DEMAND FOR CLEAN DRINKING WATER IN KHARTOUM MIDDLE ADMINISTRATIVE UNIT

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Prepared by: Ahmed AbdelRahman Ahmed ElNawrani

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Supervised by: Dr. Nour Eldin Ahmed Mahmoud Maglad

Faculty of Economic and Social Studies-Department of Economics

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Abstract

Name: Ahmed AbdelRahman Ahmed ElNawrani

Title: Demand for Clean Drinking Water in Khartoum middle administrative unit

The study aims at analyzing attitudes of citizens in general and household heads in particular, towards the problem of the quality of drinking water. The main question is whether the household head is willing to pay extra fees in order to get a better quality of drinking water or not, since there has been a noticeable deterioration in the quality of drinking water in Khartoum State, according to the citizens and some health authorities. The study basically relates willingness to pay of the citizens to socioeconomic factors such as income, age, education, gender and etc…It also intends to explore this area and opens a space for investing projects in improving the drinking water quality based on the principle of cost and benefit.

The study depends primarily on the information from the questionnaires that were distributed to the citizens. A random sample of 100 individual representing 100 families of those residing in the area of middle Khartoum of the Khartoum Locality, was chosen. Accordingly, a model has been constructed to test the hypothesis of the study where the amount of money a household head is willing to pay being as a dependent variable and those of income, gender, age and education as independent variables.

Different statistical packages were then used to fit the regression of the model in order to find the correlation of coefficients of the variables, and

test the statistical significance to prove the validity of the hypothesis of the study and reach the conclusions.

The study indicated that there was a direct significant relationship between the amount of money a household head is willing to pay as extra fees and water with a better quality, his income and education level and negative relationship concerning his age. While the relationship regarding the gender variable was statistically insignificant.

The study showed that 50% of the sample is willing to pay extra fees ranging from 1.6 to 13.8 SDG. Also, 92% of the sample thinks that the quality of drinking water is bad, 85% concern about the quality of water, and 63% took an action towards the quality of drinking water by either using filters or buying bottled water. Moreover, 38% confirmed that their families are suffering from health diseases due to the quality of water. Above all, the study concluded that the income is the most important variable, and so it recommends an increase on income average of the individual to give the study a practicality characteristic.

المستخلص

الاسم : أحمد عبد الرحمن أحمد النوراني

العنوان : الطلب على مياه الشرب النظيفة بوحدة الخرطوم وسط

تهدف الدراسة إلى تحليل سلوك المواطنين عموما وأرباب الأسر على وجه الخصوص تجاه نوعية مياه الشرب والسؤال الرئيسي هو ما إذا كان رب الأسرة مستعد لدفع نفقات إضافية مقابل الحصول على مستوى نوعية أفضل لمياه الشرب . وخاصة بعد سيادة شعور عام بتدني ملحوظ في مياه الشرب في ولاية الخرطوم من قبل المواطنين ومن وجهة نظر بعض الجهات الصحية . وتعمل الدراسة على ربط استعداد المواطنين للدفع بالعوامل الاجتماعية الاقتصادية مثل الدخل والعمر ومستوى التعليم والنوع ... إلخ . وترمي الدراسة إلى استكشاف هذا المجال وقد تفتح الآفاق لإقامة مشاريع استثمارية لتحسين مياه الشرب بناءً على مبدأ تحليل التكاليف والمنافع ..

تعتمد الدراسة وبشكل أساسي على المعلومات التي تم الحصول عليها من المواطنين عن طريق الاستبيان حيث تم اختيار عينة عشوائية من مائة فرد يمثلون مائة أسرة من سكان وحدة الخرطوم وسط التابعة لمحلية الخرطوم ومن ثم تم بناء نموذج لاختبار فرضيات الدراسة بحيث يكون المبلغ الذي يستعد رب الأسرة لدفعه هو المتغير التابع والدخل والعمر والنوع والمستوى التعليمي متغيرات مستقلة ومن ثم تم استخدام الحزم الإحصائية المختلفة لإجراء الانحدار وإيجاد قيم معاملات النموذج لاختبار فرضيات الدراسة والتوصل للنتائج.

توصلت الدراسة إلى وجود علاقة طردية ذات دلالة إحصائية بين المبلغ الذي يستعد رب الأسرة لدفعه كنفقات إضافية مقابل الحصول على نوعية أفضل لمياه الشرب ، وكل من دخله ومستواه التعليمي وعلاقة عكسية مع عمره بينما لم تتمتع العلاقة مع النوع بالدلالة الإحصائية .

وأفادت الدراسة إلى أن 50% من أفراد العينة مستعدين لتحمل نفقات إضافية تتراوح بين 1.6جنيه و13.8 جنيه ويرى 92% بأن نوعية مياه الشرب تتصف بالرداءة و85% يشعرون بالقلق تجاه نوعية مياه الشرب و63% اتخذوا بالفعل تصرف تجاه رداءة المياه باستخدام الفلتر أو شراء المياه المعدنية و28% أفادوا بوجود إصابات مرضية في الأسرة بسبب نوعية المياه . كما خلصت الدراسة إلى أن الدخل هو أهم المتغيرات المؤثرة في قرار الأفراد حول الاستعداد للدفع ولذا لا بد من العمل على زيادة متوسط دخل الفرد لإكساب هذه الدراسة الصفة التطبيقية .

Dedications

To my mother's soul …

To my father and sisters…

To my teachers…

To my friends and everyone who encouraged me to complete this work…

Acknowledgment

First, I would like to thank my Supervisor Dr. ***Nour Eldin Ahmed Mahmoud Maglad*** for his ideas and tremendous support in supervising this thesis.

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Chapter one

Introduction

1.0 Introduction:

Garnering widespread and international interest, environmental economics aims to extend beyond the conventional disciplinary paradigm of economics; that is, to better involve and include environmental impact in the study of economics. The study of environmental economics further aims to defy the misconception that economy is the enemy of the environment. It is concerned with the impact of development and production on environment, by way of study of pollution as a byproduct of economic activity, the significance of environment to the economy, and extends to studying the designation of public policy and regulation in order to control the aforementioned pollution.

The emergence of environmental economics relates to the growing concern over lack of pollution regulation and the unbridled negative effects of economic activity on environment. The necessity for such a study springs out of simple market truths: polluters, in the form of corporations/firms, emit pollutants as a byproduct of production of goods which there is an apparent demand for; consumers want the goods but eventually suffer their polluting byproducts. Such disutility to the consumer is the basic incentive for linking the study of environment and economy in order to develop preventive mechanisms. However, the study of environmental economics requires a multi and inter-disciplinary approach for its application. Questions include, but are not limited to: What are the incentives for the generation of

pollution? What are the costs of cleaning up pollution? What are the societal gains from pollution control? What is the right balance between costs of control and gains from control? What regulatory mechanisms can be designed to ensure the right balance between costs and gains?

In this study, the theory of environmental economics will be tackled through looking at the problem of water pollution in Sudan. There is a major problem concerning the quality of drinking water in Sudan which has led and continuing in leading in critical health issues. Specifically talking, this paper will research and measure the willingness to pay by respondents in order to have a better quality of drinking water, in accordance to the above mentioned aspects of the environmental economics.

This chapter will define the problem of the study, the objective, the hypothesis, and the methodology. Finally, it will represent the organization of the following chapters.

1.1 The problem:

There has been a general significant decline in the quality of drinking water in Khartoum State in general, and specifically the area of Middle Khartoum. This study attempts in knowing whether the citizens of this area are willing to pay extra fees on their water bill in order to get a better quality of drinking water, and then relate their answers to the social economical factors which will be tackled in the following questions:

1. Is there a relationship between the variables willingness to pay and income of the respondent?

2. Is there a relationship between the variables willingness to pay and age of the respondent?
3. Is there a relationship between the variables willingness to pay and level of education?
4. Is there a relationship between the variables willingness to pay and gender of respondent?

In addition to the previous questions, there are questions like: what does the respondent think about the environmental situation in general and the quality of the drinking water specially? What are their reactions towards the deterioration in the quality of drinking water: whether they use filter or buy bottled water? The purpose is to see the attitudes of respondents towards the environmental issues, to put basis for the environmental policies, and to know whether the society is willing to pay for a better environment, or to whether the citizens need awareness on such issues.

1.2 The objective of the study:

The study aims at measuring the attitudes of respondents towards the issue of the quality of drinking water, as an example to measure their concern with environmental issues in general. Also, it attempts to analyze the respondents' attitudes by knowing its determinants, and finally puts the appropriate policies in order to solve the environmental problems.

1.3 The study hypothesis:

The study formulates the following hypothesis for the relationship of the variable of the willingness to pay extra fees to get a better quality of drinking water and the social and economical variables:

1. There is a statistical significant and direct relationship between income and willingness to pay.
2. There is a statistical significant and inverse relationship between age and willingness to pay.
3. There is a statistical significant and direct relationship between the educational level and willingness to pay.
4. There is a statistical significant and direct relationship between the gender and willingness to pay.

1.4 Methodology:

A stratified random sampling technique was used to collect data by classifying the study sample into threes groups according to the residential type. The sample size was 100 households. For the survey, a contingent valuation questionnaire was designed and administered to the selected households.

The questionnaire consists of 22 questions, only one of them is an open question, while the others are closed. Some of the closed questions are about the personal information of the respondents such as income, education, gender, etc... And some are there to know to the quantity and quality of water. With regard to open question, it was posed to know the opinion of respondents on the potable water quality. The last two questions

were about the improvement of water quality in accordance with the standards and requirements that are specified by the respondent, and whether the respondents are willing to pay or not. And if he or she is willing to pay, he or she should select the additional percentage that is he or she can pay.

An econometric model is estimated using a multiple linear regression equation so as to know the influence of socio-economic characteristics of the respondent on his or her willingness to pay for getting potable water with better quality.

The researcher adopted willingness to pay variable (W) as a dependent variable to the regression in which the income, gender, age, education and children were independent variables.

1.5 The Study Organization:

The following chapters are divided and organized as the following:

Chapter Two (Literature Review) will discuss the environmental problems regarding water pollution in the Third World, the environmental demand theory and the concept of contingent valuation used in this study. Finally, it discusses some relevant studies that used this concept of contingent valuation in different countries worldwide.

Chapter Three (Water Pollution Risks, Guidelines and the Case of Sudan) will discuss types of water pollution, sources of water pollution, how to detect it, and the guidelines specified by the World Health Organization (WHO) for drinking water. Finally, it discusses the specific situation of drinking water in Sudan.

Chapter Four (Analysis and Results) shows the methodology used in this study and analyses statistically all the dependent variables tackled through the study. Finally, it discusses the models used for the study, and shows the final adopted one to analyze the results.

Chapter Five (Discussion of Results, Conclusion and Recommendations) discusses the variables which are found to be the most influencing on the willingness to pay, according to the model used. Finally, the researcher draws his final conclusions and recommendations.

Chapter two

Literature review

2.0 Introduction:

The environmental problem has now become more evident. In the past it did not receive the consideration it deserved because the priority was given to the economic activity, particularly to industrial development after the Second World War. Generally speaking, the contrast between the economic activity and the environmental situation is well known. However, in the developing countries the situation is more severe as the developing countries are yet initiating their economic activity. Adding the poverty of these countries results a very deteriorated environmental situation.

The environmental problem divides into; water pollution, air pollution, toxics polluters and exhaustion of natural resources. In developing countries water pollution is the most persistent problem, while air pollution is characteristic of developed countries. Sudan, as a less developed country suffers a bad environmental situation.

The researcher in this study attempts at addressing the environmental situation in Sudan, namely, drinking water quality, as Sudan faces a lack of clean drinking water. Specifically, the quality of drinking water in Khartoum locality. It is hard to conduct the study outside Khartoum state because we will find ourselves more remote from the basic study problem. For, if the national capital suffers such a problem, it is likely to face more complicated problems in rural areas and small towns not only in water quality but even water quantity and availability of the private water connection service.

The researcher will utilize statistical method to estimate willingness to pay equation as a function in the socio-economic characteristics such as income, education level, employment status etc… through analysis of data obtained from questionnaires that will be distributed to respondents to assess their readiness for extra bills to get their desired quality water.

2.1 Environmental Problems in the Third World:

It has been stated that poor urban districts are the leading cause of death and illness. In particular, in many parts of the poor city districts, infants are 40-50 times more likely to die before the age of one than in Europe or North America, and virtually all such deaths are environment-related. Over 600 million urban citizens in Africa, Asia and Latin America live in `life and health threatening' conditions because of unsafe and insufficient water, overcrowded and unsafe shelters, inadequate or no sanitation, no drains and garbage collection, unstable house sites, risks of flooding and other environment-related factors. Moreover, most of the diseases and injuries which result are preventable at a low cost.

However, the growing interest in urban environmental problems is based too much on Northern perceptions and precedents. It appears biased towards addressing the environmental problems which Third World cities have in common with cities in Europe and North America. This often means a greater attention to chemical agents in the air, rather than biological agents in water, food, air and soil -including those responsible for diarrhea diseases, dysentery and intestinal parasites. This bias often means that critical environmental problems such as the control of disease vectors which spread malaria, dengue fever, filariasis and yellow fever are forgotten or at

maximum given little attention . It can also mean more attention paid to the loss of agricultural land due to urban spread than to the fact that half, or more, of the urban population lack access to safe and sufficient water supplies. As a recent report by the WHOCHE[1] points out, it is biological pathogens in the human environment plus the high proportion of people who lack access to fresh water and other essential natural resources which represent far more serious environmental problems than chemical contamination, both in urban and in rural areas.(WHOCHE, 1992).

The most immediate environmental problems in the world are the ill health and premature death caused by biological agents in the human environment: in water, food, air and soil. They contribute to the premature death of millions of people (mostly infants and children) and to the ill health or disability of hundreds of millions more. The problems are most acute in Third World countries where:

- Four million infants or children die every year from diarrhea diseases largely as a result of contaminated food or water.
- Two million people die from malaria each year and 267 million are infected.
- Hundreds of millions of people suffer from debilitating intestinal parasitic infestations.

In addition, all countries have serious environmental health problems, affecting:

[1] World Health Organization Commission on Health and Environment

- Hundreds of millions of people who suffer from respiratory and other diseases caused or exacerbated, both indoors and outdoors, by biological and chemical agents in the air.
- Hundreds of millions who are exposed to unnecessary chemical and physical hazards in their home, workplace or wider environment.

Health also depends on whether people can obtain food, water and shelter and over 1000 million people lack the income or land to meet such basic [2]needs. (Source: World Health Organization, (1992) Report of the WHO Commission on Health and the Environment: Summary, WHO/EHE/92.1, Geneva.).

2.1.1 Water and sanitation:

It is no doubt that, lack of readily available drinking water, of sewage connections (or other systems to dispose of human wastes hygienically), of garbage collection and basic measures to prevent disease and provide primary health care can result in many debilitating and easily prevented diseases becoming endemic among poorer households. These include diarrhoea, dysenteries, typhoid, intestinal parasites and food poisoning. When combined with under-nutrition (as is often the case), these can so weaken the body's defense that measles, pneumonia and other common childhood diseases become major causes of death. Cholera remains a threat for poorer groups in many urban centers.

The above and many health problems are linked to water - its quality, the quantity available, the ease with which it can be obtained and the

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[2] Jorge E. Hardy, Diana Mitlin and David Satterthwaite, environmental problems in third world cities, 1997, earth scan publication ltd, London.

provisions made for its removal, once used. Hundreds of millions of urban dwellers have no alternative but to use contaminated water, or at least water whose quality is not guaranteed. A small minority have water piped into their homes while rather more have to collect water from a standpipe nearby. As one specialist commented, `those not served are obliged to use water from streams or other surface sources which in urban areas are often little more than open sewers, or to purchase water from unsanitary vendors. It is of little wonder that their children suffer frequently, often fatally, from diarrhoea diseases'.

The quantity of water available to a household and the price which has to be paid can be as important to a family's health as its quality. The cost of water and the time needed to collect it influence the quantity used. Where public agencies provide no water supply - as is common in illegal settlements - the poor often obtain water from private vendors and can pay 4-100 times the cost per litre paid by richer groups with piped supplies (see Table 2.2). Water vendors probably serve between 20 and 30 per cent of the Third World's urban population.

Table (2-1) differentials in the cost of water (ratio of price charged by water vendors to prices charged by public utility)

City	**Water price ratio private vendors : public utility**
Abidjan	5:1
Dhaka	12:1 to 25:1

Istanbul	10:1
Kampala	4:1 to 9:1
Karachi	28:1 to 83:1
Lagos	4:1 to 10:1
Lima[3]	17:1
Lome	7:1 to 10;1
Nairobi	7:1 to 11:1
Port-au54-Prince	17:1 to 100:1
Surabaya	20:1 to 60:1
Tegucigalpa	16:1 to 34:1

Source: World Bank (1988). World Development Report 1988. p. 146.

Where there is a public supply - a well or public standpipe - the quantity used per person will depend on the time and energy needed to collect and carry water back to the home. There are often 500 or more persons for each tap; in one part of Dakar, a survey in the late 1980s found that there were 1513 persons per tap. Very often, water will only be available in the piped system for a few hours a day.

Since water is very heavy, consumption levels are influenced by the distance that it has to be carried. It is a common feature that low-income

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[3 3] Jorge E. Hardy , Diana Mitlin and David Satterthwaite , environmental problems in third world cities , 1997 , earth scan publication ltd , London .

people often work very long hours, so for them to queue at a tap or carry in water takes away from their time which is already in short supply. Limited quantities of water mean inadequate supplies for washing, personal hygiene, washing food, cooking utensils and washing clothes. Eye and ear infections, skin diseases, scabies, lice and fleas are very difficult to control without sufficient supplies of water.

Around two thirds of the Third World's urban population has no hygienic means of disposing of excreta and an even greater number lack adequate means to dispose of waste waters. Most cities in Africa and many in Asia have no sewers at all. This is not only in the smaller cities.

Many major cities with a million or more inhabitants have no sewers. Rivers, streams, canals, gullies and ditches are where most human excrement and wastewater ends up, untreated. For those cities with sewers, rarely do they serve more than a small proportion of the population - typically the richer residential, government and commercial areas. The majority of people in major cities such as Jakarta, Calcutta, Dar es Salaam, Accra, Khartoum, Kampala and Manila live in housing lacking adequate sanitation. In India, defecating in the open is common practice since one third of the urban population (over 50 million people) have no latrine or any kind while another third rely on bucket latrines. A third may use latrines connected to sewers but only 10 per cent have sewage connections to their homes. Removing and disposing of excreta in ways which prevent human contact is central to reducing the burden of disease.

It is common for official statistics to overstate the proportion of people adequately served; for instance, people in neighborhoods with public latrines are often considered `adequately served' when there are 100 or more

persons per latrine and maintenance and cleaning are so poor that the latrine itself is a major health hazard and many people avoid using it. In addition, no one who knows Bolivia or Kenya can take seriously official government figures which suggest that 100 per cent of their urban populations were adequately served with piped water in 1980[4]. Criteria for `adequate service' often seem more appropriate for exaggerating the impact of government or aid programs than for meeting poor households' needs. A family of six [5]needs at least 300-400 liters of water a day to meet all its needs, the equivalent of 30-40 buckets a day. One of the most widely used criterion for judging whether a water supply is adequate is the existence of a communal tap within 100 meters. It is not appropriate to claim that a household has an adequate supply for its health and convenience when household members have to fetch and carry two bucketfuls of water for 100 meters, 15-20 times a day (and no doubt queue to get to the water tap). The existence of a water tap within 100 meters does not mean that the tap works or that water is available from it 24 hours a day.

2.1.2 Water pollution:

In terms of impact on human health in Third World cities, the dangers from most toxic industrial wastes are probably more localized and more open to swift and effective government control than those from other industrial pollutants. With regard to water pollution, there are usually four main sources: sewage, industrial effluents, storm and urban run-off and agricultural run-off. Agricultural run-off is often an `urban' problem since

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Jorge E.Hardy and others , obcite. [4]

Jorge E. Hardy , Diana Mitlin and David Satterthwaite , environmental problems in third world cities , [5] [5] 1997 , earth scan publication ltd , London .

water sources from which an urban centre draws may be polluted with agricultural run-off and contains dangerous levels of toxic chemicals from fertilizer and biocides.

Virtually all Third World cities have much more serious `nonpoint' sources of water pollution than cities in the North because of the lack of sewers and the inadequacies in garbage and trash collection services. A comprehensive sewage and storm drainage system makes it much easier to control water pollution since the wastes collected by this system can be treated, before being returned to rivers, lakes, estuaries or the sea.

Most water pollution falls into one of three categories: liquid organic wastes; liquid inorganic wastes; and waterborne or water-based pathogens.

Liquid inorganic wastes: Most inorganic liquid wastes come from industry; these are not broken down in water in the same way as organic wastes but for most, their dilution in large water bodies renders them harmless. Many such wastes kill animal and plant life, unless diluted sufficiently. Some inorganic wastes can become concentrated up the food chain to fish or through other fresh- or salt-water products (shellfish, seaweed) to the point where they can kill or do severe damage to the health of humans who eat them. Wastes which include certain chemical elements known as heavy metals (which include cadmium, mercury and lead) or some of their compounds can be particularly dangerous. Many of the pollution incidents which have resulted in the largest number of deaths and serious injuries from water pollution have arisen from human ingestion of fish, or crops contaminated with heavy metals or their compounds.

Liquid organic wastes: These can be termed `oxygen demanding' wastes since when disposed of into water, bacteria and other micro-organisms

combine oxygen dissolved in the water to break them down. The biochemical oxygen demand (B O D) of such wastes is a measure of how much oxygen dissolved in the water they will need to be broken down and as such, is one of the most widely used indicators of pollution. Liquid organic wastes include sewage, many wastes from industries (especially industries [6]processing agricultural products) and run-off from rains and storms which picks up organic wastes from land, before flowing into streams, rivers, lakes or seas. Too great a volume of organic wastes can overload the capacity of the water's bacteria and other micro-organisms to the point where all dissolved oxygen becomes exhausted. As the concentration of dissolved oxygen decreases, so fish and aquatic plant life suffer or die. Some portions of rivers or lakes which receive large volumes of organic wastes can have all their dissolved oxygen used up. They then lose their ability to break down these kinds of wastes and become black and foul smelling[7].

Waterborne or related pathogens: Many pathogens (disease causing agents including bacteria, viruses and worms) are spread in water - either through human ingestion of contaminated water or because water provides the habitat for intermediate hosts. Much the most common and widespread problem is pathogens from human excreta which contaminate water supplies. Typhoid, diarrhoea diseases and cholera are among the diseases spread in this way. Contaminated water also has a central role in the transmission of many intestinal worms.

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[6] Jorge E. Hardy , Diana Mitlin and David Satterthwaite , environmental problems in third world cities , 1997 , earth scan publication ltd , London .

[7] In this case the concept of thirst-hold is used indicating that up to a limit the capacity of the environment is able to safely assimilate organic waste disposed in it .

In the absence of sewage systems, much of the liquid wastes from households and businesses (and often industries) and a considerable proportion of the solid wastes end up washed into the nearby streams, rivers or lakes, greatly increasing the biochemical oxygen demand. The advantage of point sources is that treatment plants can be easily added - although in most Third World cities, in the absence of adequate treatment, most `point' sources (liquid wastes coming from sewers and industrial waste pipes) with minimal or no treatment are also major sources of water pollution. Most rivers in Third World cities are literally large open sewers.

2.1.3. Cases of cities with severe water pollution problems:

Alexandria (Egypt): Industries in Alexandria account for around 40 per cent of all Egypt's industrial output and most discharge liquid wastes, untreated, into the sea or into Lake Maryut. In the past decade, fish production in Lake Maryut has declined by some 80 per cent because of the direct discharge into it of industrial and domestic effluents. The Lake has also ceased to be a prime recreational site because of its poor condition. Similar environmental degradation is taking place along the sea front as a result of the discharge of untreated waste waters from poorly located outfalls. Paper, textile and food industries contribute most to the organic load.

Jakarta (Indonesia): All the rivers crossing Jakarta are heavily polluted although some of the pollution arises from wastes entering the rivers upstream of the city. While passing through the city, the rivers receive discharges from drains and ditches carrying untreated wastewaters from

households, commercial buildings and institutions and the discharges from industries, solid wastes and faecal wastes from overflowing or leaking septic tanks. Water-related diseases such as typhoid, diarrhoea diseases and cholera increase in frequency, downstream across the metropolitan area. The sea water and sediment in Jakarta Bay are clearly affected by the pollution load carried by the rivers discharging there. Apart from sediment and high biochemical oxygen demand, high concentrations of certain heavy metals have been found in the sea sediment and seawater in the bay.

Khartoum (Sudan): The water supply system is working beyond its design capacity while demand continues to rise. The coverage is poor, with low-income groups in squatter settlements paying the most for water, often bought from vendors. Breakdowns and cuts in the supply system are common. The municipal sewage system serves only about 5 percent of the Khartoum urban area. Even that system is susceptible to breakdowns when waste is discharged either directly into the river or onto open land.

Karachi (Pakistan): The Lyari river which runs through Karachi (Pakistan's largest industrial city) is an open drain from both chemical and micro-biological points of view; a mixture of raw sewage and untreated industrial effluents. Most industrial effluents come from an industrial estate with some 300 major industries and almost three times as many units.

Three fifths of the units are textile mills. Most other industries in Karachi also discharge untreated effluents into the nearest water body.

Sao Paulo (Brazil): The Tiete River, as it passes through Greater Sao Paulo receives 300 tones of effluents each day from 1200 industries located in the region. Lead, cadmium and other heavy metals are among the main pollutants. It also receives 900 tones of sewage each day, of which only 12.5

per cent is treated by the five sewage treatment stations located in the area. A shortage of water adds greatly to the problem of disposing of wastes - especially liquid wastes from industries and sewage. Large volumes of water dilute wastes and can render them much less dangerous; in addition, bacteria in the water break down organic wastes, as long as the volume of wastes relative to the volume of water is not too great.

Mexico City: Like most of the largest cities and many smaller cities, Mexico City is facing the mounting cost of increasing the water supply. Over-exploitation of underground water sources has made the city sink - in some areas by up to nine meters. New sources of water are at a considerable distance and these have to be pumped up 1000 meters or more which adds considerably both to costs and to fuel consumption. Mexico City is just one of many cities which developed in an area with limited water resources and which has now outgrown the capacity of the region to provide adequate, sustainable supplies.

Dakar (Senegal): provides an example of a smaller city which is also facing serious problems of water supply. Water has to be drawn from ever distant sources as local groundwater supplies were fully used (and polluted) and local aquifers over-pumped, resulting in saltwater intrusion; a substantial part of the city's water has to be brought from the Lac de Guiers, 200 kilometers away. Hundreds of urban centers which developed in relatively arid areas have grown beyond the point where adequate supplies can be tapped from local or even regional sources. Many of the coastal cities in Peru (including Lima), La Rioja and Catamarca in Argentina and various cities in Northern Mexico are among the many cities with severe constraints

on expanding freshwater supplies. Many others are facing problems in financing the expansion of supplies to keep up with demand.

2.2 Environmental Demand Theory:

One of the cornerstones of economics understands consumer preferences for goods .The typical way those preferences are represented is through demand functions relationships that gives the amount of a good an individual at a given income level will desire. When facing a particular set of prices that relationship can be presented through demand curve which summarizes how important a particular good is to an individual.

In much the same way that demand curves are useful summaries of consumer preferences for use in analyzing markets for private goods, a demand curve can also be useful in summarizing preferences for environmental goods .The problem with demand curves for environmental goods is that there are typically no markets. So we have no observations on how much of an environmental good is consumed at different prices.

Our task is to examine the environmental demand theory in accordance to our specific environmental good: Water. The demand for environmental goods is the same for the economical ones. However, environmental goods have some specialty in the amount of their demand in the market and in their concept of price. The demand of an environmental good depends on how the consumer perceives the importance of this good in environmental and health terms. The price, on the other hand, depends on the consumer's own awareness of the environment and the problems associated with it. And water pollution, or viewed as goods, air quality and

water quality. Also included would be amenity values such as a beautiful vista over a city.

Even more distant from the conventional notion of a good might be the existence of species (which is important to many people) or the lives of particular members of a species (such as birds that might be killed in an oil spill). The challenge to economists is to be comprehensive, viewing all aspects of the environment, over which have preferences, within the paradigm of consumer theory.

Why force the things we value in the environment theory?

The most important reason is that all environmental problems really involve a trade-off between using resources (money) for conventional goods and services and using those same resources for environmental protection. We really are talking about trade-offs. And that is precisely what a demand curve represents, at least from the consumer's point of view: how much is the consumer willing to give up (pay) for particular levels of an environmental good? No matter how esoteric or intangible the environmental good might be, its protection usually requires money. And it is usually appropriate to inquire how much people are willing to contribute to protect that environmental good. Eliciting true values is not easy; but that does not diminish the validity of the principle of demand for environmental goods and services.

It is of course much more difficult to generate a demand curve for clean air in an urban area. Leaving aside how precisely we would define "clean air," we have no observations on different consumption levels and prices. Yet clearly, individuals who value clean air would be willing to pay for it. The more expensive clean air is to provide, the more people would be

willing to tolerate some pollution; the cheaper clean air is, the more of it people would demand.

The absence of a market is the major factor that complicates finding the demand curve for environmental goods. But the absence of a market is the problem with nearly all public goods-including but not limited to environmental goods. For instance, schools are provided publicly in many parts of the world (education has elements of no rivalry). Finding the demand for public schooling is no easy task, basically because of the lack of markets. But the big difference between environmental goods and ordinary public goods is the supply side. Ordinary public goods are produced at a cost. Thus citizens have a reference point of the cost of supply to take into account when determining how much of the good they want at particular prices.

Although strictly speaking this should not impact the value to consumption, it can make the process of valuation easier. Furthermore, people may have experience with different points on their demand curve; perhaps they have lived in different communities with different amounts of the public good or are aware of the cost of private schools.

In contrast, environmental goods are often quite disconnected from the supply side. In determining how worthwhile the protection of a wilderness area might be, it is difficult to anchor that value, since the wilderness area is not produced. Air quality is in fact supplied, since there is a cost associated with cleaning up the air .However, this is a much more dispersed cost, much different than that associated with constructing a public school or park .This too makes the job of determining demand more difficult.

2.2.1 Willingness to pay:

A conventional demand curve plots quantity demanded as a function of price. Without a market there is, of course, no price. This is not really a problem, though we need to understand what underlying information is contained in a demand curve. Similarly, the consumer surplus associated with consuming a certain amount of a good is defined terms of a market transaction. In this section we see how similar concepts are equally applicable to environmental goods in the absence of markets. The key concept corresponding to price and surplus is willingness to pay. We first discuss how marginal willingness to pay is analogous to price and then show how total willingness to consumer surplus.

Each point on a demand curve indicates, for a particular quantity of the good, how the consumer values one more unit of the good--the marginal willingness to pay. In market, it is fundamental that for every consumer the price is the marginal willingness to pay. There is a nuance that has to do with whether the consumer is acquiring one more unit of the good or giving up a unit. If the consumer is giving up a unit that is possessed, the appropriate term is marginal willingness to accept compensation. In most contexts, these two concepts are equivalent.

There is one more issue of terminology that arises in the case of pollution often. We speak of the damage from pollution or the benefit of having less pollution, and the marginal benefit of one less unit of pollution is the same as the marginal damage of one more unit of pollution. Furthermore, the marginal willingness to pay for one more unit of pollution is negative and equal to the negative of the marginal benefit of one less unit of pollution or the negative of the marginal damage of one more unit of pollution.

Confusing ?The benefits of less pollution are the other side of the coin of damages from more pollution. When expressed in monetary terms, these benefits and damages are simply willingness to pay, the sign (positive or negative) is correct.

2.3 The Concept of Contingent Valuation:

Contingent valuation is a method of estimating the value that a person places on a good, usually one that is not sold in markets, such as environmental quality or good health. The approach asks people directly what they are willing to pay (WTP) for the good, or what they are willing to accept (WTA) to give it up, rather than inferring this from observed behavior. The commodities most often valued using this technique include public goods such as improvements in air and water quality, and private non-market goods such as reductions in risk of death, days of illness avoided or days spent hunting or fishing.

While other methods are available for estimating the values people place on some of these goods, such as the travel cost method and hedonic pricing, contingent valuation is the only method that can recover existence or non-use values--benefits from knowing that a good exists, even though one may not experience it directly. Contingent valuation is also of use when the policy option to be analyzed is outside of the range of available data. It is, for example, difficult to use observed behavior to value proposed improvements in water quality at a lake if the lake has always been polluted.

Although WTA is the appropriate measure of value when a good that someone owns is damaged, it is often difficult to measure WTA accurately in contingent valuation surveys.

Evidence of this is provided by the fact that willingness to accept compensation for quasi-private goods (hunting licenses) in contingent valuation surveys has been found to exceed actual willingness to accept compensation for the same goods (Bishop and Heberlein 1979; Bishop,

Heberlein and Kealy 1983). It is also the case that willingness to pay for a good is usually many times lower than willingness to accept compensation to forego the same good (Bishop and Heberlein 1979; Knetsch and Sinden 1984). When the good is not unique, this is interpreted as evidence that WTA is more difficult to measure than WTP. For these reasons, researchers have focused almost exclusively on WTP as the measure of value in contingent valuation surveys.

In early applications of the contingent valuation method, WTP amounts were sometimes elicited using iterative bidding protocols (Randall, Ives and Eastman 1974). In bidding game respondents were queried about a certain WTP figure. Those who agreed to pay were offered higher and higher amounts, until they finally switched to a "no" answer. Respondents who declined to pay the initially offered amount were offered lower amounts, until they said "yes."

This approach has been virtually abandoned, because it was found to produce starting point biases, i.e., the final WTP amount was significantly related to the choice of the initial figure.

The behavioral assumptions that typically underlie most rural water supply planning efforts are simple. It is commonly assume that as long as financial requirements don't exceed 5% of income. Rural consumer will choose to an abandon their existing water supply in favor of the improved system. Several reviews by the World Bank, Bilateral donors, and water

supply agencies in developing countries, have shown however that this simple model of behavioral response to improve water supplies has usually proved incorrect. In rural areas many of those ' served' by new system have chosen to continue with their traditional water use practices.

If rural water have to be both sustainable and replicable, an improved planning methodology is required that includes a procedure for eliciting information on the value placed on different level of service, and tariffs must be designed so that at least operation and maintenance costs (and preferably capital costs) can be recovered. A key concept, in such an improved planning mythology is that of ' willingness to pay. If people are willing to pay for the full cost of particular service, then it is clear that the service is valued (and there for will most likely be used and maintained) and so it will be possible to generate the funds required to sustain and even replicate the project. Most attempt to incorporate willingness to pay consideration into project designed have, however, been ad hoc, in large part because of the absence of validated, field-tested methodology for assessing willingness-to pay for water in context of rural communities in developing counties

Two basic theoretical approaches are available for making reliable estimates of households willingness to pay but neither has been adequately tested in the field. The first is ' indirect approach. It uses data on observed water use behavior (such as quantity used, travel times to collection point, perception of water quality) to assess the response of consumers to different characteristics of an improved water system.

Several modeling approaches are possible candidates here, among them varying parameter demand, hedonic property value, and hedonic travel cost models.

The second is direct approach which is simply to ask an individual how much he or she would be willing to pay for the improved water service, for instance, a public stand post or yard tap. This survey approach is termed the " contingent valuation method" because the interviewer posses questions within the context of the hypothetical market.

2.4 Previous Studies:

The research sheds the light on many studies that were concerned with the contingent valuation approach for pricing non marketing goods, among these are:

James N Mbata1 (1999)

Estimating household willingness to pay for water services in a rural economy: The case of Kanye in southern Botswana.

This study used the contingent valuation approach to examine the relationship between selected socio-economic characteristics of households and their willingness to pay for private water connection. An iterative bidding method was used to obtain survey data from 135 households randomly selected from Kanye in southern Botswana and the ordinary least-square regression technique was used to estimate the effects of selected exogenous variables on willingness to pay. The results show that household income, level of education and employment status of the head of the household and level of consumers' awareness are the key factors influencing willingness. This suggests that any government policy that increases these factors will increase households' willingness. In addition, because consumers' income is associated with their willingness to pay, it is

suggested that policies on connection and user fees recognize income inequalities when determining the amount that households should pay.

The study examines eight socio-economic characteristics as explanatory variables household income , household size, education level of respondents , age of respondent , distance of household from existing water sources , employment status of household , gender and incidence of water-borne disease in the family .

From the statistical analysis, most of the explanatory variables are statistically significant. That means that the variables are relevant to willingness to pay as will be shown. In addition, in contrast to this study, our study, as will be shown, suggests that additional need to be used such as children in families.

In 1986, World Bank in collaboration with Care Organization conducted a contingent valuation survey and source observations in Laurent, a village in southern Haiti.

The study addressed the possibility of constructing public stand posts and private connection. The study examined the impacts of socio-economic characteristics (income, education, occupation, and distance from water sources, water quality and sex) on villager's willingness to pay for both services in two separate models.

Through statistical analysis all the variables were statistically significant for both services at the 0.05 level, except the variable of gender that was significant only in the case of stand posts. The results clearly

indicate that the WTP bids are not random numbers but are systematically related to the variables suggested by the economic theory.

Generally speaking, the study of Southern Heiti is similar to that of James N Mbata1 (1999). They both focus on availability of water from a quantitative view, paying little attention to quality. The researcher will utilize the technical aspects of these studies to conduct surveys, taking into consideration the privacy of study community in selecting variables such as age, gender, education, and adding of other variables relating to the main focus of the study that is, water quality.

. *Another case study presented at the conference of "The Southern Economic Association in Baltimore" called "Willingness to Pay and Drinking Water Quality: An Examination of the Averting Behavior Approach."* This study tackles the averting behavior approach to the valuation of drinking water quality, and reviews studies made in Pennsylvania and Virginia to measure the averting expenditures. Averting behavior studies assumes that people adapt to the changes of the quality of drinking water by maximizing their level of well-being. The averting expenditures that would be needed to exactly counteract the harmful effects of drinking water quality, holding health (and utility) constant, is a theoretically correct measure of the willingness to pay (WTP) to avoid the decline in drinking water quality. However, practically speaking, a variable of the variation in drinking water quality is lacking as a variable in measuring the WTP. The study then presents empirical models of averting behavior with data from two surveys conducted during 1990 and 1995 and it shows that socio-economic variable such as education, age, gender, income, race and also factors like the use of filter, bottled water and septic, wells in

corresponding to changes in the quality of water, turned to affect the averting behavior of the respondents as predicted. Moreover, the study reaches a conclusion that the best methodological approach to conduct a benefit-cost analysis appears to be a combination of the three averting behavior, contingent behavior, and contingent valuation methods.

This study tackles the same variables that were used in the other two studies; nevertheless, it has a different approach in measuring the willingness to pay by using the averting behavior approach. Since the contingent valuation methods are mentioned to be useful in this study, the researcher will use them in his surveys. He will pose direct questions to the respondent as whether they are willing to pay for a better quality of drinking water or not.

To conclude, the case studies that have been undertaken here are not good representative of the third world countries which this study is representing one of them (Sudan). The use of these studies was mainly due to the fact that there are limitations in the availability of studies in such countries. Therefore, the researcher will only use the technical aspects of the above mentioned studies to conduct his surveys.

Moreover, the fact that measuring WTP is not a simple calculated variable, the surveys will try to tackle all related questions to the quality of water especially the viewpoint of the respondents. The point of asking direct questions is that in developing countries people are more concerned with the necessities of life, acquiring the basic needs such as food and water. To be more specific, water availability, in Sudan, has been a major problem for a long time, and thus people will be caring more about the quantity rather than the quality. This is why asking direct questions will be the best

methodological way to make awareness and also show how people will respond to such an issue.

Chapter three

Water Pollution: Risks, Guidelines and the Case of Sudan

3.0 Introduction:

According to WHO, "an estimated 80% of all diseases and over one-third of deaths in developing countries are caused by the consumption of contaminated water and on average as much as one-tenth of each person's productive time is sacrificed to water related diseases". For this fact, water pollution is considered a major problem in our world today.

Water pollution is any change in the quality of water that would have harmful consequences on any living organism when it is used for beneficial purposes. This change can be microbiological, chemical, or even a radiological one. The change might result in having health associated problems with water pollution. In this chapter, we will discuss the main types of water pollution and their harmful health effects to humankind, the sources of water pollution, the method of detecting water pollution, the guidelines that should be followed to ensure a safety drinking-water, and finally the specific case of water pollution in Sudan.

3.1 Types of Water Pollution:

3.1.1Microbiological Pollution:

The health-related diseases that come from water pollution are mainly due to bacteriological or other biological contamination. Drinking-water should not contain any pathogenic microorganisms or any kind of bacteria, virus, protozoa or helminth that can lead to faecal pollution. Not only that, also microbial hazards such as *Dracunculus medinesis* (known as Guniea worm), toxic cyanobacteria and Legionella may be a risk under certain circumstances.

Drinking-water can be the only way of transmission for pathogens that are transmitted through faecal-oral route,. However, this does not mean that contamination of food and hands can also play a role particularly when domestic sanitation and hygiene are poor. Therefore, improvements can be made for the quality and availability of water, especially in excreta, so that faecal-oral disease transmission can be prevented.

One must mention that contaminated water does not only come from faecal pollution, but also from distribution systems and water sources. Some organisms grow in piped water distribution systems (e.g.Legionella), whereas others exist in source waters such as Guinea worm.

Moreover, there are some organisms that might be found, naturally, in water that might "cause diseases in people with impaired or local or general immune defense mechanisms such with the elderly or the very young, patients with burns or extensive wounds, those undergoing immunosuppressive therapy or those with acquired immunodeficiency

syndrome" (WHO,2008). If water was exposed to such people by drinking, various infections of skin, nose, ear, eye and throat can be developed by them.

3.1.2 Chemical Pollution:

Chemical pollution is also of hazardous health significance. In general, most of the harmful chemicals in water do not become alerting except after a long period of time, sometimes years rather than months. However, the chemical compound Nitrate can only have an immediate harmful effect if found in excess of the supposed normal amount.

Chemicals that result in water pollution can be classified into three different categories. First class is inorganic Contaminants, such as fluoride and lead, which might result in bone diseases and neurological and behavioral disturbances, respectively. A second class is volatile organic contaminants which are due to: *disinfectants* such as chlorine which can cause irritating effects to their eyes and nose and chlorine dioxide which leads to nervous system effects for some infants and young children or due to *disinfection by-products*, such as total tri-halomethanes which, on the long run, might cause liver, kidneys or central nervous systems and may have increased risk of getting cancer.

3.1.3 Radiological Pollution:

This type of pollution might be caused due to the fact that some minerals, existing in water, might emit radiations known as alpha radiation or beta radiation or due to already radioactive material existing in water, such as Radon or the combined Radium226/228. In all cases, this radioactive

activity existence in water might result in an increase risk of cancer for those who drink such water.

3.2 Sources of Water Pollution:

Water pollution has many sources and this is one of he main reasons why it is such a complex problem to get to the bottom of it. In general, there are two types of sources: point and non-point sources. Point sources release water pollutants at certain locations through pipelines or sewers into the surface water. Non-point sources, on the other hand, are those sources that are hard to be traced to a single location of release.

Point sources are such as factories, sewage treatment plants, oil tankers, underground mines and agriculture. Commercial and industrial businesses use dangerous substances such as solvents in manufacturing or maintenance, and then they release toxic materials such as petroleum products or heavy metals, from their operations. Also, there are source pollutants from Agriculture such as pesticides, fertilizers or even petroleum. Community point sources can include sewage and waste water treatment plants, and motor pools. For all the few mentioned activities and others too, if their hazardous raw materials processed and their waste material generated, are not treated and disposed well, they will end up untreated in the water supply as pollutants.

Nonpoint Sources are such as acid deposition from the air, pollutants that are spread through rivers and pollutants that enter the waste water, and traffic. Nonpoint sources, thus, occur as water moves across the land or through the ground or through the ground capturing with it, natural or human-made pollutants, which can then be deposited in lakes, rivers,

wetlands, coastal water, and even groundwater. The water that contains nonpoint source pollution may come from natural processes such as rainfall or snowmelt, or even from human activities such as crop irrigation or lawn maintenance. Nonpoint source pollution is usually hard to track down to its exact origin of these pollutants because they are the result of different widespread range of human activities on the land as well as natural changes (such as soil and climate changes).

3.3 Detection of Water Pollution:

There are two main ways of measuring the quality of water. The first one is to take samples of the water and measure the concentrations of different chemicals that it contains. If the chemicals' concentrations are greater than the specified guideline values, then the water is regarded as polluted. Measurements like these are known as chemical indicators of water quality. The second one to measure water quality involves examining the fish, insects and other invertebrates life, if there is any change in their behavior or growth , then the water I likely to be polluted; if the river supports no fish life at all, the quality is obviously much poorer. Measurements like this are called biological indicators of water quality. Moreover, laboratories also use computer models to determine what dangers there can be in certain waters. They import the data they own on the water into the computer, and the computer then determines if the water has any impurities.

3.4 Guidelines for drinking-water:

According to WHO, "a drinking-water quality guideline value represents the concentatiron of a constituent that does not result in any significant health risk to he consumer over a lifetime of consumption". As mentioned previously, guideline values are compared to those values of water samples under examination to detect for water pollution. These guidelines values are considered for all microbiological, chemical, radioactive and radiological analyses. They are found in the published book by the WHO, *Guidelines for drinking-water quality*; Volume 1, which also explains how the values should be interpreted. When a guideline value is exceeded, an immediate action should be taken. The amount by which and for how long a certain guideline value should be exceeded without jeopardizing human health depends on the specific substance involved.

One must mention that national guideline values might vary from those guideline values specified by WHO. This conclusion is due to the fact that national guideline values are drawn up according to the corresponding local, socio-economic, geographical and cultural factors. It is for national authorities to establish medium and long-term targets for such factors. In this section, microbiological, chemical, and physical and aesthetic aspects regarding these guidelines will be discussed.

3.4.1For microbiological aspects:

Drinking-water should not carry any microorganisms known to cause disease (pathogenic) or any bacteria indicative of faecal pollution. In order that drinking-water supply satisfies these guidelines, samples should be

examined regularly. The detection of Echerichia coli provides definite evidence of faecal pollution, in practice, the detection of thermotolerant (faecal) coliform bacteria. The guidelines that are available in Volume 1 of the *Guidelines,* are for large supply systems, therefore here is the reproducible values for treated and untreated water supplies of community supplies, taken from the *Guidelines* volume 3.

Table (3-1): Guideline values for bacteriological quality

Organisms	**Guideline Value**
All water intended for drinking E. Coli or thermo tolerant coliform bacteria	Must not be detectable in any 100 ml sample
Treated water entering the distribution system E. Coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample Must not be detectable in any 100 ml sample

Total coliform bacteria	
Treated water in the distribution system E. Coli or thermotolerant coliform bacteria Total coliform bacteria	Must not be detectable in any 100 ml sample Must not be detectable in any 100 ml sample. In the case of large supplies, where sufficient samples are examined, must not be present in 95% of samples taken throughout any 12-month period

Another useful approach the WHO has conducted to ensure the microbiological safety of drinking-water was based on the minimum elimination of faecal pathogens by defining the conditions and the special treatment needed to be done at the water-treatment plant.

It is not easy to give general guidelines for biological hazards, especially for parasitic protozoa and helminthes. The application of any proposed guidelines and procedures must be considered under epidemiological considered in at least two respects:

- Many parasites have complex geographical distribution and thus taking precautious against those which do not occur locally will be of no importance.
- The majority of waterborne parasites are not only transmissible by water; but also by other ways such as food and direct faecal-oral

spread. Thus, these ways should also be considered in the formation of strategies of control.

Disinfection is an important process for surface waters after treatment and for protected groundwater sources when E.coli or thermotolerant (faecal) coliforms are detected. Chlorine is considered the most disinfectant substance used worldwide. The amount of chlorine that should be used in disinfection is listed on the table below (WHO, 2008).

Table (3-2): Guideline values for bacteriological quality

Type of Chlorination	The Specified Guideline Value
Terminal Chlorination for the inactivation of enteric viruses	a free chlorine residual of at least 0.5mg/liter after a minimum contact time of 30 minutes at a pH of less than 8.0
Chlorination in piped distribution systems for reducing the risk of microbial re-growth and the health risk of recontamination	a free chlorine residual of 0.2-0.5mg/liter

Emergencies cases (e.g. Refugee Camps) during outbreaks of potentially waterborne diseases	A free chlorine should be increased o greater than 0.5mg/liter throughout the system.

Chlorine can be easily monitored and controlled as a drinking-water disinfectant, and regular, frequent monitoring is recommended wherever chlorination is practiced.

3.4.2For chemical aspects:

Significant number of very serious problems may occur as a result of the chemical contamination of water resources. Some potentially chronic effects may occur in rural areas where overuse of agrochemicals leads o significant levels of pesticides in water sources. Fertilizers, leaching of wastewater or other organic wastes, into surface water and groundwater, can cause an excessive presence of both nitrate and nitrite. Also, the use of lead pipes and fittings or solder can result in an increased lead level in drinking-water. In order to avoid such relatively high chemical concentrations, a selected number of physiochemical parameters may have to be measured. Although, this can be both physically impractical and very costly to cover a large number of parameters, especially in the case of rural water supplies in developing countries. If special chemical contaminants are of special local significance, the levels should be measured and the results evaluated in the light of the guideline values and other recommendations made in Volume 1.

3.4.3 For physical and aesthetic aspects:

Characteristics of water like turbidity, color, taste, and consumer can affect the consumer behavior and perception towards using water for any of its beneficial uses. Consumers might even sometimes refuse the water because of its unacceptable aesthetically nature, although sometimes it might just be safe to drink. It is therefore not necessary to only ensure the following up of the guidelines mentioned above regarding the microbial and chemical pollution mentioned above, but to make guidelines for aesthetic water necessary to follow too.

Table (3-3): The guideline values for aesthetic parameter

Aesthetic Parameter	Guideline Value
Turbidity	In excess of 5 NTU (JTU) might be noticeable and consequently objectionable to consumers.
Color	Not exceeding 15 TCU. Drinking-water should ideally be colorless
Odor and Taste	Sanitary surveys should include investigations of sources of odor and taste when odor and taste problems are identified.

With community water supplies, the case is different. Only certain parameters known as the critical parameters are conducted to ensure the safety of supplies. The parameters recommended for the minimum monitoring of community supplies are those that best establish the hygienic state of the water and thus the risk (if any) of water borne infection. The critical parameters are:

*E coli; thermotolerant (faecal) coliforms are accepted as suitable substitutes;

*Chlorine residual (if chlorination is practiced), these should be supplemented, where appropriate by:

*pH (if chlorination is practiced);

*turbidity (if any treatment is affected).

3.5 The Case of Sudan:

3.5.1 History of Water Services in Sudan:

3.5.1.1 Historical Background:

People have been provided with water services since 1920s. Before this date citizens of Khartoum used to get their drinking water directly from the Nile, as well as from surface water wells in the areas relatively remote from the Nile.

Places east to the governor's palace and around Gordon Memorial College (Khartoum University now), where there was a beginning of a population increase of British neighborhoods, were blessed to have pure water by the British Administration. The standards of this pure water were established according to WHO's specifications and standards. They had also

dug the first two ground wells in 1900 out of which water was pumped to supply the general governor's palace and those districts with clean water. This task was given to the light and electrical power company which had then established the first Nile Purification Station in Khartoum, Bury area, in the period of (1924-1925) with productivity capacity amounting 16000 cubic meters per day. During the period of (1927-1936), a work has been conducted in Beitlalmal water purification station together with its three phases completed. The station's capacity was 20000 cubic meters per day. In the year 1954, the company also installed Old Bahari purification station with a maximum productivity of 12000 cubic meters per day in order to meet the need of the city for pure water. All through the period of (1925-1954) there prevailed a water supply system known as *Alnagata* in Bahari and Alabaseya district. . The name *Alnagata* has been derived from the fact that the flowing of water from the taps was in a very slow way resembling dripping into concert barrels intended especially for this purpose. Finally, in 1954 the system was replaced gradually with the present day water supply.[8]

3.5.1.2 El- Mogran Water Purification Station:

Through the 10 years from 1964 until 1974, Elmogran water purification system was being installed with its four phases with a design capacity of 72000 cubic meters per day to supply the city of Khartoum as well as the city of Omdurman through water caring line passing through the White Nile. In 1979, a work on the fist stage of the new Bahari water purification station was accomplished with a capacity of 3600 cubic meters per day, while another station that was used for storage and re-pumping was

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[8] Osman,Elbashir Osman,LIFE TRIP,First Edition 2003,Khartoum State Water Corporation

created in Bahri industrial area to have water net works in the city and its outskirts, especially those net works of the northern and eastern country – side of Bahari, through supply lines of different sizes. In 1984, work on Tuti water purification station was completed with a productivity of 2000 cubic meter per day. Also, work on the second phases in the new Bahari water station in 1986 with productivity of 36000 cubic meters per day to enhance water supply to the two areas of Bahari and Omdurman by transferring the clean water produced to the restoration and re-pumping station in Algamari via water transferring line over Shambat Bridge.

In addition to that, a high pressure station in Algamauir area was completed in 1992 and it is similar to those in the industrial area of Bahri and Al sahafa in Southern Khartoum. In 1990 work on the expansion of Elmogran purification station was completed by addition of 18000 cubic meters per day to its productivity to raise the total capacity to 90000 cubic meters per day. In 1999, the third and fourth stages of Bahari's new water purification station were completed to feel all the water networks in the state with abundant waters through the storage and re-pumping stations in the three areas and clean water was transported from the station to the high pressure in Alsahafa via water line of 28 inches extending from the station through the armed forces bridge. In 2002 work on the expansion of Beitalmal water purification station was complete with the addition of 11000 cubic meters per day, making productivity of the station 27000 cubic meters of water per day.[9]

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[9] Osman,Elbashir Osman, obcite

3.5.1.3 Ground water:

Sources of ground water were not restored until the late 1950s, when the water purification station was existent but there was still a shortage in meeting the increasing needs for the drinking water in the three-town capital (Khartoum-Omdurman- Bahri). Ground wells were drilled and installed in the areas of Khartoum2, Algouz, Eastern Eldum , Elgiraif and Burri. The ground wells dug in Bahari city included Elhalfaiah ,Shambat ,Industrial area and Eastern Elgiraif .In Omdurman two wells were dug on Elwadi street ,Elmahadia area , and since then the digging and fixing of wells continual until they reached 280 ground water wells, distributed among the towns of the state and its outskirts . Their total capacities were 2700 cubic meters per day.

3.5.1.4 Evaluation of Khartoum state water:

Several of administrative tasks took turn at the drinking water sector in Khartoum state ,starting with the light and electricity power company during the British ruling providing water services in the national capital , while the Public Works department provided water utilities in the regional towns .Following this, the Sudan government revoked the contract signed with British company "Sudan light and power", by acquisition at all shares and issuing an act in 1957, under which the central administration of electricity and water was placed under the supervision of the ministry of Public Works to assume control of the power and water in Khartoum and some towns such as Madani and sinnar.[10]

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[10] Osman,Elbashir Osman, obcite

In 1972 the control administration of power and water was transformed to the general electricity and Water Corporation to assume supervision over electricity and water utilities in the different towns in the country, while Water Supply Corporation undertakes supervision over rural water.

In 1982 water services was separated from electricity's ones, and Khartoum Province Water Corporation was established to comprise the urban and rural areas of the city .The year 1986 had witnessed the establishment of both of the National Urban Water Corporation and the National Rural Water Corporation under the supervision of the Ministry of Energy and Mining ,then it moved to the Ministry of Irrigation and Water Resource only to go back to the Ministry of Energy and Mining following the abolition of national corporation .In 1993 ,the two corporations were dissolved and the national water corporation was established as a consultancy body acting under the supervision of the Ministry of Irrigation and Water Resource. Accordingly, the Khartoum State Water Corporation was established in June 1994 under the supervision of the then Minister of Engineering Affairs, to include the two urban and rural sectors. It became an independent body with its own laws, board of directors, general director, executive departments as well as having a separate budget for operation and maintenance .It estimates its tariffs to cover the steering charges of operation and maintenance and specific margin. As for the development budget, it is financed by the state government and the federal government.[11]

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[11] Osman,Elbashir Osman, obcite

3.5.2 Objectives of the Corporation:-

- Provision of clean drinking water as per Sudanese specifications issued in the of the directives stated in the WHO's resolution to supply the resident ,commercial and services sectors at the level of the state's towns and villages and hence contributing to the development required.
- Conclusions of the necessary studies to develop and improve the existing water sources and to find new ones by establishing more purification station to cope with the architectural and population expansion as well as the rate of growth in productive sector.
- Promotion and development of the worker's abilities to ensure the highest rate of the production.

3.5.3 Investigation on Water Quality:

A water quality investigation study was conducted in 2001-2003 by the Department of Environmental Health- Ministry of Health in Khartoum State. It involved the collection and analysis of random samples obtained from the different sources of water that supply Khartoum State. The study revealed that a large percent of sample (up to 29%) show a level of pollution not suitable for drinking by human as indicated in the table below:

Table (3-4): Tested Water

Samples	**Year 2001**	**2002Year**	**2003Year**
Total no of sample	652	607	704

Not suitable for drinking	151	164	278
%	% 23, 2	%27	%29,5

- This critical situation underlined the need to undertake a more comprehensive and an updated study for water quality in Khartoum (2007). The study covered all water sources (stations) and distribution channels (network, taps, tankers, etc) in the state. The results show varied levels of turbidity in the water obtained from the different sources.
- The consumption of highly turbid water may constitute a health risk, because, as mentioned above, excessive turbidity can protect pathogenic microorganisms from the effects of disinfectant, stimulate the growth of bacteria in distribution system, and increase the chlorine demand. (WHO, 1996).
- Some of the samples contain living causal agents. This is mainly due to contamination, either directly or indirectly, by sewage, by other wastes, or by human or animals excrement. If such contamination is recent and if among the contributors there are carriers of communicable enteric diseases, the drinking of water so contaminated or its use in the preparation of certain foods may result in further cases of infection.

- Feacal pollution of drinking –water may introduce variety of intestinal pathogens – bacterial, viral, and parasitic- their presence being related to microbial diseases and caries, present at that moment in the community.
- Some samples from houses network showed pollution from pipe corrosion of pipe line, this is even if the source of water supply and it is treatment are of high standard, water pollution may also occur due to leaky joint and cross connections between water supply pipes and sewage drainage pipes.

Results from some of the station are presented on the tables below.

Table (3-5) Result from the Chemical and bacteriological analysis of a sample of water from Bahri Water Station that supplies Bahri City

Sample Source	Number Of Samples	*Coliform* test		*Thermotolerant* test		*E.coli* test		Res.chlorine mg/l	Turbidity NTU
		-	+	-	+	-	+		
Bahary (A)Plant	1	1	0	1	0	1	0	0.27	6.9
Bahary (A)storage	1	1	0	1	0	1	0	0.22	7.7
Area No.	14	13	1	14	0	14	0	0.3	22

(1)									
Area No. (2)	13	12	1	13	0	13	0	0.07	13
AreaNo(3)	13	11	2	13	0	13	0	0.05	8

Table (3-6) Result from the Chemical and bacteriological analysis of a sample of water from Bahri Water Station that supplies Khartoum City

Sample Source	Number No of Samples	*Coliform* test		*Thermotolerant* test		*E.coli* test		Res.chlorine mg/l	Turbidity NTU
		-	+	-	+	-	+		
Bahary Plant	1	1	0	1	0	1	0	0.07	15.03
Bahary storage	1	1	0	1	0	1	0	0.02	12
Area	14	11	3	13	1	14	0	0.11	9

No. (1)									
Area No. (2)	14	12	2	14	0	14	0	0.1	21
Area No. (3)	14	10	4	12	2	14	0	0.10	7

Table (3-7) Result from the Chemical and bacteriological analysis of a sample of water from AlMogran Water Station that supplies Omdurman City.

Water samples	Samples frequency	Coliform test		Thermotoleta nt test		E.coli test		Residual chlorine mg/l	Turbidit y NTU
		+	-	+	-	+	-		
Mugran plant	1	0	1	0	1	0	1	0.59	12
Mugran storage	1	0	1	0	1	0	1	0.30	8

Area NO(1)	4	0	4	0	4	0	4	0.64	13.4
Area NO(2)	3	1	2	0	3	0	3	0.3	20
Area NO(3)	4	0	4	0	4	0	4	0.31	11

3.5.3.1Questionnaire analysis:

- Factories were covered by specialized teams from the cooperation of water services , the company helped the team to be acquainted with the internal sewers and the exact connection point of each factory main public sewers list
- Some factories are not connected to main public sewer; waste is A
- Some factories have not adopted pretreatment and are disposed directly to main sewer untreated waste with bad nature of odor

3.5.3.2 Lab results analysis:

- Some factories have treatment unit which are not efficient enough with high concentration of organic matter, oil and grease, sulfur content pH, temperature, and solid out of specification compared

to the last study that was carried in 2001. This is due to lack of

Number and Source of Sample	Thernotolerant Coliforn test	Coliforn Test	A.P.C (c.f.u./1m1)	Confirmed E.coli test	Presumtive E.coli test	Coliforn Test. M.F.(c.f.u/100m1)

continuous follow up.

- Samples result from point of connection to sewer (combined) shows less degree of contaminants due to dilution with domestic waste from other line.
- Large number of factories are out of work due to high prices of raw materials mainly in soap-oil sector and also due to short in electricity supply
- The response from factories owner was encouraging and they interested to know the results of the study because it helps in policy of quality control department and implementation of ISO 14000 for environment.

3.5.4 Further Investigations:

1.Jezirah Bank, Alamarat st 59		Negative				
2. Dar Aljalal Ahmed Saeed-Alamarat-st 59 -	Negative	Posotive				
3.Abdu Mahmoud Abdu-Alamarat- Sq.9	Negative	Posotive				
4. Taj Alsir Ibrahim-Alamarat-st 59	Negative	Posotive				
5. Alsheikh Mohamed Alhassan –Alamarat- st59-	Posotive	Posotive		Negative		
6-Abdelrahman Awad-Alamarat-st.59	Negative	Positive				
7. Hamadna Allah Ibrahim- Alamarat- sq. 10	Posoyive	Positive		Negative		
8- Nyala University Coordination Office-Alamarat- Sq. 10	Posotive	Positive		Negative		
9- Abdallah Rahma-Alamarat St.59	Posotive	Positive		Negative		
10- Ibrahim Eljazouli-Alamart-Sq. 9	Posotive	Positive		Negative		

Also, in addition to the previous examination, examinations on water quality are constantly conducted by the Health office of Khartoum locality due to the citizen's complaints. Following is an illustration of such an investigation which was carried in 2007. The following tables describe the problems associated with the drinking water quality in the areas of Aldweim, Khartoum 2, Khartoum 3, and Alsajana

Table (3-8)

Date: 31/5/2007

Area: Alamarat

Samples Report:

Samples Number: 5,7, 8, 9 , 10 are polluted, should be further investigated for health purposes.

Table (3-9)

Date: 21/5/2007

Area: Eastern Dweim

Number and Source of Sample	**Thermotolerant Coliform test**	**Coliform test (A/P)**	**Confirmed E.coli test**	**A.P.C (c.f.u./1m1(**	**Presumptive E.coli test**	**Coliform test .m.p.n. (c.f.u/250 ml**
1.Adam Omar Mohamed	Positive	Positive	Positive			
2. Taj Alsir Mohamed Osman	Negative	Positive				
3. Adam Ibrahim	Positive	Positive	Negative			
4. Abdalhameed Ibrahim	Positive	Positive				
5. Hussein AbdelGadir	Negative	Positive				
6. Abdelmonem Mohamed Ahmed	Negative	Positive				
7. Lola Gubra	Negative	Positive				
8. Mohamed Saeed Hamza	Negative	Positive				
9. Abdelfattah Alnaseeh	Negative	Positive				
10. Mohamed Abdelmawla	Negative	Positive				

All the above samples are polluted free except for the samples number 1 and 3. Re-examination should be considered for health purposes

Table (3-10)

Date: 2/7/2007

Area: Aloshra

Number and Source	Thermotolerant Coliform test	Coliform Test .	Presumptive E.coli test	Confirmed E.coli test	Coliform Test .m.f. (c.f.u/100 ml	A.P.C (c.f.u./1m1(
1.Ismail Ahmed Kabashi-Sq,3 .1	lNegative					
2. Mohi Eldin Ibrahim- Sq 4	Positive		lNegative			
3. Omar Abdallah- Sq.4	Negative					

All above samples are polluted free except for sample number 2, which should be further investigated for health purposes

Table (3-11)

Date: 9/9/2007

Area: Khartoum 2 and Khartoum 3

Number and Source of Sample	Thermotolerant	A.P.C (c.f.u./1m1(	Confirmed E.coli test	Presumptive E.coli test	Coliform test	Coliform test .m.f.. (c.f.u/100 ml

	Coliform test					
Mohamed Hussein, Khartoum 3, Sq-4	Negative					
Hussein Babiker, Khartoum 3, Sq-5	Negative					
Jaafer Salih Resturant- khartoum 3	Negative					
Abdel Monem Mohamed School for girls, Sq. 5	Negative					
Abdel Monem Elias Jad Alrab- khartoum 2	Negative					
Hussein Babiker, Khartoum 3, Sq.5	Negative					
Private Secondary School for girls, Khartoum 2	Negative					
Omar Mohamed Hussein Abras- Khartoum 2	Negative					
Mohamed Ahmed Almurdi School for girls- Khartoum 2	Negative					
Mohamed Zein – Khartoum 2- Sq.2	Negative					

Report:

All above samples are polluted free.

Table (3-12)

Date: 2/8/2007

Area: Aloshra (Tap Water Analysis)

Number and Source of	Thermotolerant	Coliform test .	Confirmed	Presumptive	A.P.C (c.f.u./1m1(	Coliform test .m.f.. (c.f.u/100

Sample	Coliform test		E.coli test	E.coli test		ml
Ahmed Makki- Alryadh- Sq. 8	Negative					
Amir Almubarak Ali Alryadh Sq.8	Negative					
Mohammed Ali Alsafi- Alryadh Sq. 8	Negative					
Mahmoud Alsheikh Ahmed- Alryadh- Sq.8	Positive			Negative		
Mohamed Naseem- Alryadh Sq. 8	Negative					
Alryadh Mosque- square 8	Negative					
Tuna Education Institution- Alryadh- Sq. 8	Negative					
Mohamed Tahir- Alryadh Sq.8	Negative					
Makki Ismail- Alryadh- Sq. 8	Negative					
Said Ahmed Hussien Alrayadh Sq. 8	Negative					

All above samples are bacteria polluted free except for sample 4 which should be investigated further for health purposes.

Table (3-13)

Date: 9/6/2007

Area: Aloshra and Jabra

Number and Source of Sample	**Thermotolerant**	**Coliform test .**	**A.P.C (c.f.u./1m1(**	**Confirmed E.coli test**	**Presumptive E.coli test**	**Coliform test .m.f.. (c.f.u/100 ml**

	Coliform test					
Alzein Mohamed Alzein – Jibbat Aleskan- Sq. 3	**Negative**	**Negative**				
Santino Mileik Aloshra Sq. 4	**Negative**	**Negative**				
Rabab Ismail Jabra Sq. 3	**Negative**	**Negative**				
Ismail Ahmed Kabashi- Jabra Aleskan- Sq. 3	**Positive**	**Positive**			**Negative**	
Omar Abdallah Burhan – Aloshra- Sq. 4	**Positive**	**Positive**			**Negative**	
Abdelazeem Alnawrani – Aloshra Sq.2	**Negative**	**Negative**				
Seliman Alsir Seliman- Aloshra Sq. 2	**Negative**	**Negative**				
Salmn Nagash – Aloshra Sq. 4	**Positive**	**Positive**			**Negative**	
Alsir Seliman Idris- Aloshra sq. 4	**Negative**	**Negative**				
Mohee Aldin Ibrahim – Aloshra Sq. 4	**Positive**	**Positive**		**Positive**	**Positive**	

Samples number 1, 2, 3,6,7,9 is free from bacterial pollution. While samples number 4, 5, 8, 10 are polluted and should be further investigate for health purposes.

Table (3-14)

Date: 26/7/2007

Area: Al-Emtidad

Number and Source of Sample	Thermotolerant Coliform test	Presumptive E.coli test	A.P.C (c.f.u./1m1(	Confirmed E.coli test	Coliform test .	Coliform test .m.f.. (c.f.u/100 ml
Aldisougi Mousa- Al-Emtidad	Negative					
Bashir Jomaa Sq.13	Negative					
Atta Alsayyid Hussein Sq. 13	Negative					
Ihsan Abdelgadir Sq.13	Positive	Negative				
Ahmed Almahadi- Sq. 13	Positive	Negative				
Ali Mohamed Ahmed Alzibeir Sq.13	Negative					
Fadul Mohamed Alhassan Sq. 13	Positive	Negative				
Osman Farah Sq.13	Negative					
Ahmed Mohamed Fadul Sq. 13	Negative					
Ibrahim Eissa Sq. 13	Negative					

.Samples number 1, 2, 3, 6, 8, 9, 10 are bacterial polluted free. While samples number 4,5 and 7 are polluted and should be further investigated for health purposes.

Table (3-15)

Date: 6/9/2207

Area: East of Alsajana

Number and Source of Sample	Thermotolerant Coliform test	Confirmed E.coli test	Presumptive E.coli test	Coliform test .	A.P.C (c.f.u./1m1(	Coliform test .m.f.. (c.f.u/100 ml
Alshajarah- Egyptian Irrigation- Water Tank	Positive	Positive	Positive			
Merghani Hussein Shareef, Sq.2	Negative					
Aisha Ahmed Naji, Sq. 10	Negative					
Abdallah Mohamed Mokhtar, Sq.1	Negative					
Ahmed Ibrahim Hassan, Sq. 2	Negative					
Mohamed Ali Osman Sq. 2	Positive		Negative			
Ahmed Alsaffi	Negative					
Ibrahim Abdelrahman Mohamed Salih, Sq.2	Positive		Negative			
Hassan Mostafa, Sq. 2	Negative					
Mohamed Ali Satti	Negative					

All above samples are free from bacterial pollution, except for samples number 1, 6,8 which are polluted and thus should be further investigated for health purposes.

Table (3-16)

Date: 10/7/2007

Area*:* AlJerreif areas and Al Jerreif Correctional Centre

Number and Source of Samples	Thermotolerant	Confirmed	Presumptive	A.P.C	Coliform	Coliform test .m.f..

	Coliform test	E.coli test	E.coli test	(c.f.u./1m1(	test .	(c.f.u/100 ml
Awad Mohamed Ali- Correctional Centre	Negative					
Ali Mahmoud – Correctional Centre	Positive		Negative			
Correctional Centre Club- Al-Jerrief	Negative					
Correctional Centre Mosque – Al Jerrief	Negative					
Seliman Adam- Correctional Centre	Negative					
Sharinnat Albada- Correctional Centre	Positive		Negative			
Hassan Sir Alkhatim – Correctional Centre	Negative					
Mahmoud Hassan Khalil – Correctional Centre	Negative					
Mustafa Alamin – Correctional Centre	Positive	Negative	Positive			
Tarig Abdelkarim- Correctional centre	Positive		Negative			

Samples number 1,3,4,5,7, 8 are polluted free, while samples 2,6,9, 10 are bacterial polluted and thus further investigation should be carried on for health purposes.

Table (3-17)

Date: 16/6/2007

Area: Alsahafa

Number and Source of Sample	Confirmed E.coli test	Presumptive E.coli test	Thermotolerant	Coliform test .	A.P.C (c.f.u./1m1(	Coliform test .m.f.. (c.f.u/100

			Coliform test			**ml**
Mohamed Osman Suliman, Sq. 15		**Negative**	**Positive**			
Jaafer Abdelrahman, Sq. 15		**Negative**	**Positive**			
Ahmed Alhassan Osman, Sq. 15	**Positive**	**Positive**	**Positive**			
Mohamed Tibin, Sq. 15		**Negative**	**Positive**			
Ibrahim Mohamed kheir, Sq. 15			**Negative**			

All the above samples are polluted except for sample number 5 which is not polluted. Thus, a further investigation should be carried on for the polluted samples.

All the above tables indicate the level of water of pollution in different areas of Khartoum state. However, in this study, we are concerned with areas of middle Khartoum which include Alsajjana, Khartoum 2, Khartoum 3, Al-dweim, and Alamarat.

From the tables of these certain areas, it is clear that the water pollution is a major problem in the area of Middle Khartoum. Accordingly, the researcher took the study further to investigate the following questions: Are the citizens aware of this problem and its consequences? If they are aware and concerned with it, are they willing to pay extra fees to have a better quality of water? What are the variables that influence their

willingness to pay? In attempt to answer these questions, the researcher tries to find the relationship between the dependent variables and the independent variable (willingness to pay) statistically for further analysis.

Chapter Four

Analysis and result

4.0 The Study area:

The study area is located in the middle of Khartoum city. It is one of Khartoum Locality-affiliated Administrative units: Khartoum North, Khartoum East, Khartoum West, Elshuhada, and Soba. It extends to cover

Alseeka Hadid at the north, Road 61 at the South, Africa Road at the east and Alhuriya Road at the west. Additionally, it consists of Alamarat, Khartoum 2, Khartoum 3, Al-Dweim and Al-Sajjana. But some parts of Al-Amarat and Khartoum 2 units are considered as the first class housing, while Khartoum 3 is second class housing then Al-Sajjana & Al-Dweim are third class.

The number of houses in each unit as the following table (4-1) shows:

Table (4-1) : Number of houses in the area of middle Khartoum

The unit	Number of houses	Percentage	the selected sample
Al-Amarat	1468	15.4%	15
Khartoum 2	1140	12%	16
Khartoum 3	909	9.5%	8
Al-Sajjana	430	4.5%	8
Al-Dweim	5587	58.6%	53
Total	9534	100%	100

Source: Khartoum Middle Administrative Unit.

With respect to services of water supply, it is necessary to say that the whole area is provided with potable water by the National Water Network.

Regarding the health services in this area, there are some hospitals, health centers and clinics as the following table shows:

Table (4-2): Number of medical units in Middle Khartoum area

Administrative unit	Number of private and public hospitals	Number of health centers	Number of clinics	Number of medical centers	Number of private clinics
Al-Dweim	1	3	1	5	0
Middle of Khartoum	3	0	0	1	4
Al-Amarat	6	0	7	0	0
Total	10	3	8	6	4

Source: Khartoum Middle Administrative Unit.

From the above mentioned table (4-2), it appears that, hospitals and clinics were established in Al-Amarat while there are no health centers or private clinics. We found health centers in El-Dweim. The areas which are located in the middle of Khartoum Locality are characterized by accessibility to private clinics and hospitals.

In spite of the high density of population in El-Dweim, there is only one hospital in this area which indicates that the inhabitants of this area are completely dependent on health and medical centers. Also, it is clear that there is a lack of health services in El-Dweim area compared to Al-Amarat one.

We found that only Khartoum 2, Khartoum 3 and Al-Amarat are provided with sewage network services. Moreover, there are variations in per capita income, employment status and education level, which will be

examined for the effect of these variables in household willingness to pay to be provided with better water quality.

4.1 Methodology:

According to the definition of healthy and clean drinking water, we notice that there is a harmony among those who want to get it .Above all, the evaluation of the quality of the water by the user is dependent upon the people's income in addition to other factors such as the culture, education level, environment and other economic and social variables.

Therefore, the researcher used the stratified random sample via categorizing the residents of the study population into three groups in terms of their residential type which is considered to what extent as function of the other variables. So, we classified the residential areas as follows:

Khartoum (2) and part of Alamarat classified as first class.

Khartoum (3) and the other part of Alamarat classified as second class.

Alsajana and Aldeaim classified as third class.

It is worth-mentioning that a random sample method was used in selecting the sample of the study in Khartoum Locality which represents the study population. The households were numbered using existing information at the Locality headquarters

. Thereafter, 100 households were selected for the purposes of data collection. Then, 100 households were divided into three categories as according to the real distribution of the population as table (4-2) shows: the households at each category were numbered, then we selected a random

sample as follows: 21 houses from the first category,18 from the second category and 53 from the third category. For the survey, a contingent valuation questionnaire was designed and administered to the selected households. The questionnaire was structured into three specific categories: households' information, information on health and water use, and information on households' WTP for getting better potable water.

One hundred questionnaires were distributed and administered by the researcher himself to avoid misconception of some questions. The questionnaire consists of 22 questions, only one of them is an open question, while the others are closed.

Some questions were posed to know general information about gender, income, age, education, and employment. Besides, some details concerning potable water in terms of its quantity and quality, if the respondents get worried or concerned about its quality: how do the respondents react towards such a problem? Is there sewage system and what is their opinion on it? Do they have children under five years old? Is a member of his or her family infected by diseases due to using of potable water?

With regard to open question, it was posed to know the opinion of respondents on the potable water quality. The last two questions were about the improvement of water quality in accordance with the standards and requirements that are specified by the respondent, while the second question was about whether the respondents are willing to pay or not. And if he or she is willing to pay, moreover, he or she should select the additional percentage that is he or she can pay.

4.2 Descriptive Statistics:

The following table shows statistics evaluation (mean, standard deviation, skewness, and kurtosis) in regard to the questions asked in the questionnaires. Each question discusses a variable that will be discussed further in this section.

Table (4-3): Descriptive Statistics

Variable	Mean	Standard Deviation	Skewness	Kurtosis	Representation
1. Gender	0.87	0.34	-2.2	-	(1) for male (2) for female
2. Age	55.06	13.35	0.07	2.4	In years
3. Education level	13	3.5	-0.03	2.5	(6) for primary school, (9) for intermediate school, (12) for higher secondary school, (16) for graduate, and (19) for postgraduate.
4. Income	738 (SDG)	486	-	-	SDG
5. Occupation	0.52	0.51	-0.08	1.01	(1) for employed, (0) for others
6. Water bill	25.2	8.25	1.23	4.57	SDG
7. Children under five years	0.48	0. 5	0.08	1.01	(1) for children under five years old, and (zero) for older
8. Housing	2.35	0.82	0.72	1.88	(1) for first class, (2) for second class and (3) for third class
9. Residing or staying in the current house	30.5	20.25	0.10	1.76	In years
10. Sufficient water	0.19	0.39	1.58	3.5	(1) for sufficient

supply					supply and (0) for insufficient
11. Source of potable water	1.01	1.1	9.85	0.98	(1) for the Nile and (0) for groundwater
12. Sewage system	1.95	0.9	0.1	1.22	(1) for sewage system connected with a network, (2) for septic tank and (3) for no swage system
13. Opinion of respondents on the sewage system	1.01	1.25	0.63	1.67	(1) for good, (2) for satisfactory and (3) for bad
14. Worrying about Water quality	0.85	0.36	1.96	4.84	(1) for worrying about the water quality and (0) for not worrying.
15. How the respondents take action regarding water quality	0.63	0.49	0.54	1.29	No (1) if he or she uses filter or purchases bottled water, and zero (0) if not.
16. Water Diseases	0.28	0.45	0.98	1.96	No (1) if a member of respondent's family had been infected by water diseases and zero (0) if not.
17. Opinion of respondent on water quality	0.08	0.27	3.1	10.59	No (1) if the respondent's opinion on water quality is good and No (0) if the water quality is bad.
18. Purchasing bottled water	0.52	-0.08	1.01	-	No (1) If the respondent purchases bottled water regularly, and zero (0) if not
19. Using Filter	0.36	0.48	0.58	1.34	No (1) if he or she uses filter and zero (0) if not.

20. Willingness to pay so as to improve the water quality	0.50	0.50	0	1	No (1) if he or she uses filter and zero (0) if not.
21. Paying extra fees	1.64	2.39	2.86	13.75	By percentage

Gender: It is a qualitative variable, it was coded to take No (1) if the respondent is male and No (0) if the respondent is female. The table (4-3) shows that the Mean was (0.87) and the standard deviation (0.34) and it skewed to left (the skewness was -2.2). And this can be attributed to the number of males (87 person) compared to 13 females.

Age: the table (4-3) shows that the average of age of respondent was (55.06 year), standard deviation was (13.35) years. The maximum age was (88 years old), while the minimum age was (26 years).The age variable distributed normally (the skewness = 0.07, and the kurtosis = 2.4). Furthermore, the value of skewness indicates that the persons whose ages more than average age (median) are slightly large than small ages, especially we found that the age of 76% of the sample was more than 59 years old.

Education: the number of respondents according to their education level was found as follows: the number of persons who completed primary school was 7, intermediate school= 9, higher secondary school = 39, graduate = 34 and postgraduate =11. Thus, the table (4-3) shows the following:

The mean was 13, standard deviation was 3.5. Also we found that 19 were postgraduate, 6 were primary so the education level was normally distributed whereas the skewness = -0.3, and the kurtosis = 2.5

Income: It is a quantitative variable and the results were as follows:

The median of income was 738(SDG) with standard deviation 486 and the maximum income in the sample was 2200 SDG, while the minimum income was 100 but this variable is not distributed normally. More specifically we found that the number of persons whose income less than 500 was 36, less than 1000 was 48, less than 1500 was 4 and 1500 and more was 12.

Occupation: this variable was coded as a qualitative variable, so if the respondent is an employee, he was coded to take (1) and zero for others. The results were as follows:

The mean was 0.52 ,the standard deviation 0.5.It appears that 52 persons were employees , while 48 persons were others and the variable was found out to be normally distributed, the skewness was -0.08 and the kurtosis was 1.01 the matter which ensures that the number of employees was slightly more than others.

Water bill: it is a quantitative variable but it was categorized to three groups according to the amount of the bill. The results were as follows:

The minimum amount of bill was 16 (SDG), the amount of medium bill was 26 SDG; the maximum amount was 46 SDG.And the sample was distributed as follow: The minimum group consisted of 28 respondents, the middle group consisted of 62 respondents and the upper group consisted of 10 respondents. Regarding the mean, it was 25.2, standard deviation 8.25. So it doesn't distribute normally so the skewness was 1.23 and the kurtosis was 4.57.

Children under five: It is a qualitative variable so if the respondent has children less than five years he was coded to take No (1) and zero (0) for others. The mean was 0.48 with standard deviation 0.5. It appeared that 48 persons had children under five years, while 52 persons didn't have. There was slight difference between the two groups which makes the curve approximates to be normal distribution .We found that the skewness was 0.08 and the kurtosis (1.01).

Housing: It is a qualitative variable, the respondent was coded to take No (1) if he or she takes up residence that is categorized as the first class, No (2) for second class, and No (3) for third class residence.

According the answers of respondents, the researcher found that 21 persons of the sample live in first class residence, 22 persons live in second class, and 57 persons live third class residence.

The mean was 2.35 and the standard deviation was 0.82 but this variable didn't distribute normally, while it skewed to left (the skewness was 0.72) and the kurtosis was 1.88 which indicates that the population of third class residence were more than the population of other areas.

Residing in the current house: It is a quantitative variable which measures the duration or period of residence .The mean was 30.51, the standard deviation 20.25 .The maximum duration was 65 years while the minimum duration was one year. And the skewness was 0.10, and the kurtosis was 1.76.Thus, this result can be referred to the number of persons who have been staying for along time.

Sufficient water: It is a qualitative variable, the respondent was coded to take No (1) if the water is sufficient and zero if it is insufficient. The

results showed that 19 persons said that the quantity of water was sufficient, while 81 said it was insufficient. And the mean was (0.19), the standard deviation was (0.39) so the curve skewed to right (the skewness = 1.58, and the kurtosis =3.5) and this variable distributed normally.

Sources of potable water: It is a qualitative variable, if the Nile represents the source of potable water, it was coded to take No (1) and No (2) for groundwater. The results showed that all respondents selected No (1) which means that their main source of potable water is the Nile except one respondent who selected No (2). It is expected to have people who do not know or ignorant about their source of water. This person's answer is not considered seriously then. In addition, the mean was (1.01), the Standard deviation (1.10), the skewness was 9.85 and the kurtosis was 0.98.And this can be explained that 99% of the sample depends on the Nile a source for their potable water supply .This question was posed so as to know general information about sources of potable water.

Sewage system: It is a qualitative variable, it was coded to take No (1) if the respondent has a sewage or sanitary system that is connected with a network and No (2) if the sewage system is septic tank, and No (3) if there isn't a sewage or sanitary system. The findings were as follows:

(44) Persons said that they have sewage system, while (17) of them use septic tank, and 39 didn't have sewage or sanitary system. Regarding the statistics, the mean was 1.95, the Standard deviation was 0.91, the skewness 0.1, and the kurtosis 1.22.

Respondents' opinion on the sewage system: It is a qualitative variable, it was coded to take No (1) if the performance of the sewage

systems is good, No (2) if it is reasonable, and No (3) if it is bad. The statistics were as follow:

8(18.2) respondents of the sample said that the network was good, 15 (34.9%) respondents said it is reasonable, and 21(47.7%) said the sewage system was bad. And didn't apply on 66 respondents. .

The mean was (1.01), the value of standard deviation was 1.25, the skewness was 0.63, and kurtosis was 1.67. The findings assured that the majority of the respondents said the sewage system was bad.

Worrying about water quality: It is a qualitative variable, it was coded to take No (1) if the respondent worries about the water quality, and zero (0) if not. The findings were as follows:

88 respondents said that they worried about the water quality that is delivered by the water network, while 15 respondents didn't worry.

Regarding the statistics, the mean was 0.85, the standard deviation 0.36, the skewness was 1.96, and the kurtosis was 4.84. Therefore, the curve skewed to left which indicates that the majority of respondents worried about the quality of water.

Actions taken regarding water quality: It is a quantitative variable, it was coded to take No (1) if he or she uses filter or purchases bottled water, and zero (0) if not. The results were as follows:

63(74.1%) respondents said they use filters or buy bottled water, while 22(25.9%) respondents said neither use filter nor buy bottled water.

With respect to statistics, they were as follows: The mean was 0.63, the standard deviation 0.49, the skewness 0.54, and the kurtosis was 1.29 .Thus, the curve of this variable skewed to left the matter which means that the majority of respondents tried to take action concerning the quality of potable water.

Water diseases: It is a quantitative variable, it was coded to take No (1) if a member of respondent's family had been infected by water diseases and zero (0) if not. The findings were as follows:

28 respondents said that one of them were infections in their families, while 72 respondents said that no one of their families infected by water diseases. With respect to statistics, the mean was 0.28, the standard deviation 0.45 so the variable didn't distribute normally. The skewness was 0.98, the kurtosis was 1.96, therefore, the curve which represents this variable skewed to right because the majority of respondents were not infected by water diseases.

Respondents' on water quality: It is qualitative variable, it was coded to take No (1) if the respondent's opinion on water quality is good and No (0) if the water quality is bad. The findings were as follows:

92 respondents of the sample said that the quality of water is bad, and 8 of them said the quality of water is good. Regarding the statistics, the Mean was 0.08, the Standard deviation was 0.27 and this variable didn't distribute normally. Moreover, the Skewness was 3.1, and Kurtosis was 10.59 so the curve of this variable skewed to right because 92% of the sample said the quality of water was bad.

Purchasing of bottled water: It is a quantitative variable and it was coded as follows: If the respondent purchases bottled water regularly, he or she takes No (1) and zero (0) if not. It appeared that:

52 respondents purchase bottled water, while 48 respondents don't purchase bottled water. Regarding the statistics they were as follows:

The Mean was 0.52, and the Standard Deviation was -0.08 and the Kurtosis was 1.01 but the curve skewed too slightly to left.

Using filter: It is a qualitative variable and it was coded to take No (1) if he or she uses filter and zero (0) if not.

The researcher found that 36 respondents use water filter, while 66 of them don't use any filter. Regarding the statistics they appeared as follows:

The Mean was 0.36, the Standard deviation was 0.48, the Skewness was 0.58, and the Kurtosis was 1.34.Therefore, the curve of this variable skewed to right because the majority of respondents don't use filter.

WPT for improvement of water quality: It is a quantitative variable which was coded to take No (1) if he or she is willing to pay, and zero (0) if not.

The researcher found that 50 respondents said that they are willing to pay. Also 50 of them said are not willing to pay. Regarding the statistics, the table No (4-3) shows that the Mean was 0.50 , the Standard deviation was 0.50,therefore,the variable distributed normally according to the Skewness(0),and the value of Kurtosis was (1).

Paying extra expenses: It is a quantitative variable (scale).The respondent takes the percentage according to his or her water bill per month. Thus, the findings were as follows:

The maximum percentage was 13.8, and the minimum was zero .The percentage is coming more from the avoiding the risks associated from the bad quality of drinking water, rather than from an additional quality improvement. People in societies like these give much consideration to such problems unless they are faced with risks. Thus, the marginal benefit of willingness to pay represents the price in this case. And 30 respondents assured that they are willing to pay 2.6 SDG as extra amount, while 12 respondents said that they are willing to pay 1.6 SDG, and 2 respondents said that they were not willing to pay 4.6 SDG. While the other remaining respondents each one of them said he or she was willing to 3.2 SDG, 5.2 SDG, 7.8 SDG, 9.SDG, 13 SDG, and 13.8 SDG respectively. With respect to statistics, they were as follows:

The Mean was 1.64 , the Standard deviation was 2.39, the Skewness was 2.86, and the Kurtosis was 13.75 so the curve skewed to right because there were 62 items less than the Mean but it doesn't reflect the tendency of this variable due to the existence of zero (50% of the variable's data is equal zero).

4.3Correlation matrix:

We will discuss the correlation of willingness to pay variable (w) with other variables that have been mentioned in the questionnaire. Also, the t-calculated of some variables will be compared to the t-tabulated of this

sample which was found to be 1.992, in order to see the significance of the variables statistically.

Table (4-4) Correlation Coefficients of variables

	Adge	Bill	Em	Inc	Per	Ill	Ed
Adge	1.0	0.077	0.071	-0.287	-0.408	-0.165	-0.421
Bill	0.077	1.0	0.0283	0.189	0.248	-0.156	0.075
Em	0.071	0.028	1.0	0.130	0.115	-0.114	0.271
Inc	-0.287	0.189	0.130	1.0	0.511	0.123	0.419
Per	-0.408	0.248	0.116	0.511	1.0	0.165	0.438
Ill	-0.165	-0.156	-0.114	0.123	0.165	1.0	0.165
Ed	-0.421	0.075	0.271	0.419	0.438	0.165	1.0

Gender: the researcher found that there was a very weak positive correlation, which means that there was a direct relationship between the respondent's willingness to pay and the gender variable (the correlation coefficient was 0.033). The t-calculated of this variable was found to be 0.326 which is less than the t- tabulated (1.992). This means that the gender variable is of no much statistical significance when it comes to influence the respondent's decision regarding his or her willingness to pay extra money for getting potable water with best quality.

Age: the table No (4-4) shows that there is a strong negative relationship between age variable and willingness to pay (the coefficient of correlation was -0.57) and this result conforms to the research hypothesis. The t-calculated value for this variable turned out to be -6.7845 which is greater than the t- calculated, but negative. Therefore, it has a statistical

significance and gives an indication that the older the respondent becomes, the more he/she doesn't change his or her current situation

Education level: the correlation coefficient was 0.67. Thus, there is a positive correlation which indicates that there is strong direct relationship between education and the respondent's willingness to pay which means that the more the respondent is educated the more he/she pays attention or gives consideration to his or her health and his/her dependents. This finding inclines with the research hypothesis. Also, the t- calculated for the education variable was found to be 8.9 which is greater than that of t-tabulated. This means that this variable is statistically significant.

Income: there was strong relationship between the respondent's income and willingness to pay (the coefficient of correlation is 0.45).Thus, the more the income increases ,the more the respondent is willing to pay on-cost or extra amounts for .getting potable water. And this result inclines with the research hypothesis which assumed or presupposed that the factor of willingness to pay depends on the income which is considered as an important factor that influence on the factor of willingness to pay. Also, the t calculated turned to be 4.988 which is greater than the t-tabulated, which shows that income variable is statistically significant.

Housing: the results showed that there was very weak correlation between housing variable and willingness to pay (the correlation was 0.07); this means that there wasn't statistically significant relationship between these two variables and this result can be referred to the other factors that have influenced the respondent's decision of payment.

Period of stay: the value of correlation indicates that there was a weak negative relationship between the period that the respondent stays in the house and his or her willingness to pay (the correlation coefficient was 0.17) which means that the more the respondents stays for along time, the less he or she changes his decision including his or her willingness to pay on-cost (extra expenses). This variable can be correlated along with the age variable, the longer the duration of stay, the older the household head is, and so the more he/she is not willing to pay because of the inflexibility of changing, as discussed previously.

children under five years old: the findings showed that there was a correlation which indicates to existence of positive relationship between the variable of existence of children under five and the respondent's willingness to pay (the value of correlation was 0.15), therefore, the children under five represents an incentive for the respondent to pay on-costs or extra amount in order to get potable water with best quality because the households give great consideration to their children health more than themselves. Bad quality of water affects children more and in quicker way than it affects the old people. This is why parents/ old people in general tend to care about their children, and this is clear in the positive correlation between the existence of children and willingness to pay, although it is weak but still it has its significance.

Occupation: there was a correlation which indicates that there was very weak positive relationship between the occupation level and willingness to pay (the value of the correlation was 0.05) which means that there wasn't any relationship between these two variables so this result coincides with research hypothesis which assumed that there is positive

relationship between the above mentioned variables because the employees can pay for getting potable water. But due to the large numbers of pensioners in the present time, the result didn't incline with the research hypothesis. Most of the families in this sample have their household as an old person who is probably a pensioner, and this is due to the existence of smaller families within the family. This demographical nature of the sample is also the same for the Sudanese society, since the sample represents this society. This variable can also be attributed to the variables of age and income. Since, the age of household is old, then it is expected that the correlation becomes weak. Also, since pensioners are not well paid (income is small), then it is again expected to have this weak relationship between occupation and willingness to pay.

Water bill: there was a correlation (0.07) which indicates to a very weak negative relationship between the water bill amount and willingness to pay .Moreover, there wasn't a relationship between these two variables. And this can be attributed to incoherence of large variations in the bill amounts which was categorized as follows: 16 SDG, 26 SDG, and 46 SDG respectively whereas the Standard Deviation for water bill was 8.25.

Respondents' opinion on sufficient water: there was a correlation (0.07) which indicates to existence of very weak positive relationship between the opinion of respondent on the quantity of water and willingness to pay. The correlation coefficient was (0.07) which means that there wasn't any relationship between these two variables. And this weak positive relationship can be explained that the respondent who takes the view that there is problem concerning quantity of water, he doesn't pay attention to the problems of water quality.

Sources of potable water: there was a correlation (0.10) which indicates a weak negative relationship which is statistically insignificant because there were no variations regarding this variable. Therefore, the researcher found that 99 respondents of the sample said that their main source of potable water was the Nile.

Sewage system: there was a correlation of (0.00004) which indicates a very weak positive relationship between the type of sewage system and willingness to pay. Furthermore, these variables correlate to housing variable. There was statistically insignificant relationship between these two variables (sewage system and housing) and willingness to pay.

Respondents' opinion of sewage system: there was a correlation that indicates to existence of very weak negative relationship between the opinion of respondent about the sewage system and willingness to pay because the correlation coefficient was (0.07) which means that the relationship between these two variables was statistically insignificant. These findings can be attributed to the large number of respondents who are willing to pay although they haven't had a sewage system yet.

Existence of diseases: there was a correlation which indicates to the existence of weak positive relationship between the existence of diseases and variable of willingness to pay, because the correlation coefficient was (0.27) which can be explained that the members of families, who were infected with diseases due water quality, were able to pay on-cost (extra expenses) for getting potable water with best quality.

Paying extra expenses: there was a correlation indicating a weak positive relationship between these two variables whereas the correlation

coefficient was 0.15 and the tendency of this relationship is right because if the water quality is bad, the respondent is willing to pay additional expenses or costs for getting water with high quality. But the value of correlation coefficient was small and that can be attributed to the effects of other factors – such as age and income , on the respondent's willingness to pay because many people are not satisfied with the water quality but they are not willing to pay any additional amount of money and this in line with our results which show that 81respondents of the sample said the water quality was bad , while only 50 respondents of them said they were willing to pay additional or extra amount of money for getting water with high quality.

Respondents' opinion on water quality: there was a correlation which indicates to existence of very weak negative relationship between their opinion on the water quality and willingness to pay, but this relationship is illogical because the correlation coefficient was (-0.003) .And this negative relationship can be referred to the method that was followed in coding the questionnaire. As we mentioned above, this variable was coded to take No (1) if the water quality is good, and zero (0) if the quality is bad.

With regard to correlation coefficient, it can be attributed to the large number of respondents who said the water quality was bad; therefore, the value of correlation coefficient was statistically insignificant .But the research hypothesis assumed that there is positive relationship between the opinion of respondents on the water quality and their willingness to pay.

Worrying about water quality: there was a correlation which indicates to the existence of positive relationship between the variable of worrying about the quality of potable water and willingness to pay because the

correlation coefficient was (0.26) the matter which means that the respondents worried about the quality of water and they were willing to pay more to get water with best quality.

Action taken due to water quality: there was a correlation which indicates to the existence of weak direct relationship between the variable that concerns with action that is taken due to worrying about water quality and willingness to pay. The correlation coefficient was (0.15) which means that the respondents who took action by purchasing bottled water or using filters, they had more willingness to pay. This variable is considered general factor in determining the willingness of respondents, in general, to use bottled water or use filter (to take an action). But then, we will separate and discuss each action on its own as a way to see the sincerity of the respondents in actually taking an action.

Purchasing of bottled water abidingly: There was a correlation (0.05) which indicates the existence of very weak positive relationship between the variable of purchasing bottled water and willingness to pay. This relationship is reasonable and in line with the research hypothesis but the value of correlation coefficient was very weak and this can be referred to the large number of respondents who said that they purchase bottled water.

Using filter: there was a correlation which indicates the existence of very weak direct relationship between the variable of using filter and willingness to pay because the value of correlation coefficient was (0.03). We found that this relationship doesn't confirm research hypothesis but the value of correlation coefficient was weak and that can be attributed to the

small number of respondents (36 respondents) who use filters and able to pay on-cost (extra amounts).

4.4 The Model:

An econometric model is estimated using a multiple linear regression equation of the following form was postulated:

$$WTPi = \beta o + \beta_1 INCi + \beta_2 AGEi + \beta_3 EDUi + \beta_4 Gi + \beta_6 CHi + + Ui \text{---------- (1)}$$

Where WTP = WTP bid by household; INC = Household income (per month); AGE = age of respondent (years) ; EDU = education level of respondents (number of years of formal schooling) , G = gender male or female, EM=employment status, CH= existence of children under five years old, Ui = random error term assumed distributed as normal with mean and variance, so as to know the influence of socio-economic characteristics of the respondent on his or her willingness to pay for getting potable water with better quality. The data were entered in E.VIEWS Program for estimating the model.

The researcher adopted willingness to pay variable (W) as a dependent variable to the regression in which the income, gender, age, education and children were independent variables and the results were showed as the following equation:

W= -0.00018inc+0.37g-0.14edu-0.08age+6.7**ch…… (2)**

(0.651) (0.473) (0.011) (0) (0)

R^2= 0.31273 , Adjusted R^2= 0.283792

Note: the digits between the two brakets represent the values of probabilities which represent significance of coefficients.

The results show that the income was statistically insignificant and has negative impact, which is contrary to the economic theory and hypotheses of the study. The impact of education variable is negative, which is inconsistent with the hypotheses of the study and finally the gender variable was statistically insignificant, therefore, the researcher excluded this model.

The researcher then used TOBBIT as a method by using the following equation and (per) as the dependent variable instead of (w):

$$Per = \beta o + \beta 1 INCi + \beta 2\ AGEi + \beta 3 EDUi + \beta 4 Gi + \beta 6 CH + Ui \text{-- } (3)$$

Where per = the mount of money should be paid by respondent as additional expenses; INC = Household income (per month); AGE = age of respondent (years) ; EDU = education level of respondents (number of years of formal schooling) , G = gender male or female, CH= existence of children under five years old, , Ui = random error term assumed distributed as normal with mean and variance, so as to know the influence of socio-economic characteristics of the respondent on his or her willingness to pay for getting potable water with better quality.

The results showed the influence of the independent variables- such as income, gender , age ,education level ,employment , existence of children under five years old, and infection with diseases due to use of water- on willingness to pay for water was examined. However, per (the mount of money should be paid by respondent as additional expenses) was used as the dependent variable here. The expected signs of the variables' coefficients are positive except the age variable which is expected to be negative. The results were as the following **equation** shows:

$$Per = -3.28_{+}\ 0.002inc\ -0.087age + 0.4396edu_{+} 0.218g_{+} 0.118799_{ch} \text{.....(4)}$$

(0.27) (0.002) (0.003) (0.001) (0.84) (0.79)

R^2= 0.345437 , Adjusted R^2= 0.287894

It appears from the equation No (4), there were only three statistically significant coefficients of the following variables: income, age and education level. While the other variables coefficients were statistically insignificant even at 10 percent. Also there is no problem of multi-co linearity because R^2=0.35.I

In order to reach required accuracy, the researcher adopted regression in the adoption of PER as a dependent variable to the regression in which the income, gender, age and education were independent variables and the results were

The researcher then made some changes in the model by excluding the insignificant variables except the gender so it became as follows:

Per =βo + β1INCi+ β2 AGEi + β3EDUi + β4Gi+U------- (5)

Equation (5) then becomes:

Per=5.9323306+0.001941INC-0.203038AGE+0.1299EDU+0.821948sG- (6)

(0.043) (0.0343) (0) (0.0478) (0.5484)

R^2= 0.309781, Adjusted R^2= 0.273067

All variables coefficients were significant at 0.05 level except the gender variable's coefficient which was insignificant even at 0.10 level but it appears from equation No (4) the numerical values of coefficients were very small. For instance, the income coefficient was 0.0019 and this can be attributed to the large values of income compared to the per extra amount of

money that is should be paid by respondent which is very small. The sign of the income coefficient is positive which is consistent with the research hypothesis and economic theory that assumes that an increase in income increases the demand for that good, all other things being equal. Therefore, the income is an important variable affecting the decision of willingness to pay for getting potable water with better quality. Also the results indicate that there is negative relationship between the respondent's willingness to pay and his or her age and that may be referred to psychological reasons. For instance, the over age people (the elders) are rigid in their decisions and this is again is consistent with the research hypothesis.

Furthermore, the results show that an increase in the level of education would raise the respondent's level of awareness about the safe and reliable sources of potable water supply. Educated people are more willing to pay because they are conversant with effects of diseases that are caused by polluted water and they are not rigid.

The gender variable has no effect on the respondent's willingness to pay for getting potable water with better quality whereas the coefficient of this variable is statistically insignificant because in urban areas the female's willingness to pay doesn't differ from the male's willingness. Above all, the employment status of women may be equal to men's employment status in urban areas despite the fact that this finding doesn't complement with the results of Mabat's study which was conducted in Kenye south east of Botswana in 2006 who assured that the gender variable affects the willingness to pay for private water connection in rural areas. However, this study was conducted in rural areas where the availability of water in the

house is traditionally the role of women. Thus, they are expected to be more willing to pay here.

In order to reach more accuracy regarding the age variable, the researcher used the squared formula of the age variable (agesq +age) with taking into account the following equation:.

Per =βo + β1INCi+ β2 AGEi + β3 AGESQ + β4EDUi + β5Gi+U…….(7)

Regarding the results, the statistical analysis led to following equation:

Per=11.40009+0.002INCi-0.51AGEi+0.0033AGESQi+0.288EDUi+0.645Gi… (8)

(0.001) (0.017) (0.0002) (0.017) (0.047) (0.62)

R^2= 0.397411, Adjusted R^2= 0.358535

The results show that all variables are statistically significant including the intercept, except the gender variable. As for the age variable, the effect on the dependent variable is negative which agrees with the hypotheses of the study as [d (per/age) = 0.006(age) - 0.51], the sum turns to be negative by compromising for the age factor in the first derivative. We notice that there is a decreasing behavior of the effect of age on the willingness to pay variable. After analyzing all the results and in accordance with the hypotheses of the study and the principles of economic theory, the researcher found that the model offered by the equation(8), which included per as dependent variable and income ,educational level ,age and gender being the independent variables. This is because it is considered as one of the most models that represent the reality so the R-*Sq* is 38% which

means that 38% of the change in the dependent variable explained by the independent variables and this expected due to the difficulty of the method of contingent valuation which depends on the virtual market that is difficult to deal with because the respondent is unable to give the accurate results.

For the individual parameters, we found that independent variables of the model including the intercept were statistically significant under 0.05 except the gender variable. In the coming chapter; we will discuss the above mentioned results in detail.

Chapter five

Discussion of Results, Conclusion, and Recommendations

5.0 Introduction:

In this chapter, the variables which were found to be the most influencing are going to be discussed. Finally, the researcher will draw his conclusions and recommendations on the subject.

5.1 Discussing Variables:

5.1.1 Income variable:

This variable is considered as one of the most important variables because the economic theory stating that there is relationship between income and demand for any commodity with other factors remaining equal. As, the willingness to incur additional expenditure in return for a better quality of drinking water is considered as a demand for clean drinking water. So the study assumes that the sign of the parameter that is associated with the income variable is positive and as the coefficient of income in this model was 0.002, which was statistically significant at 5% since t calculated was found to be greater than t-tabulated. Thus, the coefficient is positive and comes in line with the economic theory and hypotheses of the study. For value calculation, it means that if the income increases by one thousand SDG, the respondent is willing to incur extra two SDG to get better quality of drinking water. Therefore, this result is logical if we compare the income

with other choices of extra expenses. Also, it is more per capita income increases, the more willingness to incur additional expenses.

5.1.2Education variable:

The results of this model were consistent with the hypotheses of the study, which indicate to the direct relationship between education and the willingness to incur additional expenses, because the more educated people, the more they are aware of diseases and problems caused by poor water quality, the better the community of health and finally the more they are flexible and acceptable to new ideas. As the coefficient representing the education variable was 0.67 which is statistically significant at 0.05 (t-calculated is greater than t-tabulated) with a positive sign, it is concluded that the higher educational level, the more willingness to pay and any additional one year of schooling means an increase of 0.29 pounds per capita to incur extra expenses.

5.1.3 Age variable:

With regard to the age variable, the researcher applied the square function instead of linear function so the age variable becomes (agesq + age) rather than age only. In this case the influence of age depend on the age of respondent, which represent the first differential derivative of the additional expenditures for age variable dper / dage = 0.006age -0.51. By considering that the maximum age of the sample is 88 and the minimum is 26, we find the coefficient of age is negative. For example, taking into account the minimum age (26 years) and the mean age (55 years) and substituting into the equation we find out that $d(per/age)_{minimum}$= -0.354 and d(per/age)mean =

-0.180. However, it is found out when substituting the age (85 years) , the sum becomes zero, while by substituting from this age to the maximum (88 years), the sum turns positive reaching a d $(per/age)_{maximum}$ = 0.01. Thus, 85 years would be considered a turning point when plugging in the curve of the function. Although, the overall behavior of the effect of the age on the willingness to pay variable is found to be negative, the sum turns positive for only substituting the last three numbers of the age. The researcher, therefore, will disregard this positive effect and will consider the overall behavior which is consistent with the economic theory and the hypothesis of the study. By plugging into the first derivative, the value of coefficient differs from age to another, but in general the negative effect decreases as the age increases. This can be attributed to the psychological reasons because individuals in the minimum ages respond to change more than those of higher ages which means that individuals after the age of sixty, for example, do not tend to change their decisions from year to year in contrast to individuals who are in their earlier ages . We found that the coefficient of age variable was on average -0.18. Also, since t-calculated is greater than t-tabulated, the inverse relationship is statistically significant for the two parameters, the over ages seems to be more rigid regarding their willingness to incur additional expenses in contrast to persons of small ages that are concerned about the health of their children.

Then, the study shows that the older the individual, the less he/she is willing to pay extra fees for a better quality of water.

5.1.4 Gender Variable:

The results showed that the gender variable alone has no effect on the willingness to pay variable and this is due to the fact that the special coefficient of this variable has no statistical significance on the level of 5% since its t-calculated is much less than the t-tabulated (discussed earlier in chapter 4). This might be due to the fact that women in civilized societies do not differ from men when it comes to making decisions, since women almost have the same place where they also have the same occupational work. Although the study of Botswana showed that the gender variable is of a significance to the willingness to pay variable, the study was actually conducted in a rural area, where the availability of water is the women's responsibility and as the study's main concern was whether individuals are willing to pay for the water transport service to the homes, then it would be common sense that the women would be more willing to pay than the men.

5.2.0 Discussion of the results:

The results were consistent with the hypotheses of the study, which relied primarily on economic theory and in particular the theories of environmental economics that take into account the specificity of environmental goods and the demand for them, and what has been found from previous studies in this area. Although, this study might be insufficient to determine the integrated model to explain the reality of demand for better quality of drinking water and thus the development of projects for improvement, and despite the insufficiency of sample and limitation of the study in a small area and the fact that this kind of study is beginning in Sudan; it does provide indicators from which to discover the problem's features, and submit to some extent the determinants of the demand for

drinking water quality and reflects the responses of citizens to such environmental issues and how they interact to research studies based on the principle of resolution in general.

In order to discuss the results of this study, there is a need to know the amount of fees which the respondents actually pay for water services, so that we can get to see how much extra fees they are willing to pay for a better quality of water. The tables provided in appendix II show the monthly water payment according to the size of main pipeline, the level of the residential area, the type of building (residential or commercial).

The number of participants in Khartoum 2, Khartoum 3, and Alsajana: 3354 participants

The expected monthly payment from all participants is 96, 992, 70

The percentage of collecting from payers is 86%

According to the Khartoum State, The headquarters office of collecting:

-The number of participants in both Al-Deweim and Al-Amarat : 5970 participants

- Number of participants in Aldarrasa is 9324 participants.

They are distributed based on the following matter:

By focusing more on the distribution of the participants according to the different categories of the use of water, and so according to the monthly payment bill, we find that the large number of the population of the 3rd grade who use tub of half an inch (261) with a monthly payment 15 pounds, represents 38%. Next, in the ordering, comes the population of the 2nd grade

which are (262, ¾ inch), and who have a monthly payment of 25 pounds; they represent 32%. After them, comes the population of the 1st grade (1 inch 263) who pays monthly 45 pounds are of percentage of 15%, and so we notice that the three categories are the dominant participants, as they represent 85% of the overall participants.

One of the obstacles that faced the researcher is that the participants are not satisfied with what they pay for the water services since the supplies of water they receive are unsatisfactory and do not meet them their daily needs which, in turn, made them even not really concerned about the issue of the quality of water. But even though this was the case, half of the individuals of the sample showed a willingness to pay extra to receive a better quality of water, the reason which makes this issue still important and shows the deterioration in the quality of water to the point the users became aware of it and of the health issues associated with it which made some of them react to this problem, even if it was only for the study's sake. While on the other hand, some became non trusty of the governmental institutions as they felt that the real issues and problems concerning the quantity of the water prevents them from considering the problem of the quality of water seriously, and so such studies will not be effective at all if the problem of the quantity of water does not get solved.

By looking at the results, it becomes apparent that the income variable is the most essential variable and it can be dealt with as a controllable variable because of its changing nature, unlike the other variables that deal with the decisions of the individuals for putting extra fees, like the education and the age variables, that are not controllable especially

in the short term. The average monthly payment over the average of income represents 3%.

The researcher found some obstacles in determining the income of the participants of the survey which in turn showed some differences, as for the participant with the lowest monthly income (100 pounds as they claimed), his monthly bill is 45 pounds and still he is willing to pay extra fees for a better quality of drinking water. This can be either due to the participant being dishonest about his income and this is expected or due to the other factors which affect the willingness to pay variable. While the participant with the highest monthly income (2200 SDG) showed a willingness to pay with water monthly bill representing 1.18% of his monthly income.

In general, income represents the most essential variable when taking into account the precision in investigating it and this can be achieved by taking the indirect questions approach which was not tackled in this study since it was mainly focusing in showing the issue of the quality of the water to the users, their reactions to the issue and showing only the indicators to deal with the problem from the theoretical aspect, and not for solving it in a practical manner.

The study also showed that a change in the income variable by
pound results in an increase in the amount of money the participant is willing to pay as extra fees by 0.002 pounds, i.e. 0.2 pounds as extra fees is equivalent to 100 pounds increase in the income. This shows that participants, who are willing to pay extra fees for a better quality of water, will actually pay if their income doubles in the amount in Sudan. This means that it is necessary to increase the income by an amount that would be close

to the median of the income that was found in this study (738 SDG) in order to make the participants willing to pay extra fees by 10% of the monthly water bill as to get a better quality of water.

The second variable, according to importance, is age. It is also inversely proportional with the willingness to pay variable, and this in turn agrees with the assumptions of the study. This can be due to psychological reasons; as those who are of old age, especially over 60 and retired, do not have the efficient flexibility to accept new ideas, as well as the pensions that they get are just not enough even to cover their basic needs of food and medicine, needless to say being willing to pay for a better quality of water. Also, the fact that they used to have this better quality of water in the past when they were young might give them the feeling that the purpose of this study is just an attempt to go back, which is not that tempting after all. Unlike, the participants of the young age who are more willing to change and accept new ideas; they would want to use the present technological advances to develop further and have a better quality of water in general, even if the presence the technological advance means a cost. Also, the effect of the other factors like the relatively high incomes for the young people and the presence of children of ages less than five years in their young families, and the better education they have are all reasons to make young people are more willing to pay extra fees to get a better quality of drinking water.

Even though the age variable is not directly controllable, but the fact that the social evolution in which small families are becoming substitute of extended families can result in big change in the results of such studies later on. This social change can be accelerated by providing housing with reasonable prices and good installments which will encourage the youth of

making families of their own, and so this will in turn make a significant change in the results of studies similar to this one. This is clear proved by the this study since the average age of the sample was 55 years, which means that the heads of households of youth families are a minority and most of the heads of households in the sample are of old age that is close to the retirement age (60 years).

Also, by considering the squared function as a formula for the age variable showed that the difference in the willingness to pay extra fees from the participant of the lowest age (26 years) and the median (55 years) is 7.656 pounds less than the participant with the median age, who is less willing to pay extra fees. Also, the difference in pounds between the median and the participant with the highest age (88 years) is 2.673 pounds less than the participant with the highest age. Although the difference of the age groups according to years is equal, as it is almost 30 years, this result proves that the effect of age variable on the willingness to pay extra fees, according to the age group by which the participant is represented, is explained by the psychological reasons which the researcher adopted for the age variable, and so the squared formula is the best formula to represent the age in the model used.

For the education factor, the results proved that it affects the decisions of the respondents significantly, as those who are more educated are generally more open to new ideas, more concerned and aware of their health and the health of their children, more understanding of this study and more accurate in answering the questions of the survey. The results also showed that there is a strong connection between the level of education and the willingness to pay as the coefficient of the relationship reached 0.67, which

proves of a direct relationship between the two variables. In addition to that, the model, which was adopted by the study for analysis, showed that the higher the level of education the more willing a person becomes to be willing to pay by 0.29 pounds.

Like the age variable, the education variable needs a social change which has already been discussed to be slow. An increase of education years for an individual by five years leads to an increase in the willingness to pay by 1.45 pounds as extra expenses to get a better quality of drinking water and this is equivalent to 10% from the overall monthly water bill value.

Thus, consequently, to increase the influence of the education variable, it requires a change in the structural change of the families' households, in addition to an increase in the educational area, and a demographical change (migration from rural to urban areas) which leads to establishing of new families with parents being more educated. All of the above changes show that studies like this with education being a very important factor, will gain more accuracy in the future, will be more capable of evaluating the reality of the situation, and will draw effective policies, and this is all because of the expected positive change in education quality in the coming years.

As for the gender variable, it is an important variable in analyzing any economic and social phenomena. It can not be excluded from any study that deals with such issues, as what have been seen from the previous studies that were dealing with the factor of willingness to pay. Although the results of this study showed that the associated coefficient with the gender variable has no statistical significance, this result might be due to the natural setting of

families in Khartoum where most of the family households are male. From the sample of the study, it is clear that the percentage of the male households is 87%, and on the study of Botswana, for example, the percentage of female households was 47%. Women in Khartoum society enjoy an equal opportunity with men when it comes to education and employment, which decreases the effect of the gender variable in the study's results, but there are also the psychological factors which exist within the men and women in like societies, as that for women become more concerned about the health of their children with their emotional nature and their continued support and follow up of their children. Also the educational level of the females is rather lower than that of the males of the age group of being parents. On the other hand, families whom females are the households heads are exceptional cases, in this study, mostly due to the death of the father for example, and on such cases the income of the family is found to be low,. This shows why female parents are less willing to pay extra expenses to pay for a better drinking quality of water. In general, the study shows that the gender variable alone is of no effect on the decision of the willingness to pay, unless it is looked at through the other variables.

For the other variables that were not included in this model, most of them were taken into account by the researcher in the survey for measuring up the environmental awareness of the respondents, and also to see how much the respondents react to such issues and finally to see how honest they are when giving personal information. The answers of the subjects came out to be agreeable and useful in helping in getting the results which are in a great extent agreeable with the economic theory and the assumptions of the

study which was managed according to the researcher's abilities, despite the smallness of the sample and the difficulty of the problem generally.

5.3 Conclusion :

The study showed that there is an environmental problem concerning the quality of water. However, when it comes with dealing with the problem, this is done on various levels since there were differences in the incomes, ages, and educational levels of the respondents. These three components are the most important factors in determining the willingness of the respondents to pay extra fees to get a better quality of drinking water.

Also, the study has revealed that there are non-perspective factors that affect the respondents in dealing with such studies, such as being more concerned with the basic needs of life such as getting food and medicine, which makes them not really concerned about environmental issues in general and feels that the quality of water is the least of their problems when the quantity is still a major problem in Sudan.

Also, there is over sensitivity problem from the citizens when it comes to paying money to the state, as there is a general feeling what they pay of taxes and fees to the state is exceeding what they get in return of services.

In addition to that, the study also showed that the income variable is the major factor in determining the amount which the individual is willing to pay in return of a better quality of water. Despite the fact of the low incomes, half of the respondents were willing to pay the extra fees.

Moreover, the age variable has a great influence on the willing to pay factor, since the older the parent is, the less he/she is willing to pay extra fees.

Furthermore, the education variable is the most associated variable with the willingness to pay, as the more the education years an individual has, the more he/she is willing to pay extra fees.

Last but not least, the gender variable has no effect on its own on the willingness to pay variable.

5.4 Recommendations:

According to the results of the study and the nature influencing variables on the fees that the respondents are willing to pay in return for a better quality of drinking water, the study recommends the following:

- Carry out different field studies before taking any decisions concerning the services which are provided to the citizens. This will help in training the citizens with dealing with such studies, so that the researchers can reach more accurate and real results which will help the decision makers to make the right decisions.

- Work on increasing the incomes of the citizens which will make discussing affording extra fees more realistic and easier to them. According to this study, the average of the incomes of the citizens is 700, while according to the results; it should be 1500 at least, so that the citizens will be able to afford the extra fees which are equivalent to 10% of the monthly water bill they receive.

- Working on increasing the educational institutes and broaden the education scale on all over the country. This will make the individuals be more aware and concerned about the problem, and so be more willing to pay extra fees.

- Work on having awareness from those in charge in environmental issues by using the media and the educational curricula as methods.

- Sponsor similar studies based on cost and benefit principle to establish projects with an objective of providing valid drinking water in return of paying extra fees that are affordable to the citizens. Providing water is a state's responsibility and it should invest on this area, and at the same time, citizens should also be able to bear extra fees since this is the case with environmental goods, just like the other goods with costs or else there will be problems that will cost more in dealing with them, than the cost of the goods.

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APPENDIX I

A questionnaire has been conducted for the thesis titled: " Demand of a Clean Drinking Water in Khartoum State" in order to know how much citizens are willing to pay to get a better quality of drinking water, taking into account economical and social factors.

Please note that the questionnaire is for academic purposes. Thus, we ask the respondents to be as precise as possible in answering the questions.

The survey is specified for household heads.

1. Gender

a. male b. female

2. Age ……..

3. Education

a. Primary b. Intermediate c. Secondary d. Undergraduate

e. Post-Graduate f. illiterate

4. Housing

a. First Class b. Second Class c. Third Class

5. How long have you been staying at this house? ……

6. Do you have children under five years old?

a. yes b. no

7. What is your occupation?

a. employee b. worker c. businessman d. Handicraft

e. others……..

8. How much is the salary in SDG?

a. less than 500 b. 500-1000

c. 1000-1500 d. more than 1500

9. What is your monthly water bill?

10. Do you think the quantity of water provided is sufficient to your needs?

a. yes b. no

11. What is the source of the water reaching your house?

a. The Nile b. underground water

12. What type of sewage system do you have?

a. Network b. septic Tank c. not available

13. If your answer is (a), what do you think of the sewage network system?

a. good b. satisfactory c. bad

14. Do you have any concerns regarding the quality of the water reaching your house by this general water network?

a. yes b. no

15. If your answer is yes, what kind of action have you taken towards this?

a. used filter b. purchased bottled water

c. I didn't take any action d. I don’t consider taking any action

16. Do you have diseases in your family associated with the water you receive for drinking or bathing?

a. yes b. no

17. What do you think of the quality of water reaching you by the general water network?

a. good. b. satisfactory c. bad

18. If your answer is (c), what kind of problem do you have?

……

19. Do you or anyone in your family purchase bottled drinking water?

a. always b. sometimes c. rarely d. never

20. Do you use Filter at home?

a. yes b. no

21. If the quality of water has been improved from the current level to the level of your satisfaction, are you willing to pay extra fees to your monthly water bill?

a. yes b. no

22. If the answer is yes, choose the appropriate percentage to you as an increase to your current monthly water bill

a. 10% b. 20% c. 30% d. 50%

APPENDIX II

Information on the cost of water:

Table (1)

Symbol	Explanation	Cost (SDG)
261	½ inch residential, 3rd grade	1500
262	¾ inch, 2nd grade (residential apartments, offices, stores, clinics)	2500
263	1 residential inch, 1st grade	2500
562	Small cafeterias, farms for drinking purposes and laundries	3700
563	Big restaurants	7500
662	Fire points	3700
761	Small workshops	3000
762	Baladi ovens	5200
961	1 ½ residential inch	9700
962	2 residential inches	12000
963	Automatic Ovens	8900

Source: Khartoum Water Cooperation

Non-Constant Cost:

Table (2)

Symbol	Explanation	The minimum cost	The cost (SDG)	What escalated from the minimum cost (SDG)
231	½-1 residential	60-m	45000	0.9
232	1 ½ - 2 residential	85-m	10000	1.35
234	Commercial, governmental, …	50-m	9500	1.55
235	Soft drinks, ice	50-m	8400	1.90
237	Kiosks		500	1.00
350	Electricity			2.00

Number of participants

Table (3):

Symbol	Number of Participants
261	2271
262	1911
263	916
562	44
563	19
762	6
961	153
962	44
963	13
334	153
332	18
331	249

Note: The report does not include data on schools and governmental institutions.

Source: Al-Deim and Al-Amarat office (Archive)