90(3): 229–244.

Saad, M., Cicmil, S and Greenwood, M (2002). Technology transfer projects in developing Countries-furthering the project management perspectives. *International Journal of Project Management* 20: 617–625.

Saarikoski, H (2000). Environmental impact assessment as collaborative learning process. *Environ Impact Assess*; 20(6): 681–700.

Sachs, J (2000). A new map of the world. The Economist 24 June 2000.

Sadler, B (1996). Environmental assessment in a changing world: Evaluating practice to improve performance. Final report. International study of the effectiveness of environmental assessment. Canadian Environmental Assessment Agency. International Association for Impact Assessment: 37.

Sairinen, R (2000). Regulatory reform of Finnish environmental policy. Centre for Urban and Regional Studies Publications A27. Espoo: Helsinki University of Technology: 165-176.

Sandelowski, M (1995). Focus on qualitative methods: Sample sizes in qualitative research. *Research in Nursing & Health,* 18: 179-183.

Santini, R., Santini, P., Danze, J. M., Le Ruz, P and Seigne, M (2002). Investigations on the health of people living near mobile telephone relay stations: Incidence according to age and sex. *Pathol Biol* (Paris): 50(6): 369-373.

Santini, R and Santini, P (2001). Symptoms experienced by people living in the vicinity of cellular phone base stations: Influence of distance and sex. *La Presse Medicale,* 10th September 2001.

Santos, S. L (1987). Risks: How to get more science in assessments. Environmental Science

& Technology, 21: 239-240.

Saunders, A. M and Bailey, M (2009). Appraising the role of relationships between regulators and consultants for effective EIA. *Environ Impact Assess*; 29: 284–294.

Schade, J and Schlag, B (2003). Acceptability of urban transport pricing strategies. Transportation Research Part F: Traffic Psychology and Behaviour 6: 45–61.

Schlummer, M., Gruber, L., Mäurer, A., Wolz, G and van Eldik, R (2007). Characterisation of polymer fractions from waste electrical and electronic equipment (WEEE) and implications for waste management. *Chemosphere* 67: 1866–1876.

Schroeder, W., Franzle, O., Keune, H and Mandy, P (1996). Global Monitoring of Terrestrial Ecosystems. Ernst & Sohn. Berlin.

Schuitema, G., Steg, L and van Kruining, M (2011). When is transport pricing policies fair and acceptable? Social Justice Research 24: 66–84.

Scott, J. M., Heglund, P. J., Morrison, M. L., Haufler, J. B., Raphael, M. G., Wall, W. A and Samson, F. B (2002). Predicting species occurrences: Issues of accuracy and scale. Island Press, Washington D.C., USA.

Seitz, H., Stinner, D., Eikmann, T., Herr, C and Röösli, M (2005). Electromagnetic hypersensitivity (EHS) and subjective health complaints associated with electromagnetic fields of mobile phone communication – a literature review published between 2000 and 2004. *Sci Total Envir*; 349: 45-55.

Senese, V., Boriani, E., Baderna, D., Mariani, A., Lodi, M and Finizio, A (2010). Assessing the environmental risks associated with contaminated sites: definition of an ecotoxicological classification index for landfill areas. *Chemosphere*, 80(1): 60–66.

Shenk, T. M and Franklin, A. B (2001). Modeling in natural resource management: Development, interpretation, and application. Island Press, Washington, D.C., USA.

Shepherd, A and Bowler, C (1997). Beyond the requirements: improving public participation in EIA. *J Environ Plann Manag*; 40(6): 725–738.

Shifley, S. R., Thompson, F. R., Dijak, W. D., Larson, M. A and Millspaugh J. J (2006). Simulated effects of forest management alternatives on landscape structure and habitat suitability in the Midwestern United States. Forest Ecology and Management 229: 361–377.

Siegrist, M., Keller, C and Kiers, H. A. L (2005). A new look at the psychometric paradigm of perception of hazards. *Risk Anal* 25: 211–222.

Siegrist, M and Cvetkovich, G (2001). Better negative than positive? Evidence of a bias for negative information about possible health dangers. *Risk Anal* 21: 211–218.

Siegrist, M (2000). The influence of trust and perception of risks and benefits on the acceptance of gene technology. *Risk Anal* 20: 195–203.

Sienkiewicz, Z., Jones, N and Bottomley A (2005). Neurobehavioural effects of electromagnetic fields. *Bioelectromagnetics*; Suppl 7: 116-126.

Similä, J (2007). Regulating industrial pollution. The case of Finland. Helsingin yliopiston oikeustieteellisen tiedekunnan julkaisuja. Helsinki: Helsingin yliopisto: 13.

Simone, L., Bishop, I and Evans, D (2001). Assessing the demand of solid waste disposal in urban region by urban dynamics modeling in a GIS environment. Resources, Conservation and Recycling, 33: 289–313.

Sinclair, A.J., Sims, L and Spaling, H (2009). Community-based approaches to strategic environmental assessment: lessons from Costa Rica. *Environ Impact Assess* 29: 147–156.

Singh, U. K., Kumar, M., Chauhan, R., Jha, P. K., Ramanathan, A. C., and Subramanian, V (2008). Assessment of the impact of landfill on groundwater quality: A case study of Pirana Site in Western India. Environmental Monitoring and Assessment, 141(1–3): 309–321.

Sjoberg, L (1997). "Explaining Risk Perception: An Empirical Evaluation of Cultural Theory." *Risk Decision and Policy 2*: 113–130.

Skehan, C. D and González, A (2006). Spatial data management requirements and strategic environmental assessment. Paper presented at the Society of Chartered Surveyors, Euro SDR and the Dublin Institute of Technology joint workshop, Dublin, Ireland.

Skowronski, J. J and Carlston, D. E (1989). Negativity and extremity biases in impression formation: A review of explanations. *Psychol Bull* 105: 131–142.

Slovic, P., Kraus, N and Covelo, V.T (1990). "What Should We Know About Making Risk Comparisons?" Risk Analysis 10: 389–391.

Slovic, P(1986). "Informing and Educating the Public about Risk." Risk Analysis 6: 403–415.

Slovic, P (1987). Perception of risk.*Science* 236: 280-285.

Slovic, P(1993). Perceived risk, trust and democracy. *Risk Anal* 13: 675–682.

Slovic, P (1999). Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield. Risk Analysis, 19(4): 689–701.

Slovic, P(2000). The Perception of Risk. London: Earthscan Publishing.

Smith, A (2003). The concept of noise sensitivity: Implications for noise control. Noise and Health 5: 57-59.

Songsore, J (2003). Regional Development in Ghana: The Theory and the Reality (Ghana Universities Press, Accra).

Songsore, J and McGranahan, G (1993). "Environment, Wealth and Health: Towards an Analysis of Intra-Urban Differentials within the Greater Accra Metropolitan Area, Ghana", *Environment and Urbanization*, Vol. 5, No.2: 10-34.

Songsore, J., Nabila, J. S., Yangyuoru, Y., Amoah, E., Bosque-Hamilton, E. K., Etsibah, K. K., Gustafsson, J. E., and Jacks, G (2005). State of Environmental Health Report of the Greater Accra Metropolitan Area, 2001. (Ghana Universities Press, Accra).

Starfield, A. M (1997). A pragmatic approach to modeling for wildlife management. *Journal of Wildlife Management* 61: 261–270.

Starfield, A. M and Bleloch, A. L (1991). Building models for conservation and wildlife management. Second edition. Interaction Book Company, Edina, Minnesota, USA.

Stansfeld, S. A., Berglund, B., Lopez-Barrio, I., Fischer, P., Ohrstrom, E., Haines, M. M., Head, J., Hygge, S., van Kamp, I and Berry, B. F (2005). Aircraft and road traffic noise and children's cognition and health. *Lancet* 365 (9475): 1942-1949.

Steg, L and Vlek, C (2009). Encouraging pro-environmental behaviour: an integrative review and research agenda. *Journal of Environmental Psychology* 29: 309–317.

Steg, L., Dreijerink, L and Abrahamse, W (2005). Factors influencing the acceptability of energy policies: a test of VBN theory. *Journal of Environmental Psychology* 25: 415–425.

Steinemann, A (2000). Rethinking human health impact assessment. *Environ Impact Assess Rev*; 20: 627–645.

StEP Initiative (2013). StEP Annual Report. 2013. Retrieved from: http://step-initiative.org/tl_files/step/StEP_AR/StEP_AR.html.

Stewart, B. W and Kleihues, P (2003). World Cancer Report, Lyon: IARC Lyon; 11–18.

Stewart, B. W. Report (2000). Independent Expert Group on Mobile Phones. Mobile phones and health. *Didcot*: Independent Expert Group on Mobile Phones.

Stewart-Oaten, A., Murdoch, W. W and Parker, K. R (1986). Environmental impact assessment: “pseudo replication” in time? Ecology 67: 929-940.

Sultan, B and Janicot, S (2003). The West African Monsoon Dynamics, Part II. Preonset and onset of the summer monsoon. *J. Clim. (16)*: 3407-3427.

Sundararajan, C (1991), Guide to Reliability Engineering: Data Analysis, Applications, Implementations and Management, Van Nostrand Reinold.

Supriadi, S., Kriwoken, L. K and Birley, I (2000). Solid Waste Management Solutions for Semarang, Indonesia. Waste Management and Research 18: 557.

Sutanto, H. B (2007). Solid Waste Disposal on Land in Indonesia. In: Proc. of the 4th Workshop on Greenhouse Gas Inventories in Asia, Jakarta; 14–15 February, 2007.

Suter, G. W., Vermeire, T., Munns, W. R. Jr and Sekizawa, J (2003). Framework for the integration of health and ecological risk assessment. *Hum Ecol Risk Assess*, 9: 281–301.

Sutton, I.S (1992). Process Reliability and Risk Management, Van Nostrand Reinhold.

Suzanne, B (2004). Managing toxic chemicals in Australia: A regional analysis of the risk society. *J Risk Res* 7(4): 399–412.

Taurino, R., Pozzi, P and Zanasi, T (2010). Facile characterization of polymer fractions from waste electrical and electronic equipment (WEEE) for mechanical recycling. *Waste Manag.* 30: 2601–2607.

Taylor S. E (1991). Asymmetrical effects of positive and negative events: The mobilization minimization hypothesis. *Psychol Bull* 110: 67–85.

Taylor-Gooby, P and Zinn, J. O (2005). Current directions in risk research: reinvigorating the social. Social Contexts and Responses to Risk Network (SCARR). ESRC priority network. UK: Kent .

Teh, T., Dougherty, M.P and Camire, M.E (2007). How do consumer attitudes influence acceptance of a novel wild blueberry–soy product? Journal of Food Science 72 (7): 516–521.

Terry, L. L (1979). “Health and Noise” *EPA J;* 5(9): 54-60.

The Climate Group and GeSI (Global e-Sustainability Initiative) (2008). SMART 2020: Enabling the low carbon economy in the information age. Available from http://www.smart2020.org/publications/.

Therivel, R., Wilson, E., Thompson, S., Heaney, D and Pritchard, D (1992). Strategic environmental assessment. London: Earthscan.

Therivel R. (2004). Strategic environmental assessment in action. London: Earthscan, IncNet Library.

Thurstone, L. L (1959). The Measurement of Values. University of Chicago Press, Chicago.

TMT (2010). *Journal of Trends in the Development of Machinery and Associated Technology*. (29): 110-112.

Triandis, H. C (1995). Individualism and Collectivism. Boulder, CO: Westview Press.

Tripp, J and Alley, N (2003). Streamlining NEPA's environmental review process: suggestion for agency reform. NY Univ Environ Law J; 12: 75-110.

Trower, B (2001). Report on TETRA Strictly for the Police Federation of England and Wales.

Tsang, C. F (1991). The modeling process and model validation. Ground Water 29(6): 825–831.

Tyler, T. R (1984). Assessing the risk of crime victimization: The integration of personal victimization experience and socially transmitted information. *Journal of Social Issues* 40: 27 – 38.

Uchman'ski, J and Grimm, V (1996). Individual-based modelling in ecology: what makes the difference? *Trends Ecol. Evol.* 11: 437–441.

Uloziene, I., Uloza, V., Gradauskiene, E and Saferis, V (2005). Assessment of potential effects of the electromagnetic fields of mobile phones on hearing. BMC Public Health; 5: 39.

United Nations Conference on Environment and Development (UNCED) (1992). Earth Summit '92. London: Regency Press.

US EPA (1974). "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," EPA 550/9-74-004.

US EPA (1991). Guidelines for developmental toxicity risk assessment. *Fed Regist*, 56: 63798.

US EPA (1992). Guidelines for exposure assessment. *Fed Regist*, 57(104): 22888–22938.

US EPA (1993). Office of Research and Development (EPA/600/R-05/093A).

US EPA (2005) A framework for assessing health risks of environmental exposures to children. Washington, DC, United States Environmental Protection Agency, Office of Research and Development (EPA/600/R-05/093A).

US EPA (2011). Soil, ground water and sediments standards for use under for EPA Act, Ministry of the Environment.

van Loenen, B and Onsrud, H. J (2004). Geographic data for academic research: assessing access policies. Cartography and geographic information science; 31(1): 3-17.

Vanclay, F and Bronstein, D (1995). Environmental and social impact assessment. Chichester (UK) Wiley.

Vanderhaegen, M and Muro, E (2005). Contribution of a European spatial data infrastructure to the effectiveness of EIA. Environmental impact assessment review; 25(2): 123–142.

Veerman, J. L., Mackenbach, J. P and Barendregt, J. J (2007). Validity of predictions in health impact assessment. *J Epidemiol Community Health*; 61: 363–366.

Veerman, J. L., Barendregt, J. J and Mackenbach, J. P (2005). Quantitative health impact assessment: current practice and future directions. *J Epidemiol Community Health*; 59: 361–370.

Vilaplana, F and Karlsson, S (2008). Quality concepts for the improved use of recycled polymeric materials: a review. *Macromol. Mater. Eng.* 293: 274–297.

Von Borgstede, C., Johansson, L. O and Nilsson, A (2012). Social dilemmas: motivational, individual and structural aspects influencing cooperation. In: Steg, L., Van den Berg, A., De Groot, J.I.M. (Eds.), Environmental Psychology: An Introduction. BPS Blackwell, John Wiley & Sons Ltd., Chichester: 175–184.

Walker, B., Holling, C. S., Carpenter, S. R and Kinzig, A (2004). Resilience, adaptability and transformability in social-ecological systems. Ecology and Society 9 (2): 5-10.

Wang, B., Feng, J., Huisman, C., Meskers, M., Schluep, A., Stevels, C and Hageluken A (2012). “The Best-of-2 Worlds philosophy: Developing local dismantling and global infrastructure network for sustainable e-waste treatment in emerging economies.” *Waste Management* 32: 2134-2146.

Watanabe, M. E (1997). Phytoremediation on the brink of commercialization. Environmental Science and Technology News. 31: 182-186.

WDI (2008). The World Bank, Development Indicators, Open Data by Country. Available at: http://data.worldbank.org/country/ghana

Wenzel, W. W., Adriano, D. C., Salt, D and Smith, R (1999). Phytoremediation: A plantmicrobe based remediation system: 457-508. *In* D.C. Adriano et al. (ed.) Bioremediation of contaminated soils. American Society of Agronomy, Madison, WI.

Weston, J (2002). From Poole to Fulham: a changing culture in UK environmental impact assessment decision making? *J Environ Plann Manag*; 45: 425–443.

White, M. P and Eiser, J. R (2005). Information specificity and hazard risk potential as moderators of trust asymmetry. *Risk Anal* 25: 1187–1198.

White, M. P., Pahl, S and Buehner, M (2003). Trust in risky messages: The role of prior attitudes. Risk Anal 23: 717–726.

WHO (1998). Communicating about risks to environment and health in Europe. Gray, P.C.R., R.M. Stern & M. Biocca, eds. WHO Regional Office for Europe in collaboration with the Centre for Environmental and Risk Management, Dordredv, Dordrecht, The Netherlands. Kluwer Academic Publishers.

WHO (1999). Guidelines for community noise. Retrieved from: www.who.int/docstore/peh/noise/guidelines2.html

WHO (1999). European Centre for Health Policy. Gothenburg consensus paper: health impact assessment: main concepts and suggested approach. Brussels: European Centre for Health Policy: 4.

WHO (2006). Electromagnetic fields and public health: Base stations and wireless technology, Fact sheet No 304, May 2006.

WHO (2011). Electromagnetic fields and public health: mobile phones. Fact sheet N°193.

WHO (2011). Needs Assessment for Medical Devices. 2011. Available at: http://whqlibdoc.who.int/publications/2011/9789241501385_eng.pdf.

WHO (2002). Handbook on "Establishing a Dialogue on Risks from Electromagnetic Fields"

WHO (2005). Base Stations and Wireless Networks: Exposures and Health Consequences.

Widmer, R., Heidi, O. K., Deepali, S. M and Heinz, B (2005). Global perspective on e-waste. *Environ. Impact Asess* 25: 436.

Wilding, S and Raemaekers, J (2000). Environmental compensation: can the British planning regime learn from Germany? *Plan Theory Pract* 1 (2): 187–201.

Wilke, H.A. M (1991). Greed, efficiency and fairness in resource management situations. European Review of Social Psychology 2: 165–187.

Wilson, E (1993). Strategic environmental assessment of policies, plans and programs. European Environment, 3 (2): 2-6.

Wilson, R and Crouch, E.A.C (1987). Risk assessment and comparisons: An introduction. *Science* 236: 267–270.

Wood, C (1995). Environmental impact assessment: A comparative review. Harlow, U.K.: Longman Scientific and Technical.

Wood C (2003). Environmental Impact Assessment: a comparative review (Second ed.), Pearson-Prentice Hall, Harlow.

Wood, C. M and Djeddour, M (1992). Strategic environmental assessment: EA of policies, plans and programmes. Impact Assessment Bulletin, 10: 3-22.

World Bank (2010). The city of Accra, “Ghana consultative citizens’report card”: 11.

Wu, T. N., Yang, K. C and Wang, C. M (1996). Lead poisoning caused by contaminated Cordyceps, a Chinese herbal medicine: Two case reports. The Science of the Total Environment 182: 193-195.

Xu, L and Liu, G (2009). The study of a method of regional environmental risk assessment. *Journal of Environmental Management*, 90(11): 3290–3296.

Yamagishi, T (1986). The structural goal/expectation theory of cooperation in social dilemmas. In: Lawler, E.J. (Ed.), Advances in Group Processes, vol. 3; JAI Press, Greenwich, CT: 51–87.

Yeboah, E and Obeng-Odoom, F (2010). "We are Not the Only Ones to Blame District Assemblies" perspectives on the state of planning in Ghana', *Commonwealth Journal of Local Governance*, 7; 78-98.

York, R (2004). The treadmill of (diversifying) production. Organization & Environment, 17: 355-362.

Zain. (2005). "Information, Tools, Product andService for Zain Telecommunication Network Community" www.zain.com.

Zartarian, V., Bahadori, T and McKone, T (2005). Adoption of an official ISEA glossary. *Journal of Exposure Analysis and Environmental Epidemiology* 15: 1-5.

Zwamborn, A. P. M., Vossen, S. H. J. A., van Leersum, B. J. A. M (2003). Effects of Global Communication System Radio-Frequency Fields on Well-Being and Cognitive Functions of Human Subjects with and without Subjective Complaints.TNO. Physics and Electronics Laboratory, The Hague, the Netherlands.

APPENDIX A

Locationsof BSs and results of radiation levels in Accra

SITE NAME	MEASUREMENT POSITIONS	GPS COORDINATES LATITUDE	LONGITUDE	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
Anyaa_NIC_Top N05°36.793´, W000°18.289´	Point A	N05°36.792´	W000°18.288´	5.30E-03	3.82E-03
	Point B	N05°36.801´	W000°18.310´	6.33E-03	5.86E-04
	Point C	N05°36.777´	W000°18.209´	1.21E-02	2.42E-03
	Point D	N05°36.717´	W000°18.174´	6.07E-03	3.54E-04
	Point E	N05°36.711´	W000°18.142´	2.12E-03	8.05E-04

SITE NAME	MEASUREMENT POSITIONS	GPS COORDINATES LATITUDE	LONGITUDE	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
Ofankor N05°39.444´, W000°16.235´	Point A	N05°39.440´	W000°16.236´	3.00E-03	1.28E-03
	Point B	N05°39.512´	W000°16.215´	8.14E-03	3.24E-03
	Point C	N05°39.539´	W000°16.229´	1.60E-03	5.77E-04
	Point D	N05°39.535´	W000°16.352´	1.14E-03	1.93E-03
	Point E	N05°39.453´	W000°16.470´	4.79E-04	2.77E-04

SITE NAME	MEASUREMENT POSITIONS	GPS COORDINATES LATITUDE	LONGITUDE	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
Spintex_RD_GT N05°38.459´, W000°06.371	Point A	N05°38.459´	W000°06.373´	2.27E-02	2.89E-02
	Point B	N05°38.527´	W000°06.317´	2.19E-02	1.92E-02
	Point C	N05°38.459´	W000°06.201´	2.21E-02	1.91E-02
	Point D	N05°38.432´	W000°06.461´	3.07E-02	2.14E-02
	Point E	N05°38.369´	W000°06.401´	7.39E-02	3.80E-02

SITE NAME	MEASUREMENT POSITIONS	GPS COORDINATES LATITUDE	LONGITUDE	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
Abelemkpe N5°36.139´, W0°12.868´	Point A	N05° 36.234'	W000° 12.822'	3.93E-02	3.51E-02
	Point B	N05° 36.304'	W000° 12.775'	3.64E-02	1.58E-02
	Point C	N05° 36.181'	W000° 12.911'	5.32E-02	1.58E-02
	Point D	N05° 36.059'	W000° 12.876'	6.60E-02	4.44E-02
	Point E	N05° 36.053'	W000° 12.838'	2.17E-02	2.05E-02

SITE NAME	MEASUREMENT POSITIONS	GPS COORDINATES LATITUDE	LONGITUDE	ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
Haatso N5°39.992´, W0°11.628´	Point A	N05° 40.007'	W000° 11.613'	1.75E-02	7.70E-07
	Point B	N05° 39.969'	W000° 11.683'	1.58E-02	1.12E-02
	Point C	N05° 39.991'	W000° 11.720	1.26E-02	1.58E-02
	Point D	N05° 39.931'	W000° 11.664'	1.78E-02	1.58E-02
	Point E	N05° 39.979'	W000° 11.555'	5.01E-02	2.93E-02

SITE NAME	MEASUREMENT POSITIONS	GPS COORDINATES		ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
		LATITUDE	LONGITUDE		
New Russia N5°33.006´, W0°15.444´	Point A	N05° 33.020'	W000° 15.444'	2.42E-02	1.58E-08
	Point B	N05° 33.086'	W000° 15.454'	2.49E-02	2.73E-02
	Point C	N05° 32.975'	W000° 15.467'	1.95E-02	1.58E-02
	Point D	N05° 32.970'	W000° 15.502'	3.02E-02	1.58E-02
	Point E	N05° 32.996'	W000° 15.543'	2.05E-02	2.93E-02

SITE NAME	MEASUREMENT POSITIONS	GPS COORDINATES		ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
		LATITUDE	LONGITUDE		
Legon N5°38.532´, W0°10.665´	Point A	N05°38.527´	W00°10.663´	2.62E-02	1.01E-02
	Point B	N05°38.504´	W00°10.663´	3.98E-02	8.91E-03
	Point C	N05°38.499´	W00°10.624´	1.61E-02	1.05E-02
	Point D	N05°38.494´	W00°10.583´	2.62E-02	1.01E-02
	Point E	N05°38.440´	W00°10.586´	1.26E-02	1.14E-04

SITE NAME	MEASUREMENT POSITIONS	GPS COORDINATES		ELECTRIC FIELD (V/m) 900MHz	ELECTRIC FIELD (V/m) 1800MHz
		LATITUDE	LONGITUDE		
Oyarifa N5°44.746´, W0°10.604´	Point A	N05°44.746´	W00°10.604´	5.56E-03	1.01E-02
	Point B	N05°44.706´	W00°10.615´	4.58E-03	1.04E-02
	Point C	N05°44.915´	W00°10.529´	4.13E-03	9.29E-03
	Point D	N05°44.738´	W00°10.641´	7.24E-03	1.58E-02
	Point E	N05°44.646´	W00°10.623´	6.24E-03	9.15E-03

Source: Field Survey Data, 2014

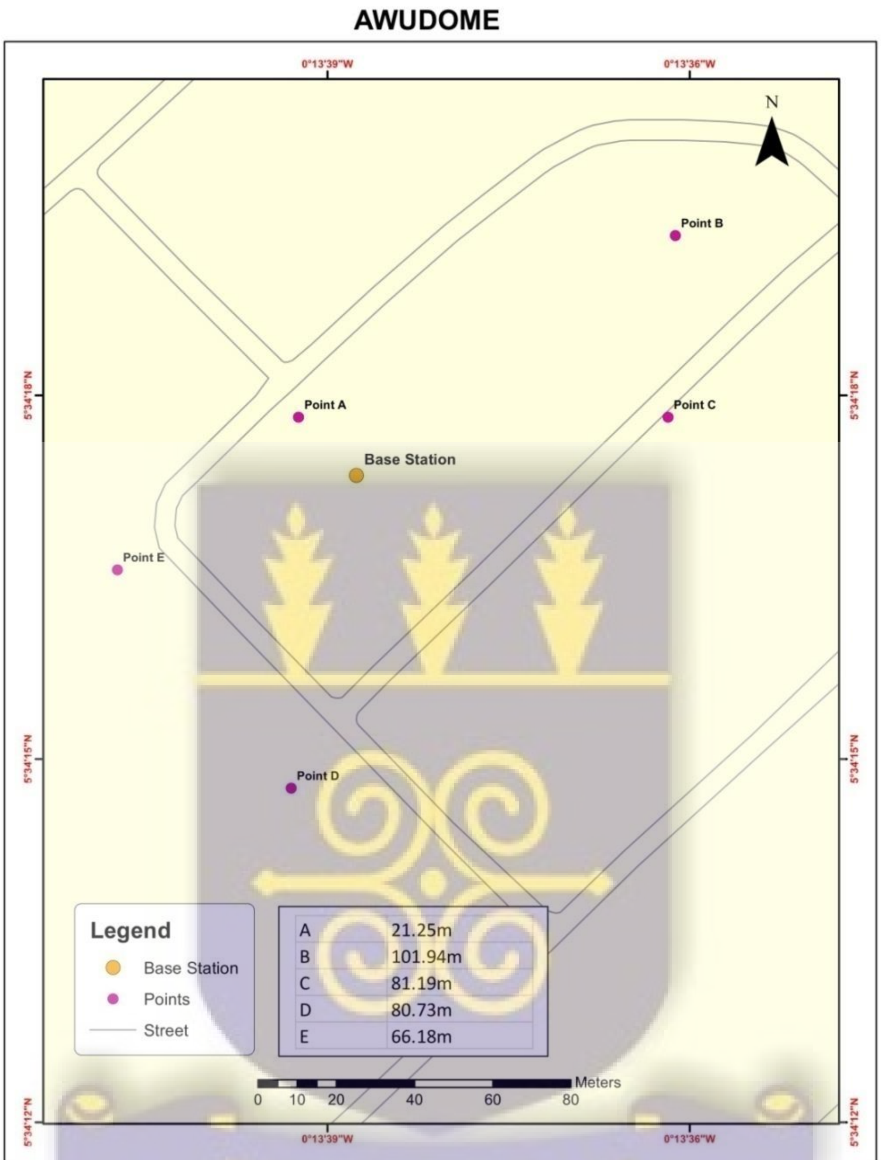


Figure I: Map indicating locations where radiation levels were measured at "Awudome"

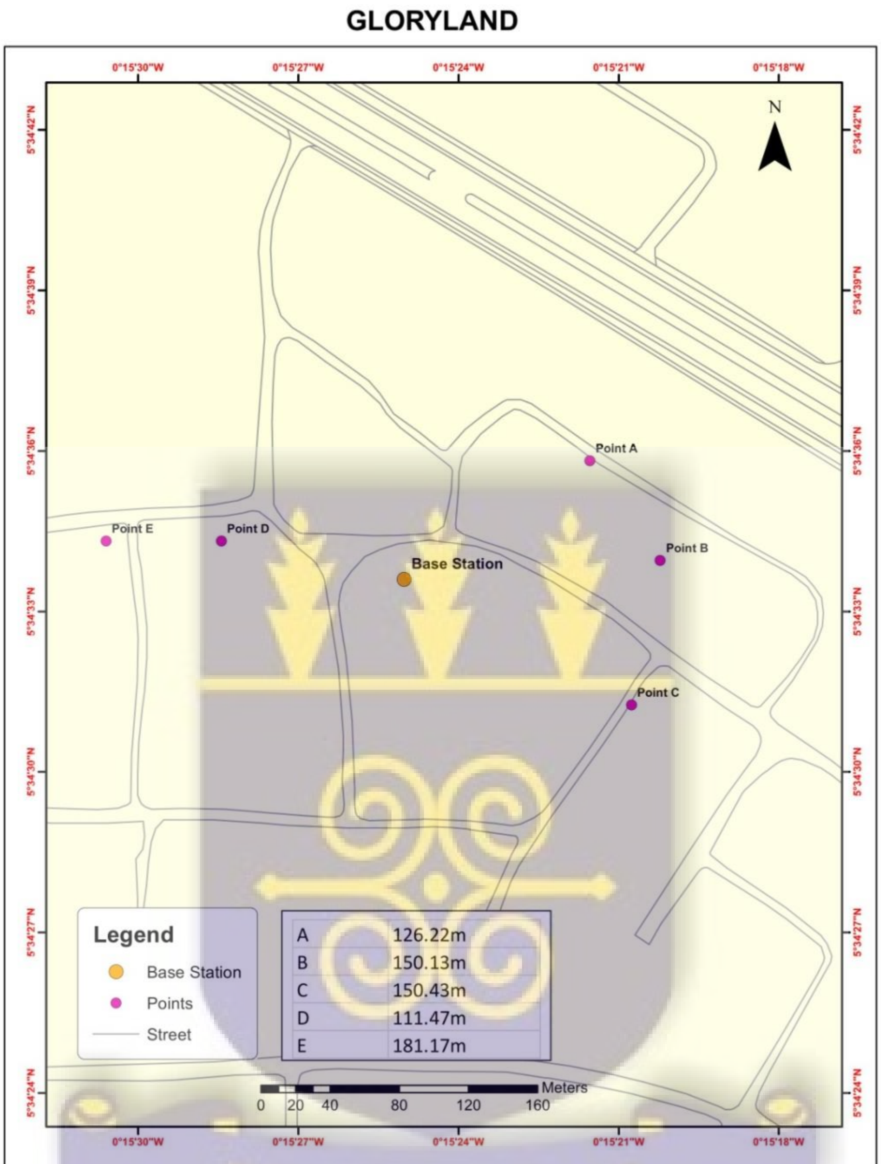


Figure II: Map indicating locations where radiation levels were measured at “Gloryland”

APPENDIX B

Four (4) positions at approximately the geographical N, S, E and W positions on a radius

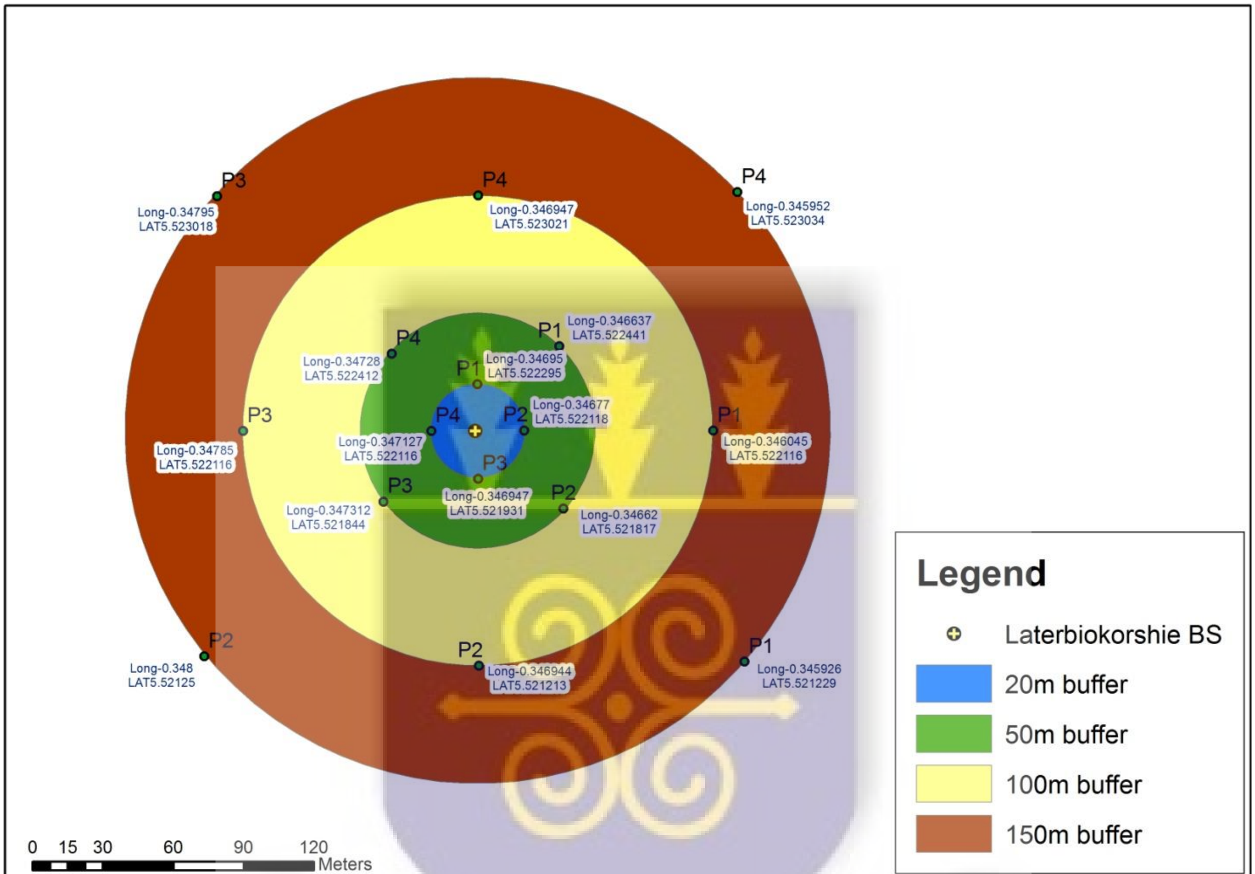


Table I: GPS coordinates of positions where noise levels were measured.

BS site	20m	50m	100m	150m
A Laterbiokoshie (Black Smith) N 5.60537000 W0.25021000	P_1 W0.34695 N5.522295 P_2 W0. 34677 N5.522118 P_3 W0.346947 N5.521931 P_4 W0.347127 N5.522116	P_1 W0.346637 N5.522441 P_2 W0.34662 N5.521817 P_3 W0.347312 N5.521844 P_4 W0.34728 N5.522412	P_1 W0.346045 N5.522116 P_2 W0.346944 N5.521213 P_3 W0.34785 N5.522116 P_4 W0.346947 N5.523021	P_1 W0.345926 N5.521229 P_2 W0.348 N5.52125 P_3 W0.34795 N5.523018 P_4 W0.345952 N5.523034
B Kokrobite N05°29.997 W000°22.104	P_1 W0.368401 N5.500128 P_2 W0.368221 N5.49995 P_3 W0.368398 N5.499764 P_4 W0.368578 N5.499948	P_1 W0.368087 N5.500274 P_2 W0.36807 N5.49965 P_3 W0.368762 N5.499677 P_4 W0.368731 N5.500245	P_1 W0.367496 N5.499949 P_2 W0.368395 N5.499046 P_3 W0.369301 N5.499948 P_4 W0.368398 N5.500853	P_1 W0.367376 N5.499062 P_2 W0.36945 N5.499083 P_3 W0.3694 N5.500851 P_4 W0.367403 N5.500867
C N05°31.327 W000°20.817	P_1 W0.346959 N5.522293 P_2 W0.346779 N5.522115 P_3 W0.346956 N5.521929 P_4 W0.347136 N5.522114	P_1 W0.346646 N5.522439 P_2 W0.346629 N5.521815 P_3 W0.34732 N5.521842 P_4 W0.347289 N5.52241	P_1 W0.346054 N5.522114 P_2 W0.346953 N5.521211 P_3 W0.347859 N5.522114 P_4 W0.346956 N5.523018	P_1 W0.345934 N5.521227 P_2 W0.348008 N5.521248 P_3 W0.347959 N5.523016 P_4 W0.345961 N5.523032
D New Bortianor N5°32.086	P_1 W0.374887 N5.535083 P_2 W0.37487	P_1 W0.374887 N5.535083 P_2 W0.37487	P_1 W0.374295 N5.534759 P_2 W0.375194	P_1 W0.374176 N5.533871 P_2 W0.37625

W0°22.512	N5.534459 P3 W0.375198 N5.534573 P4 W0.375377 N5.534758	N5.534459 P3 W0.375562 N5.534486 P4 W0.37553 N5.535054	N5.533855 P3 W0.376101 N5.534758 P4 W0.375197 N5.535663	N5.533892 P3 W0.3762 N5.53566 P4 W0.374202 N5.535676
E N5°36.083 W0°07.456	P1W0.124367 N5.601561 P2W0.124087 N5.601383 P3W0.124264 N5.601197 P4W0.124444 N5.601381	P1 W0.123954 N5.601706 P2 W0.123937 N5.601082 P3 W0.124628 N5.601109 P4 W0124597 N5.601677	P1 W0123362 N5.601382 P2 W0.124261 N5.600478 P3 W0.125167 N5.601381 P4 W0.124264 N5.602286	P1 W0.123242 N5.600494 P2 W0.125316 N5.600515 P3 W0.125267 N5.602283 P4 W0.123269 N5.602299
F Abeka-Lapaz N 5.60537 W0.25021	P1 W0.25021 N5.605548 P2 W0.25003 N5.60537 P3 W0.250207 N5.605183 P4 W0.250387 N5.605368	P1 W0.249896 N5.605693 P2 W0.249879 N5.605069 P3 W0.250571 N5.605096 P4 W0.25054 N5.605664	P1 W0.249305 N5.605369 P2 W0.250204 N5.604465 P3 W0.25111 N5.605368 P4 W0.250207 N5.606273	P1 W0.249185 N5.604481 P2 W0.251259 N5.604502 P3 W0.251209 N5.60627 P4 W0.249212 N5.606286
G N5°37.773 W0°15.450	P1 W0.2575 N5.629727 P2 W0.25732 N5.629549 P3 W0.257498 N5.629363 P4 W0.257677 N5.629547	P1 W0.257187 N5.629873 P2 W0.25717 N5.629249 P3 W0.257862 N5.629275 P4 W0.25783 N5.629843	P1 W0.256595 N5.629548 P2 W0.257494 N5.628644 P3 W0.258401 N5.629547 P4 W0.257497 N5.630452	P1 W0.256476 N5.628661 P2 W0.25855 N5.628681 P3 W0.2585 N5.63045 P4 W0.256502 N5.630465
H	P1 W0.21008 N5.556454	P1 W0.209767 N5.5566	P1 W0.209175 N5.556275	P1 W0.209056 N5.555388

N 5.55627717 W0.21008018	P_2 W0.2099 N5.556277 P_3 W0.210078 N5.55609 P_4 W0.210257 N5.556275	P_2 W0.20975 N5.555976 P_3 W0.210442 N5.556003 P_4 W0.21041 N5.556571	P_2 W0.210074 N5.555372 P_3 W0.210981 N5.556275 P_4 W0.210077 N5.55718	P_2 W0.21113 N5.555409 P_3 W0.21108 N5.557177 P_4 W0209082 N5.557193
I N 5.53112175 W0.24106715	P_1 W0.241067 N5.531299 P_2 W0.240887 N5.531121 P_3 W0.241065 N5.530935 P_4 W0.241244 N5.531119	P_1 W0.240754 N5.531445 P_2 W0.240737 N5.530821 P_3 W0.241429 N5.530848 P_4 W0.241397 N5.531416	P_1 W0.240162 N5.53112 P_2 W0.241061 N5.530216 P_3 W0.241968 N5.531119 P_4 W0.241064 N5.532024	P_1 W0.240043 N5.530233 P_2 W0.242117 N5.530254 P_3 W0.242067 N5.532022 P_4 W0.240069 N5.532038
J N5°36.970 W0°11.658	P_1 W0.1943 N5.616343 P_2 W0.19412 N5.616166 P_3 W0.194298 N5.615979 P_4 W0.194477 N5.616164	P_1 W0.193987 N5.616489 P_2 W0.19397 N5.615865 P_3 W0.194662 N5.615892 P_4 W0.19463 N5.61646	P_1 W0.193395 N5.616164 P_2 W0.194294 N5.615261 P_3 W0.195201 N5.616164 P_4 W0.194297 N5.617069	P_1 W0.193276 N5.615277 P_2 W0.19535 N5.615298 P_3 W0.1953 N5.617066 P_4 W0.193302 N5.617082
K N5°36.136 W0°18.121	P_1 W0.3021 N5.60236 P_2 W0.30192 N5.602183 P_3 W0.302097 N5.601996 P_4 W0.302277 N5.602182	P_1 W0.301787 N5.602506 P_2 W0.30177 N5.601882 P_3 W0.302462 N5.601909 P_4 W0.30243 N5.6024477	P_1 W0.301195 N5.602181 P_2 W0.302094 N5.601278 P_3 W0.303 N5.602181 P_4 W0.302097 N5.603085	P_1 W0.301076 N5.60129 P_2 W0.30315 N5.601315 P_3 W0.3031 N5.603083 P_4 W0.301102 N5.603099

L N5°39.992 W0°11.628	P_1 W0.204135 N5.668921 P_2 W0.203955 N5.668744 P_3 W0.204132 N5.668557 P_4 W0.204312 N5.669038	P_1 W0.203822 N5.669067 P_2 W0.203805 N5.668443 P_3 W0.204496 N5.66847 P_4 W0.204465 N5.669038	P_1 W0.20323 N5.668742 P_2 W0.204129 N5.667839 P_3 W0.205035 N5.668742 P_4 W0.204132 N5.669646	P_1 W0.203111 N5.667855 P_2 W0.205184 N5.667876 P_3 W0.205135 N5.669644 P_4 W0.203137 N5.66966
M N5.56158253 W0.18374881	P_1 W0.183749 N5.56176 P_2 W0.183569 N5.561582 P_3 W0.183747 N5.561396 P_4 W0.183926 N5.56158	P_1 W0.183436 N5.561582 P_2 W0.183419 N5.561282 P_3 W0.184111 N5.561308 P_4 W0.184079 N5.561876	P_1 W0.182844 N5.561581 P_2 W0.183743 N5.560677 P_3 W0.18465 N5.56158 P_4 W0.183746 N5.562485	P_1 W0.182725 N5.560694 P_2 W0.184799 N5.560714 P_3 W0.184749 N5.562483 P_4 W0.182751 N5.562498
N N5°40.715 W0°09.996	P_1 W0.1666 N5.67876 P_2 W0.16642 N5.678582 P_3 W0.166598 N5.678396 P_4 W0.166777 N5.67858	P_1 W0.166287 N5.678906 P_2 W0.16627 N5.678282 P_3 W0.166962 N5.678308 P_4 W0.16693 N5.678876	P_1 W0.165695 N5.678581 P_2 W0.166594 N5.677677 P_3 W0.167501 N5.67858 P_4 W0.166597 N5.679485	P_1 W0.165576 N5.677694 P_2 W0.16765 N5.677714 P_3 W0.1676 N5.679483 P_4 W0.165602 N5.679498
O N5.59672054 W0.19658616	P_1 W0.196586 N5.596898 P_2 W0.196406 N5.59672 P_3 W0.196584 N5.596534 P_4 W0.196763	P_1 W0.196273 N5.597044 P_2 W0.196256 N5.59642 P_3 W0.196948 N5.596447 P_4 W0.196916	P_1 W0.195681 N5.596719 P_2 W0.19658 N5.595815 P_3 W0.197487 N5.596718 P_4 W0.196583	P_1 W0.195562 N5.595832 P_2 W0.197636 N5.595852 P_3 W0.197586 N5.597621 P_4 W0.195588

	N5.596718	N5.597015	N5.597623	N5.597636
P N05°38.545 W000°15.470	P_1 W0.257833 N5.642594 P_2 W0.257653 N5.642416 P_3 W0.25783 N5.64223 P_4 W0.25801 N5.642414	P_1 W0.25752 N5.642116 P_2 W0.257503 N5.642116 P_3 W0.258195 N5.642142 P_4 W0.258163 N5.64271	P_1 W0.256928 N5.642415 P_2 W0.257827 N5.641511 P_3 W0.258733 N5.642414 P_4 W0.25783 N5.643319	P_1 W0.256809 N5.641528 P_2 W0.258883 N5.641548 P_3 W0.258833 N5.643317 P_4 W0.256835 N5.643332

Table II: Noise levels recorded at specific locations.

BS site	20m	50m	100m	150m
A	P_1 62 P_2 67 P_3 70 P_4 64 66	P_1 50 P_2 56 P_3 50 P_4 52 52	P_1 ** P_2 ** P_3 ** P_4 **	P_1 ** P_2 ** P_3 ** P_4 **
B	P_1 63 P_2 66 P_3 75 P_4 67 68	P_1 45 P_2 52 P_3 55 P_4 49 50	P_1 ** P_2 ** P_3 ** P_4 **	P_1 ** P_2 ** P_3 ** P_4 **
C	P_1 74 P_2 77 P_3 73 P_4 81 76	P_1 55 P_2 62 P_3 61 P_4 63 60	P_1 ** P_2 45 P_3 42 P_4 46 44	P_1 ** P_2 ** P_3 ** P_4 **
D	P_1 67 P_2 70 P_3 73 P_4 71 70	P_1 56 P_2 59 P_3 61 P_4 57 58	P_1 43 P_2 41 P_3 41 P_4 ** 42	P_1 ** P_2 ** P_3 ** P_4 **
E	P_1 59 P_2 61 P_3 63 P_4 62 61	P_1 43 P_2 47 P_3 49 P_4 42 45	P_1 ** P_2 ** P_3 ** P_4 **	P_1 ** P_2 ** P_3 ** P_4 **
F	P_1 69 P_2 68	P_1 48 P_2 48	P_1 ** P_2 **	P_1 ** P_2 **

	P_3 66 P_4 66 67	P_3 46 P_4 46 47	P_3 ** P_4 **	P_3 ** P_4 **
G	P_1 71 P_2 71 P_3 68 P_4 71 70	P_1 59 P_2 62 P_3 59 P_4 61 60	P_1 ** P_2 43 P_3 ** P_4 45 44	P_1 ** P_2 ** P_3 ** P_4 **
H	P_1 60 P_2 58 P_3 50 P_4 57 56	P_1 50 P_2 42 P_3 ** P_4 ** 46	P_1 ** P_2 ** P_3 ** P_4 **	P_1 ** P_2 ** P_3 ** P_4 **
I	P_1 58 P_2 52 P_3 45 P_4 50 51	P_1 52 P_2 47 P_3 ** P_4 44 48	P_1 ** P_2 ** P_3 ** P_4 **	P_1 ** P_2 ** P_3 ** P_4 **
J	P_1 53 P_2 71 P_3 60 P_4 64 62	P_1 ** P_2 57 P_3 49 P_4 45 50	P_1 ** P_2 44 P_3 ** P_4 ** 44	P_1 ** P_2 ** P_3 ** P_4 **
K	P_1 69 P_2 66 P_3 70 P_4 56 65	P_1 45 P_2 ** P_3 ** P_4 50 48	P_1 ** P_2 ** P_3 ** P_4 **	P_1 ** P_2 ** P_3 ** P_4 **
L	P_1 44 P_2 50 P_3 65	P_1 ** P_2 43 P_3 44	P_1 ** P_2 ** P_3 **	P_1 ** P_2 ** P_3 **

	P_4 58 54	P_4 47 45	P_4 **	P_4 **
M	P_1 56 P_2 55 P_3 55 P_4 65 58	P_1 49 P_2 50 P_3 50 P_4 52 50	P_1 ** P_2 42 P_3 ** P_4 44 43	P_1 ** P_2 ** P_3 ** P_4 **
N	P_1 71 P_2 54 P_3 59 P_4 57 60	P_1 50 P_2 ** P_3 46 P_4 ** 48	P_1 ** P_2 ** P_3 ** P_4 **	P_1 ** P_2 ** P_3 ** P_4 **
O	P_1 59 P_2 58 P_3 71 P_4 41 57	P_1 41 P_2 ** P_3 41 P_4 ** 41	P_1 ** P_2 ** P_3 44 P_4 ** 44	P_1 ** P_2 ** P_3 ** P_4 **
P	P_1 64 P_2 68 P_3 64 P_4 64 65	P_1 55 P_2 60 P_3 59 P_4 58 58	P_1 ** P_2 45 P_3 43 P_4 ** 44	P_1 ** P_2 ** P_3 ** P_4 **
	62.9Db	**51Db**	**43.6dB**	**

APPENDIX C

<u>Site "A"</u>

PLOT	COORDINATES		HEIGHT ABOVE SEA LEVEL
	LATITUDE	LONGITUDE	
A1	N $05^{0}33.179'$	W $000^{0}13.578'$	33m
A2	N $05^{0}33.179'$	W $000^{0}13.579'$	34m
A3	N $05^{0}33.181'$	W $000^{0}13.579'$	33m
A4	N $05^{0}33.184'$	W $000^{0}13.579'$	35m
A5	N $05^{0}33.189'$	W $000^{0}13.581'$	32m
A6	N $05^{0}33.189'$	W $000^{0}13.582'$	33m
A7	N $05^{0}33.185'$	W $000^{0}13.582'$	35m
A8	N $05^{0}33.184'$	W $000^{0}13.581'$	35m
A9	N $05^{0}33.181'$	W $000^{0}13.581'$	34m
A10	N $05^{0}33.179'$	W $000^{0}13.579'$	35m
A11	N $05^{0}33.176'$	W $000^{0}13.580'$	41m
A12	N $05^{0}33.180'$	W $000^{0}13.583'$	37m
A13	N $05^{0}33.181'$	W $000^{0}13.583'$	34m
A14	N $05^{0}33.185'$	W $000^{0}13.584'$	35m
A15	N $05^{0}33.188'$	W $000^{0}13.587'$	37m

Source: Field Survey Data, 2014

<u>Site "B"</u>

PLOT	COORDINATES		HEIGHT ABOVE SEA LEVEL
	LATITUDE	LONGITUDE	
B1	N 05^{0}33.106'	W 000^{0}13.556'	33m
B2	N 05^{0}33.110'	W 000^{0}13.557'	35m
B3	N 05^{0}33.114'	W 000^{0}13.559'	33m
B4	N 05^{0}33.118'	W 000^{0}13.560'	33m
B5	N 05^{0}33.121'	W 000^{0}13.563'	34m
B6	N 05^{0}33.124'	W 000^{0}13.562'	33m
B7	N 05^{0}33.122'	W 000^{0}13.559'	34m
B8	N 05^{0}33.120'	W 000^{0}13.557'	33m
B9	N 05^{0}33.117'	W 000^{0}13.554'	34m
B10	N 05^{0}33.109'	W 000^{0}13.552'	31m
B11	N 05^{0}33.113'	W 000^{0}13.550'	35m
B12	N 05^{0}33.116'	W 000^{0}13.552'	38m
B13	N 05^{0}33.118'	W 000^{0}13.553'	34m
B14	N 05^{0}33.124'	W 000^{0}13.558'	34m
B15	N 05^{0}33.129'	W 000^{0}13.561'	35m

Source: Field Survey Data, 2014

Site "C"

PLOT	COORDINATES		HEIGHT ABOVE SEA LEVEL
	LATITUDE	LONGITUDE	
C1	N 05^{0}33.182'	W 000^{0}13.459'	32m
C2	N 05^{0}33.182'	W 000^{0}13.458'	37m
C3	N 05^{0}33.187'	W 000^{0}13.454'	37m
C4	N 05^{0}33.191'	W 000^{0}13.452'	34m
C5	N 05^{0}33.192'	W 000^{0}13.446'	29m
C6	N 05^{0}33.195'	W 000^{0}13.448'	32m
C7	N 05^{0}33.193'	W 000^{0}13.453'	31m
C8	N 05^{0}33.189'	W 000^{0}13.455'	32m
C9	N 05^{0}33.187'	W 000^{0}13.457'	32m
C10	N 05^{0}33.186'	W 000^{0}13.461'	34m
C11	N 05^{0}33.192'	W 000^{0}13.460'	31m
C12	N 05^{0}33.193'	W 000^{0}13.459'	32m
C13	N 05^{0}33.197'	W 000^{0}13.455'	35m
C14	N 05^{0}33.199'	W 000^{0}13.453'	34m
C15	N 05^{0}33.202'	W 000^{0}13.451'	34m

Source: Field Survey Data, 2014

APPENDIX D

Wood (2003) proposed "14 pointevaluation criteria".

1. Is the EIA system based on a clear and specific legal provision?

2. Must the relevant environmental impacts of all significant actions be assessed?

3. Must evidence of the consideration, by the proponent of the environmental impacts of reasonable alternative actions for environmental significance take place?

4. Must screening of actions for environmental significance take place?

5. Must scoping of the environmental impacts of actions take place and specific guidelines be produced?

6. Must EIA reports meet prescribed content requirements, and do checks to prevent the release of inadequate EIA reports exist?

7. Must EIA reports be publicly reviewed and the proponent respond to the points raised?

8. Must the findings of the EIA report and the review be a central determinant of the decision on the action?

9. Must monitoring of action impacts be undertaken and is it linked to the earlier stages of the EIA process?

10. Must the mitigation of action impacts be considered at the various stages of the EIA process?

11. Must consultation and participation take place prior to, and following, EIA report publication?

12. Must the EIA system be monitored and, if necessary, be amended to incorporate feedback from experience?

13. Are the financial costs and time requirements of the EIA system acceptable to those involved and are they believed to be outweighed by discernible environmental benefits?

14. Does the EIA system apply to significant programmes, plans and policies, as well as to projects?

APPENDIX E

Questionnaires used to collect data

UNIVERSITY OF GHANA

Dear Respondent,

We humbly request your kind assistance in the successful completion of a project entitled "Environmental impact of the mobile telecommunication technology in Ghana (A case study in Accra)".

The researcher is a PhD student from the Environmental Science Department.

District Assemblies

1. Name of assembly;____

2. What are your main duties as well as the mobile telecommunication industry is concerned?____

3(a). How many base stations have you issued permits to in this assembly?____

(b). How fast has the number of base stations increased over the years?________________

4(a). Are there possible risks associated with the mobile telecommunication industry?

Yes ☐ No ☐

(b). If yes, what are the risks;____

5. Are residents consulted/educated during the siting of base stations?

Yes ☐ No ☐

6(a). Do you receive complaints from residents dwelling close to base stations?

Yes ☐ No ☐

(b). If yes, what are the complaints?____

(c). How do you resolve the complaints?_____________________________________

7(a). Do telecommunication operators comply with local and international regulations governing the mounting of base stations?

Yes ☐ No ☐

(b). If no, which regulation(s) do operators flout?________________________________

(c). What sanctions are imposed against operators?_____________________________

8. Are telecommunication operators really committed to EIA principles?

Yes ☐ No ☐

9. Do the EIA measures implemented actually attain their expected effects?

Yes ☐ No ☐

10 (a). Do base stations have significant adverse impacts?

Yes ☐ No ☐

(b). If yes, what are the significant adverse impacts?_____________________________

(c). Have you identified any riskin neighbourhoods that you can link to base stations?

Yes ☐ No ☐

(d). If yes, what are the identified risks? __________________

11(a). Is there an issue of risk perception among people living close to base stations?

Yes ☐ No ☐

(b). What are the risk perceptions? _________________________________

12. Will you consider compensation for people to relocate?

Yes ☐ No ☐

13.What major environmental factors do you consider before permitting base station proposals?

____

14. Is there a minimum legal distance for locating base stations from the public?

____

15(a). Are material wastes or products of the telecommunication industry (plastics, metals, glasses, batteries, SIM cards and chargers) properly managed?

Yes ☐ No ☐

(b). If yes, how are they managed? ___________________________________

16(a). Does the assembly monitor and evaluate measures implemented to mitigate environmental impacts?

Yes ☐ No ☐

(b). If yes, how often? ____

(c). If no, why?____

Wood (2003) proposed "14 pointevaluation criteria".

1. Is the EIA system based on a clear and specific legal provision?

Yes ☐ No ☐

2. Must the relevant environmental impacts of all significant actions be assessed?

Yes ☐ No ☐

3. Must evidence of the consideration, by the proponent of the environmental impacts of reasonable alternative actions for environmental significance take place?

Yes ☐ No ☐

4. Must screening of actions for environmental significance take place?

Yes ☐ No ☐

5. Must scoping of the environmental impacts of actions take place and specific guidelines be produced?

Yes ☐ No ☐

6. Must EIA reports meet prescribed content requirements, and do checks to prevent the release of inadequate EIA reports exist?

Yes ☐ No ☐

7. Must EIA reports be publicly reviewed and the proponent respond to the points raised?

Yes ☐ No ☐

8. Must the findings of the EIA report and the review be a central determinant of the decision on the action?

Yes ☐ No ☐

9. Must monitoring of action impacts be undertaken and is it linked to the earlier stages of the EIA process?

Yes ☐ No ☐

10. Must the mitigation of action impacts be considered at the various stages of the EIA process?

Yes ☐ No ☐

11. Must consultation and participation take place prior to, and following, EIA report publication?

Yes ☐ No ☐

12. Must the EIA system be monitored and, if necessary, be amended to incorporate feedback from experience?

Yes ☐ No ☐

13. Are the financial costs and time requirements of the EIA system acceptable to those involved and are they believed to be outweighed by discernible environmental benefits?

Yes ☐ No ☐

14. Does the EIA system apply to significant programmes, plans and policies, as well as to projects?

Yes ☐ No ☐

THANK YOU

UNIVERSITY OF GHANA

Dear Respondent,

We humbly request your kind assistance in the successful completion of a project entitled "Environmental impact of the mobile telecommunication technology in Ghana (A case study in Accra)".

The researcher is a PhD student from the Environmental Science Department.

---

1. How many years have you lived in this neighbourhood?

____

2. Were you living here before this telecommunication base station was mounted?

Yes ☐ No ☐

3. If yes, were you consulted before the siting of the base station?

Yes ☐ No ☐

4. If yes, how was the consultation done?

____

5. What suggestions did you make?

____

6. Were your suggestions taken into consideration when the base station was mounted?

Yes ☐ No ☐

7. Are you content living closer to a base station?

Yes ☐ No ☐

8. Why? ____

9. Have you sent any complaint to any authority?

Yes ☐ No ☐

10. What is the name of that authority?

____

11. How were your complaints resolved?

____

12. Are you aware of any regulation governing the mounting of base stations?

Yes ☐ No ☐

13. Do telecommunication companies comply with the regulations governing the mounting of base stations?

Yes ☐ No ☐

14. If no, which regulation(s) do telecommunication companies flout?

____

15. Have you identified any health risk in your children that you can link to base stations?

Yes ☐ No ☐

16. If yes, can you list them?

____

17. Would you like your child/children to be medically examined?

Yes ☐ No ☐

18. Have you identified any health risk in your neighbourhood that you can link to base stations?

Yes ☐ No ☐

19. If yes, can you help us locate the person?

Yes ☐ No ☐

20. Are you familiar with the mobile telecommunication technology?

Yes ☐ No ☐

21. Where did you acquire this knowledge from?

22. Will you relocate when compensated?

Yes ☐ No ☐

23. Do you have any further suggestions?______________________________

PERSONAL DETAILS

24. How old are you?

(i) 21 - 40 year (ii) 41 - 50 years (iii) over 50 years

25. Sex: (i) Male (ii) Female

26.Are you a landlord or tenant? ------------------

27. What is your highest level of education?

(i) None (ii) JHS (iii) SHS (iv) Post-secondary (v) Tertiary.

28. What is your main occupation?

THANK YOU

UNIVERSITY OF GHANA

Dear Respondent,

We humbly request your kind assistance in the successful completion of a project entitled "Environmental impact of the mobile telecommunication technology in Ghana (A case study in Accra)".

The researcher is a PhD student from the Environmental Science Department.

EPA/NCA

1. What are your main duties as far as the mobile telecommunication industry is concerned?____

2 (a). How many base stations have you issued permits to in Ghana? ________________

(b). How fast has the number of base stations increased over the years?______________

3 (a). How many base stations are in Accra? __________________________________

(b). How fast has the number of base stations increased over the years?_______________

4 (a). Are there possible risks associated with the mobile telecommunication industry?

Yes ☐ No ☐

(b)If yes, what are the risks? ____

5. Are residents consulted/educated during the siting of base stations?

Yes ☐ No ☐

6 (a). Do you receive complaints from residents dwelling close to base stations?

Yes ☐ No ☐

(b). If yes, what are the complaints?____

(c). How do you resolve the complaints?______________________________________

7(a). Do telecommunication operators comply with local and international regulations governing the mounting of base stations?

Yes☐ No ☐

(b). If no, which regulation(s) do companies flout and why?______________________

(c). What sanctions does the EPA impose against operators?_____________________

8(a). Are telecommunication operators really committed to EIA principles?

Yes☐ No☐

(b). Do the EIA measures implemented actually attain their expected effects?

Yes☐ No☐

9(a). Are there possible risks associated with the mobile telecommunication industry?

Yes☐ No☐

(b). If yes, what are the risks? _______________________________________

(c). Do base stations have significant adverse impacts?

Yes ☐ No ☐

(d). If yes, what are the significant adverse impacts?_________________________

(e). Does the EPA monitor and evaluate measures implemented to mitigate environmental impacts?

Yes ☐ No ☐

(f). How often? ____

10(a).Is there an issue of risk perception among people living close to base stations?

Yes ☐ No ☐

(b). What are some of the of risk perceptions?______________________________

11. Will you consider compensation for people to relocate?

Yes ☐ No ☐

12. What major environmental factors does the EPA take into consideration before permitting base station proposals?_______________________________________

13(a). Is there a minimum legal distance for locating base stations from residential areas?

Yes ☐ No ☐

(b). If yes, what is the minimum distance?____________________________________

14(a). Are material wastes or products of the telecommunication industry (plastics, metals, glasses, batteries, SIM cards and chargers) properly managed?

Yes ☐ No ☐

(b). If yes, how are they managed?_______________________________________

Wood (2003) proposed "14 pointevaluation criteria".

1. Is the EIA system based on a clear and specific legal provision?

Yes ☐ No ☐

2. Must the relevant environmental impacts of all significant actions be assessed?

Yes ☐ No ☐

3. Must evidence of the consideration, by the proponent of the environmental impacts of reasonable alternative actions for environmental significance take place?

Yes ☐ No ☐

4. Must screening of actions for environmental significance take place?

Yes ☐ No ☐

5. Must scoping of the environmental impacts of actions take place and specific guidelines be produced?

Yes ☐ No ☐

6. Must EIA reports meet prescribed content requirements, and do checks to prevent the release of inadequate EIA reports exist?

Yes ☐ No ☐

7. Must EIA reports be publicly reviewed and the proponent respond to the points raised?

Yes ☐ No ☐

8. Must the findings of the EIA report and the review be a central determinant of the decision on the action?

Yes ☐ No ☐

9. Must monitoring of action impacts be undertaken and is it linked to the earlier stages of the EIA process?

Yes ☐ No ☐

10. Must the mitigation of action impacts be considered at the various stages of the EIA process?

Yes No ☐ ☐

11. Must consultation and participation take place prior to, and following, EIA report publication?

Yes ☐ No ☐

12. Must the EIA system be monitored and, if necessary, be amended to incorporate feedback from experience?

Yes ☐ No ☐

13. Are the financial costs and time requirements of the EIA system acceptable to those involved and are they believed to be outweighed by discernible environmental benefits?

Yes ☐ No ☐

14. Does the EIA system apply to significant programmes, plans and policies, as well as to projects?

Yes ☐ No ☐

THANK YOU

APPENDIX F

Table. I: The main duties of the NCA as well as the MTT is concerned

	Main Duties
NCA	1. Grant licenses and authorizations for operation of communication systems and services. 2. Ensure fair competition among licensees. 3. Establish and monitor quality of service indicators for operators and service providers. 4. Consumer education and protection. 5. Equipment standards and type approval. 6. International frequency coordination.

Source: Field Survey Data, 2014

Table. II: The main duties of the MMDAs as well as the MTT is concerned

MMDA	**Main Duties**
Ga East (TP)	To ensure that tower masts erected acquire all necessarily official permits.
Adentan (TP)	Ensuring that communication base stations are sited according to land use conformity and technical specification.
AMA	1. Issuance of business operating permit (B.O.P)
Ga Central (WD)	1. Inspect site and also issue permit for the construction of base stations. 2. Drawings are checked for structure purposes before the approval of construction is done.
Ga East (WD)	Receive and process applications by town and country planning dept for approval by the statutory planning committee.
La Nkwantang-Madina (TP)	Issuing of development permit.
Adentan(WD)	1. Approve the area for sighting the telecom base station. 2. Grant structure permit for the construction of masts. 3. Ensure structure safety for the permit granted.
Ga West	Receive development permit application from operators

Source: Field Survey Data, 2014

Table. III: Rate of increase in the number of BSs over the years and the number of BSs issued with permits

How fast has the number of BSs increased over the years?		
MMDA	Base stations issued with permits	Rate of increase in base stations over the years
Ga West	About 50	Not too fast
Ga East (TP)	Over 100	Very fast
Adentan (TP)	About 5	Mast erection has increased at a fast rate
AMA	About 400	Not too fast within the Accra metropolis
Ga Central	About 14	Not frequent
Ga East (WD)	About 44	Very fast
La Nkwantanang-Madina	About 8	Occurred in last 3 years in newly developing communities
Adentan(WD)	No response	Very fast

Source: Field Survey Data, 2014

Table. IV: Compliance of telecommunication operators to local and international regulations and sanctions imposed against operators

Do telecommunication operators comply with local and international regulations governing the mounting of BS?			
MMDA	Response	If no which regulation(s) do operators flout?	What sanctions are imposed against operators?
Ga East (WD)	Yes	-	-
Adentan (TP)	No	1. Acquisition of building permit which requires issues like; Land title, EPA report, Fire report and Structural audit (of existing base stations)	1. Refusal to grant permits 2. Assemblies and other agencies do nothing NOTE: But facilities remain operational
Adentan (WD)	Yes	-	-
AMA	Yes	-	-
Ga Central	Yes	-	-
Ga East (TP)	No	1. EPA report 2. Supervision of constructing base of	1. Removal of structures

		structure	2. Penalties
La Nkwantanang-Madina	No	The permissible setback for siting base stations	Sanctions are contained in the NCA Guidelines
Ga West	Yes	-	-

Source: Field Survey Data, 2014

Table. V: Monitoring and evaluation of measures implemented to mitigate environmental impacts and effects of the EIA measures implemented

MMD As	Does the assembly monitor and evaluate measures implemented to mitigate environmental impacts?		Do the EIA measures implemented actually attain their expected effects?
	Response	If yes, how often? /If no, why?	
Ga East(TP)	No	Various logistics to do the monitoring is a challenge to the assembly.	No idea
Adentan (TP)	No	EPA is supposed to monitor and evaluate measures implemented.	May be
Ga West	Yes	Once a while	Yes
AMA	Yes	Not very regular	No
Ga Central	No	The EPA is mandated to ensure the mitigation of any environmental impact ofbase stations.	Yes
Ga East (WD)	Yes	Once a year	Yes
Adentan(WD)	No	The assembly does not have the capacity to manage or regulate such technical area.	Yes
La Nkwantanang-Madina	Yes	From project commencement to completion before certificate of operation is issued to the operator.	Yes

Source: Field Survey Data, 2014

Descriptive Statistics

Table. VI: Number of years lived in neighbourhood

	N	Minimum	Maximum	Mean	Std. Deviation
How many years have you lived in this neighborhood?	142	6	35	15.78	5.581

Source: Field Survey Data, 2014

Table.VII: Residents on site before the mounting of BSs

	Frequency	Percent
Yes	129	90.8
No	13	9.2
Total	142	100.0

Source: Field Survey Data, 2014

Table. VIII: Residents consulted before the siting of BSs

Were you consulted before the siting of the base station?	Frequency	Percent
Yes	26	20.2
No	103	79.8
Total	129	100.0

Source: Field Survey Data, 2014

Table. IX: Methods of consultation

How was the consultation done?	Frequency	Percent
Individual consultation/discussion	16	64.0
General meeting with landlords	3	12.0
I was just informed without any discussion(Landlord)	6	24.0
Total	25	100.0

Source: Field Survey Data, 2014

Table. X: Suggestions from residents

What suggestions did you make?	Frequency	Percent
I told them it should be mounted far away from residential home/neighborhood	7	53.8
I told them it should be mounted above 35 meters	1	7.7
I told them it should be mounted out of town	4	30.8
We rejected the mounting of the base station	1	7.7
Total	13	100.0

Source: Field Survey Data, 2014

Table. XI: Reasons for comfortably living closer toBSs

Why are you contentliving closer to BSs?	Frequency	Percent
Not aware of any consequences/side/harmful effects	36	73.5
No disturbance (not harmful) to people	1	2.0
I think I am far away from it (I am at a reasonable distance)	7	14.3
I feel OK, not aware of any side effects, however, noise/fumes are my problem	3	6.1
Not aware of side effects, however, heard it has collapsed in one or two places	1	2.0
I think am far away from it though heard it causes diseases	1	2.0
Total	49	100.0

Source: Field Survey Data, 2014

Table. XII: Suggestion(s) from neighbourhoods

Do you have any suggestion(s)	Frequency	Percent
Government should educate the public/clarify masts related issues	10	5.1
Base stations should be sited far away from homes	59	30.3
There should be public education	71	36.4
Service providers should be truthful in discussing radiation issues with the public	9	4.6
Government should enforce all laws to ensure compliance	2	1.0
EPA should come out and clarify mast related issues brought before it	1	.5
EPA should be strict on the rules about the mast	1	.5
Service providers should resolve all complaints brought before it	1	.5
Service providers should consult/seek the consent of the neighborhood	27	13.8
Activities of service providers should be seriously monitored	1	.5
Mast should be strong enough to stand the test of time/not collapse	2	1.0
Warning lights should always be on	2	1.0
Noisy generators should be replaced	1	.5
Medical checkups be conducted regularly	2	1.0
Residents should demonstrate/protest against sitting of mast closer to homes	1	.5
No, even if I have suggestions, nothing will be done about it	2	1.0
Stakeholders should ensure that mast has no any health implications	2	1.0
Landlords should not just collect monies and let others suffer	1	.5
Total	195	100.0

Source: Field Survey Data, 2014

Table. XIII: Consultation before the siting of BSs * Residentsfamiliar with the MTT

	Were you consulted before the siting of the BS?				Total	
	Yes		No			
	N	%	N	%	N	%
Yes	19	73.1	63	61.2	82	63.6
No	7	26.9	40	38.8	47	36.4
Total	26	100.0	103	100.0	129	100.0

Source: Field Survey Data, 2014

Table. XIV: Landlords and tenants * Residents comfortable living closer toBSs

		Are you a Landlord or a tenant?				Total	
		Landlord		Tenant			
		Count	%	Count	%	Count	%
Are you content living closer to the base station?	Yes	28	41.2	23	30.3	51	35.4
	No	40	58.8	53	69.7	93	64.6
Total		68	100.0	76	100.0	144	100.0

Source: Field Survey Data, 2014

Table. XV (a): Suggestions included in making decision * Residents comfortable living closer toBSs

	Were your suggestions taken into consideration?				Total	
	Yes		No			
	N	%	N	%	N	%
Yes	2	100.0	0	.0	2	14.3
No	0	.0	12	100.0	12	85.7
Total	2	100.0	12	100.0	14	100.0

Source: Field Survey Data, 2014

Table. XV (b): Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	14.000[a]	1	.000		
Continuity Correction[b]	7.024	1	.008		
Likelihood Ratio	11.483	1	.001		
Fisher's Exact Test				.011	.011
Linear-by-Linear Association	13.000	1	.000		
N of Valid Cases	14				

a. 3 cells (75.0%) have expected count less than 5. The minimum expected count is .29.

b. Computed only for a 2x2 table

Table. XVI (a): Residents willing to relocate when compensated * Landlords and tenants

	Will you relocate when compensated?				Total	
	Yes		No			
	N	%	N	%	N	%
Landlord	6	21.4	62	53.4	68	47.2
Tenant	22	78.6	54	46.6	76	52.8
Total	28	100.0	116	100.0	144	100.0

Source: Field Survey Data, 2014

Table. XVI (b): Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.279[a]	1	.002		
Continuity Correction[b]	8.038	1	.005		
Likelihood Ratio	9.827	1	.002		
Fisher's Exact Test				.003	.002
Linear-by-Linear Association	9.214	1	.002		
N of Valid Cases	144				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.22.

b. Computed only for a 2x2 table

Table. XVII (a) Familiarity with the MTT * Highest level of education

Crosstabulation

	Are you familiar with the MTT?				Total	
	Yes		No			
	N	%	N	%	N	%
None	2	2.3	0	.0	2	1.4
JHS	2	2.3	7	12.5	9	6.3
SHS	12	13.6	8	14.3	20	13.9
Post-secondary	40	45.5	29	51.8	69	47.9
Tertiary	32	36.4	12	21.4	44	30.6
Total	88	100.0	56	100.0	144	100.0

Source: Field Survey Data, 2014

Table. XVII(b) Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.795[a]	4	.044
Likelihood Ratio	10.543	4	.032
Linear-by-Linear Association	3.541	1	.060
N of Valid Cases	144		

a. 3 cells (30.0%) have expected count less than 5. The minimum expected count is .78.

APPENDIX G

One - way between – groups ANOVA for heavy metal content and sampling sites as grouping variables

Dependent Variable	Categorical Variable		Mean Difference (I-J)	Sig.
Cd	A1 - A15	B1 - B15	1.47400*	.028
		C1 - C15	1.73200*	.009
	B1 - B15	A1 - A15	-1.47400*	.028
		C1 - C15	.25800	.887
	C1 - C15	A1 - A15	-1.73200*	.009
		B1 - B15	-.25800	.887
As	A1 - A15	B1 - B15	2.33200*	.004
		C1 - C15	1.58467	.063
	B1 - B15	A1 - A15	-2.33200*	.004
		C1 - C15	-.74733	.522
	C1 - C15	A1 - A15	-1.58467	.063
		B1 - B15	.74733	.522
Pb	A1 - A15	B1 - B15	4.94667*	.005
		C1 - C15	3.82867*	.037
	B1 - B15	A1 - A15	-4.94667*	.005
		C1 - C15	-1.11800	.737
	C1 - C15	A1 - A15	-3.82867*	.037
		B1 - B15	1.11800	.737
Zn	A1 - A15	B1 - B15	.22933	.068
		C1 - C15	.25867*	.035
	B1 - B15	A1 - A15	-.22933	.068
		C1 - C15	.02933	.954
	C1 - C15	A1 - A15	-.25867*	.035
		B1 - B15	-.02933	.954
Cu	A1 - A15	B1 - B15	5.45133*	.002
		C1 - C15	3.19800	.086
	B1 - B15	A1 - A15	-5.45133*	.002
		C1 - C15	-2.25333	.283
	C1 - C15	A1 - A15	-3.19800	.086
		B1 - B15	2.25333	.283

APPENDIX H

Dendrogram obtained by HCA for heavy metal contents in soil samples (Ward method).