

SCHOOL OF SCIENCE AND TECHNOLOGY, KUMASI
DEPARTMENT OF SCIENCE AND INDUSTRIAL MANAGEMENT
SCHOOL OF NATURAL SCIENCES

**MONETARY VALUATION OF THE DAMAGE EFFECTS OF WATER
POLLUTION ON HUMAN HEALTH (THE CASE OF SUBIN, SISA AND ODA
RIVERS IN KUMASI)**

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(APRIL 2003)

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I thank God Almighty for His Mercies, Power and Invaluable help throughout my study. Valuable consultants and writing provided by my supervisor, Dr. Osei Fosu of the Economics and Industrial Management Department, KNUST, Kumasi are highly acknowledged. His guidance, patience and observations have been invaluable. May God richly bless him. My other thanks to all the lecturers at the department, especially Mr. Osei Fosu Agyei

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Diseases), Dr. Isaac Asamoah, (Jahne Francis M. Michael Hospital) and Dr. Bosque Ayitley and Nana Amankwah (WRI, CSIR Accra)

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FOR THE AWARD OF MASTER OF ARTS (M. A. ECONOMICS) DEGREE.**

Last but not least, I thank my uncles Messrs. Samuel Opoku Agyeman, John Opoku-Fofie and Kwaku Opoku Banting. I duly recognise and deeply appreciate all other persons for tireless help in one way or the other, May God Bless you.

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DEDICATION

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Richard Adu- Poku.

DEDICATION

CERTIFICATION

I dedicate this work to Mr. H. Korankye Gyasi and Mrs. Margaret Opoku of Poano (my parents) , Dr. Osei A. Kufuor, (my supervisor) KNUST, Kumasi and Mrs. Irene Adu – Poku (my wife).

RESEARCHER

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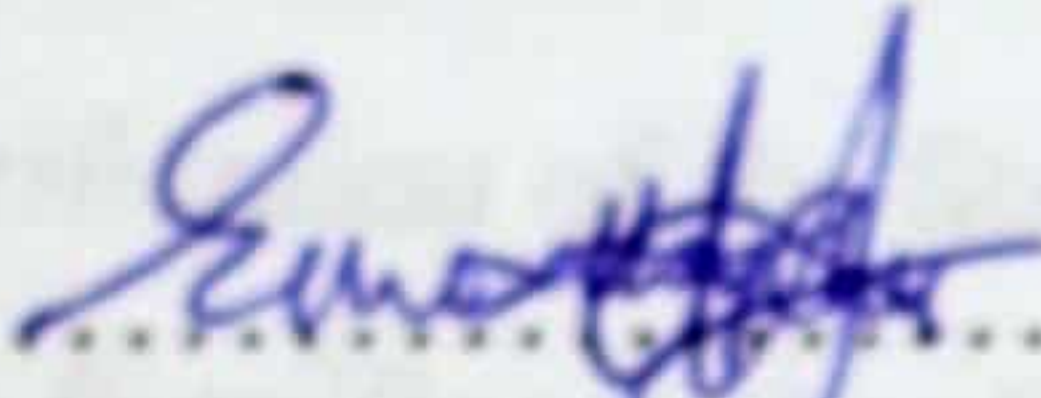
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CERTIFICATION

While acknowledging the sources of information, offices and individual's effort, I declare that no part of this work or whole has been presented or provided by any person.

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ABSTRACT

Surface water quality in some parts of peripherals of Kumasi are affected by discharge of industrial and domestic pollution. This has negatively influenced the health of inhabitants living too close to the banks of these rivers.

The problem of the study is to identify whether there is a relationship between water pollution and human health. Consequently it has a goal of putting monetary valuation on the damage effect caused by this act of pollution on human health.

This has been done with three main objectives in mind. First of all, to examine an established relationship between water pollution and human health as stated. Secondly, to put monetary evaluation on the damaged caused by pollution using cost of illness from the environmental economics point of view. And thirdly, to use the peoples willingness to pay for a quality supplies. This, is to check the reliability and validity of cost of illness valuation methods applied in the study.

A brief case study is presented. This highlights the negative effect of uncontrolled exploitation of the surface water due to rampant domestic and urban development and industrial activities.

Data for this research work were gathered through literature search, questionnaire and personal interviews. The findings of the study were tested through standard economics statistical tools.

The results of research indicated that there is a relationship, even though at a lower degree, between water pollution and human health in the area studied. Also there is an economic cost, which is incurred by the people in the area due to this damage. This cost was verified through the method of willingness to pay for quality water as a substitute of the polluted water. Thus it is an environmental problem that needs, further critical assessment to reduce the hardship and burden imposed by these water pollution.

It is recommended that some essential promotional and awareness activities be carried out at regular interval. This can help to inform target affected people and those that do not come about such consequently really. There should be a monitoring; assessment and evaluation

programme that must be arranged by technical and sound economics analysts to use the scarce economic resources allocated to the area to great advantage. The sector that controls environmental and water bodies should be improved through proper economic management, institutional and administrative influences to enable better development of resources in the area and similar places facing the same problem.

1.1 GENERAL OVERVIEW OF THE STUDY

1.1.1 WATER AND ECONOMIC DEVELOPMENT

Water resources contribute enormously to economic productivity and social well-being of

CHAPTER ONE:

INTRODUCTION

1.1 GENERAL OVERVIEW OF THE STUDY

1.1.1 WATER AND ECONOMIC DEVELOPMENT

Water resources contribute enormously to economic productivity and social well-being of human beings since both social and economic activities rely heavily on water availability and in sufficient quantities.

The African continent is relatively the most impoverished, underdeveloped and marginalized amongst the community of continents. The South Sahara Africa countries (Ghana inclusive) suffer not only from the negative image problems but also from inefficient and misapplication of the scarce resources for remarkable accelerated economic developments. These effectively militate against the quest for a dignified life for a vast majority of the people.

In addition to these difficulties and challenges, environmental degradation is springing up at an alarming rate that needs a serious empirical consideration. Amongst such environmental problems is the most common one, water pollution. There is the need to adopt development paradigms, strategies and sophisticated technologies and reliable methods to extricate the inescapable aftermaths (unpleasant state) of water pollution in Ghana.

With increasing growth in population and the subsequent socio-economic pursuits (including urbanization, industrial production, tourism and agricultural activities) demand for water has increased rapidly. In some areas of Ghana the stage has reached, where technically, the availability of water is a limiting factor for further development and increasing the deterioration of quality of life. In such areas conflicts have arisen amongst various competing sectors and users of water.

This is further compounded by the fact that currently water resource management responsibilities are fragmented amongst several agencies, a situation which has become the number one impediment to integrated water resource policy. This situation is undermining the sustainability of water resources, the quality of life and health status of the population.

A number of these challenges are attributed to factors both within and outside the water sector, such as, climate variability and increasing demand and overuse of water due to development and population pressure. The major problematic issue in this resource and its impact is water pollution.

Increasing pollution is apparently intensifying poverty and curbing economic development. Most of the municipal sewerage plants and industries in the cities of Ghana are believed to discharge partially treated or untreated waste water containing high levels of organic, heavy metal and other toxic substances that easily pollute the surface water bodies.

The economic cost of water pollution relates to issues such as

- human health risks
- increase cost of water treatment
- damage to the watershed and coastal resources that could have been used for intrinsic values
- insecure and unsustainable water supply due to misallocation and the inefficiency they bring.

Ghana over the last two (2) decades has, and continues to experience urban growth and has become quite rapid. But one of its targets is to make industry become one of the central planks of her long-term national development policy drive, and to take her economy into the middle income category by the 2020. (Vision 2020, 1995).

Alongside the above projection, one of the long-term economic objectives of the government is to ensure that all residents, (especially those at the downstream of the vulnerable water polluted areas) in the country, have access to clean and potable water and that water is available for key economic activities and importantly for personal and domestic duties without any discomfort where necessary. This is only possible if the available water resources are protected from pollution. Surface water resources in Kumasi, Accra and Obuasi amongst other towns in the country are becoming polluted currently from both point and non-point sources.

There is the need to check this because pollution and its related hazards started slowly without much attention or perceive or forecast consequences.

It is time to consider the study of water pollution, way to minimize losses, reduce its intensified problems and promote efficient allocation of scarce resources. This will help to monitor and enforce the water quality and waste water discharge standards.

1.1.2 POLLUTION AS A HARMFUL ENTITY IN SURFACE WATER (S)

Water resources that are polluted, with some selected benefits, have lot of a harmful impact when reused as the source of main water downstream, with potential cost attached to its use. For instance it leads to

- increases exposure of the people in these communities to infectious diseases.
- groundwater contamination
- have a long-term negative impact on soil resources – building of salts, heavy metals in the soils, which may reduce productive capacity in the long run;
- have an impact on property values in the vicinity; and
- other negative qualitative impacts on socio-ecological systems.

1.1.3 POLICY AND ECONOMIC QUESTIONS

Under the changing situation of the environmental resources, rapidly, towards a declining state, especially, on surface water resources, economists and policy makers are facing difficult questions such as:

- Should the traditional and cheapest practice of discharging human excreta (explained in chapter 2) and other of waste into the sub-tributaries (most of which look like gutters) which join the main rivers be continued or discontinued to save human life and increase productivity of downstream dwellers who might not have any other comparable alternative uses?
- Should such contaminated water(s) and those from most industries be treated and at what cost?
- Should incentive-based measures be adopted or regular mechanisms be enforced and at what cost?
- Should proper and better water resources be made available to the victims when pure empirical evidences are shown?

In the absence of a sound scientific research and a proper field study, these and other relevantly questions that affect human health status – (one of the valuable assets to be distorted) due to water pollution, remain unanswered and decisions are often based on unsound ad hoc judgments – which not only lead to litigation and serious underestimation or overestimation but also may result in inefficient, misallocation and unsustainable use of its scarce resource (Akuffo S. K., 1979)

1.1.4 ENVIRONMENTAL IMPACT OF WATER POLLUTION

The current publication and reports established by the human health risks division of WHO, have it that water quality, when affected by any form of pollution can result in seriously unbearable limits. In almost every year, 90 million people are affected by water-borne and water related diseases. In the developing countries in Africa and Latin America, 30% of this number are found in Sahara Africa (Ghana inclusive). This environmental problem also goes with complicated issues like lack of water and water insecurity among others. The ultimate impact is that men of all levels are not free from such diseases. This implicitly reduces the labour force and results in misallocation of scarce human resources. There is an indication from empirical data that due to water pollution, at least some girls at or above school going ages are negatively affected by either going to school randomly or stopping school altogether.

The returns to and projected outcomes of national fund invested in human resources become minimal or totally lost. Mortality also combines with the above problems.

1.2 THE STATEMENT OF THE PROBLEM

A World Bank position on domestic water supply (World Bank, 1975) cautiously limited itself to saying "other things being equal", a safe and healthier adequate and sufficient water supply is generally associated with healthier people. Most municipalities and metropolises in the country are faced with this double-edged problem. The first is the need to provide suitable and useful water. The other one is the disposal of waste be it liquid, solid or gaseous.

The later case contributes to an undue and alarming rate of water pollution. That is, most rivers flowing through these areas are presently littered with a legacy of industrial wastes,

waste dumps, sullages and sewerage-mismanaged materials, mining chemicals, to mention but a few.

The impacts are not yet known well. This makes management and allocation of the scarce economic resources ineffective and at low efficient level. Even though there is a good understanding of effluents and specific elements going into the rivers, wells, lakes and other surface water bodies, the water resource data that currently exists in Ashanti region and other major parts of the country in the database showing the trend, causes, extents etc are inadequately and inaccurately able to prove the extent and value lost of pollution. This trend does not reflect the significant changes that have occurred over the last few years due to rapid urbanization and the springing up of small and large industries.

Meanwhile, water pollution exacerbates water scarcity, prones human to health risks and results in insecurity of the continuous flow of water because of limits it brings or imposes on cost for treatment on downstream users. The effluent from various pollution sources (both point and non-point sources) contributes significant organic loads, heavy metals and toxic substances to receiving rivers. The problems of pollution are heavily felt and experienced particularly during low flow periods. Lack of effective control compromises the quality of water, posing potential health hazards and bringing imbalances in ecosystems. This has been also common because all undue water pollution experienced are not recorded or documented properly because of lack of information and data regarding the nature, extent and its impacts on human health. This supports general disregard of the needs and rights of other water users and their effects.

The systematic study of water pollution and its economic cost on human health is in its infancy. It is gradually accepted that serious human health problems are mainly introduced in many parts of Kumasi, Obuasi, Tarkwa, Accra etc and other immediate surroundings through the uses of polluted water for drinking, washing and other purposes.

A report not yet quantified has it that major rivers in Kumasi and Obuasi in the Ashanti Region are highly vulnerable to domestic and industrial pollution. The attitude towards the environmental issue has changed towards the central focus and interest of commercial, social and political fronts.

The media and environmental economists are eager and keep on pressing to find a way to improve quality of life, lower the high risk level of water pollution, and more than double the impact and economic growth when things are improved. In this wise, it is time to carry out a study to establish the exact nature, extent and the links (relationship) between water pollution and human health risks.

1.3 OBJECTIVES

The main objectives of this study are

- (i) to provide a framework for the qualitative measure (determination) of the extent of urban polluted water on human health status in the immediate sub areas down of rivers chosen.
- (ii) evaluating the economic cost of health risks. The study has the following specific objectives:
 - to identify some major pollutants in the polluted surface waters to be studied, that are believed to have a relationship with human or have the potential to cause the "indigenous diseases".
 - to assess the nature and extent of water pollution on human health to have first hand information.
 - to identify and assess the main sources of water pollution.
 - to evaluate the economic cost of the water pollution; that is quantifying the health hazards and estimating the cost of immediate economic policies and socio-economic intrinsic values to be resolved.
 - to estimate the WTP if a quality water is to be provided, using the Contingent Valuation Method. This is to check both the reliability and validity of the main valuation models used.

The research has the aim to reduce the common issue among all industries and most domestic activities; ejection and discharge of pollutant to the surface water resources, which have direct impact of hazards.

1.4 JUSTIFICATION OF THE STUDY

Recently, majority of publications on water quality and resource management focus on water pollution. The numerous effects and more specifically on human health, are considered and reviewed in economic wise.

It is postulated and strongly agreed that pollutants that are contained in the polluted surface water bodies tend to produce or support microbiological viruses and bacteria that cause the indigenous diseases. And also, the chemicals deoxygenate the chemical qualities of the water. This action makes water resources very weak to withstand any impact. The economic impact is proving to be an economic problem. The implication of the problem makes it not localized any longer, but regional, national and even global. It is therefore imperative to research into this problem so as to exactly establish whether there exist pollutants that are present enough in the water resource and can cause or have the potential to cause diseases.

The economic cost can be analysed in details. This will help to reduce the tension that surrounds the speculation through the pronouncement by the medical houses and other field workers as it is to identify the sources, variables responsible and those that are not responsible for the diseases.

Human health is a crucial economic resource, needed for rapid socio-economic development. It then requires proper assessment to be made when affected by water pollution.

This in no small measure, is likely to throw more light on relevant areas and will highlight both good techniques, failure and success of the issue at stake to avoid the unnecessary duplication of effort and expenditure of the nation's limited resources.

Poor health due to water pollution imposes at least, an economic cost and prevalent pressure, and a degree of cost to the community or society; there is the pain and anguish experienced by patients and their families. Additional health services and medical resources (drugs, doctors, inputs, nursing, hospitalisation, time consumed), productivity losses in days lost from work, etc are affected negatively. Sufficient and adequate information in a concrete database form is needed to identify and facilitate the real appropriate health risks, management and preventive measures based on proper documents.

It is therefore demanding to undertake a comprehensive risks evaluation with the most applied techniques by environmental economists based on reliable key sectors. The study is very flexible, feasible and can prove valid with the reliable tools to be used. The materials, logistical and other tools can be used without much technical difficulty.

1.5 THE SIGNIFICANCES OF THE STUDY

The determination of the nature and extent of water pollution and human health risk and the evaluation of the economic cost focus on the signals obtained in day-to-day production and consumption decision plans. These signals have in essence the economic implications of unconsciously influencing the behaviour in an environmentally positive or negative fashion.

The work will help to prompt environmental economists to get the real underskin of the economy to actually and empirically underscore the ample incentive that can encourage conservation or destruction: allowing society to see what is happening, why and what the environmental implications and economic consequences are in both the domestic, industrial and mining operations that affect water quality or otherwise that tend to pollute the numerous water bodies beyond levels accepted for natural purification and the assimilation capacity of these resources becoming hardly possible and damaging.

Environmental problems and their solutions are technical and complex which do not go completely:

They can be reduced or changed considerably to a more acceptable and a recommended level. The work aims to give a solid and formidable framework to guide us in dealing with such environmental woes.

In allocating resources and valuable time at disposal, it is important to relate it to spending time in analysing the effect of the pollution in order to immensely contribute with perfect knowledge towards a balanced growth between macro-economic and considerable assessment in environmental resources and their relative changes. The work with a proper research and documentation procedure would bring into light the actual gap that exists between the variables (macro-economic environmental resources) and the sustainability of the later.

The outcome based on a closer and vivid observation associated with the health issues is hoped to alert the general public so that, concerned groups, NGO's, Civil Society etc. will be abreast with up-to-date data and act accordingly.

Alongside, regional seminars, lectures and important meetings can be opened / held to help reduce undue acts or practices that increase the rate of pollution and in a corollary utilise the very few economic resources efficiently.

When proper links are identified, assessed and evaluated, some rampant diseases associated with water resource will be exposed and dealt with or eradicated. This will help to restore health, improve the production capacity and boost the economic growth and development of the people affected without any compromise on the environmental resources. It will also improve the quality of the water bodies.

Furthermore, the government will be able to estimate how many resources to be invested in such problematic areas in order to save lives and improve the quality of life. These can be generalised and the effects and benefits will be felt and acknowledged also by the generations yet to be born. This group of people should not be left with the legacy of a poorer environment, low quality amenities or chronic diseases as these may directly retard economic growth and development, socio-economic productions and implicitly a huge amount of indebtedness to face the nation. There is therefore the urgent need to embark upon such a study to identify the situation which apparently is over-estimated or underestimated and even sometimes roughly quoted due to political strategies and subjective judgment.

Any new findings and observations will be applied for the benefit of the general public to educate people, create awareness and follow informed economically recommended choices.

This in a way is hoped to influence people and generations to come for smooth and realistic national growth and ensure sustainability of the environmental resources in the future.

1.6 HYPOTHESIS

Postulating a number of causal relations, which exist between water pollution and human health begins the actual study on the ground. To keep the analysis simple and not losing

the essence of the problem, it is limited to only possible relationships. The relationships are clearly not mutually exclusive and as such can be presented simultaneously. It starts with a null hypothesis as:

H_0 ; There is no effect of water pollution on human health in the selected peripherals in Kumasi.

An alternative hypothesis is also co-stated as

H_1 ; There is an effect of water pollution on human health in the selected area. The following initial conditions are deemed crucial and important to the study.

No water pollution

No indigenous diseases (negative effect of water pollution) and:

The possibility of the existence of exogenous diseases in the area already.

1.7 METHOD OF STUDY

The data was collected through a simple statistical sampling method to get fair and clear representatives from the target population to be studied. In view of this the following main duties were accomplished.

- Administering of questionnaires and questions on one-to-one basis after the sampling has been done.
- Interviews at some selected medical posts and the medical officers at The Komfo Anokye Teaching Hospital – Kumasi, Jachie-Pramso St. Michael Hospital which are very close to the area of study.
- Reports from EPA offices and other key sectors which are environmentally friendly were analysed.
- Physical and microbiological qualities of the water bodies were tested and analysed briefly. However, due to the complex nature of heavy metals which are very common in polluted water, only records available (most current data) were analysed.

After it was established that pollutants found (variables) have the potential to cause health hazards (health risks) on the victims in the surface water bodies, an economic cost was estimated using the most applicable method used in most developing countries for estimation of impact negatively felt on environmental resources. The model used was the economic cost of illness approach model.

This was due to the theoretical problems of others like the willingness to pay (WTP) and the straight line approach. The situation on grounds for instance, low level of education commonly found in the area and time factor pave way for the COI. The model estimated only the cost on labour, medical cost and preventive cost.

1.8 FRAMEWORK FOR VALUING RISKS ON HUMAN HEALTH

The framework given below explains the simple paths that a commodity needs to go through so that its economic cost on human health is identified and estimated. It works better for intangible environmental entities like pollution, which is really difficult to estimate its cost.

The framework, also gives the necessary steps to follow in order to plan and implement good economic policies alongside, especially, when the water pollution is becoming serious. It indicates the economic cost less of, medical costs, labour hour rate equivalent among others. They are the main ingredients for the both economic models used. It also serves as a guide to the public, showing how much is to be the cost on water pollution.

Figure 1.1 explains the framework for assessing the risk on human health as a result of water pollution.

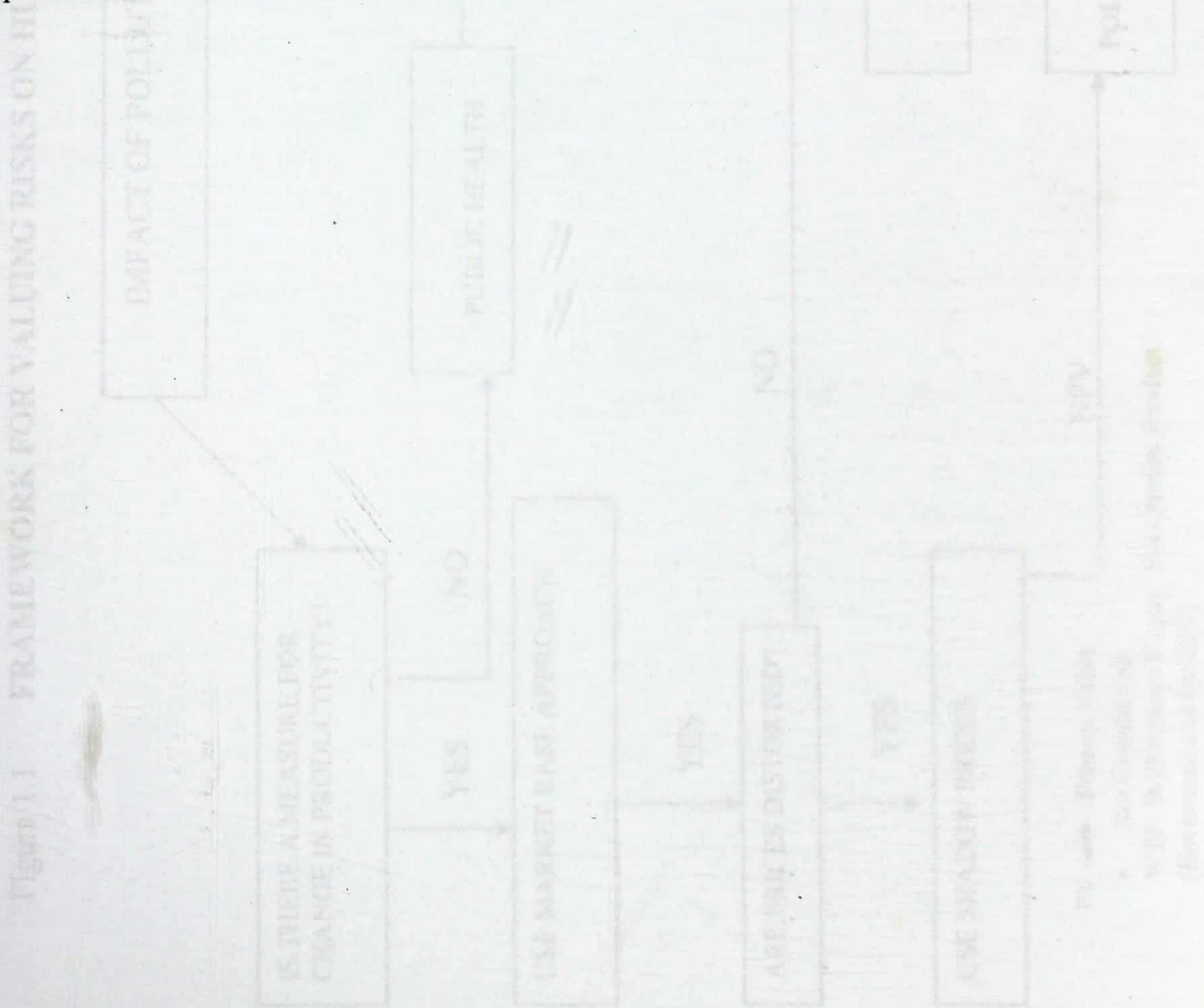
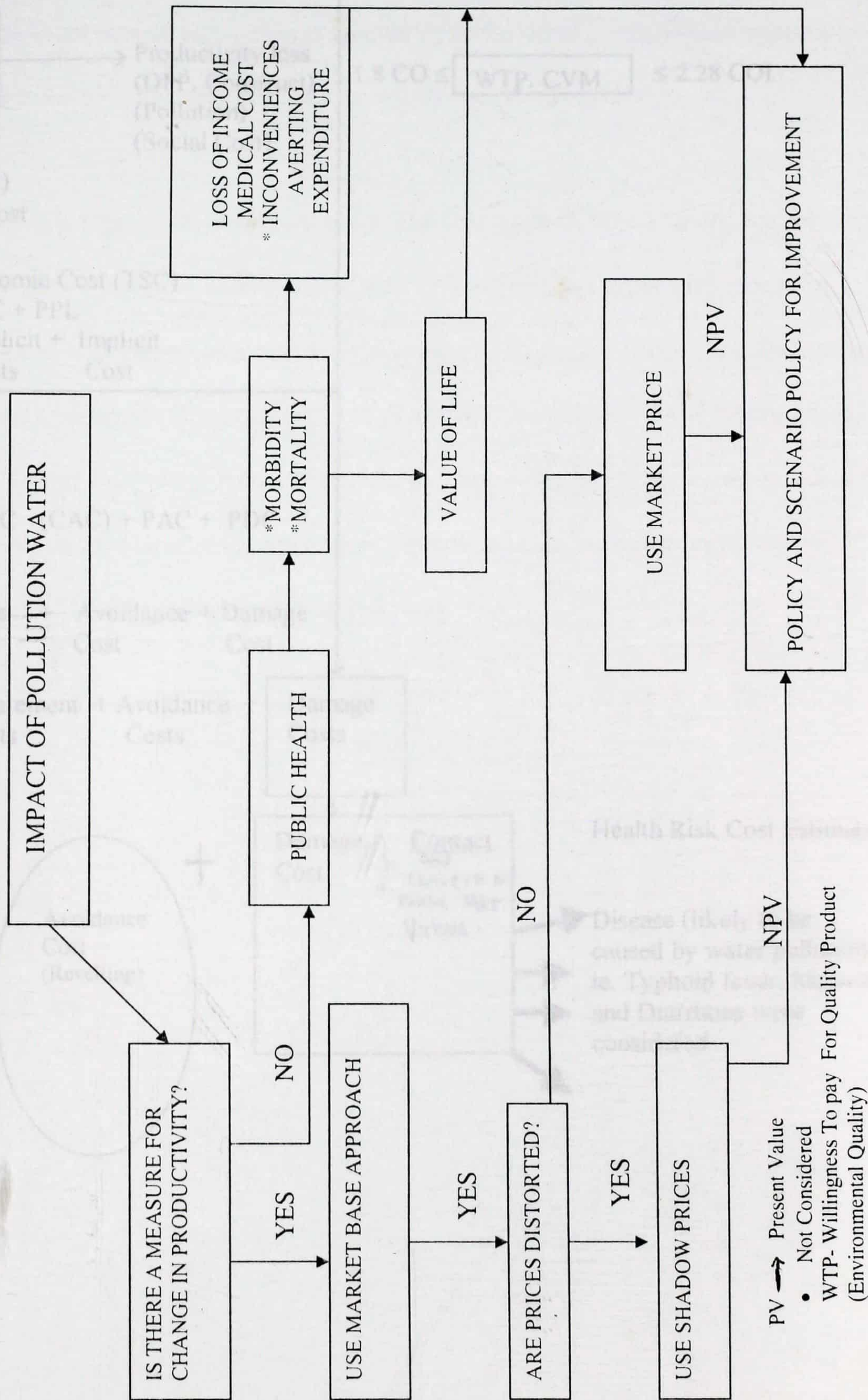


Figure 1.1 FRAMEWORK FOR VALUING RISKS ON HUMAN HEALTH



SOURCE: OD/95 (IWMI)

22/06/2002

MODIFIED BY THE RESEARCHER

From the two frameworks, a set of paths for identifying, assessing and evaluating all kinds of environmental commodities are presented. They explain the necessary steps, taken in finding out what and/or which commodities have market prices. They also lead us from the grass root of estimating economic costs for these commodities, especially what happens if a commodity does not have existing market prices.

The framework 1 gives the necessary and acceptable steps to follow in order to plan and implement good economic policies alongside with estimations especially when the situation under consideration is becoming alarming. The second framework assisted by the first work, indicates the economic cost of income, medical costs and labour hours rate wasted and their equivalent values in economic terms. The frameworks, when followed properly can be used to give figures and guidelines suitable for model in assessing the risk, on human health, caused by water pollution.

1.9 THE SCOPE

The study covered the peripherals of Kumasi where the Rivers Subin and Wiwi flow through. There were twenty (20) communities used in the studies:- along each river and additional reference community from each upstream were considered and those areas without diseases likely to be caused by the pollutants in the committed waterbodies. The study developed and tested a framework of the proposed network of water pollution assessment sampling points, in a range from upstream and downstream closely, to monitor the odour and microbiological quality of the presumed water polluted rivers at distinct sampling points.

A proper evaluation was done to exhibit the real cost of human health due to the water polluted. The work covered only a small part of Kumasi and its peripherals in the Ashanti Region. The detailed and reasons of choice are explained in **chapter 3**.

1.10 THE ORGANISATION OF THE STUDY

The study consists of five main chapters. The first chapter focuses on the introduction, the statement of the problem, the hypothesis, justification and others. The second chapter takes into consideration the literature review of water pollution, the conceptual frameworks of water pollution, the selected cases of the approaches needed to estimate the economic cost of human health as a result of water pollution. The third chapter focuses on the methodology, the appropriate methods for measuring the economic cost in developing countries including Ghana. The survey methods for eliciting the willingness to pay for better water is also covered in this chapter. The fourth chapter is devoted to the results of the study and their relevant analyses. Most of the critical findings are also discussed in detail. The last part of the work is found at chapter five. This includes the summary, conclusion and some recommendations for economic and effective planning for immediate actions.

CHAPTER TWO

LITERATURE REVIEW

2.1 THE CONCEPT OF WATER POLLUTION

The serious problem(s) associated with pollution is to cause the water resources to eruophicate and lower the capacity of the water(s) for other recognized purposes in the development of country's economy. That is, it can de-oxygenate the chemical and metals needed for healthier life. This in a whole, results in the backward movement, or retards slowly the growth rate of the major economic activities of the victims including major duties like farming, rearing of animals and regular domestic activities which can contribute positively to a sustainable economic standard.

The presence of the pollutants in the major water resources causes the hazards, and de-oxygenates some remarkable commodities and reduces the intrinsic values of the resources. For developing countries like Ghana where the literacy level is so low, especially, in the peri-urban areas, most of the people may not be aware of how to prevent or mitigate against it. The stock of health of most economic valuable resource is not properly cared for.

2.2.1 THEORETICAL REVIEW OF WATER POLLUTION

In all, most water related diseases have their roots through bacteria, viruses or insects that spend part or all their life in water. Improving quality and surface water sanitation services around highly vulnerable areas, can help to control diseases associated with water pollution. It is recorded that drastic improvement in public health and proper care undertaken in the industrial and mining communities, and better water supply can lead to a corresponding increase in supply of stock of human (labour) at all levels of developments.

This was noted in the major public sectors, mining areas and industrial set-ups in nations like North America and Europe, in the early parts of twentieth century.

In September 1954, Dr. John Snow, a worker and researcher in environmental health division in London, traced an outbreak of cholera to a particular hand pipe source in London.

This water source had caused death of over five hundred (500) people in a single neighbourhood within a short period of time. He managed to end the outbreak. This was done successfully by removing the pumps of the hand pipes. This proved the possible connection between contaminated water supply and cholera reported.

These improvements have not led much protection of health in major parts of the world, (Keita B, 2001). Nearly fifty (50) years now, new epidemics continue to rage in many parts of the world without regular and proper checking. The practice of poor sanitation and irregularities in environmental resource management (from operational to planning stages) lead to very common water pollution, lack of safe drinking water (and for other domestic uses). Persistence poor attitude and continued ignorance and negligence of the various links between water and diseases keep on resulting in significant world labour supply loss and economic woe (taking those human resources who fall outside the range of these abled labour supply into consideration).

(Nash 1992) reported in her book "Environment, Pollution and Economics of Human health Effect", that in Latin America, statistics indicates that the national domestic production and growth rate of the planned economy reduced remarkably. This was as a result of an unprecedented outbreak of world cholera that occurred in 1991. She also highlights the failure and inability of the nation to control the contamination of drinking water, to educate people about the actual basis, and implications of the water pollution. This, she says, affects a nation's development and could easily lead to total economic misallocation and lower production performance.

2.2.2 EMPIRICAL REVIEW OF WATER POLLUTION AND HUMAN HEALTH (RISKS) CASES

Ebenezer, et al (1993), Ghana undertook a research along the Ankobra River Basin where most mining activities take place. This research was one of their regular research planned operations, in response to the requirement of statutory standard and reports from the area. It was aimed to establish, among other things, whether there exist certain serious pollutants that could affect the health status of the people living along the Basin of Ankobra River. Out of five stations chosen and tested, it was found that the reference point which was Sefwi Anhwiaso recorded low levels of toxic, metals such as Cyanide,

Mercury and Cadmium. These chemicals have higher level potential to affect human health. The evidence was shown that the river invertebrates sampled had higher level Arsenic as concentration. This suggested a serious and dangerous widespread of the chemicals, and as a consequence pollution. The result emphasised the urgent need for effective environmental auditing programmes. These invertebrates were likely to be subjected to food chain poisoning with a clear consequent danger to human beings at the apex of the trophic levels. The Mercury levels at all the sampling sites, with the exception of Sefwi Anhwiaso (the reference point), were very high relatively. In both agricultural and other minor industrial activities in mining companies and similar ones people must regulate and regularly check the ejection of the pollutants into such resources.

Nicholas and Ebenezer M (1993) took a similar work to investigate the water pollution potential from agrochemicals. This was due to the fact that people had unofficially reported the negative attitudes against farmers that use chemical and practices high level of agrochemical farming around Rivers at Akomadan and Agogo.

Akomadan and Agogo both in the Ashanti Region are well noted for tomatoes cultivation. The two areas are situated at the fringes of the transitional and semi-deciduous forest zone of Ghana respectively.

The study took 9 months, from March to December 1991, (a period which covers the main farming activities). Some chemicals were selected to be tested for. After a thorough study, it was identified that agrochemical drift during spraying of crops and pumping of water eject more toxic substances into streams and rivers and around these areas. Also containers for some chemicals are used randomly in these rivers and also, later used as drinking cups in their farms or / and their homes. This makes people highly exposed to pollution problems and leads to proportional effects on economic development in the areas. Sometimes ground waters are contaminated through such practices. Skin rashes and chemical burnt diseases were evident. Some farmers did complain of occasional dizziness after spraying. It was obvious that pollution of surface and groundwater sources was as a cause from runoffs, seepages, drifting of agrochemical and rivers from direct disposal. This led one of the main perennial rivers in Agogo to suffer partial eutrophication (due to continuous application of phosphorus nitrogen and other nutrients).

In light of these farmers and other users of the rivers were advised to undertake control measures and education given by EPA officers and extensive services more seriously. The studies did not quantify the human health risks. They were however able to come out with the correct relationship between the water pollution state and human health cases.

Mara and Cairneross (1989) also undertook a thorough research into the elements and heavy metals that are closely related to water pollution. They assert that the human health hazards due to chemical pollution are of only minor importance when considering the re-use and cycling of polluted water resources.

Pescod (1992) in a review of polluted water resource and use in both households and agriculture acknowledges that municipal waste water may contain toxic levels of trace elements (heavy metals and other chemical element).

It is widely accepted that levels of trace elements and heavy metals in irrigation for instance, are likely to be toxic to plants at concentrations below that at which they can pose a significant risk to human health and this provides a degree of caution. There is therefore an economic development challenges and strategic concern over possible long-term accumulation of heavy metals in soils, sewages and rivers as a result of the polluted water used. (Kaddous and Stibbs 1983; Sieb and Cituentes 1995).

There are currently no worldwide guidelines for permissible levels of trace elements and heavy metals in the polluted water(s) for human consumption and for irrigation which relate to the potential risk of human health as a consequence of water intake, washing, cooking and that of crop uptake and bio-accumulation. Most studies cite a table to phytotoxic thresholds prepared by National Association of science (1972) and Pratt (1972), or refer to the WHO drinking water guidelines (WHO, 1993). These data are reproduced in Table 2.1.

It is to be noted that an additional investment of facilities against water pollution contributes far more than the invested facility. From various data and statistical trend, developed countries are trying to seriously fight either to reduce to zero level of water pollution or far minimum level, which proves to be better than the situation now. The developing countries are not making any good initial and strategic plans to implement measures and to even curb the issue down.

Debilitating rather than fatal in most cases about 30% -40% of infant mortality are associated with water pollution related problems. The reports has it that about 500 million people are annually affected by diarrhea, cholera and typhoid fever (World Development, Report 1992). Serious human health problems are introduced in many parts continuously by unchecked water pollution. This is very common in relation to the spread of Guinea Worm, onchocerciasis, yellow fever, and schistosomiasis mostly along rivers in this Region.

2.3.1 WATER QUALITY STANDARDS

It is worth to know the extent and limits of water qualities before proper consideration can be given to an action.

Water is not only local but rather regional, national and global at large. It is therefore accepted that to judge and accept any quality or not, standards have to be set and adhered to, strictly. It is also noted that, in economic development and management of the environment, activities towards water resources uses have drastically changed the quality of water. There is the need and cause for a critical standard and assessment yardstick laid down to find out its total economic supportive capacity in the phase of development.

It is readily seen for instance, that water quality for navigation, fishing or swimming is relatively quiet different and far lower than water quality for drinking, washing and cooking and sometimes, even for irrigation.

In most cases, the standard is set in time and space and mostly on existing factors like knowledge, technology, the nature of resources as well as the availability of other closed alternatives.

The quality standard for water resource used in drinking and cooking is strictly set and regulated by the World Health Organisation (WHO). It is however not fixed. The quality is also not compromised and relegated far below the minimum levels. Far above or below, depending on how a given set of standards are read, the set limits of certain standards call for critical studies to find out the outbreak and its main consequence; determine whether that deteriorating level is liable to human hazard problems or not and in some cases, the degree is checked.

Despite the relatively low degree of contents of certain chemicals, recommended and recognised by the WHO guides, (as a situation and condition for developing countries), the quality of most rivers found around Agogo (near Konongo in Ashanti), Wiwiso and Subinso in and around Kumasi, is low and more often fall short of the required standard by the local GWCL (Ghana Water Company Limited).

Besides the prime objective of any firm which is to minimize cost to a reasonable level and maximize profit, the treatment facilities for treatment of pollution, as a social responsibility are very scarce and highly expensive. Even those few ones available have reduced their efficiency and running rate. In most production sectors, these pieces of equipment are in an appalling state (Water Research Institute, CSIR, 2001).

Banning of the uses of these pollution practices in the firms must be regularized. For the settlers of the downstream, this is not practical because they have to survive on these resources and use the same resources also, for economic activities in the households and other areas (purpose) so as to feed the increasing population.

More so, a few and comparable alternatives of these water(s) are found in specific areas, in-depth research for compatible and appropriate measures to achieve a safe water policy and guidelines are henceforth necessary and must be observed (Avoitre 2001). Table 2.1 and 2.2 explain the quality guidelines, risks and other diseases related to water qualities, as explained above.

Source: WHO 1993, Loba et al 1994, Bakry and Lock 1998

Table 2.1: WHO AND E.U DRINKING WATER QUALITY GUIDELINES FOR RISKS AND MANAGEMENT

Elements	WHO drinking water guideline (a) Mg/l	EU drinking water guideline(b) mg/l	Recommended maximum concentration for crop
Arsenic	0.01	0.05	0.1
Mercury	0.001	0.2	----
Copper	2	0.1 – 0.3	0.2
Lead	0.01	0.05	5.0
Zinc	3	0.1 – 5.0	2.0
Cadmium	0.003	0.005	0.01
Manganese	0.5	0.05	0.2

Sources:

- a. WHO (1993) b. Cited by Chapman (1996) c. Cited by Pescod (1992)
 Ghesquie're (1999) prepared a summary of the effects of heavy metals on human health

TABLE 2.2: HEAVY METALS AND THEIR EFFECTS ON HUMAN HEALTH

ELEMENTS	SOURCE	EFFECT ON HEALTH
A.s – Arsenic	Industrial effluents, an Impurity in some detergents	Very harmful, cumulative poison carcinogenic, skin diseases
Cu – Cupper	Plumbing, animal wasters, pesticides, earth's crust	Liver cirrhosis food main source intake, uncertain toxicity in human.
Hg – Mercury	Pesticides, Industrial effluents	Very harmful for pregnant women, cumulative poison, neurological diseases.
Pb – Lead	Lead – acid batteries, solder alloys	Accumulate in skeleton, harmful for children and pregnant women.
Mn – Manganese	Industrial effluents	No convincing data of human toxicity
Cadmium	Leather; Washing powders as impurity in phosphate, impurity in zinc steel industry, paint, plastic	Very harmful, cumulative poison, food as main source of intake

Source: WHO 1993, Leita et al 1995, Birley and Lock 1998

2.3.2 THE HEALTH DIMENSION OF WATER POLLUTION

Given its ubiquity, water cannot act as conduit of water diseases. It is also not remarkable that water can carry free pathogens which are transmitted either facultatively or of necessity without any diseases. Whether it is caused by water resources that are highly contaminated or are collorany dependent on it for their survival.

This results in a highly varied and often complex relationship between water, pollutants and human health. For the purpose of the study, only two are relevant for identification and discussions.

A. WATER WASHED DISEASES

They are mostly found in mining areas and places where water resources are partially or totally contaminated by the various mining operations or industrial effluents from tameries and the like. These diseases, as it has been increasingly realised, are prevalent where scarcity of good quality water supply makes washing, bathing and other personal cleanliness infrequent. These can conveniently be called water-washed diseases since they diminish considerably once adequate supply of good and reliable water resources for washing and other personal cleanliness are made available. They are manifested on the victims' skins and are not temporary in most cases. They are capable of changing the colour of the skin. The resources that are needed to reverse or control these outbreaks are of high value. It also reduces the stock of human resources in the areas characterised by such diseases.

B. WATER BORNE DISEASE

These diseases are caused by organisms that can survive in water and be ingested when contaminated water is drunk. They are the classical disease associated with water supply in homes – typhoid, cholera, fever, etc which are of great concern to those responsible for pipe-borne water supply and rivers in human settlement at the downstreams. This is very common and affects people because contaminated water resource in various categories could reach many people simultaneously and lead to explosive common source and epidemics.

2.3.3 HEALTH RISKS OF POLLUTANT IN WATER

Human health, as it is known, can be affected easily by exposure to the identified hazardous or toxic chemicals released from the various defined sources of pollution. Its impact can be short term (even though acute) and long term (chronic). Acute effects are sometimes or often the result of an emergency condition such as an accidental chemical spill while chronic effects are associated with year of exposure to generally low concentrations of chemicals such as Arsenic, Mercury and Cadmium.

The human health impacts under economic perspective, which are caused by exposure to hazardous or toxic chemicals and other pollutants found in any food of polluted resources

can be an important element of an economic assessment and valuation of the economic cost cannot be overemphasized. This is because the potential cost related to the health impacts can be high, especially if the impacts include increased mortality.

2.4 WATER POLLUTION AND ITS MAIN FORMS

2.4.1 WATER POLLUTION

Water is a useful economic resource, highly technical without perfect substitute. It is also considered as natural which is supposed to be free. It needs to be used cautiously. Water, when it is not properly checked, can be falsely placed under serious risks for all forms of vulnerable and susceptible levels. There has been an overwhelming rate of water pollution recently as a result of how people use water bodies in continuous and diverse ways.

Water pollution, is a state whereby the presence of foreign substances that have the potential or can cause the degradation of quality of water resources and constitutes a hazard or impair the total usefulness of the resource in a chronic or temporary state. This means that the affected people are either totally or partially denied the right uses of this resources due to the deterioration of the resource both in quality and quantity wise. (Irene and Ben, 1989 WRI).

Unesco, (1992), defined water pollution as any modification either natural or artificial (prime focus) which one or the other has the potential and is able to change the state of the water resource or destroy the balances of the ecosystems and natural resources so that it causes

- (i) hazards to public health and or
- (ii) destructions from convenience, efficiency, best allocation and welfare of human and their commodities or health hazard thereof.
- (iii) the level of dissolved oxygen in the water (deoxygenated capacity) and
- (iv) the presence of materials (variable) injuries to plants and human life (victims)

The level of this capacity to support human health is greatly affected when these materials, mostly liquids (about 95%), a few solids (4.73%) and a very small percentage as chemicals, (e.g. gaseous) are discharged into the surface water bodies. Mercury, for instance, is a chemical that is far toxic and not easily broken down and has created

problems of contamination in various health levels. This is clearly seen along the basin of the Ankobra River in the Western Region and Rivers in Obuasi where the use of Mercury and Arsenic is abundant due to mining operations and processing.

No one likes the pollution of water bodies. It is believed rivers and other water bodies are indiscriminately polluted recently because of;

- (a) the fact that no one has the property right, or enforces the rights fully in the rivers being polluted.
- (b) the collectively consumed characteristics of the water pollution. If an owner cannot police it or has it policed or no one owns a portion of the stream(s) or rivers, then it becomes possible for people who are not much aware, or technically not environmentally friendly living in the towns and urban centres to use these water resources as wastebaskets. Some people even go an extra mile to ease all kinds of human excreta into these free “wastebasket”
- (c) production sectors always thinking of maximizing profit and minimizing cost without committing themselves to the welfare of other users of these waters and the future economic uses of water and its sustainability;
- (d) legal and institutional framework to guide and strictly protect these resources being loosely observed by urban dwellers.

2.4.2 INDUSTRIAL DEVELOPMENT, URBAN DEVELOPMENT AND WATER POLLUTION

There are so many point and non-point sources of pollution. The state of pollution of water bodies (most surface ones) are influenced by their sources, locations and prevailing management practices. Presently, the main sources of pollution in the major centres of the country are industrial, urban development and domestic activities. Agricultural activities that can cause water pollution are not much felt in the cities. This means the pollutants that are considered strongly and of interest with respect to the study are the industrial and domestic ones.

INDUSTRIAL WATER POLLUTION

Water is a major input in industrial production, mining processing etc. It is therefore counted as vital for industrial development. For example it is used for dilution of harmful

effluents. The water demand for small scale manufacturing industries, agricultural industries and households are sometimes considered as domestic. Some of these urban-based industries, with high reliance on water, include tanneries, textiles, mills, breweries, creameries, paper recycling mills, slaughterhouses, chemicals and food processing factories, soft drink industries, engineering and metal fabrications and various small scale industries.

Currently many industries that use water do not take into account the true environmental constraints they face and their counter impact posed and the necessary related factors due to the discharge of their wastewater and effluent (pollutants that have potential to threat human health).

The industrial pollutants are not directly discharged into the adjacent watersheds but finally, with a support of other forces like the wind and rainfall or both.

The common type of industrial pollution in economic perspective in most areas of Kumasi is organic pollutants due to rapid accumulation of various wastes such as yeasts, hops and grains from breweries.

At Kassi, where the Subin and other rivers flow, dust deposited at adjacent watersheds of tributaries of Atonsu and Anloga (Susan River) etc are all empirical facts.

Also water pollution was real along the manufacturing, production and mining centres.

The contents have high turbidity levels; arsenic, mercury, cyanide, and are mostly present at the mining centres. These, according to standards (identified in table 2.1 and 2.2) are clear indicators of the pollutants presence, potential and able to cause the water resource to pose or assist the water-related diseases viruses and other microbiological to cause potential health risks Avoitre (1992).

2.4.2.2 URBAN DEVELOPMENT AND WATER POLLUTION

Urban development, which covers mostly the domestic activities, is considered as one of the main predominant sources of water pollution in the Kumasi Metropolis and Obuasi Municipality. Such rapid development is connected to the domestic everyday activities and is organic in nature and stems from all components of human excreta.

Many parts of the country (Ghana) still lack adequate wastes collected and sufficiently wide range of treatment and disposal facilities.

About less than 5% are connected to a standard re-cycling and treatment system, almost 20% standard sewerage systems and the rest do just hazardly eject any used or waste material into gutters and may form of water resources (Report OD/TN, 95/09/99).

Due to poor and bad culture of ejection of wastes, the bacteriological qualities of the resources are beyond reasonable doubt, highly affected. It therefore follows that towns and cities of Ghana have rivers and other water bodies left with a legacy of waste dumps and used waters from domestic areas. Odaw River in Accra, Pomposo and Kwabrafo at Obuasi, Ankobra in the Western Region and other similar areas are not far from this. Their strength for a preventive purpose is critically lowered.

The downstream settlers do not normally have any other sources but to use these polluted water resources without proper treatment or any another means before their uses. This means that people at the upstream or alongside of the river ejects human excreta and waste water from their homes, thus improving hygiene within their dwellings, but potentially deteriorating that of their neighbourhood, unless waste water treatment plants are built; however, untreated sewage is released or spilled into these surface water bodies anyhow.

Since raw sewage ends up contaminating local down and the environs, it has the potential in diminishing the total welfare of such residents, such as incidence of illness and hazards and other social, cultural and recreational uses (to satisfy both extrinsic and intrinsic uses). Sanitation practices to reduce this tendency is not viewed as a high priority by these dwellers, but concern over drainage of floods water and safe water supply to them seems to be stronger and highly expensive than the causes and the consequences of the hazards.

2.5.1 QUANTIFICATION OF HUMAN RISKS

The potential for the exposure to water contaminants which may cause a negative health effect (referred to as health risks) can be estimated using the standard economic tools. Risks are calculated for the pollutant by pathways (the means through which the pollutant is taken into the body such as ingestion or to affect the body), and then summed to show the total risk of health impacts from the pollutants. The steps taken to calculate human health risks are

- (a) determine the exposure pathway or ways of concern
- (b) estimate the intake for each exposure pathway
- (c) calculate by means of appropriate environmental economics impact methods.

These steps are clearly explained in chapter 3.

2.5.2 DETERMINE THE EXPOSURE WAYS OF CONCERN

In order to make good attempts to calculate the risks (economic cost), it is important to determine the path by which humans may be exposed to the pollutants. The first is to determine which resources (e.g. the media – water resource) are polluted and then to assess the likelihood of human exposure to these resources. For instance if the surface water is contaminated (polluted) and is used as a source of drinking water, washing and bathing, etc then there are both possibility and different levels of degree of effects that someone will at least ever, in one way or the other, come into contact with the main pollutants. This results in risks of injury to human health. The main and actual forms of ingestion that are easily seen and everyday identified are summarized as the uses of;

- (i) contaminated drinking or surface water
- (ii) pollutants, mostly the chemicals in foods
- (iii) contaminated bath or shower water
- (iv) polluted or contaminated irrigated water resource

2.6.1 ECONOMICS OF HUMAN HEALTH AND RISK EVALUATION

Evaluating health impact is an area where humanitarian and egalitarian instincts can easily be seen to clash with the economist' calculus and algebra. The valuation of losses of earnings can be interpreted as imputing no value if no earnings are forgone; this in turn might lead to the conclusion that environmental protection programmes could be purely concentrated on the so called "productive and potentially labour force who are presumably earning the most highly. This actually ignores the old, relatively unproductive poor and chronically ill. The young ones whose economic earnings are long deferred based on genuine reasons may be totally overlooked and / or highly underestimated.

More so, it follows that much interest will be shifted or concentrated on areas and nations or regions with highly potential productive individuals. However, it does not reflect any economic implications and fair conclusions as it apparently portrays wrong pictures.

The operational procedures, outcomes and the benefits of such estimation are to be more accurate and far economic. It has been identified that human health risks and environmental quality are mutually interwoven and interdependent.

From the analysis above, it is clear that adverse health impacts on communities from water pollution; may increase the exposure of local communities to serious diseases viruses and vectors such media include mosquitoes for breeding effects, water snails or guinea worms which are responsible for different diseases may also undermine the simple principles of environmentally sustainable implication if factor in the economic cost evaluation is not properly considered. But whatever happens, evaluating of water pollution should factor in the real cost of measures to mitigate against adverse impact involved.

2.6.2 THE NECESSITY OF ECONOMIC COST EVALUATION

The monetary valuation which is calculated in the most developing countries will help to at least reveal;

- (a) the inefficiency, misallocation or misapplication of the scarce resources by some people whilst denying others right to it. This can be determined by a proper estimate of the extent.
- (b) the actual and statistical base-line data linking the benefits and investment of water pollution programmes on water bodies. This will likely show the welfare to be accrued from such a programme and other similar environmental quality options.
- (c) the current cost of capital on the facilities needed to protect water pollution may be poorly estimated. The implication is that most resources may be estimated wrongly.
- (d) the right picture of whatever has been overlooked or overemphasized about the environmental and health. This in a way helps to caution polluters and also leads

to demonstrate the underlying principles of environmental policies in economic terms for optimum and effective utilization.

2.6.3 ECONOMIC MEASURES OF THE HUMAN HEALTH (RISKS)

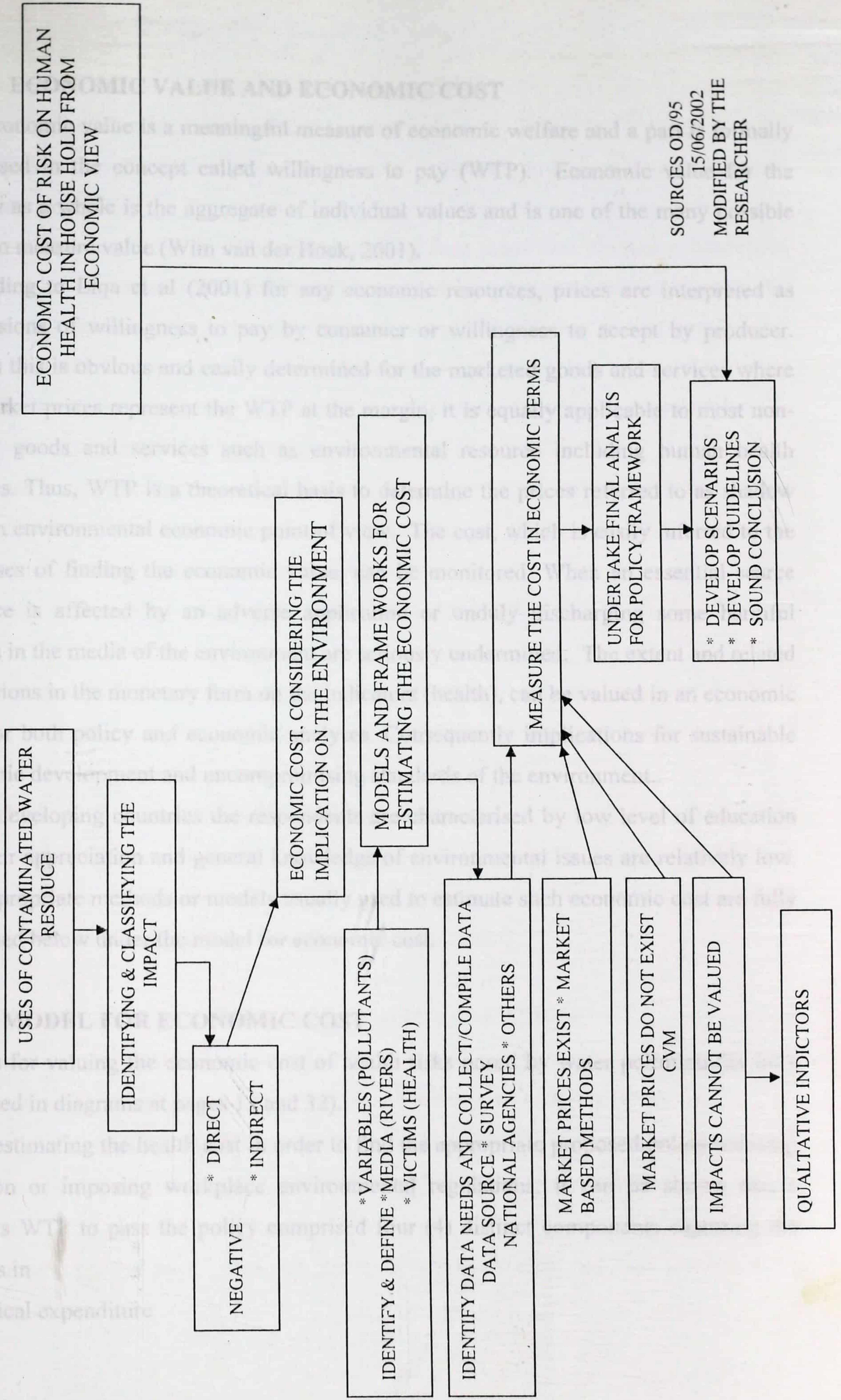
Most of the economic valuation concepts began in the developed countries and later re-stated in developing countries in Asia, Africa and most Latin American Countries.

The monetary valuation of environmental impacts on human health is complicated by the fact that human health is not a simple market commodity with readily observed marketed prices that are determined by the forces of demand and supply. Although there are market aspects and observable costs for health care, out-of-pocket health care costs are clearly only one part of the serious economic costs (impacts) on human health imposed by uses of polluted surface water resources(s), Nash, (1992) and Portney and Harrington, (1987). There is no universally accepted approach or methodology for evaluating the economic cost of risks associated with water pollution. The basic steps, however, should mainly constitute;

- Identifying the population at risk and disaggregating that population into vulnerable community groups, for instance age, gender, social status, marital status etc.
- Evaluating the reversibility and irreversibility of the effect in qualitative form – does a disease respond to drug therapy or the effect of exposure to certain pollutants (variables), sources of pollution are removed or reduced to the natural assimilated levels or recommended by WHO guidelines?
- Developing appropriate and reasonable good managerial measures on risks for inclusion. It helps to quantify the risks and other related problems.

Figures 2.1 and 2.2 simplify the paths of concern in order to find the steps to estimate the values for the environmental commodities.

FIGURE 2.1 FRAMEWORK FOR ASSESSING RISK ON HUMAN HEALTH DUE TO WATER POLLUTION



SOURCES OD/95
15/06/2002
MODIFIED BY THE
RESEARCHER

2.7.1 ECONOMIC VALUE AND ECONOMIC COST

The economic value is a meaningful measure of economic welfare and a part is formally expressed in the concept called willingness to pay (WTP). Economic value for the society as a whole is the aggregate of individual values and is one of the many possible ways to measure value (Wim van der Hoek, 2001).

According to Liqa et al (2001) for any economic resources, prices are interpreted as expressions of willingness to pay by consumer or willingness to accept by producer. While this is obvious and easily determined for the marketed goods and services where the market prices represent the WTP at the margin, it is equally applicable to most non-market goods and services such as environmental resource including human health changes. Thus, WTP is a theoretical basis to determine the prices referred to as shadow price in environmental economic point of view. The cost, which is easily inferred to the processes of finding the economic value, can be monitored. When an essential scarce resource is affected by an adverse application or unduly discharging some harmful entities in the media of the environment are seriously undermined. The extent and related dimensions in the monetary form on the indicators (health), can be valued in an economic term for both policy and economic analyses. Consequently implications for sustainable economic development and uncompromising standards of the environment.

In the developing countries the respondents are characterised by low level of education and their appreciation and general knowledge of environmental issues are relatively low. The appropriate methods or models usually used to estimate such economic cost are fully explained below under the model for economic cost.

2.7.2 MODEL FOR ECONOMIC COST

Models for valuing the economic cost of health risks posed by water pollution (as fully explained in diagrams at pages 13 and 32).

When estimating the health cost in order to find the appropriate proposed policy reducing pollution or imposing workplace environmental regulations, it can be shown that a person's WTP to pass the policy comprised four (4) distinct components capturing the changes in

- Medical expenditure

- Work income lost to illness (loss of labour productivity)
- Expenditure of averting behaviour due to water pollution
- The value of the discomfort, pain, suffering etc. associated with illness due to exposure to water pollution

Portney and Harrington in (1987) expanded these four areas and defined a household models of risk on human health which has been used by most economist to measure the estimated full economic cost for the changes in individual's health that result from changes in water quality. This model defines the value to the individual of marginal changes in the qualities of water. The model is reflected by the economic cost and is the four main blocks in relation to health risks as explained (Keita B 2001).

- Changes in expenditure on averting behaviour to avoid or reduce exposure to the harmful pollutants. For instance, buying water from taps or transported ones, sachets, etc instead of the stream which is presumed to be polluted.
- Changes in mitigation expenditure made when the health status is affected by such changes.
- Loss in potential productivity and salaries – changes in salaries, wages or kinds of payments as a result of the problem. Disease in time of production reduces rate of production
- Direct leisure, pain and agony and sleeping disturbances. The psychological problems etc. The study strictly excludes the fourth component. The reason behind this exclusion is partly due to its complexity and difficulty in putting values in economic terms on characters such as leisure, pain etc found in these components.

2.7.3 THEORETICAL MODELS FOR COST VALUATION

To illustrate, it is assumed that an individual's well being increases with aggregate consumption (X) and leisure (L) but is negatively affected by sick days (Sd).

Equation(α) : $U = U(X, L, D; Z_u)$ where U is increasing in X and L and decreasing in D and Z_u is a vector of individual characteristics capturing preferences for income, leisure and health.

In this model, pollution P, does not influence utility directly but only indirectly by triggering illness.

The relationship between pollution and health risks (outcomes) is summarized into dose-response function $D(d) = D(P; Z_d)$. This function is amended to accommodate for averting activities, A , undertaken by the individual to reduce expenses to pollution and hence illness; $D(d) = D(P, A; Z_d)$ where it is assumed that $\partial D / \partial A < 0$ and $\partial D / \partial P > 0$. We include the vector of individual characteristics Z_d , among the argument of the dose-response function to allow for individuals. The individual chooses the levels of L , D , X and A to maximize utility subject to the budget constraints;

$$\text{Equation}(\beta) : y [w (T - L - W(D(P, A))] = X + P_m \cdot M(D(P, A)) + P_A \cdot A$$

Equation (β) assumes that the individual must allocate his time between work-hours and spend his income on aggregate consumption and medical care M , which in turn depends on the number of sick days and on the averting activity. The prices of M and A are equal to P_m and P_A respectively, whereas the prices of a unit of the aggregate consumption good is normalized to one. Sick time enters in the budget constraint because it reduces work time available to the individual. In equation (β) $W(x)$ denotes work time lost to illness

2.8.1 WILLINGNESS TO PAY FOR ENVIRONMENTAL QUALITY

An individual's WTP for a reduction in pollution is the amount that must be taken away from the individual's income while keeping his or her utility unchanged;

(a) $V^* [(y) - WTP, w (P_m, P_o, P_1)] = V^*$ is the indirect utility function and P_o and P_1 are the initial and final levels of pollution (where $P_o > P_1$ that is environmental quality is improved after a certain amount is taken from the income).

Following Harrington and Portney (1987) it can be shown that WTP for a small change in water pollution and other similar environmental problems can be decomposed into

$$(b) \quad WTP = W \frac{dw}{dp} + P_m \frac{dm}{dp} + \frac{P_a \partial A^*}{\partial p} - \frac{UD}{\partial p} + \frac{dD}{dp}$$

Where A^* is the function A , $\frac{dA^*}{dp}$ gives the optimum adjustment of A to a potential

threat to human health. P as a variable, changes in water pollution and has a potential thread to human health on the affected victims.

2.8.2 REVIEW OF EMPIRICAL STUDIES ON WILLINGNESS TO PAY IN DEVELOPING COUNTRIES

In 1994, Swallow and Woudyalew estimated WTP for public health programme in Ethiopia. The method used is called Contingent Evaluation Method (CVM) model. In the study people were queried about their willingness to contribute cash and labour to the monitoring of a tsetsefly control programme. This illness treated as a private commodity to be valued (illness) had been experienced by the respondent and was not framed in a probability sense; (Keita B. 2001).

The respondent was to experience in a few days a certain recurrence of the episode of illness [s]he had most recently experienced (e.g. episode) of acute respiratory of fever illness. It was revealed that about 85%, were willing to pay for an approximate value(s) of the actual cost of the health.

This method of WTP through contingent valuation methods proved far better as compared to the cost of illness alongside. It elicited that those who were to be affected seriously were prepared to pay higher than other groups.

Whittington in 1993 used an application of CVM extensively to evaluate the environmental quality. A survey of about 200 respondents was carried out statistically. It was to obtain residents' WTP for improved environmental quality. This CVM was used to estimate WTP to avoid illness typically associated with contaminated drinking water or food prepared with polluted water. It was elicited from the framework payment questions that WTP was reflecting about 91% of the actual estimated cost from the economic perspective (Keita B. 2001).

Whittington concludes therefore, that it is highly imperative to secure the cooperation of local officials and authorities before the onset of the survey. This is to ensure that responses will not be unduly influenced by pressure placed on the respondent or the community's wish to influence the outcome of the study by means of strategic answers.

It also helps to curb the problem of likelihood that respondent may "talk to one another" thus receiving the survey questionnaire with pre-formed judgments influenced by other residents' opinions. This, according to Whittington, could influence the WTP estimates.

The problem such as;

- (i) quality of cash available to individuals for them to properly transact and do the accurate measurement is limited
- (ii) logistics and socio-demographic features
- (iii) people relying heavily on barter and access to credit which may be virtually non-existing could affect the validity of WTP and should be checked.

Another study was conducted by Altaf et al (1993) The study examined willingness to pay for piped water in two areas of the Pakistan. The researchers selected two regions for their study, one with relatively sweet groundwater and the other with brackish groundwater due to pollution in both regions. Household with and without connections to the pipe borne water system were interviewed. In the sweet water region, many households relied on the ground-unpolluted water as their exclusive source of water for drinking, cooking and other domestic purposes; but the use of pumps was common even among households with connections to the piped water system due to the unreliability of the pipe-borne water supply. Both electric and hand pumps were necessary to reach deeper and better-quality water than the polluted ones.

The survey instrument queried respondent about their WTP only for the most immediate improvement over the current situation. For instance, respondents in the villages without private connections to the piped water supply system were asked how much they would be willing to pay for a private connection to a system with level of reliability comparable to the current one and the system with improved reliability. Respondents living in villages with piped water were asked to state how much they would pay for connections to a system with improved reliability invade connections to the piped water system would be paid for by households. Regression of the project showed that wealthier and more educated respondents have higher WTP values for quality and improved environmental commodities. WTP values are always higher among residents of the blackish water region who are more educated. This was consistent with economic theory in that WTP should be higher in the absence of VIABLE SUBSTITUTES for the commodity in question (piped water).

It was captured that cost recovery is not unlikely for the sweet water region unless the authority raises the degree of reliability of the water supply which in turn secures greater WTP and higher revenues.

Singh suggested that the water authority in order to save people from illness and to improve quality of life, has to devise financing schemes to people and connect them directly to the general public water system in the polluted blackish area.

(iv) Singh et al (1993) examine a similar issue in Karalla, India, a region where a pipe water system has been built with both public and private water pipe-borne connections. Specially respondents were queried about reasons why they had not yet connected to the pipe water system and also about their alternative water resources and WTP for these resources. Regression analysis shows that WTP depends on socio-economic characteristics including income and education and on the cost and availability of alternative sources of water which may be necessarily of the same quality as the one in question.

It was also indicated that the reasons most frequently reported by people were that:

- (i) they could not afford it.
- (ii) they were renters and the landlords would not pay to have taps installed.
- (iii) they believed their title to the land was affected by some irregularity and some respondents about nine percent (9% stated that they lived very close to a public and that did not need an individual connections.

These researchers constructively indicate that WTP is well-correlated with individual characteristics and with the convenience of the alternative sources. It was also found that marginal WTP was increasing in each case.

It is therefore expected that highly educated people will like to quote higher values of WTP for improved environmental commodities as compared with those with lower educational background. Also, those who are too closed to the rivers that are polluted will be willing to pay or quote higher values to avoid complication of associated water pollution.

CHAPTER THREE

METHODOLOGY AND SURVEY DESIGN

OVERVIEW:

This chapter is divided into three main areas. The first area covers the steps and processes used in survey and statistical methods of the study. It explains how the site was selected. It also shows the process of obtaining the data through questionnaire, the distributions of the questionnaires and other sources. The second part covers the mathematical models used in the calculations of the cost of illness (monetary valuation of the damage of health caused by water pollution). A consideration is given on the rational and the relationships between the two main approaches used in the study in the third phase.

3.1 RESEARCH AREA AND THE DATA COLLECTION

3.1.1 RESEARCH AREA

The study was limited to the peri-urban areas in Kumasi where Oda, Subin and Sisa Rivers (specifically the downstream) flow with their tributaries. Kumasi is the second largest and most centralized positioned city in Ghana. It is the capital of Ashanti Region. It links almost all the other regional capitals in Ghana. It has a population of a little over one million. Most of this population (about 54 –65%) fall into the labour force. (population census 2000). It has an annual population growth rate of 2.6 – 3.0%. the city, Kumasi, is located $06^{\circ} 43'N$ and $01^{\circ} 42'N$ and lies approximately 260m above sea level (Keita B 2001). The schematic views of the location of the study are attached at the appendices 2A1 and 2A2.

As mentioned earlier, the major rivers and streams in Kumasi include the Oda, Sisa, Subin, Nwabie, Wiwi. The water bodies which mostly flow from certain upstream catchment areas in the study include Oda, Sisa and Subin. These areas are where people find these water polluted streams as resources for most domestic uses.

Irrigation and small scale industrial uses also form quite a significant part of their uses. This irrigation becomes inevitable during drying seasons.

With a limited set of resources, time and other factors a small number, of but carefully chosen, sample sites were used. This was to provide an indication of the changes in the quality of water resources in upstream and downstream areas under the work.

This was to estimate the damage of the pollution where possible, at sites thought to be highly polluted.

3.1.2 SAMPLING UNIT AND SIZE

The sampling unit is the number of households in the selected communities. The coverage area of the study is (20) twenty communities. These are made up of (12) twelve towns as shown at the appendix 3.1. All these towns are under the Atwima Kwanwoma District, except Kaasi, Daban, Sokuban and the upstream site Sepetinpon. The selected communities comprise those that could benefit from the provision of quality water due to the relative nature of their rivers which serve as water supply for most of their domestic activities.

These groups of people have reasonable willingness to pay (WTP) drive values. Population choice biasness is eliminated considerably. This is because the people whose willingness-to-pay for a clean water and COI, due to the water pollution, measured are the same people who are to benefit from a quality water supply (beneficial commodity) and suffer the damage effect from the water pollution (Damaging or hazardous commodity).

3.1.3 STRATIFICATION OF THE POPULATION

A stratified random sample was used to obtain the sample units from among the twenty communities. This was done by grouping the target population elements into clearly, non-overlapping divisions called strata. From each stratum, a sample was carefully selected. These people represented the entire population with respect to the main economic and social measurable features. The method employed to choose each household was by picking every sixth house in a row within a community and then continuing on the third row till the required number of twenty –one houses obtained. In each house, the head of the family was given a questionnaire after a brief introduction.

In a situation where more than one household were found, a random selection was made.

There were about sixty-five thousand people in the 20 communities. A total of 420 households were selected from these 20 communities. Out of these a total of 300 completed questionnaire were retrieved for the study. The statistical means, medians and other features of the population calculated are shown at the appendices (3) three. From a total of 20 communities, which constitute 60,000 people, 45,000 of them (forming approximately 80% of the total population was used in the final calculation) were covered.

3.2.1 DATA COLLECTION

Through questionnaires distributions, interviews (face-to-face) and other techniques, a reliable set of data were collected. All these were done before the estimation on the economic costs of damage of the pollution was undertaken.

- A wide range of available literature at Water Research Institute (WRI), the Council for scientific and Industrial Research (CSIR), Accra, Institute of Water Management International (IWMI), Ghana office, the KNUST main library and departments and other related data were studied.
- Resources (both human and logistics) from other areas like Ghana Water Company Limited (Environmental Department at Suame, Kumasi), Environmental Protection Agency in Kumasi and journal publications were studied.
- From the information obtained (Including papers on water quality in Kumasi by Cornish et al 1999, 2000 and KNRMRP, 2000) suitable research sites and appropriate communities best fit for the ground studied were identified.
- From a reliable and available sources and records, (most of them from IWMI and SIR) the pollution level quantified as documentary collected from March – December 1999 and July 15 to October 15 2000 (Keita, 2001) were used. This study was based on the post-quantification and test records done by water and environmental engineering specialists and groups from EPA and IWMI. It includes a publication by Keita B. 2001)
- Recent records and documents at some government hospital in Kumasi were also considered in detailed.

3.2.2 SAMPLE INTERVIEWS AND FIELD OBSERVATION

- Semi-structured interviews, coupled with observation, were used to get information from both upstream (Sepetinpom) and downstream communities. A guiding questionnaire was used. Additional questions were made for the officers at the medical centres used. However, due to the nature and culture of the population, most of the problems were treated at homes. It was either under a strict herbal healing or a combination with the orthodox medication from these hospitals. The responses from these areas are comparatively high for such work. The main hospitals where the data, documents and figures retrieved and transmitted into the needed information include KATH, south Kumasi Hospital. These hospitals are very close to the communities taken. The questionnaire used was straightforward. Also the mode of language suited the officers and the people easily. Both questionnaires are found at Appendices A.

- Most of the people selected could not speak English hence, the language of communication was "twi" or both in most cases. About 80% of the women contacted could speak only Twi. Though that could have been a hindrance to the questionnaire structure, a careful note was taken and proper action was undertaken. Thus the interpretation was done from English to "Twi" and notebooks were used for all the needed information obtained. This was reviewed within 4 – 7 days. A revisitation was done and further information received. This was to check the consistency of the information, and to buttress the validity of the technique used.

3.3.1 THE LINKS BETWEEN WTP AND COST OF ILLNESS APPROACHES

It is useful to link and compare the ratios of cost of illness and WTP as employed in this study and similar situations. The WTP acts as validity instrument and reliability limits for the expected COI figures. Economic theory, as specified in chapter two, posits that WTP, to avoid illness, should be greater than cost of illness measured values. Since cost-of-illness can be obtained under certain level of certainty (due to source of data and careful handle of the models to be applied) and are easier and less expensive to obtain than survey based WTP data, cost of illness are sometimes preferred. Notwithstanding this truth, an approximation is done as the researcher knows what fractions and links each approach represents to each other.

3.3.2 INEQUALITIES LINKS OF THE TWO APPROACHES

The inequalities have been found to exist between the COI and WTP approaches. These are reported by many researchers in both developed and developing countries environmental commodities studies.

The ranges below are the standard and reliable inequalities reported by such researchers.

- **1.6 of COI $\leq$ WTP $\leq$ 4.8 of COI** in developed countries and
- **1.8 of COI $\leq$ WTP $\leq$ 2.28 of COI** in developing countries of some selected environmental commodities (including quality water supply and health damage issues).

It is believed that as the variable is likely to increase as pollution worsens the people in the developing countries experience more symptoms. However, their doctor (medical officers) visits, prescription, medication expenses and respective / relative cost of earnings do not increase proportionally as compared to the developed countries. Similarly as the situation (water pollution) is improved, the otherwise happens.

A few empirical studies between the two concepts also reveals that COI values provide a lower bound and upper bounds WTP measures quite different from those of the developed countries.

Albania and Krupnick (2000) and similar evidence unprinted reports, found that the ratio of WTP to COI ranges from 1.48 at very low levels of consummation to 2.28 at the highest. The ratio increases its lowest consummation limit marks in more rural areas towards 1.8 but does not have really any upward changes in the 2.28 bound.

(Rewe and Chestnuts, 1988 and Discie and Gelling, 1991).

It has been consistently found that these inequality relations of COI and WTP can be applied for this study and, as it is with the economic cost theory, the COI can predict that WTP to avoid the health effects damages of water pollution in monetary terms is more meaningful hence the COI is used initially and later the appropriate adjustments are made to elicit the WTP measures. The actual economic cost analyses provided by the two approaches are justified.

3.4.0 MATHEMATICAL SPECIFICATIONS: METHODS AND PROCESSES FOR THE HEALTH RISKS(DAMAGES OF WATER POLLUTION)

3.4.1 MODEL FOR COST OF ILLNESS

The pollution risks, diseases, morbidity and mortality (at extreme cases) with pollution summarized by Harrington and Portney in 1987, can be captured under the opportunity cost principles used to estimate the cost-of-illness. It is widely recognised that COI and WTP are used to provide and act as validity and check instruments against biasness and other shortcoming.

As stated already the COI provides covers or a cover bound for correct expected measures of WTP in developing countries (Harrington and Portney 1987). It is identified in this model also that the sum of expenditures and income loss, and values of the discomfort caused by illness are quite large in developed countries population eg. US (Rewe and chestnuts, 1985, Chestnut et al 1988 and Gelling 1991). The opportunity cost models are fully given below to cover the COI steps for both medication costs and loss of labour productivity.

3.4.2 OPPORTUNITY COST PRINCIPLES MODEL AS APPLIED

Loss of potential earnings or labour production is evaluated using opportunity cost principles. These losses can be quantified in economic terms by using the information on prevalence of diseases:- on number of sick days both full time and part time, and off work, generally called Restricted. Activity Days (RAD), existing average wage and incidence of disease – the number of people likely to be affected by an incidence of the pollution. Other items such as the interest rate used and discounted inflationary rate and annual population growth rates are also featured in the opportunity cost models.

The productivity loss of children, unemployed and underemployed, sick individual is estimated by the same tool but a little lower deflator. The accepted average adjustment level by many environmental economics researchers is 0.62 of the working group if the entire population is more educated. However if the level of education is too low, a deflator of 0.88 is used to cover every individual. This is obtained after the net present values used to incorporate the discount for future generation and their implications are estimated. All these are shown at the appendices and figures given in chapter 4.

3.4.3 MATHEMATICAL MODELS IN THE OPPORTUNITY COST METHODS FOR COST OF ILLNESS (COI)

Clearly, 2 (two) but similar presentations are done for the present value (PV) for losses of labour productivity and medical (prevalence) costs borne due to the health damage caused by water pollution.

The first PV is the total medical cost.

A. PV of MC is given as

$$PV\ Mc = \frac{[(C_{ci} + T_{ci} + P_{ci} + O_{ci}) \times (ID_{ww} \times T_{pi})]}{(i + d)^1}$$

ID_{ww} , T_{pi} and others are the same as the values used for the diseases.

Medical or health cost $\frac{[(C_{cii} + T_{cii} + P_{cii} + O_{cii}) \times (ID_{ww} \times T_{pii})]}{(i + d)^2}$ + ... +

consultations and cost $\frac{[(C_{cni} + T_{cni} + P_{cni} + O_{cni}) \times (ID_{ww} \times T_{pni})]}{(i + d)^n}$

where C_{ci} : The cost of medical consultation and the cost of obtaining medical card at the 1st year

M_{ci} : The cost of medicine prescribed by the medical officer, as a result of the effect

T_{ci} : The transportation cost

P_{ci} : Preventive cost

O_{ci} : Other / miscellaneous (12% of all the other costs)

n : the total period in active employment in years (here 10 years span is used)

ID_{ww} : The incidence of diseases on the total population considered.

T_{pi} : The total population. The growth of the population is considered for realistic values.

d : discount rate C_{cn} , T_{cn} , O_{cn} are the values for the calculations in the tenth year.

The most tropical diseases associated / identified and used in the study were Diarrhea, Cholera and Typhoid fever.

B: The PV pc is also, the net present value of loss of labour productivity and is expressed as

$$PV(pi) = \frac{(Sdi \times IDww \times Tpi \times Wri)}{(1+d)^1} + \frac{(Sdii \times IDww \times Tpii \times Wrii)}{(1+d)^2} + \dots + \frac{(Sdn \times IDww \times Tpn \times Wrn)}{(1+d)^n}$$

Wri: Productivity loss of employed labour in the area, this is taken at the prevailing wage rate)

SDi: The number of sick days attributed to the damage of pollution per period of the hazard

i: The year of estimation

IDww: TP and others are the same as the values used for the diseases.

Medical or health cost and other inconveniences related to the damage are captured in the monetary values by these two main models. The medical cost includes cost of medical consultations and cards – (hospital attendance cards), transport cost, cost of defensive expenditure (continual use of medicine, preventive measures, etc) to avert the diseases now and the near future and any out-of-pocket illness or diseases related expenses. The total cost is elicited from Government subsidised hospitals and other information from the questionnaires administered. The private hospitals were not conducted. The reasons are that, they are not common in the research areas. Also their charges are not streamlined. And the diseases identified can equally be treated at the government hospitals. These differences in charges can bring discrepancy in approximation process of the costs.

3.4.4 FIELD APPLICATIONS OF THE MODELS USED IN THE STUDY

The following assumptions and figures were necessary.

- The population growth rate of 3%, per annum be used and its incremental trend, observed and used
- The discount rate (d) of 42.5% , taken from the average rate of 5 commercial banks in Kumasi (consultation at the banks' management levels for the rates).
- The average prevailing wage rate (WR) of ₵25,000 per person was used. Reported in the questionnaire and records on wages in Ghana.

- The number of years considered in the near future is 10 years, from 2001 to 2010. This means the calculations were taken from year 1 to year 10 and averages and outcomes observed.

- Inflation rate was 20%. (Reports from the same banks in 2001)

- Base year of 2001 was used.

The actual calculations are shown at the appendices 3. The first Five (5) years are shown in details including the steps. From 6th to 10th year have only their figures quoted.

3.5.1 CONTINGENT VALUATION METHODS

The CVM uses a direct approach – basically asking people what they are willing to pay for benefit or / and what they are willing to receive by way of compensation to tolerate a cost. The personal valuations of the respondent for increase or decrease in the water quality is sought through a questionnaire survey or other familiar techniques.

A contingent market is taken to include not just the good improvement itself only, (better water quality) but also the institutional context in which it will be provided, and the way in which it will be financed. Technically, the major attraction of CVM is applicable to all circumstances. It has two important features;

- a. as a technique for benefit estimation
- b. applicable to most contexts of environmental policy.

A contingent valuation proves particularly useful when implemented along or jointly with other valuations. (As the study intends to operate a technique for such good) it remains the only technique capable of placing a value, and when the environmental improvement to be valued is outside the range of existing market or of available data.

3.5.2 PROBLEMS ASSOCIATED WITH THE CVM

The contingent valuation method CVM is an expressed preference valuation method and as such is inherently susceptible to various types of biases. Since actual markets do not exist and therefore hypothetical, the basic aim of CVM is to “elicit real values”, a bid will be accurate if its COI coincides with one that will result if an actual market existed, accuracy must be tested and be seen that:

The result bid is similar to one achieved by introducing the kinds of incentives that exist in real markets to reveal preference.

The resulting bid is similar to that achieved by other techniques based on surrogate markets (house price approach, wage studies etc).

There are various ways of classifying the nature of the biases that may be presented in the CVM. A classification that is conventional is shown in table 2.51

A wrong choice of payment vehicle affects WTP bid.

The researchers can reduce this bias to a reasonable minimum by avoiding the most questionable instrument like taxes and bills increases and instead charge directly on the goods to be investigated. Also if more than one instrument is to be introduced the mean bid should not be varied by type of vehicle: an increase in tax or charge on better quality water should be roughly the same.

3.5.3 PROBLEMS, CRITICISMS AND JUSTIFICATION OF CONTINGENT VALUATION METHOD(CVM) IN DEVELOPING COUNTRIES STUDIED

Much controversy surrounds the use of CVM. At least most of the values of the good derived from passive use had been typical in litigation over the damage to natural resources and amenities are caused by released pollutants. Critics of contingent valuation allege that the quality of stated preference data is sometimes inferior to observing revealed preferences, considering contingent valuation a “deeply flawed method” for valuing non-use goods and point at the possible biases affecting contingent valuation data.

In spite of these criticisms, CV has formed the basis for a significant amount of policymaking in many developed countries including US (see Cropper and Alberini 1998). Recently the World Bank, the US Agency for International Development and other donor agencies have taken an interest in CVM studies in developing countries. This is a means of assessing the cost and benefit that are associated with water pollution and improvement of water quality. The benefits of establishing national park, benefit of restricting land use to reduce tropical deforestation in developing countries are also assessed for the same purpose.

The proposed improvement in the study does not exist at the location of the study currently. Willingness to pay cannot be extrapolated from the existing conditions or from the expenditure incurred to secure the comment level of such quality service.

This makes it necessary to use “stated preference” approach such as (CVM) which ask the individuals what they will do under a hypothetical circumstances. It will make it viable and possible to study the feasibility of such improvement and of various financing schemes. This will improve the technical, operational and economical feasibility of the study .Recent work by the World Bank shows that CVM correctly predicted 91% of the actual connections to the piped water system (Cropper and Alberin 1998)

3.6.0 SOURCE OF BAIS IN CVM DESIGN

Table 3: Source of bias in contingent valuation methods design

TYPES	DESCRIPTION IN BRIEF
STRATEGIC	Incentive to “free ride”?
DESIGN	a. Starting point bias b. Vehicle bias c. Information bias
HYPOTHETICAL	Are bids in hypothetical market different from actual marked bids?
OPERATIONAL	How are hypothetical markets consistent with market in which actual choices are made?

3.6.1 STRATEGIC BIAS

The concern with strategic bias is long-standing in economics and emanates from the supposed problem of getting individuals to reveal their true preferences in contexts whereby not telling the truth, they will still secure a benefit in excess of the costs they have to pay. This is the free rider problem.

Economists therefore expect such an individual “to pretend to have less interest in a given collective activity than he/she really has in mind (Samuelson 1954). Each will be charged a price according to their maximum WTP, with the presumption that each individual will understate his/her true demand for a public good.

Such goods are difficult to provide in a way that excludes anyone from enjoying them. The consumption of the good by each individual tends not to be the same as the cost of consumption to other individual avoiding problem associated with pollution.

3.6.2 INFORMATION BIAS

The general amount and quality of information is of significance, particularly if the total cost of the environmental improvement is included in the information. The sequence and arrangement and degree in which information is supplied may influence the respondent. For instance, indicating the "importance" or "side effect" of a feature before explaining the nature of the choice remarked. There is a clear measured difference in WTP according to information differences. There is the need to consider the starting point, content, simplicity and other qualities of the CVM survey used. Implicit value judgments are not recommended and must be inadmissible (Samples et al 1985).

3.6.3 OPERATIONAL BIAS

It deals with the extent to which the actual operational conditions in the CVM approximate actual market conditions

- suggestions of "reference operating conditions". At least the respondents being familiar with the respondents know the goods being asked to value, and the experience of varying the qualities and quantities of the goods.

CVM studies have not found strategic bias to be significant as care is taken to reduce its impact through correct interpretation of the studies to the respondents.

3.6.4 DESIGN BIAS

The potential for design bias arises from various sources. The first of these is the *starting point bias*. As the interviewer suggests the first bid, the starting point, it is possible to have an influence on the respondent in one way or the other. Perhaps by suggesting the range over which the "bidding game" will be played by the interviewer will cause the respondent to agree too readily with bidding values in the vicinity of the initial bid in order to keep the game as short as possible. Findings have it that mean and median bids are very much affected by the starting bids.

Several studies in anchoring and discreting bid levels indicate that the choice of a low (high) starting point leads to a low (high) mean WTP (Green, 1991, Tunst, 1991 and Desvousges et al. 1983).

By allowing also the respondents to start at a wrong point will lead to respondents' cognitive short-cut to arrive at a decision rather than thinking seriously about the correct economic WTP.

3.6.5 VEHICLE BIAS: Is the next element in the design bias category. This arises from the choice of the "vehicle" or instrument of payment used in the approach. Such vehicles include changes in local taxes, higher prices on the good or increasing surcharge on bills (e.g. new rate for water bills and electricity). Respondents are sometimes sensitive to the vehicle, perhaps regarding Q cedis paid through taxes or bills as more costly to him than paying it directly as and when he goes for the goods. Finally the respondents preferred paying the price directly on either a daily or monthly basis.

3.7 APPLICATION OF CVM FOR WTP

At many locations, proper application of CVM provides valuable information to policy-makers and donor agencies seeking to evaluate the benefits of interventions; or the revenues associated with investment in infrastructure. Most of the CVM studies have been designed and implemented following vigorous standards in the environmental economics professions. For a less criticism and justified valuations, CVM must capture the following:

3.7.1 ELECTING BIDS – STRUCTURE OF THE QUESTIONNAIRE

Once the survey instrument is set up, the survey is then undertaken. Most of CVM surveys open with general ("warm-up") questions aimed at making the respondent comfortable with participating in the survey and answering questions. This is usually followed with a description of the scenario depicting a plan for the provision of a public good, a change in environmental quality (such as a reduction in the risk and recurrence of an episode of illness to be experienced by the respondent. Mitchell and Carson (1989).

In-person and telephone survey respondents are usually allowed to ask questions and may be offered a summary of the positive and negative aspects of the good or policy at the end of the scenario description.

This is followed by the payment questions which query respondents about their WTP for the proposed plan (or about their WTP) to accept a degradation/deterioration in water-quality due to pollution or loss of access to this natural resources. It is important that respondents be explicitly told what the payment vehicle is, that is the method through which people are willing and able to finance the provision of the quality environmental resource or the policy delivering the improvement in environmental quality will incur payments. For instance, to improve the water quality at these sites either cleansing plants, abatement plants or better water quality facilities might be required to be installed. To pay for the associated capitals and other operational cost, a surcharge may be added to the respondents' utility bills over a number of specified numbers of billing periods. Will the respondent be willing to incur such surcharges to secure better reduction, and if so, what is the maximum amount he will be willing to pay? Respondents also are asked to name the maximum increase in income taxes that they will be prepared to incur to finance the government programme that will deliver the improvement in the water quality. Also the maximum percentage increase in the cost of purchasing products manufactured by the firms/companies which are likely to install pollution equipment controls systems.

Questions about socio-demographics of the survey questionnaire for analyses are needed. The main ones must capture the respondent's age, household income, marital status, educational attainment, the total cost of obtaining alternative resources, whether the respondent considers him/herself as an environmentalist. The details have been provided in the appendixes.

3.7.2 RELEVANCE CRITERION

CVM implies obtained responses from the samples who will be beneficiaries of the provision of the better quality water (easing from recurrence of episode disease and improvement of water supply services). This implies that the people at the sites considered have a direct criterion to be interviewed and questioned. Those in the population who were too young were not considered.

3.7.3 WTP ELICITATION TECHNIQUES

In this research, the respondents were asked open-ended questions about their WTP such as “what is the most highest / lowest you will be willing to pay if the water quality used today is improved, both in quality and quantity”? This was intended to elicit a point estimate of the respondents WTP. Respondents were either faced with a personal face-to-face interview and / or given a questionnaire showing details of the present water quality and the intended “better one”

3.7.4 ITERATIVE BIDDING APPROACH

The work also contained this approach of bidding to elicit the respondent's WTP in a different style. It started by querying individuals at an initial (amount) cedi value and kept rising (or lowering) until the respondent declines (accepts) to pay. This final Cedis amount obtained is interpreted as the WTP of the respondent. Care was taken to reduce the starting point bias. The final WTP amount of the bidding game was systematically related to the initial bid value and the median WTP, maximum WTP identified.

By this technique, a certain WTP amount is started with and the amount quoted is varied at a uniform interval in the leave it or take it scenario where in response to “yes” reply, the amount goes up progressively until the respondent replies “No”.

A scenario like this was created: The river and stream waters from the urban area (Kumasi), which happened to be the main water source, is polluted. Its continuation may worsen the situation in the near future if we continue to fetch from such rivers. It is now argued that an amount should be charged for the individuals to pay so as to drastically improve the water quality. Do you like to pay for it? How much do you like to pay for a bucket of such water or for a month?

Given that the respondent has announced “Yes” to a body, it is revised then from 0 cedis as an amount to be paid for the month and repeated with higher order of ₵9,999 -₵19,999, ₵29,999, etc. If the respondent's answer is no, the question is repeated with a lower bid of say ₵2000 to less bids. The iterative processes get on and on till the respondent's maximum WTP is reached.

An amount of ₦69,999 as highest and final bid for WTP for a month was obtained. On the '30 litre' tin, a maximum of ₦850 (Midpoint value) cedis as highest bid value was obtained. This started with a minimum value of 0 cedi (Pre-test). It was observed that an average of 4 "30 - litre" quality water is needed for a household for a day.

3.7.5 DICHOTOMOUS - CHOICE FORMAT

It is the most widely used approach in eliciting information about the respondent's WTP.

A dichotomous choice payment question asks the respondent if he/she will pay cedis to get a better environmental good. A frequently used wording of the payment question is whether the respondent will vote in favour of the proposed better water quality in place of the contaminated ones. The two responses to a dichotomous choice payment question are "yes" and "no" (or "vote for" and "vote against"). The amount P Cedis is varied across respondents and is usually termed the bid VALUE.

The dichotomous choice approach mimics behaviour in regular markets where people usually purchase or decline to purchase the good to be provided. It also closely resembles people's experience with political markets and proposition on a ballot. The dichotomous choice approach has also been shown to be incentive-compatible as the respondent understands that provision of the better water quality depends on the majority of votes and the respondents own vote in itself cannot influence such provision; truth-telling is in the respondent's best interest, Hoehn and Randall, (1987).

The WTP, however, is not directly observed from such an approach as it needs to be informed that the respondent's WTP amount was greatest than the bid value (if the respondent is in favour of the provision of the better alternative), or less than the bid value (if the respondent votes against it) and form broad intervals around the WTP amount of the respondent.

The way out to improve the precision of the WTP is the follow-up questions to the dichotomous choice payment question. From empirical studies, the bid level offered in the follow-up question will be greater than that offered in the initial payment question which calls for the follow-up. (Keita B. 2001).

Dichotomous choice payment questions typically require a different type of statistical analysis based on the assumption that if the individual states he is willing to pay the bid

amount, his WTP must be greater than the bid. If WTP^* be unobserved, willingness to pay, which is assumed to follow a distribution flow, (where $I_1, \dots, I_n$) is a vector of parameters, and forms an indicator, I , that takes on a value of one for "yes responses and 0 for "no" responses, the probability of observing a "yes" (or $I = 1$ when the respondent has been offered a bid equal to B_i).

$Pr(I_i = 1) = Pr(WTP_i^* > B_i) = 1 - F(B_i; 0)$ whereas the probability of observing a "no" $Pr(I = 0)$ is simply $F(B_i; 0)$ i.e. the cdf of WTP evaluated at the bid value.

3.7.6 THE PRETEST AND FOCUS GROUP

A pilot survey of 40 respondents staying far from the target group was interviewed and consulted with questionnaires in advance. They were not interviewed in the main study.

This was to:

- explore issues with regard to comprehension of information provided and some of the questions in the survey instrument,
- evaluate the respondent's in-depth understanding and the interest of the contingent market description in order to avoid market specification,
- assess and identify an acceptable WTP elicitation technique and the local appreciated payment vehicles and the statistical effects. After the pilot survey, the monthly payment and surcharge on taxes vehicles were introduced finally in the main research.

This eventually led to the provision of possible answers for most relevant questions that were needed in both the questionnaire and one-to-one interview. Only two people were interviewed on telephone. This was just to test how far this approach will be different from those above.

3.8.0 OPERATIONAL DEFINITION OF THE WTP VARIABLES FOR THE STUDY

3.8.1 HOUSEHOLD DISPOSABLE INCOME (Y_d)

The disposable income level of a given household determines how much it will be able to express its effective demand. It is a presumption that the income of a household is directly positive and of a greater magnitude with its willingness to pay and that WTP

elicited for better quality water by the household with higher income levels will be greater than those with lower levels. Respondents were asked to state how much they earn for a month ranging from $X < \text{₦}250,000$, $\text{₦}250,000 \leq X < \text{₦}500,000$, $\text{₦}500,000 \leq X < \text{₦}750,000$, $\text{₦}750,000 \leq X < \text{₦}1,000,000$, $\text{₦}1,750,000 \leq X < \text{₦}2,000,000$.

3.8.2 EDUCATION AND KNOWLEDGE

From various surveys on CVM eliciting WTP, it is expected that the higher the educational level of the head of the family the greater the value a respondent places on environmental quality (even though it could be a public good), all things being equal. The rationale behind this expectation is that education and basic knowledge on environmental resources expose individuals to indepth values of environmental resource especially as it affects their health and their children or dependents. This stands to reason that there is a high and positive relationship (with a higher expected constant) between the level of the education and knowledge and the level of WTP. The levels were coded from the highest of Ten (10) tertiary level to the lowest of One (1) non formal education with little or no knowledge on environmental resources.

3.8.3 GENDER AND AGE

For most environmental resources that affect homes directly and are used for domestic purposes, women express higher and positive WTP than their counterparts of the same levels of other variables. And also, it is commonly believed that the aged place value higher on environmental resources than the young ones. The respondents were asked to state the range of their ages and gender in order to ascertain these relationships with respect to the WTP (if regression is to performed in the study). Further divisions and response are shown at appendices 3

3.8.4 QUANTITY OF WATER NEEDED (Qh)

The more the amount of water a given household needs to satisfy its basic needs the greater the marginal utility expected. It therefore follows that until a household has had enough and sufficient quality of water to meet its domestic needs, which is likely to be affected by polluted water, it will be expected to place a reasonable and affordable high

WTP value on this commodity. This means that a demand function for water to be provided will be constructed through the relationship acquired at the latter part of the work. The function could be used to interpret the extent to which quantity of better quality water needed can estimate consumers' WTP. This demand relation can be used subsequently to estimate the amount of money in Ghanaian cedis, given a certain group of households who are prepared to pay to benefit from this water project.

To arrive at quantity of such commodity needed by a household, respondents were asked carefully to take into account the number of people in their households and the relative charge per '30-litre bucket'. The number of people in a household is defined as the number of people in a nuclear family, or close dependents of the household. Thus in both the questionnaire and interviews, respondents were allowed to estimate the amount of quality water they need in a given period of time for instance, an amount of water required for purely domestic purpose in a day. The implication is that the number of people in a household has been considered with respect to the number of buckets to be used is known in the process of the bidding. This was to check and reduce the possibility of multicollinearity in the WTP general function.

Only one household was contacted from the twenty communities were contacted. Out of these, 300 households responded. This response rate is relatively high and ideal for the study. About 70% of the respondents were Christians. Fifteen per cent indicated as Moslems, 5% as other religious followers whilst the rest did not indicate their religious background. This means about 90% are believed to know God. From the data, it was seen that almost 88% have the belief that rivers and other forms of water sources are good, valuable gifts and social resource(s) given by God through His own divine wisdom and as such must be observed sacred. These resources must not be polluted by common or unacceptable means at the expense of both the present generation and the yet to be born ones. They therefore believe that it is culturally and morally wrong and prohibitive to pollute these rivers. They had common cultural beliefs and practices in spite of their educational and religious differences.

Even though there were so many age groups, those consulted were mature with the age range of 19 years and 73 years. The men are quiet transforming from their old style of living into a relative modern stage but not at a gradual pace.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

4.0 OVERVIEW:

This chapter focuses on the discussion of the major relevant empirical findings obtained from the study. The trend analysis of water pollution using the data available, qualitative analysis of water pollution in the area studied and the detail findings of WTP are discussed. The last part considers how the cost of illness (COI) is reconciled with the Willingness To Pay estimated from the CVM (WTP from CVM approach) of health effect. A brief discussion on the independent variable of the sample has been presented.

4.1.1 SOCIAL AND CULTURAL CHARACTERISTICS OF THE SUBJECTS

The main research area of the study is at the downstream of the Rivers Oda, Sisa and Subin. The main towns in this area include Agogo, Daban, Aduaden, Kaasi, Krofrom, Ampeyoo, etc. Only one town was selected from the upstream of Sisa, Sepekupom. In all four hundred and twenty (420) households from the twenty communities were contacted. Out of these, 300 households responded. This response rate is relatively high and ideal for the study. About 70% of the respondents were Christians. Fifteen per cent indicated as Moslems, 5% as other religious followers whilst the rest did not indicate their religious background. This means about 90% are believed to know God. From the data, it was seen that almost 88% have the belief that rivers and other forms of water sources are good, valuable gifts and social resource(s) given by God through His own divine wisdom and as such must be observed sacred. These resources must not be polluted by common or unaccepted means at the expense of both the present generation and the yet to be born ones. They therefore believe that it is culturally and morally wrong and prohibitive to pollute these rivers. They had common cultural beliefs and practices in spite of their educational and religious differences.

Even though there were so many age groups, those consulted were mature with the age range of 19 years and 75 years. The areas are quiet transforming from their old style of living into a relative modern stage but not at a gradual pace.

For the literary rate, there is a clear distinction if it is compared to the city of Kumasi. However, some individual could compare favourably with the Kumasi's standard. The rate of illiteracy is relatively high and characterized by a higher drop-out of females mostly before the JSS level. A few are able to go through even the 2nd cycle and as identified more of these females' drop-out give birth before they reach (20) twenty years. These people turn to be purely housewives.

The youth males who end their education at the JSS stage or below enter to either farming (traditional practices, or apprenticeship in masonry, carpentry, fitting (automobile) etc as their main occupation. A few migrate to Kumasi, Accra Obuasi, Tema, etc for various forms of labour. In real terms the ration of tertiary level people at the site is almost 1:25 (from the selected group).

4.1.2 DATA PRESENTATION ANALYSIS

The information obtained from the survey was used to perform basic checks of the accuracy of the data. Thus inspection was done (as a signal that the respondents have given a little consideration to their budget constraint when announcing the bidding values of the water). Ideally, the reported WTP OF CVM approach for an environmental policy should not have figures in excess of 15% of their disposable incomes. Also descriptive analyses were made in brief to generally identify the findings of the survey. The frequency distribution of the respondents related to WTP OF CVM approach questions were examined. Thus, to obtain undoubtful total WTP from CVM approach, which could be compared with the cost and benefits of implementing a given environmental resources projects, it must be tested well. The WTP from CVM approach figures reported were used to estimate the totals, means, expected revenues etc, of the people studied. The mean WTP:

$$\text{MWTP} = \frac{1}{n} \sum_{i=1}^n y_i \text{ where } n \text{ is the sample size and each } y \text{ is the reported WTP}$$

amount.

$$i = 1 \text{ to } n = 10$$

Because the distribution of the WTP may not be necessarily normal, the sample averages remain the valid way to estimate the true population mean.

4.2.1 WATER POLLUTION AWARENESS AND PATHOGENS CONTENTS ANALYSIS

Of the 300 respondents / households, almost 95% were aware of water pollution and take various precautions to avoid its consequences. Table 4.1 shows how the respondents indicated their awareness level.

Table 4.1 AWARENESS OF WATER-POLLUTION TABLE

	REASONS	PERCENTAGE	NO OF RESPONDENTS
1.	YES	84	252
2.	No	5	15
3.	Yes but depends on time	11	33

The pathogen content distribution is also given in Table 4:2. This explains the knowledge of potential pollutants present in the main rivers and how they can cause a consequence. From this data, it was observed that almost all the respondents except 3% (9 households) did have an idea that pathogens can cause harmful effects on various degrees.

Table 4.2 AWARENESS OF PATHOGENS CONTENTS IN POLLUTED WATER(S)

Responses	Percentages	No. Of Respondents
Yes	67%	201
No	3%	9
Yes but based on time	30%	90

Table 4.1 indicates that almost 97% of the respondents were aware of the possible existence of the variable (pathogens) that are likely to cause diseases and discomfort. Out of these, 30% were able to clearly distinguish as where and when and whom the pollution could be harmful and not. This means that those people cold identify with others during the dry seasons, the intensity of pollution is high hence the greater chance of causing more harm relatively than raining season. This means economic activities are more hampered and interrupted by water pollution during dry season. It is therefore imperative to use the data collected during this period for the calculations and other

reasoning. This is to bring out the actual losses in the productivity and deteriorating stage of the rivers.

A general health effect from the contaminated crops could be adverse but at minimal level, hence not serious attention was directed to this area. It was realised that most highly potential risks of the pollution are those associated with exposure and contact directly with the polluted water. The general overview was the creation of awareness and sensitisation coupled with research into technologies for safe household water and vegetable production invaluable elicited from the questionnaire administered.

Apart from this category, it was revealed from the conducted interview and offices (EPA and KATH) that almost 90% were aware of the faster and harmful effects of water pollution and those unsafe water resources should be either treated thoroughly or completely banned. The common idea brought out from the questionnaires, interviews and information from other environmental affiliated agencies was their willingness of prevention of water pollution to recommended World Health Organisation (WHO) guideline was seen as a major factor to turn from the risk that is at stake.

Psychologically, the overall indications from the factors on the polluted water use in irrigation play insignificant roles. This means they did not have much problems on whether to pay or not for an improvement of water quality for irrigation purposes.

Table 4.3 METHODS TO REDUCE WATER POLLUTION EFFECTS

Methods	Percentages	No. Of Respondents
1. Prevent, Educate and Treat	25%	75
2. Treat Polluted water before use	33%	99
3. Do not use polluted water for domestic purposes	30%	90
4. stop using contaminated water for all purposes	12%	36
Total	100%	300

It was identified that, almost a quarter of the people covered were of the view that there was the need to use the polluted water, whilst an intensive education and proper treatment are given. From the same group, about 12% were also in a different view. Thus there was no need for them to use contaminated water. This they thought could give them negative economic impact. 30% also accepted that the polluted water should be used but, not for domestic purposes.

4.2.2 ANALYSIS OF THE POLLUTANTS IN THE MAIN RIVERS STUDIED

This test was among others, the standard, easy and accurate mostly recommended for study like this. They are better established as "Standard Practice" and form the basis of any initial effort to quantify microbiological water quality for polluted/contaminated water use. Table 4.5 generally supports this pragmatic conclusion. The data suggest that water both upstream (ST & WE) and down stream (KA, DB, AS) considered fail to comply with the WHO guidelines with respect to parasitological content and WHO Guidelines especially the count on FC/100ml. However, at 1000 per 100ml the polluted water has two nematode eggs per litre in the clear water sample.

4.2.3 TOTAL AND FAECAL COLIFORM

Table 4.6 shows the number of faecal coliform detected in sample from each site for the last three sampling dates. Samples taken on 18th February; 1999 were only analysed for total coliform number and the faecal coliform count was calculated from these data based on the correlation between total and faecal coliform observed over the last three sampling dates. Numerical data and regression analysis are included in Appendix 2.

- a. Determine by correlation with total coliform number
- b. Samples reported to have zero coliform through inadvertent sterilization of the sample by residues of disinfectant in the sample bottle.

S = Standard deviation

- There is a pattern of increasingly poor water quality moving from Septimpon (ST) and Wiwi (WE) sites, upstream of the main urban centre towards the most microbiologically polluted site of Asaago (AS), 9km south of Kumasi at the confluence of the Sisa and Oda rivers.

4.3.1 DISCUSSION ON MICROBIOLOGICAL DATA

Based on this small data set it might be concluded that even irrigation practised on the Sisa and Wiwi rivers upstream of Kumasi, may pose a minor threat to the health of consumers as the faecal coliform numbers are close to the monitoring limit recommended by Westcof.

The nematode numbers at both these sites were high around Kaase, Daban and as far south as Asaago there is no evidence of the river water (Oda) being used extensively for irrigation. This is not due to water quality but for the fact that irrigation is not practised extensively. On the other sides, a group of people was used for drinking whether with little or not treatment. There was a very high count of faecal coliform at Asaago and Aduaden. The results at Daban and Asaago indicate that these points, 6km – 9km downstream of Kumasi – faecal coliform numbers are still high for the River Oda in predominantly rural catchments.

The data from Asaago village, 9×10^4 , suggest higher levels of contamination than the values reported at the upstream, especially at Sepetimpom. With this case, it is not clearly concluded that only the faecal coliforms are a useful baseline for comparison. However, the records from EPA, KATH and even the current records provide a suspicion for future comparisons to determine if there is any improvement in the quality of the Oda in subsequent dry seasons. By the records of the total and count coliform of faecal taken, when the water collected is not treated thoroughly with regard to the deteriorating quality over time, an outbreak of any water-related diseases can occur. It is also confirmed from the health posts that some patients at KATH are from these rural catchments.

At least of every 1000 cases, 175 – 195 patients are from the south of Kumasi. There is a pattern of increasingly poor water quality moving from Sepetimpon but more pollution was identified at Asaago and Kaasi which is serious in human health pattern for the respondents.

With the cessation of dumping of seepage in the Subin River and the commissioning of new waste stabilization ponds there can be an improvement when the staff strictly regulate the water bodies in the Kumasi city as a whole. This is needed for all other rivers in Kumasi and other similar areas, where major road and frequent human activities are present. There can also be an improvement or less bearable risk, far better than now, if consistent inspections are undertaken along the banks. Also further complaints on levels of contamination from different non -governmental offices in these areas are recommended especially in subsequent dry seasons.

4.4.1 HEAVY METALS RESULTS

Results of the heavy metal analysis for only 3 elements are summarized in, 2c and presented in Appendix 2. They show the mean values from samples analysed in the department of Mining and Minerals at the KNUST – Kumasi. In addition to this, the duplicate analysed for lead was taken in the UK and the results shown.

The results of mercury detected at the KNUST lab merit comment but Arsenic and Lead proof otherwise.

4.4.2 ANALYSIS OF MERCURY CONTENTS DISCOVERED

With the reported values from the analysis of the data set, the values were apparently far less than the recommended limit of 0.5 mg/l for drinking. It is only the mean value of Kaasi 0.46 which is too close to the limit. This means there could not be a genuine high risk of Mercury pollution for drinking and household purposes.

However, with the exception of (ST AND WE) the sites downstream the city record higher levels than the FAO limits of 0.2 mg/l for crops.

The reliability of the result is considerably beyond the limit. The interpretation is that these thresholds values are not good for irrigation but only for drinking.

4.4.3 DISCUSSING THE (3) THREE COMMON HEAVY METALS DATA

There was no evidence of relatively much water pollution in heavy metal concentration in the surface waters of these rivers in Kumasi that exceeds limits for irrigation purposes, except manganese levels at Kaasi, Daban, Asaago and Aduaden (assuming that the recorded levels are not of errors). The concentration of the other two elements tested for fell below the FAO limits for crops. The concentrations of the elements tested for the WHO drinking limits are either close or slightly exceeding the required levels. There are no clear or notable trends between locations. No site stands out as having higher or lower concentration of the elements considered.

While urban pollution is causing serious microbiological contamination of waters potentially used for drinking and irrigation that are likely to cause health risks, there is no clear evidence of heavy metal pollution and its consequence.

The limited resources that are available should be focused on monitoring and reducing the levels of microbiological pollution rather than non-heavy metals.

4.4.4 CONDUCTIVITY ANALYSIS

In this area, it is accepted by the technicians that the higher the conductivity, the higher the river waters tested become polluted.

The trend in conductivity between sites closely follows the trend of microbiological contaminations. The sites ST and WE upstream have 0.04/m and 0.035/m respectively showing relatively unpolluted water source for drinking.

The Sisa at KA with 0.160/m is highly polluted by urban run-off and this is reflected in the increased conductivity at that site. The Asaago site at the confluence of the Sisa and Oda Rivers shows the highest conductivity of 0.185/m and the highest faecal coliform count. This trend slightly drops at Aduaden probably as a result of a consequence of dilution effect at increasing distance from the source of pollution.

4.5 HYPOTHESIS TESTED

By both WHO and EU standards on water pollution at the urban centres in the developing countries, it was obvious to reject the null hypothesis that water pollution does not have negative effect on human health through their contact with contaminated streams, rivers, etc. The outcome suggests that the alternative hypothesis that water pollution has a direct negative effect on human health could be accepted. This is very clear and severe during the dry seasons where dilution is very low. Also, it was identified that the Subin and Oda rivers are relatively more polluted with higher level amount of microbiological pathogens than the others. It must however, be noted that polluted water resources can be harmful depending on the contents, concentration, and the period of pollution from the point of view of economic approaches.

Table 4.4: SEX DISTRIBUTION OF THE RESPONDENTS

<u>Sex</u>	<u>Response in %</u>	<u>Number of Respondents</u>
Male	65%	195
Female	35%	105
Total	100%	300

The sex distribution of the people who participated in the research is given above. The number of male was far exceeding that of the females. This could be due to the fact that most of the heads of the households within the area covered were men.

Table 4.5 AGE DISTRIBUTION TABLE FOR THE RESPONDENTS

Age Group	Mid-Age	Percentage	Number Of Respondent	Total %	Total Respondent
20 – 29.5	24.75	10	30	100	300
30 – 39.5	34.75	27	81	90	270
40 – 49.5	44.75	30	90	63	189
50 – 59.5	55.75	16.67	50	33	99
60 – 69.5	64.75	11.33	34	16.33	49
70 +	74.75	5	15	5	15

An upper bound of 80 years was used and from the appendix 4b the oldest respondent considered in the study was 76 years. From the above data, more that 90% are either 30 years or more years. This means they can be in household responsibility group in the Ghanaian set-ups.

Table 4.6 EDUCATIONAL AND INCOME DISTRIBUTION OF THE RESPONDENTS

INCOME INTERVAL PER MONTH OF RESPONDENT S (¢)	%	TOTAL (%) OF RESPONDENTS	EDUCATIONAL LEVEL	
			Level	(%)
X < 250,000.00	4	100	Non-Formal	12
250,000 ≤ X < 500,000.00	9.8	96	JSS /MSLC	64
500,000 ≤ X < 750,000.00	38.0	86.2	SSS/Equivalent	20
750,000 ≤ X < 1,000.000	28.6	48.2	Tertiary	4
1,000,000 ≤ X<1,250.000	10.2	19.6		
1,250.000 ≤ X <1,500.000	5.6	9.4		
1,500,000 +	3.8	3.8		

The income levels of the respondents are fairly the same as the average for the Ghanaian workers. Out of this respondent less than 5% falls below ¢250,000. Over 80% of the respondents earn more than ¢500,000 per month. More than 95% of the respondents

indicated that they were very much aware of the effect and the threat that water pollution in the area has on them and their economic resources. It was shown clearly that this awareness trend was proportionate to the, income groups. Thus those at the higher income groups indicated relatively higher than those at the lower groups.

The respondents were willing to bid clear values based on their budget constraints to benefit from this proposed quality water supply.

The respondents' educational background is highly skew towards illiteracy side as very few are able to go to school after the JSS / MSLC stages.

4.6.0 COST ESTIMATIONS

This part of the analysis deals with the full presentation and detail discussions and the tables of each of the main methods used. The first part is the comprehensive estimates of the cost of illness by the method of present values of the both the medical/prevalence costs and loss of labour productivity respectively. This is followed by the willingness to pay for a clean water by the same respondents. The next section is a discussion of the links (inequalities between the two models). The other part explains, in brief, the other factors that could be used to explain the push or pull of the demand for clean water.

4.6.1 THE ESTIMATES OF MEDICAL AND PREVALENCE COSTS AND LOSS OF LABOUR PRODUCTIVITY

The medical costs of the three common tropical diseases used for the study are expressed in table 4.8. The last column in the table considers the total cost of the three diseases in each year for the 10 years period. The details in estimation are given at the appendix 3A. Apart from this table, adjusted medical costs of the total are also given in Table 4.9. The deflated indexes used, according to developing countries studies, is 0.88. The values are given in Ghanaian cedis. A base year used for both PV and real cost is 2001.

The index 0.88 was used just to take care of any miscellaneous changes that are believed to make the estimated cost a little higher than the expected, due to price effect (in most developing countries).

TABLE 4.8 MEDICAL COSTS FOR THE THREE COMMON TROPICAL DISEASES IDENTIFIED

YEARS NO.	DISEASES			TOTAL PV
	DIARRHOEA	CHOLERA	TYPHOID FEVER	
	¢	¢	¢	¢
1	78,947,368.42	117,473,684.2	118,421,052.60	314,842,105.22
2	74,038,781.16	110,169,435.10	111,058,171.70	295,266,387.96
3	69,435,378.7	103,319,857.50	104,153,067.70	276,908,303.67
4	65,118,178.49	96,895,896.59	97,677,311.16	258,691,386.24
5	61,069,447.97	90,871,354.04	91,604,187.54	243,544,989.55
6	57,272,428.26	85,221,387.75	85,908,657.00	228,402,473.01
7	53,711,489.91	79,927,710.59	80,567,248.57	214,201,449.07
8	50,371,954.47	74,953,481.0	75,557,944.56	200,883,380.03
9	47,240,056.1	70,293,215.45	70,869,096.22	188,402,367.80
10	44,302,884.89	65,922,703.95	66,454,338.65	176,679,927.49

TABLE 4.9 ADJUSTED PV FOR THE MEDICAL COSTS OF THE 3 COMMON TROPICAL DISEASES (THE DEFLATOR: 0.88)

YEAR NO.	TOTAL PV OF MC	ADJUSTED VALUE: TPV x 0.88
	¢	¢
1	314,842,105.22	227,061,052.60
2	295,266,387.86	295,834,421.40
3	276,908,303.67	243,679,307.20
4	258,691,386.24	227,648,419.90
5	243,544,989.55	214,319,590.80
6	228,402,473.01	200,994,176.20
7	214,201,449.07	188,497,275.70
8	200,883,380.03	176,777,374.40
9	118,402,367.80	165,794,083.7
10	176,679,927.49	155,478,336.1

The medical costs quoted on the human resources when spread over the 10 years span, has an annual mean average of :

$$\begin{aligned} \text{AMC (PV)} &= \frac{1}{10} \text{ of the TOTAL (adjusted value)} = \frac{1}{10} (\text{¢}1,936,103,287) \\ &= \text{¢}193,610,328.7 \end{aligned}$$

This is how much the 20 communities may loss medical costs as a result of water pollution hazards.

4.6.2 ESTIMATED LOSS OF PRODUCTIVITY OF LABOUR (IN PV FORMS)

The present values, adjusted for both the employed (0.88) and unemployed (0.48) are also estimated. The estimates do not cover the aged or pensioners as they were eliminated from the studies. These people are too old to work for a standard income (Pasbeye 1992, Reed 1996). Later, these values are emerged with the medical costs of the same period before converted to WTP OF CVM approach.

This was done, based on the standard indexes of 1.8 and 2.28 of the same LLP and MC after they have been adjusted accordingly. The estimations are shown at appendix 3B.

TABLE 4.10 A TABLE FOR LOSS OF LABOUR PRODUCTIVITY FOR EMPLOYED AND UNEMPLOYED OVER A PERIOD OF TEN YEARS

YEAR	EMPLOYED GROUP	UNEMPLOYED GROUP	TOTAL LLP
NO	¢	¢	¢
1	24,138,947.37	726,231.58	24,865,178.95
2	22,638,097.73	681,077.81	23,319,175.54
3	21,230,561.32	638,731.42	21,869,292.74
4	19,910,341.11	599,018.09	20,509,359.2
5	18,672,597.61	561,773.88	19,234,371.49
6	17,511,620.66	526,845.34	18,038,465.47
7	16,422,827.97	494,088.50	16,916,916.47
8	15,401,731.43	463,368.33	15,865,098.76
9	14,444,122.03	434,558.20	14,878,680.23
10	13,546,052.41	407,539.35	13,953,591.76

The figures of both the employed and unemployed groups have the same trend. The tendencies to decrease from the first year to the subsequent years are the same. What is different is that the employed group has relative high estimates of loss of labour productivity than the unemployed group. The meaning for this is that there were only 6.4% unemployed out of the total respondent of 300 which represented the total net of 7500 households. Also their quoted wage level was only 44% of that employed group.

TABLE 4.11:
ADJUSTED PV FOR HOUSEHOLD OF THE LLP (DEFLATOR 0.88)

	¢	¢
YEAR	TOTAL PV LLP	ADJUSTED TOTAL PV X 0.88
1	24,865,178.95	21,881,357.48
2	23,319,175.54	20,520,874.48
3	21,869,292.74	19,244,977.61
4	20,509,359.2	18,048,236.10
5	19,234,371.49	16,926,246.91
6	18,038,465.47	15,873,849.61
7	16,916,916.47	14,886,886.49
8	15,865,098.76	13,961,286.49
9	14,878,680.23	13,093,238.6
10	13,953,591.73	12,279,160.75

The LLP on the households when spread evenly over the 10 years span is the same as

$$\begin{aligned}
 ALLP &= \frac{1}{10} \sum_{i=1}^{n=10} (TLLP) \\
 &= \frac{1}{10} (\text{¢}166,716,115.1) = \text{¢}16,671,661.51. \quad \text{This value is the same and}
 \end{aligned}$$

equal to the moving average of the LLP at the 10th year. It means, also that on average, a lost of 21,881,357.48 is incurred within a total of 7500 household and each household loss.

Table 4.11 COST OF ILLNESS PER HOUSEHOLD, MINIMUM AND MAXIMUM WTP, AS ADJUSTED FROM COI STANDS.

4.6.3 THE TOTAL COST OF ILLNESS ADJUSTED VALUES ON HOUSEHOLD BASIS.

The values obtained from the table 4.8 and 4.9 which explain the total cost of medicals can be taken to the household level before adjusted to the minimum WTP and maximum as a way of verification and comparison of values. To obtain the figures for the households, the figures (total of medical costs at PV is divided by 6 as an average mean of 6 was per household. Their totals can then be taken with the LLP.

Table 4.12 ADJUSTED MEDICAL COSTS ON HOUSEHOLD BASIS

YEAR	TOTAL MC	COI For A household
	¢	¢
1	314,842,105.22	52,473,684.2
2	295,266,387.96	49,211.064.65
3	276,908,303.67	46,151,383.93
4	258,691,386.24	43,115,231.03
5	243,544,989.55	40,590,831.58
6	228,402,473.01	38,067,078.83
7	214,201,449.07	35,700,241.50
8	200,883,380.03	33,480,563.33
9	188,402,367.80	31,400,394.63
10	176,679,927.49	29,446,654.57

Table 4.13: COST OF ILLNESS PER HOUSEHOLD, MINIMUM AND MAXIMUM WTP, AS ADJUSTED FROM COI STANDS.

(The indexes of 1.8 and 2.28 are used respectively on the total COI)

Year	MC (2)	LLP (3)	Total COI (4):(2)+(3)	Min WTP OF (5):(4) x 1.8	Max WTP (6):(4) x 2.28
1	52,473,648.2	21,881,357.48	74,355,041.68	133,839,075.0	163,581,091.7
2	50,842,374.43	21,201,115.98	72,043,490.41	129,678,2822.7	158,495,678.9
3	49,278,710.93	20,549,069.86	69,827,780.61	125,690,005.1	153,621,117.3
4	47,737,840.96	19,923,861.42	67,661,702.38	121,791,064.3	148,855,745.2
5	46,308,439.08	19,324,388.52	65,632,827.6	118,139,089.7	144,392,220.7
6	44,934,879.04	18,749,257.04	63,684,136.08	114,631,444.9	140,105,099.4
7	43,615,645.11	18,197,489.82	61,813,134.93	111,263,642.9	135,988,896.8
8	42,348,759.89	17,667,964.46	59,800,239.32	107,640,430.8	131,560,526.5
9	41,132,274.86	17,159,661.59	58,291,936.45	104,925,485.6	128,242,260.2
10	39,963,712.83	16,671,611.51	56,635,324.34	101,943,583.8	124,597,713.5

Both tables 4.12 and 4.13 explain the final values for the total medical costs. The first table is the adjusted total medical costs (both the medical and prevalence) and the cost of illness for a household. The second table has the net values that are used to compare those on the willingness to pay for the clean water. The inequalities are shown later.

4.7 WTP AND EXPECTED REVENUE DISTRIBUTION(S) OBTAINED BY THE CVM MODEL

Tables 4.14 and 4.15 and figures 4.1, 4.2 and 4.3 gives a summary of the WTP distributions from the study. Table 4.14 shows at a glance, the concise distribution of willingness to pay and expected revenue figures. Table 4.15 also indicates, specifically, how the respondents demonstrated their willingness to pay as shown by the various bars. The frequency distribution bars for the various WTP mid-point values are also displayed in figure 4.1. The function of WTP of respondents is also shown in brief. This indicates

the various points of different levels of WTP by the respondents. Figures 4.2 and 4.3 consider similar cases, but this time, on monthly bases.

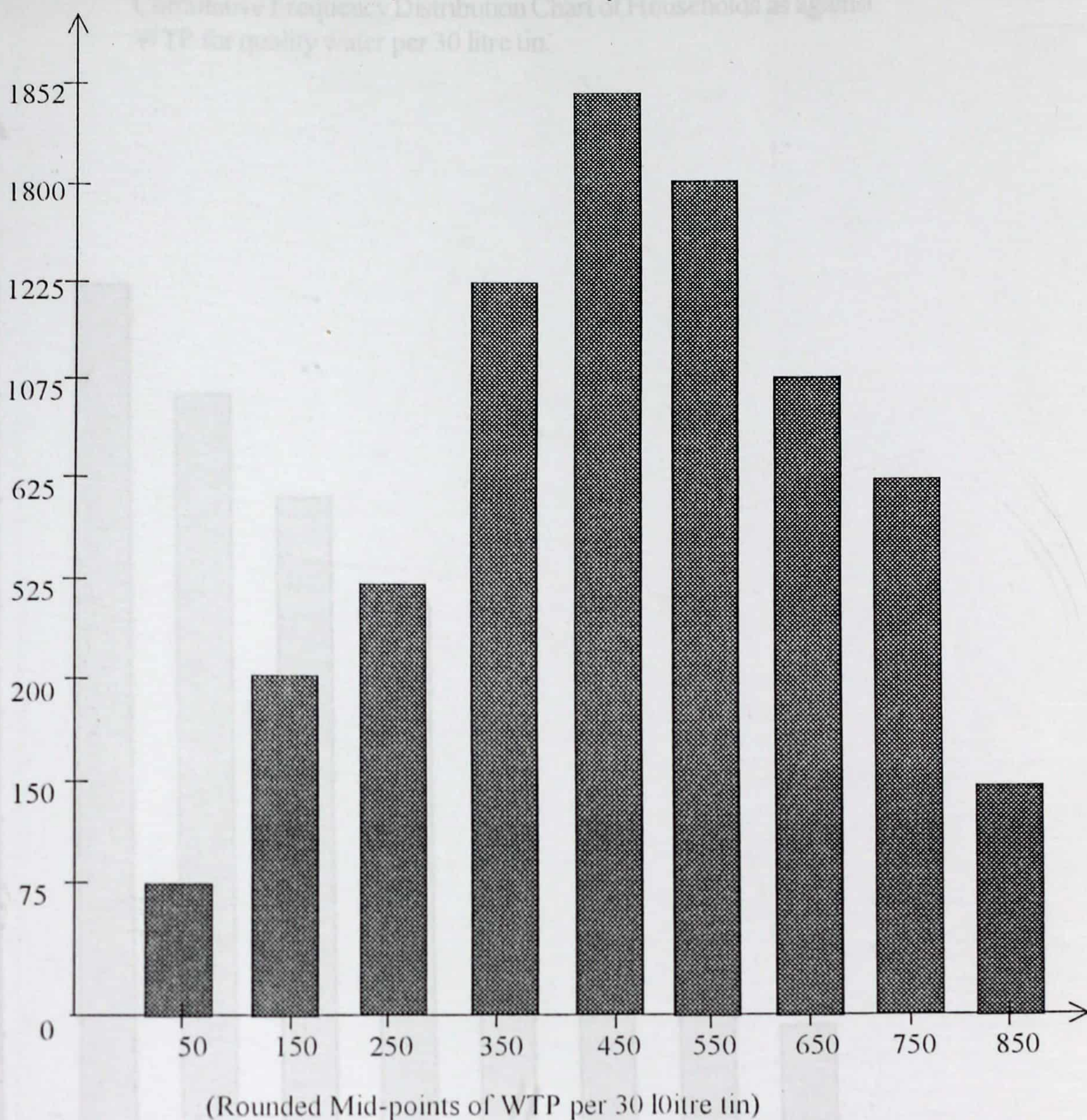
It was observed from the two approaches (models) that the cost of illness estimated on the damage effects is not too far from the inequalities given in chapters two and three. This supports the reliability and consistency of the cost of illness model used for the study. From pages 74, the total WTP to avoid water pollution by the respondents is estimated as ₦444,450,000 per month. The cost of illness estimated has minimum of ₦535,356,300;- a 120% of the estimated value from COI. This value compares favourably with the cost of illness figure of ₦444,450,000.00 for the same period of one month.



The average price for the 30 litre -tin obtained is ₦450.00. This value yields the highest amount. Also the expected number of household is very closed to 1850. The lowest mid-points are found at the extreme ends. It is therefore not economically wise to quote such values for the supply of quality water in the study area.

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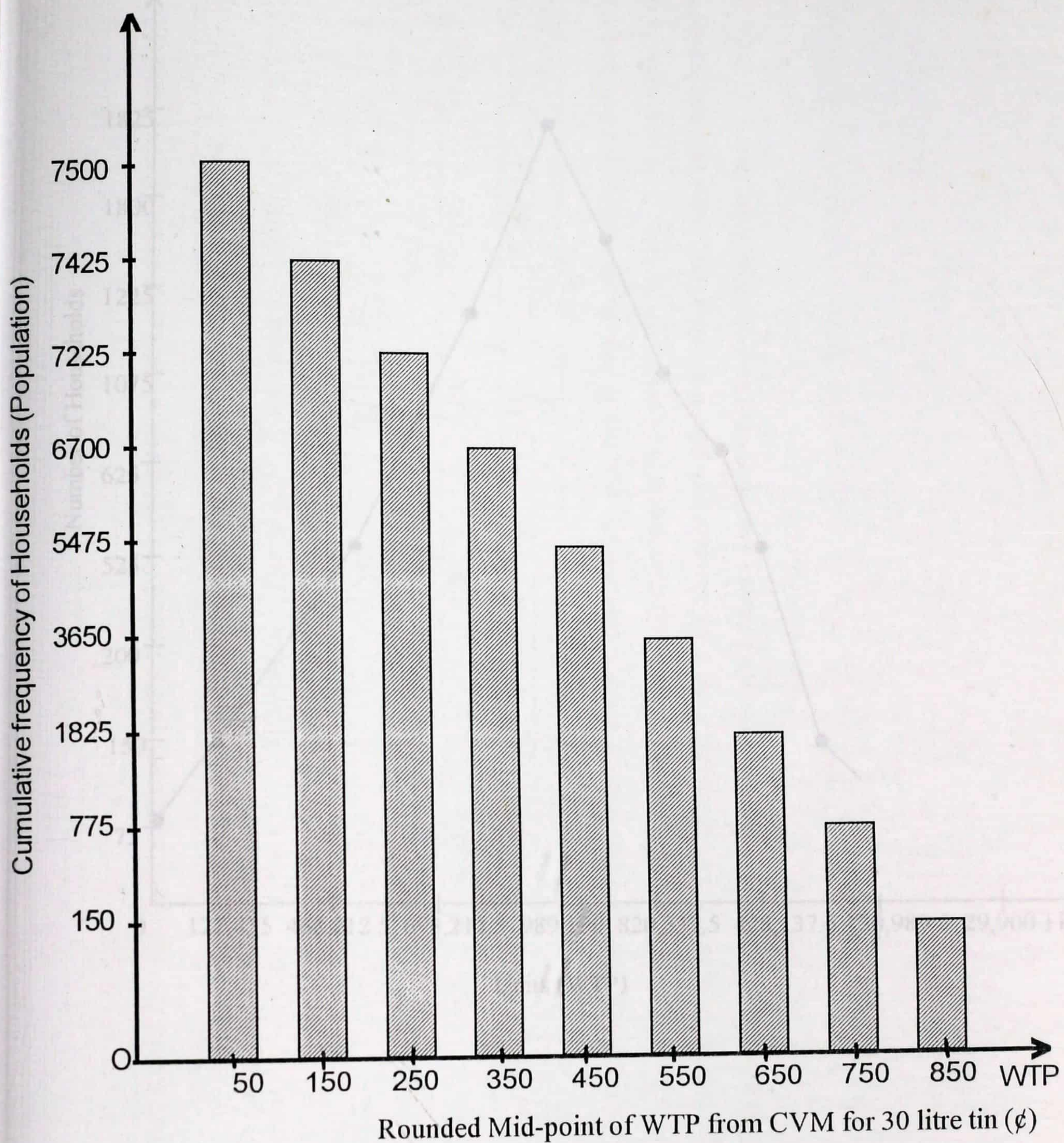
FIG. 4.1. Distribution of the Respondents and mid-points of WTP value per 30 litre tin.



The average price for the 30 litre -tin obtained is ¢450.00. This value yields the highest amount. Also the expected number of household is very closed to 1850. The lowest mid-points are found at the extreme ends. It is therefore not economically wise to quote such values for the supply of quality water in the study area.

Fig. 4. 2

Cumulative Frequency Distribution Chart of Households as against WTP for quality water per 30 litre tin.



This distribution of bar shows the cumulated distribution chart. The first bar indicates the total households. The last bar of a mid point of 850, shows the number of households ready to buy the 30 litre - tin of quality water at this point. A continuous set of points from the highest bar through the lowest bar could be used to have an idea of Demand function for the quality water as a result of health problem posed by the pollution of water supply.

FIG. 4.1.3

A function of WTP for Quality Water (30-litre tin) by the Respondent, on daily basis.

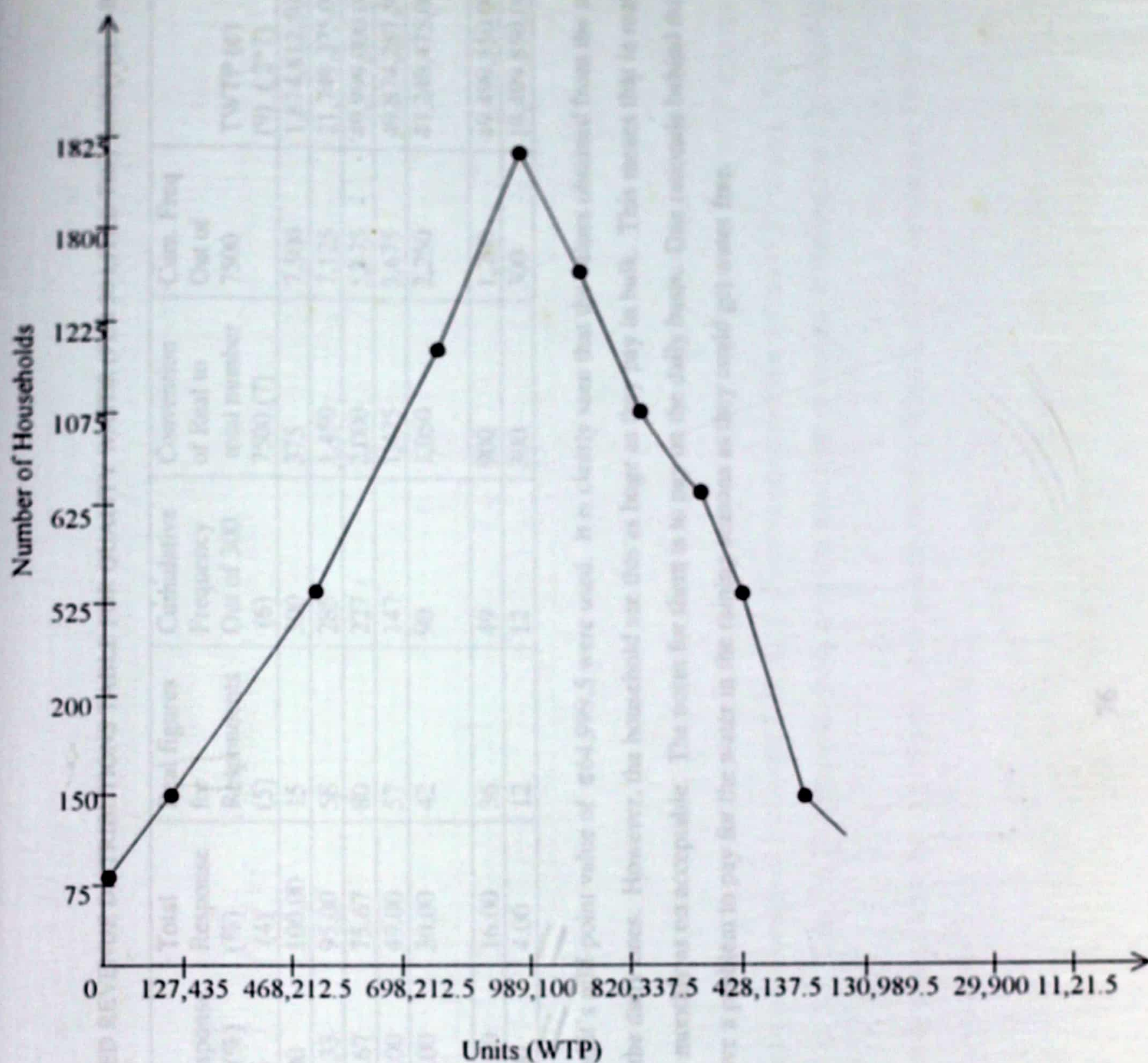


TABLE 4.15 THE WTP EXPECTED REVENUE DISTRIBUTIONS TABLE FOR QUALITY WATER (PER 30 LITRE TIN) MONTHLY BASIS

Bidding Int. of WTP ¢ (1)	Mid-point Values of WTP (2)	Response In (%) (3)	Total Response (%) (4)	Real figures for Respondents (5)	Cumulative Frequency Out of 300 (6)	Convention of Real to total number 7500 (7)	Cum. Freq Out of 7500	TWTP (¢) (9): (2*7)	Expected Revenue (¢) (10): (2*8)
0-9,999	5,000	5.00	100.00	15	300	375	7,500	1,874,812.50	37,496,250.00
10,000-19,999	15,000	19.33	95.00	58	285	1,450	7,125	21,749,275.00	106,871,437.50
20,000-29,999	25,000	26.67	75.67	80	227	2,000	5,675	49,999,000.00	141,872,162.50
30,000-39,999	35,000	19.00	49.00	57	147	1,425	3,675	49,874,287.50	128,623,162.50
40,000-49,999	45,000	14.00	30.00	42	90	1,050	2,250	47,249,475.00	101,248,875.00
50,000-59,999	55,000	12.00	16.00	36	49	900	1,200	49,499,550.00	65,999,400.00
60,000	65,000	4.00	4.00	12	12	300	300	19,499,850.00	19,499,850.00

An upper boundary of ¢70,000 and it's mid-point value of ¢64,999.5 were used. It is clearly seen that the values obtained from the monthly basis is fairly lower than those on the daily ones. However, the household see this as huge as they pay in bulk. This means that in reality, the people do see the payments on the monthly as on acceptable. The norm for them is to pay on the daily basis. One rationale behind this unwillingness is that the people have a problem to pay for the water in the raining seasons as they could get water free.

TABLE 4.14 THE WTP EXPECTED REVENUE DISTRIBUTIONS TABLE FOR QUALITY WATER (PER 30 LITRE TIN) DAILY BASIS

Bidding Int. of WTP (1)	Mid-point Values of WTP (2)	Response In (%) (3)	Total Response (%) (4)	Real figures for Respondents (5)	Cumulative Frequency Out of 300 (6)	Convention of /real to total number 7500 (7)	Cum. Freq Out of 7500	TWTP (¢) (9): (2*7)	Expected Revenue (¢) (10): (2*8)
0-99	50	1.00	100.00	3	300	75	7,500	37,500	375,000.00
100-229	150	2.67	99.00	8	297	200	7,425	30,000	113,750
200-299	250	7.00	96.00	21	289	525	7,225	131,250.00	1,806,250
300-399	350	16.33	89.33	49	268	1,225	6,700	428,750	2,369,500
400-499	450	24.33	73.00	73	219	1,825	5,475	821,250	2,463,550
500-599	550	23.33	48.67	70	146	1,800	3,650	990,000	2,007,500
600-699	650	15.00	25.33	45	76	1,075	1,850	698,750	1,202,500
700-799	750	8.33	10.33	25	31	625	775	468,750	581,250
800+	850	2.00	2.00	6	6	150	150	127,000	127,500

An upper boundary of ¢899 was used and it mid-point value was estimated 850.00

An upper boundary of ¢800+ was used with limit bound of ¢899.99. As shown above the total WTP for a quality water of 30 litre (7.5 gallons) at an average of 4 of this quantity is estimated as ¢3,700,000 x 4=¢14,800,000. Thus the total WTP at column 9 times 4 (the average). This means an average of ¢444,450,000.00 is what the communities will be likely to pay. This is obtained by multiplying the daily payment by 30. This TWTP compares fairly with the total cost of illness. It means the COI value is more reliable.

Similarly, it is seen that the monthly values from the distribution of values on monthly basis; the COI values and TWTP are also in consistent with the ratios stated in chapter 3

4.7 THE DETAIL ANALYSIS OF THE TWO MAIN METHODS USED IN THE CALCULATING THE COST OF ILLNESS

The medical costs and loss of labour productivity of the affected victims have a meaningful trend. First of all, it is an evidence that the people are ready to pay for an alternative clean water. This is either to avoid the present condition of poor sanitation.

The values obtained from the medical and prevalence cost and the loss of labour productivity are consistent with the WTP by the contingent valuation method's values. The inequalities are fairly within the acceptable limit for the developing countries from the page, it is seen that the minimum value is ₵33,939,075. When this figure is multiplied by the average of $3\frac{1}{2}$ days, (the accepted days used for the final minimum value is the maximum value for the same method which is estimated at 535,365,300.00 for the same number of days.

When the WTP for the clean water is observed, the average value is 450,000,000 Ghanaian cedis with an average price of ₵400 per 30 litre tin of clean water. This supports the reliability and consistency of the cost of illness to avoid water pollution by the respondents.

On the monthly basis, the best price is ₵60,000 per month the amount of water to be served to those households of 7500 is not relatively different from those on the daily basis. This total WTP obtained is almost ₵300 million. The number of households is 6000. Therefore if the same 7500 households are used, amount could rise to ₵375,000,000 very closed to this inequality band.

This also means, it is far better to serve the people in these areas on the daily basis as the system provides best for it and the people are also ready for it. The technical policy behind this is that, the government could identify the source and push, a fraction of the cost through a nice economic package, on them so that the communities would not be push for nothing. The most serious burden will be experienced by the respondents when the population growth rates rise within the 10 years span and when the inflation goes up.

This is very common with the developing countries when this happens, the figures given could be higher.

4.8.1 ANALYSIS OF THE OTHER VARIABLES IN "WTP"

From the results of the questionnaire in Appendices 5 it was observed that in most cases, the figures quoted were related to the factors such as the education level, level of wages and salaries and the number of Households. It was clear that those households with less number of family members were ready to pay above the average price level of ₦450 per 30 litre tin for clean water. And contrary, the family with more family members quoted just around the average of ₦450. This means that the number of family member within a household is inversely proportional to the figures given by the respondents.

The trend for wages/salaries as against prices for the same quantity of water was directly related. This is because from appendices 5, almost 80 – 89% of those whose salaries were 25,000 or more gave at least ₦350 and as high as ₦850 for the same quantity of 30 litre tin.

Therefore, it is observed that apart from the price, other factors are responsible for the charge for demand for clean water or peoples total willingness to pay for clean water or prepared to pay the same amount, in order to avoid such illness and other consequences.

Most of the employed family heads (head of the chosen households) expressed their readiness to pay this "cheap price" in order to get out of their current situation. For instance it is cheaper to buy a clean water at the cost of $(₦450/30/\text{litre}) = ₦15$ per litre.

4.8.2 THE ECONOMIC IMPLICATIONS OF THE RESULTS OF THE STUDY

Any time water pollution is serious with its health risks as state, a group of people spend or lose a significant amount of money. In economic wise such waste prolongs and derail their economic development and tightens poverty cycle of the victims and delays development. Almost 40-46% of their productivity can be lost when there is an outbreak.

People in such and other similar sites could, among other things, suffer greatly.

One consequent is a result of large pool of unemployment at the nearby relative "developed areas". Thus it results in migration of able-bodied males and young men from these areas to the so-called economically viable areas. The agricultural output and

other sectors reduce drastically and can lead to famine. There is an increase in depravity and in this climate of deprivation, women and children suffer the effect much. It proves the fact that young women and girls in these areas especially, Asaago and Aduaden lack opportunities, adequate and economic security now and is speculated to either remain or worsens if nothing is done. The next option is to seek support from men by trading sex for security and expose themselves to contracting HIV diseases. It is no wonder that the rate of dropout is high ,15% - 21%, and from information gathered, most of them are female.

Currently and in the near future, the people at such areas are likely to be affected by lower level of education, health status, political influence, personal status and psychological triumph of premature death, brain drain overcharging of other social vices.

4.8.3 INVESTMENT ANALYSIS

The statistics on productivity and real wage losses have depreciation on both short-term and long-term prospects and plans for the area concerned and the direct impact is felt gradually at the national level. The lower flow of funds and stocks in such places impairs the rate of returns and ability to finance both human and capital investment out of the retained earnings. The established firms can raise capital, and this lead to create a relative challenges and issues more frequently.

The adverse perceptions of abled investors put fear in them and hinder them from investing in these areas. This means that businessmen will consider those places as "areas of economic high risks in returns, labour and return outflows and may not be prepared to invest. Banks and other financial resource industries might not be willing to encourage or even contract loans / flows for any investors plan as to invest there. The obvious implication for the future is that they are likely to lack – behind in terms of development as the government alone cannot develop these areas.

4.8.4 THE STANDARD OF LIVING & QUALITY OF LIFE

As the areas suffer from pollution, loss of labour productivity the real wages and salaries gradually declines and the quality of life goes from bad to worse as the standard of living

for the local people in particular are not far from reached. There is reduction trend of economic activities especially, for the females as they may tend to spend more hours on quality water or other related unpolluted rivers. The economic consequence of this incidence is that the pay per hour decreases and losses drastically its values. When the working time of the husband and wife is added up, the average family, for instance works more hours, but the incomes go down and do not show any improvement in nominal or real situation. Their standard of living is therefore in danger. Their GDP per capita does not reflect any change, pre-condition for development and for the near generation and their resources.

The result has an implication that is connected negatively to the standard of living and the quality of education for the people in these areas now and the future. Thus its discharge of municipal and industrial effluent into these natural watercourse should remain the norm in the cities; threat to health will be widespread and more extensive. The working hour of the males and females even though increases, when added up, there is a clear show-down in real income and low per capita. The quality of life decreases. The reflective from both GDP of per capital and per capita, pre-requisite conditions for rapid development is deeply affected and quality of education is also affected.

The children's drop out goes up greatly or as the able-bodies leave for other areas, the more with their children and pose a misuse of state resources both human and capital wise. This incidence of diseases and related poverty must be checked in order to improve both the quality of life and education for the people in these areas.

5.2 THE LIMITATION OF THE STUDY

The relevant technical and persistent limitations encountered in the study by the researcher are briefly explained below. First of all, there were no substantial data for smooth studies. For instance, time series data, continuous monitoring activities and technical logistics were relatively low, according to the social research standard for any meaningful official work. Those available have clear gaps in them because of

CHAPTER FIVE

THE CONCLUSION, SUMMARY AND RECOMMENDATIONS OF THE STUDY

5.0 OVERVIEW

Chapter Five covers all the summary of the study. It further captures the recommendations from the findings, strategies laid for the appropriate offices and the major conclusions. The last part is the research note and further proposed areas of study.

5.1 CONCLUSION

From the study undertaken, it will be concluded that good drinking water is granted priority status so that stakeholders will augment relevant supplies to the highly vulnerable water-borne diseases areas as deemed fit;

- For irrigation and watering of crops, a relatively lower level of water quality within the WHO standards recommended can be used;
- Government must incorporate municipal and local level organisations providing for private sector involvement; encouraging active and fair participation of other interest investors in the water resources management.
- Media houses must be allowed to play their active role of reporting the authorised and authentic reports for civil society to make decisions.
- Though water is vital for industries, their disposal and wastes must be properly located or recycled, or if it must be discharged, it must not get into the main tributaries or rivers. A way out like oxidation pond of higher standard is possible;

5.2 THE LIMITATION OF THE STUDY

The relevant technical and persistent limitations encountered in the study by the researcher are briefly explained below. First of all, there were no substantial data for smooth studies. For instance, time series data, continuous monitoring activities and technical logistics were relatively low, according to the social research standard for any meaningful official work. Those available have clear gaps in them because of

irregularities in sampling. There was lack of a defined management station responsible for various activities carried out along the banks of these affected areas. Lack of funds, inadequate resources and tedious procedures compounded by inaccurate data did not allow the research to cover many areas at the target sites. Also, most of the operational methods were very difficult to be applied in the area due to the level of education. Records are not taken and kept to facilitate reliable works. However, the researcher managed to get access to the most valid and reliable information for the study. The researcher used the best appropriate survey methods to reduce much spuriousness in the calculations of the regression values in the study.

5.3 RESEARCH NOTE

- Alternative sources, of water pollution that need critical attention are the products from car wash bays, weeds planted by certain plantations in their oil-palm farms for higher yield. This weed tends to cover the rivers and produces the bacteria responsible for onchocerciasis.
- There is a risk of using major rivers that flow through urban centres without any research done on them.
- There is a risk of definitive riverbed change and the idea of mere palliative measures instead of permanent solution.
- Government prepare joint river basin plans, provision of adequate and sustainable financial and endowment funds for effective and operational duties.

5.4 SUMMARY

From chapter 4, it is observed that the main duty of the researcher was to determine the economic costs of some specified diseases that are commonly found in areas dominated by people who use the polluted water in one way or the other. Even though the main work was on the economic costs, certain criteria were used to find out whether River Oda, Subin and Sisa which are the main rivers of the study areas are polluted or not. It was found that in relative terms, the rivers are polluted during dry seasons than the rainy seasons. Also some parts such as the southern area of Kaasi (a suburb of Kumasi) are more polluted than the upper areas.

Also the economic costs calculations for the three main diseases were done. The disease that has the highest economic cost hence the greatest economic adverse effect is typhoid and the lowest is diarrhea. It was identified from the study that rich people and educated ones are likely to pay more for an alternative resource.

The health and the economic costs studied associated with water pollution are real and undoubtedly represent a formidable obstacle to the improvement of the quality of life in their similar occurrence points. The prevalence of these identified diseases and the potential for epidemics is closely linked to the accessibility of clean water and the success of these communities in eliminating exposure sources of infectious diseases. These disease:- *Cholera, typhoid, diarrhea and paratyphoid*, which are related to water pollution deeply and are water borne also contribute immensely to the health risk of people of deprived areas in Ghana currently. Provision of pollution free-water and fresh, if possible and healthier sanity, can reduce mortality and morbidity rates.

It is therefore justified and revealed from these studies that children in the few households with these facilities are 60%-65% less likely to die or be affected from these water-borne diseases than those in households with little or without any.

The estimated economic cost resulting from lost productivity and the cost of medical and related costs represent a real DRAG on economic growth and development in these and similar locations. Alongside, both chronic and acute ill-health are also a consequence and a cause of poverty. Poor nutrition, poor school performance (the health state, frequent absence from school and high rate of drop-out) normally reduce productivity levels and can lead strictly to perpetual disability and thus give little hope for the present and future economic advancement and quality of life.

Also the people face the problem of limited alternative resources. Thus because there are no cost effective alternative sources, most of the people identified at the sites downstream areas collect drinking water and domestic waters from these rivers without or with little treatment. The rate of the pollution could be alarming as the affordable and accessible alternative which could have reduced the incidence rate and the intensified rate of exposure and contributing to the spread of diseases are not available and force them to use the contaminated water(s). This is more severe and unbearable during the dry season.

5.5 RECOMMENDATIONS

The recommendations have been captured under the following:

a) **LEGAL/INSTITUTIONAL:** It is acknowledged that the quality of water is high on political and economic agenda in Ghana. As a result of the maintenance of environmental integrity, participants need to recognise and support the view that water is no more infinite and vulnerable resource. It must therefore among other things, be noted that:

- Capacity building needs on water and health assessment must be undertaken regarding Human Resources, Institutions, Technology and Finance with a view of rapid and continuous field works on pollution and Health implications.

- Social and environmental impact assessment be made mandatory and standardised with shared water resources

- Water laws be reviewed to reflect common approaches to handle pollution cases with extra care. The concept of demand and distribution management of water resources in only urban centres and neglecting or paying little attention to the peri-urban sites must be reversed.

- Political and legal commitment should be reflected in the national budget, allocating at least, a fixed and sustainable minimum funds for the water management. Proper policy measures and information plans in relation to water pollution and health implication be made clear and not of complex technical operations.

5.6 REGULATIONS, STANDARDS AND CODES

There should be effective programmes to control the sources of drinking water based on the existing legislation supported by regulations, standards, codes, the treatment levels, its regular practices and what to choose. These include:

- I. Specification of the scope and powers of authority
- II. Delegation of powers to administer the law to a specified contributor(s) of the undue pollution practices in the urban areas and rural as well.
- III. Provision for the establishment of a strong and reliable management team consisting of lawyers, economic environmentalists, environmental engineers etc,

and proper amendment of regulations for efficient development, production and distribution of good water in urban areas which greatly affects the distribution and maintenance of safe drinking-water.

- IV. Provision for enforcement - This is necessary because the consequences of water pollution maim the victims, lower productivities and entrench poverty. The implementation under proper codes and measure will invaluablely help a lot.
- V. An absolute mandatory requirement in a permissive system which is far above doubtful criticisms must be issued to those who wish to invest near river courses.
- VI. Create a regional or district framework for cooperation in integrated water resources management, curb pollution and must be supported by legalised and constitutional action plans at the national level.
- VII. Develop national and regional strategies for the mobilization of financial resources necessary to assist the victims and educate the sites that are likely to be affected.

5.7 FIVE COMMON TECHNICAL PARADIGMS OF WATER RESOURCE IDENTIFIED

1. Power is centrally retained with little consideration of the needs, desires and aspirations of inter-district borderland inhabitants;
2. The power structure of these central authorities and organizations often reflect political and economic imbalances among industrial establishments, their environmental impact assessments, evaluation and analysis.
3. Implementation of accords and codes in relation to the prohibition and eradication of pollution is more often (generally) left to the discretion of signatory and political lines rather than being clearly programmed into an economic development and natural resources management agreement for a better future and quality environment.
4. Mechanisms for meaningful public participation and valid regular research are rarely provided for.
5. The composition of institutional team and other organisational bodies (both governmental and non-governmental) is slanted toward development objectives without any proper cost and evaluation of social, economic and other related values. The government is strongly advised to re-plan for new strategies, models and

recommendations to overcome local parochialism and overwhelming central predominance that is serving as obscure pillar in dealing with water resources issues in Ghana.

The amendment of the regional and district water boundary treaty or a fresh treaty to be established, to give the appropriate authorities and concerned organisations, legal stands/advice, security and power to prohibit bulk removals of wastes disposals etc.

Government should try to remove the 5 main closed and top-down paradigms of river basins that have a structurally and tactically weak approach in dealing with pollution issues.

5.8 CHALLENGES FOR LONG TERM RESPONSES

From the field of economics and environmental development growth, a major challenge is to provide an open access to basic information and data set, so that the investors, stakeholders in thorough informed decision making, and meaningful discussion could be made.

Also environmental resource management programmes need to be streamlined in order to decrease the complex nature of the pollution whose effects are borne by innocent ones who are encountered with multiple economic implications and drastic reduction of the quality of the scarce resources. This will derail the progress of the children yet to be borne in the area and the subsequent generation.

In a number of river basins, authorities and municipal leaders have to be educated to change traditional paradigms. Attitudes of damage and destruction of valuable resources can be minimised by means of forming a strong and a reliable economic valuation methods in complex economic and pressing environmental issues.

Another challenge is to bridge the gap of information asymmetry and power imbalances, acknowledge and treat thoroughly all the linkages between river basin management, economic expertise advisory reports and regulatory bodies. The economic focus of production of the urban areas should incorporate health and its economic consequences of pollution.

GLOSSARY

COI	Cost Of Illness
WTP	Willingness To Pay
WRRI	Water Resource Research Institute
CSIR	Centre For Scientific And Industrial Research
IWMI	International Water Management Institute
GNDP	Gross National Domestic Product
RAD	Restricted Activity Days
ID	Incidence Of Diseases
CVM	Contingent Valuation Method
FAO	Food And Agricultural Organisation (International Body)
WHO	World Health Organisation
GWCL	Ghana Water Company Limited
EPA	Environmental Protection Agency
Epa	Environmental Protection Association
KATH	Komfo Anokye Teaching Hospital, Kumasi
KNUST	Kwame Nkrumah University Of Science And Technology
HH	Households
Water	- Refers to all surface water in rivers, lake and resevoir; wetlands; and aquifers
Water Quality	– This includes both the change in availability (increase or decrease) in quantity, the content of particles and dissolved materials and contamination with diseases.
Waste Water	– Water from households and cities that has been used domestically, and often contains urine and feaces of human (and animals), plus organic remainders of food preparations.
Urban & Pre-Urban Areas	– Those part of river basins where people and land water management are strongly affected by large concentration of people. This refers to cities both more than a few hundred thousands inhabitants.

HUMAN EXCRETA

- **NIGHT SOIL:** Human feces and urine transported without flushing toilet, also referred to as brackish water
- **SLUDGE:** A mixture of solids and water deposited on the bottom of most septic tanks
- Tanks, stabilization ponds etc
- **SEPTAGE:** sludge removed from the septic tanks and stabilization ponds.
- **SULAGE:** Wastewater from washroom, waterlosed bathing rooms, kitchens Etc. Also gray water.
- **SEWAGE:** A mixture of night soil and sullage that is usually collected by a network of pipes to a treatment that can be (de) centralized (Pesco,1992).

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APPENDIX 1

**AN ACADEMIC PURPOSED QUESTIONNAIRE ON WATER POLLUTION
AND MONETARY VALUATION OF DAMAGE EFFECTS OF THE WATER
POLLUTION. IT IS PURELY FOR A THESIS WRITING**

**SCHOOL: KWAME NKRUMAH UNIVERSITY OF SCIENCE AND
TECHNOLOGY**

**DEPARTMENT : ECONOMIC AND INDUSTRIAL MANAGEMENT
PROGRAMME: M.A ECONOMICS**

PERSONAL DATA

1. NAME (OPTIONAL)..... 2. SEX: MALE ☐ FEMALE ☐
2. AGE BRACKET 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60-69 ☐
☐ 70-79
3. EDUCATIONAL BACKGROUND
☐ TERTIARY LEVEL ☐ A, O-& S.S.S. LEVEL
☐ MSLC/ JUNIOR SEC. SCHOOL ☐ BELOW J.SS/NOT AT ALL
4. OCCUPATION: ☐ PROFESSIONAL / SKILLED ☐ SEMI-SKILLED/
APPRENTICE ☐ FARMING/ UNSKILLED
5. NUMBER OF YEARS STAYED IN THIS COMMUNITY ☐ 0-2 YEARS
☐ 2-5 YEARS ☐ MORE THAN FIVE YEARS
6. RELIGION (OPTIONAL) ☐ CHRISTIAN ☐ MOSLEM
☐ TRADITIONAL ☐ OTHERS
7. MARITAL STATUS ☐ SINGLE ☐ MARRIED ☐ DIVORCED
☐ SEPARATED
8. NUMBER OF CHILDREN IF ANY.....

WATER POLLUTION

1. WHAT IS THE NAME OF THE MAIN RIVER IN YOUR AREA?.....
2. HOW OFTEN DO YOU USE THIS RIVER?
☐ EVERY TIME ☐ ONCE IN A WHILE ☐ RARE SITUATION
☐ NOT AT ALL

3. IN WHAT PERIOD OF THE YEAR IS THE RIVER MENTIONED VERY USEFUL?

☐ ALL TIMES ☐ RAIN SEASON ☐ DRY SEASON ☐ NOT AT ALL

4. FOR WHAT PURPOSES DO YOU USE THIS WATER RESOURCE IN SPECIFICATION (3) ABOVE?

You CAN CHOOSE AS REQUIRED

A, DRINKING, COOKING AND BATHING

B, BATHING AND WASHING

C, FARMING AND WASHING

D, FARMING ONLY

E, OTHER(s) SPECIFY _____

5. IS THE RIVER SPECIFIED POLLUTED? ☐ YES ☐ NO ☐ NOT KNOWN

6 DOES THE USAGE OF THIS RIVER BRING DISEASE? ☐ YES ☐ NO ☐ NOT KNOWN

7 DO YOU NEED TO TREAT THE WATER AT ANY LEVEL, FOR THE PURPOSE IDENTIFIED AT (4) ABOVE? YES ☐ NO ☐

8 WHAT MEANS/METHODS ARE USED IF TREATMENT IS REQUIRED? (RANKING IS NEEDED: 1ST, 2ND, 3RD, 4TH)

☐ FILTERING ☐ BOILING ☐ COOLING ☐ OTHERS NOT SPECIFIED

9. WHICH TYPE (IF ANY) OF OTHER WATER SOURCE(S) DO YOU WISH TO REPLACE THE RIVER'S WATER OR ALONGSIDE? (WELL, TAPED WATER, SACHED WATER, (BORE HOLE WATER (RANK THE OTHER OF PREFERENCE)

1ST _____ 2ND _____ 3RD _____ 4TH _____

10. FOR WHAT PURPOSE (s) DO YOU USE THE MOST RANKED WATER SOURCE (s) IN A ABOVE FOR?

11. IT IS TRUE THAT WATER POLLUTION IS DANGEROUS TO HEALTH STATUS: ☐ STRONGLY ☐ AGREE ☐ AGREE ☐ NOT AGREE

12. WHICH OF THESE DISEASES HAVE YOU OR YOUR RELATIVE(s) BEEN SUFFERED BEFORE DUE TO WATER POLLUTION?

☐ MALARIA ☐ CHOLERA ☐ DIARRHOEA ☐ ONCHOCYCLIASIS
OTHERS _____

13. WHICH OF THE ABOVE DISEASES IN 12 IS VERY COMMON IN YOUR AREA? -----

EVALUATION OF COST OF ILLNESS AND WILINGNESS TO PAY

1. WHEN SUFFERING FROM DISEASES DUE TO WATER POLLUTION, IT IS SAFE TO.

☐ ATTEND HOSPITAL ☐ USE TRADITIONAL HERBS & OTHER MEANS ☐ DO NOT TREAT IT

2. ARE THERE ALTERNATIVE WATER RESOURCES YOU COULD USE?

☐ YES ☐ NO

3. IF WE ANSWER TO 2 IS YES, DOES IT CONSUME TIME, MONEY, and EFFORT IN GETTING THESE ALTERNATIVE RESOURCES?

☐ TIME ☐ MONEY ☐ TIME & MONEY ☐ EFFORT ONLY
☐ ONCE

4. CAN A VALUE BE PUT ON A BUCKET OF 30-LITRES TIN (BIG PAN) OF QUALITY WATER YOU NEED TO SUBSTITUTE THE POLLUTED WATER?

☐ YES ☐ NO ☐ NOT KNOWN

5. HOW DO YOU WISH THIS COLLECTION BE DONE ?

☐ ONLY ☐ MONTHLY ☐ OTHER SPECIFY -----
☐ ON BUCKET OF 30-LITRE TIN (PAN)

6. HOW MUCH DO YOU WISH TO PAY FOR FULL OF 30-LITRE-TIN OF QUALITY WATER? (IN CEDIS)

☐ 0-99 ☐ 100-199 ☐ 200-299 ☐ 300-399 ☐ 400-499 ☐ 500-599
☐ 600-699 ☐ 700-799 ☐ 800 +

7. HOW MUCH DO YOU WISH TO PAY FOR THIS QUALITY OF WATER IF IT IS IN MONTHLY BASIS? (IN CEDIS)

☐ 0-9,999 ☐ 10,000-19,999 ☐ 20,000-29,999 ☐ 30,000-39,999
☐ 40,000-49,999 ☐ 50,000-59,999 ☐ 60,000 OR MORE

8. SOMETHING IS TO BE DONE TO REDUCE THE OPERATION THAT TENDS TO POLLUTE THE RIVER ☐ YES ☐ PARTLY ☐ NO

9. IT IS IMPORTANT THAT GOVERNMENT OR OTHER CONCERNED ORGANISATION(S) SHOULD HELP TO ☐ BAN ☐ TAX ☐ EDUCATE PROSECUTE, THE POLLUTERS WHEN IDENTIFIED (YOU CAN CHOOSE MORE THAN ONE IF NECESSARY)

10. HOW MANY TIMES SHOULD THE GOVERNMENT OR OTHER ORGANISATIONS EDUCATE OR REGULATE SO THAT POLLUTION BE REDUCES?

☐ ONCE EVERY MONTH ☐ ONCE EVERY SIX MONTHS ☐ ONCE EVERY SIX MONTHS ☐ ONCE EVERY YEAR ☐ NOT AT ALL

11. DO YOU HAVE ANY SUGGESTION (s) TO REDUCE POLLUTION?
SPECIFY (1) (2) (3)

12. SPENDING TIME, MONEY AND OTHER RESOURCES TO MANAGE THE SOURCES AND RISKS OF POLLUTION IS NECESSARY

☐ STRONGLY AREE ☐ AGREE ☐ DISAGREE

13. WOULD YOU LIKE TO JOIN ANY BODY OR GROUP OF PEOPLE TO SOLVE THE WATER POLLUTION IN YOUR ARM? ☐ YES ☐ NO

PART IV PLEASE COMPLETE THE FOLLOWING

1. HOW DO YOU WISH WATER POLLUTION PROBLEM BE SOLVED? (TICK AS APPROPRIATE)

	FULL SERVICE BY GOV'T	PARTIAL	NGOS	SELF HELP	NO.T
YES NO, WOULD NOT					

2. HOW DOES EACH OR MORE AFFECT YOUR REGULAR DUTIES?(TICK AS APPROPRIATE)

	STRONGLY	NORMAL	LITTLE	NOT AT ALL	NOT AWARE
DISEASE(s)					
LEISURE					
PAIN AND					
10% CONTINGENT					
HOSPITAL ATTENOMAE					

3. GENDER AND OCCUPATION (PROFESSIONAL WORK STRUCTURES) (TICK AS APPROPRIATE)

	MARRIED MAIN	SINGLE MAN	DIVORCES EPARATED	SINGLE WOMAN	MAR WON
HIGLLY SKILLED ACADECIC					
APPRENTICE SHIP					
FULLY EMPLOYED					
CASUAL / UNSKILLED					
NOT EMPLOYED					
NOT SKILLED					

4. ARE YOU A SALARY OR WAGED WORKER? ☐ YES ☐ NO ☐ NOT NECESSARY

5. HOW MUCH DO YOU (WISH TO) RECEIVE A DAY? ☐ 0-14999
☐ 15,000-29,999 ☐ 30,000-49,999 ☐ 50,000 OR MIXE

6. COULD YOU INDICATE ONLY ONE AS APPROPAIATE,
 I RECEIVE ALMOST ¢ ☐ 0-150,000 ☐ 151,000-400,000 ☐ 401,000-7000,000
☐ 701,000-1,000,000 ☐ 1001,000-1,500,000 ☐ 1,501,000

APPENDIX 2

COMPARISON BETWEEN BACTIOLOGICAL AND PARASITOLOGICAL QUALITY AND WHO GUIDES

TABLE 2A1

SAMPLING SITE	NEMATODES EGGS/L	FC/100ml	CONSISTENCY
ST	1= 1 EQUAL	B 890<1,000	In Consistent
WE	3> 1 EXCEEDS	E 1,277<1,000	Consistent
KA	5> 1 EXCEEDS	E 8,658>1,000	"
DB	1> 1 EQUAL	E 6,524>1,000	"
AS	0< 1 BEOW	E 8,770>1,000	"
AD	4< 1 EXCEES	E 31,1807>1,000	"

E – EXCEEDS the limit

B – BELOW the limited

Source: OD/TN 95 22/03/01

This test was among others, the standard, easy and accurate mostly recommended for study like this. They are better established as "Standard practice" and from the basic of any initial effort to quantify microbiological water quality for polluted/contaminated water use. The table 4.5 generally supports this pragmatic conclusion. The data suggest that water upstream (ST & WE) and downstream (KA, DB AS) considered fails to complete and Guidelines especially the count on FC/100ml.

However at Septimpon Site ST, it has a faecal coliform count just below 1000 per 100ml and has two nematode eggs per tire in the clear water sample.

TOTAL AND FAECAL COLIFORM

The table 2AI shows the number of faecal coliform detected in sample from each site for the last three sampling dates. Samples taken on 18th and February 1999 were only analyzed for total Coliform number and the faecal coliform observed over the last three sampling dates. Numeric data and the regression analysis are include.

APPENDIX 2 B1 WHO AND E.U DRINKING WATER QUALITY GUIDELINES AND RISKS MANAGEMENT

TABLE 2 B1

ELEMENTS	WHO DRINKING WATER GUIDELINE (A) mg/L	EU DRINKING WATER GUIDELINE(B) mg/L	RECOMMENDED MAXIMUM CONCENTRATION FOR CROP
Arsenic	0.01	0.05	0.1
Mercury	0.001	0.2	
Copper	2	0.1-0.3	0.2
Lead	0.01	0.05	5.0
Zinc	3	0.1-5.0	2.0
Cadmium	0.003	0.005	0.01
Manganese	0.5	0.05	0.2

Source:

- World Health Organisation (1993)
- Cited by Chappinan (1996)
- Cited by Pescod (1992)

Appendix 2B2: HEAVY METALS AND THEIR EFFECTS ON HUMAN HEALTH table 2B2

Elements	Source	Effect on health
A.S - Arsenic	Industrial effluents, an Impurity in some detergents	Very harmful, cumulative poison carcinogenic, skin diseases
Cu – Cupper	Plumbing, animal wasters, pesticides, earth's crust	Liver cirrhosis food main source intake, uncertain toxicity in human
Hg - Mercury	Pesticides, Industrial effluents	Very harmful for gregnant women, cumulative poison neurological diseases
Ph – Lead	Lead – acid batteries, solder alloys	Accumulate in skeleton, harmful for children and pregnant women.
Mn – Manganese	Industrial effluents	No convincing data of human toxicity
Cadmium	Leather; Washing powders as impurity in phosphate, impurity in phosphate, impurity in zinc steel industry, paint, plastic	Very harmful, cumulative poison, food main source of intake

Source: WHO 1993, Leita et al 1995, Birley and Lock 1998

Appendix 2.B3

DESCRIPTIONS OF THE SELECTED MONITORING SITES

Table 2 B3

CODE	SITE NAME	DESCRIPTION
1.ST	SEPTIMPON	River Sisa: upstream of the Kumasi. Use the river for both domestic and irrigation
2. KA	KAASE	Subin River sampled 1.5 south of the waste stabilization ponds at the Georgia Hotel. The river is heavily polluted from this source and other municipal waste from the city center.
3. AD	ADUADEN	River Oda sampled due west of Aduaden village 18km south of the Kumasi central
4. AS	ASAGO	River Oda sampled immediately Downstream of the confluence with Sisa. 9 km south of Kumasi city center. The river is used for domestic and irrigation purposes
5.DB	DABA	Daban river sampled at old Bekwai Road crossing. The upstreams catchment drains polluted materials

Appendix 3IA

The steps for estimation of present value of total medical costs of the three common tropical diseases associated with water pollution in the area as were used are explained below.

- A straight line approach into the present values for the period of 10 years for all the medical costs
- A deflator (r). discount rate of 42.5% (A mean of discount rates from 5 commercial banks in Ghana was used)
- A 10 year span was used for the costs
- A base year for the calculation was 2001, the data for the justification of water pollution was the same year (2001)
- An inflationary rate 30% - quoted from 3rd quarter of 2001 Bank of Ghana's Report.
- Population of 4500 (20 communities) within 10 towns.
- Distance was used to select the site first.
- A total households of 420 were served with the questionnaires.
- IDww: Records from Questionnaire, interviews and other historical records from the main medical centres contacted. (KATH & Jackie Pramso data)
- MC= medical costs of ₵100,000 (including all charges)
- Number of days: 7 days (Including RAD)
- All values are in Ghanaian cedis (GHC)

Appendix 31B

For the PV[COI] the estimation are as follows

PV of 3 diseases over 10 years hence

$$PV[COI] = \sum_{j=1}^3 \sum_{t=1}^{t=10} \frac{Mi(1+p)^{t-1} \cdot ID_{www} \cdot TP_j \cdot (1+g)^{t-1}}{(1+d)^t}$$

For the first disease: DIARRHOEA : j=1

$$= \sum_{t=1}^{t=10} \frac{(100,0000x(1.3)^{t-1} x 0.025x45x(1.028)^{t-1}}{(1.425)^t}$$

$$PV = \frac{\text{₹} 112,500,000}{1.425} = \text{₹} 78,947,368.42$$

$$PV(COI) = \sum_{t=2}^{t=10} \frac{(\text{₹} 100,000x1.3x0.025x1.028x45,000)}{(1.425)^2}$$

$$= \frac{\text{₹} 150,345,000}{2.030625} = \text{₹} 74,038,781.16$$

$$PV(COI) = \sum_{t=3}^{t=10} \frac{(\text{₹} 100,000x(1.3)^2 x 0.025x(1.028)^2 x 45,000)}{(1.425)^3}$$

$$= \frac{\text{₹} 200,921,058}{2.893641} = \text{₹} 69,435,378.42$$

$$PV(COI) = \sum_{t=4}^{t=10} \frac{(\text{₹} 100,000x(1.3)^3 x 0.025x(1.028)^3 x 45,000)}{(1.425)^4}$$

$$= \frac{\text{₹} 268,510,901.9}{4.12344} = \text{₹} 65,118,178.49$$

$$PV(COI) = \sum_{t=4}^{t=10} \frac{(\text{₹} 100,000x(1.3)^4 x 0.025x(1.028)^4 x 45,000)}{(1.425)^5}$$

$$= \frac{\text{₹} 358,837,969.3}{5.8759} = \text{₹} 61,069,447.97$$

t=6 years 6: ₹57,272,428.26

t=7 years 7: ₹53,711,489.91

t=8 years 8: ₹50,371,954.47

t=9 years 9: ₹47,240,056.1

t=10 years 10: ₹44,302,884.89

Appendix 3IC

For Disease 2: CHOLERA $j=2$. $ID_{wwj}=3.1\%$

$MC_j = \text{¢}120,000$

$$PV(COI)_{2t} = \sum_{t=1}^{t=10} \frac{(\text{¢}120,000 \times (0.031 \times (0.031 \times 45,000)))}{1.425}$$

$$= \frac{\text{¢}167,400,000}{1.425} = \text{¢}117,473,684.20$$

$$PV(COI)_{2t} = \sum_{t=2}^{t=10} \frac{(\text{¢}120,000 \times 1.3 \times 0.031 \times 1.028 \times 45,000)}{(1.425)^2}$$

$$= \frac{\text{¢}233,713,360}{2.03063} = \text{¢}110,169,435.10$$

$$PV(COI)_{2t} = \sum_{t=3}^{t=10} \frac{(\text{¢}120,000 \times (1.3)^2 \times 0.031 \times (1.028)^2 \times 45,000)}{(1.425)^3}$$

$$= \frac{\text{¢}298,790,534.3}{2.893640} = \text{¢}103,319,857.50$$

$$PV(COI)_{2t} = \sum_{t=3}^{t=10} \frac{(\text{¢}120,000 \times (1.3)^3 \times 0.025 \times (1.028)^3 \times 45,000)}{(1.425)^4}$$

$$= \frac{\text{¢}399,544,222}{4.123438} = \text{¢}96,895,896.59$$

$$PV(COI)_{2t} = \sum_{t=4}^{t=10} \frac{(\text{¢}120,000 \times (1.3)^4 \times 0.025 \times (1.028)^4 \times 45,000)}{(1.425)^5}$$

$$= \frac{\text{¢}533,950,898.30}{5.875899} = \text{¢}90,871,354.04$$

$t=6$ years 6: $\text{¢}85,221,387.75$

$t=7$ years 7: $\text{¢}79,922,710.59$

$t=8$ years 8: $\text{¢}74,953,481.00$

$t=9$ years 9: $\text{¢}70,293,215.45$

$t=10$ years 10: $\text{¢}65,922,703.95$

Appendix 3ID

For Disease 3: TYPHOID FEVER j:3

$$MC_j = \text{¢}150,000$$

$$ID_{wwj} = 0.025 \quad \text{Number of days : an average of 7 days}$$

$$= 2.5\% \quad d = 42.5\% \Rightarrow (1 + 0) = 1.425$$

$$PV(COI)_{j=3} = \sum_{t=1}^{t=10} = \frac{(\text{¢}150,000 \times 0.025 \times 45,000)}{1.425}$$

$$= \frac{\text{¢}167,500,000}{1.425} = \text{¢}118,421,052.60$$

$$PV(COI)_{3t} = \sum_{t=2}^{t=10} = \frac{(\text{¢}150,000 \times 1.3 \times 0.025 \times 1.028 \times 45,000)}{(1.425)^2}$$

$$= \frac{\text{¢}225,517,500}{2.03063} = \text{¢}111,058,171.7$$

$$PV(COI)_{3t} = \sum_{t=3}^{t=10} = \frac{(\text{¢}150,000 \times (1.3)^2 \times 0.025 \times (1.028)^2 \times 45,000)}{(1.425)^3}$$

$$= \frac{\text{¢}301,381,587}{2.893641} = \text{¢}104,153,063.70$$

$$PV(COI)_{3t} = \sum_{t=4}^{t=10} = \frac{(\text{¢}150,000 \times (1.3)^3 \times 0.025 \times (1.028)^3 \times 45,000)}{(1.425)^4}$$

$$= \frac{\text{¢}402,766,325.90}{4.123438} = \text{¢}97,677,311.16$$

$$PV(COI)_{3t} = \sum_{t=5}^{t=10} = \frac{(\text{¢}150,000 \times (1.3)^4 \times 0.025 \times (1.028)^4 \times 45,000)}{5.875899}$$

$$= \frac{\text{¢}538,256,954}{5.875899} = \text{¢}91,604,187.54$$

PV for 6th year = ¢85,908,657

PV for 7th year = ¢80,567,248.57

PV for 8th year = ¢75,557,944.56

PV for 9th year = ¢70,860,096.22

PV for 10th year = ¢66,454,338.65

Appendix 3.2A : LOSS OF LABOUR PRODUCTIVITY

The present values (PV_{LLP}) for both employed and unemployed are shown below. A total households of 7500 was used. Out of this figure, only 6.4% do not have job or work that could give them any realistic economic value.

Hence they are considered unemployed.

$$PV(LLP)_h = \sum_{t=1}^{t=2} \sum_{t=10}^{t=10} \frac{(PCoi \cdot SDwwxTPLxIDww)}{(1+d)^t}$$

l : labour : both employed and unemployed

t: as usual time span)

IDww = Average rate of incidence for the three diseases

$$= \frac{1}{3} (2.8\% + 3.1\% + 2.5\%) = 2.8\% = 0.028$$

SDi= 7 days PC =Average cost for shows labour in a day

TPc = 93.6% of 7,500 households = 7,020 households → taken

from the heads of families

TP unemployed = 7,500 – 7020 = 480 households → taken from heads of families

Other values are the same as cost of illness values

Average labour cost of ¢25,000 for employed family head and ¢11,000 for

unemployed : 0.44 of full employed Rate.

$PV(LLP)$ for 60 year = ¢17,511,620.66

$PV(LLP)$ for 70 year = ¢10,412,827.97

$PV(LLP)$ for 80 year = ¢15,401,731.43

$PV(LLP)$ for 90 year = ¢14,444,122.03

$PV(LLP)$ for 100 year = ¢13,546,052.41

Appendix 3.2B

LLP for Employed Group:

$$PV(LLP) = \sum_{t=9}^{t=10} \frac{(\text{₡ } 25,000 \times 7 \times 0.028 \times 7020)}{1.425}$$

$$= \frac{\text{₡ } 34,398,000}{(1.425)} = \text{₡ } 24,138,947.37$$

$$PV(LLP)_{l=1, t=2} = \frac{\text{₡ } (25,000 \times 7 \times 0.028 \times 1.028 \times 7020 \times 1.3)}{(1.425)^2}$$

$$= \frac{\text{₡ } 45,969,487.2}{2.03063} = \text{₡ } 22,638,097.73$$

$$PV(LLP)_{l=1, t=3} = \frac{\text{₡ } (25,000 \times 7 \times 0.028 \times (1.028)^2 \times 7020 \times 1.3)^2}{(1.425)^3}$$

$$= \frac{\text{₡ } 61,433,622.69}{2.893641} = \text{₡ } 21,230,561.32$$

$$PV(LLP)_{l=1, t=4} = \frac{\text{₡ } (25,000 \times 7 \times 0.028 \times (1.028)^3 \times 1.3 \times 7020)}{(1.425)^4}$$

$$= \frac{\text{₡ } 82,099,893.37}{4.123438} = \text{₡ } 19,910,341.11$$

$$PV(LLP)_{l=1, t=5} = \frac{\text{₡ } (25,000 \times 7 \times 0.028 \times (1.028)^4 \times 7020 \times (1.3)^4)}{(1.425)^5}$$

$$= \frac{\text{₡ } 109,718,297.5}{5.875899} = \text{₡ } 18,672,597.61$$

PV (LLP) for 6th year = ₡17,511,620.66

PV (LLP) for 7th year = ₡16,422,827.97

PV(LLP) for 8th year = ₡15,401,731.43

PV (LLP) for 9th year = ₡14,444,122.03

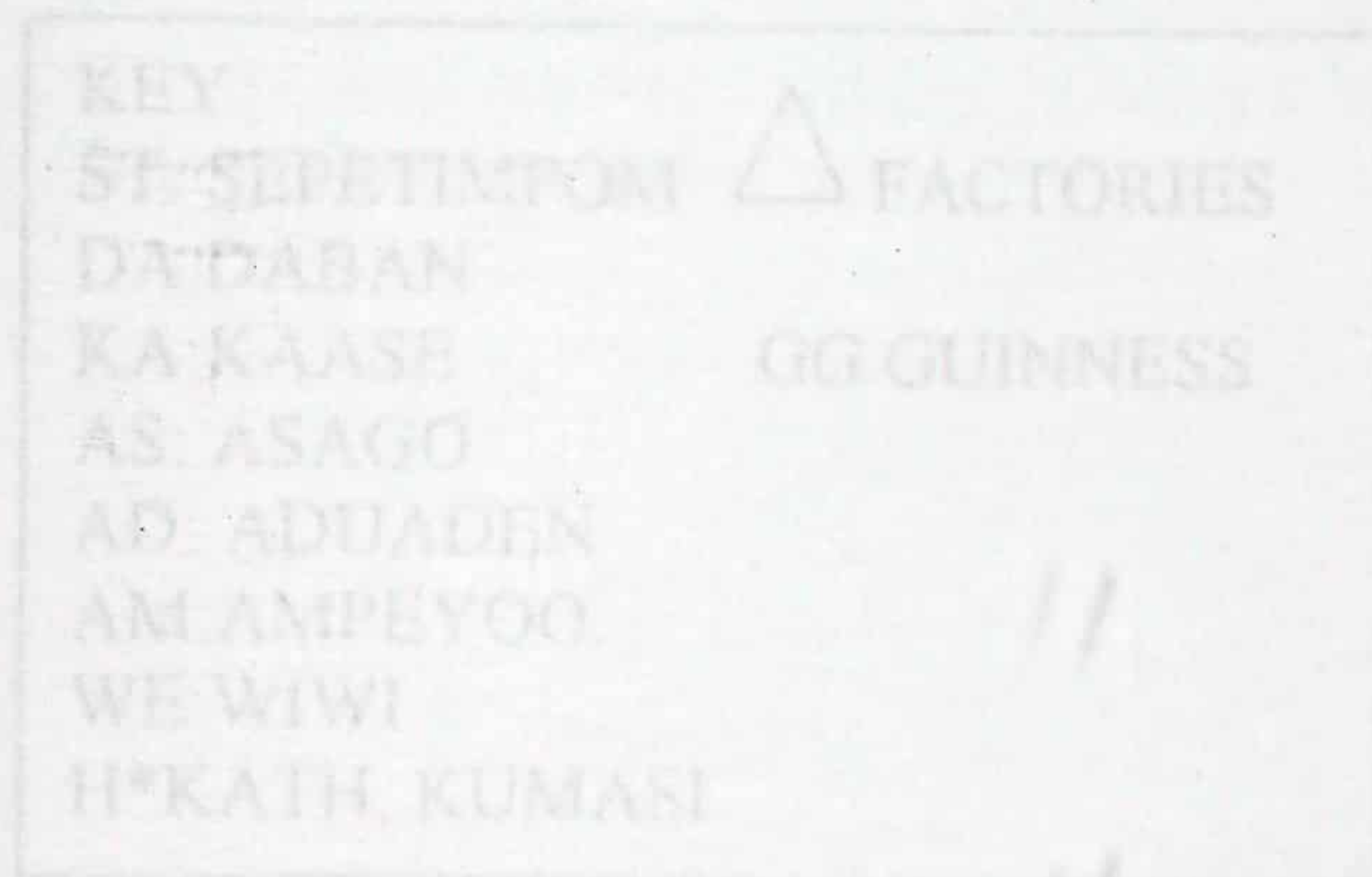
PV (LLP) for 10th year = ₡13,546,052.41

INDUSTRIAL CONTRIBUTIONS

The main industries in Kumasi were identified and visited for their wastewater quality and quantity information. Table A3.1 gives a summary of data obtained from the industries on wastewater production.

TABLE A 3.1: MAJOR SOURCES OF INDUSTRIAL WASTEWATER IN KUMASI

Industry	Activity	Used (L/Day)	Wastewater (L/ Day)	Solid waste (Kg/Day)	Treatment	Distance to stream(m)	Comments
Nnuro Kente	Textile	10,000	3,000	10	None	200	High levels of river Pollution
Kumasi Abattoir	Abattoir	100,000	100,000	N/A	Yes	100	No major Pollution
GBL	Brewery	500,000	275,000	N/A	None	200	None Reported
Guinness Ghana	Brewery	800,000	600,000	50	None	200	None Reported
Paul Sagoe	Sawmill	2,000	No Data	Quite a lot	None	No Data	No Major



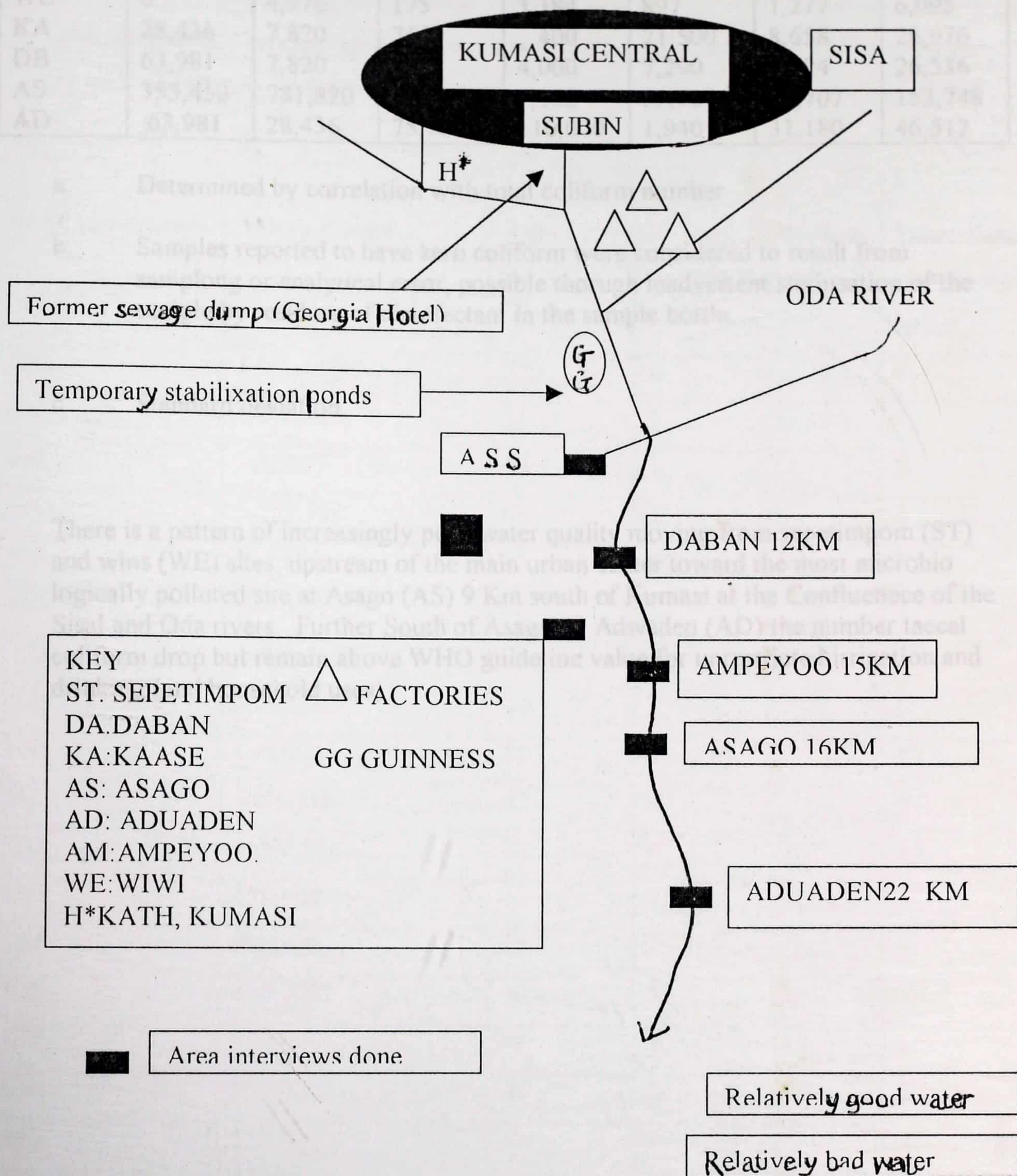
Area under investigation

Relatively good water

Relatively poor water

FIG A.4 Stream flow and areas interviews wee carried

RESEARCH AREA AND ITS STREAM FLOW NETWORK



DESIGNED BY THE
RESEARCHER

TABLE: TOTAL AND FAECAL COLIFORM

SITE	18/02/99	24/02/99	02/03/99	08/03/99	16/03/99	Mean	S
ST	2,844	2,133	729	1,500	84	890	6,095
WE	0	4,976	175	3,384	897	1,277	6,095
KA	28,436	7,820	7650	400	71,500	8,658	28,976
DB	63,981	7,820	810	4,000	7,290	6,524	26,536
AS	353,450	781,820	51,700	7,500	53,900	89,707	153,748
AD	63,981	28,436	75,900	110,000	1,940	31,180	46,512

- a. Determined by correlation with total coliform number
- b. Samples reported to have zero coliform were considered to result from samplong or analytical error, possible thorough inadvertent sterinsation of the sample by residues of disinfectant in the sample bottle.

- c. Standard deviation.

There is a pattern of increasingly poor water quality moving from sepetimpom (ST) and wins (WE) sites, upstream of the main urban center toward the most microbio logically polluted site at Asago (AS) 9 Km south of Kumasi at the Confluenece of the Sisal and Oda rivers. Further South of Asago, at Adwaden (AD) the number taecal coliform drop but remain above WHO guideline value for unrestricted irrigation and drinking (and household uses)

APPENDICES 5

VARIABLES USED

This Appendix shows the various figures indicated on the questionnaire of the study with regard to how much respondents wish to pay for "a 30-litre tin" of Quality water, their salary ranges, age in years number of "a 30 litre tin of Quality water per day and the last column takes the "Education and knowledge" level. (See Chapter 3)

WTP per Bucket	Salary Range	Age	# of Buckets needed Per day	Education & Knowledge Level
800	1,000,000	52	6	8
650	1,200,000	36	3	7
450	750,000	42	2	8
460	1,350,000	68	3	4
500	500,000	45	6	2
450	980,500	60	5	1
150	4,000,000	38	4	3
600	2,500,000	40	3	6
300	840,000	52	4	10
350	1,100,000	42	4	9
800	2,000,000	72	6	10.
350	150,000	42	4	3
500	900,000	52	2	6
500	800,000	50	3	5
550	750,000	38	5	4
650	800,000	42	4	8
420	670,000	40	4	9
130	250,000	38	5	10
150	200,000	29	6	10
190	550,000	52	8	4
370	750,000	43	4	7
800	1,800,000	62	4	8

850	950,000	60	3	6
900	2,200,000	48	4	6
400	350,000	42	4	5
500	850,000	33	5	4
640	900,000	51	6	5
330	700,000	50	4	6
400	450,000	62	3	3
480	500,00	42	4	6
700	950,000	54	4	6
300	400,000	38	3	3
200	1,200,00	68	4	9
300	850,000	52	4	8
350	500,000	42	4	6
400	560,000	43	5	7
500	600,000	50	6	2
350	180,000	31	6	4
550	250,000	32	5	5
400	300,000	42	2	3
650	900,000	25	1	4
400	550,00	40	3	10
800	1,100,000	40	2	10
600	450,000	43	1	3
450	650,000	42	4	2
800	1,300,000	72	4	-
400	740,000	52	4	-
850	300,000	42	3	3
700	1,200,000	48	2	2
400	950,000	47	5	10
950	1,600,000	49	6	10
700	750,000	-	7	9
600	900,000	-	7	5
400	850,000	35	3	5

450	900,000	46	4	5
600	2,000,000	55	4	4
620	1,700,000	52	5	5
350	2,000,000	32	4	6
300	1,400,000	29	4	3
400	550,000	35	3	6
400	350,000	60	4	7
500	450,000	62	5	8
550	500,000	57	4	9
300	800,000	47	5	10
120	750,000	52	5	12
150	700,000	39	2	10
500	350,000	38	4	2
350	450,000	64	4	3
400	500,000	53	3	4
480	800,000	64	5	8
900	3,200,000	29	1	10
650	1,000,000	32	5	9
300	750,000	42	4	8
700	480,000	48	4	9
450	950,000	46	5	3
400	1,200,000	38	5	6
420	500,000	25	6	9
500	400,000	52	3	5
520	750,000	58	4	5
480	300,000	60	4	4
530	150,000	38	6	3
620	340,000	42	2	8
550	600,000	46	5	8
600	900,000	51	4	9
350	750,000	64	4	10
200	600,000	64	3	4

150	550,000	38	5	3
400	450,000	49	5	-
450	400,000	38	4	2
650	540,000	29	3	9
350	630,000	32	4	-
260	180,000	38	4	8
750	7,201,000	45	4	6
800	490,000	46	-	6
400	500,000	45	5	6
350	800,000	48	3	7
250	650,000	45	3	8
400	540,000	40	4	8
500	1,000,000	48	4	6
600	850,00	50	3	4
700	650,000	53	4	8
630	950,000	50	4	8
500	500,500	48	3	7
640	600,000	38	2	8
280	450,000	37	3	4
200	990,000	35	2	2
350	850,000	45	5	1
600	620,000	39	6	3
700	380,000	52	4	6
750	950,000	53	4	10
600	900,000	48	3	9
350	700,000	42	4	10
400	340,000	40	4	3
400	450,000	39	5	6
520	980,000	42	2	5
430	750,000	38	3	4
360	300,000	37	1	8
700	1,250,000	39	3	9

850	1,300,000	42	4	10
400	500,000	25	3	10
900	1,800,000	57	6	4
900	1,000,000	62	7	7
920	1,500,000	60	4	8
800	800,000	73	2	6
120	720,000	61	5	6
100	260,000	52	4	5
100	350,000	59	4	4
100	200,000	38	3	5
150	450,000	43	2	6
120	375,000	47	4	3
130	500,000	29	5	6
250	300,000	60	6	6
450	450,000	39	3	3
500	750,000	42	2	9
500	350,000	50	5	8
350	250,000	51	4	6
400	630,000	60	5	7
600	400,000	27	1	7
750	350,000	35	2	2
250	500,000	48	5	4
400	250,000	60	3	5
500	800,000	59	1	3
400	500,000	54	4	4
450	400,000	39	2	10
320	600,000	55	3	10
300	720,000	49	4	3
250	320,000	38	4	2
300	450,000	29	2	-
500	180,000	34	4	-
450	720,000	39	3	3

600	500,000	60	3	2
720	400,000	43	4	10
700	400,000	40	1	9
800	350,000	55	6	5
500	700,000	53	5	5
600	900,000	42	4	5
500	480,000	39	4	4
500	400,000	38	4	5
480	350,000	42	1	6
400	520,000	35	2	3
500	390,000	28	4	6
500	480,000	34	3	7
600	820,000	42	5	8
350	640,000	40	5	9
300	720,000	43	2	10
100	500,000	53	5	12
150	740,000	55	2	10
150	360,000	48	1	8
150	800,000	63	4	7
400	508,000	58	4	7
500	742,000	49	3	6
400	355,000	42	4	6
350	420,000	35	2	4
500	400,000	37	4	2
300	450,000	49	5	8
300	450,000	49	3	5
300	300,000	52	5	6
300	120,000	38	2	7
300	300,000	44	1	2
300	700,000	51	2	3
400	400,000	39	4	4

350	300,000	40	3	5
400	400,000	39	2	5
400	520,000	28	2	6
300	800,000	43	4	2
350	450,000	47	3	3
150	400,000	49	2	3
700	500,000	56	2	2
900	450,000	39	5	6
500	320,000	40	2	4
400	300,000	42	2	4
350	180,000		8	3
500	250,000	43	5	5
540	600,000	38	3	2
520	750,000	37	2	4
400	900,000	42	3	4
420	600,000	50	5	3
400	300,000	50	2	2
420	450,000	59	4	1
380	400,000	53	3	4
450	350,000	60	2	5
500	250,000	45	10	1
600	200,000	39	4	4
400	300,000	38	8	5
420	450,000	42	2	6
350	400,000	50	2	1
300	500,000	51	6	2
450	600,000	53	5	
500	600,000		1	
340	420000	25	10	3
300	600,000	43	8	4
400	1,200,000	42	6	2
480	180,000	49	4	1

410	220,000	50	4	4
730	440,000	66	2	2
650	300,000	62	2	3
650	720,000	31	8	2
150	500,000	35	9	2
180	120,000	38	7	8
340	1,600,000	42	10	4
420	700,000	61	10	2
200	820,000	50	8	3
280	400,000	54	2	2
200	750,000	42	2	1
250	900,000	43	4	1.5
250	550,000	32	6	3.5
250	580,000	31	5	3
180	620,000	36	5	4
350	706,000	60	6	2
300	550,000	43	10	8
550	925,000	43	4	9
580	850,000	48	4	4
250	800,000	48	3	6
120	900,000	37	2	9
150	190,000	53	1	4
200	220,000	54	4	3
200	240,000	58	7	5
470		55	7	4
350	900,000	38	4	8
450	850,000	42	4	9
500	600,000	60	3	4
500	450,000	53	5	5
300	1,400,000	42	4	6
400	1,000,000	62	3	7
380	980,000	51	4	7

120	180,000	42	3	7
100	200,000	38	4	9
130	150,000	62	5	8
380	209,000	43	5	10
450	3,200,000	48	2	9
550	2,500,000	60	2	7
600	450,000	32	4	9
450	350,000	43	4	3
350	450,000	44	5	5
400	150,000	53	4	4
500	800,000	62	4	6
750	950,000	38	4	8
400	1,500,000	40	2	6
400	500,000	48	2	5
400	500,000	51	4	5
400	500,000	60	4	8